Examining the relationship between climate change and migration and its socio-economic implications in Dhaka, Bangladesh

by

Dilruba Fatima Sharmin

A thesis

presented to the University of Waterloo

in fulfillment of the

thesis requirement for the degree of

Doctor of Philosophy

in

Social and Ecological Sustainability (Water)

Waterloo, Ontario, Canada, 2023

Examining Committee Membership

The following served on the Examining Committee for this thesis. The decision of the Examining Committee is by majority vote.

External Examiner	Dr. Robert McLeman Professor, Department of Geography and Environmental Studies, Wilfrid Laurier University
Supervisor	Dr. Roy Brouwer Professor, Department of Economics, University of Waterloo
Internal Member	Dr. Derek Armitage Professor, School of Environment, Resources and Sustainability, University of Waterloo
Internal Member	Dr. Andrea M. Collins Associate Professor, School of Environment, Resources and Sustainability, University of Waterloo
Internal-external Member	Dr. Susan J. Elliott Professor, Department of Geography and Environmental Management, University of Waterloo

Author's Declaration

This thesis consists of material, all of which I authored or co-authored: see the Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

I was the sole author of Chapters One and Five under the supervision of Dr. Roy Brouwer, which were not intended for publication. I led the development of Chapters Two, Three, and Four, taking on the primary and lead authorship responsibilities. I conceptualized the study design, conducted data collection and analysis, and drafted these chapters. Chapter Two was developed and written with comments and feedback from Dr. Derek Armitage and Dr. Roy Brouwer (in preparation). In Chapter Three, Dr. Roy Brouwer provided supervision, and additional input was provided by Dr. Derek Armitage (in preparation). Chapter Four benefited from the insights and feedback of Dr. Andrea Collins, Dr. Roy Brouwer, Dr. Derek Armitage, and Dr. Susan Elliott (in preparation).

Abstract

Climate change and migration are two urgent global issues of our time, and their relationship is complex and unpredictable. Understanding the nature and implications of this relationship is crucial for policymakers, practitioners, and scholars seeking to devise effective responses and policies to tackle these “wicked problems.” Drawing on emerging scholarship and primary research, this dissertation sheds light on three interlinked issues related to climate change and migration nexus. First, earlier efforts to reconcile diverse conceptualizations of the climate change and migration nexus have had limited success. So far, despite significant research efforts by a few scholars to develop conceptual frameworks, challenges remain in our ability to gain a holistic understanding of diverse perspectives, knowledge domains, dimensions or scales, and drivers or factors that lead to differing migration decisions under climate change. Current limitations include inadequate comprehension of the migration patterns driven by climate change (e.g., who migrates, who remains, and the underlying reasons behind these choices). Second, our current knowledge about the effectiveness of migration as an adaptation strategy is inadequate, stemming from limited conceptual and empirical investigations conducted on this issue. As such, the extent to which migration can effectively serve as an adaptation response and any potential drawbacks associated with it remain unclear. Third, the significance of gender in shaping migration decisions under climatic conditions remains under-theorized and less comprehensively explored, even though gender plays a crucial role in shaping migration decisions and patterns. The specific ways in which climate change may shape gendered migration in varied contexts are not well understood, as there is no comprehensive review of empirical studies on gender and climate migration.

This dissertation aims to contribute to the evolving knowledge of the complex relationships between climate change and human migration by addressing these interlinked issues. Chapter 2 is dedicated to developing an expanded, more holistic, and generally applicable conceptual framework that can be applied to understand migration decisions and different migration patterns in diverse contexts and regions worldwide. Building upon the identified limitations of existing conceptual frameworks and covering extensive theoretical and empirical grounds, this chapter develops a conceptual framework that integrates diverse perspectives and concepts (e.g., vulnerability, agency) to provide a more nuanced understanding of the complex nature of the relationships between multi-faceted climatic conditions and varying migration decisions and their effectiveness. This framework seeks to lay a foundation for further research examining climate migration in diverse forms and sets the tone for the rest of the dissertation. Chapter 3 presents the findings of an empirical case study on post-migration vulnerability situations of climate migrants in Dhaka, Bangladesh, to gain insights into the effectiveness of migration as an adaptation strategy. Based on large-scale household (n = 2,000) survey data and applying principal component analysis (PCA), this chapter assesses the socio-economic vulnerability of the climate migrants and compares that with other migrants and long-term residents by developing a composite vulnerability index (CVI). This chapter also analyzes and compares the longitudinal recall (perception) data

on different aspects of their before and after migration situations. Chapter 4 conducts a systematic review of the empirical evidence (n = 33) in South Asia to fill out pertinent gaps in the empirical scholarship of the gender-climate change-migration nexus. This chapter identifies and characterizes different gender-differentiated migration responses under varying climatic conditions, assesses the agency involved in differentiated migration decisions, identifies emerging theories and methodological considerations, and examines how well ideas are distributed among disciplines through a bibliometric analysis. This chapter also highlights pathways through which gendered inequalities in climate migration may occur. Overall, this dissertation contributes to the emerging field of climate migration by offering theoretical, methodological, and empirical insights into these complex issues. By doing so, this dissertation advocates for further transdisciplinary and sustainability-oriented research and expects to guide future research and policy-making efforts aimed at developing effective and sustainable policies and practices for communities affected by climate migration.

Acknowledgments

Pursuing this doctoral degree has been an uphill battle, with many challenging moments that seemed insurmountable. Completing this dissertation would not have been possible without the will and blessing of Allah Subhanahu wa ta'ala.

Just like the old proverb goes, *"It takes a village to raise a child,"* I also needed a community of supporters, who span the globe, to lift me up, offer guidance, and accompany me until the completion of this significant chapter in my life.

At the University of Waterloo, my academic advisor, Dr. Roy Brouwer, has persevered through every challenge, always encouraged me to think more critically, refine my work, and inspired me to become a better version of myself. Your unwavering guidance and support have been an anchor throughout my doctoral journey, and I am deeply grateful for your invaluable contributions to my growth. I am also forever grateful to my committee member Dr. Derek Armitage for your supportive nature, insightful and strategic guidance, which has given me the confidence to pursue my ideas and navigate the challenges of academia. Additionally, I would like to express my immense gratitude to my committee members, Dr. Andrea Collins and Dr. Susan Elliott, for their guidance. Dr. Andrea, your passion and enthusiasm for gender research is contagious, and I have learned so much from your insights. Dr. Susan, thank you for your continuing encouragement throughout the process. Together, I feel incredibly fortunate to have an amazing committee of diverse experts who have guided me throughout various stages of developing this dissertation. Their wealth of knowledge has equipped me with valuable skills that I will carry throughout my career. Additionally, I am thankful to my external Dr. Robert McLeman, for insightful and stimulating discussion during the defense.

I would also like to take the opportunity to thank Amanda Campbell, Mary Anne Hardy, Jennifer Nicholson, and Cynthiya Subramaniam for their exceptional administrative support. Their efficiency and dedication have made the administrative tasks associated with my studies far more manageable. Additionally, I sincerely appreciate Marian Davies from our library for her interest in my research and for offering assistance and insights.

I feel incredibly fortunate to have crossed paths with an extraordinary group of cohorts, colleagues, and friends during my time in Waterloo. I especially appreciate Dr. Dustin Garrick and Dr. Graham Epstein's amazing collaboration, which has enriched my research experience. Thanks to Lowine, Madu, Anita, Augustine, Tim, Zehua, and Jorge for their support and positive attitude, making this journey even more rewarding. Thanks to my dear friends Dani, Noushin, Megan, Noelle, and my wonderful former roommate Julie who helped me settle in Waterloo when I initially arrived and showed great care and support in numerous ways. I am thankful to my brother from another mother, Dr. Omar Faruk from U of T, for actively motivating me to pursue higher studies. Additionally, I want to express my heartfelt gratitude to my Muslim sisters from different countries at the KTA mosque in Kitchener for their exceptional care, hospitality, and generosity, as their warm presence, shared meals of diverse homemade cuisines throughout the month of

Ramadan, and the fostering of a deep sense of belonging makes me feel at home, despite being far away.

Back in Bangladesh, I am deeply grateful for the contributions of numerous Professors at NSU and beyond who have played a pivotal role in guiding my academic journey. They have shaped my interests and encouraged me to explore ideas, learn from mistakes, and emerge from the experience with improved confidence. I sincerely thank Dr. Mizan R Khan, Dr. Niaz Ahmed Khan, Dr. Md. Jakariya, Dr. ATM Nurul Amin, and the late Junaid K Choudhury for their encouragement in pursuing higher studies. I also sincerely thank Dr. Ainun Nishat for generously sharing his extensive knowledge of climate change, which has significantly enriched my understanding.

My heartfelt acknowledgment goes to the wonderful Dhaka residents who participated in this research, especially climate migrants, for their warm and welcoming attitudes, sharing their stories and insights of their experiences, which inspired me to be more open-minded, humbled, and grateful for being privileged. I also extend my gratitude to the incredibly hardworking and energetic team of interviewers and data entry personnel. Their dedication and efforts have made the daunting task of fieldwork and data collection an enjoyable and successful endeavor. I am also thankful to my friends and relatives for their impact on my journey.

My family has been my biggest strength. I feel very blessed to have wonderful parents by my side. Their unconditional love, care, and constant prayers have significantly impacted my upbringing and always inspired me to be a better human no matter what. I am grateful to my two guardian angel brothers, Mohsen and Ehsan, for their influence on my education and life. Thanks to my beloved nephews Sa'ad Abdullah, Talha bin Mohsen, Abdur Rahman, and Abdul Walid for their sweet love. The adorable quirkiness, love, and affection of my precious angels, Katy, and the late Leo, have had a great touch on my overall well-being. I deeply miss the priceless affection of my Leo every single moment. Last but not least, no words can adequately express how much I am thankful to Tanbir for always having my back through thick and thin, never letting me fall apart, and making a lot of sacrifices while showing remarkable patience, especially in tolerating me.

Special acknowledgment is due to the funding sources that have supported my doctoral journey: Ontario Graduate Scholarship (OGS) International Award, President Graduate Scholarship (PGS), International Doctoral Student Award (IDSA), Queen Elizabeth Scholarship - Advance Scholars (QES-AS) and the funding provided by my advisor.

Dedication

To all those enduring immense suffering in our world, this dissertation is dedicated with the hope that it may contribute, even in a small way, to alleviating your pain and fostering a brighter future filled with compassion, empathy, and understanding.

To my beloved parents, supportive brothers, cherished nephews, precious feline angels, and my caring husband. Your steadfast support, unlimited care, and endless belief have been the driving force behind my academic journey.

To fearless spirits who have dared to push past their comfort zones,
your true limits can only be discovered by genuinely embracing and challenging them.

Table of Contents

Abstract ..... **v**

List of Figures xiii

List of Tables xiv

List of Abbreviations xv

Chapter 1: Introduction **1**

1.1 Background 1
1.2 Problem statement 4
1.3 Research questions 6
1.4 Research aim and objectives 7
1.5 Research design, methodology, and methods 8
1.5.1 A more comprehensive conceptual framework 9
1.5.2 Case study approach 11
1.5.2.1 Empirical setting 11
1.5.2.2 Survey design and data collection 12
1.5.3 Systematic review approach 13
1.5.4 Ethical consideration 14
1.6 Positionality statement 14
1.7 Organization of dissertation 16

Chapter 2: Connecting the dots: A framework for examining the interplay between climate change and human migration **18**

2.1 Introduction 18
2.2 Assessing existing climate and/or environmental migration frameworks 21
2.3 Research approach 25
2.4 Clarification of key terms in climate change and migration 26
2.5 Understanding the complexity of the climate-migration relationship 27
2.5.1 Dimensions of climate migration 27
2.5.2 Understanding agency in climate migration decisions 28
2.5.3 Climate change is a multifaceted driver of migration 30
2.5.3.1 Extreme/sudden-onset events and their effects on migration 31
2.5.3.2 Slow-onset events and their effects on migration 31
2.5.3.3 Natural resource risks and their effects on migration 31
2.5.4 Vulnerability assessment for understanding climate migration effectiveness 33
2.5.5 Non-climatic factors influencing migration decisions 36
2.5.5.1 Macro-level factors 36
2.5.5.2 Meso-level factors 37
2.5.5.3 Micro-level factors 38
2.6 A proposed extended conceptual framework 39
2.6.1 Preliminary application of the conceptual framework to the case of Bangladesh 42
2.7 Potential implications for advancing climate migration research and policy practice 44

Chapter 3: Assessing climate migration and vulnerability in Dhaka: A dual approach using principal component analysis and perception-based assessment **47**

3.1 Introduction 47
3.2 Materials and methods 50
3.2.1 Case study: Dhaka, Bangladesh 50
3.2.2 Conceptual framework for vulnerability assessment 51
3.2.3 Data collection 53
3.2.4 Data analysis 56
3.2.4.1 Calculation of composite vulnerability index 56

3.2.4.2 Measuring migrants' perception of migration situations....69
3.3 Results....69
3.3.1 Sample characteristics....69
3.3.1.1 Identification of climate migrants....69
3.3.1.2 Differences in sample background characteristics....73
3.3.2 Towards the creation of a CVI for climate migrants....75
3.3.2.1 Interpretation of the PCA results: Retaining and extraction of principal components....75
3.3.2.2 Vulnerability assessment based on PCA....78
3.3.2.3 Vulnerability assessment – IPCC approach....82
3.3.3 Migrants' perceptions of pre- and post-migration living and livelihood conditions....83
3.4 Discussion....87
3.4.1 Comparing vulnerabilities and perceptions among groups: Real-world implications....88
3.4.2 Limitations....90
3.5 Conclusions....91

Chapter 4: Shining a gender lens on climate migration: A systematic review of the empirical evidence in South Asia....93
4.1 Introduction....93
4.1.1 Understanding gender, agency, and climate migration....95
4.2 Methods....97
4.2.1 Search strategy....98
4.2.2 Inclusion and exclusion....99
4.2.3 Data extraction, analysis, and quality assessment....100
4.2.4 Bibliometric analysis....101
4.3 Results....102
4.3.1 Overview of the selected studies....102
4.3.2 Characterizing gendered migration in response to climate change....104
4.3.2.1 Migration versus non-migration....105
4.3.2.2 Distance covered in migration or spatial dimension....108
4.3.2.3 Time in migration or temporal dimension....108
4.3.3 Gender-differentiated agency in migration decisions....109
4.3.3.1 Aspirations for migration and non-migration....110
4.3.3.2 Capabilities for migration and non-migration....111
4.3.4 Theoretical development and disciplinary fields....112
4.3.4.1 Bibliographic coupling analysis....113
4.3.5 Methodological development and study designs....114
4.4 Discussion....118
4.4.1 Pathways of gender-differentiated climate migration....119
4.4.2 Gaps and potentials for future research....122
4.4.3 Limitations....123
4.5 Conclusions....124

Chapter 5: Conclusion....125
5.1 Introduction....125
5.2 Revisiting research aim and objectives....125
5.3 Summary of key findings....125
5.4 Knowledge contributions....128
5.4.1 Theoretical contributions....128
5.4.2 Empirical contributions....131
5.4.3 Methodological contributions....132
5.5 Limitations and directions for future research....133
5.5.1 Limitations....133
5.5.2 Directions for future research....135
5.6 Personal reflection....137

References **139**

Appendix **181**

Supplementary material A: Household survey questionnaire – Dhaka, Bangladesh 181

Supplementary material B: Some important migration theories and their strengths and limitations ... 194

Supplementary material C: Mann-Whitney Test Statistics 199

Supplementary material D: Preferred Reporting Items for Systematic Reviews and Meta-Analyses PRISMA 2020 item checklist 200

Supplementary material E: Systematic review search stretegy 202

Supplementary material F: Detailed features and findings of the selected studies in the systematic review 204

List of Figures

Figure 1: Number of new displacements in 2022 due to weather-related events 2
Figure 2: Migration and non-migration typologies in climate change context based on aspirations-capabilities frameworks. 29
Figure 3: Vulnerability assessment framework to determine climate migration's effectiveness. 35
Figure 4: A comprehensive conceptual framework for examining climate-migration relationships. 40
Figure 5: Number of weather-related internal displacements per year in Bangladesh 50
Figure 6: Conceptual framework presenting the relationships between different dimensions for vulnerability assessment in this study 53
Figure 7: Location of Dhaka city (study area) in Bangladesh and the distribution of the 2,000 surveyed households across the city 54
Figure 8: Climate migrants' place of origin 71
Figure 9: Ranking of most frequently mentioned drivers for climate migration 71
Figure 10: Reasons for migration 72
Figure 11: Scree plot of eigenvalues of components 76
Figure 12: Radar diagrams of the principal components underlying the composite vulnerability index (CVI) for each surveyed sample 80
Figure 13: Radar diagram of the IPCC vulnerability dimensions for climate migrants, long-term residents, and other migrants 82
Figure 14: Frequency distribution (in %) of the perceptions of the two migrant samples regarding their various pre-migration and post-migration living conditions 85
Figure 15: Conceptual framework on relations between climate change and migration decisions 96
Figure 16: PRISMA 2020 flow diagram 101
Figure 17: Number of selected studies in South Asia in each year (left) and country (right) 103
Figure 18: Geographic locations of selected empirical studies 103
Figure 19: Study settings (left) and climatic exposure(s) (right) considered in selected studies 104
Figure 20: Bibliographic coupling network overlay of sources 114

List of Tables

Table 1: Summary of research questions, objectives, and methodologies 10
Table 2: Summary of the key ideas, strengths, and limitations of the key conceptual frameworks 23
Table 3: Terms and definitions relating to climate and migration 26
Table 4: Categories of climate change as a driver of migration 30
Table 5: Dimensions and forms of (non)migration decisions in response to climatic events 32
Table 6: Factors of migration at different scales 37
Table 7: Key aspects of climate migration in Bangladesh 42
Table 8: Selected variables for vulnerability assessment 58
Table 9: Results for Cronbach's alpha coefficient, the Kaiser-Meyer-Olkintest and Bartlett's test of Sphericity 69
Table 10: Socio-demographic and economic characteristics of respondents across the three sub-samples of long-term residents and migrants* 74
Table 11: Eigenvalues and percentage of the variance explained by the components 76
Table 12: Component loadings of different vulnerability variables based on PCA 77
Table 13: Calculated vulnerability indexes of long-term residents, climate migrants, and other migrants based on the principal components analysis. 79
Table 14: Average standardized index scores for the three main dimensions underlying vulnerability as defined by the IPCC across the three survey samples 83
Table 15: Climate migrants' occupations before and after migration to Dhaka City 84
Table 16: Means and modes of each statement for climate and other migrants related to their pre-migration and post-migration living conditions 86
Table 17: Search terms 99
Table 18: Differences observed between men's and women's migration across different dimensions under different climatic exposures 106
Table 19: Study methods, data collection strategies, and gender data analysis of the selected studies 116
Table 20: Dissertation outcome and contribution to knowledge 130

List of Abbreviations

AF:	Adaptation Fund
AQI:	Air Quality Index
BBS:	Bangladesh Bureau of Statistics
BMD:	Bangladesh Meteorological Department
C3ER:	Centre for Climate Change and Environmental Research
CEGIS:	Center for Environmental and Geographic Information Services
CVI:	Composite Vulnerability Index
DI:	Thermal Discomfort Index
DoE:	Department of Environment
DWASA:	Dhaka Water Supply and Sewerage Authority
GCM:	Global Compact for Migration
GEF:	Global Environment Facility
GHG:	Greenhouse Gas
GIS:	Geographic Information System
GPS:	Global Positioning System
ICCCAD:	International Centre for Climate Change and Development
Icddrb:	International Centre for Diarrhoeal Disease Research, Bangladesh
IDMC:	Internal Displacement Monitoring Centre
IDPs	Internally Displaced Persons
IDRC:	International Development Research Centre
IEP:	Institute for Economics and Peace
IOM:	International Organization for Migration
IPCC:	Intergovernmental Panel on Climate Change
LLA:	Locally led Adaptation
MDGs:	Millennium Development Goals
MoEFCC:	Ministry of Environment, Forestry and Climate Change
MoWR:	Ministry of Water Resources
NELM:	New Economics of Labor Migration
NOAA:	National Oceanic and Atmospheric Administration
PCA:	Principal Component Analysis
PRISMA:	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RMG:	Ready-made garments
SDGs:	Sustainable Development Goals
UN:	United Nations
UNEP:	United Nations Environment Programme
UNFCCC:	United Nations Framework Convention on Climate Change
UNHCR:	United Nations High Commissioner for Refugees
UNISDR:	United Nations Office for Disaster Risk Reduction
WHO:	World Health Organization

Chapter 1: Introduction

1.1 Background

Climate change is one of the most pressing issues of the 21st century. Dealing with the present and future impacts of climate change is a significant sustainability challenge we cannot ignore. As our understanding of the factors contributing to climate change and its consequences increases, the situation becomes increasingly complex (Martin et al., 2022; Pörtner et al., 2022; Raymond et al., 2020). The global average temperature increase, extreme weather events, melting glaciers, rising sea levels, wildfires, shifting populations and ecosystems, and various other impacts all have significant sustainability implications (IPCC, 2021; NOAA, 2021; UNFCCC, 2015a).

The complex issue of climate change creates challenges from global-level to individual-level decision-making. In 2015, at the Conference of the Parties (COP 21), the political leaders and negotiators adopted the "Paris Agreement" in line with recommendations from scientists, agreeing to hold the global average temperature rise below 2 degrees Celsius and, if possible, 1.5 degrees Celsius (Paris Agreement, 2015). However, countries' efforts to reduce carbon dioxide emissions through green energy and new technology remain insufficient to prevent the projected global temperature rise by the end of the century (UNEP, 2022). It is projected that global temperatures will rise by 2.8 degrees Celsius by the end of the century based on current policies in place (UNEP, 2022). Furthermore, the COVID-19 pandemic adds to the urgency as countries face pressure to rely on inexpensive fossil fuels to stimulate their economies, thereby setting a trajectory toward a potential temperature rise of 5 degrees Celsius by the end of the century (Tollefson, 2020). This projected increase in temperature carries devastating consequences for both natural ecosystems and human systems, as highlighted by the recent Intergovernmental Panel on Climate Change (IPCC) reports (IPCC, 2021; 2023). Moreover, future climate change is expected to exacerbate the severity of impacts across these systems and contribute to increased regional differences (IPCC, 2023).

Countries worldwide are increasingly experiencing the detrimental impacts of climate change, leading to more frequent and severe natural disasters. This affects both developed and developing countries, as well as small island developing states, threatening livelihoods, economies, and societies (Ashrafuzzaman, 2022; Hossain et al., 2020; Seo et al., 2022; UN DESA, 2020). In response, human mobility has emerged as a prominent concern. The recent IPCC Sixth Assessment Report (AR6 WGII) confirms with "high confidence" that climate change is already influencing displacement[1] and migration globally (Pörtner et al., 2022; Shukla et al., 2022).

[1] There are slight differences between the terms "displacement" and "migration". "Displacement" refers to when people are uprooted from their place of origin and forced to move due to generalized conflict, violence, or disasters (UNHCR, 1998). Whereas "migration" refers to the movement of people either within the states or across international borders (IOM, 2019). If people remain outside of their place of origin for more than three months, that would be considered migration (UN, 2012). The term "human mobility" is used in this dissertation while referring to both displacement and migration.

International organizations, such as the IDMC and the World Migration Report, have also emphasized the significance of climate change in their recent reports (IDMC, 2022; World Migration Report, 2022). Notably, the IDMC's Global Report (2023) reveals that approximately 31.9 million people were newly displaced due to weather-related events in 2022 (see Figure 1).

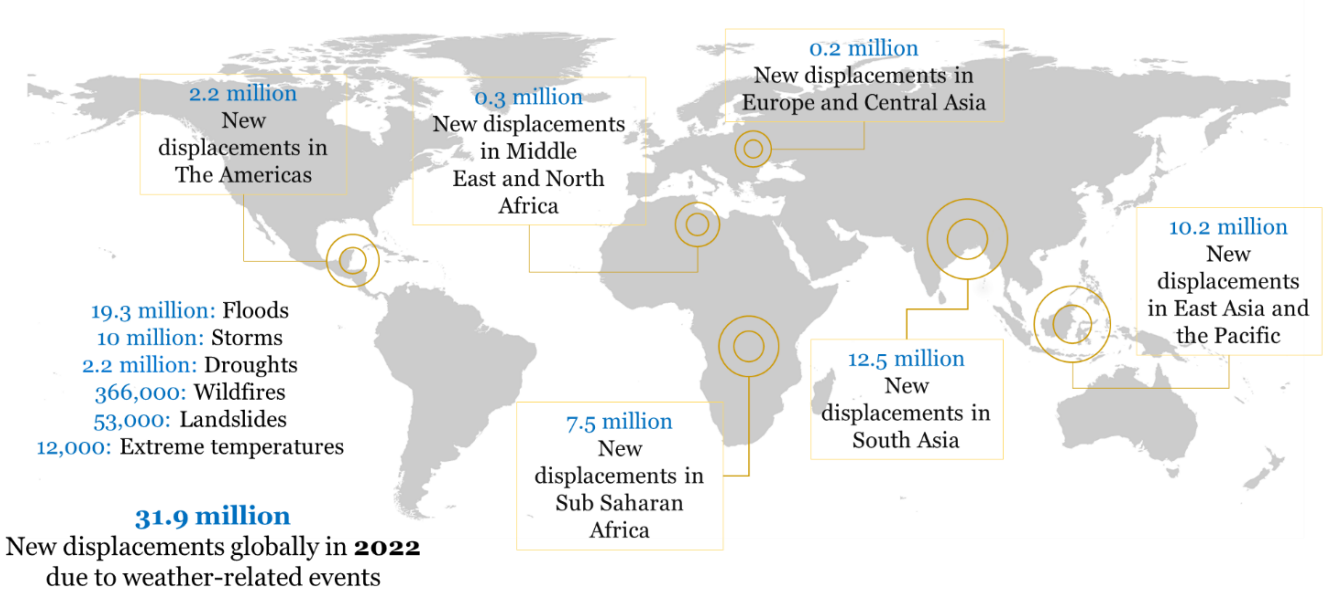


Figure 1: Number of new displacements in 2022 due to weather-related events

Note: Data source IDMC (2023)

Global climate change is expected to significantly impact human mobility in the future. The Institute for Economics & Peace IEP (2020) predicts that climate change and related ecological threats (e.g., water stress and food insecurity) could result in 1.2 billion population displacements by 2050 in vulnerable countries lacking sufficient societal resilience.[2] The World Bank's Groundswell Part 2 report identifies migration "hotspots" in six regions, projecting total internal migration between 78.4 and 170.3 million by 2050 under different emission scenarios. These scenarios include maximum warming ranges from 0.4 to 1.6°C and 1.4 to 2.6°C above baseline for "low" and "high" emission scenarios, respectively (Clement et al., 2021). These projections disproportionately affect low-income communities and developing countries, primarily in the global south.

Further research supports the overarching trend. Kam et al. (2021) project a 50% increase in "global displacement risk" for every degree of global warming, with even greater consequences considering anticipated population growth. Smirnov et al. (2022) simulate even more severe outcomes, suggesting that under scenarios of failed global collaboration and uncontrolled greenhouse gas emissions, drought-induced migration could increase by approximately 500%. Moreover, mass displacement and migration

[2] Societal resilience refers to the capacity of communities to bounce back and sustain their core functionalities in the face of major disruptions while also adapting to new circumstances to ensure long-term sustainability (Turner et al., 2022).

can lead to unsustainable urbanization, socio-economic inequalities, and ecological burdens (Ferreira et al., 2019; Hobbie & Grimm, 2020; Schwerdtle et al., 2018; Xu et al., 2022; Mega, 2022).

Countries face pressure to address climate change-induced human mobility issues through both mitigation and adaptation measures. Mitigation strategies, such as transitioning to renewable energy sources and sustainable land use practices, are vital to slow climate change (Fekete et al., 2021). Meanwhile, adaptation measures, including coastal defenses, resilient infrastructure, early warning systems, and managed retreats, are necessary to help communities deal with existing climate change impacts (Bongarts Lebbe et al., 2021).

The impact of climate change on global human mobility is a significant topic in scholarly and public discussions. Key initiatives addressing this issue include the UNFCCC's recognition of “human mobility” in the Cancun Adaptation Framework (2010) and the adoption of the Paris Agreement (UNFCCC, 2015b) and the Sendai Framework for Disaster Risk Reduction 2015-30 (UNISDR, 2015), which emphasize considering human mobility in climate change adaptation and disaster risk reduction processes. Migration is also recognized as a global issue within the Sustainable Development Goals (SDGs), with indicators related to migration conditions attached to 11 out of 17 SDGs (Adger et al., 2019). Target 10.7 focuses on facilitating orderly and safe migration through well-managed policies. SDG 13 on "climate action" also addresses climate-related aspects not explicitly covered in previous Millenium Development Goals (MDGs). Recent literature explores the connections between migration, mobility, and core aspects of sustainability such as justice, security, and well-being (Franco et al., 2021; Janker & Thieme, 2021; Martin et al., 2022; Siders & Ajibade, 2021).

These initiatives show promise in addressing climate-related migration. According to the most recent IPCC's AR6 Synthesis Report, there is a "very high confidence" that implementing these agreements would reduce the impacts of climate change on various aspects, including health, well-being, migration, and conflict (IPCC, 2023). However, it is important to note that these initiatives still do not fully capture the complex nature of the climate change-human mobility nexus. Recent literature emphasizes the need for comprehensive and coordinated policies that address the multifaceted challenges of climate-related mobility and migration (Stojanov et al., 2021). Furthermore, some countries, like Bangladesh, have developed their own policies and plans, such as the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) and the Bangladesh Climate Change and Gender Action Plan (CCGAP), to address the impacts of climate change on displacement and migration. These policies include measures to enhance community resilience, support livelihoods, and mitigate the adverse effects of climate change through early warning systems and community training (Naser et al., 2019).

Understanding and addressing the sustainability of climate-related migration involves considering environmental and societal factors in both origin and destination areas (Adamo, 2023; Adger et al., 2020; Benveniste et al., 2022; Franco et al., 2021). However, the complexity of the phenomenon makes it challenging to assess the impacts of climate change on human mobility (IPCC, 2022; Martin et al., 2022; Thalheimer et al., 2021). While research on climate migration has grown, the precise relationship between climate change and migration patterns remains uncertain. Recent reports from the IPCC, World Bank, and the White House acknowledge that climate change already influences and will continue to impact human mobility, but the specific patterns are unpredictable (Clement et al., 2021; IPCC, 2022; The White House, 2021). Researchers are actively engaged in studying the drivers, impacts, and policy responses to climate migration to gain a clearer understanding of the complex relationship between climate change and migration and inform effective interventions (McCarney & Kent, 2020; Piguet et al., 2018; Sedova & Kalkuhl, 2020).

1.2 Problem statement

This dissertation highlights three critical issues related to climate change and migration. To inform my understanding of these key areas, I conducted an extensive exploration of the literature, including scholarly articles, reports from non-governmental organizations and think tanks, and policy documents. Notably, two influential review papers by Piguet (2022) and Piguet et al. (2018) have significantly contributed to shaping the direction of this research. These reviews have affirmed the importance of the identified issues and provided an up-to-date overview of the expanding literature on climate change and migration. Moreover, these have shed light on stimulating areas of inquiry that have emerged recently, necessitating further investigations to refine the theoretical foundation and advance the scholarship in this field. This process contributed to my deeper understanding of the debates and themes within the literature, ultimately informing the identification of the three critical areas of inquiry that underpin my research.

The first issue in understanding the nexus between climate change and migration is the limited theorization of how climate change, either alone or interacting with other factors of migration, shapes individuals' or households' migration decisions and different types of migration and non-migration. The phenomenon of climate change, displacement, and migration is not a new or hypothetical concept but rather a current reality, leading to perpetuated vulnerability (IPCC, 2023). While establishing causal or multicausal links between climate change and migration is challenging (Ekoh et al., 2023; Hoffmann et al., 2021), it is essential to have a holistic understanding of the complex phenomenon by integrating diverse perspectives. Until now, a few scholars have developed integrated conceptual frameworks to theorize the climate and migration nexus with diverse foci (e.g., Black et al., 2011a; McLeman & Smit, 2006; Perch-Nielsen et al., 2008). However, these frameworks do not capture and incorporate some crucial aspects, such as the multifaceted nature of climate change, individual-level migration factors, level of agency or freedom of choice in decisions,

different dimensions and typologies of migration, and how the effectiveness of migration as adaptation can be understood, and only partially managed to provide a comprehensive view of the issue. Furthermore, discussions on the climate-migration nexus have previously seen the emergence of conceptualizing migration as a cure rather than a symptom (Piguet, 2022). Despite some attempts by scholars to develop integrated conceptual frameworks to theorize the climate-migration nexus, there are still debates on the lack of a robust conceptual framework to comprehensively capture its complexities (Baldwin & Fornalé, 2017; Hunter et al., 2015; Piguet et al., 2018; Santos & Mourato, 2022; Tschakert & Neef, 2022; Zickgraf, 2021), which is essential to strengthening scientific knowledge and support effective policymaking (Hoffmann et al., 2023).

The second issue is related to the lack of understanding of whether migration can serve as a successful adaptation strategy to avoid the adverse impact of climate change or if it generates more adverse socio-ecological consequences and challenges (e.g., increased inequalities and heightened vulnerability). Climate change has exacerbated pre-existing challenges, such as natural disasters, environmental degradation, poverty, and political instability, which have historically posed destructive forces. As a result, we are witnessing new migration patterns, heightened vulnerability, and a surge in uncontrolled urbanization (IPCC, 2022; Kotkin, 2023; Talbot & Ranjan, 2022), particularly in climate-vulnerable developing countries like Bangladesh. However, literature to date falls short in building an understanding of the impacts of climate migration on both places of origin and destinations of the climate migrants (Ghosh & Orchiston, 2022). As such, there is a significant gap in our understanding of how climate migration shapes and transforms both the areas of origin and destination, including a gap in understanding the effectiveness of migration as an adaptation strategy. However, some studies outline that migration is a viable adaptation strategy for people experiencing impacts of environmental and climatic change (e.g., Bardsley & Hugo, 2010; Black et al., 2011b; Castro & Sen, 2022; McLeman & Smith, 2006). On the other hand, other research outlines that migration can be a maladaptive response and may increase the vulnerability of migrants, those who are unable to migrate, and migrants' destinations (e.g., Afifi et al., 2016; Jacobson et al., 2019; Singh & Basu, 2020; Tacoli, 2009). This gap in understanding stems from insufficient empirical research examining the post-migration conditions of migrants who relocated due to climatic change that requires further study (McLeman & Gemenne, 2018; Piguet, 2022).

The third issue that arises in the climate change and migration field is the inadequate understanding and exploration of the role of gender and gender relations in shaping migration decisions and patterns, leading to gender inequality in climate migration. Despite increasing acknowledgments that "gender matters" in climate change and migration discussions (IOM, 2021; IPCC, 2019), the existing literature falls short of adequately theorizing and exploring this aspect (Chindarkar, 2012; Gioli & Milan, 2018; Hummel, 2021; Hunter & David, 2009; Lama et al., 2021; Purwar et al.,

2022). This knowledge gap is problematic because unequal gender relations can significantly impact peoples' vulnerability and resilience to climate change (Chindarkar, 2012; Gioli & Milan, 2018) and influence their migration decisions. Particularly for women who face social and cultural constraints that limit their access to resources, constrain their decision-making power, and restrict their mobility (Habib et al., 2022; Patel et al., 2020). Moreover, it is important to recognize that gender is not an isolated factor but intertwined with power dynamics, including authority, subjectivities, and knowledge, similar to other dimensions of inequality (Eriksen et al., 2015). To advance gender equality in climate change policy and practice, it is crucial to engage in scholarly research that goes beyond narrow assumptions about the causes of gender inequality (Lau et al., 2021). For example, Lau et al. (2021) emphasize the significance of considering various intersecting factors, such as caste, class, age, ethnicity, and health, when investigating climate change's gender-differentiated impacts. They stress the need for improved data collection, rigorous analysis, and the inclusion of diverse perspectives to adequately address the specific challenges experienced by marginalized communities, with a particular emphasis on women. To bridge the existing literature gap and inform effective policy interventions, comprehensive examinations of empirical studies are needed (Ahmed & Eklund, 2021; Zaidi & Fordham, 2021). Therefore, there is a need to analyze methodological and theoretical aspects, address gaps and diversity in perspectives, and provide insights into gendered dimensions and their implications in climate migration.

Drawing on these emerging conceptual and empirical issues and knowledge gaps, this dissertation argues that more in-depth investigations are essential regarding the relationships between and consequences of climate change and migration. Of particular importance is the connection between climate change, migration, and gender and their implications. This dissertation seeks to contribute to the evolving knowledge of the complex relationship between climate change and human mobility patterns by addressing these three issues. It is also worth noting that these identified issues are empirically related, conceptually interlinked, and mutually reinforcing, yet little attention has been given to exploring their interconnectedness. Therefore, this dissertation carefully examines them individually and attempts to make the connection, providing a more nuanced understanding of the challenges posed by climate change on migration and generating insights into the potential strategies to support affected populations.

1.3 Research questions

In addition to identifying the importance of addressing these above-mentioned key issues and research gaps for an improved understanding of complex relationships between and implications of climate change and migration, I have had a unique privilege. Since the beginning of my doctoral journey, I have had the opportunity to engage with a diverse range of organizations, experts, and local government agencies in my home country Bangladesh, such as the Ministry of Environment, Forestry and Climate Change (MOEFCC), International Organization for Migration (IOM), International Centre for Climate Change and Development (ICCCAD), Centre for

Climate Change and Environmental Research (C3ER), WaterAid, and Uttaran. These organizations are well-established and respected in climate change, adaptation, and migration. Moreover, I had the opportunity to directly converse with climate migrants in Dhaka, Bangladesh, and witness their difficulties, highlighting the pressing need for effective policies and interventions. It was also through these interactions and experiences I was inspired to formulate the following research question:

- *RQ1:* How does climate change influence individuals' migration decisions, and what are the different types of migration and non-migration outcomes that result?
- *RQ2:* What are the post-migration vulnerability situations of climate migrants in their destination?
- *RQ3:* How does gender intersect with the impacts of climate change to shape migration decisions and patterns?

1.4 Research aim and objectives

This dissertation aims to advance a more comprehensive understanding of the relationships between and implications of climate change and human migration patterns to strengthen scientific knowledge and support evidence-based decision-making. The specific objectives of this research are as follows:

A. *To develop a more comprehensive conceptual framework for examining the relationships between climate change and migration:* Considering its multi-dimensional nature, this research develops a more comprehensive conceptual framework that integrates diverse perspectives to examine the relationships between climate change and migration. Based on a comprehensive literature review of the multi- and interdisciplinary literature and evidence, this research identifies key factors that shape migration decisions and types and how migration patterns can be measured and understood in climate change. The conceptual framework builds upon and expands further on the emerging theoretical and empirical case-based literature and provides a more holistic understanding of how climate change interacts with various migration factors (e.g., social, economic, demographic, psychological, environmental, and political) to shape migration decisions and patterns, both in internal and international contexts. By incorporating vulnerability and agency as key aspects, the framework also considers the role of vulnerability in understanding the effectiveness of migration as an adaptation strategy and the role of agency in shaping migration decisions. Finally, this comprehensive conceptual framework further guides the conceptual and analytical orientation of the empirical research in this dissertation.

B. *To empirically assess the post-migration vulnerability situations of climate migrants:* This research investigates the vulnerability situations of climate migrants in one of the most climate-vulnerable countries, Bangladesh, where one in every seven people is at risk of being displaced from their place of origin by 2050 due to climate change (Khan, 2019). This investigation helps to identify the factors contributing to

their vulnerability, including access to basic services and social, economic, and environmental factors, to compare them with those of the host communities and migrants who relocated for other reasons. This comparison helps understand the challenges and opportunities faced by climate migrants in their new destinations and whether migration can serve as a successful adaptation strategy to reduce vulnerability to climate change in Bangladesh's capital city of Dhaka.

C. *To analyze and synthesize empirical studies to gain a deeper understanding of how gender shapes climate migration:* This research analyzes and synthesizes the relationship between gender and climate migration decisions and patterns. Specifically, the objective is to explore how gender shapes climate migration by examining the connections between climatic events and gender-differentiated migration decisions and patterns. The study also considers the theoretical and methodological aspects of the selected literature to identify differences, similarities, and gaps in knowledge, contributing to a deeper understanding of the role of gender in shaping migration decisions and patterns under climate change. Finally, the results of this study outline pathways through which gender differentiation in climate migration occurs, providing valuable insights for evidence-based decision-making. This research is hoped to bridge the existing literature with the need for a clearer understanding of gender and its implications in climate migration. This will be particularly valuable for researchers with limited knowledge of gender studies and unfamiliar with the diverse analytical approaches used in this field.

1.5 Research design, methodology, and methods

The research design for this dissertation adopts a pragmatism methodological approach, prioritizing practicality and real-world relevance (Gray, 2021; Kelly & Cordeiro, 2020). Within epistemology, pragmatism acknowledges that knowledge is influenced by its practical application and ability to address practical challenges. It recognizes that there can be multiple interpretations and realities and acknowledges the limitations of relying solely on a single point of view (Yvonne Feilzer, 2010). Pragmatism highlights the importance of meaningful research questions and encourages empirical investigation and abstract idea exploration to work together to comprehend reality (Jackson, 2022). Regarding ontology, this research understands reality as dynamic and shaped by various factors and contexts. It also seeks to avoid becoming entangled in contentious metaphysical ideas, instead focusing on the practical aspects of research (Morgan, 2007). In line with pragmatism, the chosen methodology allows for a combination of positivism and interpretivism approaches, depending on the nature of the research question. The methodologies employed in this research include a comprehensive literature review, a case study, and a systematic review of empirical evidence. By utilizing these methodologies, the research design aims to address the research questions and achieve desirable outcomes while remaining grounded in practical relevance.

This dissertation employs a mixed-method approach to address the research questions and achieve the objectives. The comprehensive literature review employs qualitative methods to explore in-depth insights and perspectives on the phenomenon under investigation (an extended interdisciplinary framework for climate migration). In contrast, the case study on climate migrants' socio-economic vulnerability utilizes quantitative methods to gather large-scale, largely closed-ended public survey data and analyze numerical data using statistical techniques and testing procedures. The systematic review of empirical evidence of gender-differentiated climate migration employs a mixed-method design, more specifically, an explanatory sequential design based on both quantitative and qualitative data collection and analysis. By integrating multiple methods (e.g., use of quantitative and qualitative views, numerical data collection strategy, statistical, and other inference techniques), the study aimed to enhance the breadth and depth of scientific knowledge (Johnson et al., 2007; Schoonenboom & Johnson, 2017), validate concepts empirically and gain a comprehensive understanding of complex social and ecological phenomena (Ferraro et al., 2019; Schlüter et al., 2019). This pragmatic strategy allowed for a more holistic view of the research problem, providing in-depth insights into the causes of the phenomena being investigated (Bernard & Bernard, 2013; Biggs et al., 2021; Ivankova & Plano Clark, 2018).

The research questions (RQs) mentioned in section 1.3 guided and adapted the choice for the research methodology, including for data collection and analysis. Different methods were required to answer each RQ. Both secondary literature and primary data were collected and analyzed to answer the RQs. The insights gained from the answers to the RQ1 informed and guided the methodological approaches and data collection and analysis in the subsequent questions. Each chapter of this dissertation includes an overview of the method that explores the specific approaches to answering the specific RQ and sub-questions in that chapter. Table 1 summarizes the research questions, objectives, methodologies, and methods adopted in this doctoral research.

1.5.1 A more comprehensive conceptual framework

To answer research question 1 (RQ1) – *"How does climate change influence the migration decisions of individuals, and what are the different types of migration and non-migration outcomes that result?",* this research conducted a comprehensive literature review. I collected, analyzed, and synthesized state-of-the-art thinking and conceptualizations and developed a new conceptual framework. Here, the research presents an extensive review of how different climatic conditions interact with other determinants of migration shape individual-level differentiated migration decisions and then suggests a more comprehensive framework for investigating the climate change migration nexus to avoid confusion and boost inter- and trans-disciplinary research transparency. This review took an "inquiry-driven" literature review approach, allows the inquirer to situate themselves in the landscape of ideas by inquiring about diverse perspectives, integrating ideas from the inquiry (Lebow et al., 2018; Montuori, 2013), and enables one to be creative and gather knowledge from various disciplines to act

wisely (Mimoun-Sorel, 2016; Montuori, 2022). Therefore, this review covered materials from academic sources such as peer-reviewed papers and books and gray literature published by the government, non-government, research institutes, think tanks, and other relevant documents on local and national, and international policies, guidelines, projects, and initiatives. In addition, this research critically reviewed literature related to (a) migration theories; (b) environmental and climate migration (both theoretical and empirical case-based literature); (c) climatic change as a migration driver; (d) other non-climatic drivers of migration; (e) gender, climate change, and migration; and (f) vulnerability in the context of climate change and migration. In addition, the conceptual framework developed here provides the foundation for answering the subsequent questions.

Table 1: Summary of research questions, objectives, and methodologies

Research Question (RQ)	Research Objective	Methodology and methods
RQ1: How does climate change influence individuals' migration decisions, and what are the different types of migration and non-migration outcomes that result?	To develop a comprehensive conceptual framework for examining the relationships between climate change and migration and its effectiveness as an adaptation	▪ A comprehensive review of both theoretical and empirical literature. ▪ Qualitative method
RQ2: What are the post-migration vulnerability situations of climate migrants in their destination?	To empirically assess the post-migration vulnerability situations of climate migrants	▪ Case study approach: Vulnerability assessment and comparison among climate migrants, other migrants, and original residents in migrants' destination Dhaka, Bangladesh. The comprehensive conceptual framework developed in Chapter 2 helped understand migration drivers to distinguish climate migrants from other types of migrants. ▪ Quantitative method ▪ Household survey and secondary data
RQ3: How does gender intersect with the impacts of climate change to shape migration decisions and patterns?	To analyze and synthesize empirical studies to understand better the ways in which gender-specific migration may be shaped differently under climate change	▪ A systematic review of empirical studies on climate change, gender, and migration in South Asia following the PRISMA 2020 guideline. The comprehensive conceptual framework developed in Chapter 2 initially guided the systematic review. Later the systematic review contributed to further extensions highlighting key pathways. ▪ Mixed-method: Explanatory sequential design - combines quantitative and qualitative data collection and analysis in a sequential manner.

1.5.2 Case study approach

To address research question 2 (RQ2) – *"what are the post-migration vulnerability situations of climate migrants in their destination?",* I conducted a quantitative case study to assess and compare the vulnerability of (1) climate migrants, who migrated due to climate-related reasons, (2) other types of migrants, who migrated for reasons unrelated to climate change, and (3) long-term residents, who have been living there since birth in an urban destination. The specific objectives of this assessment and comparison are: (a) to examine distinct socio-economic, health, physical, and environmental factors that contribute to varying vulnerabilities among climate migrants, other migrants, and long-term residents.; (b) to assess how climate migrants and other migrants perceive the differences between their pre-migration and post-migration situations. The comprehensive conceptual framework I developed in Chapter 2 helped identify the drivers of migration to distinguish climate migrants from other migrants.

In this study, the IPCC's (2007) vulnerability assessment framework of three interrelated functional dimensions, i.e., exposure, sensitivity, and adaptive capacity (Adger, 2006; Füssel, 2005; Parry et al., 2007; Smit & Wandel, 2006), incorporating diverse elements such as demographic, social, economic, health, water and sanitation, physical, climate, and environmental factors. The assessment involved the use of Principal Component Analysis (PCA) to create a composite vulnerability index and compare vulnerabilities across three groups. Vulnerability assessments are essential tools for evaluating how and where systems or people are vulnerable to climate change or other hazards and enabling the design of feasible and sustainable interventions (Huong et al., 2019). Recognizing the significance of vulnerability assessments, the Global Adaptation Fund allocates funding for climate change adaptation projects in developing countries, which requires detailed vulnerability assessments to ensure targeted interventions address the specific needs and vulnerabilities of the communities involved (Global Environment Facility, 2022). In this dissertation, vulnerability assessments are particularly important to understand the vulnerabilities of climate migrants and determine their specific needs for allocating adaptation funds.

1.5.2.1 Empirical setting

In this research, I choose the mega-city Dhaka, the capital of Bangladesh, as the case study area. The reason behind choosing this country and area is that Bangladesh, often referred to as "ground zero for climate change," is a developing country prone to various weather-related catastrophic events reinforced through climate change. The country ranked seventh on the Global Climate Risk Index 2021 (Eckstein et al., 2021). The combination of its geographical location, increased frequency and intensity of climatic events (e.g., floods, cyclones), and population density results in high exposure, vulnerability, and displacements (Khan et al., 2021; Nishat & Mukherjee, 2013). Furthermore, Bangladesh faces a severe rural-to-urban migration challenge, and thousands of migrants, including climate migrants, arrive in Dhaka yearly (Castellano et al., 2021). Dhaka's population in 2020 was just over 21 million, increasing 3.56% from the previous year, with internal migration accounting for most of the growth.

Therefore, Dhaka is a suitable case study area for conducting my fieldwork and collecting data.

1.5.2.2 Survey design and data collection

I conducted the empirical fieldwork from December 2018 to October 2019 as part of a funded research project conducted by a group of researchers at the University of Waterloo focusing on the water security of urban residents. The primary data were collected through household surveys in Dhaka, Bangladesh.

Questionnaires are a helpful tool for getting data from large populations. Surveys provide several advantages, including large representative sample size and hence greater statistical power, the ability to collect large amounts of data, and the availability of validated models (Ertl et al., 2020; Jones et al., 2013). According to Kriel et al. (2014), household surveys are a significant data source in developing countries. In addition, the Marrakech Action Plan for Statistics (World Bank, 2004) and the Busan Action Plan for Statistics both emphasize the importance of survey data in producing evidence to guide policy and development strategies (Ngo, 2015; PARIS21, 2013). Household surveys collect a wide range of information about people's living conditions, including socio-demographic characteristics, welfare, and behavioral aspects, as well as social and economic change (Angelsen & Lund, 2011; Grosh & Glewwe, 2000; Hogan et al., 2018; Wagstaff et al., 2007).

During the period specified above, a total of 2,000 households (including climate migrants, other migrants, and original residents) in Dhaka city were interviewed. Appendix supplementary material A contains the questionnaire developed in collaboration with other researchers. I added migration-related questions regarding their migration, from where they migrated, how many months or years ago they migrated, and the reasons behind their migration, including climatic reasons, among others, in one part of the questionnaire, which is a primary focus of my dissertation. The RQ2 is addressed in this research using the data collected from the survey. Questionnaire surveys and quantitative data from the household interviews contributed to (a) identifying people for whom climatic factors are the main reason for migration; (b) generating individual and household information (e.g., age, sex, education, income, occupation, health conditions, household compositions, number of income earners); and (c) assessing and comparing the vulnerability of climate migrants with others concerning socio-demographic, economic, health, water and sanitation, physical, and climatic and environmental parameters. In addition, the survey also generated data regarding the perception of climate migrants and other migrants on their pre-migration and post-migration conditions. In addition to the survey data, I conducted an additional literature search to collect secondary data, such as flood risk maps (GIS shapefiles) and population density and thermal discomfort index (DI) maps in Dhaka. Furthermore, with the help of my contacts (e.g., DoE, MoEFCC), I also collected weather, climatic data (e.g., maximum, minimum temperatures, rainfall), and air pollution index data for my research. However, these data were not disaggregated for each administrative

border, making it unsuitable for comparative analysis; therefore, I had to omit those data from my analysis.

1.5.3 Systematic review approach

To answer research question 3 (RQ3) – *"How does gender intersect with the impacts of climate change to shape migration decisions and patterns?",* I systematically reviewed empirical studies on climate change, gender, and migration.

The choice to focus on case studies from South Asian countries in this research is driven by the region's vulnerability to climate change impacts (Rigaud et al., 2018). This region is already facing the impacts of climate change, and in 2020 over 20 million displacements took place due to weather-related events in this region (IDMC, 2021), and the number of empirical studies is increasing (e.g., Bhatta et al., 2015; Maharjan et al., 2020; Yadav & Lal, 2018). Therefore, focusing on this region ensures a richer and more diverse dataset from multiple case studies to identify differences and commonalities in research findings, methodologies, and theoretical underpinnings and helps capture a range of events in diverse contexts over time. Studying the gendered dimensions in this context is crucial as women and marginalized groups are disproportionately affected by climate change in developing countries, particularly in the Global South (Glazebrook et al., 2020). By exploring gendered dimensions, this study will inform future research, guides evidence-based policymaking, and promotes more inclusive research and effective adaptation strategies for all gender groups in the context of climate change and migration.

The systematic review is a well-established evidence synthesis approach and increasingly becoming helpful and considered the best practice for comprehending the current state of the evidence in a specific field (Munn et al., 2018a; Siddaway et al., 2019). A systematic review identifies and retrieves transnational evidence pertinent to a specific question or set of questions. In other words, a systematic review aids in identifying the global evidence, confirming current practices, addressing variations, identifying new practices, examining results that are in conflict, identifying and guiding future research areas, and producing statements to aid in decision-making (Aromataris & Pearson, 2014; Munn et al., 2018b). Thus, the systematic review findings can help understand and inform evidence-based policy and practice for eliminating gender-based inequalities and injustice in climate migration, identify gaps, and address further research.

I followed the latest Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to perform this systematic review (Page et al., 2021). To demonstrate a literature review's novelty and replicability, transparent and rigorous reporting is crucial (Sovacool et al., 2018). This allows readers to evaluate significant aspects of the methodological quality of the review and its credibility (Snyder, 2019). The most recent PRISMA 2020 is considered best-practice guidelines that help to conduct a systematic review more clearly, transparently, and with sufficient details (Page et al., 2021). Consequently, contribute to a thorough and accurate

reporting of systematic reviews and improves the use of evidence in decision-making. Section 4.2 outlines the detailed methods of conducting this systematic review, and Appendix supplementary material D contains the item checklist.

A part of the comprehensive conceptual framework that I developed to answer RQ1 was the foundation for guiding this systematic review. The specific objectives of the systematic review were: (a) to synthesize empirical evidence regarding the linkage between climate change and gender-differentiated migration and non-migration; (b) to determine temporal (time of migration) and spatial (geographical distance covered) scales of migration; (c) to identify how gender associated with other factors result in differentiated migration decisions; (d) where possible, to determine the level of agency (freedom of choice) involved in migration decisions; (e) to investigate emerging theories used to explain the relationships between gender and climate migration and how widely ideas are distributed and communicated among the disciplinary communities and fields; and (f) to assess methodologies employed to study gendered dimensions in these empirical investigations in South Asia. This systematic review utilized an explanatory sequential design as a mixed method approach, incorporating initial quantitative analysis followed by qualitative analysis to explain further and elaborate the quantitative findings (Hong et al., 2017).

1.5.4 Ethical consideration

Ethical considerations were required for data collection since my case study involves human participants. Therefore, conforming to the ethical guidelines outlined in the Tri-Council Policy Statement on Ethical Conduct for Human Research (TCPS 2), the research approval was taken from the Office of Research Ethics (ORE) at the University of Waterloo in May 2019 (ORE # 40508). The approved ethics protocol for the field research addressed informed consent during participant recruiting, ensuring privacy, confidentiality, anonymity, data storage and password protection, reciprocity, relationships, trust, and the associated responsibilities of the researcher and interviewers.

1.6 Positionality statement

Researcher positionality is a critical aspect of the research process that can significantly influence knowledge production. Researchers need to be aware of how their identities and experiences shape their research approach and outcomes, including study design, methodology, data interpretation, and ethical practices (Holmes, 2020; Knott et al., 2022). While positionality statements are commonly seen in qualitative research or studies with an interpretivist worldview (Smith et al., 2021), researchers with a pragmatism perspective and engage in critical quantitative and mixed-method inquiry must also articulate their positionality and reflexivity to ensure transparency and rigor in their research (Cain et al., 2019; Feldon et al., 2022; Jamieson et al., 2022; Popa et al., 2015). As a researcher, I strive to approach complex socioenvironmental issues with a transdisciplinary perspective, which involves integrating diverse perspectives to address challenges effectively. My research

involved comprehensive review and systematic reviews that adopted qualitative and mixed methods, respectively, and a case study chapter dominated by a quantitative approach, aiming to contribute to advancing the common good. My lived experience and academic background have shaped my identity and positionality as a researcher.

I am a South Asian woman, born and raised in Bangladesh and now pursuing higher studies in Canada. Despite being Bangladeshi, I belong to an upper-middle-class family. Therefore, I am more privileged than many poor people, especially climate migrants. However, throughout my life, I have been able to engage with various communities from diverse backgrounds and socio-economic statuses in different places in Bangladesh, including my parental villages. Through these experiences, my diverse academic background, and the learning gained in developing and developed countries, I have developed a nuanced understanding of how my socio-economic background can shape my research approach.

During fieldwork, I carefully considered my socio-economic and power position and sought to understand the perspectives and experiences of the climate migrant communities I was studying. I kept asking how much I could put myself in their position to see and experience things from their perspective and how my research could benefit them eventually. Even though I am affiliated with a Canadian University, because I spent a substantial amount of time on fieldwork and my Bangladeshi upbringing, I was not an outsider during my fieldwork, and it was much easier for me to connect with the communities and develop an understanding of their experiences and challenges. I am eternally grateful for individuals' and communities' welcoming attitudes toward me and their openness and acceptance of my intended work. In addition, I spent much time chatting with climate migrants, learning about their stories, lifestyles, and worries, which allowed me to put myself in their shoes and experience their lives. Besides, I do have firsthand experience in making migration decisions and migrating within the country and across countries and from a developing to a developed country, though not related to climatic impacts. While my migration decisions and experiences differ from the context investigated in this dissertation, it did prove to be grounding while interacting with individuals and communities and writing this dissertation regarding migration decisions and vulnerability situations.

Transdisciplinary researchers are expected to exhibit particular attributes, such as curiosity, intrinsic motivations, openness to diverse ideas, adaptability, willingness to learn from other disciplines, and readiness to take (intellectual) risks (Augsburg, 2014; Fam et al., 2016; Guimarães et al., 2019; Lazurko et al., 2020). As an aspiring transdisciplinary researcher, I seek to cultivate these skills and qualities while also recognizing the importance of humility in the face of knowledge immensity. I hope to develop these further through learning, practice, and exposure to diverse experiences and perspectives. By acknowledging my positionality and embracing a transdisciplinary perspective, I hope to contribute to advancing knowledge and socio-environmental benefits. This awareness of my positionality influenced how I framed my

research questions, methods, and analyses and contributed to the rigor and quality of my research.

1.7 Organization of dissertation

This dissertation is structured into five chapters, including the introduction (chapter 1) and the conclusion (chapter 5). Chapters 2, 3, and 4 each cover specific questions and objectives. Each chapter utilizes distinct methodologies, contributing to the study's overall goal. Moreover, these chapters are designed to complement one another, working together to achieve the overarching aim of the dissertation.

Chapter 2 of the dissertation addresses the first research question and objective. Through an extensive literature review, this chapter presents an extended and more comprehensive conceptual framework for understanding the relationships between climate change and migration decisions and patterns that applies to diverse contexts. This framework is developed as generally applicable and provides comprehensive direction for emerging climate migration scholarship and practices in the field. In doing so, this chapter explores and critically evaluates the existing migration theories and identifies limitations in existing environmental migration frameworks. Based on this, this chapter establishes the need for a comprehensive understanding of the nature of migration decisions under multifaceted climatic conditions. This framework also guides conceptual and analytical orientations of the subsequent chapters of this dissertation.

Chapter 3 addresses the second research question and objective and presents the findings of the empirical case study on post-migration vulnerability situations of climate migrants in Dhaka, the case study area of Bangladesh. In doing so, this chapter assesses the socio-economic vulnerability of the climate migrants and compares that with other migrants and long-term residents. The conceptual framework developed in Chapter 2 helped in distinguishing climate migrants from other migrants and investigating the reasons behind their migration. Furthermore, the vulnerability assessment framework in Chapter 2 helped conceptually drive the vulnerability assessment. This chapter develops composite vulnerability indexes (CVIs) based on large-scale household data analysis. Finally, it compares those among climate migrants, long-term residents, and other migrants to explain where the differences in vulnerability occur. This chapter also assesses and compares the perceptions of climate and other migrants between their pre-migration and post-migration situations on different aspects.

Chapter 4 addresses the third research question and objective through an original systematic review of the empirical evidence in South Asia. This systematic review fills out pertinent gaps in the empirical scholarships of the gender-climate change-migration nexus. Initially driven by a part of the comprehensive conceptual framework, this systematic review identifies and characterizes different gender-differentiated migration responses under different climatic conditions. This systematic review also assesses the agency level involved in differentiated migration decisions from aspirations and capabilities analytical points. This systematic review also identifies and

discusses emerging theories and methodological considerations to study gender and climate migration and examines how well ideas are distributed among disciplines through bibliometric analysis. Drawing insights from reviewed empirical studies, this systematic review highlights pathways through which gendered inequalities in climate migration may occur.

The last chapter, chapter 5, recapitulates the dissertation's aims and objectives and highlights the main findings from the previous three chapters (i.e., 2, 3, 4). The significant and original contributions to knowledge advancement are also highlighted in this chapter, focusing on conceptual, methodological, and empirical insights. The chapter concludes with a discussion of study limitations, potential areas for future research, and personal reflection. Finally, the dissertation concludes with a list of references alphabetically arranged that includes all the cited publications and a list of appendices that include those mentioned in all chapters.

Chapter 2: Connecting the dots: A framework for examining the interplay between climate change and human migration

Abstract

Climate change has emerged as a significant concern, impacting global migration patterns, livelihoods, and sustainability. The complex relationship between climate change and migration necessitates a comprehensive understanding to drive effective research and policy development. Existing frameworks offer valuable insights, yet they partially integrate diverse perspectives, leaving knowledge gaps regarding how climate change influences individual-level migration decisions, the role of agency in shaping these decisions, the different dimensions in which various types of migration occur, and the effectiveness of migration as an adaptation strategy. This chapter develops a conceptual framework drawing on emerging theoretical and empirical literature to bridge these gaps. The framework incorporates various climatic factors (e.g., sudden/extreme- and slow-onset events, natural resources risks) independently or in conjunction with non-climatic factors at different scales (i.e., macro, meso, micro) that influence individual's migration decisions and the migration patterns that unfold across spatial and temporal dimensions. By incorporating more individualistic factors (e.g., aspirations, values, hope) and capabilities (e.g., skills, health, savings), along with structural determinants, the framework captures a more nuanced interplay between these factors and others in shaping potential migrants' agency (i.e., freedom of choice). As such, this personalized perspective recognizes the degree of human agency, considering the trade-offs between individual aspirations and capabilities. It aims to incorporate potential climate migrants' psychological aspects, and voices, leading to various types of (non)migration (e.g., forced, adaptive, trapped, voluntary immobility). Furthermore, it links vulnerability to illustrate how migration effectiveness can be evaluated. A concise case study of Bangladesh is presented as an exemplar, demonstrating the practical application of this conceptual framework within a local context and its potential for informing policies and interventions worldwide to mitigate vulnerability and promote sustainable outcomes for affected populations.

2.1 Introduction

Climate change is leading to increasingly severe weather events and rising sea levels, displacing communities and disrupting livelihoods. Such displacements can cause migration, both within countries and across international borders. An often-repeated prediction is that climate change will lead to substantial migration flows with enormous numbers of people. In the early 1990s, the Intergovernmental Panel on Climate Change (IPCC) predicted the possible impacts of climate change on human migration (IPCC, 1990). Following the IPCC's fifth assessment report (AR5), which highlighted the implications of climate change on human migration, the empirical research on the linkage between climate change and human migration started growing (Berlemann & Steinhardt, 2017; IPCC, 2014). The IPCC's sixth assessment report (AR6) further confirms this relationship with "high confidence" (Pörtner et al., 2022).

According to the Internal Displacement Monitoring Center (IDMC), in 2022, globally, over 31.9 million new internal displacements took place only due to weather-related events (IDMC, 2023). However, recent predictions for future displacements and migration due to climate change are more alarming. Climate change is projected to cause significant displacements and migration by 2050, with estimates ranging from 200 million to 1 billion people affected worldwide (Clement et al., 2021; IEP, 2020; Rigaud et al., 2018). If accurate, these projections imply that in the coming decades, a significant portion of human mobility may be driven by climate change. The urgency of this issue is further highlighted by the seventh chapter of the AR6 report, which specifically focuses on critical aspects of human security, risk, health, and well-being related to displacement and migration caused by climate change (Cissé et al., 2022).

Despite various assertions that climate change can inevitably lead to increased migration, the exact patterns and magnitude are still uncertain due to the complexity of factors that affect migration decisions,[3] making it challenging to predict the future (Nabong et al., 2023). Migration can be an effective adaptation strategy, but it may also be a last resort for those forced to move due to climate vulnerability (Hoffmann et al., 2022). Additionally, people may encounter various barriers and circumstances that are beyond their control, which can prevent them from being able to migrate even when migration appears to be the most suitable option (McLeman, 2018). To adequately address this, pre-emptive measures to improve voluntary migration options and create new pathways may be sensible solutions. However, it is also critical to recognize that not all individuals wish to migrate (Mallick et al., 2023), or some family members migrate, and some do not, even under climatic conditions. Additionally, it is equally important to consider the destinations where these people will end up migrating and the implications of their migration, which further add to the complexity. This raises two critical questions: 1) the extent to which climate change influences individuals' migration decisions and the various types of migration and non-migration outcomes that may result? and 2) how to evaluate the implications and effectiveness of such migration?

Ensuring sustainable migration amidst climate change requires thoroughly considering both biophysical and societal factors (i.e., human, social, economic, and political) in origin and destination areas (Cissé et al., 2022; Franco et al., 2021). Several recent publications have reported complex interactions between climate and migration, as demonstrated by empirical evidence (e.g., Hoffmann et al., 2019; Khavarian-Garmsir et al., 2019; Mianabadi et al., 2022). While empirical studies have shed light on the significant consequences of climate migration, the insights remain divergent with limited conceptual grounds. So far, only a few studies have attempted

[3] "Decision" and "decision-making" are often used interchangeably but have different meanings. "Decision" is the act of making a choice or reaching a conclusion after considering various options or alternatives. At the same time, "decision-making" refers to the process or cognitive activity of evaluating options, weighing factors, and making a choice or reaching a decision (Beresford & Sloper, 2008). So, "decision-making" is a more complex process that involves thinking through different options, while a "decision" is the outcome or result of that process. This research focuses on understanding the factors that contribute to migration "decisions" and/or "decision-making" rather than delving into the intricate details of the decision-making process.

to develop frameworks or models considering beyond the simple idea that people affected by climate or environmental change can migrate (McLeman & Smit, 2006; Perch-Nielsen et al., 2008; Warner et al., 2012), and examining additional economic, political, and social drivers that also influence migration (Black et al., 2011).

The recent surge in conceptual and empirical scholarship on how migration interacts with climate change partially fills the knowledge gap. However, gaps remain in the precise understanding of the interplay between various climatic and non-climatic factors and different types of migration decisions (Bates-Eamer, 2019; Piguet, 2022; Willett & Sears, 2020). Climate migration researchers with diverse disciplinary backgrounds, including geography, demography, economics, environmental and computer science, often prioritize methods and data over fully engaging with migration theory or conceptualization (Hoffmann et al., 2021). Piguet (2022), in an updated review of the last ten years' progress, noted that despite advancements in understanding the phenomenon at hand, there are still no consistent and definitive solutions to this complex issue. These inconsistencies in the research field result from a lack of a robust conceptual framework and diverse methods for exploring and analyzing climate/environment interactions with migration decisions (Piguet et al., 2018). These inconsistencies and completeness in the current knowledge base of migration decisions hinder policymakers' efforts to create evidence-based policies and adaptation strategies that support safe, orderly, and regular migration patterns. Piguet (2022) further argues that different approaches are rarely integrated to comprehensively understand migration processes in environmental or climatic situations.

This chapter seeks to develop a comprehensive conceptual framework to help us better comprehend migration decisions and patterns considering climatic and non-climatic factors. To achieve this, the chapter first critically examines existing theoretical and conceptual frameworks depicting climate or environmental change and migration nexus (section 2.2). It then proceeds with a comprehensive literature review of state-of-the-art empirical academic and non-academic literature (section 2.3 research approach) to uncover migration decisions and patterns that are different due to varying climatic exposures, spatial and temporal scales, capacity for agency, and a higher degree of complexity (section 2.5). Drawing on these distinctions and gaps in existing frameworks, the chapter presents a conceptual framework for recognizing the nexus between climate change and migration in section 2.6. This proposed framework integrates various perspectives and disciplines, building on the works of Black et al. (2011), de Haas (2021), Schewel (2020), and other significant emerging new bases. It also seeks to clarify important concepts like “climate migrants” and “agency,” linking “vulnerability” and understanding their significance and manifestations in the context of climate change. A preliminary application of this framework to the local context of Bangladesh is briefly discussed (section 2.6.1). The envisioned framework intends to foster collaboration and interdisciplinary research among scholars, practitioners, and stakeholders studying migration in the context of climate and global environmental

change, ultimately promoting sustainability and adaptation efforts (section 2.7). The chapter concludes by emphasizing the crucial need for empirical validation of the proposed framework to establish its validity and reliability and guide future research.

2.2 Assessing existing climate and/or environmental migration frameworks

Researchers have been studying human migration and movement for over a century and have identified trends, theories, and frameworks that explain why, how, and under what conditions people migrate (de Sherbinin et al., 2022). For example, migration patterns are influenced by push and pull factors in both the origin and destination areas, leading to migration streams and counter-streams, while costs can act as intervening obstacles and limit migration (Lee, 1966). Migration is also selective, and the likelihood of movement can vary based on context and sociodemographic factors such as age and gender, as well as psychological responses to external stress (Wolpert, 1965). Economic incentives are often the main driving force behind migration (Sjaastad, 1962), although other incentives (e.g., better life and education) also have influences (De Jong et al., 1983) (supplementary material B contains strengths and limitations of each general migration theory).

However, research on environmental migration[4] has undergone a paradigm shift in recent decades, with more recognition of the complex environmental factors involved in human migration. For example, Hugo (1996) modified and simplified a theoretical framework developed by Richmond (1993) that includes feedback loops (i.e., migration reduces population pressure on the origin area; as a result, reduces the occurrence of future environmental hazard), intervening variables (e.g., facilitators and constraints to migration), and different types of environmental factors that can cause migration. However, Hugo's framework focuses primarily on environmental factors, policy response and international migration and overlooks other aspects. Hunter (2005) contends that existing migration theories can provide valuable insights and guidance for the emerging literature on migration and the environment. To this end, Hunter attempted to connect environmental factors with some migration theories by drawing upon models such as Lee's (1966) push-pull theory and Wolpert's (1966) stress-threshold model; however, the specifics of this integration remain unclear. For example, Hunter (2005) notes the "potential placement" of ecological threats or environmental hazards as a "push" factor and "stressors" in the push-pull theory and stress-threshold model, respectively, without fully elaborating upon the specific causal mechanisms involved in decisions. This demonstrates the need for theories to efficiently combine environmental factors with other factors of migration, such as socio-economic, household, and personal characteristics, across various temporal and spatial contexts.

[4] While the primary focus of this research is climate-related migration, it is worth noting that the analysis begins with the environmental migration frameworks, as climate change was rarely studied in isolation from broader category of environmental change or hazards in many frameworks.

More recently, some scholars have integrated the concept of vulnerability with migration to explain the link between climate change and migration. For example, McLeman & Smit's (2006) procedural diagrammatic model considers household capital and migration as possible adaptive responses. It considers the vulnerability of a system to climatic stress, determined by exposure and adaptive capacity in a specific place and time, and accounts for household capital. However, the authors note that while this model suggests migration potential, it cannot predict migration decisions or outcomes. Perch-Nielsen et al.'s (2008) models have a different focus as they categorize "direct effects" and "indirect effects" (i.e., interacting with other intervening variables such as land loss, reduced income) of climate change that influence vulnerability and people's subsequent migration as one of the available adaptation options. Perch-Nielsen et al. (2008) highlight that mass displacement often occurs after extreme climatic events; however, capturing the subsequent migration decisions without considering migration's non-climatic and behavioral components is challenging.

Black et al. (2011) contribute to the evolution of conceptual frameworks by highlighting five significant drivers that influence migration. This framework takes a more integrated perspective, highlighting the relationships between environmental change and migration decisions alongside other macro-level political, economic, social, and demographic drivers. This conceptualization significantly advances debates on the environment-migration nexus and is currently recognized as a widely accepted framework for environmental and climate migration (Hauer et al., 2020). However, this framework may not fully account for the influence of environmental factors at the micro or personal level (e.g., personal environmental circumstances), where migration decisions are ultimately made. While the framework acknowledges the role of meso-level factors, such as facilitators and obstacles, in shaping individual decisions to migrate or stay, it does not delve into the specific interplays between environmental factors and individual migration decisions. Therefore, while the framework is a valuable tool for understanding the overall picture of the environment-migration nexus, it may not capture the nuanced understanding of decisions taken at the micro level.

The decision to migrate is not simply a fixed, one-dimensional process; along with external stimuli (e.g., climatic factors), behavioral and psychological factors also influence different decisions. Along with advancing conceptual frameworks, scholars working on the issue of climate change and migration started recognizing the importance of including the perspectives, voices, and autonomy of those affected by climate change. For example, while Black et al. (2011) incorporated the concept of "agency" in their framework as a means to represent the "barriers and facilitators" to migration at the meso level, a more precise definition and approach to measuring this concept of agency is still necessary.

Furthermore, Black et al. (2011) conceptualize climate change as a subset of environmental change in their framework. However, recent research (Kaczan & Orgill-

Meyer, 2020), scientific reports (IPCC, 2023), projections (Clement et al., 2021), and policy discussions (e.g., Paris Agreement, 2015; The White House, 2021) underscore the significance of climate change as a primary driver of migration and its ability to exacerbate other factors, including existing environmental conditions (e.g., ecological threats, water stress). Acknowledging climate change as a separate and significant driver of migration is crucial for identifying and comprehending the situations, experiences, and needs of climate migrants, as classifying them can be challenging.

Additionally, all existing frameworks overlook one crucial aspect of integrating gender considerations in conceptualizing climate change and migration nexus. Gender may be one of the most significant factors shaping migration decisions and experiences (Lama et al., 2021; Purwar et al., 2022). Additionally, there is a growing recognition of the importance of gender in climate and policy discussions (IOM, 2021; IPCC, 2019a), and incorporating gender considerations into the framework is crucial for designing policies and interventions that are inclusive and equitable. While fully capturing the complex dynamics of gender in the climate migration framework may be challenging, incorporating the concept of gender can serve as an initial step towards exploring, conceptualizing, and expanding the framework to include gendered dimensions. Notably, the existing frameworks view migration as a potential adaptive response to climatic conditions. However, they do not conceptualize how we can understand the implications of migration decisions, measure or evaluate the success of such migration, or explore the potential negative implications of migration. Table 2 summarizes the key ideas, strengths, and limitations of the key conceptual frameworks regarding climate change and migration nexus.

Table 2: Summary of the key ideas, strengths, and limitations of the key conceptual frameworks

Conceptual model/framework	Key ideas and strengths	Limitations
"Migration as an adaptation response to climate change, reflecting household capital" (McLeman & Smit, 2006)	▪ Addresses interaction between climate change & household capital. ▪ Recognizes migration as a potential adaptation option. ▪ Considers household capital as a factor affecting migration outcomes	» Does not fully explain possible migration decisions and outcomes. » Does not address essential factors (e.g., demographic, social) and other behavioral and/or psychological aspects.
"The direct and indirect influence of climate change on migration" (Perch-Nielsen et al., 2008)	▪ Identifies two mechanisms: the direct impact of climate change leading to migration and the indirect impact of climate change through other intervening variables (e.g., land loss, reduced income) influences migration ▪ Offers a transparent overview of links between climate change and migration.	» Over-emphasizes environmental and economic factors and ignores other variables. » Cannot answer an important question about how adaptation options are evaluated as other factors (e.g., social, emotional) are associated with decisions. » Do not capture the migration decisions or possible responses.

Conceptual model/framework	Key ideas and strengths	Limitations
"Framework for the drivers of migration" (Black et al., 2011)	▪ Provides a more integrated perspective on the relationship between environmental change and migration decisions by incorporating some of the aspects overlooked by previous ones. ▪ Considers the interplay between five drivers of migration: environmental, demographic, social, economic, and political. ▪ Introduces the concept of human "agency" in environmental migration decisions.	» Shows that environmental change interacts with other macro-level factors to shape migration and could not adequately capture the interplays between biophysical and human elements at different scales. » Underemphasizes the subjective interpretation of individual or personal factors that allow or restrict migration. » Treats climate change as a subcategory of environmental change rather than as a separate driver. » Ignores the role of gender and health conditions in shaping migration decisions. » Cannot adequately capture the concept of an individual's "agency" and way of understanding this in migration decisions. » It only shows migration decisions as "migrate" or "stay" and does not present typologies. » Do not conceptualize the implications of migration decisions, do not offer a way of measuring or evaluating their success, or explore potential negative implications.
Climate risk-migration conceptual framing (Cissé et al., 2022; McLeman et al., 2021)	▪ The framework seamlessly integrates climate-migration research with broader climate change risk paradigms, offering a comprehensive approach to address migration within the context of climate change. ▪ Enhances communication between researchers and policymakers, facilitating effective collaboration on migration and climate change risks.	» The absence of a clear definition for "agency" in migration decisions may hinder its comprehensive application and pose interpretational challenges. » General application of "agency" without clear delineation weakens precision and practicality, necessitating further clarification for scholarly robustness.

Recently, scholars argue that the discourse on climate-migration has emerged as a distinct field, separate from other investigations into climate change impacts (McLeman et al., 2021). The IPCC's Fifth Assessment Report (AR5) address migration mainly from the perspective of human security, without directly linking it to the conceptualization of climate risk (Pachauri et al., 2014). McLeman et al. (2021) recognized this oversight and responded by introducing a novel conceptual framework that aims to bridge the gap between climate-migration research and the broader climate change risk paradigms, thereby facilitating more effective communication between researchers and policy makers. This framework, also utilized in the IPCC's Sixth Assessment Report (AR6) to address broader migration-related issues (Cissé et al., 2022), views agency in migration decisions as a continuum, ranging from high to

low or no agency, with outcomes categorized as voluntary or involuntary migration. However, the lack of a clear and well-defined explication of “agency” is a limitation that may hinder the comprehensive application of the framework. Additionally, the broad application of “agency” across migration outcomes without discerning distinctions weakens the framework’s precision, requiring further clarification to strengthen its scholarly underpinnings.

2.3 Research approach

The emerging field of climate migration calls for a comprehensive understanding beyond what current frameworks provide. Therefore, developing a new conceptual framework to gain a more holistic understanding of the climate and migration nexus is a critical area of research. This involves organizing and synthesizing knowledge to uncover connections between variables and concepts (Cronin & George, 2023; Grant & Osanloo, 2014; Ravitch & Riggan, 2016). An extensive review is conducted to achieve this, drawing on literature from various disciplines, non-academic initiatives, and policy reports. In addressing complex problems like sustainability, climate change, and environmental issues, the academic literature increasingly embraces inter- and transdisciplinary approaches at global and local scales (Klein, 2020; Lang et al., 2012; Schlüter et al., 2022). An interdisciplinary approach integrates knowledge and methods from diverse disciplines to address research questions or solve problems, fostering idea exchange and acknowledging the contributions of each discipline, allowing for a broader perspective and a more comprehensive understanding that surpasses the sum of its parts (Gardiner, 2020). A transdisciplinary approach surpasses interdisciplinary collaboration by integrating diverse knowledge, values, expertise, and know-how from non-academic sources, engaging stakeholders from various sectors to bridge the gap between research and application, and aiming to foster positive social change (Rigolot, 2020; Wuelser et al., 2021). Thus, these approaches can lead to more comprehensive and integrated solutions to these “wicked problems”[5] (Simm et al., 2021), like climate migration. This review adopts an “inquiry-driven”[6] approach that allows the inquirer to situate themselves in the landscape of ideas (Montuori, 2013; Oliver et al., 2017). Thus, pulling together information from many sources helps create distinct conceptual frameworks that span disciplinary boundaries and reveals the larger context that research is meant to address (Marshall, 2014; Oliver et al., 2017). Reviewed disciplines include but are not limited to, climate science, geography, demography, economics, sociology, environmental psychology, political science, environmental studies, human rights, gender studies, public health, and development studies.

[5] A “wicked problem” is a complex and interconnected social or environmental issue that is challenging to solve due to incomplete information, contradictory perspectives, and uncertain scope and scale. To address these problems, inter- or trans-disciplinary collaboration, empathy, and iterative design are essential to mitigate their negative impacts and guide society toward positive change (Wicked Problems, 2019).

[6] An “inquiry-driven” approach actively engages with the existing literature by asking questions, making connections, and identifying patterns and themes. It brings together diverse perspectives and sources of information to construct meaning and develop a more comprehensive understanding of the research problem. This highlights gaps in existing knowledge, generates new insights, and identifies areas for future research (Hicks et al., 2020).

2.4 Clarification of key terms in climate change and migration

Establishing clear and consistent definitions of key terms related to climate change and migration is crucial for analyzing and understanding the phenomenon. However, the abundance of literature on climate change, environmental change, and migration needs to be more consistent in terms and definitions. Luetz & Merson (2019) found that climate change and migration literature contain over 30 terminologies and 12 definitions, leading to confusion and inconsistencies. Standardized terminology is needed to identify and explain migration caused by climate change (Piguet et al., 2011). For instance, terms like “displacement” and “migration” are sometimes used interchangeably, despite their distinct meanings. “Displacement” refers to being uprooted or forced to flee due to conflict, violence, disasters, human rights violations, or other similar reasons (UNCHR, 1998). Whereas “migration” is an umbrella term that typically involves the movement of people away from their usual residence, whether within the country or across international borders (IOM, 2019). The movement’s duration needs at least three months to be classified as migration (United Nations, 2012). Displacement is typically involuntary, while migration can be forced and voluntary, depending on the circumstances. Understanding the conditions influencing migration decisions requires careful investigation.

Further debates persist among academics, NGOs, and political actors regarding the terminology used to describe human mobility caused by environmental factors. “Climate refugees” and “environmental refugees” are often used to describe a group of environmentally displaced people whose migration is evidentially forced (Luetz & Merson, 2019; Piguet et al., 2011). These terms are employed to raise awareness and advocate for legal protection (Ahmed, 2018; Berchin et al., 2017). However, their acceptance is limited, and these terms have no legal definitions. The International Organization for Migration (IOM) instead uses the terms “environmental migrant” and “climate migration” (see Table 4).

Table 3: Terms and definitions relating to climate and migration

Terms	Definitions	Reference
“Environmental migrant”	“A person or group of people who, predominantly due to sudden or progressive environmental changes that negatively impact their lives or living conditions, are compelled to leave their usual homes or choose to do so temporarily or permanently and move within or outside their country of origin or usual place of residence.”	IOM, 2011, p. 33; IOM, 2019, p. 64
“Climate migration”	“The movement of a person or group of persons who are obliged or choose to leave their habitual place of residence due to sudden or progressive change in the environment caused by climate change. This can be either temporary or permanent, within a state or across an international border.”	IOM, 2019, p. 31
“Refugee”	“An individual forced to flee from their home country due to armed conflict or persecution.”	UNHCR, 1951; 1979

Under international law, refugees are only recognized as individuals fleeing persecution or armed conflict in their home country (UNHCR, 1951). Therefore, internally displaced persons (IDPs), including those forced to move due to natural disasters or environmental hazards, are not considered refugees (Cohen & Bradley, 2010; Piguet et al., 2011; Swayamprakash & Priydarshini, 2020). However, the IOM acknowledges "climate migrants" (IOM, 2019), and the IPCC (2014) and the Paris Agreement (2015) stipulate the need to protect “climate migrant” rights.

In this research, the terms “climate migration” and “climate migrants” are used strategically to refer to migration and migrants resulting from the adverse effects of climate change. These terms are chosen for their growing recognition and to ensure clarity and simplicity in communication. Furthermore, climate “displacement” describes temporary displacements due to climate change lasting less than three months, and “human mobility” involves both displacement and migration.

However, it is also important to note that further research is needed to better understand the preferences and perspectives of people directly affected by climate change. This research could shed light on their preferences and opinions to determine the most appropriate and sensitive terms to refer to them, respecting their rights and experiences while ensuring clear and effective communication about climate-related migration and displacement.

2.5 Understanding the complexity of the climate-migration relationship

The increasing focus on the climate-migration nexus and emerging innovative efforts and evidence offer valuable opportunities to deepen our understanding of this complex phenomenon (Hoffmann et al., 2023). Therefore, the following features warrant further consideration and reflection, which contribute to the development of a more comprehensive framework for studying climate migration:

- Consideration of different dimensions to unfold migration patterns.
- Focus on agency in migration decisions.
- Placing more attention on climate change.
- Conceptualization of migration effectiveness as an adaptation strategy.
- Inclusion of an exhaustive list of non-climatic factors that may interact with climate change to shape migration decisions and patterns.

Expanding on these features, it is crucial to undertake an extensive investigation into the relationship between climate change and migration. We can enhance our comprehension of this complex phenomenon by critically examining the diverse factors that contribute to and shape migration decisions and patterns. Furthermore, this comprehensive understanding will aid in developing a more comprehensive conceptual framework, incorporating fresh insights and perspectives.

2.5.1 Dimensions of climate migration

Examining the complexities of climate migration requires critical consideration of multiple dimensions that contribute to and shape migration decisions and patterns. As

put forth by emerging research, these dimensions include societal, spatial, and temporal.

The societal dimension considers the extent of the society affected by environmental changes, ranging from individuals or households (micro) to countries and regions (macro) (Liehr et al., 2016; Rechkemmer, 2009). This dimension helps predict and mitigate migration's potential consequences by understanding the size and composition of populations affected by climate change.

The spatial dimension captures the geographical distance covered by migration, which can be either internal or international (Niedomysl & Fransson, 2014). While shorter distances within a country characterize internal migration, international migration involves longer distances between countries and continents (Piguet et al., 2011). Studies show evidence of both internal (e.g., Cundill et al., 2021) and international migration (e.g., Beine & Parsons, 2017; Hunter et al., 2013) because of environmental or climatic events, as well as no evidence of migration in response to environmental change (e.g., Gray & Bilsborrow, 2013; Goldbach, 2017). Therefore, it is essential to understand the geographical scales of migration to better forecast the geographical distribution of climate migrants.

The temporal dimension considers the time frame of migration, which can be short-term (3 months to 1 year), long-term (>1 year), or permanent (typically >10 years) (Piguet et al., 2011; UN, 1998). Circular migration, characterized by repeated back-and-forth movements within a set time frame (IOM, 2019), is also a common adaptation strategy (Cundill et al., 2021; Kelman et al., 2019). Permanent migration occurs when individuals leave their place of origin without intending to return (Stojanov et al., 2014). Assessing the temporal dimension of migration helps to understand the dynamics of migration, including the frequency and persistence of movements.

As a whole, migration is a multi-dimensional phenomenon influenced by various societal, temporal, and spatial scales. While evaluating these dimensions is challenging, a deeper understanding can help unfold complex climate migration patterns and irregularities.

2.5.2 Understanding agency in climate migration decisions

In migration, agency refers to the active role played by individuals in shaping their migration choices and outcomes (Czaika et al., 2021). It encompasses their "freedom" and control to make decisions and take action in response to their migration circumstances. Agency recognizes that migrants are not passive victims but rather active participants who navigate their migration journeys, negotiate challenges and pursue their goals and aspirations. Low agency implies less involvement or ability to influence migration decisions, while high agency indicates greater involvement and freedom (Carling, 2002; Erdal & Oeppen, 2018; Fussell, 2012). Structuralist approaches to migration tend to prioritize the role of external factors (e.g., socioeconomic conditions and political contexts) and downplay the agency of migrants

(Echeverría & Echeverría, 2020). Recognizing agency challenges deterministic views that attribute migration solely to external factors (de Sherbinin et al., 2022), highlighting the significance of subjective experiences, values, voices, and perspectives of migrants in shaping migration decisions (de Haas, 2021).

In the context of climate change, the aspirations-capabilities framework can provide a deeper understanding of agency and structure in migration decisions (Carling, 2002; de Haas, 2021; Schewel, 2020). This framework can measure the degree of agency involved in migration decisions from the relationship between individuals' aspirations (e.g., values, desires, hopes, goals) and capabilities (e.g., structural determinants, skills, health, liquid assets, and social networks). It aligns with Sen's perspective that expanding people's capabilities to pursue the lives they value is a fundamental concern for societies (Sen, 1999). Additionally, this framework draws upon Sen's (1999) capabilities framework by incorporating the instrumental (means-to-end) and intrinsic (direct impact on one's well-being) aspects of human mobility, providing a better understanding of individuals' aspirations, capabilities, and well-being in migration decisions influenced by social and ecological changes (de Haas, 2021).

By incorporating the concept of "agency" or "freedom" and human rights, the aspirations-capabilities framework offers a valuable approach to surpass conventional categorizations of climate migration decisions. It goes beyond simplistic classifications such as forced migration (Erdal & Oeppen, 2018) versus adaptive migration (Stojanov et al., 2014), voluntary immobility (Mallick et al., 2023) versus trapped (Black & Collyer, 2014) scenarios, and implications of planned relocations (Farbotko et al., 2020). Instead, this framework enables a nuanced analysis that considers the interplay of aspirations and capabilities, facilitating a more comprehensive understanding of the complex dynamics of climate migration (see Figure 2).

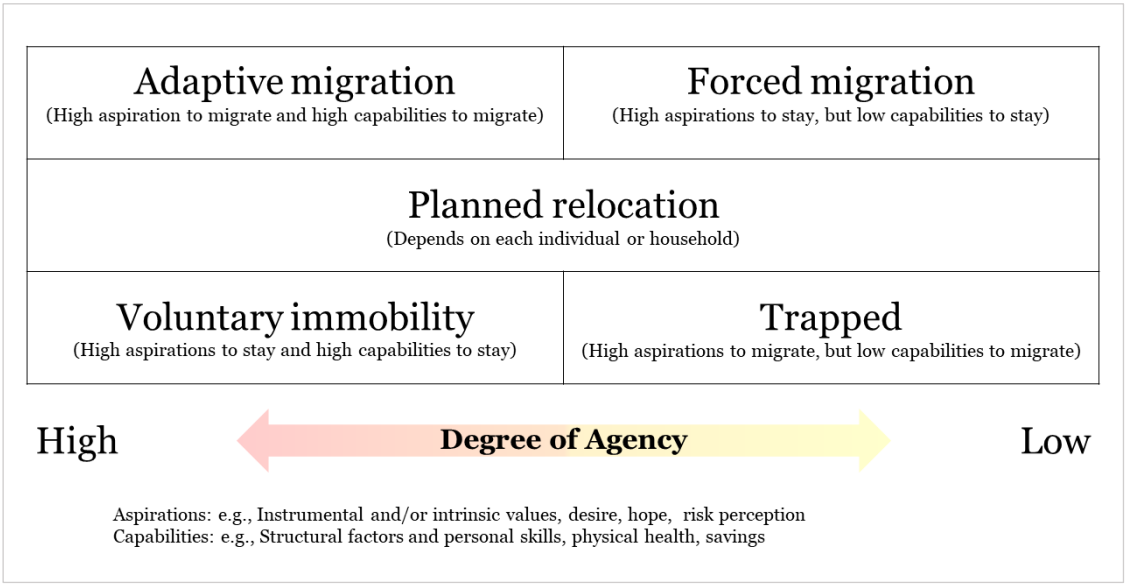


Figure 2: Migration and non-migration typologies in climate change context based on aspirations-capabilities frameworks.

Note: Carling (2002); de Haas (2021); Schewel (2020) and own elaboration

Figure 2 categorizes migration and non-migration under climate change based on individuals' aspirations and capabilities, reflecting the varying degrees of agency possibly involved in each typology. For example, forced migration might represent low agency, where individuals might have high aspirations not to migrate due to place attachment, but low capabilities, for example, to stay. Adaptive migration often indicates relatively high agency, with individuals possessing high aspirations and capabilities to migrate. Voluntary immobility could demonstrate high agency, as individuals have both aspirations and capabilities not to migrate. Trapped populations often lack the necessary capabilities or resources to fulfill their aspirations, resulting in limited agency. While necessary for adaptation, planned relocations may not always align with individuals' preferences, potentially leading to forced migration and increased vulnerability. The freedom to choose whether to migrate or stay is crucial for overall well-being (de Haas, 2021).

2.5.3 Climate change is a multifaceted driver of migration

Climate migration literature commonly classifies climate change-related events into two main categories: sudden-onset and slow-onset events (Berlemann & Tran, 2020; Cattaneo et al., 2019). However, recent studies suggest that the deterioration of water and ecological systems due to climate change also creates natural resource risks contributing to human migration (IDMC, 2018; IEP, 2020; IPCC, 2023). Therefore, it is necessary to consider natural resource risks as a third category in the study of climate migration. It is important to note that these distinct categories of climatic events have varying effects on migration decisions and patterns. Table 4 provides a simplified classification of climatic events based on evidence and projections. The following sections will briefly explore the specific impacts of these climatic event categories on migration.

Table 4: Categories of climate change as a driver of migration

Categories of climatic factors	Climatic factors
Extreme/sudden-onset events	Flash floods, landslides (due to prolonged precipitation), storms (tropical cyclones/typhoons/hurricanes), storm surge, flooding (river, coastal), agricultural and ecological drought, extreme heat/heatwave, wildfire
Slow-onset events	Glacial retreat, sea-level rise, saline intrusion (soil, freshwater, groundwater), coastal erosion, riverbank erosion, ocean temperature increase, ocean acidification, rainfall variation, desertification, increasing temperature, land and forest degradation, soil degradation, coastal and marine ecosystem degradation, loss of biodiversity
Natural resource risks	Changes in freshwater availability, water stress and/or insecurity, crop failure, changes in fishing catches, food insecurity

Note: IDMC & UNFCCC (2018); IEP (2020); IOM (2017); IPCC (2021); McLeman & Hunter (2010); Rigaud et al. (2018).

2.5.3.1 Extreme/sudden-onset events and their effects on migration

Extreme and sudden-onset climatic events are those with devastating impacts, such as cyclones, floods, wildfires, and storm surges, which can cause temporary displacement and short-term, circular, forced, or involuntary migration, often covering short distances such as internal or rural-urban migration (Adger et al., 2015; Berlemann & Steinhardt, 2017; Berlemann & Tran, 2020; Call et al., 2017; Foresight, 2011; McLeman & Hunter, 2010; Privara, 2019). However, repeated occurrences of such events can lead to temporary displacement and loss of livelihood, motivating long-term or permanent migration (Berlemann & Tran, 2020; Foresight, 2011; Roeckert & Kraehnert, 2022). Vulnerable populations may be trapped in adverse situations due to asset and resource loss and diminished migration capability (Adger et al., 2018; Black et al., 2013; Cattaneo et al., 2019). Heat stress in urban areas can influence people's migration intentions to better areas (e.g., colder) and sometimes results in urban trapped populations (Adger et al., 2020; Adger et al., 2021).

2.5.3.2 Slow-onset events and their effects on migration

Slow-onset events, characterized by gradual changes to the climate system, can lead to the loss of essential environmental amenities and human well-being (Adger, 2010; IDMC, 2018). While slow-onset events are unlikely to initiate migration in the short run (Goldbach, 2017), events such as sea-level rise, saline intrusion, and long-lasting ecological droughts can render lands uninhabitable, leading to adaptive migration (IDMC & UNFCCC, 2018; McLeman & Smit, 2006; Stojanov et al., 2014). Slow-onset events are more likely to drive longer-term and permanent types of migration (Bohra-Mishra et al., 2014; Foresight, 2011; Mueller et al., 2014; Piggott-McKellar et al., 2019), covering both short and long distances, including international migration (Backhaus et al., 2015; Berlemann & Steinhardt, 2017; Mastrorillo et al., 2016; Sedova & Kalkuhl, 2020). Planned relocations worldwide are taking place in response to slow-onset events (Adger et al., 2020; Lindegaard, 2020; McMichael et al., 2019).

2.5.3.3 Natural resource risks and their effects on migration

The changes in ecology driven by climate can put critical natural resources and livelihoods at significant risk in various regions. While the physical effects of climate change are more visible, the indirect effects can be just as catastrophic since communities and livelihoods are likely to be severely affected by the impact of climate change on the provision of ecological services and goods (Rigaud et al., 2018). For example, rising sea levels, increased flooding, saline intrusion in soil and water, and ecological and agricultural droughts will likely put freshwater availability, household water security, crop productivity, and food security at risk (IDMC, 2018; Nagabhatla et al., 2020; Richards et al., 2021; Stoler et al., 2022). In addition, the impacts of climate change on the ocean, including ocean warming and acidification, are of concern, as they pose threats to marine ecosystems and resources (e.g., reduced fish stocks), as well as the people who depend on the ocean for their livelihoods, food, and cultural

values (Baker et al., 2019; Borja et al., 2020; Inniss et al., 2016; IPCC, 2019b; Mendenhall et al., 2020). A comprehensive global ocean assessment of the implications of climate change projects massive and sudden drops in future fisheries production (Lotze et al., 2019). Consequently, the depletion of natural resources could trigger long-term or permanent migration, encompassing both short-distance and long-distance migration (Cai et al., 2016; Cattaneo & Peri, 2016; Chen & Mueller, 2018; Falco et al., 2019; Fischer et al., 2021; Islam et al., 2020; Mendenhall et al., 2020; Nagabhatla et al., 2020).

However, the frequency and intensity of climatic events are likely to persist and potentially worsen because of future climate change (Ripple et al., 2022). Complex interconnections and geographical disparities between these events also make it challenging to categorize them. For example, sea-level rise and coastal erosion can suddenly result in flooding, prolonged precipitation can lead to flashflood or flooding, and flooding can exacerbate riverbank erosion. Higher temperatures can turn into heat waves and force people to migrate (IDMC, 2018; IDMC & UNFCCC, 2018). Climate change accelerates desertification and makes the environment more prone to wildfires, which increasingly harm rural communities and are becoming more frequent in many regions (Al Jazeera, 2022; IDMC, 2018; Pörtner et al., 2022).

Furthermore, spatial proximity to climatic event-prone areas can shape migration decisions. Those living closer experience more involuntary migration and trapped populations, while those living further away from such areas may undergo adaptive migration and immobility (Conigliani et al., 2022; Lujala et al., 2015). However, despite its potential significance, research on the relationship between extreme or sudden-onset events, slow-onset events, climate-related natural resource risks, and migration in different spatial proximities has received limited attention. These complex interactions underscore the importance of continued research to understand better the various mechanisms through which climate change drives (non)migration and to inform effective adaptation and mitigation strategies. Table 5 synthesizes the dimensions and types of (non)migration in response to climatic change, including the categories of climatic events.

Table 5: Dimensions and forms of (non)migration decisions in response to climatic events

Types of migration decisions	**Categories of climatic events**	**Spatial Proximity**	**Dimensions of migration**			**Agency**
			Societal	Spatial	Temporal	
Migrate						
Forced	- Extreme/sudden-onset - Slow-onset - Natural resource risks	Higher Proximity	- Macro-scale	- Short-distance - Internal (rural-urban)	- Short-term - Circular - Long-term	- Low

Types of migration decisions	Categories of climatic events	Spatial Proximity	Dimensions of migration			Agency
			Societal	Spatial	Temporal	
Migrate						
Adaptive	- Slow-onset - Natural resource risks	Lower Proximity	- Meso-scale - Micro-scale	- Short-distance - Internal (rural-urban, rural-rural, urban-urban - Long-distance - International	- Circular - Long-term - Permanent	- Moderate - High
Planned relocation	- Slow-onset	Mixed	- Mixed	- Short-distance - Long-distance	- Long-term - Permanent	- Mixed
Not to migrate						
Immobile	- Slow-onset - Natural resource risks	Lower Proximity	- Micro-scale - Meso-scale	-	-	- High
Trapped	- Extreme/sudden-onset	Higher Proximity	- Macro	-	-	- Low

Note: Own elaboration based on review and discussions above and in previous sections

2.5.4 Vulnerability assessment for understanding climate migration effectiveness

The relationships between climate change and migration are influenced by the varying vulnerability experienced by people and places, and it is essential to highlight these interrelationships. The IPCC defines vulnerability as "the degree to which a system or population is susceptible to and unable to cope with adverse effects of climate change, as determined by the nature, magnitude, and degree of climate change and variability to which a system or population is exposed to, a system's or population's sensitivity, and adaptive capacity" (Field et al., 2014, p. 1772; Parry et al., 2007, p. 364).[7]

Three core components influence this vulnerability: exposure, sensitivity, and adaptive capacity (Adger, 2006; Füssel, 2005; Parry et al., 2007; Smith & Wandel, 2006). Exposure refers to the degree of impact on biophysical elements, such as sea-level rise, flooding, and cyclones (Field et al., 2014). For example, coastal communities face higher exposure to sea-level rise, while arid regions are more exposed to drought. Sensitivity reflects how climate change impacts adversely affect or modify a system or population (IPCC, 2014). Communities relying on subsistence farming and fishing and people with pre-existing health conditions are examples of sensitive groups. Adaptive capacity is the ability to manage exposure and sensitivity using resources like

[7] The definition of vulnerability provided by the IPCC is considered universal and applicable at various levels, ranging from system-level to individual-level. It can be assessed at different levels and recognizes that individuals may experience varying degrees of vulnerability based on their unique circumstances and characteristics (e.g., age, gender, health, and socio-economic conditions) (Field et al., 2014).

knowledge, technology, and social networks (Füssel, 2007; IPCC, 2014). For example, communities with access to early warning systems, financial resources, and social networks have higher adaptive capacity than communities without these resources. The combination of these core components, in turn, can influence migration as one of the adaptation options.

While some scholars have attempted to develop climate migration models using different vulnerability approaches (e.g., Grecequet et al., 2017; McLeman & Smit, 2006; Perch-Nielsen et al., 2008), these approaches do not fully demonstrate how vulnerability leads to migration decisions (Black et al., 2011). Research on the relationship between climate vulnerability and migration has demonstrated the complexity of this relationship and the diversity of adaptation strategies. Broader drivers and factors that shape adaptive capacity and adaptation choices influence individual and household migration decisions (McLeman & Hunter, 2010; Tacoli, 2009). However, these adaptation factors should not solely be considered motivators for migration (McLeman & Hunter, 2010) or non-migration. Instead, evaluating households' or individuals' subjective, psychological, and agency aspects is crucial to determine (non)migration decisions (as discussed in previous sections). So far, vulnerability assessments do not account for these aspects. Thus, vulnerability alone cannot fully capture the complex nature of how households make decisions regarding migration in the context of climate change.

However, vulnerability is dynamic and varies across populations, locations, and time (Cutter & Finch, 2008; Thomas et al., 2019). While it does not explain the entirety of (non)migration decisions, examining vulnerability can help understand the variations among groups before and after migration. For instance, climatic shocks often drive rural-urban migration among vulnerable populations (Adger et al., 2020; Findlay, 2011; Mianabadi et al., 2022; Rigaud et al., 2018). However, this can result in migrants living in overcrowded urban slums without essential infrastructure, clean water, sanitation, and public health services. Furthermore, migrants from farming households may switch to other sectors (Bhowmik et al., 2021; Sedova & Kalkuhl, 2020), which can either enhance or reduce their vulnerability depending on the availability of better livelihoods and services at their destination.

Assessing vulnerability can help understand the impact of climate migration and the challenges climate migrants may face at their destination. However, measuring the "success" of migration as an adaptation strategy is highly complex, and there are diverse approaches can be used to gauge it. This chapter proposes that by evaluating variations in vulnerability across different groups and locations, we can measure the effectiveness of climate migration and develop targeted policies and interventions. The vulnerability assessment suggested by the IPCC (2007) can be a valuable tool to evaluate the success and failure of migration by examining the variations in vulnerability among different groups (e.g., climate migrants versus other migrants) and places (e.g., origins versus destinations). Conducting a simple vulnerability assessment can provide insights into how migration has affected vulnerability and the

consequences faced by climate migrants at their destination. A detailed analysis of vulnerability in Chapter 3 provides specific insights into how climate migrants are uniquely affected and highlights the specific vulnerabilities they face compared to other groups at their destination. This chapter serves as an illustrative example of how vulnerability assessments can inform our understanding of the success of climate migration. Figure 3 visually represents how the assessment of vulnerability can be used to evaluate both the positive and negative outcomes of climate migration.

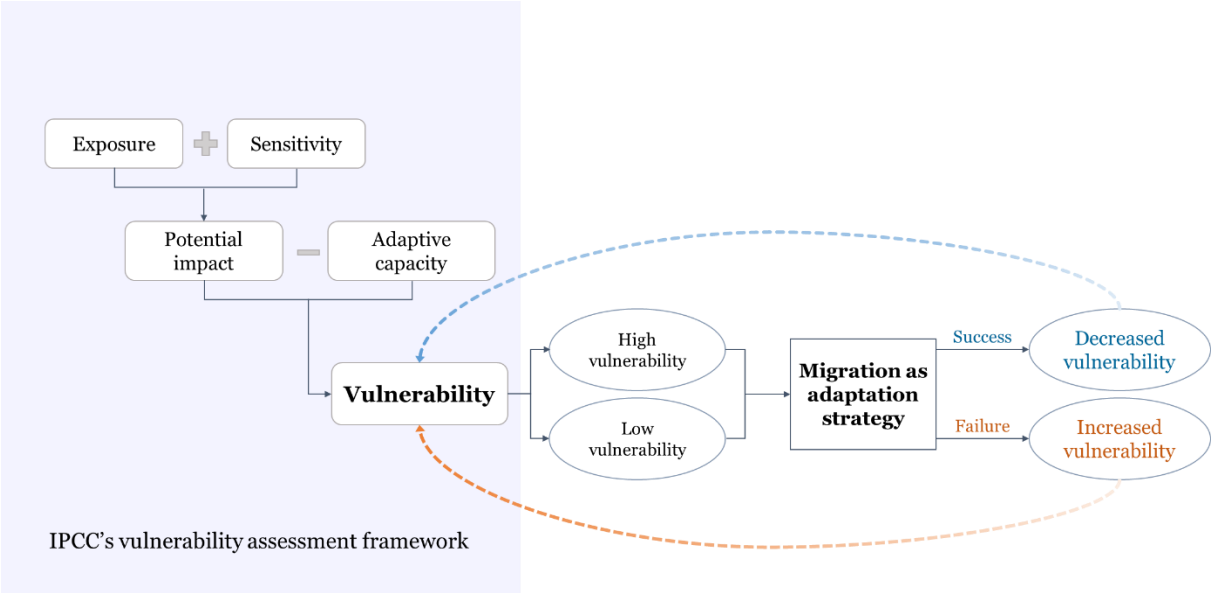


Figure 3: Vulnerability assessment framework to determine climate migration's effectiveness.

The IPCC's vulnerability assessment framework, depicted on the left side of the figure, comprises three core components: exposure, sensitivity, and adaptive capacity. Migration can initially serve as an adaptive response to reduce vulnerability. Nevertheless, the implications of climate migration in terms of vulnerability can be either positive or negative, as illustrated on the right side of the figure. If vulnerability decreases following migration, it can be deemed a successful adaptation strategy. Conversely, if vulnerability increases due to migration, it can be considered an unsuccessful adaptation strategy.

While the IPCC's AR5 and AR6 reports introduce risk assessment as an alternative approach to vulnerability assessment, this chapter does not focus on risk assessment. Risk estimation involves quantifying the likelihood and potential consequences of specific climate-related events or changes by combining information about hazards, exposures, and vulnerabilities (Pachauri et al., 2014). While both frameworks aim to assess climate change impacts, they differ in focus and purpose. The emphasis of vulnerability assessment is to understand susceptibilities and adaptive capacity, while the risk assessment framework aims to prioritize potential adverse impacts.

Vulnerability assessment, tied to adaptation planning, therefore, is crucial in understanding climate migration effectiveness. It identifies vulnerabilities and adaptive

capacity, providing a foundation for developing appropriate and effective adaptation strategies. In contrast, risk assessment, though broader in scope, may not fully capture the underlying vulnerabilities and sensitivities of people to climate change impacts. Thus, the chapter prioritizes vulnerability assessment as the primary approach to comprehending the effectiveness of climate migration.

2.5.5 Non-climatic factors influencing migration decisions

Migration is not a straightforward phenomenon and is influenced by various non-climatic factors in addition to climate change. As relying solely on climatic factors to understand and predict (non)migration may not be sufficient, this framework seeks to capture all relevant non-climatic macro-, meso-, and micro-level factors (Table 6) and discusses their interactions with climatic factors across diverse regions to provide a better understanding of the relationship between climate change and migration decisions.

2.5.5.1 Macro-level factors

Macro-level factors such as political, economic, demographic, and environmental conditions play a significant role in migration (Black et al., 2011; Castelli, 2018). These factors are primarily exogenous, i.e., beyond the control of individuals, and can lead to involuntary migration decisions, whether to migrate or not to migrate and whether internally or internationally (Castelli, 2018; Foresight, 2011). In macro-level studies, climatic, political, economic, demographic, and environmental factors are often considered confounding variables influencing large-scale displacements or migration flows (Abel et al., 2019; Hauer et al., 2020; Marotzke et al., 2020), making it challenging to determine the specific reasons of migration.

Climatic factors can destabilize agricultural economies, leading to economic loss and migration (Cattaneo et al., 2019; Cattaneo & Peri, 2016; Kubik & Maurel, 2016; Mueller et al., 2014; Nawrotzki & Bakhtsiyarava, 2017). Ecological threats and weak governance can exacerbate socio-political conflicts and violence, resulting in displacement and migration (Abel et al., 2019; Burke et al., 2015; Burrows & Kinney, 2016; Castelli, 2018; Richards et al., 2021). Climate-induced environmental depletion at the place of origin and better ecological conditions at the destination can also influence migration (e.g., “snowbird” migration of older North Americans to the US sunbelt to avoid harsh winter conditions) (Hunter et al., 2015; McLeman & Hunter, 2010). Recent political interventions (e.g., policy incentives) and governance systems, trust in government, and infrastructure levels can also play a critical role (Beine & Parsons, 2015). Additionally, the receptiveness of potential destination countries, sentiment towards immigrants, and border policies could be significant mediating factors for international migration in a climate-disrupted future (Benveniste et al., 2022; McLeman, 2019).

Table 6: Factors of migration at different scales

Non-climatic factors		
Macro-level	Meso-level	Micro-level
Demographic driver ▪ Population density ▪ Population size and growth ▪ Population mortality and morbidity	Social driver ▪ Social networks ▪ Social support systems ▪ Information channels ▪ Social conflict/ Insecurity ▪ Cultural ties ▪ Attitudes and receptiveness toward communities	Demographic driver ▪ Age ▪ Sex ▪ Marital status ▪ Language
Economic driver ▪ Economic growth ▪ Employment rates ▪ Employment opportunities	Economic driver ▪ Loss of livelihoods (community-level) ▪ Shift in job opportunities ▪ Access to resources (community-level) ▪ Infrastructure and housing (community-level) ▪ Access to job ▪ Access to healthcare ▪ Communication and transportations	Social driver ▪ Ethnicity ▪ Gender ▪ Family structure ▪ Change in marital status ▪ Level of education or seeking education ▪ Occupation ▪ Family ties
Political driver ▪ Political conflict ▪ Migration law ▪ Governance ▪ Policy incentives ▪ Migration policy ▪ Receptiveness of destination ▪ Attitude/sentiment toward migrants ▪ Legal protection	Political driver ▪ Institutionalization and infrastructure (community level) ▪ Political conflict (community level)	Economic driver ▪ Average household income ▪ Average household expenditure ▪ Assets (shelter, infrastructure, land) ▪ Seeking employment ▪ Access to resources
Environmental driver ▪ Environmental Health ▪ Land-use change ▪ Soil quality ▪ Water quality ▪ Air quality	Environmental driver ▪ Freshwater pollution ▪ Air pollution ▪ Water availability for irrigation	Psychological and personal ▪ Religious belief ▪ Risk perception ▪ Experience ▪ Place attachment ▪ Aspirations to migrate ▪ Capabilities to migrate (e.g., liquid assets, health)

Note: References in the text

2.5.5.2 Meso-level factors

At the meso-level, several factors are identified to play a crucial role in influencing migration decisions in the context of climate change. These include existing local and transnational migrant networks and the community's ability to cope with climate change impacts (Cattaneo, 2019; Van Praag et al., 2021). In addition, social networks can influence migration through information exchange and remittances (Hunter et al., 2015), and the presence of networks in destination regions can lead to increased out-migration (Entwisle et al., 2020; Fu & Hao, 2018). However, meso-level factors are also interdependent with macro- and micro-level factors, as climatic impacts (e.g., water insecurity, changes in ecosystems) can lead to poverty and conflict, affecting the

community's ability to adapt and perceive forced migration (Mendenhall et al., 2020; Perumal, 2018; Koubi, 2018; Marotzke et al., 2020).

2.5.5.3 Micro-level factors

At the micro level, various factors influence migration decisions and destination choices. These include individual characteristics such as age, income, sex, ethnicity, education level, religious belief, marital status, and personal attitudes toward migration (Castelli, 2018; Hunter et al., 2015). For example, older individuals are usually less inclined to migrate due to adverse environmental conditions, whereas younger individuals are more likely to migrate from rural areas (Koubi et al., 2016; McMichael et al., 2019). Nevertheless, Zander et al. (2019) found that older individuals are more disposed to migrate to cooler regions in Southeast Asia's urban areas to evade heat stress. Welch-Devine & Orland (2020) also observed that African (black) Americans are more likely to migrate away from coastal areas than white Americans after hurricane impacts.

The interplay between economic and social factors shapes migration decisions. For example, studies show that climate change-related loss of livelihood or assets can trigger migration as households seek to reduce uncertainty and diversify their income (Bohra-Mishra et al., 2017; Brouwer et al., 2007; Cattaneo et al., 2019). Conversely, sudden income disruptions may also necessitate migration as compensation (Ajani & van der Geest, 2021; Call et al., 2017). Education and literacy also play a crucial role in migration decisions, with lower education levels associated with lower migration likelihoods (Koubi et al., 2016). Furthermore, individuals with more assets, such as shelter, infrastructure, and land, and those in certain occupations, such as farming or fishing, may be less likely to migrate to protect their assets or may migrate temporarily or repeatedly as a coping strategy in response to seasonal climate events (Curran & Meijer-Irons, 2014; Hirvonen, 2016). However, frequent and extreme climate events can lead to permanent migration for individuals regardless of occupation due to the continuous loss of assets, wealth, and livelihoods (Jha et al., 2018; Petrova, 2021).

The intersection of gender with other socioeconomic and cultural factors can lead to gender-specific vulnerabilities to climate change and subsequent migration decisions (Ayeb-Karlsson, 2021; Lama et al., 2021). For example, studies demonstrate that women and men have different levels of access to resources, education, and income diversification strategies, leading to varied migration outcomes (Erwin et al., 2021; Carrico, 2023). Women, in particular, are less likely to migrate due to a lack of education and skills, while men have more opportunities to migrate (Erwin et al., 2021). Moreover, gender influences the perception of risks, migration pressure, strategies, priorities, employment prospects, and destination choices (Lama et al., 2021; Van Praag, 2021), making it a crucial variable in studying migration.

Risk perception is a crucial psychological component that influences migration decisions in the context of climatic events. Studies, such as the one by Koubi et al. (2016), in five developing countries, found that the perception of risk associated with

slow-onset events and experience with sudden-onset events significantly contribute to migration tendencies. Similarly, Parsons & Nielsen (2021) found a significant correlation between subjective risk perception of climate change and migration behavior in Cambodia. However, the literature is also careful in directly linking local risk perception and climate data (Parsons & Nielsen, 2021; Rana et al., 2020). Recent studies also emphasize the role of place attachment in shaping migration decision-making (Leviston et al., 2023; Szaboova et al., 2022). For example, Adams's (2016) research on the migration decisions of Peruvian villagers affected by severe droughts identified various factors, including attachment to their current location, resources, and perceptions of alternative locations, influencing migration. Likewise, Farbotko & McMichael (2019) found that similar factors influenced Tuvaluans' migration decisions. Migration costs and personal capabilities, such as financial resources and health, influence migration decisions. For example, in low- and middle-income countries where agriculture is a primary source of income, climatic shocks can reduce liquidity, making it challenging to cover migration expenses (Black et al., 2013; Cattaneo & Peri, 2016; Wesselbaum & Aburn, 2019).

2.6 A proposed extended conceptual framework

Drawing on the theoretical insights and empirical perspectives discussed above, this section presents a proposed expanded conceptual framework that offers a comprehensive and holistic perspective on climate migration decisions and patterns, as well as the identification of climate migrants and evaluation of migration effectiveness (Figure 4). The framework is the result of careful consideration of various dimensions, factors, scales, and gaps identified in existing frameworks.

To begin with, the framework builds upon the existing conceptual framework developed by Black et al. (2011) over a decade ago while incorporating a more nuanced approach. This framework considers various drivers influencing migration decisions, including social, demographic, economic, political, and environmental. These drivers are categorized based on different scales, namely macro, meso, and micro (Table 6), allowing for a comprehensive analysis of their impacts on migration outcomes. Moreover, the proposed framework incorporates previously overlooked factors, such as psychological and personal aspects (e.g., place attachment, risk perception), which are expected to shape migration decisions significantly. The framework acknowledges the crucial role of gender as a social factor in climate migration and underscores the necessity for additional research to explore its dimensions more thoroughly. This way, researchers are prompted to explore and analyze the gendered dimensions of climate migration in dedicated studies, such as Chapter 4, contributing to a more comprehensive understanding of the complexities involved.

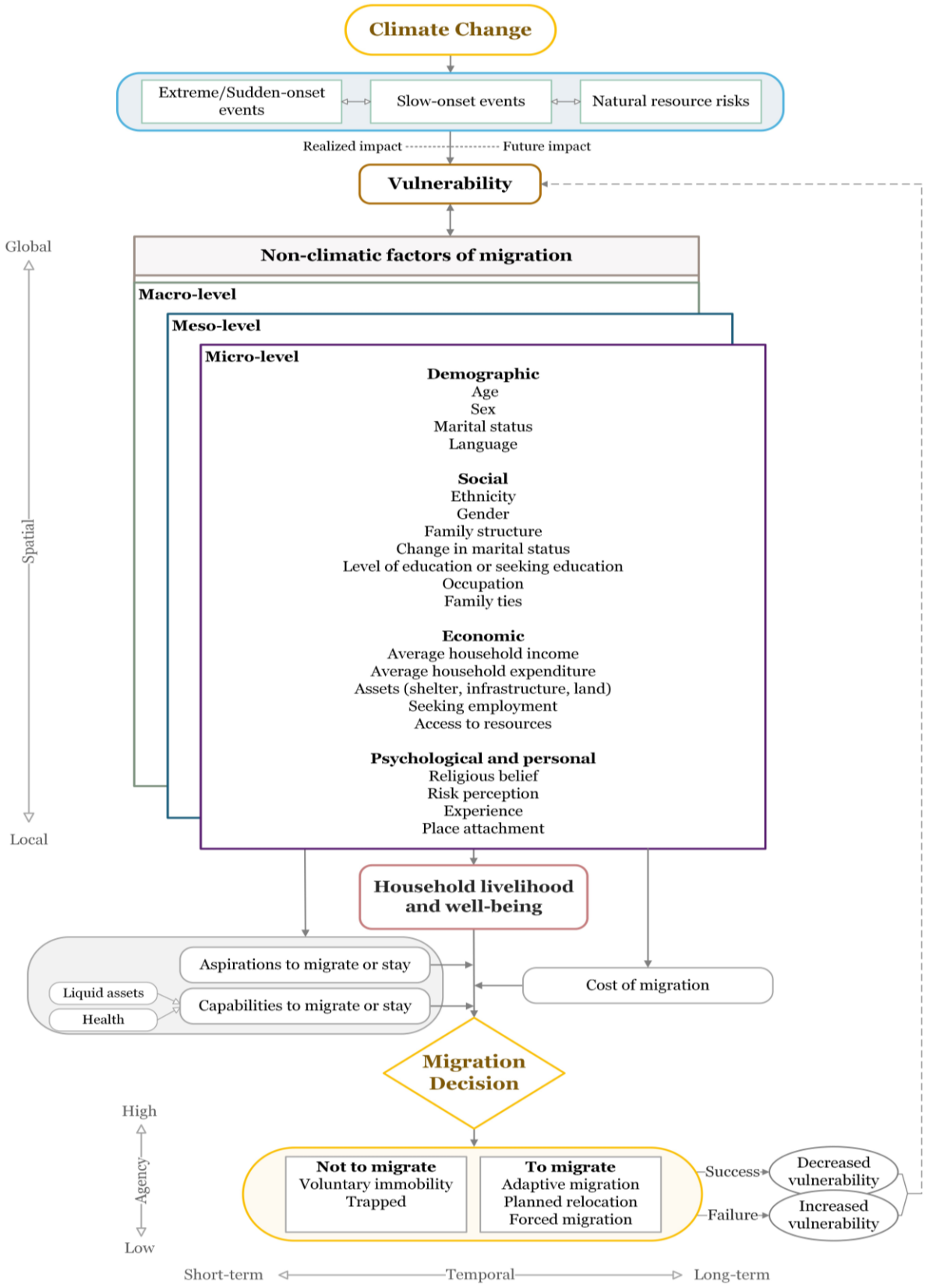


Figure 4: A comprehensive conceptual framework for examining climate-migration relationships.

The impact of “climate change” is placed at the top of the framework, directly affecting livelihoods and well-being at the micro-level and acting as a catalyst for other push factors at different scales that influence migration decisions. Therefore, this enables researchers to investigate direct associations between climate change and migration, considering climate change as a single exogenous driver and its interactions with other exogenous and endogenous migration factors at different scales. The framework considers both realized and future impacts of climate change based on spatial and temporal proximity to climatic factors (as discussed in section 2.5.3 and Tables 4 and 5).

The “vulnerability” experienced by places and people to climate change is acknowledged in the framework below climate change (which presents IPCC’s vulnerability concept from the previous section 2.5.4), recognizing that worldwide there are variations in vulnerabilities (e.g., high or low, present or future) among people and across places due to climatic and non-climatic determinants at different macro, meso, and micro-scales. Therefore, in the context of climate change, people make migration decisions under vulnerable situations, and other factors of migration determine those decisions. In addition, decreased and increased vulnerability at the bottom right side of the figure summarizes Figure 3, which can help measure if migration is a successful or unsuccessful adaptation strategy.

In the context of climate change, similar to Wallerstein’s (1974) World-systems theory, drivers and factors at macro and meso-levels (e.g., political, economic, and social structures) can create structural inequalities and control differentiated migration decisions at the micro-level. This conceptual framework aims to provide in-depth insights into the migration decisions under climate change by illustrating the dynamic and complexity of the interactions among different drivers and factors and their linkage across multiple scales. Furthermore, the framework recognizes possible (non)migration decisions, i.e., forced, adaptive, trapped, and voluntary immobility (at the bottom), that may result from different contextual and causal factors and emphasizes potential migrants’ “aspirations” and “capabilities” to migrate or stay. Migrants’ aspiration is a crucial factor that connects the root causes and migration outcomes (Carling & Collins, 2018). Plenty of research in migration investigates the concept of migration aspirations in general. However, when it comes to the specific context of climate change, limited research has explicitly focused on the development of migration aspirations. In addition, potential migrants’ capabilities to migrate or stay can be influenced also by migration costs, liquid assets, and health conditions. Thus, the migrants’ agency is conceptualized at the micro-level, connecting individual migration aspirations and capabilities with structural (e.g., macro and meso-level political, institutional barriers and facilitators) and subjective and psychological interpretations. This, to some extent, relates to de Haas’s (2021) and Schewel’s (2020) “aspirations-capabilities frameworks” and the psychological interpretations further supported by Wolpert’s (1965) “stress-threshold model.”

Measuring migrants' agency will help differentiate between different types of migrations and non-migrations (as discussed in section 2.5.2 and depicted in Figure 2). Lastly, including spatial and temporal dimensions (left side and bottom of the figure) will enable us to unfold the migration pattern under different climatic conditions (as discussed in section 2.5.1). The framework offers a holistic lens through which the interplay of various elements can be observed and better understood, providing valuable insights into their significance in the study of climate migration.

When examining the relationships between climate change and migration decisions, it is crucial to consider relevant climatic and non-climatic factors. As there are complex intersections between climate change and different factors of migration, this framework advises against assuming that one factor (e.g., economic or social) can solely influence (non)migration decisions. Not considering all possible factors and aspects may lead to overlooking critical factors contributing to the outcome. Although it is typically assumed that a specific climatic event may affect all households in an area equally at the macro or meso levels, the variations in interhousehold experiences and migration decisions within the same locality can be better understood through micro-level analysis.

2.6.1 Preliminary application of the conceptual framework to the case of Bangladesh

This section briefly applies the proposed conceptual framework to the case of Bangladesh, a country known for its high vulnerability to climate change in South Asia (Table 7). Its primary aim is to gain initial insights into the relationship between climate change and migration in Bangladesh. Situated in a riverain region bordered by India, Myanmar, and the Bay of Bengal, Bangladesh faces numerous challenges due to its geographical location, population density, and exposure to natural disasters.

Table 7: Key aspects of climate migration in Bangladesh

Key aspects	Description
Country profile	Bangladesh, a climate-vulnerable country in South Asia, faces environmental and socio-economic challenges due to its geographical location, high population density, and exposure to natural disasters.
Climate challenges	Climate-related events pose significant risks to agriculture, fisheries, and livelihoods, threatening the socioeconomic stability of Bangladesh.
Drivers of climate migration	*Climatic factors:* Cyclones, storm surges, floods, riverbank erosion, extreme temperatures, changing precipitation patterns, sea-level rise, droughts, saline intrusions, crop failure, and freshwater scarcity are key drivers of displacement and migration in Bangladesh
	Non-climatic factors: Loss of livelihoods, economic opportunities, and access to services, as well as factors such as infrastructure, social networks, place attachment, sense of belonging, and the desire for improved living standards, can all contribute to the decision to migrate in Bangladesh
Attractive destinations	Urban areas like Dhaka and Chittagong offer developed infrastructure, higher employment opportunities, and access to services, attracting migrants seeking better economic prospects and living conditions.
Migration patterns	*Migration:* internal migration is prominent, particularly from rural areas to urban centers like Dhaka and Chittagong. Short-term, circular, and permanent migration patterns are

Key aspects	Description
	observed. Limited data are available regarding international migration driven explicitly by climate change, but the potential for climate-related migration across borders exists.
	Non-migration: non-migration can occur due to financial constraints, high living costs in urban areas, and strong place attachment, despite facing challenges.
Vulnerability assessment	Identify migration-prone areas and vulnerable populations through vulnerability assessments to understand the effectiveness of migration as an adaptation strategy in addressing climate-related vulnerabilities.
National policies and strategies	Bangladesh has implemented the National Adaptation Plan (2023-2050), Bangladesh Climate Change Strategy and Action Plan (BCCSAP), and the National Strategy for Disaster Risk Reduction to enhance climate resilience and reduce disaster risks. BCCSAP aims to strengthen capacity for managing and mitigating climatic impacts, while the National Strategy for Disaster Risk Reduction focuses on reducing disaster risks and improving climate resilience.
Locally led adaptation (LLA)	Engaging communities, NGOs, and LLA foster effective and sustainable climate adaptation through incorporating local perspectives and knowledge and community-driven approaches for equity and sustainability.
Proposed conceptual framework	The framework enables the analysis of the complex interplay between climatic and non-climatic factors driving climate migration decisions and patterns. It serves as a tool for informing targeted interventions, including infrastructure development, job creation, social protection measures, and disaster risk reduction strategies.

Bangladesh faces various climatic events, both sudden and gradual, such as cyclones, floods, extreme temperatures, and sea-level rise. These events have detrimental effects on the country's agriculture, fishing industries, and overall livelihoods, forcing people to seek alternative means of survival. This has already led to significant climate-related displacements, with approximately 17 million individuals being displaced between 2008 and 2022 due to 99 weather-related disasters (IDMC, 2023).

Simultaneously, urban centers in Bangladesh, such as Dhaka and Chittagong, present attractive prospects for climate migrants due to their well-developed infrastructure, abundant employment opportunities (in both formal and informal sectors), and strong social networks. These urban centers have become magnets for individuals seeking improved livelihoods, drawing migrants from rural regions (Adger et al., 2021). Dhaka, one of the world's fastest-growing megacities, has experienced rapid economic growth, primarily fueled by government initiatives to attract foreign investment and promote export-oriented industries (Mujeri & Mujeri, 2020). Notably, the garment industry, a vital contributor to the country's exports, has flourished, benefiting from enhanced infrastructure and a reliable energy supply (Zhang et al., 2022). The pressing need for investments in infrastructure, renewable energy, information technology, and agro-based commodities is a strong force pulling individuals from rural areas to urban centers.

However, it is important to acknowledge that not all individuals affected by climate change have the financial means to migrate or sustain themselves in destination areas

with higher living expenses (Islam, 2022). After losing everything in extreme disasters, some may be trapped in their current locations. Additionally, strong place attachments and a sense of belonging may discourage migration for some individuals (Mallick et al., 2022). As a result, internal migration within Bangladesh, including rural-to-urban, rural-to-rural, and urban-to-urban movements, is likely to be the dominant migration pattern. The form of migration can vary, including short-term, circular, or permanent relocations, depending on individual circumstances and opportunities.

Additionally, vulnerability assessments help understand the impacts of climate change on migration by evaluating the exposure of communities and regions to climatic events. These assessments consider political, social, economic, demographic, and environmental factors and identify coping mechanisms and adaptive and resilience-building measures. Bangladesh has taken steps to address climate migration through initiatives such as the National Adaptation Plan (2023-2050), the Climate Change Strategy and Action Plan (2019-2030), and the establishment of National Climate Finance Mechanisms (MoEFCC, 2022). Projects like the Coastal Climate Resilient Infrastructure Project and Comprehensive Disaster Management Programme specifically target climate-related migration and displacement. Efforts are also being made to create climate-resilient and migrant-friendly cities (Khan et al., 2021).

However, there is still room for improvement in policies and programs addressing Bangladesh's complex challenges associated with climate change-related migration. Cross-sectoral policies integrating climate change's economic, social, and environmental dimensions are needed to recognize individuals' mobility rights (Stojanov et al., 2021). It is also important to ensure that displaced and vulnerable populations can access adequate housing and basic services while creating opportunities for regular migration and human mobility (Martin et al., 2021). Policymakers can make evidence-based decisions by applying this conceptual framework to understand the relationship between climate change and migration in Bangladesh. This framework helps uncover the complexities of the relationship and highlights the need for sustainable solutions. While some progress has been made, much work still needs to be done to ensure affected communities' long-term resilience and well-being.

2.7 Potential implications for advancing climate migration research and policy practice

Expanding beyond the specific case of Bangladesh to a broader global perspective, the relationship between climate change and migration has garnered increasing attention in both global and local policy debates. This growing recognition has prompted various initiatives to address the multifaceted challenges associated with this issue. Notably, global agreements such as the United Nations Framework Convention on Climate Change (UNFCCC) acknowledged the importance of addressing "human mobility" in the "Cancun Adaptation Framework" in 2010. This recognition was reinforced by subsequent agreements, including the "Cancun

Adaptation Framework" in 2010 and the "Paris Agreement" and "Sendai Framework" in 2015, which emphasized the need to consider human mobility in the face of climate change.

The comprehensive conceptual framework presented in this chapter offers a potentially valuable tool for exploring the interactions between climate change and migration. One of its main strengths is the recognition that climate change can impact various migration factors in complementary or contradictory ways, potentially influencing individual migrants' agency in deciding whether to migrate. To ensure a homogenous application of the framework, it is essential to incorporate the perspectives and voices of potential climate migrants, thereby facilitating a more inclusive analysis and a deeper understanding of climate change and migration dynamics. The framework also serves as a common ground for integrating different perspectives, assumptions, and methodologies in framing empirical studies. Primary studies (e.g., surveys) and secondary literature reviews (e.g., systematic reviews and meta-analyses) can be conducted within the framework.

To operationalize the framework, a range of methods and data sources can be employed. Quantitative methods, including surveys and statistical analysis, allow for examining migration patterns and drivers. Qualitative approaches, such as in-depth interviews, provide valuable insights into the subjective experiences of migrants. Longitudinal analysis helps track changes in migration patterns over time. Integrating survey or census information, climate data, and geographic information system (GIS) based models can make it possible to understand better the connections between climate change impacts and migration flows and patterns (McLeman, 2013). Furthermore, advancements in computational models for migration studies, such as agent-based modelling (ABM), can provide valuable insights into the complexity and dynamics of individual decision-making processes and the nature of migration decisions (Hailegiorgis et al., 2018; Lamperti et al., 2019; Thober et al., 2018). These sophisticated approaches, combined with an improved understanding of the factors influencing migration behavior, contribute to the development of more comprehensive climate change and migration models, as also noted by McLeman (2013).

The framework presented here is envisioned to contribute to our understanding of the complex and evolving relationships between climate change and migration patterns and assess climate migrations' success. However, further empirical validation is needed to determine its effectiveness, and the proposed conceptual framework needs further contextualization and grounding in empirical data to better understand the interactions between climate change and migration and to improve sophisticated modelling. Nevertheless, the proposed framework has the potential for numerous positive implications, including aiding in the planning and coordinated implementations of adaptation and disaster risk reduction processes that are in line with international frameworks like the Sustainable Development Goals (SDGs), the Global Compact for Migration (GCM), the UNFCCC's Cancun Adaptation Framework, and the UN's Sendai Framework. Additionally, this approach could lead to more effective, sustainable, and

equitable actions for individuals affected by climate migration, such as identifying the root causes and ensuring that migration remains a choice. Building on this improved understanding, the proposed framework has the potential to help reduce future displacements and forced migration, enable adaptive migration that ensures people migrate safely without increasing their vulnerability, allow people to remain in their homes and livelihoods without feeling trapped, and, when necessary, facilitate sustainable planned relocations. This holistic approach to addressing future risks of climate-related human mobility necessitates cooperative international efforts to enhance institutional adaptive capacity and sustainable development, with active involvement of local populations in planning and decision-making, as highlighted by the IPCC's AR6 report (Cissé et al., 2022).

Chapter 3: Assessing climate migration and vulnerability in Dhaka: A dual approach using principal component analysis and perception-based assessment

Abstract

In the era of climate change, increased rural-to-urban migration poses severe and complex challenges. This study delves into the complex issue of climate migration by exploring the vulnerability of climate migrants in an urban destination, Dhaka, Bangladesh. It addresses two primary questions: 1) Are climate migrants more vulnerable than other migrants and long-term residents? 2) How do climate migrants perceive their socio-economic conditions after migration compared to other migrants? The study utilizes the IPCC's vulnerability assessment framework (see Chapter 2, section 2.5.4) and principal component analysis (PCA) to develop a composite vulnerability index (CVI) for comparing climate migrants with long-term residents and other migrants. A perception-based assessment was also conducted to evaluate climate migrants' pre- and post-migration situations. Data was collected from 2,000 households in Dhaka, distinguishing climate migrants from long-term residents and other migrants. Environmental data, such as flood risk and thermal discomfort index maps, were also collected. The aggregated data was analyzed using PCA and CVI. Results indicate that climate migrants remain the most vulnerable in terms of socio-economic status, the standard of living, flood and waterlogging risks, concerns over nearby water bodies, access to sanitation, health costs, age dependency, and child education. The analysis of self-reported conditions before and after migration reveals that climate migrants perceive worsened situations regarding water, sanitation, and health but improvements in exposure to natural disasters and earning opportunities compared to their pre-migration circumstances. By employing a combination of conceptually driven approaches and data-driven techniques, this research provides valuable empirical insights into the effectiveness of migration as an adaptation strategy and serves as an example for future studies. This research will interest researchers, policymakers, and practitioners in this field and inform policies and interventions to improve climate migrants' lives and urban development.

3.1 Introduction

Rural-to-urban migration is a widespread phenomenon in many developing countries, driven by a range of "voluntary" and "forced" factors. While research on identifying the drivers of migration is growing (Moore & Wesselbaum, 2022; Schewel, 2020; Selod & Shilpi, 2021), research on the relationship between migration reasons and implications on socio-economic status and living conditions of migrants in urban destinations is limited. Few existing studies have shed light on the influence of migration reasons on migrants' health and socioeconomic conditions in urban destinations (e.g., Biswas et al., 2019; Ishtiaque & Nazem, 2017); however, significant knowledge gaps persist on the issue. This study addresses this limited knowledge by

investigating this relationship, specifically focusing on climate migrants' vulnerability in urban destinations.

Climatic or environmental migration often occurs within migrants' home countries (Kaczan & Orgill-Meyer, 2020; Rigaud et al., 2018), with major cities being the most attractive places to migrate to due to better income-generating options and opportunities for transforming their lives (Adger et al., 2020; Chung et al., 2022; Islam et al., 2021; Rosengärtner et al., 2022). Migrants often migrate stepwise to larger cities by first moving to the nearest urban center and then to, for example, the capital city of a country (Adger et al., 2020). However, cities are at greater risk from global environmental change due to high population densities and significant infrastructure, such as roads and railways (Leal Filho et al., 2019). The IPCC (2014) predicts that urban areas will face significant economic, environmental, and hydro-geophysical risks and challenges in housing, health, transportation, energy, and environmental services. Low-income residents living in urban slums are likely to be the most vulnerable to climate change impacts and are likely to be climate migrants (Adger et al., 2021). Research shows that climate change exacerbates social inequality, worsens health outcomes, decreases resource availability, and has significant implications for cities (Kaur & Pandey, 2021; Koop & van Leeuwen, 2017; Long & Rice, 2019; Wang et al., 2020).

In addition, there is an ongoing and unsolved debate regarding the effectiveness of migration as an adaptation strategy. Some research suggests that migration can be a successful adaption strategy (Afifi et al., 2016; Maharjan et al., 2020), while others argue that it has adverse effects and is maladaptive (Jacobson et al., 2019; Pörtner et al., 2022; Tacoli, 2009; Turhan & Armiero, 2019). Other scholars also pointed out that migration may only be an effective adaptation strategy for specific people and situations (Vinke et al., 2020; Wiegel et al., 2019). However, empirical studies examining these mechanisms in detail are still rare (McLeman & Gemenne, 2018; Piguet, 2022). This research investigates the under-investigated issue of how underlying reasons for migration impact the socio-economic conditions of climate migrants in urban areas. While various scenarios and socio-economic pathways exist for observed and anticipated climate changes, a remarkable gap remains in our limited understanding of the socio-economic vulnerability of groups directly or indirectly affected by climate change, like climate migrants in urban areas. Due to their limited financial capacity and access to resources, these migrants are considered more vulnerable than other groups.

In this study, we distinguish climate migrants from migrants who moved away from their original residence for other reasons and then compare these two groups with a control group of long-term residents in a mega-city in South Asia. Through this comparison, the following two questions are answered. First, are climate migrants more vulnerable than other migrants and long-term residents? Second, how do climate migrants perceive their socio-economic living conditions after they have migrated compared to other migrants? Based on primary data collection in a large-scale

household survey and secondary data collected from the existing social scientific literature, a composite vulnerability index is created that allows us to compare vulnerability differences among the three groups. In addition to this cross-sectional analysis, a longitudinal analysis is carried out based on recall (perception) data to understand and compare migrant groups' perceptions of their socio-economic conditions before and after migration. The study hence contributes to the existing empirical evidence base by testing the vulnerability as defined by the IPCC (Chapter 2, see section 2.5.4) of climate-induced migrants vis-à-vis other migrants and long-term residents at their destination, combining primary and secondary data and information about their demographic, socio-economic, health, and other livelihood-related conditions, and comparing climate and other migrants' living conditions before and after their migration.

The case study is conducted in Bangladesh, a country that has long been recognized as one of the most vulnerable to the impacts of climate change (Brouwer et al., 2007; Karim & Mimura, 2008; Rahman et al., 2019), further exacerbated by multiple factors such as geographic disadvantage, poverty, rapid urbanization, and high population density, and inadequate institutional capacity (Goosen et al., 2018; Khan et al., 2021). In addition, the capital city, Dhaka, is rapidly growing and attracting more migrants. This migration trend is likely to amplify as the effects of climate change across this low-lying, flood-prone country intensify over the next 1-2 decades. Although migration is a strategy for climate change adaptation, it may come at considerable costs for migrants and the cities where they settle. Local authorities are concerned about managing the growing number of migrants in an already overcrowded city, which lacks the necessary resources to accommodate them. For example, the arrival of more migrants in Dhaka will lead to more people inhabiting low-lying areas, exacerbating the city's drainage congestion (Alam & Rabbani, 2007; Bird et al., 2018; Rashid, 2009).

With the increasing severity of climate change impacts, institutions and policies ought to effectively address unplanned migration challenges. Vulnerability is a significant determinant of allocating the Adaptation Fund (AF) to least-developed countries under the provisions of the United Nations Framework Convention on Climate Change (UNFCCC, 2019), funded through the Global Environment Facility (GEF). Identifying climate migrants in urban areas and understanding their socio-economic vulnerability is crucial to developing strategies to reduce observed vulnerabilities and inequalities. While discouraging them from migrating would be an option, many vulnerable communities, especially those in coastal areas, are expected to experience deteriorating living conditions, which is, therefore, only expected to be of limited success. Creating and understanding vulnerability indicators can help urban planners and decision-makers responsible for adequate housing and infrastructure better understand the composition and needs of the most vulnerable groups based on the factors contributing to their vulnerability. This, in turn, will enable cities to develop strategies and allocate funding to reduce the observed vulnerabilities and inequalities among climate and other migrants and create more equal opportunities and facilitate

their integration into sustainable cities and communities as aimed for in Sustainable Development Goal 11.

This paper is organized as follows: Section 3.2 describes the study methods, including a description of the case study area, data collection, and steps for analyzing data and constructing the composite vulnerability index based on Principal Component Analysis (PCA) and the Likert scales used to analyze the longitudinal recall data related to living conditions before and after migration. Section 3.3 presents the results from the data analysis. Section 3.4 discusses this study's main findings and limitations, and section 3.5 concludes.

3.2 Materials and methods

3.2.1 Case study: Dhaka, Bangladesh

Bangladesh has been one of the most critical regions of concern for both academics and the public when it comes to discussions about climate change. The World Bank's Groundswell report projected that, by 2050, the adverse impacts of climate change, including rising sea levels, storm surges, and decreased water availability and crop productivity, could induce 19.9 million people to migrate from the affected areas of Bangladesh (Rigaud et al., 2018). This number represents nearly half of the total climate migrants predicted for South Asia (Clement et al., 2021). In addition, an estimation from the Global Internal Displacement Database 2022 (see Figure 5) reveals that between 2008 and 2021, over 15.5 million people were already displaced in Bangladesh due to weather-related events (IDMC, 2022). Climatic events predominantly drive these displaced people to migrate to urban areas in Bangladesh, such as Khulna, Dhaka, Chittagong, Barishal, Rajshahi, and Satkhira (GIZ, 2022; Hasnat et al., 2022).

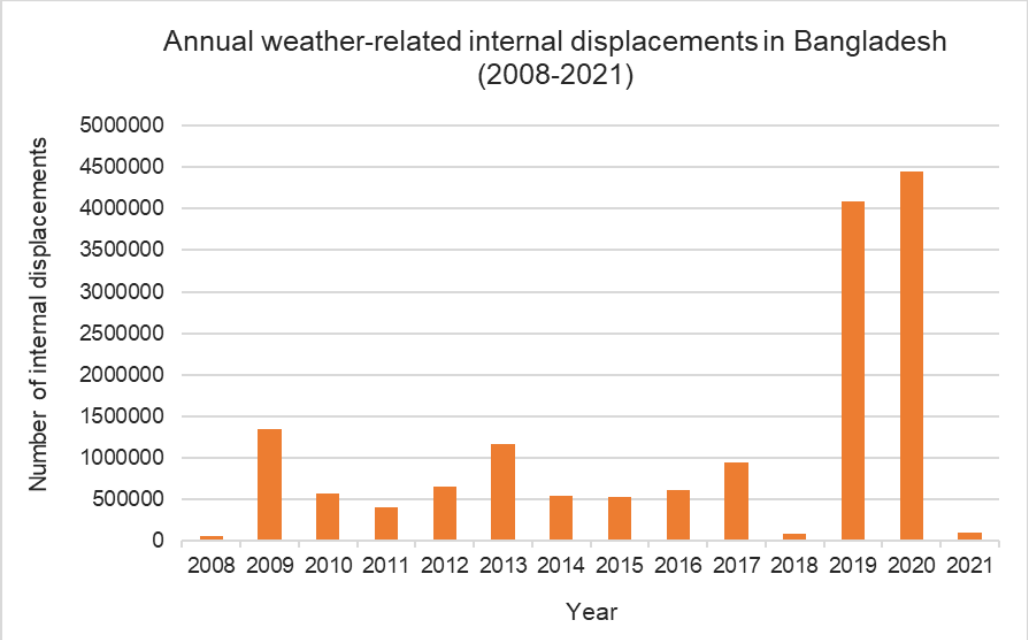


Figure 5: Number of weather-related internal displacements per year in Bangladesh

Source: Data from the Global Internal Displacement Database 2022 (IDMC, 2022).

The capital Dhaka is the rapidly growing largest city used here as the study area. It is located in the middle of Bangladesh (see Figure 7) and extends between 24º40´ and 24º54´ in northern latitudes and 90º20´ and 90º30´ in eastern longitudes (BBS, 2013). The average minimum annual temperature in the study area is 21.5°C, and the maximum is 30.6°C. The average annual rainfall is 179mm, with a maximum monthly precipitation of 373mm (Bangladesh Meteorological Department, 2022). The city is a hub for business, finance, healthcare, education, media, and professional services. Dhaka is expanding fast because of its geographical location, political shifts, economic opportunities, and cultural significance (Roy, 2009; Sowgat & Roy, 2022). Dhaka is the ninth largest city in the world, with a 305 sq. km area and over 18.6 million population (Demographia, 2022). In addition, Dhaka has the highest in-migration rate (Alam & Mamun, 2022), and this city alone pulls 42% of all in-migrants in Bangladesh (UNFPA, 2016). Therefore, it is highly likely that Dhaka is also a popular shelter destination for climate migrants with a desire to improve their livelihoods.

Dhaka is a part of the Ganges-Brahmaputra-Meghna (GBM) delta basin (Dasgupta et al., 2015). Five rivers and a system of canals surround Dhaka, including Buriganga in the southwest, the Tongi Khal in the north, the Balu and Shitalakhya rivers in the east, and the Turag River in the west (Hossain, 2008; Roy et al., 2021). This river system constrains the structural physical expansion of the city (Alam, 2018), making it one of the most densely populated cities in the world. Due to this high population density, increased migration, poor infrastructure, limited capacity for adaptation, and skewed distribution of land and service provisions, Dhaka has emerged as one of Bangladesh's most vulnerable and inequitable cities (Ahmed et al., 2018; Shahid et al., 2016). Over the past 40 years, the city has faced significant floods, frequent waterlogging, and increased water pollution from household and industrial waste (Hasan et al., 2019; Liu et al., 2022; Subrina & Chowdhury, 2018; World Bank, 2021). Future conditions are expected to get closer to what would be currently termed a state of a permanent heat wave, which puts Dhaka residents at some of the highest environmental risks in the world (World Bank, 2021). Furthermore, the inadequacies of Dhaka's urban drainage systems and their vulnerability to increased precipitation and flooding are anticipated to raise the risk of disease outbreaks (e.g., vector, air, and water-borne diseases) due to the pressures of climate change (Nahian, 2023; World Bank 2021).

3.2.2 Conceptual framework for vulnerability assessment

This study applies two conceptual frameworks to build the assessment of climate migrant vulnerability. First, to distinguish climate migrants from the rest of the sample population, we investigate the underlying reasons for migration using the conceptual framework (Figure 4 in Chapter 2) developed in Chapter 2. This allows us to identify climate change-driven migrants from other non-climatic-driven migrants and long-term residents. Second, we applied the IPCC vulnerability assessment framework to the individual household level, following existing empirical research conventions (e.g., Hahn et al., 2009, Huong et al., 2019 Poudel et al., 2020). According to the IPCC,

vulnerability is presented as Vulnerability = $\boldsymbol{f}$(Exposure, Sensitivity, Adaptive capacity). Thus, the vulnerability assessment considers the exposure and sensitivity of the local population to climate change and their capacity for adaptation (Füssel, 2007). The growing population in Dhaka makes it more prone to expensive and destructive flooding and waterlogging due to the rivers surrounding it, runoff from rainfall that exceeds the capacity of the drains, and heat stress (Alam & Rabbani, 2007; Mortoja & Yigitcanlar, 2020). Therefore, in this analysis, we consider the socio-economic vulnerability of the migrants and long-term residents in the study area together with their biophysical environmental vulnerability. Part of this vulnerability is exogenous (given) and possibly related to overarching system-level exposure, while another part is endogenous (controllable) and can be influenced by individual households, for example, by taking protective measures (based on adaptive capacity) to reduce individual exposure and sensitivity.

Quantitative measurements of vulnerability generally use index-based assessments (Hahn et al., 2009; Notenbaert et al., 2013; Spielman et al., 2020). This study creates a new Composite Vulnerability Index (CVI) based on indicators that account for exposure, sensitivity, and adaptive capability, the three dimensions underlying vulnerability according to the IPCC definition. Different variables related to the social and environmental conditions of migrants and long-term residents in the study area are used to characterize these dimensions. These variables were identified and analyzed using survey and secondary data. The indicators are identified and created based on a combination of external data sources related to “exogenous” climate and other weather-related variables, in particular some of the “exposure” indicators, while the “sensitivity” and “adaptive capacity” indicators refer more to “endogenous” variables employing survey data from individual households. Figure (6) presents the relationship between the dimensions and the indicators utilized in the conceptual framework of the vulnerability assessment. This study further employs principal component analysis (PCA) to construct a composite vulnerability index (CVI). As mentioned, the vulnerability indicators are created for and compared among three samples: climate migrants, other migrants, and long-term residents. This comparison thus provides insight into climate migrants’ post-migration vulnerability at their destination.

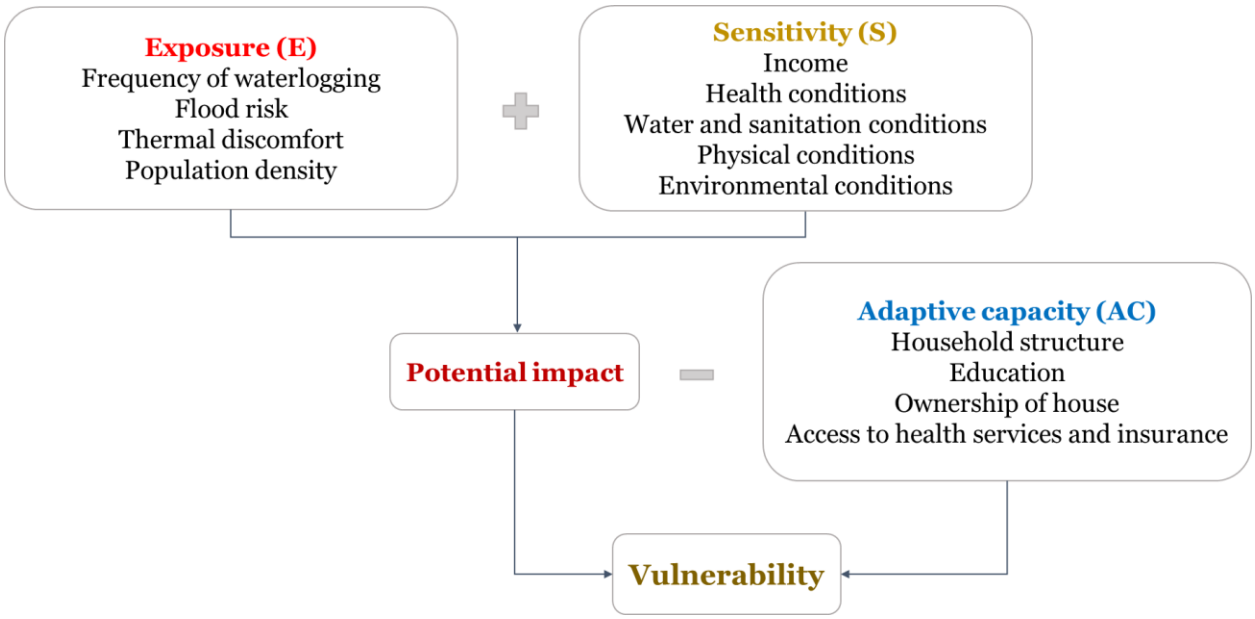


Figure 6: Conceptual framework presenting the relationships between different dimensions for vulnerability assessment in this study

3.2.3 Data collection

A city-wide survey targeting two thousand households was conducted to capture the diverse characteristics of long-term residents and all types of migrants, identify climate migrants, and assess and compare the vulnerability among the three main samples: long-term residents, climate migrants, and other migrants. Figure 7 shows the area features and distribution of surveyed households across different parts of Dhaka.

The empirical data collection took place from April to October 2019 as part of a research project conducted by a group of researchers at the University of Waterloo and funded by the non-governmental organization Water and Sanitation of the Urban Poor (WSUP), focusing on water pollution and water security in Dhaka City. The primary data for this study were collected through questionnaire surveys of 2,000 households in different parts of Dhaka city. One of the purposes of the survey was also to gather information regarding socio-economic vulnerability, migration patterns, and pre-migration and post-migration conditions of urban migrants. Questionnaire surveys and quantitative information from the interviews contributed to (a) distinguishing individuals for whom environmental or climatic factors were the primary driver of migration (i.e., identifying the nature of and reasons for migration); (b) generating individual respondent and their household socio-demographic background information, including age, sex, education, occupation, health, number of family members, and number of earning members in a household; and (c) analysis of the vulnerability of climate migrants in relation to a number of key social, economic, physical, and environmental parameters. The survey also generated data regarding perceptions of climate migrants and other migrants of their pre-migration and post-migration

conditions, including livelihood and water security, social status, health, and environmental conditions.

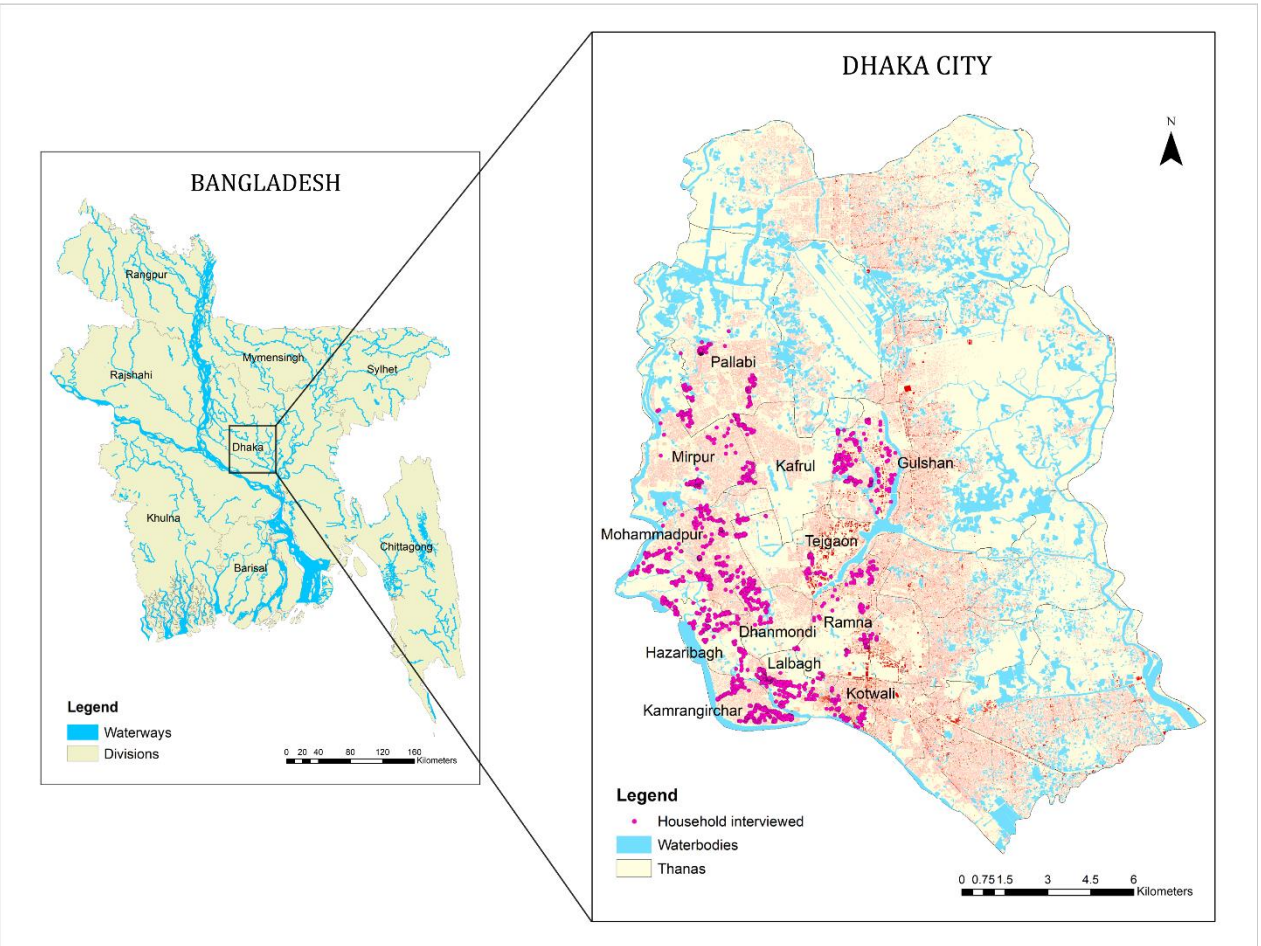


Figure 7: Location of Dhaka city (study area) in Bangladesh and the distribution of the 2,000 surveyed households across the city

The questionnaire employed during the survey was divided into four sections and contained 60 questions in total. The questions in the first section asked about the respondents' socio-demographic background information, including age, sex, religion, education, occupation, physical characteristics of the house where they lived, health conditions, and income. Questions about the respondents' original background status, including whether they migrated from somewhere else to Dhaka city, were also included in this part. More follow-up questions about the respondents' previous and present livelihood and experiences were asked if they identified themselves as migrants. Additionally, respondents were asked about their origins and the reasons behind their migration. The second section covered questions regarding household water supply and sanitation characteristics. The third section addressed household perceptions and concerns related to outdoor water quality and their family's health regarding this water quality. Lastly, the fourth section contained a discrete choice experiment, where respondents were asked for their preferences for different policy scenarios to improve their water security situation in the future, the results of which are reported in another paper (Brouwer et al., 2023).

The questionnaire was initially developed in English and then translated into Bengali for three rounds of pre-testing on 60 randomly selected city residents in April 2019. A group of 8 local interviewers (3 females and 5 males), the majority of whom were medical students from local universities, administered the questionnaires face-to-face. The interviewers were trained, explaining to them the main objective of the survey and the meaning of every single question in the questionnaire, and how to conduct the door-to-door interviews. Half of the interviewers participated in all three pre-tests and were, therefore, very familiar with the questions. In addition, internal quality control practices were ensured during the training and pre-testing. For example, all interviewers were instructed not to deviate from the carefully formulated and tested survey questions to ensure respondents interpreted and answered each question in the same way. Furthermore, data quality and completeness were regularly monitored during the entire data collection and data entry period. Ethics approval for the survey was obtained through the University of Waterloo's Ethics Committee (approval number ORE # 40508)[8].

We employed a stratified sampling technique for data collection. We included twelve out of the twenty-one administrative units called *thanas* for this study. We selected these *thanas* based on (a) population density (BBS, 2013); (b) the location of slums (BBS, 2015); (c) income groups (Labib et al., 2013); (d) the *thanas*' geographic location in relation to waterbodies; (e) Dhaka Water Supply and Sewerage Authority (DWASA) connected and unconnected areas (DWASA, 2018); and (f) inside and outside designated industrial clusters (e.g., the Mirpur and Tejgaon industrial areas). A household served as the sampling unit in this study. Here the household is defined as a person or a group of people who share a residence, domestic resources, and expenditures, such as food supply (Bisung & Elliott, 2018).

Based on the sampling criteria above, a target number of interviews was set for each *thana* to ensure geographical representativeness regarding population density. Households were selected randomly in each *thana* until the required quota for each *thana* was achieved. The final (tested) household survey took approximately three months, from early July to early October 2019. Respondents were considered eligible for interviewing if they were 18 years or older and knowledgeable about decision-making in their household. We consider the household head as one of the family members acknowledged as the head of the unit by him or herself, the other family members, or if living independently. Generally, the head of the household or his or her spouse was targeted for the interview. If respondents indicated they were not the head of the household, they were asked to specify their relationship with the household head. In addition, we sought out an equal share of male and female respondents. The response rate was 75%, meaning that 658 people refused to participate in the survey

[8] Conform ethical guidelines outlined in the Tri-Council Policy Statement on Ethical Conduct for Human Research (TCPS 2), the research approval was taken from the Office of Research Ethics at the University of Waterloo in May 2019. Respondents' consent was obtained before the questionnaire survey, and their identities were protected. Before setting up the questionnaire, all respondents were made aware of the main aim of the investigation. Furthermore, confidentiality and anonymity were guaranteed.

(2658 people were asked to participate, of which 2000 agreed). The primary reason for refusal to participate was lack of time, not feeling comfortable speaking to a male or female interviewer, or interviewers not being allowed access to a building compound by the security guard.

We also collected additional data from secondary sources. The population density for each administrative boundary was collected from the Bangladesh Bureau of Statistics – the district statistics for Dhaka 2011 (BBS, 2013). Due to the absence of published updated census data, we had to rely on older census data. In addition, we also collected flood maps (e.g., Ahmed et al., 2018), including a GIS-based shapefile for the year 2016 from the World Bank (2020) and a human thermal discomfort index (DI) from the published scientific literature (e.g., Imran et al., 2021). We identified each household's location using a Global Positioning System (GPS) that was subsequently entered into ArcGIS (version 10.8.1).

3.2.4 Data analysis

We used descriptive analysis to characterize respondents. To answer our first research question of how vulnerable climate migrants are in their destination, we developed a composite vulnerability index (CVI) to measure and compare vulnerability among climate migrants, long-term residents, and other migrants after we analyzed the underlying reasons and motivations to migrate and allocated respondents to one of these three categories. To answer our second research question, whether climate migrants felt better off after migration, we measured the migrant's perception of pre-migration and post-migration situations and compared them between climate migrants and other migrant groups.

3.2.4.1 Calculation of composite vulnerability index

As mentioned, the IPCC vulnerability framework was used to construct a vulnerability index and compare climate migrants, other types of migrants, and long-term residents. The main advantage of developing an index is that it quantifies something that cannot be measured directly (Spielman et al., 2020; Tate, 2012). We used the IPCC's three core components: exposure, sensitivity, and adaptive capacity at the individual respondent level, and further categorized these into six groups of variables, covering socio-demographic, economic, health, water and sanitation, physical, and environmental aspects. In some cases, we employed neighborhood data to characterize individual respondents' risk exposure conditions. Each group includes multiple variables that were converted into indicators related to a specific dimension or component to estimate vulnerability. Indicators are vital characteristics or specific elements of one dimension that measure and assess the condition of a system (Spielman et al., 2020). These often concentrate on small, conceivable, perceptible, and expressive system components that can help individuals understand a more comprehensive picture. As suggested by Birkmann et al. (2022) and Plummer et al. (2012), to conduct vulnerability assessment in a meaningful way, vulnerability assessment tools and indicators need to be constructed and tailored to the specific

context in which they are used. This study developed indicators conforming to the SMART (specific, measurable, attainable, relevant, and time-bound) criteria based on data availability for Dhaka City. Examples of the SMART criteria used to generate robust indicators can be found across the literature (e.g., Klopp & Petretta, 2017; Ngugi et al., 2021; Perez-Escamilla et al., 2017).

Socio-demographic variables refer to the age, sex of the household head, population density, number of household members, and education. Economic variables include income, the number of earning members, and ownership of assets (e.g., property like a house). Health variables are associated with the members of a household's health status, such as households with members with health issues, households seeking treatment during illness, households with health insurance, and distance from a respondent's home to the nearest healthcare services. Water and sanitation variables are related to the households' water and sanitation situations, such as the supply of piped water, drinking water safety, toilet sharing among multiple families, and solid waste management. Physical variables include the location and type of housing, electricity connection, and surrounding stormwater drainage facilities. Lastly, environmental variables refer to the environmental conditions, such as the distance to a nearby waterbody, concerns about the quality of these nearby waterbodies, and whether respondents ever consider moving due to the presence of these water bodies.

We considered these various variables to determine how exposed different population groups are to urban environmental issues, such as flood risk, waterlogging, water pollution, and human thermal discomfort. These are indicated as exposure (E). Additionally, the household's sensitivity and adaptive capacity were considered. Principal Component Analysis (PCA) was applied to these variables to assess and identify the dimensions underlying individual household vulnerability. In total, 29 variables were used in this assessment. Table 8 includes the complete list of variables that are used in the PCA to develop a composite vulnerability index.

Table 8: Selected variables for vulnerability assessment

Variables group	Variables and functional relationship	Unit of Measure	IPCC dimension	Explanatory notes	Survey question/ data collection	References
Socio-demographic	1. Age dependency ratio (+)	Ratio	AC	Children and the elderly populations are typically regarded as vulnerable. We calculated age dependency ratio per household as follows: ratio of the population <15 and >65 years of age to the population between 15 and 65 years of age in a household (This was counted as the working age population between 15 and 65)	Respondents were asked about their and every member of their household's age, sex, health and income earning status	Alam et al. (2017); Birkmann et al. (2022); Hahn et al. (2009); Nguyen et al. (2021); Ullah et al. (2021)
	2. Number of household members (-)	Count	AC	Number of members in each household. It is assumed that a higher number of household members increases the household's support system, including skills and income, and hence decrease the household's vulnerability	How many people live in the family?	Brouwer et al. (2007); Cutter et al. (2012); Kaźmierczak & Cavan (2011)
	3. Household head gender (-)	Dummy (0,1)	AC	A common perception is that women are among others more vulnerable than men since they usually bear more responsibility for the family (e.g., caregiving). Therefore, a female-headed household is assumed to be more vulnerable. Higher educated women are, however, more aware of and knowledgeable about the risks they may face, which lessens their vulnerability to risks or emergencies. We coded households (HH) as follows: Male-headed HH = 0; Female-headed HH = 1	Are you the head of the household? Households where females were self-identified or identified by family as head of the household	Cutter et al. (2012); Hahn et al. (2009); Maharjan et al. (2017).
	4. Respondent's education (-)	Score	AC	Households with lower educated or illiterate members are assumed to be more vulnerable than households with higher educated members. Access to information and communication is limited by low literacy.	What is your education level?	Brouwer et al. (2007); Huang et al. (2012); Mavhura et al. (2017); Miceli et al. (2008)

Variables group	Variables and functional relationship	Unit of Measure	IPCC dimension	Explanatory notes	Survey question/ data collection	References
				We coded respondents' education level as follows: Cannot read and write = 1; can read and write but no formal education = 2; High school = 3; SSC = 4; HSC or diploma = 5; Graduate = 6; Post-graduate or Medical/engineering = 7		
	5. Households where school-aged children do not attend school (+)	Count	AC	Households where respondents reported a child or children between 6 and 16 years that do not go to school are assumed to be more vulnerable	Does your child under 16 years attend school?	Authors
	6. Average population density (+)	Count per square km	E	Rapid population growth coupled with a lack of quality standards of living increases vulnerability. This measure represents the average population density of each thana where households live. The higher the population density, the higher the exposure to environmental and health risks	Data obtained from Bangladesh Bureau of Statistics - District Statistics 2011 Dhaka (BBS, 2013)	Chang et al. (2021); Donner & Rodríguez (2008); Zuhra et al. (2019)
Economic	7. Number of HH members earning income (-)	Count	AC	Households with more than one income earning member enable them higher adaptive capacity.	How many people are income earning members of the household?	Jamshed et al. (2019); Nhuan et al. (2016); Rana et al. (2018)

Variables group	Variables and functional relationship	Unit of Measure	IPCC dimension	Explanatory notes	Survey question/ data collection	References
	8. Monthly HH income (-)	Score	S	Higher degrees of vulnerability are correlated with higher levels of poverty or lower income. We coded the income of HH as follows: Monthly income ≤ BDT 5000 = 1; 5001-10000 = 2; 10001-15000 = 3; 15001-25000 =4; 25001-50000 = 5; 50001-75000 = 6; 75001-100000 =7; 100001-150000 =8; 150,001-200000 = 9; 200001-250000 = 10; >2500001 = 11. A higher score hence represents a higher ability to adapt and protect, reducing a household's vulnerability.	What is the total monthly income of the whole household?	Brouwer et al. (2007); Twinomuhangi et al. (2021)
	9. Households who do not own the house they live in (+)	Dummy (0,1)	AC	Households currently living in a home they do not own are expected to invest less in protective measures and are hence assumed to be less capable to address future climate risks. Other studies (e.g., Brouwer et al., 2007) argued similarly that land ownership reduces vulnerability. We coded house ownership as follows: own the house = 0; do not own the house = 1	Is the house where you live owned by you, rented, or a rent-free governmental settlement?	Braun & Aßheuer (2011); Cutter et al. (2012); Twinomuhangi et al. (2021)
Health	10. Cost of illness of HH (+)	Count (BDT) per month	S	If the current cost of illness for a household is high, then they are expected to be more sensitive to environmental risks due to climate change. The higher the costs of illness, the higher their sensitivity.	What is the total monthly cost of illness for the entire family?	Authors
	11. Households with one or more family members with health issues (+)	Count	S	Households reporting at least one or more member suffering from a health issue are assumed to be more sensitive to environmental risks. The more members with health issues, the more sensitive a household is.	Is anybody in your family suffering from a health issue(s)?	Ahsan & Warner (2014); Sorg et al. (2018)

Variables group	Variables and functional relationship	Unit of Measure	IPCC dimension	Explanatory notes	Survey question/ data collection	References
	12. Households that do not have health insurance (+)	Dummy (0,1)	AC	Uninsured households are expected to be more vulnerable if unexpected and costly health issues occur. We coded HH as follows: Have health insurance = 0, do not have health insurance = 1	Do you and your family members have health insurance?	Authors
	13. Distance to the nearest health clinic or pharmacy (+)	Meter	AC	Self-reported distance from the house to the nearest health center. The further away the pharmacy or health center, the more vulnerable the household.	How far is the nearest health clinic or pharmacy to your home?	Dong et al. (2020); Sahana et al. (2021)
Water and sanitation	14. Households that do not have piped water supply connection (+)	Score	S	Households not receiving piped water may have to make more effort to get water for household chores and drinking. We coded the water supply connection as follows: Have piped water connection = 0; have shared connection = 1; do not have piped water connection = 1 (hence shared connections and not having piped water are considered more sensitive)	Does your house have piped water supply?	Nuwematsiko et al. (2022); Richmond et al. (2018)
	15. Households with unsafe drinking water (+)	Dummy (0,1)	S	Access to safe drinking water is an important determinant of public health. Households reporting not receiving safe water for drinking are more prone to getting ill. We coded the response as follows: water safe = 0; water is not safe = 1	Do you think the water you use is safe for drinking?	Ahsan & Warner (2014); Bisung & Elliott (2014); Kangmennaang et al. (2020); Panthi et al. (2016); Plummer et al. (2012); Zhou et al. (2015)
	16. Households with access to a fragile sanitary latrine (+)	Score	S	Broken sanitation systems can contaminate surface water, which is frequently used for bathing and other household purposes. Households using a latrine type such as kancha are considered more sensitive to environmental risks. We coded latrine type as follows: Flush toilet connected	What type of latrine do you have?	Brouwer et al. (2007); Richmond et al. (2018); Trimmer et al. (2020)

Variables group	Variables and functional relationship	Unit of Measure	IPCC dimension	Explanatory notes	Survey question/ data collection	References
				to sewer/flush toilet connected to septic tank = 1; pacca latrine (water seal)/pacca latrine (pit) = 2; permanent kacha latrine/temporary kacha latrine/hanging/open field/river =3 (higher scores indicate higher sensitivity)		
	17. Households having to share a toilet with multiple families (+)	Dummy (0,1)	S	Households who need to share their toilet with multiple families are considered more sensitive to environmental risks. We coded toilet sharing as follows: Do not share toilet = 0; share toilet = 1	Is the toilet you use shared by multiple families?	Kangmennaang & Elliott (2021); Trimmer et al. (2020)
	18. Households without access to managed solid waste disposal (+)	Dummy (0,1)	S	Households that reported they do not have a managed waste disposal system. We coded this as follows: Use managed waste disposal = 0; do not use managed waste disposal = 1	What is your household's waste disposal method?	Bhuiyan (2010); Kita (2017); Mishra et al. (2020); Singh (2019); Williams et al. (2019)
Physical	19. Households living in vulnerable house structures (+)	Score	S	A house may be in a flood-risk area, yet improving its structure might lessen its vulnerability. House type as Jhupri, Tong, Tin/ Kachan[9] are considered more vulnerable. We coded house types as follows: Flat/apartment = 1; pacca = 2; semi-pacca = 3; jhupri/tong/tin/kachan = 4 (a higher score means a higher sensitivity to environmental risks)	What is the type of your house?	Braun & Aßheuer (2011); Gain et al. (2015); Zakour & Swager (2018)
	20. Households living in a slum (+)	Dummy (0,1)	S	Households living in crowded slums are more vulnerable. We coded HH living in slums as follows: not slum = 0; slum = 1	The interviewers noted in the questionnaire from their direct observations that the	Braun & Aßheuer (2011); Nuwematsiko et al. (2022);

[9] House types are considered fragile if roof materials are straw or tin; walls are constructed of lightwood, tin, bamboo, or plastic.

Variables group	Variables and functional relationship	Unit of Measure	IPCC dimension	Explanatory notes	Survey question/ data collection	References
					responses to this question were sensitive.	Twinomuhangi et al. (2021)
	21. Number of rooms in the house (-)	Count	S	Number of rooms in the house represents whether people have sufficient living area. If households have only one room, then they are more sensitive to risks	How many rooms are there in your house?	Twinomuhangi et al. (2021)
	22. Households without access to electricity (+)	Dummy (0,1)	AC	Households that indicated they do not have access to electricity. We coded electricity connection as follows: yes = 0, no = 1	Do you have access to electricity?	Brouwer et al. (2007); Kim & Gim (2020); Kita (2017)
	23. Households that do not have a stormwater drainage network (+)	Dummy (0,1)	S	Households do not have any man-made or natural drainage system (e.g., storm sewer lines, pipe drain, kacha drain, khal) from stormwater discharge are considered more vulnerable. We coded drainage network connection as follows: yes = 0; no = 1	Obtained from (DWASA, 2019)	Williams et al. (2019)
Environmental and climate change	24. Households that face frequent waterlogging (+)	Frequency score	E	Households who reported facing waterlogging. We coded waterlogging frequency as follows: never = 0; sometimes = 1; regularly/often = 3; all the time there is heavy rainfall = 4. A higher score hence indicates a higher degree of exposure.	How frequently do you face flooding/waterlogging in your home?	Authors
	25. Distance to nearby waterbody (-)	Meter	S	Distance from the house where the respondent lives to the nearest waterbody	How far is the nearest waterbody from your house?	Brouwer et al. (2007); Dong et al. (2020); Islam et al. (2013)
	26. Households who have concerns about the waterbody closest to their home (+)	Dummy (0,1)	S	Respondents who reported concerns about the waterbody. We coded concerns about water as follows: No concern = 0; have concern = 1	Do you have any concerns about this open water?	Authors

Variables group	Variables and functional relationship	Unit of Measure	IPCC dimension	Explanatory notes	Survey question/ data collection	References
	27. Households who considered moving due to waterbodies (+)	Score	S	Households reported considering moving due to waterbodies. We coded considering moving as follows: no = 0; yes = 1	Have you ever considered moving because of this open water?	Authors
	28. Average level of exposure to flood risk of households	Score	E	Average level of flood risk exposure in the location (city ward) where each household lives. We coded the flood risk level as follows: Flood free = 0; Low risk = 1; Medium risk = 2; High risk = 3. Higher scores represent higher risk)	Flood risk maps obtained from Ahmed et al. (2018); Dewan (2013); World Bank (2020)	Brouwer et al. (2007); Dong et al. (2020); Islam et al. (2013)
	29. Average human thermal discomfort index (DI)	°C	E	Average discomfort index in the location (city ward) where households live. We coded the discomfort index as follows: <21°C = 1; 21-24°C = 2; 24-27°C = 3; 27-29°C = 4; 29-32°C = 5; >32°C = 6. Higher scores represent higher discomfort.	Obtained from Imran et al. (2021)	Authors

Note: E = Exposure; S = Sensitivity; AC = Adaptive Capacity[10]

(+) = Positive functional relationship. A higher number indicates increased vulnerability; (-) = Negative functional relationship. A higher number indicates decreased vulnerability.

[10] *Exposure* refers to the extent to which a system or population is exposed to the impacts of climate change, such as exposure to flooding, storm surges. *Sensitivity* refers to the degree to which a system, population, community and activities are affected by the impacts of climate change, such as changes in economic activities. *Adaptive capacity* refers to the ability of a system or population to cope with and adapt to the impacts of climate change, such as using technology or changes in land use.

3.2.4.1.1 Principal component analysis (PCA)

There are several ways of calculating a vulnerability index. Incorporating a variety of indicators of interest is expected to lead to more accurate results (e.g., Balica et al., 2012). Although it may be tempting to build an index using all the available data, variables may be correlated (McLaughlin & Cooper, 2010). A commonly used method to calculate a composite vulnerability index is a balanced or equal-weighted average approach based on several selected variables. This approach assumes that all variables contribute equally to the vulnerability index to make the interpretation process simpler and easier to understand. However, giving weights to individual components can be challenging since doing so could cause bias in the results when determining how important each element is to the overall index. Moreover, in this approach, researcher's selection of variables has a risk of being arbitrary. PCA is data-driven and relies on the data to identify the main variables underlying the index.

Furthermore, equal weights may undermine that some factors may have a bigger influence on the index than others, while PCA identifies the weights based on their relative contributions (loads) in explaining the variation. One limitation of PCA is that it operates under the assumption that a linear relationship exists between variables, which may not always be the case. However, when applied correctly, PCA is one of the most powerful tools in the data analysis toolkit (Levada, 2020; Lever et al., 2017). Furthermore, considering the use of multi-dimensional data, it is crucial to explicitly articulate the methodological approach and robustness of constructing the index. Therefore, in this study, we choose to perform PCA as the underlying procedure for assigning weights to each variable and constructing a CVI. Using these weighted variables, we calculate CVIs based on IPCC's three dimensions of vulnerability, as identified in Figure 6 and the selected variables in Table 8. In this section, we first discuss the PCA, and in the next section, we discuss how we calculated the composite index using IPCC dimensions.

PCA is a statistical dimensionality reduction technique that retains trends and patterns while reducing the complexity of high-dimensional data. The technique is used to identify patterns in the data, such as correlations or linear combinations of variables, which can then be used to explain the variability in the data. The goal is to find a new set of uncorrelated variables, called principal components (PCs), which can explain the maximum variability in the dataset (Linting et al., 2007; Ringnér, 2008; Salem & Hussein, 2019). PCA determines the significant contributing components to the dimensions by applying so-called "eigenvalues" (Kaiser, 1960). Eigenvalues are scalar values associated with a matrix and are used to represent the set of linear equations represented by the matrix (Hernandez et al., 2005; Kherif & Latypova, 2020). In doing so, PCA simplifies a dataset by converting the original variables into a new set of variables that are: 1) uncorrelated with one another, 2) linear combinations of the original variables, and 3) arranged based on how the new variables can explain much variance in the initial variables. This way, PCA helps interpret and collect crucial data in the dataset by exposing hidden correlations between the indicators.

In our study, the PCA involved the following steps (Salem & Hussein, 2019). First, given that PCA is sensitive to inconsistencies in variable unit measurements (Kresta et al., 1991), all variables (X_1, X_2,…) were required to be standardized. Standardization is the process of bringing measures with various units and scales to the same level so they can be compared with one another. Standardization can be done in several ways, including through ranking, Z-score, and re-scaling. In this study, we employed re-scaling using equations (1) and (2). When vulnerability increases along with a variable's value, the following equation (1) is used to determine the standardized value:

$$X_{sd} = \frac{X_o - X_{min}}{X_{max} - X_{min}} \quad (1)$$

where X_{sd} is the standardized value, X_o is the original value of variable X, X_{max} is the maximum value for variable X, and X_{min} is the minimum value.

However, if a variable's value increases and vulnerability decreases, the functional relationship is decreased, and the following equation (2) is used to determine the standardized value:

$$X_{sd} = \frac{X_{max} - X_o}{X_{max} - X_{min}} \quad (2)$$

For example, the values for the variable "distance to the nearest health service" ranged from 1 to 5,000 meters in the different groups we surveyed. We used these maximum and minimum values to convert these values into a standardized index so that it could be integrated into the composite vulnerability index. In this case, we assumed that the increased average distance from the household to the health service increases vulnerability. Therefore, we used equation (1). In contrast, for the variable "distance the household lives from the nearest waterbody," we assumed that an increase in distance from the household decreases vulnerability, so we used equation (2).

Second, we calculated the correlation matrix to determine the correlations among variables. Third, we determined the eigenvalues and the corresponding eigenvectors. Fourth, we removed components that hardly influenced the original dataset's variance. Lastly, we applied eigenvector matrices as factors in a linear combination of standardized variables to determine the compositions of the principal components. We used the statistical software SPSS version 28.0 (IBM Corp., 2021) to perform the PCA.

There exists no theoretical foundation or strict rules for calculating the weights to construct a composite index assessment based on PCA (Cutter & Emrich, 2017). In this study, we used the indicator with the highest loading for each component to construct the index, and component scores were weighted together.

The weights for each principal component and each variable in the CVI were calculated stepwise using equations (3), (4), and (5)

$$W_{pci} = \frac{V_{pci}}{\sum V_{pc}} \qquad \forall\ i \in I \quad (3)$$

$$W_{varij} = \frac{L_{varij}}{\sum L_{var}} \qquad \forall\ j \in J \quad (4)$$

$$Index_{pci} = \sum (W_{varj} * var_j) \qquad (5)$$

$$CVI = \frac{\sum_{i=1}^{n} Index_{pci} * W_{pci}}{\sum_{i=1}^{n} W_{pci}} \qquad (6)$$

where W_{pci} is the weight of the i^{th} principal component (pc), V_{pci} is the share of the variance explained by principal component i belonging to the set of principal components I with an eigenvalue larger than one and $\sum V_{pc}$ is the sum of the explained variance of all identified principal components with an eigenvalue larger than one. W_{varij} is the weight of the j^{th} variable (var) in principal component i, L_{varij} is the loading of the j^{th} variable belonging to the set of variables J making up component i, and $\sum L_{var}$ is the sum of loadings underlying component i. $Index_{pci}$ is the indexed value of i^{th} principal component, and CVI is the composite vulnerability index.

3.2.4.1.2 CVI calculation - IPCC approach

Based on the IPCC approach, we identify relevant variables for the following three main dimensions, i.e., exposure, sensitivity, and adaptive capacity. The vulnerability index is then defined using a linear combination of the mentioned dimensions, as shown in equation (8).

$$CVI_{IPCC} = (E + S) - (-AC) \qquad (8)$$

where CVI_{IPCC} is the composite vulnerability index as defined by the IPCC, E represents exposure, S sensitivity, and AC adaptive capacity. These three dimensions are calculated following equation (9) which can be named as IPCC-defined contributing factor CF_d.

$$CF_d = \frac{\sum_{j}^{n} W_{varj} * varj}{\sum_{j}^{n} W_{varj}} \qquad (9)$$

The calculated values of CVIs range from 0 to 1, with 0 denoting the least vulnerable households and 1 denoting the most vulnerable households.

3.2.4.1.3 PCA test statistics

Various methods have been developed to determine how many principal components should be retained. Before retaining the principal components, we performed several statistical tests to assess the suitability of performing PCA on the collected survey and secondary data. This includes testing for internal consistency of the data using Cronbach's alpha (α) coefficient, which is a measure of the reliability of a test or a scale indicating how well each test item accurately measures the same underlying construct or concept (Cho & Kim, 2015; Taber, 2018). Depending on the

test item numbers, i.e., variables, their correlation, and dimensionality, the α coefficient ranges from 0 to 1, with lower values indicating weak internal consistency or heterogeneous constructs, while high values (> 0.90) imply redundancy of the study variables (Tavakol & Dennick, 2011). There is some debate among statisticians on the appropriate value for Cronbach's α. However, in social science research, conventionally, a scale is deemed "appropriate" if its α is between 0.60 and 0.80 (Taber, 2018; Tavakol & Dennick, 2011; Vaske et al., 2017). Our analysis revealed that the α coefficient for our 29 variables is 0.703, indicating that the variables have a relatively high level of internal consistency and potentially explain the similar underlying construct, in our case, the composite vulnerability index, allowing us to move forward with PCA.

The Kaiser-Meyer-Olkin (KMO) test was then applied for sample adequacy to detect multicollinearity issues (Kaiser, 1974; Shrestha, 2021). The KMO statistic is calculated as the ratio of the explained variance of the variables to the total variance. The overall KMO test statistic also ranges from 0 to 1, with a higher value indicating that the variables in the dataset are similar and that there is a more substantial justification for conducting a PCA. The KMO values have traditionally been described and labelled as falling into the following six categories (Cerny & Kaiser, 1977): a value of 0.9 to 1.00 is deemed to be "marvelous", 0.80 to 0.89 is "meritorious", 0.70 to 0.79 is "middling", 0.60 to 0.69 is "mediocre", 0.50 to 0.59 is "miserable", and lastly 0.00 to 0.49 is considered "unacceptable". KMO values greater than the cut-off point of 0.50 are often regarded as passing the test (Kaiser, 1974). However, it is also suggested that to proceed with PCA, the KMO overall value should be at least 0.60, and KMO values greater than 0.80 can be considered good, indicating the reliability of the multi-dimensional components and PCA results (IBM, 2021a; Kaiser & Rice,1974). The finding of our KMO test revealed an overall score of 0.833, suggesting the results of the PCA would be reliable as input for the CVI.

Finally, we employed Bartlett's Test of Sphericity to test the hypothesis that the correlation matrix is an identity matrix, which means that there is no correlation between the variables (Bartlett, 1954). For PCA, Bartlett's test of Sphericity is recommended to have a significance level (*p*-value) of less than 0.05 (Bartlett, 1954). For our data, we found that Bartlett's test of Sphericity's *p*-value is smaller than 0.001, which is low enough to reject the null hypothesis of the correlation matrix being an identity matrix and that the strength of the association among the selected variables in this study is significant, which is required for the PCA to be acceptable. Overall, the statistical tests performed on the dataset indicate that PCA is suitable for developing the CVI. Table 9 summarizes the various test results for our dataset.

Table 9: Results for Cronbach's alpha coefficient, the Kaiser-Meyer-Olkintest and Bartlett's test of Sphericity

Name of measure or test		Estimated value	Acceptable value range
Cronbach's alpha (α)		0.703	0.60-0.80
Kaiser-Meyer-Olkin (KMO) measure of sample adequacy		0.833	>0.60
Bartlett's test of Sphericity	Approximate chi-square	2384.072	
	Degrees of freedom	406	$p<0.05$
	Significance (p)	$p<.001$	

3.2.4.2 Measuring migrants' perception of migration situations

The migrants' perception of their pre- and post-migration conditions was assessed by an itemized psychometric measurement scale addressing aspects associated with their socio-economic, health, water and sanitation, and environmental conditions. This included assessments regarding the perceived effect of migration on the respondents and their household members. Respondents who identified themselves as migrants were asked to indicate their level of agreement with 6 different statements using a five-point Likert scale, ranging from "strongly disagree" (-2) to "neither disagree nor agree" (0) to "strongly agree" (+2). In these statements, respondents were asked to compare their: (a) earning opportunities; (b) living conditions; (c) natural disaster exposure; (d) water and sanitation facilities; (e) health conditions; and (f) social status and network before and after migration in their place of origin and their current place of residence in Dhaka city. Responses with missing values for any one of the 6 statements were excluded from the analysis.

Comparative bivariate statistical analyses were performed using the non-parametric Mann-Whitney-U test between climate migrants and other migrants using their answers to the 6 statements on the Likert scale. The analyses considered all indicators with p-values smaller than 0.05 (or 5%) as statistically significant. Analyses were performed using the statistical software SPSS version 28.0 (IBM Corp., 2021).

3.3 Results

3.3.1 Sample characteristics

3.3.1.1 Identification of climate migrants

In this study, respondents and their households were considered migrants if they moved to their current residence in Dhaka city from a place outside Dhaka city at least three months before the survey took place. Furthermore, the migrants were considered climate migrants if they reported any climate-related (environmental) event(s) as one of the reasons driving their move. Of the 2,000 surveyed households,

we identified 563 respondents (28.2%) as long-term residents living in Dhaka since birth. Of the remaining households, 578 (28.9%) moved from another neighborhood inside Dhaka city to their current residence, and 859 (43.0%) migrated from outside Dhaka city to where they currently live for more than 3 months. Households who moved around inside Dhaka city were omitted from the further analysis here because they were neither considered migrants nor long-term residents, and we had no further information about their original place of residence before moving around in Dhaka city.

We then distinguished climate migrants from other types of migrants. Among the migrant households, 240 reported climate-related natural disasters (e.g., floods, cyclones) as the main reason for their migration, 21 respondents reported that they migrated for climate-related environmental reasons (e.g., water scarcity, crop failure), and 16 respondents reported both climate-related environmental and natural disasters as reasons for migration. For respondents who stated other migration reasons, after the follow-up question, if there were any climatic reasons behind their migration, 43 respondents identified environmental or natural disasters as one of the reasons for their migration. This yielded a total of 321 climate migrants (16.0% of the whole sample and 37.4% of all migrants from outside Dhaka city) and 538 other migrant households (26.9% of the whole sample and 62.6% of all migrants) for this study. These two groups of migrants were compared to the long-term residents (n = 563).

Migrants who moved to Dhaka for climate change-related reasons were asked to mention their place of origin and rank the most critical environmental reason as a migration driver (Figures 8 and 9). This provides more detailed insight into the migration reasons of this group of climate migrants and the specific environmental factors that influenced their migration decision. Looking at Figure 8, we can see that most climate migrants lived originally in southern Bangladesh, most notably in or around Barisal and Bhola districts. This can be explained by the fact that this part of the country often faces coastal cyclones and storm surges (Dullaart et al., 2021; Mitchell et al., 2022). However, some also migrated from districts in the northern part, such as Nilphamari, Rangpur, Dinajpur, Jamalpur, Mymensing, Netrokona, and Naogaon. Among the specific environmental reasons mentioned to drive the decision to migrate, riverbank erosion was mentioned most often (69.5%), followed by flooding (19.0%), crop failure (15.6%), and cyclones (10.0%). We find that respondents often mentioned multiple interconnected reasons. For example, some respondents who ranked riverbank erosion as their most important reason for migration also mentioned flooding, crop failure, cyclones, or storm surges as second and third reasons (Figure 9).

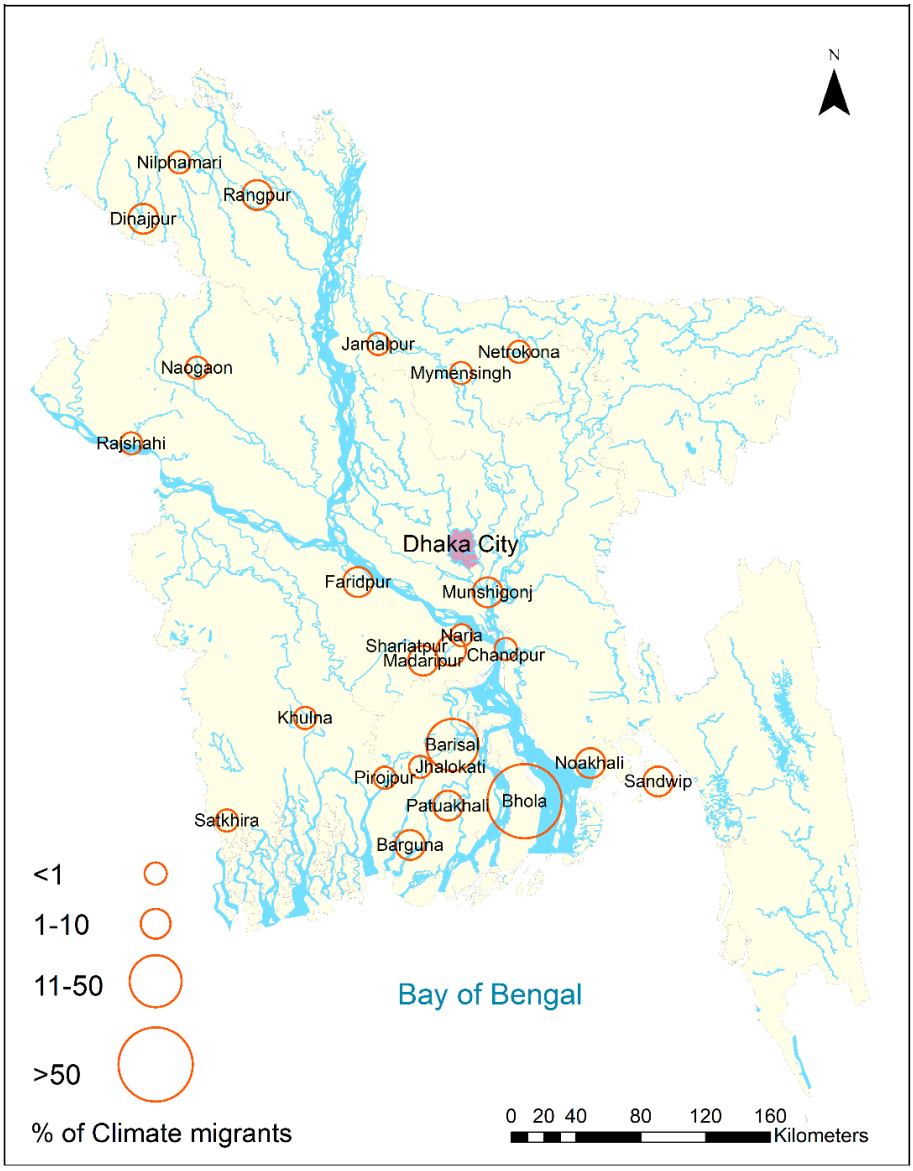


Figure 8: Climate migrants' place of origin

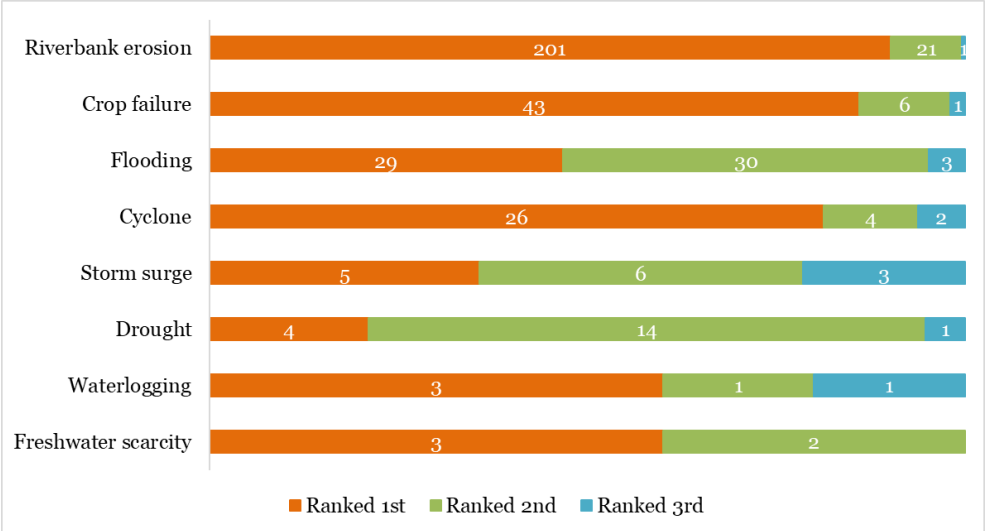
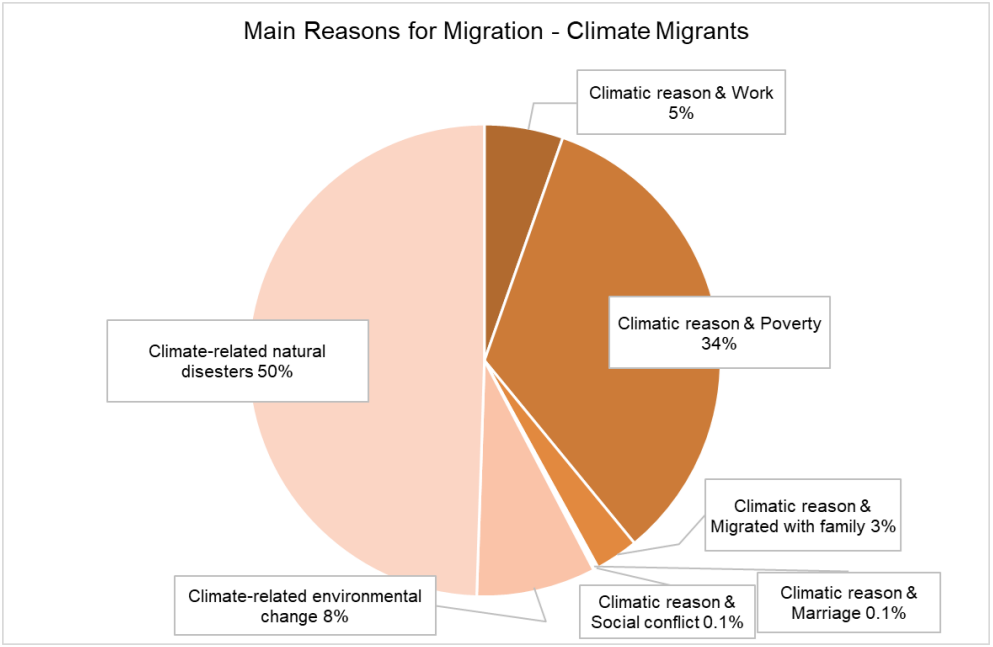


Figure 9: Ranking of most frequently mentioned drivers for climate migration



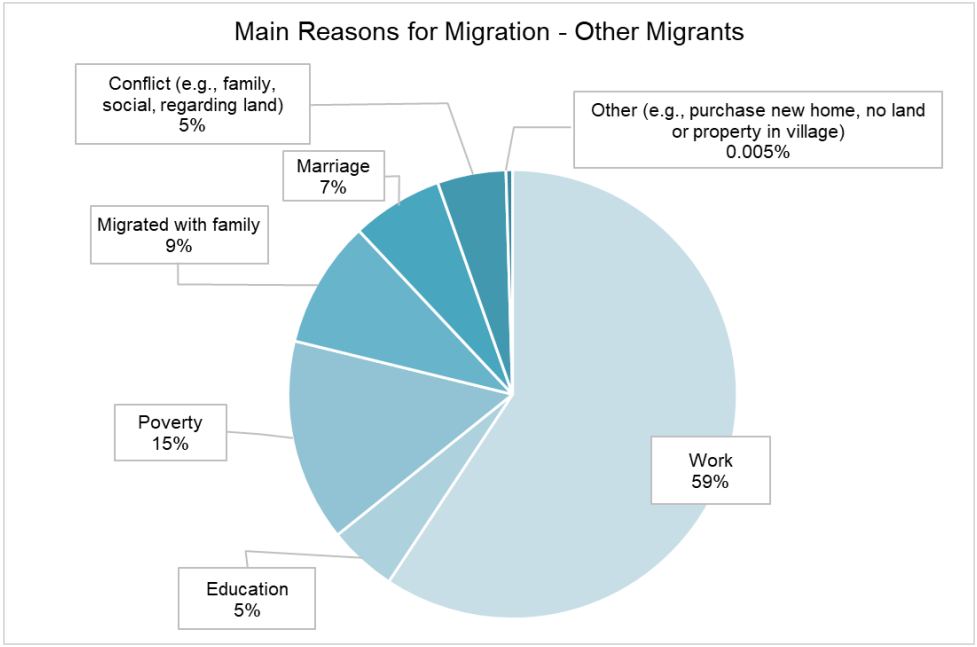


Figure 10: Reasons for migration

Figure 10 shows the most important factors mentioned during the interviews with climate and other migrants to Dhaka city. The pie diagram on the left shows the various reasons climate migrants listed. This includes the share of respondents who indicated that they migrated only for climate change-related reasons and those who mentioned both climate and other reasons. The pie diagram on the right shows the various non-climate related reasons for the other migrants.

Looking at the reasons for climate migration on the left side of Figure 10, we can see that a majority (49.5%) of the climate migrants indicated that natural disasters (e.g., flooding, cyclone) are the sole reason behind their migration decision, and 8.2% indicated that they migrated for environmental reasons (e.g., freshwater scarcity) and/or risks of natural resources. In addition to a climate-related reason, a substantial portion of the climate migrants also identified poverty (33.7%) and search for work (5.4%) as the main reasons driving their migration decision. This finding aligns with existing literature (Hoffmann et al., 2020; Moore et al., 2022), showing that climate change is not the only reason for migration and often exacerbates other migration drivers. Therefore, it is hard, if not impossible, to consider any of these drivers separately because they are closely related. Over 42% of the respondents in this study indicate that there are multiple reasons for them to migrate, with climate change impact being one of them. Our findings suggest that climate change and economic drivers such as poverty alleviation go hand in hand for a large share of the identified climate migrants in Bangladesh. The reasons for migration were nevertheless unmistakably tied to climate-related catastrophes: climatic conditions in migrants' places of origin had a substantial impact on their migration decision.

Among the other types of migrants, the search for work or transfer of work location (59%) was found to be the most important reason behind their migration to Dhaka. In addition, poverty (15%), migrating with family (9%), marriage (7%), education (5%), and conflicts related to family or over land (5%) were also found to be important reasons behind the decision to migrate to Dhaka.

3.3.1.2 Differences in sample background characteristics

The main socio-demographic and socio-economic characteristics of the three samples of long-term residents, climate, and other migrants are presented in Table 10. Looking at Table 10, we can see that the age of the respondents was almost similar across all groups. The Mann-Whitney (MW) test shows that there is no significant difference between the ages of long-term residents and climate migrant samples ($Z = -1.457$, $p > 0.1$), long-term residents and other migrant samples ($Z = -1.744$, $p > .0.05$), and ($Z = -0.016$, $p > 0.5$). However, it was not possible to interview equal portions of male and female respondents across all groups. Many female respondents were uncomfortable speaking with interviewers, even though female interviewers approached them. Looking at the table, we can see differences in terms of education and occupation. The Kolmogorov-Smirnov (KS) test reveals that there are significant differences in terms of education between long-term residents and climate migrants

(Z = 7.241, p <0.001), and the climate and other migrants (Z = 7.007, p <0.001). However, no significant differences can be detected between the long-term residents and other migrants' samples (Z = 0.870, p > 0.4). In contrast, in terms of occupation, the KS test shows that there exist no significant differences between native resident and climate migrant samples (Z = 0.770, p > 0.5), climate migrant and other migrant samples (Z = 0.954, p > 0.3), and long-term residents and other migrant samples (Z = 0.712, p > 0.5). About 43% of the climate migrants cannot read or write, and just below a quarter indicated they can read and write but have had no formal education. None of the respondents from the climate migrant sample has a higher level of education (i.e., a university degree). In terms of occupation, climate migrants were found primarily working in informal jobs, such as domestic workers, small businesses, transporter, and daily laborer.

*Table 10: Socio-demographic and economic characteristics of respondents across the three sub-samples of long-term residents and migrants**

Respondents' and households' characteristic		Long-term residents (n = 563)	Climate migrants (n = 321)	Other migrants (n = 538)
Age (in years) (mean and st. dev.)		41.6 ±12.7	40.1 ±10.9	40.0 ±12.0
Share where the respondent is head of the household (%)		64.9	55.5	53.2
Sex (%)	Female	33.7	49.5	44.5
	Male	66.3	50.5	55.5
Religion (%)	Muslim	86.3	92.5	89.9
	Hindu	13.7	7.5	9.9
	Christian	0.0	0.0	0.2
Education (%)	University post-graduate/medical/engineering	6.2	0.0	10.1
	University/college graduate	16.7	0.0	21.2
	Higher Secondary School Certificate /equivalent	17.3	13.0	13.6
	Secondary School Certificate /equivalent	10.5	2.8	7.8
	High school (Class 6-10)	6.9	1.9	5.2
	Primary school (Class 1-5)	10.8	15.9	11.9
	Can read and write but have no formal education	15.3	23.1	14.7
	Cannot read or write	16.3	43.3	15.5
Occupation (%)	Professional (doctor, engineer, lawyer)	4.6	0.0	4.5
	Full-time employee - government	4.8	0.0	8.2
	Full-time employee - private sector	11.0	0.0	8.9
	Business owner	23.7	2.9	12.5
	Dependent on rent, remittance, savings	3.1	0.9	0.6
	Housewife	9.3	16.5	18.2
	Retired	2.8	0.0	1.3
	Student	7.7	0.3	6.3
	Garments worker	2.3	6.5	3.2
	Small business owner (fruit/vegetables/meat/fish vendor)	6.9	16.8	7.1
	Transporter (rickshaw/cart puller, taxi/bus/truck driver)	4.1	14.6	5.2
	Domestic worker	3.7	20.6	6.7

Respondents' and households' characteristic	Long-term residents (n = 563)	Climate migrants (n = 321)	Other migrants (n = 538)
Daily laborer (construction, garbage/waste collector)	3.2	11.5	4.5
Unemployed	8.7	5.0	10.8
Other (mechanics, carpenters, electricians, beggars)	4.1	4.4	2.0
Average amount of time living in Dhaka (in years)	41.6	11.5	6.8
Average household size (min-max members)	4.4 (1-10)	4.3 (2-9)	3.9 (2-9)
Average income earner (median)	1.7 (1)	1.9 (2)	1.6 (1)
Average household income in BDT/month (median)	53,598 (37,500)	13,579 (7,500)	48,620 (37,500)
Households living in slums (%)	13.3	58.6	15.6
Household share toilets with other families (%)	33.2	79.1	34.8

Note: * Without missing values. Due to careful daily monitoring of the survey implementation, missing value rates range between 0.5 and 3.0%.

3.3.2 Towards the creation of a CVI for climate migrants

3.3.2.1 Interpretation of the PCA results: Retaining and extraction of principal components

We conducted several rounds of analysis with all variables to iteratively find the ideal solution, which maximized the variance explained by each component. The determination of the number of principal components to retain was based on the rule of thumb proposed by Kaiser (1960), which specifies that a component will be included if its eigenvalue is greater than one. Simultaneously, we also performed a parallel analysis using Parallel Analysis Engine (Vivek et al., 2017) to calculate percentile eigenvalues for each component or factor. We then compared the eigenvalues generated from parallel analysis and our dataset to identify the number of factors to retain. The number of eigenvalues produced from the dataset that is greater than the associated random eigenvalues generated from parallel analysis determines how many factors to retain (Horn, 1965; Vivek et al., 2017). We then generated a scree plot of the eigenvalues of the principal components in the analysis to help determine the number of factors to retain in the PCA (e.g., Jackson, 1993).

Based on the eigenvalues, parallel analysis, and scree plot, we observed that a 9-dimension component solution maximized the variance explained by each component, in this case, 69.50%. Table 11 presents the model summary of the obtained results, specifying the eigenvalues and percentage of variance explained by each component, while Figure 11 provides the scree plot of the eigenvalues against each principal component.

Table 11: Eigenvalues and percentage of the variance explained by the components

Total Variance Explained			
Component	Eigenvalues	Extraction Sums of Squared Loadings	
		% of variance	Cumulative %
1	5.899	20.34	20.34
2	3.043	10.49	30.83
3	2.931	10.11	40.94
4	2.157	7.44	48.38
5	1.459	5.03	53.41
6	1.308	4.51	57.92
7	1.184	4.08	62.00
8	1.127	3.89	65.89
9	1.046	3.61	69.50

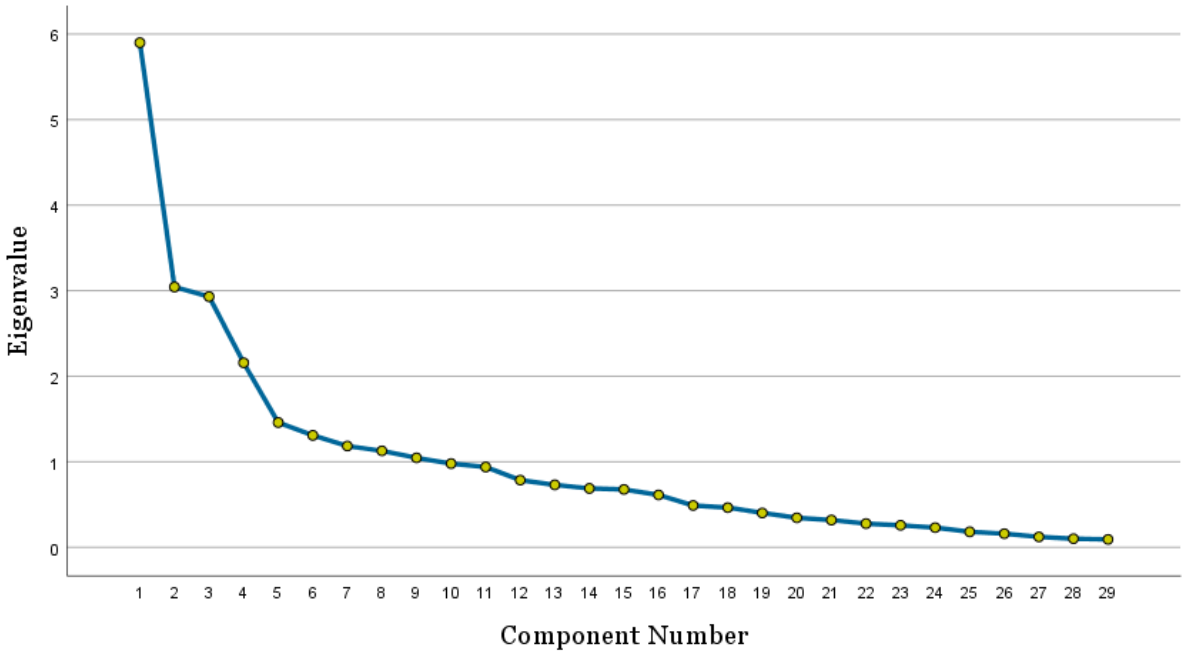


Figure 11: Scree plot of eigenvalues of components

Looking at Table 11, we observe that the eigenvalue for the first component is 5.899, which is higher than the following components. Up to component 9 the eigenvalues are greater than one. The first component alone accounts for approximately 20% of the total variance, and the first 5 components together account for more than half of the total variance in the data. Ultimately, the 9 components are able to explain around 70% of the data variance.

We assessed the component loadings related to different variables to further interpret the components extracted from the PCA. We only evaluated variables with loading greater than 0.37 on the retained components because PCA studies usually consider factor loadings larger than 0.70 to be excellent, while those less than 0.33 to

be very poor (Comrey & Lee, 1992; Tabachnick et al., 2007). In addition, rotation solutions are frequently helpful in facilitating the interpretation of retained components in PCA and highlighting the basic structure, enhancing the loading pattern's visibility or significance (Preacher & MacCallum, 2003; Yong & Pearce, 2013). PCA studies recommend employing either an oblique rotation technique (e.g., Promax) or an orthogonal rotation approach (e.g., varimax) when the factor correlation matrix has values of more than or equal to 0.32 (Corner, 2009). Consistent with the existing PCA literature, our analysis indicates that the choice between rotation methods (oblique versus orthogonal) may not significantly impact the determination of the pattern of factor loadings when factors are not strongly correlated (Corner, 2009). We used the promax rotation results to construct the index because this rotation achieved a more "simple structure" as defined by Bryant & Yarnold (1995), and Promax rotation has been argued to be beneficial for analyzing large datasets (Dien et al., 2005; IBM, 2021b). Table 12 reports the principal component loading scores for specific variables from the study conducted in Dhaka City.

Table 12: Component loadings of different vulnerability variables based on PCA

Variables	**Components**								
	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Standardized_age_dependency								.874	
Standardized_no_of_HH_members				.849					
Standardized_HH_head_gender							.702		
Standardized_respondent_education	.854								
Standardized_child_not_goto_school									.809
Standardized_incomeearner_number		.492		.418					
Standardized_monthly_income	.797								
Standardized_house_ownership				.776					
Standardized_HH_health_issue				-.385					
Standardized_cost_of_illness							.630		
Standardized_health_insurance							.655		
Standardized_distance_health		.916							
Standardized_waterpipe		.834							
Standardized_watersafe	-.489	-.466							
Standardized_latrine_type						.793			
Standardized_share_toilet	.594								
Standardized_waste_disposal						.716			
Standardized_house_type	.935								
Standardized_slum	.816								
Standardized_no_of_rooms	.705			.418					
Standardized_electricity					.473				

Variables	Components								
	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Standardized_drainage			.697						
Standardized_waterlogging_frequency	.582								
Standardized_distance_water									-.588
Standardized_concern_openwater					.866				
Standardized_consider_to_move					.560				
Standardized_flood_risk			.776						
Standardized_thermal_discomfort	.765								
Standardized_population_density	.543				-.536				
Total variance (69.50%)	**20.34%**	**10.49%**	**10.11%**	**7.44%**	**5.03%**	**4.51%**	**4.08%**	**3.89%**	**3.61%**

Explanatory notes: Extraction method: Principal Component Analysis (PCA). Rotation method: Promax rotation with Kaiser normalization. Suppressing small coefficients with loading values < 0.37

The component interpretation based on each principal component loading is as follows. The first component (PC1), which explains just over 20% of the variance in the dataset, has a high positive loading related especially to (from the highest to the lowest loading) a respondent's house type, education level, whether or not the respondent's household is living in a slum and the household's monthly income. Therefore, this component is interpreted as representing a measure of "socio-economic status and standard of living." The second component (PC2), which accounts for just over 10% of the explained variance, is interpreted to represent especially "access to health services and piped water" since variables distance to the nearest health center and access to piped drinking water have the highest loadings. The third component (PC3), which also accounts for just over 10% of the variance in the dataset, has high loadings from variables that capture the household's "flood and waterlogging risks." The fourth component (PC4), which explains 7% of the variance, contains especially high loadings on the number of household members and house ownership and is therefore interpreted as "household characteristics." The fifth component (PC5) explains 5% of the variance and contains high positive loadings on variables related to a respondent's "concern over nearby water bodies," including whether the respondent ever moved or considered moving as a result of these concerns. The sixth component (PC6) explains close to 5% of the variance and has high loadings from variables that point towards a household's "access to sanitation." The last three components each explain about 4% of the variance. The seventh principal component (PC7) is interpreted as representing "the costs of the household's health status," the eighth component (PC8) is the role of "age" in a household's vulnerability, and the last ninth component (PC9) as "children not attending school."

3.3.2.2 Vulnerability assessment based on PCA

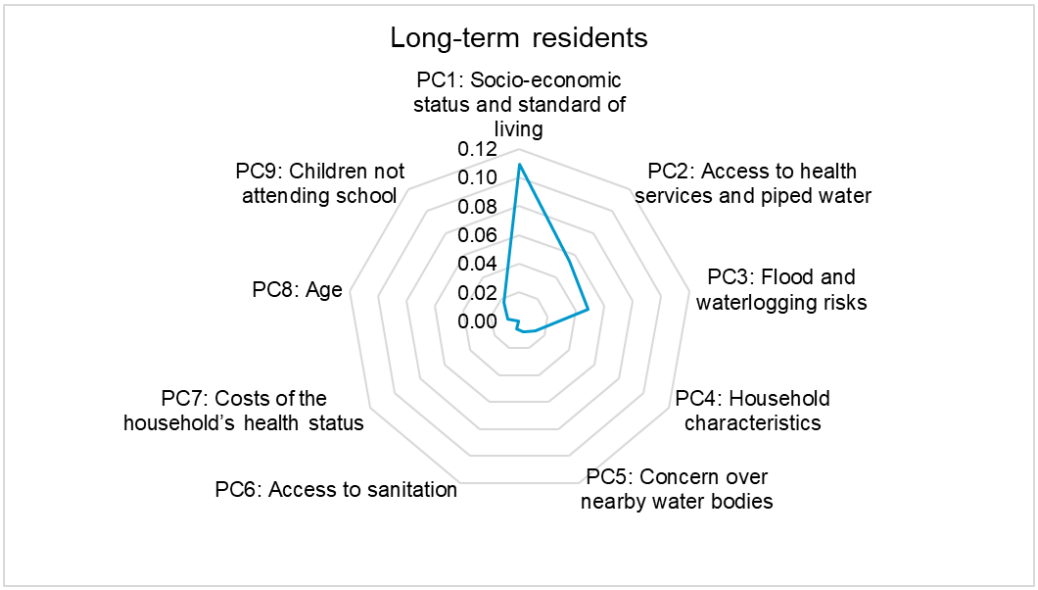
Weighted scores were generated for all households across the nine components based on the PCA results using the set of equations presented before (equations 1-

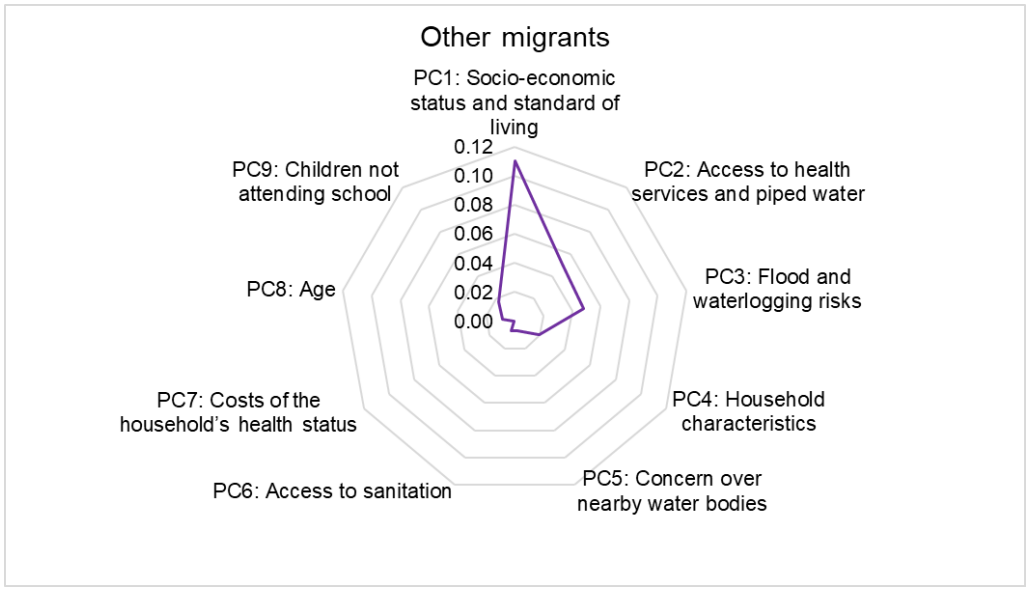
4). For example, for PC1, the proportion of the variance explained by this component was 0.2034, and the total variance explained in the data was 0.6950. Therefore, the corresponding weight for PC1 was W_1 = 0.2034/0.6950. Similarly, loadings for each relevant variable under a specific principal component were also standardized to calculate the weight for each variable in each PC. For example, the loading for a respondent's education under PC1 was 0.854, and the total positive loading for PC1 was 6.899; therefore, the corresponding weight for a respondent's education was = 0.854/5.899. Then these weighted scores were combined to obtain the vulnerability index for each respondent's household using equations (5) and (6). Table 13 and Figure 12 show the comparisons between the mean indices for all principal components for long-term residents, climate migrants, and other migrants.

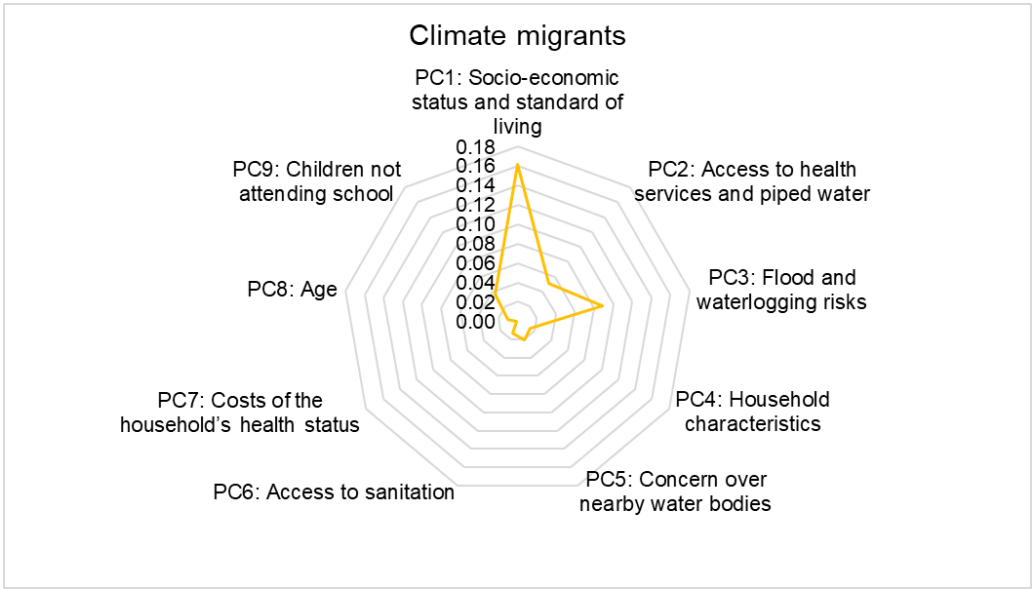
Table 13: Calculated vulnerability indexes of long-term residents, climate migrants, and other migrants based on the principal components analysis.

Principal component		**Long-term residents**	**Climate migrants**	**Other migrants**
PC1: Socio-economic status and standard of living	Mean	0.1093	0.1619	0.1100
	Std. Error	0.0016	0.0015	0.0018
PC2: Access to health services and piped water	Mean	0.0543	0.0503	0.0506
	Std. Error	0.0011	0.0015	0.0011
PC3: Flood and waterlogging risks	Mean	0.0487	0.0890	0.0484
	Std. Error	0.0020	0.0024	0.0019
PC4: Household characteristics	Mean	0.0129	0.0149	0.0193
	Std. Error	0.0009	0.0011	0.0009
PC5: Concern over nearby water bodies	Mean	0.0079	0.0201	0.0073
	Std. Error	0.0007	0.0010	0.0007
PC6: Access to sanitation	Mean	0.0058	0.0135	0.0074
	Std. Error	0.0004	0.0005	0.0004
PC7: Costs of the household's health status	Mean	0.0005	0.0013	0.0004
	Std. Error	0.0001	0.0002	0.0001
PC8: Age	Mean	0.0082	0.0101	0.0088
	Std. Error	0.0004	0.0006	0.0004
PC9: Children not attending school	Mean	0.0166	0.0361	0.0175
	Std. Error	0.0011	0.0011	0.0011
Total CVI	Mean	0.2309	0.3249	0.2346
	Std. Error	0.0039	0.0033	0.0042

Note: Missing values for PCs were at most 4%. The standardized values for each indicator are calculated in such a way that a higher value indicates higher vulnerability.







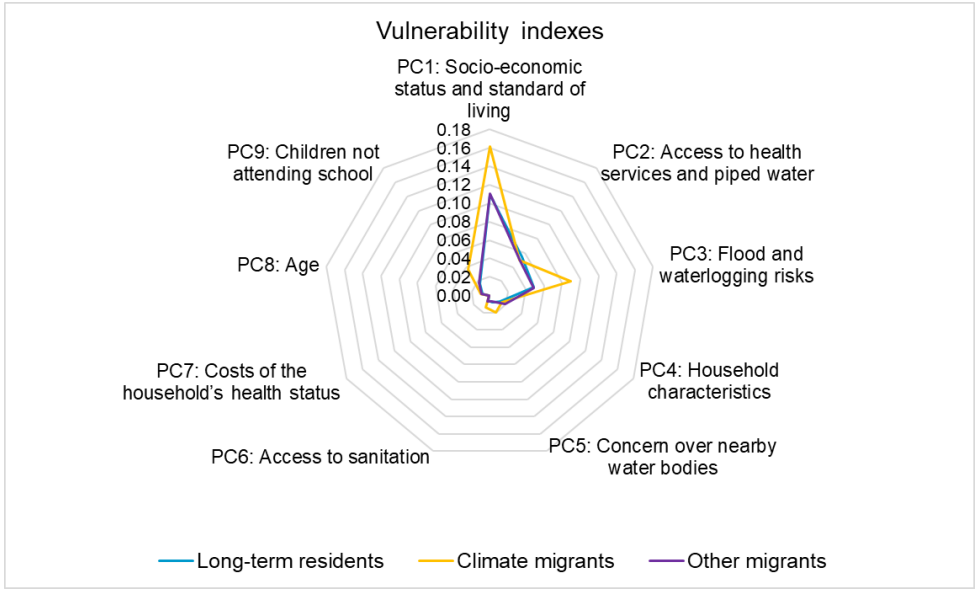


Figure 12: Radar diagrams of the principal components underlying the composite vulnerability index (CVI) for each surveyed sample

Further analysis reveals that overall, across all components, climate migrants have the highest average level of vulnerability (0.33), followed by other migrants (0.24) and long-term residents (0.23). These differences are statistically significant based on the MW test between climate migrants and other migrants ($Z = -13.967$, $p < 0.001$) and between climate migrants and long-term residents ($Z = -14.688$, $p < 0.001$). In addition, climate migrants demonstrate the most vulnerability compared to both other migrants and long-term residents based on their scores for PC1, PC3, PC5, PC6, PC7, PC8, and PC9. This means they are more vulnerable in terms of "socio-economic status and standard of living," "flood and waterlogging risks," "concern over nearby water bodies," "access to sanitation," "the costs of the household's health status," "age dependency" and "child education."

Climate migrants scored on average 0.16 on PC1, which was lower for other migrants (0.11) and long-term residents (0.109). These differences seem related to the fact that over 53% of the surveyed climate migrants reported living in kachan houses (i.e., jhupri, tong, tin). We can see in Table 12 that the house type had the highest loading. In comparison, more than 75% of both long-term residents and other migrants reported living in semi-pacca, pacca houses, or flats/apartments. Regarding PC3, the climate migrant sample's vulnerability score was, on average 0.089.

In contrast, long-term residents and other migrants scored on average almost the same, 0.0487 and 0.0484, respectively. This indicates that climate migrants face higher flood risks than these two other groups. Similarly, also for PC5, climate migrants' average vulnerability score was much higher (0.0201) than for long-term residents (0.0079) and other migrants (0.0073). This is most likely related to the health risks associated with these often highly polluted urban water bodies, which are also an important source of water-borne diseases in Dhaka. The average vulnerability score for climate migrants for PC6 (0.0135) was also higher than for other migrants (0.0074) and long-term residents (0.0058), which indicates that climate migrants have a higher vulnerability in terms of access to proper sanitation and waste management facilities. Although the average vulnerability score for PC7, i.e., household health costs, was not that high, the vulnerability score for climate migrants was significantly higher than the similar scores for long-term residents and other migrants. Studies suggest that water and sanitation are closely interconnected with the health of the household, and lack of safe water and adequate sanitation causes serious diseases (e.g., diarrheal diseases, intestinal helminths) (Montgomery & Elimelech, 2007; WHO, 2020) and adverse effects on well-being (e.g., emotional distress) (Kangmennaang & Elliott, 2021). Furthermore, the average age dependency ratio (PC8) score was somewhat higher for climate migrants than other migrants and long-term residents. Lastly, for PC9, which includes high positive loading for children's education, the average vulnerability score for climate migrants was twice as high that for other migrants and long-term residents.

Climate migrants were significantly less vulnerable than long-term residents (MW $z = -2.904$, $p < 0.005$); however, not than other migrants (MW $z = -1.823$, $p > 0.05$) when it comes to PC2, which contains high positive loadings for access to health

services and piped water. In terms of PC4, which contains high loadings for the respondent's household characteristics such as the number of household members, income earners, and house ownership, climate migrants were significantly less vulnerable than other migrants (MW z = -3.645, $p < 0.001$); however, not significantly higher vulnerable (MW z = -0.563, $p > 0.05$) than long-term residents. In the case of PC2, long-term residents appear to be the most vulnerable, and in the case of PC4, the other migrants are most vulnerable and have the highest average score.

3.3.2.3 Vulnerability assessment – IPCC approach

The CVI based on the IPCC framework (using equations 8 and 9) yielded similar results, i.e., climate migrants are most vulnerable, and long-term residents are least vulnerable. The overall CVI_{IPCC} score is highest for the climate migrant sample (0.34), which is 46% higher than for long-term residents and 48% higher than for other migrants. At the same time, the overall CVI score for other migrants is even slightly lower (1.2%) than for long-term residents. Figure 13 and Table 14 present the vulnerability index scores for the three IPCC dimensions risk exposure, sensitivity, and adaptive capacity. Detailed MW test results of statistical significance of the differences are enclosed in Appendix supplementary material C.

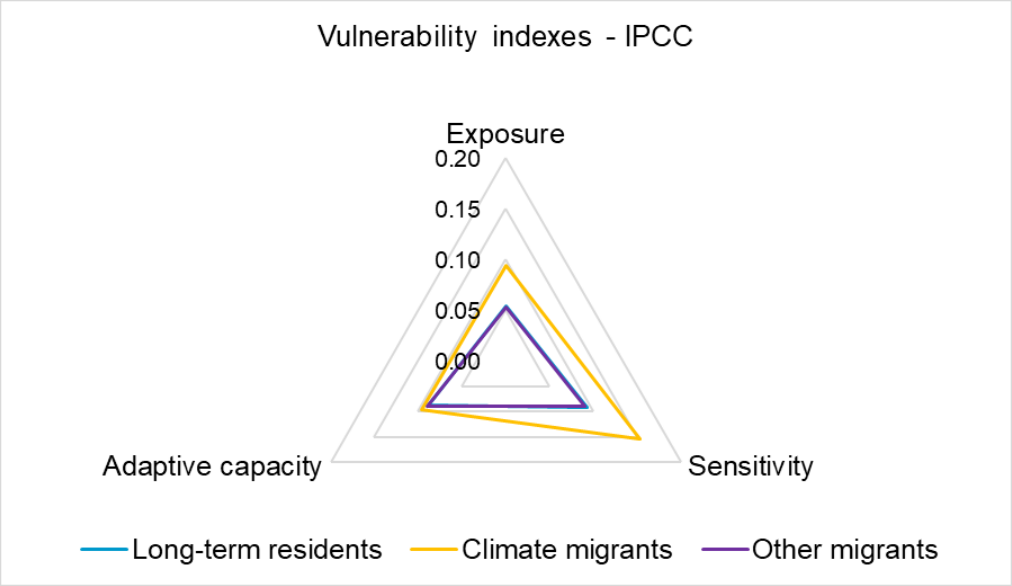


Figure 13: Radar diagram of the IPCC vulnerability dimensions for climate migrants, long-term residents, and other migrants

Table 14: Average standardized index scores for the three main dimensions underlying vulnerability as defined by the IPCC across the three survey samples

IPCC dimension		long-term residents	Climate migrants	Other migrants
Exposure	Mean	0.0547	0.0947	0.0531
	Std. Error	0.0018	0.0029	0.0021
Sensitivity	Mean	0.0926	0.1536	0.0897
	Std. Error	0.0024	0.0023	0.0025
Adaptive capacity	Mean	0.0883	0.0957	0.0900
	Std. Error	0.0013	0.0018	0.0013
Total CVI_{IPCC}	Mean	0.2357	0.3439	0.2329
	Std. Error	0.0038	0.0046	0.0042

Note: The standardized values for each dimension are calculated in such a way that a higher value for exposure, sensitivity and adaptive capacity indicates a higher degree of vulnerability. This means that also a higher index score for adaptive capacity reflects a lower adaptive capacity.

The exposure index shows that climate migrants are, on average, more exposed to natural disasters such as flooding and waterlogging than other migrants and long-term residents. The average score is 73% higher for climate migrants than for long-term residents (MW z = -11.216, $p < 0.001$) and 78% higher for climate migrants than other migrants (MW z = -11.379, $p < 0.001$). The average exposure scores for long-term residents and other migrants are almost similar, with the average exposure index score being slightly (3%) lower for other migrants than long-term residents (MW z = -1.556, $p > 0.1$).

Also, the average sensitivity index across the three groups shows that it is highest for climate migrants, followed by long-term residents and then other migrants. Climate migrants are, on average, 66% more sensitive to various sources of risk than long-term residents (MW z = -14.524, $p < 0.001$) and 71% more sensitive than other migrants (MW z = -15.042, $p < 0.001$). Other migrants are again found to be the least sensitive, namely 3% less than long-term residents (MW z = -0.939, $p > 0.3$).

Interestingly, the adaptive capacity index reveals that it is almost the same among all groups. Climate migrants also demonstrate to have the least adaptive capacity, which is, on average, 8% lower than for long-term residents (MW z = -3.936, $p < 0.001$) and 6% lower than for other migrants (MW z = -2.709, $p < 0.008$). The long-term residents' group shows the highest adaptive capacity and is, on average, 2% higher than other migrants (MW z = -0.939, $p > 0.5$). Overall, we can hence conclude that climate migrants living in Dhaka city are the most vulnerable, particularly due to their relatively higher exposure and sensitivity to various sources of risks.

3.3.3 Migrants' perceptions of pre- and post-migration living and livelihood conditions

To further assess and better comprehend their post-migration status, we also investigated how migrants perceived their pre-migration and post-migration conditions from various angles. First, we looked at the differences between the pre- and post-

migration occupations of climate migrants. We asked the respondents to specify their previous and current occupations, including any previous employment of the household's main earner, in case this was not the respondent.

Table 15 presents a summary of our findings. As mentioned, occupational shares refer to those of respondents or the head of the household in those cases where the respondent was not the head of household (as can be seen from Table 10, this was a substantial share). Our analysis reveals that many of the climate migrants were farmers (31.6%), housewives (24.4%), fishermen or fish salespersons (22.8%) at their original place of residence, while relatively smaller numbers were small business owners (8.6%), land (6.5%) or daily workers (4.6%). In contrast, most of the climate migrants' post-migration occupations are small business owners (23.5%), transporters (23.0%), domestic workers (15.2%), and daily laborers (14.3%). Hence, we observe remarkable shifts in occupation post-migration for most climate migrants. We also notice that the percentage of female household members who were housewives before migration (24.4%) more than halved to 11.9% after migration. This is because many of these female household members started working as domestic workers or garment workers to earn income. On the one hand, this could be interpreted as a positive signal that more women are entering the workforce, where they might have the opportunity to become more financially independent. On the other hand, this might also mean that the new jobs were added to their duties and responsibilities at home, and they had to work harder post-migration.

Table 15: Climate migrants' occupations before and after migration to Dhaka City

Pre-migration occupation (respondents or head of household)	%	Post-migration occupation (respondents or head of household)	%
Farmer	31.6	Small business owner (e.g., fruit/vegetables/meat/fish vendor)	23.5
Housewife	24.4	Transporter (e.g., rickshaw/cart puller, taxi/bus/truck driver)	23.0
Fisherman/Fish salesperson	22.8	Domestic worker	15.2
Small business owner	8.6	Daily labor (e.g., construction, garbage/waste collector)	14.3
Land labor	6.5	Housewife	11.9
Daily labor	4.7	Garment worker	6.0
Boatman	0.9	Unemployed	3.6
Driver	0.2	Others: e.g., carpenters, shopkeepers, barbers, mechanics, guards, beggars	2.0
Business	0.2	Dependent on rent, remittance, or savings	0.5

Next, we used the six statements to assess the various facets of perceived pre- and post-migration living conditions. This includes perceived exposure to natural disasters, earning opportunities, water and sanitation facilities, health conditions, general living conditions such as type of house and comfort of living, and social status

and social network. Figure 14 presents a visualization of the distributions of the Likert scale responses for climate migrants and other migrants to illustrate the observed patterns of perception shifts, while Table 16 summarizes the mean and mode scores and statistical test results for the observed differences between the two migrant groups.

After removing missing values, we find 314 completed responses for the climate migrants and 436 completed responses for the other migrants. The points on the itemized Likert scale were coded as -2 for "strongly disagree, -1 for "disagree", 0 for "don't know" or "neither disagree nor agree", +1 for "agree" and +2 for "strongly agree". The mean score for the first statement "less exposure to natural disasters in Dhaka than in the place of origin" is 0.29 for all migrants. The data shows that most climate migrants agreed with this statement, and their mean score is 0.51. In contrast, other migrants were less inclined to agree with this statement, with a mean score of 0.13. The chi-square test reveals significant differences between the two groups (x^2 = 37.476, p < 0.001) regarding their perception of pre-migration and post-migration exposure to natural disasters. This is also confirmed by the MW test (Z = -5.480, p < 0.001).

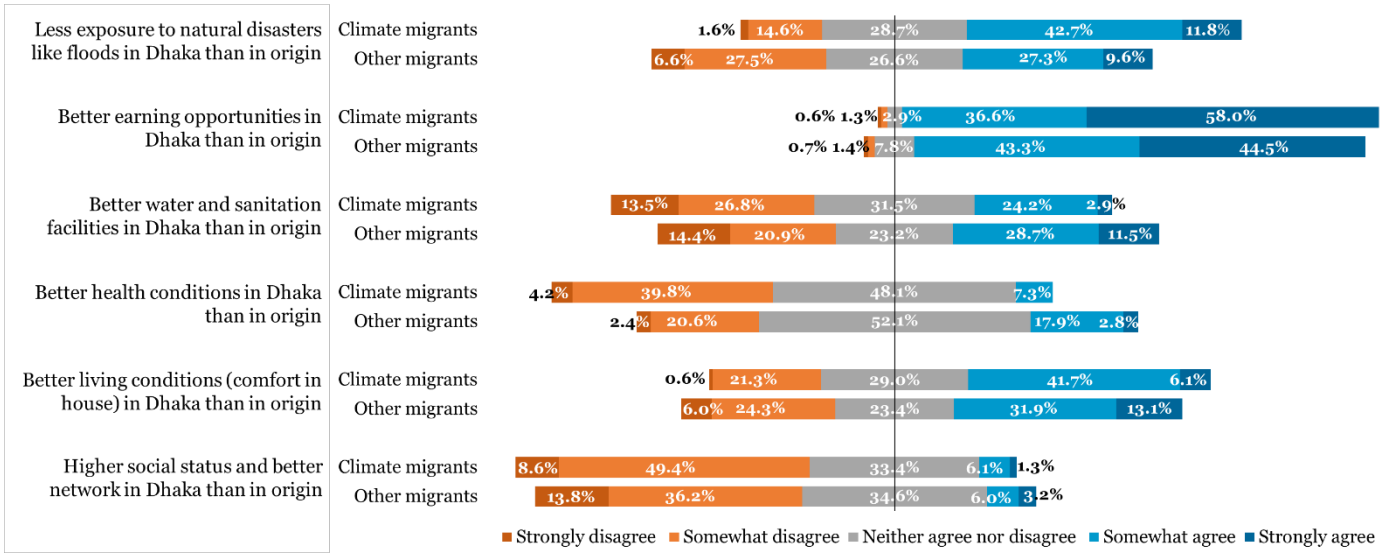


Figure 14: Frequency distribution (in %) of the perceptions of the two migrant samples regarding their various pre-migration and post-migration living conditions (the vertical line identifies the zero category)

The analysis of the statement "better-earning opportunities in Dhaka than in the place of origin" reveals that most climate and other migrants agreed with this statement. The mean score of both migrant groups is 1.39, while the individual group's mean scores are 1.51 and 1.31 for the climate migrants and other migrants, respectively. The MW test reveals that the difference between the climate migrant and other migrant groups' perception of pre-migration and post-migration earning opportunities is statistically significant (z = -3.933, p < 0.001).

Table 16: Means and modes of each statement for climate and other migrants related to their pre-migration and post-migration living conditions

	Statements	Climate migrants (n = 314) Mean (Mode)	Other migrants (n = 436) Mean (Mode)	Mann-Whitney test statistic - Standardized Z-value (2-Tailed significance)
a.	We are less exposed to natural disasters like floods in Dhaka	0.51 (1.0)	0.13 (-1.0)	-5.480 ($p < 0.001$)
b.	We have better earning opportunities in Dhaka than in our place of origin/there is more work in Dhaka	1.51 (2.0)	1.31 (2.0)	-3.933 ($p < 0.001$)
c.	We have better water and sanitation facilities in Dhaka than in our place of origin	-0.10 (-1.0)	0.17 (-1.0)	3.180 ($p < 0.002$)
d.	Our health condition is better in Dhaka than in our place of origin / we get less sick than before	-0.36 (0.0)	-0.04 (0.0)	6.169 ($p < 0.001$)
e.	Our living conditions (comfort of living/house condition) are better in Dhaka than in our place of origin	0.31 (1.0)	0.28 (1.0)	-0.563 ($p > 0.5$)
f.	We have a higher social status and better network in Dhaka than in our place of origin	-0.46 (-1.0)	-0.38 (-1.0)	1.591 ($p > 0.1$)

Interestingly, analysis of the statements related to “water and sanitation” and “health conditions” shows that climate migrants were more inclined to disagree with both statements. In contrast, other migrants agreed with having better water and sanitation conditions but disagreed with having better health conditions. The MW test convincingly rejects the null hypothesis of equality of perceptions between climate and other migrants regarding both the water and sanitation situations before and after migration (MW z = 3.180, $p < 0.002$) and the health conditions (MW z = 6.169, $p < 0.001$).

In terms of housing conditions and comfort of living, the analysis reveals that the climate migrant group was slightly more in agreement that their living conditions had improved after migration than the other migrant group. However, the MW test shows that the difference between the two samples of migrants is not statistically significant at the 10% level (MW z = -0.563, $p > 0.5$). Remarkably, the aspect of “social status and social network” was perceived as less at their destination than origin by both climate and other migrants’ groups. Both groups scored overwhelmingly negative on the Likert scale, indicating that climate and other migrants felt less well-positioned socially in Dhaka than before migrating there. The MW test statistic shows that no significant difference can be detected at the 10% level (MW z = 1.591, $p > 0.1$) between both migrant groups regarding their perception of pre-migration and post-migration social status and network.

3.4 Discussion

People evaluate shifting vulnerabilities while making complex migration decisions depending on various factors and consequences of their decision under climate change. In addition, an important question remains the debate over whether migration how successful migration as a climate adaptation strategy (Piguet, 2022; Schipper, 2020), and literature is still grappling with the complex dynamics of migration and non-migration decision-making and measuring migration flows under climatic conditions (Adams & Kay, 2019; Helbling et al., 2023; Mallick et al., 2022). Surprisingly, relatively little is found in the climate migration scholarship investigating the vulnerability situations of climate migrants in urban destinations. Thus, this study offers valuable contributions to our knowledge and understanding of the vulnerability implications of climate migration in urban settings.

While this is relatively complex to reveal the exact way of this decision-making process, our study suggests that alongside climatic reasons, the economic driver (i.e., poverty – push factor, search for work – pull factor) played the most crucial role in migrants' decisions to move to Dhaka. This is also addressed as the most important reason for considering migration in other climate migration studies conducted in Bangladesh and other parts of the world (Bernzen et al., 2019; Hoffmann, 2022; Maharjan et al., 2020; Marotzke et al., 2020).

In this study, we constructed two vulnerability assessment methods to conduct a cross-sectional analysis of the complexities of climate migration and vulnerability in Dhaka. Previous research proposed and applied various composite vulnerability indices, using PCA or equal weights, to analyze and compare the complex and multidimensional issues of the natural environment and human systems across different places (Abson et al., 2012; Ahmad et al., 2022; Hahn et al., 2009; Spielman et al., 2020). However, analyzing the vulnerability conditions across different human groups are rarely introduced. In contrast to previous vulnerability assessment methods, our study created indicators related to specific household situations that lead to differentiated vulnerability across households in Dhaka. For example, the inclusion of the number of school-aged children not attending school, cost of illness, and access to solid waste management can impact vulnerability and are important indicators related to socio-economic, health, and sanitation that were introduced in this study. Additionally, the indicators of exposure to waterlogging, flood risks, and thermal discomfort for the specific location of households were included in our assessment. These indicators more clearly depict the vulnerability to the environment and climate change.

The key strength of our study is that we distinguished different groups, i.e., long-term residents, climate migrants, and other migrants, based on their migration backgrounds. Using both PCA and perception-based comparative assessment provides more comprehensive insights into the vulnerabilities faced by climate migrants in Dhaka. This way, this study also offers subjective experiences of climate

migrants and objective data to fully grasp the complexities of climate migration and vulnerability.

3.4.1 Comparing vulnerabilities and perceptions among groups: Real-world implications

Even though migration is considered as an adaption strategy, our comparative assessment findings demonstrate that climate migrants in Dhaka remain the most vulnerable among all groups surveyed. One of the key findings of this study was that climate migrants in Dhaka are more vulnerable in terms of their socio-economic status and standard of living. The PCs were analyzed in section 3.2.2. provide further detailed information on which characteristics contribute to the most vulnerability for each group. This, in turn, might be programmed to support climate migrants by allocating the Adaption Fund (AF) or other types of funding available to support victims of climate change. For example, in PCA, we noted that climate migrants exhibit the most vulnerability regarding access to basic services such as housing. This was also our observation during the field visit that the living conditions of the climate migrants are relatively extremely impoverished in slum areas. We also noted that climate migrants living in slums constantly fear getting evicted. They also suffer from frequent fire outbreaks (there was a massive fire outbreak in Dhaka slum during our data collection period that left about 50,000 people homeless, Source: The Independent, 2019). This highlights the need for interventions that specifically target the needs of climate migrants living in slums in terms of better housing situations.

When considering the variance loading of monthly income in PC1 and Likert scale analysis, we observe that income, as expected, is an important factor. Income determines an individual household's sensitivity and coping or adaptive capacity to address climate-related exposures (Maharjan et al., 2020). Climate migrants were found more likely to be engaged in informal and low-paying occupations and more likely to live in poverty than other groups of migrants and long-term residents. Climate migrants also perceive economic conditions and better-earning opportunities as critical components of their vulnerability conditions. This is consistent with previous studies on climate migration, which have also found that climate migrants often face economic marginalization and a reduced standard of living (Adger et al., 2021; Fröhlich, 2016). This is something already known that people with better earnings can possess more assets and reduce vulnerability (Brouwer et al., 2007).

Our study reveals that climate migrants exhibit lower educational attainment and occupational status levels than other migrants and long-term residents. These findings suggest that climate migrants encounter difficulties in accessing higher-paying employment opportunities, often limiting them to low-income occupations. Notably, many individuals who were previously farmers or fishermen in their places of origin are now engaged in occupations such as rickshaw pullers and construction workers, indicating a mismatch between their previous skills and the available job market. This discrepancy highlights the challenges faced by climate migrants in effectively utilizing

their previous skills in their new environment. Interestingly, our study also reveals a reduction in the number of housewives following migration, accompanied by an increase in the number of individuals employed in the ready-made garments (RMG) sector. This shift can be interpreted as a positive sign, considering that previous research has demonstrated the significant empowerment of women in Bangladesh through their involvement in the RMG industry (Al Mamun & Hoque, 2022).

This might help explain that helping the climate migrants work on new and improve existing skills can help with better earning opportunities and will likely decrease their vulnerability. For example, providing access to employment and livelihood opportunities, as well as education and skills training, can help to improve the economic situation of climate migrants despite environmental and climatic exposures in Dhaka. Because in the Likert scale analysis, we observed that climate migrants stated more agreement that they face less exposure to natural disasters in Dhaka than in their origins. However, we cannot ignore that they still face higher exposure than other groups. Climate migrants are more exposed to natural disasters and climate change because they have limited options and often take shelter in low-lying areas with inadequate drainage facilities (Ahsan, 2019; Ahsan et al., 2016; Rashid et al., 2013).

We observed that climate migrants exhibit less vulnerability in health components. However, climate migrants have a lower socioeconomic status, so they may be unable to spend more money to diagnose and treat their health issues or illness. According to the study conducted by Adams et al. (2020), there was a notable difference in healthcare-seeking for illness among various socioeconomic classes. Wealthier households sought treatment more frequently in expensive private clinics, while poorer households depended more on less costly pharmacy stores and public hospitals (Adams et al., 2020). Climate migrants also reported suffering from fewer health issues than other groups. We also found that climate migrants do not have to travel further to receive health facilities compared to other groups. However, our analysis of the Likert scale revealed that climate migrants are more inclined to the disagreement with the statement that their health situation is better in Dhaka than their place of origin compared to other migrants. These findings suggest that climate migrants perceive their health situation as not better than their place of origin and might be more vulnerable regarding health issues than other groups.

We also observed that climate migrants exhibit more vulnerability in water and sanitation situations based on PCA and Likert scale analyses compared to other groups. Previous studies also identified that climate migrants in urban areas (Dhaka, Khulna) have limited access to safe drinking water and sanitation, which increases their vulnerability to water-borne diseases (e.g., diarrhea, cholera, typhoid, and hepatitis) (Khan, 2022; Rahaman et al., 2018). This also relates to the issue of climate migrants living in slum areas with inadequate toilet facilities shared by multiple families, as previously studied (Icddrb, 2016; McFarlane, 2008), which may increase their vulnerability. In addition, considering the IPCC's three dimensions of vulnerability, our

finding suggests that climate migrants had the most exposure, sensitivity, and least adaptive capacity among all groups.

Considering all aspects of our different analyses, our recommendations toward the decision-makers and stakeholders to focus on improving the economic (e.g., better earning, improved skills, and education) and physical conditions (e.g., housing, water, and sanitation) of climate migrants to enhance their overall situation and reduce vulnerability and inequality (SDG 10). We propose locally led adaptation (LLA) initiatives and allocating adaptation, loss, and damage funds is essential for improving their situations. Furthermore, our study findings support the establishment of migrant-friendly towns in other parts of the country to redirect migration flow away from Dhaka and improve climate migrants' situations, as Khan et al. (2021) suggested. These approaches enable future adaptive migration, ensuring safe migration and reduced vulnerability.

3.4.2 Limitations

Our study aimed to demonstrate and understand the climate migrants' situation in Dhaka city. We developed composite vulnerability indexes (CVIs) based on the literature review and data availability (as discussed in section 2.4.1. that we applied SMART criteria). Therefore, these variables and the CVIs may not apply to other contexts or populations. In addition, several other variables could be used to assess the vulnerability. For example, we also collected recent weather-related data such as monthly maximum and minimum temperature and average rainfall data from January 2016 to July 2022 from the Bangladesh Meteorological Department (BMD, 2022) and Dhaka city's daily Air Quality Index (AQI) from 27 September 2021 to 08 August 2022 (DoE, 2022). However, we had to omit those data from our analyses due to the unavailability of disaggregated data and variations across different administrative borders (i.e., thanas or city wards).

In addition, social capital and social network are also considered essential indicators in vulnerability assessment and climate change adaptation (Amoatey & Sulaiman, 2020; Hahn et al., 2009; Nguyen et al., 2021). However, we could not consider these in our analysis due to the lack of available data. The questionnaire was very long already, and addressing social capital and networks would have required another type of survey instrument, such as more in-depth discussion with respondents about key people in their surroundings and networks on whom they relied in their daily lives and in case of emergencies. Since our study predominantly relied on large-scale quantitative survey data, we also could not capture the gendered aspect of vulnerability. Here too, other research methods would be needed to further explore these aspects in more detail in a more qualitative manner.

It is also crucial to remember that we standardized the indicators using maximum and minimum values for the participants in our research. Consequently, as indicated in (Hahn et al., 2009), the CVIs and assessments that we developed and performed based on PCA are not comparable with studies carried out elsewhere or future studies,

except these are performed utilizing our approaches. Because our sample represents a relatively higher number of other migrants and long-term residents than climate migrants, we cannot remark on the possible magnitude of the underlying selection bias. Additionally, as mentioned previously, it was impossible to capture the exact equivalent response from male and female respondents as the female household member did not want to speak to the interviewers. Therefore, the results may somewhat over-represent male views. Furthermore, the perception-based Likert scale analysis relied on self-reported data, which may be subject to recall bias (Rosenman et al., 2011).

3.5 Conclusions

In summary, our study contributes to the existing knowledge in its attempt to identify the main drivers underlying socio-economic vulnerability post-migration in climate migrants' final destination, the capital city of Bangladesh, a fast-growing mega-city in the world. The strength of our research lies in its combination of conceptually rooted and large data-driven approaches, enabling us to produce measures at the household level and gain a comprehensive understanding of vulnerability.

Our findings align with prior research highlighting that urban slums serve as destinations for climate migrants, who are often low-income residents seeking refuge from the impacts of climate change (Adger et al., 2021). While the effectiveness of migration as an adaptation strategy remains a subject of debate, our study offers empirical evidence that climate migrants in Dhaka, a rapidly expanding megacity, experience heightened vulnerability in terms of their socio-economic status and living standards. This finding aligns with the arguments put forth by Jacobson et al. (2019), Pörtner et al. (2022), and Turhan & Armiero (2019), who suggest that migration may not always be an effective adaptation strategy, except in specific circumstances for certain individuals (Vinke et al., 2020; Wiegel et al., 2019). Furthermore, our research suggests climate change exacerbates social inequality, negatively impacts water, sanitation, and health outcomes, and poses significant implications for cities (Kaur & Pandey, 2021; Koop & van Leeuwen, 2017; Long & Rice, 2019). This underscores the importance of targeted interventions and the allocation of adaptation funds to address the specific challenges faced by climate migrants. By conducting a detailed examination of the vulnerability mechanisms experienced by climate migrants in a rapidly growing megacity, our study provides valuable insights that contribute to the ongoing debate on this topic.

Looking ahead, our study encourages further research to explore the evolving exposure, sensitivity, and adaptive capacity of climate migrants as adaptation policies are implemented. Incorporating additional variables related to social networks and gender aspects in future studies would enhance our understanding of social relationships and inequalities in this context. Moreover, expanding the study to other cities in Bangladesh and other countries would provide a broader perspective on the vulnerability of climate migrants. Our study is envisioned as a valuable baseline for future research and adaptation planning, enabling decision-makers to target

interventions and reduce vulnerability and inequalities among the most marginalized communities, including climate migrants in a fast-growing megacity. By establishing strategies to strengthen their resilience and well-being, we can enhance adaptive capacity and foster sustainable development in the face of climate change.

Chapter 4: Shining a gender lens on climate migration: A systematic review of the empirical evidence in South Asia

Abstract

Scholars and policymakers increasingly recognize the importance of integrating gender analysis into the study of climate migration. However, an understanding of the complex interaction between gender and climate migration remains incomplete. Inconclusive findings on gender-differentiated migration decisions and patterns may limit their application in addressing gender inequality in climate migration and adaptation policies and interventions. This systematic review examines the gendered dimensions of climate migration in South Asian countries, including migration decisions, patterns, and agency, while evaluating existing studies' theoretical and methodological underpinnings. Conforming to PRISMA guidelines, this study conducted a comprehensive search across five major databases, including Web of Science, Scopus, CliMig, GenderWatch, and Wiley Online Library, identifying 33 empirical studies for analysis. Our findings reveal an increasing trend in published articles on climate migration and the role of gender in shaping those, with uneven geographical coverage and diverse theoretical and methodological approaches. Our bibliographic coupling analysis highlights potential opportunities for greater collaboration across disciplinary fields. We observed that gender norms, roles, and relations intersect with other forms of social stratification to shape differentiated migration decisions and patterns under climate change. Drawing on these insights, we propose six pathways through which gender differentiation occurs in climate migration. The findings of this study are intended to inform future research and evidence-based decision-making. This study calls for further trans- and inter-disciplinary research endeavors integrating gendered dimensions to climate migration using an inclusive framework from open and situational perspectives. Further research is warranted to identify gendered agency in climate migration decisions to reduce inequality and promote sustainability. Policy interventions must be well-grounded in the needs and priorities of all genders to address climate migration as a global challenge effectively.

4.1 Introduction

Climate change significantly impacts many dimensions of sustainable development, and migration is no exception (McLeman, 2020). Climate migration is a phenomenon that has recently gained attention due to the increased frequency of severe weather events, such as flooding, cyclones, wildfires, and droughts, exacerbated by climate change. However, a significant body of research has demonstrated that not everyone decides to migrate equally due to climatic conditions. The decision to migrate is influenced by a wide range of factors (Black et al., 2011; Boas et al., 2022a; Castelli, 2018; Hoffmann et al., 2020). Among these, gender may be one of the most significant factors shaping migration since it influences both migration patterns and experiences (Hummel, 2021; Rao et al., 2019). For example, gender influences migration by shaping individuals' motivations, priorities,

opportunities, roles, economic factors, and social norms, playing significant roles in migration decisions and experiences (Erdal & Hagen-Zanker, 2022). Therefore, understanding the dynamics of climate migration requires consideration of gender.

The global south is home to the majority of those impacted by climate change, while it is also the region with a negligible contribution to the issue (Althor et al., 2016). In the empirical research on climate migration, the South Asian region thus holds an important position. Climate change affects the fate of women, men, and people with other gender identities differently. How well people can adapt to the impacts of climate change, as well as whether and how they will migrate, is influenced by gender inequalities. Gender inequality, which is a product of historical, economic, and societal dynamics, is a critical factor in escalating vulnerability to the impacts of climate change across sectors and regions (Jerneck, 2018; Partey et al., 2020; Rao et al., 2019; Vij et al., 2017). It is often argued that the injustice further exacerbates existing gender inequalities by limiting access to education, control over resources, participation in decision-making, and agency in migration (Donkor & Mazumder, 2021; Heise et al., 2019). In addition, gender also influences the perception of the risks, pressure to migrate, strategies, priorities, employment prospects, and destination choices, making it a crucial variable in migration decisions and the way people experience migration (Lama et al., 2021; Piguet et al., 2011; Van Praag, 2021). Recognizing the extent to which climate migration affects women, men, girls, boys, and people with other gender identities differently is a vital step toward understanding its drivers and impacts on people and communities.

A gendered perspective is crucial for developing policies to address both climate change and migration issues. This recognition is also echoed in various initiatives related to climate adaptation and disaster risk reduction, such as the Sustainable Development Goals (SDGs), Sendai Framework, and locally led adaptation (LLA), which specifically state to put a gender perspective into policy and practice. In addition, research funding organizations, including those from the United Nations Framework Convention on Climate Change (UNFCCC), the International Organization for Migration (IOM), Global Affairs Canada, the International Development Research Centre (IDRC), and many others particularly emphasize placing gender analysis at the heart of proposal calls. These initiatives and research funding calls have raised scholarly and practitioner interests in the gendered dimension of climate migration research.

This study aims to address the existing gap in the literature by conducting a systematic review of empirical studies in South Asia focused on the gendered dimensions of climate migration. This research seeks to contribute to a clearer understanding of the gendered dynamics of climate migration by critically analyzing the identified studies and examining how they conceptualize and study gender-differentiated migration responses. This study underscores the significance of agency and freedom of choice in addressing gender inequality and informing migration decisions within the context of climate change. By emphasizing the importance of

these factors, the study calls for a more nuanced and informed approach to studying and addressing the gendered dimensions of climate migration. It highlights the need to recognize and empower individuals' agency and decision-making abilities to promote gender equality and develop effective strategies for climate migration.

While the body of gender and climate migration literature is expanding, it is distributed throughout disparate academic disciplines and topics, including geography, demography, development, anthropology, feminist political ecology, vulnerability, and adaptation. We argue that it is essential to integrate diverse perspectives and methodologies to comprehend the characteristics of gendered migration and to develop adaptive strategies that are most effective in reducing gendered inequalities. Furthermore, we are unaware of any systematic review that has examined the intersection of gender and climate migration in South Asia or globally. We now seek to fill these gaps by synthesizing peer-reviewed empirical studies on this issue so as to provide insights into how gender is investigated from both theoretical and methodological perspectives and to identify the key findings emerging from this evolving field of research. In this systematic review, we ask four key questions:

1) What migration responses have been observed between men, women, and gender minority individuals in the climate change context in South Asia?
2) To what extent is agency involved in their migration decisions?
3) What emerging theories are used to explain the relationships between gender and climate migration, and how widely are ideas distributed among the disciplinary communities and fields?
4) What methodologies are employed to study gender in these empirical investigations?

Before reviewing gender and climate migration studies, it may be helpful to understand key concepts and their interrelatedness. These will be discussed in the following section.

4.1.1 Understanding gender, agency, and climate migration

Recent policy discussions and social science research define gender as the socially constructed roles, identities, relations, and behaviors that apply to men, boys, women, girls, and gender minorities and that influence people’s actions, levels of power, and access to, control over resources while varying over space and time (Gioli & Milan, 2018; IOM, 2015; IPCC, 2019). In other words, choices and opportunities are shaped partly by the socially defined categories of ‘man,’ ‘woman,’ and people with other gender identities (e.g., third gender). However, there is some confusion regarding the definition of gender in the climate change and migration literature. While many scholars have focused on one definition or the other, some studies focus on gender as biological differences or a wider social construct or using both (Bircan & Yilmaz, 2022). In this review, we choose to explore gender from mixed views that incorporate sociocultural contexts as well as biological differences because these two aspects are

directly mentioned in some gender studies (Bircan & Yilmaz, 2022; Connelly & Barriteau, 2000).

In migration, agency refers to individuals' active role in shaping their migration choices and outcomes, exercising their freedom and control in response to their circumstances (Czaika et al., 2021) (as discussed in section 2.5.2 of Chapter 2). It encompasses intentional behaviors, such as bargaining, negotiating, rebellion, resistance, and protest, demonstrating an individual's capacity to confront constraints (Emirbayer & Mische, 1998). Our review will delve into the concept of agency within the context of gender and climate migration. We will also explore individuals' aspirations and capabilities to migrate or stay in the face of climate change. By exploring the motivations behind individuals' aspirations for migration or staying in place and the factors that limit their capabilities to pursue their goals and aspirations, we aim to uncover the complexities of agency in gender and climate migration studies. By doing so, we aim to gain insights into the complexities of agency in gender and climate migration studies, contributing to a better understanding of its role in shaping migration decisions and outcomes amidst climate migration.

This systematic review builds upon a part of the comprehensive conceptual framework developed in Chapter 2 (See Figure 15), illustrating the relationships between climate change and migration decisions and patterns. We utilize this framework to develop our assessment and incorporate critical elements of climate migration. Furthermore, we incorporate articles from diverse fields and disciplines, such as human geography, vulnerability, adaptation, and feminist political ecology, and analyze them across dimensions like (non)migration, spatial, temporal, and agency and identified mediating factors. Our review uniquely contributes by cross-cutting data analysis from different climate change and migration domains. We specifically focus on understanding the underlying mediating factors behind diverse migration responses among men, women, and gender minority individuals.

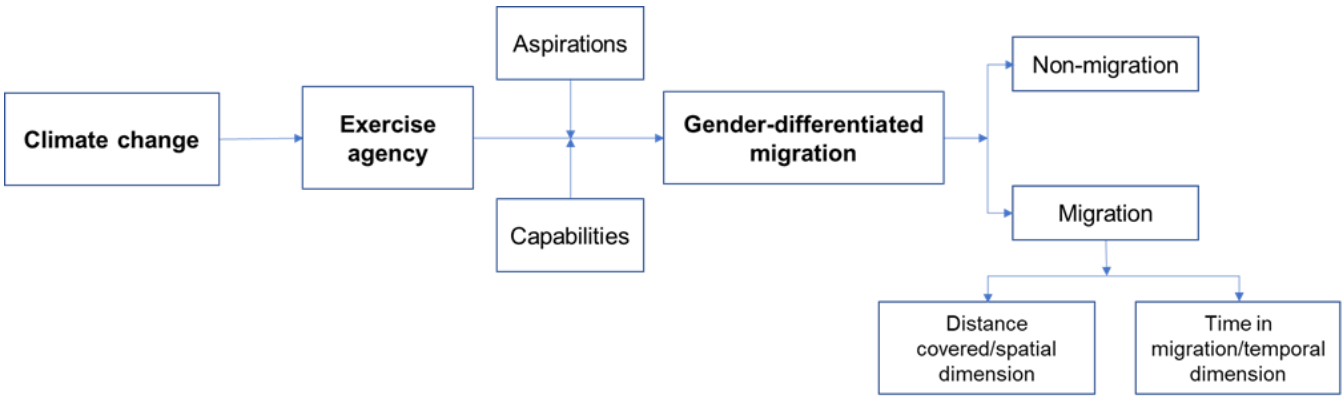


Figure 15: Conceptual framework on relations between climate change and migration decisions

This systematic review is structured as follows: In the methods section (4.2), we provide detailed information on our search strategy, screening process, and criteria for the inclusion and exclusion of studies. The results section (4.3) examines the main

migration responses and patterns under different climatic situations, explicitly focusing on gender-differentiated responses. We highlight the range of issues that can either converge or diverge migration responses, emphasizing the gendered characteristics of these migrations. The findings drawn from our review shed light on how various issues are recognized and addressed in the empirical literature. We aim to inform scholars and experts working to comprehend the complexity of climate migration by ensuring they are aware of the diverse theories driving research in this field, particularly concerning the gendered dimensions of climate migration.

Furthermore, we conducted a bibliographic coupling analysis to explore the extent to which different disciplinary paradigms inform one another in the study of gender and climate migration. This analysis facilitates future interdisciplinary research, contributing to developing a more inclusive theoretical framework to study gender dynamics in climate migration. Additionally, we discuss the empirical methods used in analyzing gender and climate migration, specifically focusing on incorporating gender data and its impact on the interpretation of findings. In the discussion section (4.4.1), based on identified mediating factors, we offer insights into the pathways through which gendered inequality in climate migration occurs. We also highlight gaps in the existing literature and consider the potential for future inter- or trans-disciplinary research and practical adaptation strategies to address and mitigate these inequalities (section 4.4.2). By comprehensively understanding the gendered dimensions of climate migration, we can contribute effectively to climate adaptation strategies.

4.2 Methods

We performed a systematic review of published peer-reviewed literature covering gender as a determinant that shapes migration decisions in the context of climate change in the South Asian region. Systematic reviews have become increasingly helpful and considered best practices for comprehending the current state of the evidence in a specific field (Munn et al., 2018a; Siddaway et al., 2019). A systematic review identifies and retrieves transnational evidence pertinent to a specific question or set of questions. In other words, a systematic review aids in identifying the global evidence, confirming current practices, addressing variations, identifying new practices, examining results that are in conflict, identifying and guiding future research areas, and producing statements to aid in decision-making (Aromataris & Pearson, 2014; Munn et al., 2018b). Thus, the systematic review findings can help understand and inform evidence-based policy and practice for eliminating gender-based inequalities and injustice in climate migration, identify gaps, and address further research.

All review steps were performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2021). To demonstrate a literature review's novelty and replicability, transparent and rigorous reporting is crucial (Sovacool et al., 2018). This allows readers to evaluate significant aspects of the methodological quality of the review and its credibility (Page

et al., 2022; Snyder, 2019). The most recent PRISMA 2020 is considered best-practice guidelines that help to conduct a systematic review more clearly, transparently, and with sufficient details (Page et al., 2021). Consequently, contribute to a thorough and accurate reporting of systematic reviews and improves the use of evidence in decision-making.

We used the PICO framework to develop our research question and search strategy, where, Population (P) is individuals involved in or affected by a migration decision, Intervention/Issue/Exposure (I) is climate change, comparison (C) is gender, and outcome of interest (O) is migration decisions/response. Formulating a focused question with clearly stated PICO components is essential to discover high-quality evidence and making evidence-based decisions effectively (Eriksen & Frandsen, 2018; Schardt et al., 2007). Furthermore, in environmental research, empirical evidence has demonstrated that the application of PICO frames enhances the specificity and conceptual clarity of issues and elicits more information, leading to more sophisticated search strategies and producing more accurate search results (Booth et al., 2019; Homar & Cvelbar, 2021; James et al., 2016).

4.2.1 Search strategy

While reporting the search strategy of a systematic review, it is crucial to provide detailed search methods and information sources in a transparent and reproducible way (Harari et al., 2020; Rethlefsen et al., 2021). Here we provide a precise search strategy following the reporting guidelines for search in a systematic review (Rethlefsen et al., 2021).

We performed a search on five electronic databases, Web of Science, Scopus, CliMig, GenderWatch, and Wiley Online Library, without time or language restriction. We used a Boolean search strategy combining relevant terms for the three core concepts “climate change,” “gender,” and “migration,” which were informed by the conceptual framework (Figure 15), relevant reviews such as (Hoffmann et al., 2020; Thorne et al., 2019; Yates et al., 2022), and our exploration and understanding of the literature to ensure broad coverage. Table 17 outlines the permutations of each search term categorized under three concepts, and the search was conducted across (OR) and down (AND) with relevant key search terms of the three core concepts. Supplementary Table E contains the complete replicable search strategy, including search strings for each database.

To test the search strategy, we conducted several preliminary pilot searches from November 2021 to February 2022. Pilot searches revealed many irrelevant studies related to, for example, medicine, engineering, and examining other species, birds, and animal migration in the context of climate change, which led to further refining of searches (e.g., adding NOT “species” NOT “bird*” and other irrelevant terms) in each selected database to keep search results manageable. The actual search was conducted on 12 March 2022. We conducted a forward and backward screening of all included full-text and relevant articles to locate new studies that met the inclusion

criteria. After screening for eligibility, we looked through the relevant studies' bibliographies. In addition, we reviewed the bibliographies of recently published reviews related to gender and climate migration, such as (Kaczan & Orgill-Meyer, 2020; Lama et al., 2021) and identified further studies for screening.

Table 17: Search terms

Concept 1: Climate Change	"climate change" OR "climatic change*" OR "climate variability" OR "weather-related event*" OR "global warming" OR "greenhouse effect*" OR "weather event" OR "environmental change" OR "climate disaster" OR "natural hazard" OR "natural disaster" OR "slow onset" OR "slow-onset" OR "sudden onset" OR "sudden-onset" OR "rapid onset" OR "extreme weather" OR "flood*" OR "cyclone" OR "storm surge" OR "typhoon" OR "hurricane" OR "coastal erosion" OR "riverbank erosion" OR "drought" OR "heat*" OR "heat-wave" OR "temperature" OR "wildfire" OR "desertification" OR "sea level rise" OR "sea-level rise" OR "rainfall*" OR "precipitation" OR "water stress" OR "water scarcity" OR "water insecurity" OR "water security" OR "water availability" OR "salinity intrusion" OR "warming ocean" OR "ocean acidification" OR "climate vulnerability"
Concept 2: Gender	"gender" OR "woman*" OR "man*" OR "male" OR "female" OR "boy" OR "girl" OR "mother*" OR "father*" OR "wife*" OR "husband*" OR "femini*" OR "masculin*" OR "caregiver" OR "caregiving" OR "breadwinner" OR "breadwinning" OR "transgender" OR "intersex" OR "nonbinary" OR "non-binary"
Concept 3: Migration	"migration" OR "human migration*" OR "displace*" OR "relocate" OR "relocation" OR "resettlement" OR "planned relocation" OR "move*" OR "mobility" OR "immobi*" OR "floating population" OR "trapped population" OR "population movement" OR "migrate" OR "migrant*" OR "immigra*" OR "refugee*"
Search strategy	Concept 1 AND Concept 2 AND Concept 3

Note: * Truncated term

The initial search identified 7,274 studies: 2,796 through Web of Science, 3,719 through Scopus, 84 through CliMig, 282 through GenderWatch, and 395 through Wiley Online Library. In addition, 695 records were identified through citation searching: 493 on Scopus and 186 on Web of Science, and 12 through a bibliography review of the existing climate migration reviews. Covidence Systematic Review Software (Covidence v2.0, n.d.) automatically removed 3,193 duplicate records and later, we manually removed 134 more duplicates.

4.2.2 Inclusion and exclusion

After removing 3,027 duplicates, this review included 4,247 unique references for further screening. Articles were considered eligible for inclusion if they evaluated the gendered aspects of climate migration. The screening and eligibility process applied a series of inclusion and exclusion criteria. We included studies if they fulfilled the following inclusion criteria:

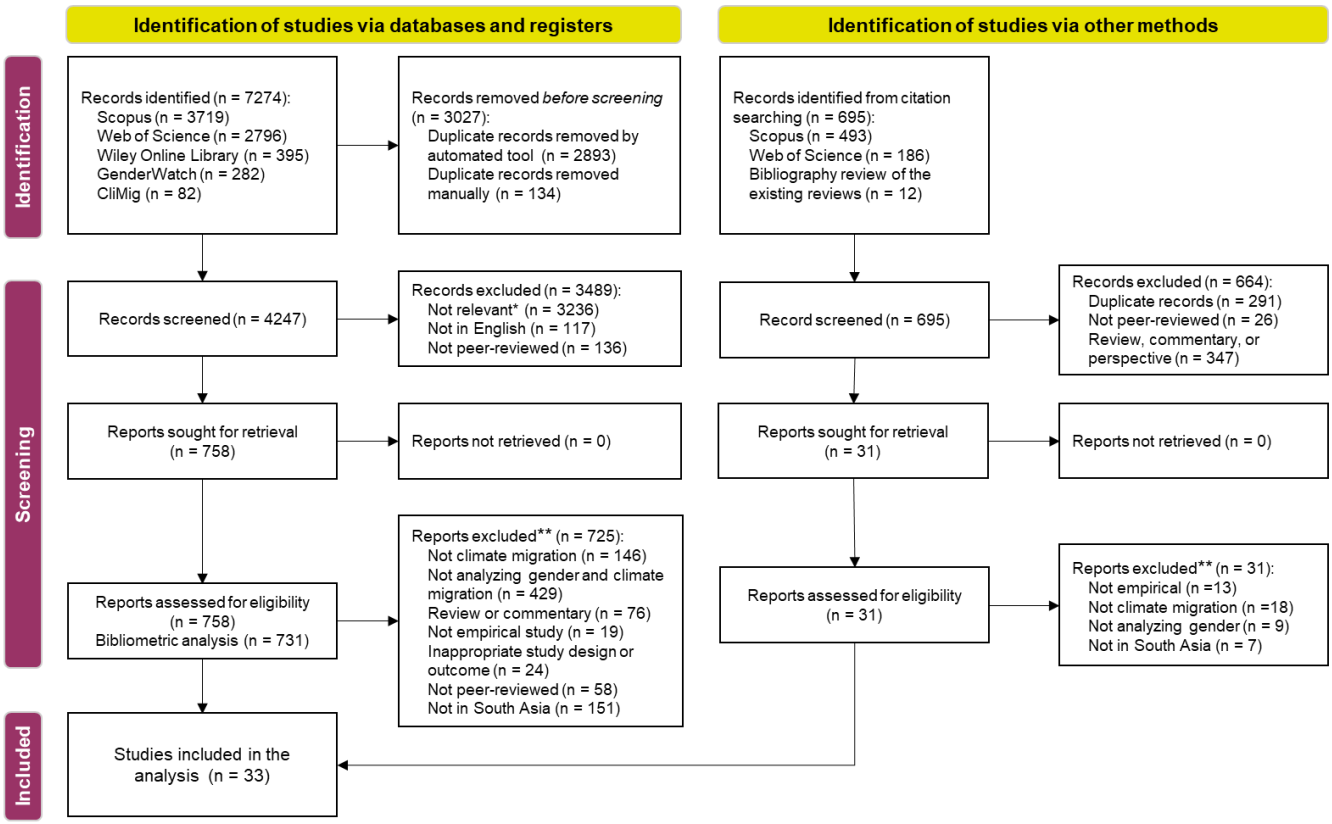
1) The study relied on empirical analysis, whether qualitative, quantitative, or mixed.
2) The study identified associations between gender and migration under any climatic event.
3) The study was conducted within the geographic location of South Asia

4) Only peer-reviewed, and
5) The document was available in English.

We excluded studies at two stages of screening. First, we screened the title, abstracts, and keywords of identified records to exclude irrelevant records (n = 3,236), for example, those not related to climate change, medicine, disease, legal, policy discussions, planning, transportation, or studies on other species and animals' migration, and records that are not peer-reviewed (n = 136). We also excluded studies not in English (n = 117) at this stage. As a next step, we screened full texts of the remaining potentially eligible records (n = 758) and removed further irrelevant records (n = 725) from the selection, applying our pre-specified inclusion criteria. The exclusion reasons after full-text review were as follows: a) the study focused on climate change and migration but did not discuss gender (n = 429); b) the study focused on either gender and migration or gender and climate change (e.g., only resilience, vulnerability or adaptation), but not focused on climate migration (n = 146); c) review, perspective or commentary (n = 76); d) not peer-reviewed further identified during the full-text review (n = 58); e) not empirical study (e.g., conceptual or modelling) (n = 19); f) inappropriate study design or outcome (i.e., do not present relationship or consequence) (n = 24); and g) not in South Asia (n = 151). Following the same procedure, we also screened and excluded the identified 695 records through citation searching and a bibliography review of the existing reviews, and this left 33 studies for data extraction and analysis. (Figure 16) represents the PRISMA flow diagram of the study inclusion process for this review.

4.2.3 Data extraction, analysis, and quality assessment

From the full text of 33 included studies, we extracted and analyzed the following elements: 1) author(s), publication year, title, journal name, aim, or main objective of the study; 2) the study settings, methods, details on data collection, study period, sample size, type of gender data analysis, and types of climatic exposures; 3) theoretical framework or approaches; 4) gender-related climate migration findings, including types of migration, distance covered, time duration and where possible, the agency involved; 5) other associated factors that shape migration decisions. Data were manually extracted to an Excel database and analyzed. The risk of bias or quality assessment was not applicable to this study due to the heterogeneity of studies and as we included all empirical study designs.



Note: * Not relevant (e.g., not related to climate change, related to legal, policy discussions, planning, energy, transportation, biodiversity, other species, plant, birds, insect, or animal study, etc.)
** Reasons for exclusion do not add up to the total as some categories overlap

Figure 16: PRISMA 2020 flow diagram (Page et al., 2021)

4.2.4 Bibliometric analysis

In transdisciplinary and interdisciplinary sustainability research, bibliometric analysis is becoming increasingly prevalent as a powerful tool to create a comprehensive picture of a given research field (Kajikawa et al., 2014; Leal Filho et al., 2021; Nielsen & Faber, 2021; Tejedor et al., 2018). Particularly in cases where a topic has a substantial body of literature and is rapidly evolving, bibliometric analysis enables a reliable methodology to generate a comprehensive picture that would be impossible for humans to execute manually without computer-assisted techniques (Kajikawa et al., 2007). To reveal further insights into the knowledge domains and their temporal dynamics of the evolving research fields, we conducted the bibliographic coupling analysis of sources to assess the relatedness of the published sources based on the number of shared references. Bibliographic coupling analysis can create a comprehensive picture, thus, helping to determine the patterns and ascertain whether insights from various fields are being acknowledged with each other or are instead situated in disciplinary siloes. As discussed elsewhere, this is crucial as failing to incorporate research from other disciplines could result in partial or inaccurate conclusions (Boyack & Klavans, 2010; Fanelli & Glänzel, 2013; Fanelli et al., 2017).

To analyze the bibliographic coupling, we used the full-counting algorithm network in VOSviewer 1.6.18 software tool and presented network overlay visualizations. The analysis was possible with the 731 eligible records because 27

records were not indexed on Scopus, where we extracted citation data from, and VOSviewer cannot analyze citation data from reference manager (e.g., Zotero) or systematic review tool (e.g., Covidence) files to identify citations, bibliographic coupling, or co-citation relationships between items (van Eck & Waltman, 2020).

4.3 Results

4.3.1 Overview of the selected studies

We first investigated the current state of the empirical research conducted in South Asian countries to comprehend the diversity of these study settings and climatic exposures. As mentioned in the method section, this review included thirty-three peer-reviewed articles investigating gender, climate change, and migration with different objectives. The core objectives of the selected studies include some overlapping topics related to drivers, factors, or perceptions of migration (n = 10), migration as a coping or adaptive mechanism (n = 9), gender and migration (n = 11), women and migration (n = 9), male out-migration (n = 2), livelihood resilience (n = 2), risk management (n = 2), vulnerability and adaptation (n = 2), and migration and well-being (n = 2). Key features and findings of the studies included are summarized in supplementary material F.

Figure 17 presents the number of selected studies by year and country. The number of studies investigating gender-related migration under climatic conditions in South Asia was steady from 2012 to 2018, with a sharp increase in 2019. The trend suggests an emergence in scholarly interest in the social phenomenon, possibly amplified by increased concerns (e.g., after the publication of The World Bank's Groundswell Report in 2018) and debates regarding the inclusion of gender in climate change adaptation as well as migration studies. However, in the years 2020 and 2021, the number of published empirical studies was comparatively less; this decline could be because of the COVID-19 pandemic. Bangladesh (n = 17) is the leading empirical study location, followed by India (n = 8), Pakistan (n = 3), Maldives (n = 2), and Nepal (n = 1). This is not a surprise that Bangladesh and India are dominant countries for empirical settings as these are among the most climate-vulnerable countries (Eckstein et al., 2021). In addition, two studies analyzed multiple countries: one on Pakistan, India, Nepal, and Bangladesh (Maharjan et al., 2021) and another on India, Nepal, and Bangladesh (Bhatta et al., 2015).

The precise geographic locations covered by the selected studies are presented in Figure 18. We find that studies are not spatially distributed evenly, and countries like Bhutan, Sri Lanka, and Afghanistan, which are heavily dependent on climate-sensitive sectors such as agriculture, are missing in the empirical investigations. This imbalance demonstrates the absence of research in countries that require it to support evidence-based decision-making. For example, according to the ND-GAIN Index score (2020), Sri Lanka and Afghanistan, both countries are among the most vulnerable to climate change and have the least capacity to respond to it. According to the IDMC’s Global Internal Displacement database, from 2008 to 2021, there were over 3.3 million

displacements in Sri Lanka and over 2 million in Afghanistan only due to weather-related events (IDMC, 2023). The absence of studies in these two countries means that these affected people's experiences and perspectives were not adequately represented in the evidence-based scholarly discussions on climate migration. This can result in a limited understanding of the gender and climate migration issues and may lead to solutions that do not fully address the needs and priorities of these countries and their communities.

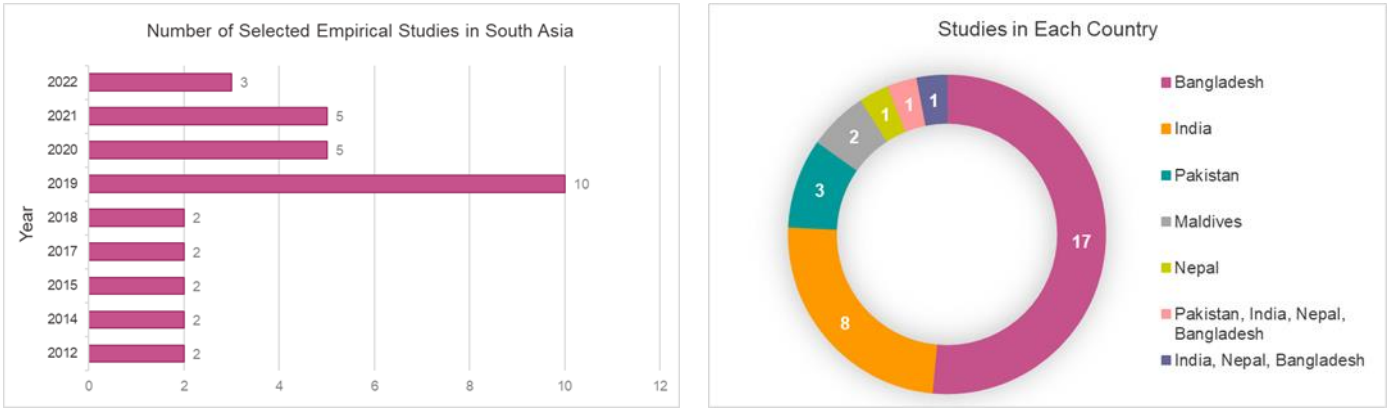


Figure 17: Number of selected studies in South Asia in each year (left) and country (right)

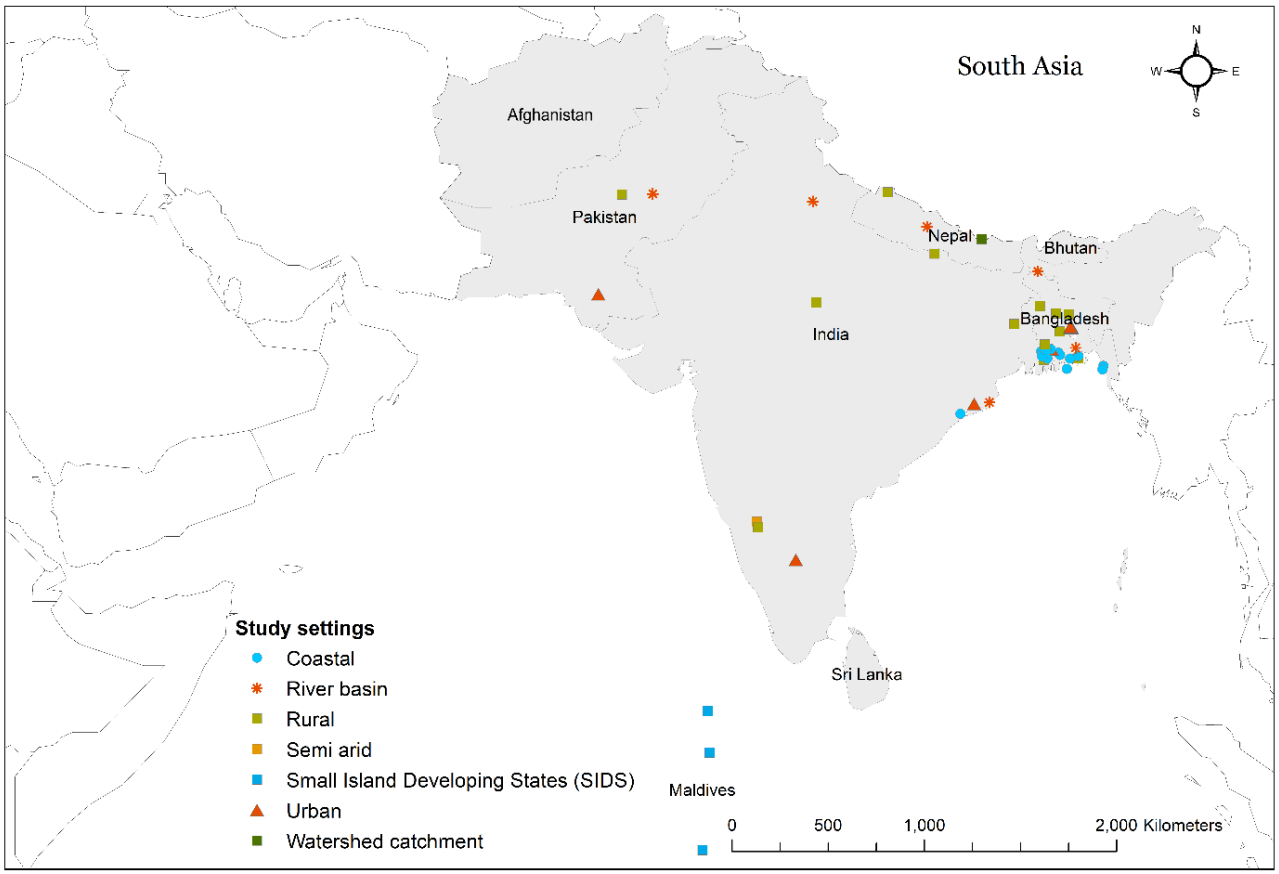


Figure 18: Geographic locations of selected empirical studies

In addition, we also investigated the settings and climatic exposures considered in these studies (Figure 19 left). Selected studies were conducted in varieties of settings, including coastal (n = 9), rural (n = 9), urban (n = 8), different river basins (n

= 4), semi-arid (n = 1), flood-affected areas (n = 1) and small and developing islands (SIDs) (n = 2).

Turning to climatic exposures, a myriad of climatic exposures is found to be causing migration in the South Asian region. Of these, cyclones (14.4%) and floods (14.4%) were the major events, mainly in Bangladesh and India (e.g., Ingham et al., 2019; Patel & Giri, 2019; Mallick, 2019), followed by rainfall variations (9.6%) (e.g., Ahmed & Eklund, 2021; Tiwari & Joshi, 2015), a decline in agricultural production (9.6%) (e.g., Gray & Mueller, 2012; Singh & Basu, 2020), saline intrusions (8.7%) (e.g., Boas et al., 2022b; Islam & Shamsuddoha, 2017), riverbank erosion (8.7%) (e.g., Ayeb-Karlsson et al., 2020), sea-level rise (5.8%) (e.g., Kelman et al., 2019), drought (5.8%) (e.g., Debnath & Kumar Nayak, 2021; Singh, 2019), storm surge (4.8%) and depletion of fishery resources (3.9%) (e.g., Khan et al., 2018; Lama, 2018) were the most critical exposures. We further categorized these climatic exposures into sudden/extreme-onset that emerge quickly or unexpectedly, slow-onset events, and natural resource risks, which emerge gradually and may appear less destructive at first (IDMC & UNFCCC, 2018). We find these studies mostly investigated sudden/extreme-onset events (44.83%) (e.g., cyclone, flood), as compared to slow-onset events (32.76%) (e.g., rainfall variations, sea-level rise) and natural resources risks (22.41%) (e.g., a decline in agricultural production, depleting of fishery resources) in various settings. The conceptualization and assessment of studies are affected by the relatively fluid borders between these categories, where exposures often vary from immediate to delayed threats (Figure 19 right). However, this categorization helps us better investigate the gendered migration under different climatic conditions in the next section.

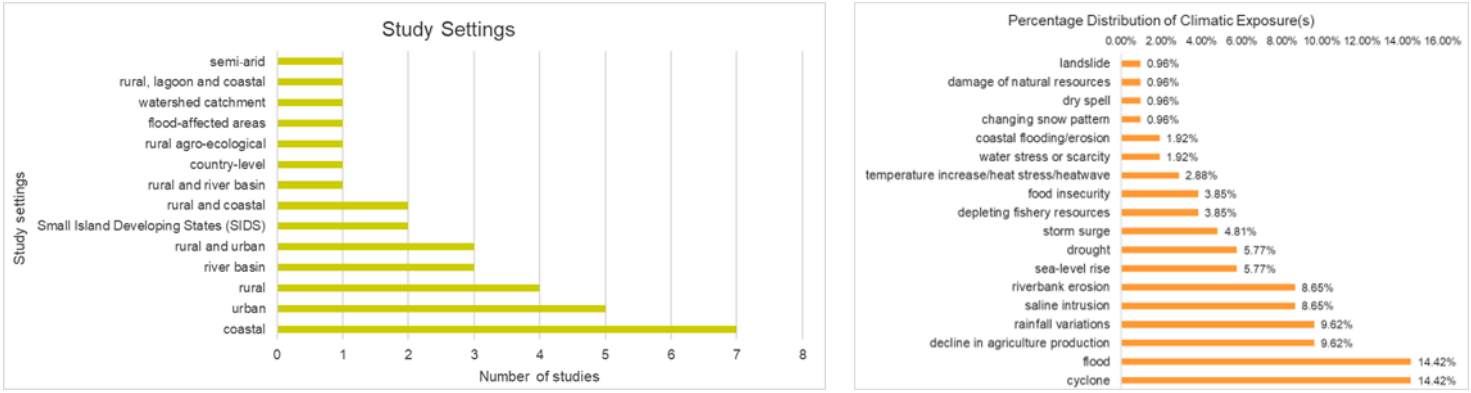


Figure 19: Study settings (left) and climatic exposure(s) (right) considered in selected studies

4.3.2 Characterizing gendered migration in response to climate change

It is essential first to investigate and recognize migration patterns that differ between men and women in the context of climate change and the role of various factors in shaping these patterns to understand gendered inequality in climate migration. Therefore, our first research question was to examine the differentiated migration responses observed between men, women, and gender minority individuals in a climate change context. To answer this question, we analyzed evidence on

differentiated migration responses between women and men under different climate-related events in different settings. We did not find any study targeting gender minority individuals; therefore, we could not consider them in our review. As guided by the conceptual framework developed to examine the relationship between climate change and migration (figure 15), we first investigated potential patterns in findings by comparing studies between women and men based on different dimensions: (1) migration versus non-migration responses; (2) distance covered in migration or spatial dimension; and (3) time duration or temporal dimension of migration.

4.3.2.1 Migration versus non-migration

Turning to the comparative analysis of migration versus non-migration, we find that migration responses of women and men are primarily similar across all countries and contexts. For example, 10 cases in Bangladesh, 9 cases in India, 4 cases in Pakistan, 3 cases in Nepal, and 2 cases in Maldives report that men mainly undertake migration due to climate change and women do not migrate.

In some cases, gender differences result from the gendered division of labor and roles in the study areas. For example, as providers of the family, men's primary reason for migrating was to seek employment opportunities due to a lack of consistent work (Ahmad et al., 2019; Akter et al., 2019; Boas et al., 2022b; Ingham et al., 2019; Islam & Shamsuddoha, 2017). Women did not migrate due to household responsibilities, such as cooking and taking care of children and family (Ahmad et al., 2019; Akter et al., 2019; Boas et al., 2022b; Ingham et al., 2019; Islam & Shamsuddoha, 2017; Khan et al., 2018; Chowdhury et al., 2021; Tiwari & Joshi, 2015), and in some cases do agricultural work (Gautam, 2017; Gioli et al., 2014). Sociocultural norms, expectations, and obligations also cause women to migrate less (Chowdhury et al., 2021; Singh, 2019). For example, Chowdhury et al. (2021) conducted a study in flood-prone regions of India and found that women who adhere to conservative practices such as veiling their faces are less inclined to travel or migrate.

Although historically, migration has been predominantly a male activity, several studies (61%) also report an increase in women's migration due to climatic conditions. For instance, Gray & Mueller's (2012) longitudinal study conducted in Bangladesh found that women's mobility increased by 178% during severe crop failure caused by flooding, while men's mobility increased by 91% (Gray & Mueller, 2012). Similarly, Mueller et al. (2014) used a 21-year longitudinal survey in rural Pakistan and found that temperature significantly affected women's and men's migration. Women were twice as likely to migrate, and men were 11 times more likely to migrate when exposed to a higher temperature.

However, the patterns and reasons for women's migration in response to climate change vary. For example, Patel & Giri (2019) identified that women migrate due to changing weather, a lack of agricultural work, and the absence of alternative employment opportunities in their place of origin. Regarding migration patterns, some women migrate with their families, conforming to social norms (Prati et al., 2022; Singh,

2019; Singh & Basu, 2020). In contrast, others migrate after their husbands have settled in their destination and found stable livelihood opportunities (Ahmed & Eklund, 2021; Boas et al., 2022b; Islam & Shamsuddoha, 2017). Women also migrate immediately with their families after natural disasters when there are insufficient resources and no other earning options (Amjad, 2019; Evertsena & Geest, 2019; Memon, 2021; Sams, 2019).

It is also visible that marginalized women, including single mothers, widowed women, and girls, migrate to urban areas to seek employment opportunities (Akter et al., 2019; Evertsena & Geest, 2019; Hasnat et al., 2020; Khan et al., 2018). However, the available studies do not provide clear evidence on whether these women and girls migrate at higher rates compared to married women. In some cases, discrimination and physical and/or sexual violence often force these women to migrate (Akter et al., 2019; Hasnat et al., 2020). Caste identity also mediates patterns of total women out-migration in response to the growing environmental crisis in India (Khan et al., 2018; Singh, 2019). Finally, Carrico et al. (2020) observed that climatic events like heatwaves or drought increase women's forced/voluntary marriage and marriage-related migration due to increased poverty in rural Bangladesh. Table 18 conveys the different dimensions of men's and women's migration responses under different climatic exposures.

Table 18: Differences observed between men's and women's migration across different dimensions under different climatic exposures

Dimensions of Migration	Evidence No. of studies n (%) *	Categories of climatic exposures	
		Extreme or sudden onset	Slow onset or natural resource risks
Migration	Men **n = 28 (84.9%)**	**n = 19** Ahmed & Eklund (2021); Ahmad et al. (2019); Akter et al. (2019); Ayeb-Karlsson et al. (2020); Ayeb-Karlsson (2020); Bhatta et al. (2015); Boas et al. (2022b); Gray & Mueller (2012); Hasnat et al. (2020); Ingham et al. (2019); Islam & Shamsuddoha (2017); Khan et al. (2018); Maharjan et al. (2021); Mallick (2019); Mueller et al. (2014); Patel & Giri (2019); Prati et al. (2022); Chowdhury et al. (2021); Sams (2019)	**n = 15** Ahmed & Eklund (2021); Ahmad et al. (2019); Bhatta et al. (2015); Boas et al. (2022b); Debnath & Kumar Nayak (2021); Gautam (2017); Kelman et al. (2019); Khan et al. (2018); Lama (2018); Mallick & Vogt (2012); Mallick et al. (2022); Patel & Giri (2019); Prati et al. (2022); Singh & Basu, 2020; Singh (2019); Tiwari & Joshi (2015)
	Women **n = 20 (60.6%)**	**n = 16** Amjad (2019); Ayeb-Karlsson et al. (2020); Ayeb-Karlsson (2020); Boas et al. (2022b); Carrico et al. (2020); Evertsena & Geest (2019); Gray & Mueller (2012); Gioli et al. (2014); Hasnat et al. (2020); Islam & Shamsuddoha (2017); Maharjan et al. (2021); Mallick (2019); Memon (2021); Mueller et al. (2014); Patel & Giri (2019); Sams (2019)	**n = 9** Amjad (2019); Boas et al. (2022b); Evertsena & Geest (2019); Islam & Shamsuddoha (2017); Kelman et al. (2019); Khan et al. (2018); Patel & Giri (2019); Singh & Basu, 2020); Singh (2019)

Dimensions of Migration		Evidence No. of studies n (%) *	Categories of climatic exposures	
			Extreme or sudden onset	Slow onset or natural resource risks
Non-migration		Men **n = 0 (0%)**	**n = 0**	**n = 0**
		Women **n = 18 (54.6%)**	**n = 12** Akter et al. (2019); Bhatta et al. (2015); Boas et al. (2022b); Gioli et al. (2014); Hasnat et al. (2020); Ingham et al. (2019); Islam & Shamsuddoha (2017); Khan et al. (2018); Maharjan et al. (2021); Mallick (2019); Prati et al. (2022); Chowdhury et al. (2021)	**n = 11** Bhatta et al. (2015); Boas et al. (2022b); Gautam (2017); Hasnat et al. (2020); Khan et al. (2018); Lama (2018); Mallick & Vogt (2012); Mallick et al. (2022); Prati et al. (2022); Singh (2019); Tiwari & Joshi (2015)
Distance covered in migration	**Short distance (Internal)**	Men **n = 26 (78.8%)**	**n = 18** Ahmad et al. (2019); Ahmed & Eklund (2021); Akter et al. (2019); Ayeb-Karlsson et al. (2020); Ayeb-Karlsson (2020); Bhatta et al. (2015); Boas et al. (2022b); Evertsena & Geest (2019); Gioli et al. (2014); Hasnat et al. (2020); Ingham et al. (2019); Islam & Shamsuddoha (2017); Mallick & Vogt (2012); Maharjan et al. (2021); Mallick (2019); Patel & Giri (2019); Prati et al. (2022); Sams (2019)	**n = 16** Ahmad et al. (2019); Ahmed & Eklund (2021); Bhatta et al. (2015); Boas et al. (2022b); Debnath & Kumar Nayak (2021); Evertsena & Geest (2019); Gautam (2017); Hasnat et al. (2020); Islam & Shamsuddoha (2017); Khan et al. (2018); Kelman et al. (2019); Lama (2018); Patel & Giri (2019); Singh & Basu (2020); Singh (2019); Tiwari & Joshi (2015)
		Women **n = 20 (60.6%)**	**n = 15** Akter et al. (2019); Amjad (2019); Ayeb-Karlsson et al. (2020); Ayeb-Karlsson (2020); Boas et al. (2022b); Carrico et al. (2020); Evertsena & Geest (2019); Gioli et al. (2014); Gray & Mueller (2012); Islam & Shamsuddoha (2017); Mallick (2019) Memon (2021); Mueller et al. (2014); Patel & Giri (2019); Sams (2019)	**n = 9** Boas et al. (2022b); Evertsena & Geest (2019); Hasnat et al. (2020); Islam & Shamsuddoha (2017); Kelman et al. (2019); Khan et al. (2018); Patel & Giri (2019); Singh (2019); Singh & Basu (2020)
	Long-distance (International)	Men **n = 8 (24%)**	**n = 6** Gray & Mueller (2012); Hasnat et al. (2020); Maharjan et al. (2021); Mallick (2019); Mueller et al. (2014); Patel & Giri (2019)	**n = 4** Gautam (2017); Hasnat et al. (2020); Patel & Giri (2019); Tiwari & Joshi (2015)
		Women **n = 1 (3%)**	**n = 0**	**n = 1** Hasnat et al. (2020)
Time in migration	**Short-term/seasonal/circular (3 to 12 months)**	Men **n = 22 (67%)**	**n = 15** Ahmad et al. (2019); Ahmed & Eklund (2021); Akter et al. (2019); Ayeb-Karlsson et al. (2020); Ayeb-Karlsson (2020); Bhatta et al. (2015); Boas et al. (2022b); Gioli et al. (2014); Ingham et al. (2019); Maharjan et al. (2021); Mallick & Vogt (2012); Mallick (2019); Memon (2021); Prati et al. (2022); Sams (2019)	**n = 11** Ahmad et al. (2019); Ahmed & Eklund (2021); Bhatta et al. (2015); Boas et al. (2022b); Debnath & Kumar Nayak (2021); Gautam (2017); Hasnat et al. (2020); Lama (2018); Singh & Basu (2020) Singh (2019); Tiwari & Joshi (2015)
		Women **n = 2 (6%)**	**n = 0**	**n = 2** Hasnat et al. (2020); Khan et al. (2018)
	Long-term or permanent	Men **n = 20 (61%)**	**n = 15** Ahmad et al. (2019); Akter et al. (2019); Ayeb-Karlsson et al.	**n = 8** Boas et al. (2022b); Evertsena & Geest (2019); Gautam (2017);

Dimensions of Migration	Evidence No. of studies n (%) *	Categories of climatic exposures	
		Extreme or sudden onset	Slow onset or natural resource risks
		(2020); Ayeb-Karlsson (2020); Boas et al. (2022b); Evertsena & Geest (2019); Gioli et al. (2014); Islam & Shamsuddoha (2017); Khan et al. (2018); Mallick & Vogt (2012); Maharjan et al. (2021); Mallick (2019); Mueller et al. (2014); Prati et al. (2022); Sams (2019)	Hasnat et al. (2020); Islam & Shamsuddoha (2017); Singh et al. (2020); Singh (2019); Tiwari & Joshi (2015)
	Women **n = 12 (36%)**	**n = 9** Akter et al. (2019); Ayeb-Karlsson et al. (2020); Ayeb-Karlsson (2020); Carrico et al. (2020); Evertsena & Geest (2019); Islam & Shamsuddoha (2017); Mallick (2019); Patel & Giri (2019); Sams (2019)	**n = 5** Evertsena & Geest (2019); Hasnat et al. (2020); Islam & Shamsuddoha (2017); Singh & Basu (2020); Singh (2019)

Note: * The number and percentage do not add up to the total and 100%, as some studies covered multiple climatic exposures and dimensions of migration

4.3.2.2 Distance covered in migration or spatial dimension

Regarding migration distance, in studies that discussed distance covered in migration, most of these studies (79%) report that men mainly migrate short distances within the country (or internally), mainly from rural to urban areas due to climatic reasons. However, 24% of the studies, including three in Bangladesh, three in India, one in Pakistan, and one in Nepal, report some incidences of men covering long distances and migrating internationally.

On the other hand, many studies report that women were not migrating. Among those that described distance for women, 61% of the studies, which includes eleven in Bangladesh, six in India, two in Pakistan (Memon, 2021; Mueller et al., 2014), and one in Maldives (Kelman et al., 2019) found that women tend to migrate internally and cover short distances from rural to urban areas as an adaptation strategy. It is worth noting that only one study (3%) conducted in coastal Bangladesh by Hasnat et al. (2020) reports instances of women undertaking international migrations due to climate change. The study reports that fewer women could migrate internationally because of family-based and social barriers that prevent them from migrating like men.

4.3.2.3 Time in migration or temporal dimension

Turning to the temporal dimension of migration, we find that men in all studied countries (67%) mainly undertake short-term, seasonal, or circular (or repetitive) forms of migration and, in some cases (61%), migrate for the long term or permanently. We note that the duration of men's migration mainly depends on three aspects. First, men who need to migrate due to seasonal or slow-onset events and migrate without their families usually undertake short-term, seasonal, or circular forms of migration (Ahmed & Eklund, 2021; Ahmad et al., 2019; Akter et al., 2019; Bhatta et al., 2015; Boas et al., 2022b; Debnath & Kumar Nayak, 2021; Gautam, 2017; Gioli et al., 2014; Ingham et al., 2019; Islam & Shamsuddoha, 2017; Lama, 2018; Maharjan et al., 2021; Mallick &

Vogt, 2012; Prati et al., 2022; Sams, 2019; Singh, 2019; Singh & Basu, 2020; Singh et al., 2020; Tiwari & Joshi, 2015). Second, if the entire family - including women household members - migrate with men, their migration typically becomes a long-term or permanent form (Boas et al., 2022b; Evertsena & Geest, 2019; Hasnat et al., 2020; Islam & Shamsuddoha, 2017; Mallick, 2019; Sams, 2019; Singh, 2019). Third, if men migrate long distances or internationally, they tend to migrate for a long term or sometimes permanently (Gautam, 2017; Gioli et al., 2014; Hasnat et al., 2020; Maharjan et al., 2021; Mallick, 2019; Mueller et al., 2014; Tiwari & Joshi, 2015). However, it is important to note that the studies reviewed did not clearly distinguish the migration patterns of specific subgroups of men, including single men, single fathers, and married men.

On the other hand, most studies (36%) that report women's migration revealed that women primarily undertake long-term or permanent migration. The reason is similar to men's long-term migration because women often migrate with male household members and family primarily due to extreme climate catastrophes such as flooding, riverbank erosion, or cyclones (Ayeb-Karlsson et al., 2020; Islam & Shamsuddoha, 2017; Mallick, 2019). However, a small percentage of studies (6%) report that women, particularly single women, migrate for the short term (Hasnat et al., 2020; Khan et al., 2018).

Our findings support the idea that migration is primarily a male-dominated adaptation strategy to climate change (Djoudi et al., 2016). However, our study indicates that both men and women may undertake different forms of migration in response to climate change, depending on their unique circumstances and needs. We find that the difference between men's and women's migration is not only shaped by gender roles, relations, and division of labor in the households but also by other factors such as dependency on agricultural income, marital status, social norms, caste identity, and social security. We also find that the categories of climatic exposures, whether extreme/sudden-onset events, slow-onset events, or natural resource risks, also play significant roles in shaping women's migration. Our findings imply that the way these climatic events are conceptualized matters. For example, those focusing on extreme/sudden-onset events are more likely to find evidence of women's migration than those focusing on slow-onset events.

4.3.3 Gender-differentiated agency in migration decisions

Our third research question explores the role of agency in men's and women's migration and non-migration decisions in response to climate change (for the definition of agency, see section 4.1.1 and Chapter 2, section 2.5.2). Understanding agency is key as this helps to differentiate between forced and voluntary migration/non-migration. However, few studies have addressed this crucial aspect.

Some studies provide insights into the agency aspect of migration, either directly or indirectly. However, these studies have used different terms to refer to agency. For example, some studies used the term "agency" (Akter et al., 2019; Boas et al., 2022b;

Evertsena & Geest, 2019; Mallick & Joachim, 2012; Patel & Giri, 2019; Singh & Basu, 2020), while others used alternative terms. In one study on flood-related migration in Bangladesh, Ingham et al. (2019) used the term “forced” to describe the lack of “agency” that men and women experienced under flooding conditions. They found that men were forced to leave their villages because of the lack of reliable work opportunities and were able to secure physically demanding but relatively stable jobs that paid better than local employment. Women and children stayed behind because they believed men’s remittances were necessary for their family’s survival (Ingham et al., 2019). Similarly, a study by Memon (2021) focused on women who had migrated to a city in Pakistan after a flood in 2010, using retrospective questions and also using the term "forced" to give insight into the lack of “agency.” This study described that flood forced both men and women, along with their families, to leave the flood zones at any cost.

The study by Patel & Giri (2019) focused on women from coastal regions of Odisha who migrated due to periodic floods and catastrophic weather events. They explicitly used “agency” and found that husbands were the primary influencers in migration decisions. However, in some cases, women were also involved in decision-making, particularly those from “Scheduled Caste” groups. Migration allows them to exercise agency and obtain construction work in urban areas. Singh & Basu (2020), who studied rural-urban migration in Karnataka, India, found that patriarchal norms influence women’s participation in decision-making processes. Islam & Shamsuddoha (2017) and Mallick & Vogt (2012) concluded that both men and women lack agency and choice in decision-making after extreme-onset events (e.g., cyclones) in rural Bangladesh. Surprisingly, Evertsena & Geest (2019) and Boas et al. (2022b) found that migrating women of all categories (i.e., married women, divorced or widowed, and young unmarried) exercise strong agency in rural-urban migration in Bangladesh. In some cases, female household members (i.e., mother, sister, or wife) took the initiative to migrate (Evertsena & Geest, 2019) or not migrate (Boas et al., 2022b).

4.3.3.1 Aspirations for migration and non-migration

The aspirations and capabilities framework is built upon identifying intrinsically complex notions of migration aspirations. However, some studies have captured these aspirations using different terminology, much like the concept of “agency.” For instance, some studies have used the term “motivations” to refer to the reasons for migration or non-migration (Akter et al., 2019; Evertsena & Geest, 2019; Mallick et al., 2022; Memon, 2021). In coastal Bangladesh, for example, studies have shown that female household members, due to their role in caregiving, social networks, and financial stability, expressed a strong sense of belonging or attachment to their homes and communities and indicated higher motivations for non-migration than male members (Akter et al., 2019; Boas et al., 2022b; Mallick et al., 2022). Conversely, women migrants in urban areas of Pakistan were found to be driven by employment and health concerns, and these amenities motivate them to reside permanently (Memon, 2021). Additionally, gendered opportunities (e.g., readymade garments,

housemaids) and higher wages are found to motivate more women to migrate (Evertsena & Geest, 2019; Hasnat et al., 2020).

Kelman et al. (2019) conducted a study in the Maldives to examine how people's perceptions of climate change, specifically sea-level rise, influenced their migration decisions. They used the terms "consider" and "desire" to describe the likelihood or aspirations for migration. Their findings revealed that men were more likely than women to consider migration in response to climate change, and they also expressed a greater need to migrate to cope with the changing environment. Conversely, women were more likely than men to desire to migrate for better access to facilities such as healthcare and schools (Kelman et al., 2019).

4.3.3.2 Capabilities for migration and non-migration

Migration is often associated with costs, which makes it challenging for poor people to bear these costs, irrespective of gender. Ingham et al. (2019) identified that the "poorest of the poor" are unable to migrate due to a lack of resources. When making migration-related decisions, individuals need to consider several factors, such as the high living costs in destination areas and choosing suitable destinations (Ingham et al., 2019; Prati et al., 2022). Often, family members need to negotiate on who migrates and who stays. Marketable skills or a wide range of occupational skills can enable migration and restrict people from doing so (Mallick & Vogt, 2012; Ingham et al., 2019; Patel & Giri, 2019; Chowdhury et al., 2021). For example, during floods in Bangladesh, the possibility of making a living is severely limited because the land is often inundated, fisheries are destroyed, and healthy adult men migrate to cities to work as day laborers (e.g., bricklayers and rickshaw pullers) while women and children remain in villages to protect themselves (Ingham et al., 2019).

In India, two studies report that women's limited access to alternative employment opportunities and resources restricts their ability to acquire advanced skills for better job opportunities and limits their migration capabilities (Patel & Giri, 2019; Chowdhury et al., 2021). Social safety and securities also influence the differentiated migration capabilities of men and women. For example, two studies in Bangladesh notably report that both women and men do not feel it is safe for women to migrate alone to cities (Boas et al., 2022b; Islam & Shamsuddoha, 2017).

Taken as a whole, the evidence indicates that gendered differences in aspirations and capabilities in migration and non-migration decisions are not only shaped by intra-household relationship dynamics but also by surrounding determinants that influence such decisions, such as lack of resources, marketable skills, and safety concerns. While there is limited research on the interplay between gender with other migration determinants, the agency plays a significant role in producing gender inequalities regarding access to migration. Further studies using the aspirations and capabilities framework could better capture the complex agency involved in migration decision-making, particularly under changing climatic conditions, and shed light on how it differs for men and women.

4.3.4 Theoretical development and disciplinary fields

Our third research question was related to the emerging theories that are in use to explain climate migration and gender linkage and how widely ideas are distributed among the disciplinary communities and fields. To answer this, we investigated the theoretical underpinnings of the included studies. However, it was apparent that there are diverse approaches to studying the gendered dimensions of climate migration, which reflects the diverse disciplinary fields investigating it. The more dominant overlapping research areas and disciplines, according to the published journal, include development studies, e.g., impacts, needs, planning, and priorities from global to local (n = 16), climate and or environmental change, disaster management, climate policy (n = 10), social science and humanities (n = 9), sustainability (n = 8), migration or mobility (n = 5), and geography (n = 5).

Theoretical approaches to understanding the linkages between climate change, migration, and gender exhibit diversity. It is worth noting that many studies (n = 17) were conducted without a clear theoretical foundation. These studies relied either on various concepts as loose guidance or solely on empirical analysis. However, among the remaining studies, several theoretical perspectives were applied. These included intersectional approaches (n = 4), relational approaches (n = 1), feminist standpoint epistemology (n = 1), political ecology and intersectional ecofeminist approaches (n =1), pluralism in studying gender dynamics approach (n = 1), sustainable livelihood approach (n = 3), psychology (n = 2), livelihood resilience in socio-ecological systems (n = 1), linguistic approach (n = 1) and the new economics of labor migration (n = 1). These diverse theoretical frameworks provide valuable lenses through which researchers analyze and interpret the complex interplay between climate change, migration, and gendered dimensions.

The adopted theories helped researchers structure their findings and better understand the gendered migration responses to climate conditions. Although these theories emerged from diverse disciplines and fields, they share some common perspectives and have their advantages. For example, studies that used intersectional pluralism in studying gender dynamics, feminist standpoint epistemology, political ecology, and ecofeminist approaches (e.g., Ahmed & Eklund, 2021; Akter et al., 2019; Boas et al., 2022b; Khan et al., 2018; Prati et al., 2022; Singh, 2019), focused on understanding the complexity of gender dynamics in the broader contexts of socio-political, economic, cultural, and ecological transformations that influence migration. These interdisciplinary studies have made notable contributions to exploring the nuanced aspects of gender and agency in migration decision-making within the context of climate change. They offer valuable insights into the diverse ways in which gender influences migration decisions and patterns, considering the complex interplay of socio-cultural, political, economic, and ecological factors. These studies highlight that gender differences in climate migration are not homogeneously distributed across populations and geographic locations, emphasizing the need to consider the specificities of different contexts.

Two studies that borrowed insights from psychology theories focus on individual or household-level cognitive processes to address the role of gender migration decision-making as protection motivation, risk appraisal, or adaptive response to environmental or climatic stressors (Evertsena & Geest, 2019; Mallick et al., 2022). These theoretical frameworks provide a deeper understanding of how individuals subjectively interpret migration as a means of adapting to climate change. They shed light on the role of gender and the subjective interpretation of migration, such as the sense of belonging (or place attachment), well-being, perception, and education, in shaping individuals' aspirations and agency in deciding whether to migrate or stay.

In one study, Mallick (2019) applied livelihood resilience in a socio-ecological system approach to ascertain how livelihood resilience influences migration and non-migration. Three studies applied a sustainable livelihood approach: Tiwari & Joshi (2015) utilized this approach to examine the patterns and factors influencing male youth out-migration and its relationship to rural women's socioeconomic development. Gautam (2017) investigated the factors contributing to seasonal migration in the context of climate change and its impact on food security and livelihood resilience. Singh & Basu (2020) explored how migration-driven changes in household structures affect household risk management practices. Lastly, one study by Maharjan et al. (2021) drew insights from the new economics of labor migration (NELM) to analyze how migration influences the factors households consider when making risk diversification or adaptation strategies. The range of data sources and methodologies in studies captured in section 4.3.5 demonstrates the complexity of integrating this interplay between quantitative and qualitative factors.

4.3.4.1 Bibliographic coupling analysis

Given that the potential relationships between gender and climatic migration integrate findings from diverse disciplinary areas, we conducted a bibliographic coupling analysis of the potentially eligible publications to identify the interconnectedness among disciplines and fields. For bibliographic coupling analysis, we used cited sources as a unit of analysis. Among 344 sources of potentially eligible studies (n = 731), only 26 journals met our requirements of containing a minimum of five documents and ten citations per source.

Figure 20 presents a network overlay visualization from our bibliographic coupling analysis based on the relatedness of nodes and timeline. The node size represents the number of documents in each source, the line indicates the presence of citations in either direction, and the color code represents the average publication year of the documents published by these sources. The distance between any two journals indicates how similar they are to one another (van Eck & Waltman, 2022). We notice that research in this field is mainly interdisciplinary, and the average publication years of the documents are generally within the last ten years. Overall, the literature is concentrated in the interdisciplinary fields of environmental change, climate change, geography, demography, economy, and society. However, interdisciplinary literature

that offers gender perspectives and promotes gender equality and social justice, such as “gender, place and culture” and “gender and development,” are sitting on the periphery, with relatively smaller node size and weaker cross-citation with the environmental or climate change, development, and disaster risk reduction literature. Interestingly, we also note an interdisciplinary review journal on climate change near the middle of gaps among journals, implying their emerging significance in acknowledging different insights across disciplines. Therefore, there is potential to widen the scope and bridge the gaps of interdisciplinary research in this field to better explain the pathway through which agency in migration decisions is shaped differently, and gendered migration inequalities are produced under climatic conditions.

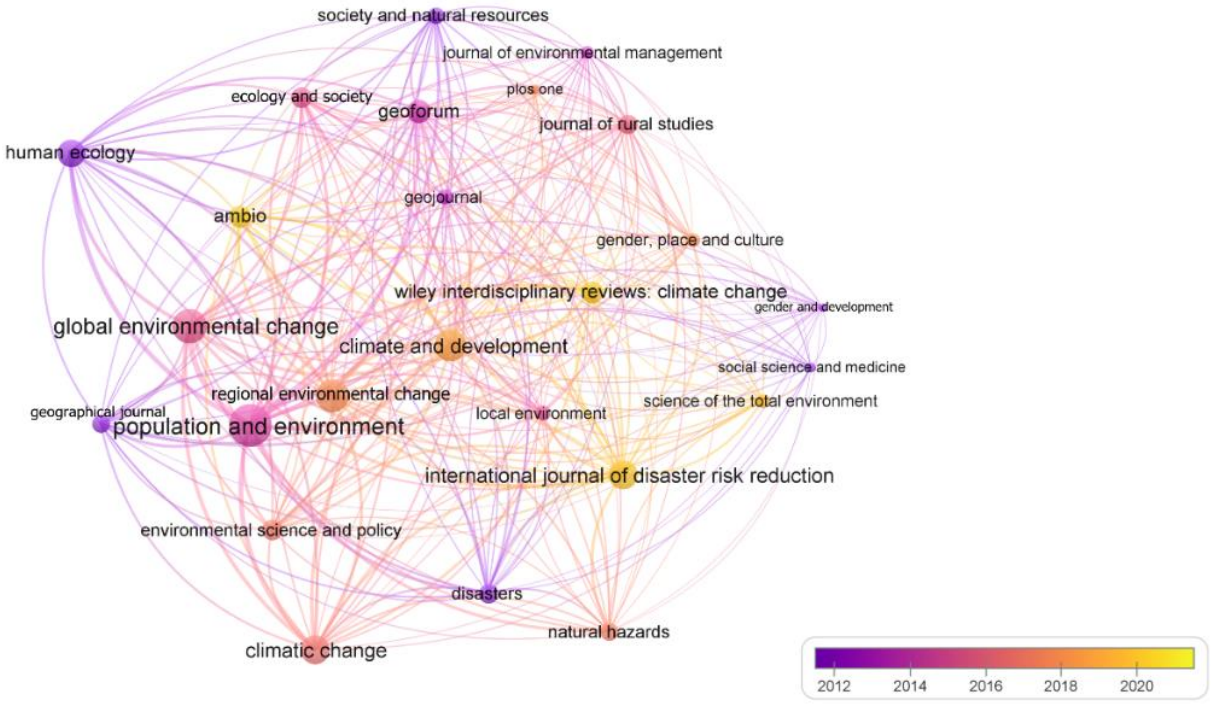


Figure 20: Bibliographic coupling network overlay of sources

4.3.5 Methodological development and study designs

Our fourth and final research question focuses on the methodologies used to examine the gendered dimensions of climate migration in South Asia. In this section, we explore the diverse range of methodologies employed in gender and climate migration studies and assess how these methodological choices shape our understanding of the nexus between gender and climate migration. Researchers have developed various approaches for collecting and analyzing gender-specific migration data, which have been applied to the existing literature on climate migration (Table 19).

The studies included in this systematic review exhibit a range of methodological approaches. Among the included studies, a significant portion (42.4%) utilized mixed methods, incorporating both qualitative and quantitative techniques. Additionally, a

substantial number of studies (39.4%) relied on qualitative methods, while a smaller proportion (18.2%) employed quantitative approaches. These methodological choices allowed researchers to capture diverse aspects of migration, including explicit aspirations, observed processes, indirect indicators, and retrospective information. Notably, studies that utilized qualitative and mixed methods proved particularly effective in providing valuable insights into the gendered differences in migrants' agency, aspirations, and capabilities and the interplay between gender, climate-related factors, and other non-climatic factors in shaping migration decisions and patterns.

Particularly, qualitative research stands out for exploring subjective matters such as the underlying factors of gender-related migration. However, these qualitative and mixed studies often emphasize migration dynamics at smaller geographical scales due to the required time and expenses. In contrast, quantitative methods prove best able to gain a broader contextual understanding and identification of large-scale climate migration. However, it is important to note that studies that applied quantitative methods relied on survey data or analyzed data based on biological differentiation and could not capture nuanced gendered differences and the agency aspect in migration decision-making. Therefore, combining diverse inquiry methods is promising because they can reveal different perspectives that can provide better insights.

Data were collected in various forms to achieve their varied study objectives. In terms of data collection, studies employed numerous data collection strategies. Most studies employed focus group discussions (FGDs) (48.5%) either alone or with other data collection methods. Other data collection strategies include individual in-depth or open-ended interviews or life histories (30.3%), structured interviews or household surveys (39.4%), semi-structured interviews (27.3%), observational surveys (9.1%), key informant interviews (KIIs) (12.1%), and macro-level survey or census (12.1%). In addition, studies at the household level were carried out either in the place of origin (63.6%), collecting direct and indirect information about migration and perception of climate change, or in the destinations (15.2%) using retrospective questions of past movements or both at origins and destinations (9.1%).

Data collection strategies such as individual in-depth or open-ended interviews (e.g., Akter et al., 2019; Ingham et al., 2019; Lama, 2018; Sams, 2019), life histories (e.g., Singh, 2019; Singh & Basu, 2020) and observational surveys (e.g., Mallick & Vogt, 2012; Tiwari & Joshi, 2015) help to explain the dynamics of gendered migration. Because these in-depth approaches investigate how gendered differences in migration occur, what influences those differences, and how migration decisions are made. These approaches thoroughly depict individuals' journeys, challenges, and obstacles that divide them and shape their perceptions, aspirations, and experiences. However, relying on these strategies alone can be a problem. For example, the research participants' representation level and the power relationships between them and the researcher(s) can be questioned (Boas et al., 2020; Khosravi, 2018). It might be challenging to argue that researchers, typically privileged people, can truly put themselves in the position of those affected. Additionally, the data collection, analysis,

and solutions these strategies provide depend on researchers' interpretation of the phenomena and their beliefs. These strategies enable researchers, to some extent, to uncover the underlying dynamics of gender, climate change, and other migration determinants. However, it is crucial to maintain reflexivity (Boas et al., 2020).

Table 19: Study methods, data collection strategies, and gender data analysis of the selected studies

Study characteristics	Total No. of studies n (%) *	Sources
Methods	Qualitative **n = 13 (39.4%)**	Ahmad et al. (2019); Akter et al. (2019); Ayeb-Karlsson (2020); Boas et al. (2022); Evertsena & Geest (2019); Ingham et al. (2019); Kelman et al. (2019); Khan et al. (2018); Lama (2018); Mallick (2019); Memon (2021); Patel & Giri (2019); Sams (2019)
	Mixed **n = 14 (42.4%)**	Ahmed & Eklund (2021); Ayeb-Karlsson et al. (2020); Bhatta et al. (2015); Debnath & Kumar Nayak (2021); Gautam (2017); Gioli et al. (2014); Hasnat et al. (2020); Mallick & Vogt (2012); Islam & Shamsuddoha (2017); Mallick et al. (2022) Prati et al. (2022); Singh (2019); Singh & Basu (2020); Tiwari & Joshi (2015)
	Quantitative **n = 6 (18.2%)**	Amjad (2019); Carrico et al. (2020); Gray & Mueller (2012); Maharjan et al. (2021); Mueller et al. (2014); Chowdhury et al. (2021)
Data collection strategies	In-depth interviews or open-ended interviews **n = 10 (30.3%)**	Akter et al. (2019); Ayeb-Karlsson et al. (2020); Ayeb-Karlsson (2020); Boas et al. (2022); Evertsena & Geest (2019); Ingham et al. (2019); Islam & Shamsuddoha (2017); Lama (2018); Mallick (2019); Sams (2019)
	In-depth life histories **n = 2 (6.1%)**	Singh (2019); Singh & Basu (2020).
	Semi-structured interviews **n = 9 (27.3%)**	Ahmad et al. (2019); Ahmed & Eklund (2021); Evertsena & Geest (2019); Kelman et al. (2019); Khan et al. (2018); Mallick et al. (2022); Memon (2021); Prati et al. (2022); Singh & Basu (2020).
	Key informant interviews (KIIs) **n = 4 (12.1%)**	Ahmed & Eklund (2021); Gioli et al. (2014); Islam & Shamsuddoha (2017); Lama (2018)
	Focus group discussions (FGDs) **n = 16 (48.5%)**	Ahmed & Eklund (2021); Akter et al. (2019); Ayeb-Karlsson et al. (2020); Ayeb-Karlsson (2020); Bhatta et al. (2015); Boas et al. (2022); Debnath & Kumar Nayak (2021); Gautam (2017); Gioli et al. (2014); Hasnat et al. (2020); Islam & Shamsuddoha (2017); Khan et al. (2018); Mallick (2019); Patel & Giri (2019); Singh (2019); Singh & Basu (2020).
	Observation survey **n = 3 (9.1%)**	Khan et al. (2018); Mallick & Vogt (2012); Tiwari & Joshi (2015)
	Household interviews/survey **n = 13 (39.4%)**	Amjad (2019); Bhatta et al. (2015); Carrico et al. (2020); Debnath & Kumar Nayak (2021); Gautam (2017); Gioli et al. (2014); Hasnat et al. (2020); Maharjan et al. (2021); Mallick & Vogt (2012); Mallick et al. (2022); Singh (2019); Singh & Basu (2020); Tiwari & Joshi (2015)
	Longitudinal survey data **n = 2 (6.1%)**	Gray & Mueller (2012); Mueller et al. (2014)
	Participatory rural appraisals (PRAs) **n = 1 (3.0%)**	Islam & Shamsuddoha (2017)
	Census data **n = 2 (6.1%)**	Prati et al. (2022); Chowdhury et al. (2021)
Gender data analysis	The binary opposition between men and women and their roles and relations in the households **n = 19 (57.6%)**	Ayeb-Karlsson (2020); Ayeb-Karlsson et al. (2020); Bhatta et al. (2015); Boas et al. (2022b); Evertsena & Geest (2019); Gautam (2017); Gioli et al. (2014); Hasnat et al. (2020); Ingham et al. (2019); Islam & Shamsuddoha (2017); Lama (2018); Mallick (2019); Mallick & Vogt (2012); Mallick et al. (2022); Sams (2019); Singh (2019); Singh & Basu (2020); Tiwari & Joshi (2015)

Study characteristics	Total No. of studies n (%) *	Sources
	Intersectional analysis or analysis that goes beyond intrahousehold relationship **n = 6 (18.2%)**	Ahmed & Eklund (2021); Boas et al. (2022b); Khan et al., (2018); Lama (2018); Prati et al. (2022); Singh (2019)
	Biological dichotomy, i.e., classifying people as male or female based on their biological attributes and not considering their gendered roles, relations, and socio-cultural contexts **n = 6 (18.2%)**	Ahmad et al. (2019); Carrico et al. (2020); Gray & Mueller (2012); Kelman et al. (2019); Maharjan et al. (2021); Mueller et al. (2014)
	Only women **n = 7 (21.2%)**	Akter et al. (2019); Amjad (2019); Bhatta et al. (2015); Khan et al. (2018); Memon (2021); Patel & Giri (2019); Prati et al. (2022)
	Only men **n = 1 (3.0%)**	Debnath & Kumar Nayak (2021)
	Gender-disaggregated data **n = 1 (3.0%)**	Chowdhury et al. (2021)

Note: * The number and percentage do not add up to the total and 100%, as some studies employed multiple methods that were calculated in this assessment.

Next, we look at how gender data was investigated among studies. Most studies investigated gender based on men and women and their roles and relations in households (n = 19), and six investigated gendered dimensions based on biological dichotomy. Seven studies focused only on women in their qualitative data collection and analysis, one study only targeted male respondents (Debnath & Kumar Nayak, 2021), and one analyzed gender-disaggregated data to examine gender-differentiated vulnerability to flooding and migration responses (Chowdhury et al., 2021). As mentioned in section 4.3.2., we found no study investigating gender minority groups (i.e., the study did not include third gender, intersex, or people with other gender identities). All thirty-three studies report migration-related responses either for women, men, or both. However, all studies in the review particularly emphasized women's or girls' marginalization in climate migration and overlooked men's or boys' situations. Additionally, simplistic dichotomies underestimate the spectrum of complexity and the power dynamics of gendered migration inequalities. This frequently occurs because gender identities are portrayed as fixed, centralized, and consistent (Bertrand, 2020), omitting the importance of other characteristics like age, wealth, status, and ethnicity (Amelina & Lutz, 2019; Kaijser & Kronsell, 2014; Winker & Degele, 2011).

We note that some studies, particularly those employing large-scale quantitative data analysis (e.g., longitudinal survey), often rely on sex-disaggregated data (i.e., based on biological dichotomy) to examine migration flows following climatic events (e.g., Gray & Mueller, 2012; Mueller et al., 2014). While these macro-level studies provide valuable insights into the relationships between climate, migration, and their long-term implications, they often fall short of capturing the nuanced realities of women's and men's experiences. Without gender disaggregation, the specific challenges and opportunities faced by individuals based on their social, cultural, and contextual identities cannot be fully understood. Furthermore, some analyses that compare the migration of female and male households as an adaptive response (e.g.,

Ahmad et al., 2019; Maharjan et al., 2021) tend to have a limited conceptualization of gender as a socially constructed, context-specific, and nuanced reality that is deeply connected to society, climate change and the environment.

4.4 Discussion

This systematic review presents the latest evidence on the intersection of gender and climate migration in South Asian countries, revealing important insights. The analysis of temporal and spatial trends in gender and climate migration studies demonstrates a growing scholarly focus on this issue in the past decade. This is particularly relevant given the region's increasing frequency of climatic events and displacements over the last two decades. South Asia has emerged as a global "hotspot" for climate migration research, with more than 100 million weather-related displacements reported between 2008 and 2022 (IDMC, 2023). However, there is still an uneven geographical coverage of studies in this area. This evaluation of the available studies also highlights the potential for leaving substantial marginalized groups behind in the global pursuit of gender equality (UN, 2015) and safe, orderly, and regular migration for all (GCM, 2018).

Although varying theoretical and methodological approaches and heterogeneity of findings across studies make it challenging to draw definitive conclusions, our findings suggest that migration decisions and patterns differ significantly between women and men in South Asia. This finding aligns with other systematic reviews on climate migration globally (Kaczan & Orgill-Meyer, 2020; Zickgraf et al., 2022). Our study indicates that gender norms and roles play a crucial role in shaping migration responses in all South Asian countries examined (Ahmed & Eklund, 2021; Amjad, 2019; Boas et al., 2022b; Chowdhury et al., 2021; Mallick et al., 2022). Furthermore, in the context of climate migration in South Asia, differentiation in migration decisions and patterns is influenced by unequal social relations, which encompass gender inequality in resource access, as well as factors such as socioeconomic status, caste, the cost of migration, the high cost of living in destination areas, and poverty. Gender is recognized as a fundamental aspect of mobility studies (Lama et al., 2021), but it is intertwined with other factors and cannot be considered in isolation. Gender interacts with agency, subjectivities, and experiences within climate adaptation and migration studies (Erwin et al., 2021; Garcia et al., 2020).

Our study reveals a positive trend in women's agency as they emerge as change agents leading migration decisions amidst challenging circumstances (Boas et al., 2022b; Evertsena & Geest, 2019). Notably, women exhibit increased mobility in urban contexts and during extreme weather events (Boas et al., 2022b) Additionally, despite their prior dependence on their husbands' incomes, some women exhibited individual agency by actively seeking new opportunities, such as pursuing supporting informal tasks like selling milk, making fishing nets, tailoring, and growing vegetables and occasionally taking on more formal paid work like road construction, especially marginalized older women who have lost their husbands to contribute to their families'

well-being (Akter et al., 2019; Boas et al., 2022b). This resilience and determination highlight the potential for positive gender transformations, supported by improved access to girls' education and a deeper understanding of women's roles in climate change (Unterhalter et al., 2022), as they continue to support themselves under challenging conditions. However, it is important to acknowledge that household decisions and migration choices are still predominantly influenced by men, while women's power and agency remain limited in many cases. The persistent impact of patriarchal norms and gendered occupational differentiations further restricts women's agency in certain migration decisions (Boas et al., 2022b).

Therefore, there is a need for a broader conceptualization of gender dimensions in climate migration that goes beyond gender identity and intra-household decision-making. It should encompass climatic events and other determinants that shape migration decisions and patterns. Furthermore, gender needs to be theorized as a dynamic and negotiated concept, taking into account sociocultural norms, values, and the economic and political structures within broader scholarship on human-nature interactions. By taking a holistic approach to comprehending gendered dimensions, policymakers, and practitioners can develop inclusive and effective strategies for addressing climate migration in South Asia and beyond.

4.4.1 Pathways of gender-differentiated climate migration

Drawing on the insights of this systematic review, we propose pathways that explain how gender differences in climate migration manifest over time and across different geographical locations. Structural disadvantages and imbalances can restrict migration opportunities and contribute to inequalities related to migration (Black et al., 2005; Chowdhury et al., 2021). While gender inequality plays a significant role, it is not the sole factor influencing these inequalities. Inequalities in migration responses to climate change arise from both gender inequality and other forms of social stratification (Lama et al., 2021). Key pathways of gender-differentiated climate migration include the following:

1) *Intersectionality:* One key finding from the reviewed studies is the presence of intersectionality that shapes gender-differentiated migration. These pathways involve the intersection of gender identity with other factors such as socioeconomic status, age, poverty, caste, marital status, and religious beliefs (Ahmad et al., 2019; Ahmed & Eklund, 2021; Hasnat et al., 2020; Sams, 2019). For example, in contexts of low-income or poverty, it was observed that men are more likely to migrate for economic reasons, while women often migrate due to family or marriage-related factors, such as joining their spouse or relocating for marital purposes (Evertsena & Geest, 2019). Moreover, their caste identity further shapes women's migration experiences, where caste-based discrimination influences their migration decisions and opportunities (Bhatta et al., 2015; Debnath & Kumar Nayak, 2021; Gautam, 2017). The broader literature on intersectionality in climate change and climate justice underscores that not all types of inequality carry the

same weight or have the same impact (Birkmann et al., 2022; Paaske, 2021). An intersectional approach recognizes how individuals' social identities can overlap, leading to compounded experiences of discrimination and disadvantage in the context of climate migration (Abimbola et al., 2021). Considering these intersections enables researchers, policymakers, and practitioners to develop more inclusive strategies to address gender-based inequalities in climate migration.

2) *Gender-differentiated exposure to climatic events:* The second pathway we identified relates to gender-differentiated exposure, where socially ascribed gender roles and division of labor contribute to differential exposure to climatic events. Our review highlights that men, often engaged in outdoor activities such as fishing or agriculture due to their dependence on agricultural income, face a higher risk of income loss caused by climatic events (Evertsena & Geest, 2019; Hasnat et al., 2020; Islam & Shamsuddoha, 2017; Rabbani et al., 2022). In contrast, women, despite their participation in outdoor work, are more likely to stay due to their responsibilities as homemakers and caretakers for the family, children, and in-laws (Akter et al., 2019; Prati et al., 2022; Maharjan et al., 2021), and to cope with the impacts of climate change. This differential exposure can lead to various social and economic consequences, including shifts in gender roles, increased poverty, poor nutritional environment, and higher rates of gender-based violence (Andrijevic et al., 2020; van Daalen et al., 2022). These factors, in turn, contribute to further patterns of migration and displacement, creating a cycle of inequality and vulnerability that can only be broken by addressing the underlying causes of gender inequality in climate migration.

3) *Gender-differentiated employment opportunities:* Gender-differentiated employment opportunities emerge as a significant pathway contributing to gender differences in migration decisions. The reviewed studies highlight that men and women face unequal access to employment opportunities, influencing their migration choices (Chowdhury et al., 2021; Ingham et al., 2019; Mallick & Vogt, 2012; Patel & Giri, 2019). Men often secure jobs that require physical labor, such as transportation, construction, and bricklaying, while women are motivated to migrate for employment in sectors like ready-made garments, housemaids, and higher-wage care or service occupations (Evertsena & Geest, 2019; Hasnat et al., 2020). For instance, the ready-made garments sector has empowered women in Bangladesh, providing them with increased economic freedom and empowerment, though the sector faces sustainability challenges due to some constraints (Al Mamun & Hoque, 2022). However, limited access to alternative employment opportunities restricts women's ability to acquire advanced skills for better job prospects and hampers their migration capabilities (Chowdhury et al., 2021; Patel & Giri, 2019). Such gendered occupational differentiations are evident not only in the context of South Asia but also in broader employment patterns, with women predominantly engaged in care occupations and men in traditionally risky

occupations (Adisa et al., 2021; ILO, 2020; Jayachandran, 2021; King-Dejardin, 2019; Petrongolo & Ronchi, 2020). However, in some destinations, equal job opportunities may not be available to all individuals, further exacerbating gendered differences in climate migration decisions.

4) *Gender-differentiated safety and security:* Gender-differentiated safety and security concerns represent the fourth pathway influencing women's migration decisions. Women may face challenges in feeling safe while traveling or migrating alone, as well as in adapting to new environments (Ayeb-Karlsson, 2021). Addressing issues of gender-based violence and discrimination is crucial in the context of climate migration. Social safety and security factors also play a role in shaping the migration capabilities of men and women. For instance, studies conducted in Bangladesh reveal that both women and men perceive it as unsafe for women to migrate alone to cities (Boas et al., 2022b; Islam & Shamsuddoha, 2017). Again, discrimination and physical or sexual violence often compel women to migrate (Akter et al., 2019; Hasnat et al., 2020). Addressing these safety and security concerns is essential to create an enabling environment for gender-equal migration experiences.

5) *Gender-differentiated access to education, resources, and information:* The fifth pathway identified in understanding the gendered dimensions of climate migration is the gender-differentiated access to education, resources, and information (Chowdhury et al., 2021; Mallick et al., 2022; Patel & Giri, 2019). Unequal access to these factors can significantly impact migration decisions for women and men (Gioli et al., 2014). For instance, women who face limitations in accessing education, wealth, and resources may have fewer opportunities to acquire advanced skills, resulting in a limited capacity to make strategic life choices, particularly in terms of employment options and migration decisions (Patel & Giri, 2019; Sams, 2019; Singh & Basu, 2020). Addressing these disparities in access to education, wealth, resources, and information is crucial for empowering women and ensuring more equitable outcomes in climate migration. This perspective aligns with Kabeer's "empowerment" concept, which emphasizes the importance of resources, agency, and achievements in enabling individuals to make informed life choices and exercise their agency (Kabeer, 1999).

6) *Gender-differentiated sense of belonging:* The sixth pathway in comprehending the gendered dimensions of climate migration centers around the notion of a gendered sense of belonging. This pathway recognizes that gender relations play a significant role in shaping individuals' attachment to their place and communities and, consequently, their migration decisions. For example, women, who often assume caregiving roles and rely on social support systems, tend to develop stronger connections and a sense of belonging to their communities (Akter et al., 2019; Boas et al., 2022b). This sense of belonging may make them less likely to consider migration as they prioritize their social networks and community

relationships (Mallick et al., 2022). However, it is important to note that a sense of belonging is not a universal experience, and it is crucial to acknowledge the social and cultural context within which migration decisions are made and recognize how it influences individuals' sense of belonging.

In light of the pathways discussed, it is worth acknowledging that the pathways identified in this research are not definitive and may differ depending on various research contexts. Moreover, these pathways may not operate independently and may interact with each other or lead to cyclic impacts. Therefore, it is essential to remain open to the possibility of alternative or additional pathways and conduct further research with greater detail to gain a more comprehensive understanding of the gendered dimensions of climate migration.

4.4.2 Gaps and potentials for future research

Although the studies in this systematic review offered valuable insights into gendered migration in the context of climate change, several gaps and limitations were identified. Our findings align with the concerns recent critique paper on the disoriented gender terminology in migration data, emphasizing the challenges in accurately capturing gender and highlighting the need for a more nuanced and comprehensive understanding of gender in migration research to address these gaps and misconceptions (Bircan & Yilmaz, 2022).

First, there is a limited understanding and implementation of gender as a relational and intersectional category in climate change and migration literature. Instead, gender was often reduced to a binary and biological dichotomy, overlooking its dynamic and socially constructed nature. This simplistic view undermines our understanding of how gender influences climate migration dynamics.

Second, a significant limitation is the lack of gender-disaggregated data availability for macro-level quantitative analysis. Many studies rely on surveys or censuses that classify gender as a dichotomous variable alongside other socio-demographic variables such as age, education, and income. However, this perspective on gender cannot capture its fluidity and dynamic nature, leading to an incorrect assumption that gender is a static variable.

Third, gender studies on climate migration often focus predominantly on women and girls, overlooking the experiences of men and boys (Gioli & Milan, 2018). However, gender is a complex construct encompassing assigned roles, norms, and expectations beyond just gender (Risman, 2018). It is crucial to examine how men, boys, and individuals with diverse gender identities are impacted by gender roles, norms, inequalities, and social expectations, shaping their migration experiences, opportunities, and decisions. We also note that empirical investigations of gender and climate migration primarily focus on the patriarchal society and culture. Although South Asia is dominated mainly by the patriarchal system (Bhopal, 2019), some empirical

investigations on matriarchal and egalitarian societies would provide better insights for the comparative assessment.

Fourth, there is a need for more rigorous investigations into agency in migration decision-making, aiming to uncover nuanced perspectives on freedom of choice and gendered differences in the context of climate migration.

Lastly, our bibliographic coupling analysis revealed a gap in interdisciplinary research encompassing environmental change, migration, gender equality, social justice, and sustainability. To address this gap and promote gender equality in climate change research and policy, a more informed and nuanced approach is needed (Lau et al., 2021). Future empirical studies should focus on identifying pathways (e.g., section 4.4.1) to reduce inequality and promote sustainability, guided by a comprehensive framework that integrates climate change, migration, and gender dynamics, considering the complexities of relations and intersections. Additionally, policy interventions concerning climate migration and adaptation should prioritize the opportunities and needs of all gender identities. Building a more comprehensive and inclusive research framework, utilizing mixed methods and embracing transdisciplinary and interdisciplinary approaches, will enable a better understanding of the social and ecological implications of the research, leading to more effective strategies and sustainable solutions.

4.4.3 Limitations

To our knowledge, this systematic review is the first to critically analyze and synthesize the emerging empirical evidence on climate migration and gender nexus in South Asia. However, we note some limitations of our systematic review. First, our systematic review did not perform quality assessments or grading of the selected studies because these studies were too heterogeneous. However, we only included research that had already undergone peer review by the journals, reducing the possibility that the included studies would be of low quality. Second, interpreting the disparate findings was highly challenging due to the varying study methodology, data collection strategies, sampling techniques, outcome measures, and other criteria employed in the studies included in this review. Consequently, they were summarized narratively. Additionally, as was already indicated, research focusing on men, boys, and gender minorities was lacking. As a result, the findings generally reflect women and girls who encountered migration challenges in the study contexts. Considering this, we recommend focusing on some investigations of men, boys, and gender minorities. Third, we included articles published in English only. This can potentially leave out some significant research undertaken and written in other languages. However, we consider that reviewing and assessing studies written in English is easy to comprehend by wider audiences. Lastly, the geographical focus of South Asian countries is also a limitation of this review. We recognize that findings do not reflect global perspectives. However, given that the South Asian region faces the greatest challenges from climate change and migration (Clement et al., 2021; Rigaud et al.,

2018), we assert that the findings are still pertinent for evidence-based global research and policy.

4.5 Conclusions

Notwithstanding a few limitations, our systematic review has several significant strengths and contributes to knowledge in many ways. First, to the best of our knowledge, this is the first-of-its-kind systematic review that attempts to investigate the relationship between climate change, gender, and migration in South Asia. This replicable systematic review will serve as a model for future systematic reviews in similar or global contexts. Second, we were able to evaluate these studies based on their findings and methodological and theoretical aspects and highlighted several significant gaps in the evidence base. Third, by performing bibliometric analysis, we have demonstrated that academic literature on gender dynamics of climate migration mainly revolves around geography, demography, economy, and society and less around gender equality and social justice. Finally, by drawing insights from various disciplines, frameworks, and empirical methods, we have identified six pathways that contribute to a better understanding of how gender inequality manifests in climate migration.

Overall, our findings demonstrate that there may be gender differences in the association of climatic exposures with migration responses. However, these differences go beyond biological and social distinctions of gender identity. We emphasize the need for further research on the extent to which gender interacts with other social positions and socioeconomic, cultural, and structural determinants of migration. In addition, there is a pressing need to elucidate the gender patterns underlying the link between climatic exposures and agency migration decisions. Future investigations should thus go beyond examining gender as a simple binary differentiation between men and women and gender as a possible intersecting element to obtain insight into these gender-differentiated pathways.

To sum up, our study suggests more in-depth, inter-, and trans-disciplinary, sustainability- and justice-oriented research that examines the complexity and diversity of human-nature interactions to understand the causes of gender-differentiated migration and the agency involved in migration decision-making under climate change. Our systematic review strengthens this foundation and moves the gender, climate change, and migration scholarship closer to achieving those goals. In addition, our systematic review contributes to achieving the SDG's core commitment to "leave no one behind" (UN Women, 2018), SDG 5 on gender equality, SDG 10 on reduced inequalities, SDG 13 on climate action and Global Compact for Migration's (GCM) core objective "safe, orderly, and regular migration for all.

Chapter 5: Conclusion

5.1 Introduction

This last chapter discusses the original and significant contributions to knowledge and outcomes of this doctoral research. Thus, the chapter reconsiders the aim and objectives of the research and summarizes the key findings from the three main chapters. Then it explains theoretical, methodological, and empirical contributions to knowledge advancement. Lastly, this chapter evaluates the study's limitations, considers potential future research areas, and offers a final reflection on the entire experience of conducting this doctoral research.

5.2 Revisiting research aim and objectives

The overall aim of this dissertation was to advance the comprehensive understanding of the relationships between and implications of climate change and human migration patterns. In pursuit of the overarching aim, this dissertation addressed the following three specific objectives:

1) To develop a more comprehensive conceptual framework for examining the relationships between climate change and migration decisions
2) To empirically assess the post-migration vulnerability situations of climate migrants
3) To analyze and synthesize empirical studies to gain a deeper understanding of the potential impact of climate change on shaping gender-differentiated migration.

This dissertation achieved its first objective through a comprehensive and inquiry-driven literature review. The review analyzed and synthesized the state-of-the-art thinking, conceptualizations, perspectives, and evidence in the field, developing a comprehensive and holistic conceptual framework (Chapter 2). The second objective was met through empirical investigations conducted among climate migrants in the urban center of Dhaka, Bangladesh (Chapter 3). Lastly, the third objective was achieved through a systematic literature review of the empirical studies on climate migration and gender in South Asian countries (Chapter 4). These efforts collectively allowed for filling knowledge gaps and addressing critical issues, as highlighted in the introduction chapter, making a significant contribution to the field.

5.3 Summary of key findings

Chapter Two of this research presented an extensive literature review that adopted an interdisciplinary inquiry-driven approach, drawing from diverse perspectives from various academic and non-academic sources. The objective of this chapter was to develop a comprehensive and more holistic conceptual framework that could provide a shared understanding of the migration decision-making process and migration patterns in the context of climate change.

The review identified some significant areas for improvement in existing frameworks (e.g., Black et al., 2011; Mcleman & Smit, 2006; Perch-Nielsen et al., 2008) that aimed to explain the relationship between climate change and migration. The chapter thoroughly analyzed and emphasized the importance of integrating multiple perspectives for a more comprehensive understanding, including the impacts of different climatic and non-climatic factors in shaping differing migration decisions and patterns and how the effectiveness of migration as an adaption can be understood. An extensive review of the latest literature and empirical studies from various disciplines and non-academic sources was conducted to identify patterns in the migration decision-making process in the context of climate change.

The chapter highlighted how the understanding of agency could offer insights into various forms of migration (e.g., forced, voluntary, planned relocation) and non-migrations (e.g., immobility and trapped) that how migration occurs in different dimensions (e.g., spatial, temporal). The chapter emphasized the importance of considering these factors to understand migration patterns in climate change, as these patterns cannot be fully comprehended without considering the different dimensions of migration and non-migration. The chapter also discussed the significance of incorporating agency in migration decision-making and how the aspirations and capability framework can help understand the complexity of agency and, thus, migration forms. The review also noted that climate change is a multifaceted phenomenon with diverse impacts (e.g., extreme/sudden-onset, slow-onset, natural resource risks), leading to various forms of migration. Furthermore, factors at different scales (i.e., macro, meso, micro) interacting with climate change and among themselves were identified based on empirical evidence, resulting in diverse migration patterns in various geographic contexts. The chapter also identified that the vulnerability assessment alone does not capture the complexity of migration under climate change. However, this chapter conceptually showed how IPCC's (2007) vulnerability assessment could be a powerful tool for measuring the success and failure of migration as an adaptation strategy which was further empirically investigated in chapter three.

These insights developed a new and extended conceptual framework, offering a potentially holistic perspective of the relationship between climate change and migration. This framework includes previously under-examined perspectives and encourages a more comprehensive picture of the climate-migration nexus. This framework can serve as a foundation for future research and provide a basis for developing a more in-depth understanding of migration complexities in the context of climate change.

In Chapter Three, I empirically investigated the post-migration vulnerability situations of climate migrants in an urban destination of Dhaka, Bangladesh. This case study aimed to understand whether migration could serve as an effective adaptation strategy for climate migrants. The comprehensive conceptual framework developed in Chapter 2 was used to guide the distinction between climate migrants, other migrants,

and long-term residents, while the IPCC's (2007) vulnerability assessment framework provided a conceptual foundation for assessing vulnerability. The study utilized large-scale survey data from 2,000 households and additional secondary data (e.g., flood risk map, thermal discomfort index) from scientific literature and applied Principal Component Analysis (PCA) to develop a Composite Vulnerability Index (CVI) and compare it among three groups.

The findings showed that, despite being touted as an adaptation strategy, climate migrants remain the most vulnerable regarding their socioeconomic status and standard of living, water and sanitation, health, and exposure to natural disasters. In addition, the IPCC's three dimensions of vulnerability assessment revealed that climate migrants had the highest exposure, sensitivity, and lowest adaptive capacity in comparison to other migrants and long-term residents. Further analysis showed that climate migrants perceived themselves as having less exposure to natural disasters and improved earning opportunities than before migration but also reported worsened water, sanitation, and health conditions. The key outcome of this chapter is that it provides a nuanced understanding of the vulnerability situation of climate migrants. Thus, this will help inform policies aimed at the post-migration vulnerability of climate migrants in urban areas and highlights the need for targeted interventions to address their unique vulnerabilities to improve the well-being of climate migrants and ensure that migration is a successful adaptation strategy.

Chapter Four conducted a systematic review to investigate the relationship between gender and climate migration in South Asian countries. This employed a part of the conceptual framework presented in Chapter Two to evaluate the existing literature, including, for example, gender-differentiated migration and non-migration decisions, temporal and spatial dimensions, agency or freedom of choice involved in migration and factors that contribute to gender-differentiated climate migration. The review found that while increasing attention is paid to the gendered dimensions of climate migration, the geographic coverage remains uneven, raising concerns about marginalized groups being left behind. The findings also revealed a lack of consistency in theoretical and methodological approaches, and limited research on gender-differentiated agency in migration decisions, making it challenging to draw clear conclusions.

Additionally, the review revealed inconsistent applications of the gender concept and emphasized the need for a more intersectional analysis that considers other forms of inequality, such as poverty, social status, age, and education. The literature is heavily focused on climate, environmental change, geography, and demography, with limited contributions from feminist geography, social justice, and gender equality-related journals. This highlights the importance of developing a more inclusive research framework, incorporating interdisciplinary approaches to addressing issues related to gender and climate migration, and fully understanding the social and ecological implications of the research.

Despite the challenges, the review found that gender inequalities play a significant role in migration responses to climate change in South Asia. The findings challenge the traditional view that women do not migrate or are left behind by men under climate by demonstrating that women also tend to migrate. The review found that gender roles and norms are the primary factors shaping migration responses, while other factors such as education, socioeconomic status, poverty, marital status, unequal employment opportunities, sense of belonging, and social networks also play a role.

In terms of agency, the study found that both men and women face constraints in their migration decisions during extreme climatic events. However, the review also found instances where women were not without power in household decision-making, including migration decisions, possibly due to increased access to education and recognition of women's roles and experiences adapting to climate change. The chapter concludes by proposing a specific gender and climate migration framework, demonstrating how gender intersects with other forms of inequality to shape migration decisions in complex ways. This review and proposed pathways will inform more effective evidence-based policies and interventions for addressing climate migration and reducing inequalities.

5.4 Knowledge contributions

The research presented in this dissertation makes several knowledge contributions to the field of climate migration scholarship. One of the strengths of the research conducted in this dissertation is that all questions were formulated based on literature gaps and incorporated the insights of stakeholders and practitioners working in this field to explain this "real-world" problem better. Engaging with practitioners helps ensure that the research questions are relevant to real-world problems and that the research findings have practical implications, a crucial characteristic of transdisciplinary research (Lawrence et al., 2022). This dissertation contributes to the field of climate migration by addressing essential gaps and advancing our theoretical, empirical, and methodological understanding of the complex relationships between climate change and migration. The following sections and Table 20 outline the specific contributions made by this research.

5.4.1 Theoretical contributions

The first theoretical contribution of this dissertation lies in developing a conceptual framework that provides a systematic, organized, and holistic perspective on the various dimensions and patterns of migration, as well as the significance of agency in migration decision-making (Chapter 2). This conceptual framework aimed to extend and refine Black et al.'s (2011) framework and integrate it with the theoretical knowledge of migration and agency in migration and non-migration decision-making (de Haas, 2021; Schewel, 2020) and other empirical insights on climate change and migration domains. This framework sought to create a shared foundation by incorporating knowledge and perspectives from a range of fields, including but not

limited to climate science, geography, demography, economics, sociology, environmental psychology, political science, environmental studies, human rights, gender studies, public health, and development studies. The framework provides a new lens for understanding migration and the role of agency in climate (non)migration decisions incorporating aspirations and capability framework (de Haas, 2021; Schewel, 2020). It encompasses migration typologies, outcomes, and determinants driving different migration and non-migration types. By integrating essential theories such as World-system theory (Wallerstein's, 1974), Stress-threshold model (Wolpert, 1965) and concepts, the framework emphasizes the importance of incorporating people's voices and psychological aspects to comprehend the complexities involved in migration. It recognizes the interplay between various climatic and non-climatic factors at different scales influencing migration decisions. To some extent, this structured framework captures causal or multicausal links between climate change and migration, which were deemed a challenging task (Ekoh et al., 2023; Hoffmann et al., 2021). This framework contributes to advancing migration scholarship by offering a new lens to analyze and understand climate migration's complexities and inform future research.

In addition, the conceptual framework developed in this chapter extends the current understanding of migration as an adaptation strategy by integrating the concept of vulnerability. It provides a clear depiction of how IPCC's (2007) vulnerability assessment framework can be integrated into evaluating migration's success and failure, offering a holistic perspective on climate migration. This contribution enhances the academic discourse on migration and adaptation and highlights the significance of considering vulnerability in climate migration.

Overall, conceptual frameworks play a significant role in academic research, facilitating the systematic analysis and understanding of complex phenomena (Grant & Osanloo, 2014; Ravitch & Riggan, 2016). While the conceptual framework developed in Chapter 2 is not the formal theory itself, it contributes to the theoretical landscape by offering a structured lens through which researchers and practitioners can explore various dimensions of the climate-migration nexus. By weaving existing theories, frameworks, models, empirical findings from diverse fields and disciplines, and non-academic literature, this framework creates a comprehensive and coherent foundation for further development of the climate migration field. Its integration of various domains enriches our understanding of complex phenomena and uncovers new insights, such as climate change impacts, agency, and dimensions while shedding light on previously overlooked connections. It also addresses the key debates surrounding the lack of a robust conceptual framework and emphasizes the voices of (potential) climate migrants in the understanding of the climate change and migration nexus (Baldwin & Fornalé, 2017; Hunter et al., 2015; Piguet et al., 2018; Santos & Mourato, 2022; Tschakert & Neef, 2022). Thus, this framework is envisioned to be helpful in various local and global contexts, serving as a valuable tool for policymakers, researchers, and practitioners.

In Chapter 4, the dissertation presents a further theoretical contribution through a systematic review of available gendered climate migration studies, critically analyzing theoretical underpinnings and identifying gaps in the literature. The bibliographic coupling analysis offers insights into how diverse disciplines can collaborate to develop an inclusive and comprehensive conceptual framework (Ellili, 2023). The review also proposes six pathways that can contribute to developing future conceptual frameworks to gain insights into the pathway through which gendered migration inequalities occur under different climatic conditions, advancing the understanding of how gender and climate change interact to shape migration outcomes. So far, such a conceptual framework illustrating the gender and climate migration relationship has not been developed. This new perspective on the gendered dimensions of climate migration highlights the importance of incorporating a gender lens in climate migration research.

Table 20: Dissertation outcome and contribution to knowledge

Outcome	Knowledge contribution	Justification and value-added of this research contribution
Chapter 2 Conceptual framework on the relationship between climate change and migration	Theoretical	Key contribution: Provides a comprehensive and holistic framework for understanding the complex relationships between climate change and migration. Key features ▪ A more structured and holistic perspective on the various dimensions and patterns of migration ▪ Integrating insights and perspectives from diverse disciplines and non-academic sources offers a nuanced understanding of migration complexities and the interplay between various climatic and all possible non-climatic factors. ▪ It offers an improved understanding of migration and the agency's role in shaping migration decisions. ▪ Improves the academic discourse on migration and adaptation by integrating the concept of vulnerability and its assessment in evaluating migration outcomes. ▪ It advances migration scholarship by offering for analyzing and understanding the complexities of climate migration and serves as a roadmap for further inquiry.
Chapter 3 Case study on vulnerability assessment of climate migrants	Empirical and Methodological	Key contribution: New empirical evidence and a unique methodological contribution to the understudied area of post-migration vulnerability situations of climate migrants in an urban destination. Key features ▪ Provides new empirical evidence on the post-migration vulnerability situations of climate migrants and identifies new directions for future research and policy development. ▪ Develops composite vulnerability indexes (CVIs) utilizing distinct indicators, IPCC's vulnerability assessment framework,

Outcome	Knowledge contribution	Justification and value-added of this research contribution
		large-scale 2000 households survey data, and principal component analysis (PCA). ▪ Distinguishes climate migrants from other migrants and long-term residents and compare CVIs among them. ▪ Offer insights into the perceived comparative situations of climate migrants between pre-migration and post-migration using Likert scale analysis. ▪ Generates new insights into the challenges and success of migration for climate migrants. ▪ Provides a replicable method for future studies in similar or other contexts.
Chapter 4 A systematic review of empirical studies investigating gender and climate migration	Empirical, Methodological and Theoretical	Key contribution: To the best of my knowledge first-of-its-kind systematic review to collect and synthesize empirical studies on climate change and gendered migration in the South Asian region. Key features ▪ It provides an overview of the current understanding of available gendered climate migration studies, analyzing theoretical and methodological aspects, identifying gaps in the literature, and offering valuable information for future research. ▪ Advances the understanding of how gender and climate change interact to shape migration outcomes. ▪ Offer insights into pathways through which gender-differentiated migration occur under different climatic conditions. ▪ Offers a baseline method for future systematic reviews on this topic, with a clear, explicit, and detailed replicable method for conducting systematic reviews on this topic. ▪ Support for evidence-based climate change adaptation, disaster risk reduction, and migration policy and practice

5.4.2 Empirical contributions

This dissertation also provides empirical contributions to the field of climate migration. The case study analysis (Chapter 3) generated new empirical evidence on the post-migration vulnerability situations of climate migrants in an urban destination. This research fills a crucial gap in the current understanding of adds to the understudied area of post-migration vulnerability situations of climate migrants. This study generates important insights into the post-migration situations of climate migrants and their challenges and sheds light on the factors contributing to their vulnerability. This comparative approach offers new evidence and contributes to our understanding of the distinct vulnerabilities faced by climate migrants. The results of this study will be valuable for future research and policy development in the field of climate migration and adaptation scholarships.

Furthermore, the systematic review of empirical studies in Chapter 4 makes a empirical contribution to the field of climate migration by collecting and synthesizing a range of studies related to climate change and gendered migration in the South Asian region. This review provides a comprehensive and thorough evaluation of the available research, including both the theoretical and methodological aspects of the studies. The review provides new insights into gendered inequalities in the context of climate migration and highlights the gaps in existing knowledge, offering directions for future research in the field. The empirical contribution of this research is may be important as it provides a robust evaluation of the available evidence and sheds light on areas for future research, thereby advancing our understanding of gendered climate migration.

The empirical contributions of this dissertation are not only in terms of the new data and findings generated but also in the broader context of providing a more nuanced understanding of the complex relationships between climate change and migration. These contributions will support evidence-based decision-making, policy and practice in the fields.

5.4.3 Methodological contributions

This dissertation makes methodological contributions through two distinct approaches. Firstly, in Chapter 3, the vulnerability assessment of climate migrants utilizes a new composite vulnerability index (CVI) that incorporates various indicators and employs the IPCC's vulnerability assessment framework (2007). This approach draws upon large-scale survey data from 2,000 households, secondary data, and principal component analysis (PCA). The method utilized in this study offers valuable insight into vulnerability assessment, identifying the primary factors contributing to vulnerability among climate migrants (Bucherie et al., 2022; Tanim et al., 2022). This study utilized the Likert scale analysis to shed light on the comparative situations of climate migrants, both before and after their migration experience. While Likert scales themselves are a commonly used methodology in research (e.g., Cárdenas-Vélez et al., 2023; Fajth et al., 2019), this study is innovative in its application of this method to reveal specific aspects of vulnerability uniquely perceived by climate migrants. Through this approach, the study uncovered new insights into the perceived changes in socio-economic conditions, access to employment opportunities, and educational attainment that climate migrants experience. Furthermore, this study goes beyond conducting a comparative analysis that includes climate migrants, other migrants, and long-term residents. It also provides a replicable methodology that can be employed in future studies conducted in similar contexts or different geographical areas.

Secondly, in Chapter 4, the dissertation makes a methodological contribution through a systematic review of gender and climate migration topics. This review is the first of its kind and provides a clear, explicit, and detailed method (Page et al., 2021) for future systematic reviews by using replicable search terms (Rethlefsen et al., 2021) to collect and synthesize empirical studies on climate change and gendered migration

in South Asia. In addition, the systematic approach offers a baseline methodology that can be applied in other systematic reviews on this topic.

Overall, these two chapters of the dissertation contribute to the field of climate migration by applying existing methodological approaches in novel ways and adapting them to elicit helpful information related to the research objectives. The research employs a combination of methods in new ways and provides new insights that can inform future research, policies, and practices in the context of climate migration. These contributions are original, rigorous, and valuable for the academic community and beyond. Additionally, the dissertation offers a replicable baseline methodology for vulnerability assessment of climate migrants in Dhaka and other contexts and provides a protocol for future systematic reviews on gender and climate migration. The emphasis on replicability ensures that other researchers can validate and build upon the findings, further advancing knowledge in the field.

In summary, this dissertation represents a substantial and innovative addition to the study of climate migration. The research has effectively addressed critical knowledge gaps and provided fresh perspectives in an expanded and enriched understanding of the connections between climate change and migration, advancing the field. This research offers new insights into the complex relationships between climate change and migration, presenting valuable resources for future research and policymaking. The theoretical, methodological, and empirical contributions of this dissertation demonstrate the impact of this research on understanding climate migration. The findings will inform future research and policy decisions, contributing to developing a more effective and equitable response to the challenges posed by climate migration and promoting sustainability in the affected communities.

5.5 Limitations and directions for future research

While this dissertation offers some knowledge contributions to the climate migration scholarship, some limitations should be acknowledged. This section explores the limitations of each chapter in this dissertation and highlights the potential directions for future research.

5.5.1 Limitations

The second chapter of the dissertation utilized an interdisciplinary, inquiry-driven literature review approach that drew on theoretical and empirical perspectives from various disciplinary areas and worldviews and linked them with policy and practice. A limitation of the study was the inability to actively engage practitioners during the conceptual framework development process due to the restrictions imposed by the COVID-19 pandemic. This limitation prevented the study from benefiting from practitioners' valuable insights and perspectives, which could have further enriched the conceptual framework and its applicability to policy and practice. To compensate for this, the research included perspectives from non-academic sources to enhance the practical applicability of the framework. The conceptual framework aimed to establish a comprehensive and coherent understanding of the relationship between climate

change and migration by defining terms, complex relationships, and their significance in understanding various perspectives and manifestations of migration. It is important to note that further empirical validation is necessary to test the effectiveness of the framework in addressing the complex and evolving nature of the relationship between climate change and migration in varied contexts. Therefore, there is a need for concise conceptualizations of climate migration to facilitate the empirical validation of the framework.

The third chapter of this dissertation focused on examining the socio-economic implications of climate migration by analyzing data obtained from a household survey conducted in Dhaka, Bangladesh, as well as other secondary literature. However, it is important to note that the variables and Climate Vulnerability Indices (CVIs) used in this study may not apply to other populations or contexts. Other variables that could be used to assess vulnerability were also omitted from the analysis due to data unavailability and variations across administrative borders. Social capital and social networks are also crucial indicators for assessing vulnerability and climate change adaptation (Hahn et al., 2009; Nguyen et al., 2021); however, these were not included in the analysis due to the unavailability of data. Since the study primarily relied on large-scale quantitative data analyses, it could not capture gendered aspects and other qualitative variables of vulnerability. Furthermore, the indicators used in the study were standardized using maximum and minimum values for the participants in the research. This standardization makes the CVIs and assessments not comparable with those of other studies, except those conducted using the same approaches. It is also important to note that the sample may not accurately represent the magnitude of the selection bias for climate migrants since it contains a relatively higher number of other migrants and long-term residents. The results may slightly over-represent male views due to the limitations of unequal female respondents. Finally, the perception-based Likert scale analysis relied on self-reported data, possibly subject to recall bias (Rosenman et al., 2011). Overall, the results provide insight into the socio-economic implications of climate migration in Dhaka; however, caution should be taken when generalizing the findings to other populations or contexts.

The fourth chapter of this dissertation undertook a systematic review to evaluate and integrate the growing body of empirical evidence on climate migration and gender relations in South Asia. While the review has its strengths, some limitations must be acknowledged. Firstly, the review did not assess the quality or grading of the selected studies, given their heterogeneity, but only included those that had undergone peer review. Secondly, interpreting the findings was challenging due to the diverse methodologies, data collection strategies, sampling techniques, outcome measures, and other criteria employed in the studies. As a result, the findings were summarized narratively. Additionally, the focus of the studies was mainly on women and girls, and little research had been conducted on men, boys, and gender minorities. Thirdly, the review was limited to English-language studies, potentially excluding significant research conducted and published in other languages. However, it is noted that

English-language studies are more accessible to a wider audience. Lastly, the review's geographical focus on South Asia is also a limitation, as the findings may not represent the global perspectives on climate migration and gender. Nonetheless, the findings are still relevant for evidence-based global research and policy, given that South Asia is one of the regions most affected by climate change and migration (Clement et al., 2021; Rigaud et al., 2018).

5.5.2 Directions for future research

The second, third, and fourth chapters of this dissertation each provided insight into specific directions for future research on climate migration. This section broadly discusses these directions, guiding the design of future studies aimed at exploring the various dimensions and experiences of climate migration.

As previously discussed in chapter two, although there is a body of literature exploring the influence of climate change on migration (Boas et al., 2019; Piguet, 2022), there are still significant gaps in our knowledge of how migration decisions are made, how to categorize different types of migration, and how to measure the level of agency in migration decision-making. Moreover, our understanding of how migration patterns evolve through different dimensions of time and space and across scales remains limited. Climate change is not uniformly experienced across geographic contexts and can affect migration patterns differently (Pörtner et al., 2022). Therefore, future research should explore the typologies and agency in migration decision-making across various climatic change and geographic contexts to fill these empirical gaps. In addition, knowledge is limited on how macro-scale policy interventions (e.g., planned relocation, international immigration policy) can be adapted to ensure they are workable in different places.

Moreover, understanding the different scales at which people are exposed to and respond to climate change is critical for developing effective interventions. Therefore, individual migration decisions alone may not provide a holistic understanding of the multi-dimensional nature of climate migration. Therefore, future research must conduct multi-dimensional analysis incorporating different scales of analysis (i.e., micro, meso, and macro), and comparative analysis between localities or countries is necessary to add different layers and gain a more comprehensive understanding of climate migration. Both longitudinal quantitative and qualitative research, as well as sophisticated artificial intelligence (AI), mathematical or geographic information system (GIS) based modelling, can provide valuable insights into the complexity and dynamism between present and future climate change impacts and migration flow and patterns (Beduschi, 2022; Hermans & McLeman, 2021; Robinson et al., 2020). The conceptual framework developed in chapter two can serve as a valuable resource in providing direction for conducting such analyses.

Chapter three of this dissertation highlighted some limitations in which the study focused on assessing the vulnerability and inequalities of climate migrants in Dhaka, Bangladesh. Future research may address these limitations by incorporating additional

variables related to social networks and gender aspects. Doing so can achieve a more holistic understanding of vulnerability and inequalities associated with climate migration. Furthermore, the study may be replicated in other cities within Bangladesh and other countries to gain a broader perspective of climate migrants' vulnerability. Additionally, longitudinal studies could be conducted to track how climate migrants' exposure, sensitivity, and adaptive capacity evolve. The implementation of adaptation policies could also be examined to identify where interventions are needed to reduce vulnerability and inequalities. Such studies' findings can be valuable to decision-makers in identifying strategies to reduce vulnerability and inequalities among climate migrants. This can potentially make migration a successful adaptation strategy. The study conducted in chapter three provides a valuable baseline for supporting adaptation planning and establishing strategies to strengthen vulnerable and marginalized communities such as climate migrants.

Chapter four emphasizes the significant role of gender in shaping migration outcomes under climate change. However, the lack of a comprehensive understanding of gendered dimensions from an intersectional, sustainability- and justice-oriented perspective, limited communication across disciplinary boundaries, and methodological constraints have made it challenging to draw definitive conclusions and identify pathways through which gendered inequalities in climate migration occur. Moreover, the agency aspect of gender migration decision-making in the context of climate change remains poorly understood. Therefore, it is imperative to conduct further research on how gender interacts with other social positions and socio-economic, cultural, and structural determinants of migration. Additionally, it is necessary to investigate the gendered patterns underlying the relationship between climatic exposures and the agency level involved in migration decisions. Future investigations need to move beyond viewing gender as a simple binary differentiation between men and women and instead consider gender as a potentially intersecting element that provides insight into these gender-differentiated pathways. Future research should also explore the experiences of underrepresented groups (i.e., men and gender minorities) to shed light on the fact that gender is not exclusively a women's issue (Gioli & Milan, 2018).

As a final point, this dissertation advocates for more comprehensive, inter- and transdisciplinary research that adopts a sustainability- and justice-oriented approach to examine the intricate and diverse interactions between humans and nature. Such research is essential for understanding the causes of diverse migration patterns and the factors that influence the forms and patterns of climate migration. Additionally, it is imperative to conduct further investigations that focus on the lived experiences of climate migrants, as this will facilitate gaining a deeper understanding of their situations. By undertaking such extensive research, we can make significant progress in achieving sustainability in this field.

5.6 Personal reflection

At the beginning of my doctoral research journey, I did not have much academic exposure and personal knowledge of the complex issues surrounding climate migration, migration decisions, its consequences, and the role of gender in shaping those. Nevertheless, I embraced this challenge with an open mind, developed a deep passion and was determined to learn as much as possible through a transdisciplinary lens. As a result, I spent countless hours poring over academic and non-academic literature from diverse domains and substantial time conducting fieldwork. I faced several challenges in navigating different disciplinary perspectives, theories, and approaches to make sense of the complex phenomenon of climate migration. One of my biggest personal challenges during this research was integrating diverse and sometimes conflicting perspectives from different schools of thought. However, when I started digging deeper into the issue and began my analysis, I came to appreciate the richness and realized that this confusion was actually a strength of the field. I kept reminding myself of the interconnectedness of environmental and social systems and the need for holistic and inclusive approaches to tackling issues of climate migration and its consequences. I was inspired to seek new insights constantly to see the interconnections between different factors, and it challenged me to persistently learn, unlearn, re-learn, and grow while remaining open to new perspectives and ways of thinking. Conducting extensive literature reviews, guidance from my advisor and committee, field visits, speaking with experts, and my own analysis and experiences (as a migrant) enriched my understanding of the nuanced realities of climate migration and the experiences of climate migrants, particularly those from Bangladesh, my home country.

My experience conducting original research in the field was both challenging and rewarding, as it required significant planning and coordination and the opportunity to gain a deep understanding of climate migrants' situations. As I interacted with climate migrants and listened to their stories of loss and struggles, I gained a new perspective on the complexity and urgency of climate migration. I was deeply moved by their experiences of abandoning their homes and livelihoods due to recurring floods, riverbank erosions, cyclones, and storm surges. Their stories of overwhelming challenges left a lasting impression on me and instilled a determination to do justice to their voices and perspectives in my research. During one of my field visits, climate migrants expressed a sentiment that has resonated with me deeply and has stuck with me ever since. They candidly said, *"Researchers like you use us as mere data points to advance your careers, but we are not just data. We remain stuck in the same dire situations without much benefiting from your research."* This statement has challenged me to reflect more deeply on my role as a researcher and the ethical implications of my work. It has taught me always to remember that we should not view our research solely as an academic exercise but also as a means of understanding the realities of the people we study. This has also made me aware of recognizing the privilege of

being a researcher and that we need to use it with the utmost respect, empathy, accountability, and a genuine desire to make positive change.

In sum, my journey into doctoral research was shaped by a persistent commitment to learning that required having an open mind, passion, and determination. Therefore, this has been a humbling experience of personal growth and transformation, not only in academic pursuit but also cultivating empathy, humility and sensitivity in building trust and rapport with communities and other stakeholders. This has further reinforced my commitment to prioritizing the perspectives of marginalized communities in research and advocating for their voices to be heard in policy discussions.

“Yesterday I was clever, so I wanted to change the world.

Today I am wise, so I am changing myself.”

~ Jalāl al-Dīn Muḥammad Rūmī

References

Chapter 1 and Chapter 5

Adamo, S. B. (2023). Future Trends: The Challenges of Climate Displacement. *Integrative Social Work Practice with Refugees, Asylum Seekers, and Other Forcibly Displaced Persons*, 123-149.

Adger, W. N. (2006). Vulnerability. *Global environmental change*, *16*(3), 268-281.

Adger, W., Boyd, E., Fábos, A., Fransen, S., Jolivet, D., & Neville, G. et al. (2019). Migration transforms the conditions for the achievement of the Sustainable Development Goals. *The Lancet Planetary Health*, *3*(11), e440-e442. doi: 10.1016/s2542-5196(19)30213-x

Adger, W. N., Crépin, A. S., Folke, C., Ospina, D., Chapin III, F. S., Segerson, K., ... & Wilen, J. (2020). Urbanization, migration, and adaptation to climate change. *One Earth*, *3*(4), 396-399.

Afifi, T., Milan, A., Etzold, B., Schraven, B., Rademacher-Schulz, C., Sakdapolrak, P., ... & Warner, K. (2016). Human mobility in response to rainfall variability: opportunities for migration as a successful adaptation strategy in eight case studies. *Migration and Development*, *5*(2), 254-274.

Ahmed, S., & Eklund, E. (2021). Climate change impacts in coastal Bangladesh: migration, gender and environmental injustice. *Asian Affairs*, *52*(1), 155-174.

Amoatey, P., & Sulaiman, H. (2020). Assessing the climate change impacts of cocoa growing districts in Ghana: the livelihood vulnerability index analysis. *Environment, Development and Sustainability*, *22*, 2247-2268.

Angelsen, A., & Lund, J. F. (2011). Designing the household questionnaire. *Measuring Livelihoods and Environmental Dependence, Methods for Research and Fieldworks*, 107-126.

AR6 Synthesis Report: Climate Change 2023. (n.d.). Www.ipcc.ch. https://www.ipcc.ch/report/ar6/syr/

Aromataris, E., & Pearson, A. (2014). The systematic review: an overview. *AJN The American Journal of Nursing*, *114*(3), 53-58.

Ashrafuzzaman, M. (2022). Climate change driven natural disasters and influence on poverty in the South Western Coastal Region of Bangladesh (SWCRB). *SN Social Sciences*, *2*(7), 1-29.

Augsburg, T. (2014). Becoming transdisciplinary: The emergence of the transdisciplinary individual. *World Futures*, *70*(3-4), 233-247.

Baldwin, A., & Fornalé, E. (2017). Adaptive migration: pluralising the debate on climate change and migration. *The Geographical Journal*, *183*(4), 322-328.

Bardsley, D., & Hugo, G. (2010). Migration and climate change: examining thresholds of change to guide effective adaptation decision-making. *Population And Environment*, *32*(2-3), 238-262. doi: 10.1007/s11111-010-0126-9

Beduschi, A. (2022). Migration and artificial intelligence. In *Routledge Handbook of Immigration and Refugee Studies* (pp. 73-81). Routledge.

Benveniste, H., Oppenheimer, M., & Fleurbaey, M. (2022). Climate change increases resource-constrained international immobility. *Nature Climate Change*, *12*(7), 634-641.

Bernard, H. R., & Bernard, H. R. (2013). *Social research methods: Qualitative and quantitative approaches*. Sage.

Bhatta, G. D., Aggarwal, P. K., Poudel, S., & Belgrave, D. A. (2015). Climate-induced migration in South Asia: Migration decisions and the gendered dimensions of adverse climatic events. *Journal of Rural and Community Development*, *10*(4).

Biggs, R., de Vos, A., Preiser, R., Clements, H., Maciejewski, K., & Schlüter, M. (2021). *The Routledge Handbook of Research Methods for Social-Ecological Systems* (p. 526). Taylor & Francis.

Black, R., Adger, W. N., Arnell, N. W., Dercon, S., Geddes, A., & Thomas, D. (2011a). The effect of environmental change on human migration. *Global environmental change*, *21*, S3-S11.

Black, R., Bennett, S., Thomas, S., & Beddington, J. (2011b). Migration as adaptation. *Nature*, *478*(7370), 447-449. doi: 10.1038/478477a

Boas, I., Farbotko, C., Adams, H., Sterly, H., Bush, S., Van der Geest, K., ... & Hulme, M. (2019). Climate migration myths. *Nature Climate Change*, *9*(12), 901-903.

Bongarts Lebbe, T., Rey-Valette, H., Chaumillon, É., Camus, G., Almar, R., Cazenave, A., ... & Euzen, A. (2021). Designing coastal adaptation strategies to tackle sea level rise. *Frontiers in Marine Science*, 1640.

Bucherie, A., Hultquist, C., Adamo, S., Neely, C., Ayala, F., Bazo, J., & Kruczkiewicz, A. (2022). A comparison of social vulnerability indices specific to flooding in Ecuador: Principal component analysis (PCA) and expert knowledge. *International journal of disaster risk reduction*, *73*, 102897.

Cain, L. K., MacDonald, A. L., Coker, J. M., Velasco, J. C., & West, G. D. (2019). Ethics and Reflexivity in Mixed Methods Research: An Examination of Current Practices and a Call for Further Discussion. *International Journal of Multiple Research Approaches*, *11*(2).

Castellano, R., Dolšak, N., & Prakash, A. (2021). Willingness to help climate migrants: A survey experiment in the Korail slum of Dhaka, Bangladesh. *PLOS ONE*, *16*(4), e0249315. doi: 10.1371/journal.pone.0249315

Castro, B., & Sen, R. (2022). Everyday Adaptation: Theorizing climate change adaptation in daily life. *Global Environmental Change*, *75*, 102555.

Chazalnoël, M. T., & Randall, A. (2021). Migration and the slow-onset impacts of climate change: Taking stock and taking action. In McAuliffe, M. & Triandafyllidou, A. (Eds.), World migration report 2022 (pp. 1–37). https://publications.iom.int/books/world-migration-report-2022

Chindarkar, N. (2012). Gender and climate change-induced migration: proposing a framework for analysis. *Environmental Research Letters*, *7*(2), 025601.

Clement, V., Rigaud, K. K., de Sherbinin, A., Jones, B., Adamo, S., Schewe, J., Sadiq, N., & Shabahat, E. (2021). *Groundswell part 2: Acting on internal climate migration*. World Bank, 2021.

Cárdenas-Vélez, M., Barrott, J., Betancur Jaramillo, J. C., Hernández-Orozco, E., Maestre-Másmela, D., & Lobos-Alva, I. (2023). A combined cognitive and spatial model to map and understand climate-induced migration. *Environment, Development and Sustainability*, 1-27.

de Haas, H. (2021). A theory of migration: the aspirations-capabilities framework. *Comparative Migration Studies*, *9*(1), 1-35.

Eckstein, D., Künzel, V., Schäfer, L., & Winges, M. (2021). *GLOBAL CLIMATE RISK INDEX 2021: Who Suffers Most from Extreme Weather Events? Weather-Related Loss Events in 2019 and 2000 to 2019.* Bonn: Germanwatch e.V.

Ekoh, S. S., Teron, L., & Ajibade, I. (2023). Climate change and coastal megacities: Adapting through mobility. *Global Environmental Change*, *80*, 102666.

Ellili, N. O. D. (2023). Bibliometric analysis of sustainability papers: Evidence from Environment, Development and sustainability. *Environment, Development and Sustainability*. https://doi.org/10.1007/s10668-023-03067-6

Ertl, B., Hartmann, F. G., & Heine, J. H. (2020). Analyzing Large-Scale Studies: Benefits and Challenges. *Frontiers in Psychology*, *11*.

Eriksen, S. H., Nightingale, A. J., & Eakin, H. (2015). Reframing adaptation: The political nature of climate change adaptation. *Global Environmental Change*, *35*, 523-533.

Fajth, V., Bilgili, Ö., Loschmann, C., & Siegel, M. (2019). How do refugees affect social life in host communities? The case of Congolese refugees in Rwanda. *Comparative Migration Studies*, *7*(1), 1-21.

Fam, D., Smith, T., & Cordell, D. A. N. A. (2017). Being a transdisciplinary researcher: skills and dispositions fostering competence in transdisciplinary research and practice. In *Transdisciplinary Research and Practice for Sustainability Outcomes* (pp. 101-116). Routledge.

Fekete, H., Kuramochi, T., Roelfsema, M., den Elzen, M., Forsell, N., Höhne, N., ... & Gusti, M. (2021). A review of successful climate change mitigation policies in major emitting economies and the potential of global replication. *Renewable and Sustainable Energy Reviews*, *137*, 110602.

Feldon, D. F., & Tofel-Grehl, C. (2022). Phenomenography as a Basis for Fully Integrated Mixed Methodologies. In *The Routledge Handbook for Advancing Integration in Mixed Methods Research* (pp. 124-138). Routledge.

Ferraro, P. J., Sanchirico, J. N., & Smith, M. D. (2019). Causal inference in coupled human and natural systems. *Proceedings of the National Academy of Sciences*, *116*(12), 5311-5318.

Ferreira, H., Robinson, N., & Serraglio, D. (2019). Climate Migration And Resilient Cities: A New Urban Agenda For Sustainable Development/Migracoes Climaticas E Cidades Resilientes: Uma Nova Agenda Urbana Para O Desenvolvimento Sustentavel. *Direito Da Cidade*, *11*(3), 304-347. Retrieved from https://go.gale.com/ps/anonymous?id=GALE%7CA624690128&sid=googleScholar&v=2.1&it=r&linkaccess=abs&issn=23177721&p=IFME&sw=w

Franco Gavonel, M., Adger, W., Safra de Campos, R., Boyd, E., Carr, E., & Fábos, A. et al. (2021). The migration-sustainability paradox: transformations in mobile worlds. Current Opinion In Environmental Sustainability, 49, 98-109. doi: 10.1016/j.cosust.2021.03.013

Füssel, H. M. (2005). Vulnerability in climate change research: A comprehensive conceptual framework.

Ghosh, R. C., & Orchiston, C. (2022). A systematic review of climate migration research: gaps in existing literature. *SN Social Sciences*, *2*(5), 47.

Gioli, G., & Milan, A. (2018). Gender, migration and (global) environmental change. Routledge Handbook Of Environmental Displacement And Migration, 135-150. doi: 10.4324/9781315638843-11

Glazebrook, T., Noll, S., & Opoku, E. (2020). Gender matters: Climate change, gender bias, and women's farming in the global South and North. *Agriculture*, *10*(7), 267.

Global Environment Facility. (2022). Sixth replenishment of the Global Environment Facility Trust Fund. Retrieved from https://www.thegef.org/sites/default/files/publications/%20GEF_Replenishment_Brochure_English_Full_20220218.pdf

Gray, D. E. (2021). Doing research in the real world. *Doing research in the real world*, 1-100.

Grosh, M., & Glewwe, P. (2000). *Designing household survey questionnaires for developing countries*. Washington, DC: World Bank.

Guimarães, M. H., Pohl, C., Bina, O., & Varanda, M. (2019). Who is doing inter-and transdisciplinary research, and why? An empirical study of motivations, attitudes, skills, and behaviours. *Futures*, *112*, 102441.

Habib, N., Alauddin, M., & Cramb, R. (2022). What defines livelihood vulnerability to climate change in rain-fed, rural regions? A qualitative study of men's and women's vulnerability to climate change in Pakistan's Punjab. *Cogent Social Sciences*, *8*(1), 2054152.

Hahn, M. B., Riederer, A. M., & Foster, S. O. (2009). The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change—A case study in Mozambique. *Global environmental change*, *19*(1), 74-88.

Hermans, K., & McLeman, R. (2021). Climate change, drought, land degradation and migration: exploring the linkages. *Current opinion in environmental sustainability*, *50*, 236-244.

Hobbie, S. E., & Grimm, N. B. (2020). Nature-based approaches to managing climate change impacts in cities. *Philosophical Transactions of the Royal Society B*, *375*(1794), 20190124.

Hoffmann, R., Šedová, B., & Vinke, K. (2021). Improving the evidence base: A methodological review of the quantitative climate migration literature. *Global Environmental Change*, *71*, 102367.

Hoffmann, R., Vinke, K., & Šedová, B. (2023). Strengthening the science–policy interface in the climate migration field. *International Migration*.

Hogan, D. R., Stevens, G. A., Hosseinpoor, A. R., & Boerma, T. (2018). Monitoring universal health coverage within the Sustainable Development Goals: development and baseline data for an index of essential health services. *The Lancet Global Health*, *6*(2), e152-e168.

Holmes, A. G. D. (2020). Researcher Positionality--A Consideration of Its Influence and Place in Qualitative Research--A New Researcher Guide. *Shanlax International Journal of Education*, *8*(4), 1-10.

Hong, Q. N., Pluye, P., Bujold, M., & Wassef, M. (2017). Convergent and sequential synthesis designs: implications for conducting and reporting systematic reviews of qualitative and quantitative evidence. *Systematic reviews*, *6*(1), 1-14.

Hossain, B., Sohel, M., & Ryakitimbo, C. (2020). Climate change induced extreme flood disaster in Bangladesh: Implications on people's livelihoods in the Char Village and

their coping mechanisms. *Progress In Disaster Science*, *6*, 100079. doi: 10.1016/j.pdisas.2020.100079

Hummel, D. (2021). 12 The Nexus Between Climate Change, Migration and Gender. *Gender, Climate Change and Livelihoods: Vulnerabilities and Adaptations*, 159.

Hunter, L. M., & David, E. (2009). *Climate change and migration: Considering the gendered dimensions*. Boulder: University of Colorado, Institute of Behavioral Science.

Institute for Economics & Peace (IEP). (2020). *Ecological Threat Register 2020: Understanding Ecological Threats, Resilience and Peace.* Sydney: IEP.

Internal Displacement Monitoring Center (IDMC). (2022). *Grid Report 2022*. Geneva: IDMC. https://www.internal-displacement.org/sites/default/files/publications/documents/IDMC_GRID_2022_LR.pdf

International Organization for Migration (IOM). (2021). Institutional Strategy on Migration, Environment and Climate Change 2021–2030 For a comprehensive, evidence and rights-based approach to migration in the context of environmental degradation, climate change and disasters, for the benefit of migrants and societies. IOM, Geneva. https://environmentalmigration.iom.int/sites/g/files/tmzbdl1411/files/documents/IOM-Institutional-Strategy-MECCC_0.pdf

IPCC. (2023, March 20). *Ar6 synthesis report: Climate change 2023*. IPCC. Retrieved March 31, 2023, from https://www.ipcc.ch/report/sixth-assessment-report-cycle/.

IPCC. (2019). *Report from the IPCC Task Group on Gender (Prepared by the Task Group on Gender)*; The IPCC: Geneva, Switzerland; Available online: https://www.ipcc.ch/site/assets/uploads/2019/01/110520190810-Doc.-10-Rev.1TG-Gender.pdf

IPCC. (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press

IPCC AR6 WGII (2022). Climate change 2022: Impacts, adaptation, and vulnerability. In Pörtner, H. O., Roberts, D. C., Adams, H., Adler, C., Aldunce, P., Ali, E., ... & Stevens, N. (2022). Climate change 2022: impacts, adaptation, and vulnerability. contribution of working group ii to the sixth assessment report of the intergovernmental panel on climate change.

IPCC AR6 WGIII (2022). Climate change 2022: Mitigation of climate change. In Shukla, P. R., Skea, J., Slade, R., Al Khourdajie, A., van Diemen, R., McCollum, D., ... & Malley, J. (2022). Climate change 2022: mitigation of climate change. Contribution of working group III to the sixth assessment report of the Intergovernmental Panel on Climate Change. *Cambridge, UK and New York, NY, USA*.

Ivankova, N. V., & Plano Clark, V. L. (2018). Teaching mixed methods research: using a socio-ecological framework as a pedagogical approach for addressing the complexity of the field. *International Journal of Social Research Methodology*, *21*(4), 409-424.

Jackson, M. C. (2022). Rebooting the systems approach by applying the thinking of Bogdanov and the Pragmatists. *Systems Research and Behavioral Science*.

Jacobson, C., Crevello, S., Chea, C., & Jarihani, B. (2018). When is migration a maladaptive response to climate change?. *Regional Environmental Change*, *19*(1), 101-112.

Jamieson, M. K., Govaart, G. H., & Pownall, M. (2022). Reflexivity in quantitative research: a rationale and beginner's guide.

Janker, J., & Thieme, S. (2021). Migration and justice in the era of sustainable development goals: a conceptual framework. *Sustainability Science*, *16*(5), 1423-1437. doi: 10.1007/s11625-021-00958-3

Jilcha Sileyew, K. (2020). Research Design and Methodology. *Cyberspace*. doi: 10.5772/intechopen.85731

Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2007). Toward a definition of mixed methods research. *Journal of mixed methods research*, *1*(2), 112-133. https://doi.org/10.1177/1558689806298224

Jones, T. L., Baxter, M. A. J., & Khanduja, V. (2013). A quick guide to survey research. *The Annals of The Royal College of Surgeons of England*, *95*(1), 5-7.

Kam, P. M., Aznar-Siguan, G., Schewe, J., Milano, L., Ginnetti, J., Willner, S., ... & Bresch, D. N. (2021). Global warming and population change both heighten future risk of human displacement due to river floods. *Environmental Research Letters*, *16*(4), 044026.

Kelly, L. M., & Cordeiro, M. (2020). Three principles of pragmatism for research on organizational processes. *Methodological innovations*, *13*(2), 2059799120937242.

Khan, A. A. (2019). Social and Legal Barriers to Improving Human Rights of Climate Change Displaced People in Bangladesh. *The Journal of Interrupted Studies*, *2*(1), 103-117.

Khan, M. R., Huq, S., Risha, A. N., & Alam, S. S. (2021). High-density population and displacement in Bangladesh. *Science*, *372*(6548), 1290-1293. DOI: 10.1126/science.abi6364

Knott, E., Rao, A. H., Summers, K., & Teeger, C. (2022). Interviews in the social sciences. *Nature Reviews Methods Primers*, *2*(1), 1-15.

Kotkin, J. (2023). *The coming of neo-feudalism: A warning to the global middle class*. Encounter Books.

Kriel, A., Randall, S., Coast, E., & De Clercq, B. (2014). From design to practice: how can large-scale household surveys better represent the complexities of the social units under investigation?. *African Population Studies*, *28*(3), 1309-1323.

Lama, P., Hamza, M., & Wester, M. (2021). Gendered dimensions of migration in relation to climate change. *Climate and Development*, *13*(4), 326-336. https://doi.org/10.1080/17565529.2020.1772708

Lau, J. D., Kleiber, D., Lawless, S., & Cohen, P. J. (2021). Gender equality in climate policy and practice hindered by assumptions. *Nature climate change*, *11*(3), 186-192.

Lawrence, M. G., Williams, S., Nanz, P., & Renn, O. (2022). Characteristics, potentials, and challenges of transdisciplinary research. *One Earth*, *5*(1), 44-61.

Lazurko, A., Alamenciak, T., Hill, L. S., Muhl, E. K., Osei, A. K., Pomezanski, D., ... & Sharmin, D. F. (2020). What Will a PhD Look Like in the Future? Perspectives on Emerging Trends in Sustainability Doctoral Programs in a Time of Disruption. *World Futures Review*, *12*(4), 369-384.

Lebow, D. G., & HyLighter, L. L. C. (2018). A social machine for transdisciplinary research. *Informing Science*, *21*, 201-217.

Maharjan, A., de Campos, R. S., Singh, C., Das, S., Srinivas, A., Bhuiyan, M. R. A., ... & Vincent, K. (2020). Migration and household adaptation in climate-sensitive hotspots in South Asia. *Current Climate Change Reports*, *6*(1), 1-16.

Martin, M. A., Boakye, E. A., Boyd, E., Broadgate, W., Bustamante, M., Canadell, J. G., ... & Zhao, Z. J. (2022). Ten new insights in climate science 2022. *Global sustainability*, *5*, e20.

Martin, S. F., Bergmann, J., Rigaud, K. K., & Yameogo, N. D. (2021). Climate change, human mobility, and development. *Migration Studies*, *9*(1), 142-149.

McCarney, R., & Kent, J. (2020). Forced displacement and climate change: Time for global governance. *International Journal*, *75*(4), 652-661.

McLeman, R., & Gemenne, F. (2018). Environmental migration research: Evolution and current state of the science. *Routledge handbook of environmental displacement and migration*, 3-16.

McLeman, R. and Smit, B. (2006). Migration as an adaptation to climate change. *Climatic change*, 76(1–2), pp.31–53.

Mega, V. (2022). A new social contract for healthy, safe and happy cities for all. In *Human Sustainable Cities* (pp. 165-194). Springer, Cham.

Mimoun-Sorel, M. L. (2016). Adopting a transdisciplinary attitude in the classroom, to create a viable future. *Journal of Futures Studies*, *20*(3), 21-34.

Montuori, A. (2013). The Complexity of Transdisciplinary Literature Reviews. *Complicity: An International Journal of Complexity and Education*, *10*(1/2). doi: 10.29173/cmplct20399

Montuori, A. (2022). Integrative Transdisciplinarity. *Transdisciplinary Journal of Engineering & Science*, *13*. https://doi.org/10.22545/2022/00209

Morgan, D. L. (2007). Paradigms lost and pragmatism regained: Methodological implications of combining qualitative and quantitative methods. *Journal of mixed methods research*, *1*(1), 48-76.

Munn, Z., Peters, M. D., Stern, C., Tufanaru, C., McArthur, A., & Aromataris, E. (2018b). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC medical research methodology*, *18*, 1-7.

Munn, Z., Stern, C., Aromataris, E., Lockwood, C., & Jordan, Z. (2018a). What kind of systematic review should I conduct? A proposed typology and guidance for systematic reviewers in the medical and health sciences. *BMC medical research methodology*, *18*(1), 1-9.

Naser, M. M., Swapan, M. S. H., Ahsan, R., Afroz, T., & Ahmed, S. (2019). Climate change, migration and human rights in Bangladesh: perspectives on governance. Asia Pacific Viewpoint, 60(2), 175-190.

Ngo, B. T. (2015). Independent Evaluation of the Marrakech Action Plan for Statistics. https://documents1.worldbank.org/curated/en/493571468279866267/pdf/840610WP0Marra0Box0382094B00PUBLIC0.pdf

Nguyen, T. A., Nguyen, B. T., Van Ta, H., Nguyen, N. T. P., Hoang, H. T., Nguyen, Q. P., & Hens, L. (2021). Livelihood vulnerability to climate change in the mountains of Northern

Vietnam: comparing the Hmong and the Dzao ethnic minority populations. *Environment, Development and Sustainability*, 1-21.

Nishat, A., & Mukherjee, N. (2013). Climate change impacts, scenario and vulnerability of Bangladesh. In *Climate change adaptation actions in Bangladesh* (pp. 15-41). Springer, Tokyo.

NOAA. (2021, August 13). *Climate change impacts*. Climate Change Impacts | National Oceanic and Atmospheric Administration. Retrieved February 7, 2023, from https://www.noaa.gov/education/resource-collections/climate/climate-change-impacts

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *International journal of surgery*, *88*, 105906.

Paris Agreement. (2015). *The Paris Agreement*. Retrieved March 17, 2021, from United Nations Climate Change: https://unfccc.int/sites/default/files/english_paris_agreement.pdf

PARIS21 (2013): Report from the Task Team on Defining Implementation Arrangements for the Busan Action Plan for Statistics

Parry, M., Parry, M. L., Canziani, O., Palutikof, J., Van der Linden, P., & Hanson, C. (Eds.). (2007). *Climate change 2007-impacts, adaptation and vulnerability: Working group II contribution to the fourth assessment report of the IPCC* (Vol. 4). Cambridge University Press.

Patel, S. K., Agrawal, G., Mathew, B., Patel, S., Mohanty, B., & Singh, A. (2020). Climate change and women in South Asia: a review and future policy implications. *World Journal of Science, Technology and Sustainable Development*, *17*(2), 145-166.

Perch-Nielsen, S. L., Bättig, M. B., & Imboden, D. (2008). Exploring the link between climate change and migration. *Climatic change*, *91*(3), 375-393.

Piguet, E. (2022). Linking climate change, environmental degradation, and migration: An update after 10 years. *Wiley Interdisciplinary Reviews: Climate Change*, *13*(1), e746.

Piguet, E., Kaenzig, R., & Guélat, J. (2018). The uneven geography of research on "environmental migration". *Population and environment*, *39*, 357-383.

Popa, F., Guillermin, M., & Dedeurwaerdere, T. (2015). A pragmatist approach to transdisciplinarity in sustainability research: From complex systems theory to reflexive science. *Futures*, *65*, 45-56.

Purwar, T., Shakelly, N., Khatib, M., Sutherland, J., & Castillo, L. (2022). Climate Change, Mass Migration and Gender: A non-linear complexity. *Bulletin of the American Physical Society*.

Raymond, C., Horton, R. M., Zscheischler, J., Martius, O., AghaKouchak, A., Balch, J., ... & White, K. (2020). Understanding and managing connected extreme events. *Nature climate change*, *10*(7), 611-621. https://doi.org/10.1038/s41558-020-0790-4

Rethlefsen, M. L., Kirtley, S., Waffenschmidt, S., Ayala, A. P., Moher, D., Page, M. J., & Koffel, J. B. (2021). PRISMA-S: an extension to the PRISMA statement for reporting literature searches in systematic reviews. *Systematic reviews*, *10*(1), 1-19.

Rigaud, K. K., De Sherbinin, A., Jones, B., Bergmann, J., Clement, V., Ober, K., ... & Midgley, A. (2018). Groundswell.

Robinson, C., Dilkina, B., & Moreno-Cruz, J. (2020). Modeling migration patterns in the USA under sea level rise. *PLoS One*, *15*(1), e0227436.

Rosenman, R., Tennekoon, V., & Hill, L. G. (2011). Measuring bias in self-reported data. *International Journal of Behavioural and Healthcare Research*, *2*(4), 320-332.

Santos, C., & Mourato, J. M. (2022). Voices of contention: the value of development narratives in the age of climate (change) migration misconceptions. *Climate and Development*, *14*(1), 13-24.

Schoonenboom, J., & Johnson, R. (2017). How to Construct a Mixed Methods Research Design. *Kzfss Kölner Zeitschrift Für Soziologie Und Sozialpsychologie*, *69*(S2), 107-131. doi: 10.1007/s11577-017-0454-1

Schlüter, M., Orach, K., Lindkvist, E., Martin, R., Wijermans, N., Bodin, Ö., & Boonstra, W. (2019). Toward a methodology for explaining and theorizing about social-ecological phenomena. *Current Opinion In Environmental Sustainability*, *39*, 44-53. doi: 10.1016/j.cosust.2019.06.011

Schewel, K. (2020). Understanding immobility: Moving beyond the mobility bias in migration studies. *International Migration Review*, *54*(2), 328-355.

Schwerdtle, P., Bowen, K., & McMichael, C. (2018). The health impacts of climate-related migration. *BMC Medicine*, *16*(1). doi: 10.1186/s12916-017-0981-7

Sedova, B., & Kalkuhl, M. (2020). Who are the climate migrants and where do they go? Evidence from rural India. *World Development*, *129*, 104848.

Seo, S. N., Felson, A. J., & Felson, J. (2022). Tropical cyclones in the small island developing nations in the world oceans: an economic analysis of the Green Climate Funds grant allocations. In *Handbook of Behavioral Economics and Climate Change* (pp. 98-116). Edward Elgar Publishing.

Siddaway, A. P., Wood, A. M., & Hedges, L. V. (2019). How to do a systematic review: A best practice guide for conducting and reporting narrative reviews, meta-analyses, and meta-syntheses. *Annual review of psychology*, *70*, 747-770.

Siders, A. R., & Ajibade, I. (2021). Introduction: Managed retreat and environmental justice in a changing climate. *Journal of Environmental Studies and Sciences*, *11*(3), 287-293.

Singh, C., & Basu, R. (2020). Moving in and out of vulnerability: Interrogating migration as an adaptation strategy along a rural–urban continuum in India. *The Geographical Journal*, *186*(1), 87-102.

Smirnov, O., Lahav, G., Orbell, J., Zhang, M., & Xiao, T. (2022). Climate Change, Drought, and Potential Environmental Migration Flows Under Different Policy Scenarios. International Migration Review, 0(0). https://doi.org/10.1177/01979183221079850

Smith, J., Blevins, B., Werse, N. R., & Talbert, S. (2021). Researcher positionality in the dissertation in practice. In *Practice-based and practice-led research for dissertation development* (pp. 43-63). IGI Global.

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. Global Environmental Change, 16(3), 282-292. doi: 10.1016/j.gloenvcha.2006.03.008

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of business research*, *104*, 333-339.

Sovacool, B. K., Axsen, J., & Sorrell, S. (2018). Promoting novelty, rigor, and style in energy social science: Towards codes of practice for appropriate methods and research design. *Energy Research & Social Science*, *45*, 12-42.

Stojanov, R., Rosengaertner, S., de Sherbinin, A., & Nawrotzki, R. (2021). Climate mobility and development cooperation. *Population and Environment*, *43*(2), 209-231.

Tacoli, C. (2009). Crisis or adaptation? Migration and climate change in a context of high mobility. *Environment and urbanization*, *21*(2), 513-525.

Talbot, I., & Ranjan, A. (Eds.). (2022). *Urban Development and Environmental History in Modern South Asia* (Vol. 48). Taylor & Francis.

Tanim, A. H., Goharian, E., & Moradkhani, H. (2022). Integrated socio-environmental vulnerability assessment of coastal hazards using data-driven and multi-criteria analysis approaches. *Scientific Reports*, *12*(1), 11625.

Thalheimer, L., Otto, F., & Abele, S. (2021). Deciphering impacts and human responses to a changing climate in East Africa. *Frontiers in Climate*, *3*, 692114.

The White House. (2021). *Report on the Impact of Climate Change Migration*. White House: Washington, DC, USA. https://www.whitehouse.gov/wp-content/uploads/2021/10/Report-on-the-Impact-of-Climate-Change-on-Migration.pdf

Tollefson, J. (2020). How hot will the Earth get by 2100?. *Nature*, *580*(7804), 443-445. doi: https://doi.org/10.1038/d41586-020-01125-x

Tschakert, P., & Neef, A. (2022). Tracking local and regional climate im/mobilities through a multidimensional lens. *Regional Environmental Change*, *22*(3), 95.

Turner, B., Devisscher, T., Chabaneix, N., Woroniecki, S., Messier, C., & Seddon, N. (2022). The role of nature-based solutions in supporting social-ecological resilience for climate change adaptation. *Annual Review of Environment and Resources*, *47*, 123-148.

UN DESA (2020). World Social Report 2020: Inequality in a Rapidly Changing World. Available online: https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2020/01/World-Social-Report-2020-FullReport.pdf (accessed on 21 August 2021).

UNFCCC (2015a). United Nations Climate Change Conference. COP 21 or CMP 11 was held in Paris, France, from 30th November to 12th December; 2015

UNFCCC (2015b). 'Draft decision COP.21 on Agenda item 4(b): Adoption of the Paris Agreement'. Proposal by the President. Available: https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

UNISDR (2015). 'Sendai Framework for Disaster Risk Reduction 2015-2030'. Available: http://www.unisdr.org/ files/43291_sendaiframeworkfordrren.pdf

United Nations Environment Programme. (2022, October 21). *Emissions Gap Report 2022*. UNEP - UN Environment Programme. https://www.unep.org/resources/emissions-gap-report-2022

Wagstaff, A., O'Donnell, O., Van Doorslaer, E., & Lindelow, M. (2007). *Analyzing health equity using household survey data: a guide to techniques and their implementation*. World Bank Publications.

World Bank (2004). The Marrakech Action Plan for Statistics: Better Data for Better Results, an Action Plan for Improving Development Statistics. Presented to the Second

International Roundtable on Managing for Development Results, Marrakech, Morocco, February 4-5.

Xu, Y., Zhang, Y., Kinnucan, H., & Chen, J. (2022). Bound to Ulaanbaatar in Mongolia. *Eurasian Geography and Economics*, 1-24.

Yadav, S. S., & Lal, R. (2018). Vulnerability of women to climate change in arid and semi-arid regions: The case of India and South Asia. Journal of Arid Environments, 149, 4-17.

Yvonne Feilzer, M. (2010). Doing mixed methods research pragmatically: Implications for the rediscovery of pragmatism as a research paradigm. *Journal of mixed methods research*, *4*(1), 6-16.

Zaidi, R. Z., & Fordham, M. (2021). The missing half of the Sendai framework: Gender and women in the implementation of global disaster risk reduction policy. *Progress in Disaster Science*, *10*, 100170.

Zickgraf, C. (2021). Theorizing (im) mobility in the face of environmental change. *Regional Environmental Change*, *21*(4), 126.

Chapter 2

Abel, G. J., Brottrager, M., Cuaresma, J. C., & Muttarak, R. (2019). Climate, conflict and forced migration. *Global environmental change*, *54*, 239-249.

Adams, H. (2016). Why populations persist: mobility, place attachment and climate change. *Population and Environment*, *37*, 429-448.

Adams, H., & Kay, S. (2019). Migration as a human affair: Integrating individual stress thresholds into quantitative models of climate migration. *Environmental Science & Policy*, *93*, 129-138.

Adger, W. N. (2006). Vulnerability. *Global environmental change*, *16*(3), 268-281.

Adger, W. N. (2010). Climate change, human well-being and insecurity. *New Political Economy*, *15*(2), 275-292.

Adger, W. N., Crépin, A. S., Folke, C., Ospina, D., Chapin, F. S., Segerson, K., ... & Wilen, J. (2020). Urbanization, migration, and adaptation to climate change. *One Earth*, *3*(4), 396-399.

Adger, W. N., de Campos, R. S., & Mortreux, C. (2018). Mobility, displacement and migration, and their interactions with vulnerability and adaptation to environmental risks. In *Routledge handbook of environmental displacement and migration* (pp. 29-41). Routledge.

Adger, W. N., de Campos, R. S., Siddiqui, T., Gavonel, M. F., Szaboova, L., Rocky, M. H., ... & Billah, T. (2021). Human security of urban migrant populations affected by length of residence and environmental hazards. *Journal of Peace Research*, *58*(1), 50-66.

Ahmed, B. (2018). Who takes responsibility for the climate refugees?. *International Journal of Climate Change Strategies and Management*.

Ahsan, M. N., Khatun, F., Kumar, P., Dasgupta, R., Johnson, B. A., & Shaw, R. (2022). Promise, premise, and reality: the case of voluntary environmental non-migration despite climate risks in coastal Bangladesh. *Regional Environmental Change*, *22*(1), 1.

Ajani, A., & van der Geest, K. (2021). Climate change in rural Pakistan: evidence and experiences from a people-centered perspective. *Sustainability Science*, *16*, 1999-2011.

Ayeb-Karlsson, S. (2021). 'When we were children we had dreams, then we came to Dhaka to survive': urban stories connecting loss of wellbeing, displacement and (im) mobility. *Climate and Development*, *13*(4), 348-359.

Backhaus, A., Martinez-Zarzoso, I., & Muris, C. (2015). Do climate variations explain bilateral migration? A gravity model analysis. *IZA Journal of Migration*, *4*(1), 1-15.

Baker, E., Harris, P., Mangalagiu, D., Fidelman, P., Gonçalves, L. R., & Hollway, J. (2019). Global Environment Outlook (GEO-6) Chapter 7: Oceans and coasts.

Balachandran, B., Olshansky, R. B., & Johnson, L. A. (2022). Planning for disaster-induced relocation of communities. *Journal of the American Planning Association*, *88*(3), 288-304.

Bates-Eamer, N. (2019). Border and migration controls and migrant precarity in the context of climate change. *Social Sciences*, *8*(7), 198.

Beine, M., & Parsons, C. (2015). Climatic factors as determinants of international migration. *The Scandinavian Journal of Economics*, *117*(2), 723-767.

Beine, M., & Parsons, C. R. (2017). Climatic factors as determinants of international migration: Redux. *CESifo Economic Studies*, *63*(4), 386-402.

Benveniste, H., Oppenheimer, M., & Fleurbaey, M. (2022). Climate change increases resource-constrained international immobility. *Nature Climate Change*, *12*(7), 634-641.

Berchin, I., Valduga, I., Garcia, J., & de Andrade Guerra, J. (2017). Climate change and forced migrations: An effort towards recognizing climate refugees. *Geoforum*, *84*, 147-150. doi: 10.1016/j.geoforum.2017.06.022

Beresford, B., & Sloper, P. (2008). *Understanding the dynamics of decision-making and choice: A scoping study of key psychological theories to inform the design and analysis of the panel study*. York: Social Policy Research Unit, University of York.

Berlemann, M., & Steinhardt, M. (2017). Climate Change, Natural Disasters, and Migration—a Survey of the Empirical Evidence. *Cesifo Economic Studies*, *63*(4), 353-385. doi: 10.1093/cesifo/ifx019

Berlemann, M., & Tran, T. X. (2020). Climate-related hazards and internal migration empirical evidence for rural Vietnam. Economics of Disasters and Climate Change, 4, 385-409.

Bhowmik, J., Irfanullah, H. M., & Selim, S. A. (2021). Empirical evidence from Bangladesh of assessing climate hazard-related loss and damage and state of adaptive capacity to address them. *Climate Risk Management*, *31*, 100273.

Bohra-Mishra, P., Oppenheimer, M., Cai, R., Feng, S., & Licker, R. (2017). Climate variability and migration in the Philippines. *Population and environment*, *38*, 286-308

Bohra-Mishra, P., Oppenheimer, M., & Hsiang, S. M. (2014). Nonlinear permanent migration response to climatic variations but minimal response to disasters. *Proceedings of the National Academy of Sciences*, *111*(27), 9780-9785.

Borja, A., Santoro, F., Scowcroft, G., Fletcher, S., Strosser, P., eds. (2020). Connecting People to Their Oceans: Issues and Options for Effective Ocean Literacy. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-88963-509-2

Black, R., Adger, W. N., Arnell, N. W., Dercon, S., Geddes, A., & Thomas, D. (2011). The effect of environmental change on human migration. *Global environmental change*, *21*, S3-S11.

Black, R., Arnell, N., Adger, W., Thomas, D., & Geddes, A. (2013). Migration, immobility and displacement outcomes following extreme events. *Environmental Science & Policy*, *27*, S32-S43. doi: 10.1016/j.envsci.2012.09.001

Black, R., & Collyer, M. (2014). "Trapped" Populations: Limits on mobility at times of crisis. In *Humanitarian crises and migration* (pp. 287-305). Routledge.

Black, R., & Collyer, M. (2014). Populations 'trapped'at times of crisis. *Forced Migration Review*, *45*.

Brouwer, R., Akter, S., Brander, L., & Haque, E. (2007). Socioeconomic vulnerability and adaptation to environmental risk: a case study of climate change and flooding in Bangladesh. *Risk Analysis: An International Journal*, *27*(2), 313-326.

Burke, M., Hsiang, S. M., & Miguel, E. (2015). Climate and conflict. *Annu. Rev. Econ.*, *7*(1), 577-617.

Burrows, K., & Kinney, P. L. (2016). Exploring the climate change, migration and conflict nexus. *International journal of environmental research and public health*, *13*(4), 443.

Cai, R., Feng, S., Oppenheimer, M., & Pytlikova, M. (2016). Climate variability and international migration: The importance of the agricultural linkage. *Journal Of Environmental Economics And Management*, *79*, 135-151. doi: 10.1016/j.jeem.2016.06.005

Call, M. A., Gray, C., Yunus, M., & Emch, M. (2017). Disruption, not displacement: environmental variability and temporary migration in Bangladesh. *Global environmental change*, *46*, 157-165.

Carling, J. R. (2002). Migration in the age of involuntary immobility: Theoretical reflections and Cape Verdean experiences. *Journal of ethnic and migration studies*, *28*(1), 5-42

Carling, J., & Collins, F. (2018). Aspiration, desire and drivers of migration. *Journal of Ethnic and Migration Studies*, *44*(6), 909-926.

Carling, J., Czaika, M., & Erdal, M. B. (2020). Translating migration theory into empirical propositions. *Changes*, *1*, 27.

Carrico, A. R. (2023). Family Well-Being in the Context of Environmental Migration. In *Environmental Impacts on Families: Change, Challenge, and Adaptation* (pp. 67-84). Cham: Springer Nature Switzerland.

Castelli, F. (2018). Drivers of migration: why do people move?. *Journal of travel medicine*, *25*(1).

Cattaneo, C., Beine, M., Fröhlich, C. J., Kniveton, D., Martinez-Zarzoso, I., Mastrorillo, M., ... & Schraven, B. (2019). Human migration in the era of climate change. *Review of Environmental Economics and Policy*.

Cattaneo, C., & Peri, G. (2016). The migration response to increasing temperatures. *Journal Of Development Economics*, *122*, 127-146. doi: 10.1016/j.jdeveco.2016.05.004

Chen, J., & Mueller, V. (2018). Coastal climate change, soil salinity and human migration in Bangladesh. *Nature Climate Change*, *8*(11), 981-985. doi: 10.1038/s41558-018-0313-8

Cissé, G., R. McLeman, H. Adams, P. Aldunce, K. Bowen, D. Campbell-Lendrum, S. Clayton, K.L. Ebi, J. Hess, C. Huang, Q. Liu, G. McGregor, J. Semenza, and M.C.

Tirado, *2022: Health, Wellbeing, and the Changing Structure of Communities. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 1041–1170, doi:10.1017/9781009325844.009.

Clement, V., Rigaud, K. K., de Sherbinin, A., Jones, B., Adamo, S., Schewe, J., ... & Shabahat, E. (2021). *Groundswell part 2: Acting on internal climate migration*. World Bank.

Cohen, R., & Bradley, M. (2010). Disasters and displacement: gaps in protection. *J. Int'l Human. Legal Stud.*, *1*, 95.

Conigliani, C., Costantini, V., & Finardi, G. (2022). Climate-related natural disasters and forced migration: a spatial regression analysis. *Spatial Economic Analysis*, *17*(3), 416-439.

Cronin, M. A., & George, E. (2023). The why and how of the integrative review. *Organizational Research Methods*, *26*(1), 168-192.

Cundill, G., Singh, C., Adger, W. N., De Campos, R. S., Vincent, K., Tebboth, M., & Maharjan, A. (2021). Toward a climate mobilities research agenda: Intersectionality, immobility, and policy responses. *Global Environmental Change*, *69*, 102315.

Curran, S. R., & Meijer-Irons, J. (2014). Climate variability, land ownership and migration: evidence from Thailand about gender impacts. *Washington journal of environmental law & policy*, *4*(1), 37.

Cutter, S. L., & Finch, C. (2008). Temporal and spatial changes in social vulnerability to natural hazards. *Proceedings of the national academy of sciences*, *105*(7), 2301-2306.

Czaika, M., Bijak, J., & Prike, T. (2021). Migration decision-making and its key dimensions. *The annals of the American academy of political and social science*, *697*(1), 15-31.

Davis, K. F., Bhattachan, A., D'Odorico, P., & Suweis, S. (2018). A universal model for predicting human migration under climate change: examining future sea level rise in Bangladesh. *Environmental Research Letters*, *13*(6), 064030.

de Haas, H. (2021). A theory of migration: the aspirations-capabilities framework. *Comparative Migration Studies*, *9*(1), 1-35. https://doi.org/10.1186/s40878-020-00210-4

De Jong, G. F., Abad, R. G., Arnold, F., Carino, B. V., Fawcett, J. T., & Gardner, R. W. (1983). International and internal migration decision making: a value-expectancy based analytical framework of intentions to move from a rural Philippine province. *International Migration Review*, *17*(3), 470-484.

de Sherbinin, A. M., Grace, K., McDermid, S., Van Der Geest, K., Puma, M. J., & Bell, A. (2022). Migration Theory in Climate Mobility Research.

Echeverría, G., & Echeverría, G. (2020). Irregular migration theories. *Towards a Systemic Theory of Irregular Migration: Explaining Ecuadorian Irregular Migration in Amsterdam and Madrid*, 41-94.

Entwisle, B., Verdery, A., & Williams, N. (2020). Climate change and migration: New insights from a dynamic model of out-migration and return migration. *American Journal of Sociology*, *125*(6), 1469-1512.

Erdal, M. B., & Oeppen, C. (2018). Forced to leave? The discursive and analytical significance of describing migration as forced and voluntary. *Journal of Ethnic and Migration Studies*, *44*(6), 981-998.

Erwin, A., Ma, Z., Popovici, R., O'Brien, E. P. S., Zanotti, L., Zeballos, E. Z., ... & Larrea, G. R. A. (2021). Intersectionality shapes adaptation to social-ecological change. *World development*, *138*, 105282.

Falco, C., Galeotti, M., & Olper, A. (2019). Climate change and migration: Is agriculture the main channel?. *Global Environmental Change*, *59*, 101995. doi: 10.1016/j.gloenvcha.2019.101995

Farbotko, C., Dun, O., Thornton, F., McNamara, K., & McMichael, C. (2020). Relocation planning must address voluntary immobility. *Nature Climate Change*, *10*(8), 702-704. doi: 10.1038/s41558-020-0829-6

Farbotko, C., & McMichael, C. (2019). Voluntary immobility and existential security in a changing climate in the Pacific. *Asia Pacific Viewpoint*, *60*(2), 148-162.

Ferris, E., & Weerasinghe, S. (2020). Promoting human security: Planned relocation as a protection tool in a time of climate change. *Journal on Migration and Human Security*, *8*(2), 134-149.

Field, C. B., & Barros, V. R. (Eds.). (2014). *Climate change 2014–Impacts, adaptation and vulnerability: Regional aspects*. Cambridge University Press.

Findlay, A. M. (2011). Migrant destinations in an era of environmental change. *Global Environmental Change*, *21*, S50-S58.

Fischer, P. A., Martin, R., & Straubhaar, T. (2021). Interdependencies between development and migration. In *International migration, immobility and development* (pp. 91-132). Routledge.

Foresight, U. K. (2011). Migration and global environmental change: Future challenges and opportunities. UK Government Office for Science.

Franco Gavonel, M., Adger, W., Safra de Campos, R., Boyd, E., Carr, E., & Fábos, A. et al. (2021). The migration-sustainability paradox: transformations in mobile worlds. Current Opinion In Environmental Sustainability, 49, 98-109. doi: 10.1016/j.cosust.2021.03.013

Fu, Z., & Hao, L. (2018). Agent-based modeling of China's rural–urban migration and social network structure. *Physica A: Statistical Mechanics and its Applications*, *490*, 1061-1075.

Fussell, E. (2012). Space, time, and volition: Dimensions of migration theory. https://doi.org/10.1093/oxfordhb/9780195337228.013.0002

Füssel, H. M. (2005). Vulnerability in climate change research: A comprehensive conceptual framework.

Füssel, H. M. (2007). Vulnerability: A generally applicable conceptual framework for climate change research. *Global environmental change*, *17*(2), 155-167.

Gardiner, P. (2020). Learning to think together: Creativity, interdisciplinary collaboration and epistemic control. *Thinking skills and creativity*, *38*, 100749.

Global Internal Displacement Database. (2023). IDMC. https://www.internal-displacement.org/database/displacement-data

Goldbach, C. (2017). Out-migration from coastal areas in Ghana and Indonesia—The role of Environmental factors. *CESifo Economic Studies*, *63*(4), 529-559.

Grant, C., & Osanloo, A. (2014). Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blueprint for your "house". *Administrative Issues Journal*, *4*(2), 4.

Gray, C., & Bilsborrow, R. (2013). Environmental influences on human migration in rural Ecuador. *Demography*, *50*(4), 1217-1241.

Grecequet, M., DeWaard, J., Hellmann, J. J., & Abel, G. J. (2017). Climate vulnerability and human migration in global perspective. *Sustainability*, *9*(5), 720.

Hailegiorgis, A., Crooks, A., & Cioffi-Revilla, C. (2018). An agent-based model of rural households' adaptation to climate change. *Journal of Artificial Societies and Social Simulation*, *21*(4).

Hauer, M. E., Fussell, E., Mueller, V., Burkett, M., Call, M., Abel, K., ... & Wrathall, D. (2020). Sea-level rise and human migration. *Nature Reviews Earth & Environment*, *1*(1), 28-39.

Hicks, T., Hyler, J., & Pangle, W. (2020). *Ask, explore, write!: An inquiry-driven approach to science and literacy learning*. Routledge.

Hirvonen, K. (2016). Temperature changes, household consumption, and internal migration: evidence from Tanzania. *American Journal of Agricultural Economics*, *98*(4), 1230-1249.

Hoffmann, E. M., Konerding, V., Nautiyal, S., & Buerkert, A. (2019). Is the push-pull paradigm useful to explain rural-urban migration? A case study in Uttarakhand, India. *PloS one*, *14*(4), e0214511.

Hoffmann, R., Dimitrova, A., Muttarak, R., Crespo Cuaresma, J., & Peisker, J. (2020). A meta-analysis of country-level studies on environmental change and migration. *Nature Climate Change*, *10*(10), 904-912. https://doi.org/10.1038/s41558-020-0898-6

Hoffmann, R., Šedová, B., & Vinke, K. (2021). Improving the evidence base: A methodological review of the quantitative climate migration literature. *Global Environmental Change*, *71*, 102367.

Hoffmann, R., Wiederkehr, C., Dimitrova, A., & Hermans, K. (2022). Agricultural livelihoods, adaptation, and environmental migration in sub-Saharan drylands: a meta-analytical review. *Environmental Research Letters*, *17*(8), 083003.

Houghton, J. T., Jenkins, G. J., & Ephraums, J. J. (1990). Climate change: the IPCC scientific assessment. *American Scientist;(United States)*, *80*(6).

Hugo, G. (1996). Environmental Concerns and International Migration. International Migration Review, 30(1), 105–131. https://doi.org/10.1177/019791839603000110

Hunter, L. M. (2005). Migration and environmental hazards. *Population and environment*, *26*, 273-302.

Hunter, L. M., Luna, J. K., & Norton, R. M. (2015). Environmental dimensions of migration. *Annual Review of Sociology*, *41*, 377-397. https://doi.org/10.1146/annurev-soc-073014-112223

Hunter, L. M., Murray, S., & Riosmena, F. (2013). Rainfall patterns and US migration from rural Mexico. *International Migration Review*, *47*(4), 874-909.

IDMC & UNFCCC. (2018, August). *Synthesizing the state of knowledge to better understand displacement related to slow onset events, Task Force on Displacement*. https://unfccc.int/sites/default/files/resource/WIM%20TFD%20I.2%20Output.pdf

Inniss, L., Simcock, A., Ajawin, A. Y., Alcala, A. C., Bernal, P., Calumpong, H. P., ... & Węsławski, J. M. (2016). The first global integrated marine assessment. *United Nations. Accessed on 31st December, 2021*.

Institute for Economics & Peace (IEP). (2020). *Ecological Threat Register 2020: Understanding Ecological Threats, Resilience and Peace.* Sydney: IEP.

Institute for Economics & Peace. Ecological Threat Report 2022: Analysing Ecological Threats, Resilience & Peace, Sydney, (October 2022). Available from: http://visionofhumanity.org/resources (accessed 10, February 2023).

International Organization for Migration (IOM). (2021). Institutional Strategy on Migration, Environment and Climate Change 2021–2030 For a comprehensive, evidence and rights-based approach to migration in the context of environmental degradation, climate change and disasters, for the benefit of migrants and societies. IOM, Geneva. https://environmentalmigration.iom.int/sites/g/files/tmzbdl1411/files/documents/IOM-Institutional-Strategy-MECCC_0.pdf

Internal Displacement Monitoring Centre [IDMC]. (2018). No Matter of Choice: Displacement in a Changing Climate; IDMC: Geneva, Switzerland.

Internal Displacement Monitoring Center (IDMC). (2022). *Grid Report 2022*. Geneva: IDMC. https://www.internal-displacement.org/sites/default/files/publications/documents/IDMC_GRID_2022_LR.pdf

IOM. (2011). *Glossary on Migration.* Geneva: International Organization for Migration.

IOM. (2017). *Assessing the Climate Change Environmental Degradation and Migration Nexus in South Asia.* Geneva: International Organization for Migration (IOM). https://environmentalmigration.iom.int/assessing-climate-change-migration-nexus-south-asia

IOM. (2019). *Glossary on Migration.* Geneva: International Organization for Migration.

IPCC. (2019a). *Report from the IPCC Task Group on Gender (Prepared by the Task Group on Gender)*; The IPCC: Geneva, Switzerland; Available online: https://www.ipcc.ch/site/assets/uploads/2019/01/110520190810-Doc.-10-Rev.1TG-Gender.pdf

IPCC. (2019b). Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. In press.

IPCC. (2021, August 9). *Climate change widespread, rapid, and intensifying*. IPCC; IPCC. https://www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr/

IPCC. (2023, March 20). *Ar6 synthesis report: Climate change 2023*. IPCC. Retrieved March 31, 2023, from https://www.ipcc.ch/report/sixth-assessment-report-cycle/.

Islam, M. M., Islam, F., Akter, M. S., Kundu, G. K., Barman, A., & Khan, M. I. (2020). Transformative adaptations to climate change: cases from the Jamuna river fishing communities of Bangladesh. *Journal of Fisheries and Environment*, *44*(3), 1-18.

Islam, M. (2022). Is Climate Change Migration an Adjustment to Extreme Weather Events? A Study on the Coastal Areas of Bangladesh. *Weather, Climate, and Society*, *14*(4), 1247-1260.

Jha, C. K., Gupta, V., Chattopadhyay, U., & Amarayil Sreeraman, B. (2018). Migration as adaptation strategy to cope with climate change: A study of farmers' migration in rural

India. *International Journal of Climate Change Strategies and Management*, *10*(1), 121-141.

Kaczan, D. J., & Orgill-Meyer, J. (2020). The impact of climate change on migration: a synthesis of recent empirical insights. *Climatic Change*, *158*(3), 281-300.

Kelman, I., Orlowska, J., Upadhyay, H., Stojanov, R., Webersik, C., Simonelli, A. C., ... & Němec, D. (2019). Does climate change influence people's migration decisions in Maldives?. *Climatic change*, *153*, 285-299.

Khan, M. R., Huq, S., Risha, A. N., & Alam, S. S. (2021). High-density population and displacement in Bangladesh. *Science*, *372*(6548), 1290-1293.

Khavarian-Garmsir, A. R., Pourahmad, A., Hataminejad, H., & Farhoodi, R. (2019). Climate change and environmental degradation and the drivers of migration in the context of shrinking cities: A case study of Khuzestan province, Iran. *Sustainable Cities and Society*, *47*, 101480.

Klein, J. T. (2020). Sustainability and collaboration: Crossdisciplinary and cross-sector horizons. *Sustainability*, *12*(4), 1515.

Kniveton, D. R., Smith, C. D., & Black, R. (2012). Emerging migration flows in a changing climate in dryland Africa. *Nature Climate Change*, *2*(6), 444-447.

Koubi, V. (2018). Exploring the relationship between climate change and violent conflict. *Chinese Journal of Population Resources and Environment*, *16*(3), 197-202.

Kubik, Z., & Maurel, M. (2016). Weather shocks, agricultural production and migration: Evidence from Tanzania. *The Journal of Development Studies*, *52*(5), 665-680.

Koubi, V., Spilker, G., Schaffer, L., & Bernauer, T. (2016). Environmental stressors and migration: Evidence from Vietnam. *World development*, *79*, 197-210

Lama, P., Hamza, M., & Wester, M. (2021). Gendered dimensions of migration in relation to climate change. *Climate and Development*, *13*(4), 326-336. https://doi.org/10.1080/17565529.2020.1772708

Lamperti, F., Mandel, A., Napoletano, M., Sapio, A., Roventini, A., Balint, T., & Khorenzhenko, I. (2019). Towards agent-based integrated assessment models: examples, challenges, and future developments. *Regional environmental change*, *19*, 747-762.

Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., ... & Thomas, C. J. (2012). Transdisciplinary research in sustainability science: practice, principles, and challenges. *Sustainability science*, *7*, 25-43.

Lee, E. S. (1966). A Theory of Migration. *Demography*, *3*(1), 47–57. https://doi.org/10.2307/2060063

Leviston, Z., Dandy, J., Horwitz, P., & Drake, D. (2023). Anticipating environmental losses: Effects on place attachment and intentions to move. *Journal of Migration and Health*, 100152.

Liehr, S., Drees, L., & Hummel, D. (2016). Migration as Societal Response to Climate Change and Land Degradation in Mali and Senegal. *Adaptation To Climate Change And Variability In Rural West Africa*, 147-169. doi: 10.1007/978-3-319-31499-0_9

Lindegaard, L. S. (2020). Lessons from climate-related planned relocations: the case of Vietnam. *Climate and Development*, *12*(7), 600-609.

Lotze, H., Tittensor, D., Bryndum-Buchholz, A., Eddy, T., Cheung, W., & Galbraith, E. et al. (2019). Global ensemble projections reveal trophic amplification of ocean biomass declines with climate change. *Proceedings Of The National Academy Of Sciences*, *116*(26), 12907-12912. doi: 10.1073/pnas.1900194116

Luetz, J. M., & Merson, J. (2019). Climate change and human migration as adaptation: Conceptual and practical challenges and opportunities. *Climate Action. Encyclopedia of the UN Sustainable Development Goals (Vol. SDG 3-Climate Action, Earth and Environmental Science ed., pp. 1–13). Cham, Switzerland: Springer Nature. https://doi. org/10.1007/978-3-319-71063-1_46-1*.

Lujala, P., Lein, H., & Rød, J. K. (2015). Climate change, natural hazards, and risk perception: the role of proximity and personal experience. *Local Environment*, *20*(4), 489-509.

Mach, K. J., & Siders, A. R. (2021). Reframing strategic, managed retreat for transformative climate adaptation. *Science*, *372*(6548), 1294-1299.

Mallick, B., Priovashini, C., & Schanze, J. (2023). “I can migrate, but why should I?”—voluntary non-migration despite creeping environmental risks. *Humanities and Social Sciences Communications*, *10*(1), 1-14.

Marotzke, J., Semmann, D., & Milinski, M. (2020). The economic interaction between climate change mitigation, climate migration and poverty. *Nature Climate Change*, *10*(6), 518-525.

Marshall, J. (2014). Transdisciplinarity and art integration: Toward a new understanding of art-based learning across the curriculum. *Studies in Art Education*, *55*(2), 104-127.

Mastrorillo, M., Licker, R., Bohra-Mishra, P., Fagiolo, G., Estes, L. D., & Oppenheimer, M. (2016). The influence of climate variability on internal migration flows in South Africa. *Global Environmental Change*, *39*, 155-169.

McLeman, R. (2013). Developments in modelling of climate change-related migration. *Climatic change*, *117*, 599-611.

McLeman, R. (2018). Thresholds in climate migration. *Population and environment*, *39*, 319-338.

McLeman, R. (2019). International migration and climate adaptation in an era of hardening borders. *Nature Climate Change*, *9*(12), 911-918.

McLeman, R., & Hunter, L. (2010). Migration in the context of vulnerability and adaptation to climate change: insights from analogues. *Wiley Interdisciplinary Reviews: Climate Change*, *1*(3), 450-461. doi: 10.1002/wcc.51

McLeman, R. and Smit, B. (2006). Migration as an adaptation to climate change. *Climatic change*, 76(1–2), pp.31–53.

McLeman, R., Wrathall, D., Gilmore, E., Thornton, P., Adams, H., & Gemenne, F. (2021). Conceptual framing to link climate risk assessments and climate-migration scholarship. Climatic Change, 165, 1-7.

McMichael, C., Katonivualiku, M., & Powell, T. (2019). Planned relocation and everyday agency in low-lying coastal villages in Fiji. *The Geographical Journal*, *185*(3), 325-337. doi: 10.1111/geoj.12312

Mendenhall, E., Hendrix, C., Nyman, E., Roberts, P., Hoopes, J., & Watson, J. et al. (2020). Climate change increases the risk of fisheries conflict. Marine Policy, 117, 103954. doi: 10.1016/j.marpol.2020.103954

Mianabadi, A., Davary, K., Kolahi, M., & Fisher, J. (2022). Water/climate nexus environmental rural-urban migration and coping strategies. *Journal of Environmental Planning and Management*, *65*(5), 852-876.

Montuori, A. (2013). The complexity of transdisciplinary literature reviews. *Complicity: An International Journal of Complexity and Education*, *10*(1/2).

Mueller, V., Gray, C., & Kosec, K. (2014). Heat stress increases long-term human migration in rural Pakistan. *Nature climate change*, *4*(3), 182-185.

Mujeri, M. K., & Mujeri, N. (2020). *Bangladesh at fifty: Moving beyond development traps*. London: Palgrave Macmillan.

Nabong, E. C., Hocking, L., Opdyke, A., & Walters, J. P. (2023). Decision-making factor interactions influencing climate migration: A systems-based systematic review. *Wiley Interdisciplinary Reviews: Climate Change*, e828.

Nagabhatla, N., Pouramin, P., Brahmbhatt, R., Fioret, C., Glickman, T., Newbold, K. B., & Smakhtin, V. (2020). Water and Migration: A Global Overview. *UNU-INWEH Report Series*, (10).

Nawrotzki, R. J., & Bakhtsiyarava, M. (2017). International climate migration: Evidence for the climate inhibitor mechanism and the agricultural pathway. *Population, space and place*, *23*(4), e2033.

Nawrotzki, R. J., & DeWaard, J. (2018). Putting trapped populations into place: Climate change and inter-district migration flows in Zambia. *Regional environmental change*, *18*(2), 533-546.

Niedomysl, T., & Fransson, U. (2014). On Distance and the Spatial Dimension in the Definition of Internal Migration. *Annals of the Association of American Geographers: Migration*, *104*(2), 357–372. https://doi.org/10.1080/00045608.2013.875809

Oliver, S., Garner, P., Heywood, P., Jull, J., Dickson, K., Bangpan, M., ... & Garside, R. (2017). Transdisciplinary working to shape systematic reviews and interpret the findings: commentary. *Environmental Evidence*, *6*(1), 1-7.

Orcherton, D., Mitchell, D., & McEvoy, D. (2017). Perceptions of climate vulnerability, tenure security and resettlement priorities: Insights from Lami Town, Fiji Islands. *Australian Geographer*, *48*(2), 235-254.

Pachauri, R. K., Allen, M. R., Barros, V. R., Broome, J., Cramer, W., Christ, R., ... & van Ypserle, J. P. (2014). *Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change* (p. 151). IPCC.

Paris Agreement. (2015). *The Paris Agreement*. Retrieved March 17, 2023, from United Nations Climate Change: https://unfccc.int/sites/default/files/english_paris_agreement.pdf

Parry, M. L., Canziani, O., Palutikof, J., Van der Linden, P., & Hanson, C. (Eds.). (2007). *Climate change 2007-impacts, adaptation and vulnerability: Working group II contribution to the fourth assessment report of the IPCC* (Vol. 4). Cambridge University Press.

Parsons, L., & Nielsen, J. Ø. (2021). The subjective climate migrant: Climate perceptions, their determinants, and relationship to migration in Cambodia. *Annals of the American Association of Geographers*, *111*(4), 971-988.

Perch-Nielsen, S. L., Bättig, M. B., & Imboden, D. (2008). Exploring the link between climate change and migration. *Climatic change*, *91*(3), 375-393.

Perumal, N. (2018). " The place where I live is where I belong": community perspectives on climate change and climate-related migration in the Pacific island nation of Vanuatu. *Island studies journal*, *13*(1)

Petrova, K. (2021). Natural hazards, internal migration and protests in Bangladesh. *Journal of Peace Research*, *58*(1), 33-49

Piggott-McKellar, A. E., McNamara, K. E., Nunn, P. D., & Sekinini, S. T. (2019). Moving people in a changing climate: lessons from two case studies in Fiji. *Social Sciences*, *8*(5), 133

Piguet, E. (2022). Linking climate change, environmental degradation, and migration: An update after 10 years. *Wiley Interdisciplinary Reviews: Climate Change*, *13*(1), e746.

Piguet, E., Kaenzig, R., & Guélat, J. (2018). The uneven geography of research on "environmental migration". Population and environment, 39, 357-383.

Piguet, E., Pécoud, A., & De Guchteneire, P. (2011). Migration and climate change: An overview. *Refugee Survey Quarterly*, *30*(3), 1-23.

Pörtner, H. O., Roberts, D. C., Adams, H., Adler, C., Aldunce, P., Ali, E., ... & Birkmann, J. (2022). Climate change 2022: Impacts, adaptation and vulnerability. *IPCC Sixth Assessment Report*.

Privara, A. (2019). Sudden and slow-onset events as triggers of migration. *Journal of Modern Economic Research*, *1*(2), 25-38.

Purwar, T., Shakelly, N., Khatib, M., Sutherland, J., & Castillo, L. (2022). Climate Change, Mass Migration and Gender: A non-linear complexity. *Bulletin of the American Physical Society*.

Rana, I. A., Jamshed, A., Younas, Z. I., & Bhatti, S. S. (2020). Characterizing flood risk perception in urban communities of Pakistan. *International journal of disaster risk reduction*, *46*, 101624.

Ravitch, S. M., & Riggan, M. (2016). *Reason & rigor: How conceptual frameworks guide research*. Sage Publications.

Rechkemmer, A. (2009). Societal Impacts of Desertification: Migration and Environmental Refugees?. In *Facing Global Environmental Change* (pp. 151-158). Springer, Berlin, Heidelberg.

Richards, C. E., Lupton, R. C., & Allwood, J. M. (2021). Re-framing the threat of global warming: an empirical causal loop diagram of climate change, food insecurity and societal collapse. *Climatic Change*, *164*(3-4), 49.

Richmond, A. H. (1993). Reactive migration: Sociological perspectives on refugee movements. *Journal of refugee Studies*, *6*(1), 7-24.

Rigaud, K. K., de Sherbinin, A., Jones, B., Bergmann, J., Clement, V., Ober, K., Schewe, J., Adamo, S., McCusker, B., Heuser, S., Midgley, A. (2018). *Groundswell : Preparing for Internal Climate Migration.* World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/29461 *License: CC BY 3.0 IGO.*

Rigolot, C. (2020). Transdisciplinarity as a discipline and a way of being: complementarities and creative tensions. *Humanities and social sciences communications*, *7*(1), 1-5.

Roeckert, J., & Kraehnert, K. (2022). Extreme weather events and internal migration: Evidence from mongolia. *Economics of Disasters and Climate Change*, *6*(1), 95-128.

Santos, C., & Mourato, J. M. (2022). 'I was born here, I will die here': climate change and migration decisions from coastal and insular Guinea-Bissau. *Geografiska Annaler: Series B, Human Geography*, 1-19.

Schewel, K. (2020). Understanding immobility: Moving beyond the mobility bias in migration studies. *International Migration Review*, *54*(2), 328-355. https://doi.org/10.1177/0197918319831952

Schlüter, M., Caniglia, G., Orach, K., Bodin, Ö., Magliocca, N., Meyfroidt, P., & Reyers, B. (2022). Why care about theories? Innovative ways of theorizing in sustainability science. *Current Opinion in Environmental Sustainability*, *54*, 101154.

Sedova, B., & Kalkuhl, M. (2020). Who are the climate migrants and where do they go? Evidence from rural India. *World Development*, *129*, 104848.

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global environmental change*, *16*(3), 282-292.

Simm, D., Marvell, A., & Mellor, A. (2021). Teaching "wicked" problems in geography. *Journal of Geography in Higher Education*, *45*(4), 479-490.

Sjaastad, L. A. (1962). The costs and returns of human migration. *Journal of political Economy*, *70*(5, Part 2), 80-93.

Stojanov, R., Kelman, I., Shen, S., Duží, B., Upadhyay, H., Vikhrov, D., ... & Mishra, A. (2014). Contextualising typologies of environmentally induced population movement. *Disaster Prevention and Management*

Stoler, J., Pearson, A. L., Rosinger, A. Y., Lee, A. E., Bombardi, R., Brewis, A., ... & Tutu, R. A. (2022). The role of water in environmental migration. *Wiley Interdisciplinary Reviews: Water*, *9*(3), e1584.

Swayamprakash, A., & Priydarshini, S. (2020). Redefining the term Climate Refugees. GLS Law Journal , 2(2), 42-53. Retrieved from http://glslawjournal.in/index.php/glslawjournal/article/view/32

Szaboova, L., Safra de Campos, R., Adger, W. N., Abu, M., Codjoe, S. N. A., Franco Gavonel, M., ... & Hazra, S. (2022). Urban sustainability and the subjective well-being of migrants: The role of risks, place attachment, and aspirations. *Population, Space and Place*, *28*(1), e2505.

Tacoli, C. (2009). Crisis or adaptation? Migration and climate change in a context of high mobility. *Environment and urbanization*, *21*(2), 513-525.

The White House. (2021). *Report on the Impact of Climate Change Migration*. White House: Washington, DC, USA. https://www.whitehouse.gov/wp-content/uploads/2021/10/Report-on-the-Impact-of-Climate-Change-on-Migration.pdf

Thober, J., Schwarz, N., & Hermans, K. (2018). Agent-based modeling of environment-migration linkages. *Ecology and society*, *23*(2).

Thomas, K., Hardy, R. D., Lazrus, H., Mendez, M., Orlove, B., Rivera-Collazo, I., ... & Winthrop, R. (2019). Explaining differential vulnerability to climate change: A social science review. *Wiley Interdisciplinary Reviews: Climate Change*, *10*(2), e565.

UN. (1998). *Recommendations on Statistics of International Migration*, New York, UN.

United Nations. (2012). *Toolkit on International Migration*. *June*, 1–15. http://www.un.org/en/development/desa/population/migration/publications/others/docs/toolkit_DESA_June 2012.pdf

UNITED NATIONS COMMISSION ON HUMAN RIGHTS [UNCHR]. (1998). Guiding Principles on Internal Displacement. In *Special Rapporteur on the Human Rights of Internally Displaced Persons*. United Nations Economic and Social Council. Retrieved February 12, 2023, from https://documents-dds-ny.un.org/doc/UNDOC/GEN/G98/104/93/PDF/G9810493.pdf?OpenElement

United Nations High Commissioner for Refugees. (1979). *Handbook on Procedures and Criteria for Determining Refugee Status under the 1951 Convention and the 1967 Protocol relating to the Status of Refugees*. UNHCR.

Van Praag, L., Lietaer, S., & Michellier, C. (2021). A qualitative study on how perceptions of environmental changes are linked to migration in Morocco, Senegal, and DR Congo. *Human Ecology*, 1-15.

Warner, K., Afifi, T., Henry, K., Rawe, T., Smith, C., & De Sherbinin, A. (2012). Where the rain falls: Climate change, food and livelihood security, and migration. *Global Policy Report of the Where the Rain Falls Project. Bonn: CARE France and UNU-EHS*.

Welch-Devine, M., & Orland, B. (2020). Is it time to move away? How hurricanes affect future plans. *International Journal of Mass Emergencies & Disasters*, *38*(1), 54-76

Wesselbaum, D., & Aburn, A. (2019). Gone with the wind: International migration. *Global and Planetary Change*, *178*, 96-109.

Wicked Problems. (2019). *Wicked Problems: Problems Worth Solving - Wicked Problem*. Wickedproblems.com. https://www.wickedproblems.com/1_wicked_problems.php

Willett, J., & Sears, J. (2020). Complicating our understanding of environmental migration and displacement: The case of drought-related human movement in Kenya. International Social Work, 63(3), 364–370. https://doi.org/10.1177/0020872818799431

Wolpert, J. (1965, December). Behavioral aspects of the decision to migrate. In *Papers of the Regional Science Association* (Vol. 15, No. 1, pp. 159-169). Berlin/Heidelberg: Springer-Verlag.

Wuelser, G., Adler, C., Breu, T., Hirsch Hadorn, G., Wiesmann, U., & Pohl, C. (2021). On which common ground to build? Transferable knowledge across cases in transdisciplinary sustainability research. *Sustainability science*, *16*, 1891-1905.

Zander, K. K., Richerzhagen, C., & Garnett, S. T. (2019). Human mobility intentions in response to heat in urban South East Asia. *Global Environmental Change*, *56*, 18-28.

Zhang, H., Jude, A., Samarasinghe, K., & Zobair, S. (2022). 16 Solar Power Financing for Energy Security and Promoting Green Growth in Bangladesh. *Financing Clean Energy in Developing Asia—Volume 2*.

Chapter 3

Abson, D. J., Dougill, A. J., & Stringer, L. C. (2012). Using principal component analysis for information-rich socio-ecological vulnerability mapping in Southern Africa. *Applied Geography*, *35*(1-2), 515-524.

Adams, H., & Kay, S. (2019). Migration as a human affair: Integrating individual stress thresholds into quantitative models of climate migration. *Environmental Science & Policy*, *93*, 129-138.

Adams, A. M., Islam, R., Yusuf, S. S., Panasci, A., & Crowell, N. (2020). Healthcare seeking for chronic illness among adult slum dwellers in Bangladesh: A descriptive cross-sectional study in two urban settings. *PloS one*, *15*(6), e0233635.

Adger, W. N., Crépin, A. S., Folke, C., Ospina, D., Chapin, F. S., Segerson, K., ... & Wilen, J. (2020). Urbanization, migration, and adaptation to climate change. *One Earth*, *3*(4), 396-399.

Adger, W. N., de Campos, R. S., Siddiqui, T., Gavonel, M. F., Szaboova, L., Rocky, M. H., ... & Billah, T. (2021). Human security of urban migrant populations affected by length of residence and environmental hazards. *Journal of Peace Research*, *58*(1), 50-66.

Afifi, T., Milan, A., Etzold, B., Schraven, B., Rademacher-Schulz, C., Sakdapolrak, P., ... & Warner, K. (2016). Human mobility in response to rainfall variability: opportunities for migration as a successful adaptation strategy in eight case studies. *Migration and Development*, *5*(2), 254-274.

Ahmad, D., Kanwal, M., & Afzal, M. (2022). Climate change effects on riverbank erosion Bait community flood-prone area of Punjab, Pakistan: an application of livelihood vulnerability index. *Environment, Development and Sustainability*, 1-29.

Ahmed, F., Moors, E., Khan, M. S. A., Warner, J., & Van Scheltinga, C. T. (2018). Tipping points in adaptation to urban flooding under climate change and urban growth: The case of the Dhaka megacity. *Land Use Policy*, *79*, 496-506. doi:10.1016/j.landusepol.2018.05.051.

Ahmed, S., Nahiduzzaman, K. M., & Hasan, M. M. U. (2018). Dhaka, Bangladesh: Unpacking challenges and reflecting on unjust transitions. *Cities*, *77*, 142-157.

Ahsan, R. (2019). Climate-induced migration: Impacts on social structures and justice in Bangladesh. *South Asia Research*, *39*(2), 184-201. https://doi.org/10.1177/0262728019842968

Ahsan, R., Kellett, J., & Karuppannan, S. (2016). Climate migration and urban changes in Bangladesh. In *Urban disasters and resilience in Asia* (pp. 293-316). Butterworth-Heinemann.

Ahsan, M. N., & Warner, J. (2014). The socioeconomic vulnerability index: A pragmatic approach for assessing climate change led risks–A case study in the south-western coastal Bangladesh. *International Journal of Disaster Risk Reduction*, *8*, 32-49.

Air Quality Index (AQI). (2022). Case.doe.gov.bd. http://case.doe.gov.bd/index.php?option=com_content&view=article&id=29&Itemid=7

Alam, M. J. (2018). Rapid urbanization and changing land values in mega cities: implications for housing development projects in Dhaka, Bangladesh. *Bandung*, *5*(1), 1-19.

Alam, G. M., Alam, K., Mushtaq, S., & Clarke, M. L. (2017). Vulnerability to climatic change in riparian char and river-bank households in Bangladesh: Implication for policy, livelihoods and social development. *Ecological Indicators*, *72*, 23-32.

Alam, M. Z., & Mamun, A. A. (2022). Dynamics of internal migration in Bangladesh: Trends, patterns, determinants, and causes. *Plos one*, *17*(2), e0263878.

Alam, M., & Rabbani, M. G. (2007). Vulnerabilities and responses to climate change for Dhaka. *Environment and urbanization*, *19*(1), 81-97.

Amoatey, P., & Sulaiman, H. (2020). Assessing the climate change impacts of cocoa growing districts in Ghana: The livelihood vulnerability index analysis. *Environment, Development and Sustainability*, *22*(3), 2247-2268.

Balica, S. F., Wright, N. G., & Van der Meulen, F. (2012). A flood vulnerability index for coastal cities and its use in assessing climate change impacts. *Natural hazards*, *64*(1), 73-105.

Bangladesh Meteorological Department BMD *(2022)*. Retrieved February 19, 2023, from http://www.bmddataportal.com/#/

Bartlett, M. S. (1954). A Note on the Multiplying Factors for Various χ^2 Approximations. *Journal of the Royal Statistical Society. Series B (Methodological)*, *16*(2), 296–298. http://www.jstor.org/stable/2984057

BBS. (2015). Census of slum areas and floating population 2014. *Bangladesh Bureau of Statistics, Dhaka, Bangladesh*.

BBS. (2013). District Statistics 2011- Dhaka. *Ministry of Planning, Government of the People's Republic of Bangladesh, Statistics and Informatics Division (SID), Parishankhan Bhaban* (p. 3). E-27/A, Agargaon, Dhaka-1207. www. bbs. gov. bd.

Bernzen, A., Jenkins, J. C., & Braun, B. (2019). Climate change-induced migration in coastal Bangladesh? A critical assessment of migration drivers in rural households under economic and environmental stress. *Geosciences*, *9*(1), 51.

Bhuiyan, S. H. (2010). A crisis in governance: Urban solid waste management in Bangladesh. *Habitat international*, *34*(1), 125-133.

Bird, J., Li, Y., Rahman, H. Z., & Rama, M. (2018). *Toward great Dhaka: a new urban development paradigm eastward*. World Bank Publications.

Birkmann, J., Jamshed, A., McMillan, J. M., Feldmeyer, D., Totin, E., Solecki, W., ... & Alegría, A. (2022). Understanding human vulnerability to climate change: A global perspective on index validation for adaptation planning. *Science of The Total Environment*, *803*, 150065.

Bisung, E., & Elliott, S. J. (2014). Toward a social capital based framework for understanding the water-health nexus. *Social science & medicine*, *108*, 194-200.

Bisung, E., & Elliott, S. J. (2018). Improvement in access to safe water, household water insecurity, and time savings: A cross-sectional retrospective study in Kenya. *Social Science & Medicine*, *200*, 1-8.

Biswas, R. K., Kabir, E., & Khan, H. T. (2019). Causes of urban migration in Bangladesh: Evidence from the urban health survey. *Population Research and Policy Review*, *38*(4), 593-614.

Black, R., Adger, W. N., Arnell, N. W., Dercon, S., Geddes, A., & Thomas, D. (2011). The effect of environmental change on human migration. *Global environmental change*, *21*, S3-S11.

Braun, B., & Aßheuer, T. (2011). Floods in megacity environments: vulnerability and coping strategies of slum dwellers in Dhaka/Bangladesh. *Natural hazards*, *58*, 771-787.

Brouwer, R., Akter, S., Brander, L., & Haque, E. (2007). Socioeconomic vulnerability and adaptation to environmental risk: a case study of climate change and flooding in Bangladesh. *Risk Analysis: An International Journal*, *27*(2), 313-326. https://doi.org/10.1111/j.1539-6924.2007.00884.x

Brouwer, R., Sharmin, D. F., Elliott, S., Liu, J., & Khan, M. R. (2023). Costs and benefits of improving water and sanitation in slums and non-slum neighborhoods in Dhaka, a fast-growing mega-city. *Ecological Economics*, *207*, 107763. https://doi.org/10.1016/j.ecolecon.2023.107763

Bryant, F. B., & Yarnold, P. R. (1995). Principal-components analysis and exploratory and confirmatory factor analysis. In L. G. Grimm & P. R. Yarnold (Eds.), *Reading and understanding multivariate statistics* (pp. 99–136). American Psychological Association.

Carter, T. R., Jones, R. N., Lu, X., Bhadwal, S., Conde, C., Mearns, L. O., ... & Zurek, M. B. (2007). New assessment methods and the characterisation of future conditions.

Cattaneo, C., Beine, M., Fröhlich, C. J., Kniveton, D., Martinez-Zarzoso, I., Mastrorillo, M., ... & Schraven, B. (2019). Human migration in the era of climate change. *Review of Environmental Economics and Policy*.

Cerny, B. A., & Kaiser, H. F. (1977). A study of a measure of sampling adequacy for factor-analytic correlation matrices. *Multivariate behavioral research*, *12*(1), 43-47.

Chang, H., Pallathadka, A., Sauer, J., Grimm, N. B., Zimmerman, R., Cheng, C., ... & Herreros-Cantis, P. (2021). Assessment of urban flood vulnerability using the social-ecological-technological systems framework in six US cities. *Sustainable Cities and Society*, *68*, 102786.

Cho, E., & Kim, S. (2015). Cronbach's Coefficient Alpha: Well Known but Poorly Understood. *Organizational Research Methods*, 18(2), 207–230. https://doi.org/10.1177/1094428114555994

Chung, J. H., Buswala, B., Keith, M., & Schwanen, T. (2022). Climate mobilities into cities: A systematic review of literature from 2011 to 2020. *Urban Climate*, *45*, 101252.

Clement, V., Rigaud, K. K., de Sherbinin, A., Jones, B., Adamo, S., Schewe, J., Sadiq, N., & Shabahat, E. (2021). *Groundswell part 2: Acting on internal climate migration*. World Bank, 2021.

Climate Risk Country Profile: Bangladesh (2021): The World Bank Group. https://climateknowledgeportal.worldbank.org/sites/default/files/country-profiles/15502-WB_Bangladesh%20Country%20Profile-WEB.pdf

Comrey, A.L., & Lee, H.B. (1992). A First Course in Factor Analysis (2nd ed.). Psychology Press. https://doi.org/10.4324/9781315827506

Corner, S. (2009). Choosing the right type of rotation in PCA and EFA. *JALT testing & evaluation SIG newsletter*, *13*(3), 20-25.

Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2012). Social vulnerability to environmental hazards. In *Hazards vulnerability and environmental justice* (pp. 143-160). Routledge.

Cutter, S. L., & Emrich, C. T. (2017). Social vulnerability index (SoVI®): Methodology and limitations. *Columbia, SC: Hazards and Vulnerability Research Institute*, 1-6.

Dasgupta, S., Zaman, A., Roy, S., Huq, M., Jahan, S., & Nishat, A. (2015). *Urban Flooding of Greater Dhaka in a Changing Climate: Building local resilience to disaster risk*. World Bank Publications.

Demographia. (2022). Demographia World Urban Areas [Review of *Demographia World Urban Areas*]. In *demographia.com* (pp. 1–95). DEMOGRAPHIA. http://www.demographia.com/db-worldua.pdf

Dien, J., Beal, D. J., & Berg, P. (2005). Optimizing principal components analysis of event-related potentials: matrix type, factor loading weighting, extraction, and rotations. *Clinical neurophysiology*, *116*(8), 1808-1825.

Dong, S., Esmalian, A., Farahmand, H., & Mostafavi, A. (2020). An integrated physical-social analysis of disrupted access to critical facilities and community service-loss tolerance in urban flooding. *Computers, Environment and Urban Systems*, *80*, 101443.

Donner, W., & Rodríguez, H. (2008). Population composition, migration and inequality: The influence of demographic changes on disaster risk and vulnerability. *Social forces*, *87*(2), 1089-1114.

Dullaart, J., Muis, S., Bloemendaal, N., Chertova, M. V., Couasnon, A., & Aerts, J. C. (2021). Accounting for tropical cyclones more than doubles the global population exposed to low-probability coastal flooding. *Communications Earth & Environment*, *2*(1), 1-11. https://doi.org/10.1038/s43247-021-00204-9

Duncan, C. (2019) *Bangladesh fire leaves '50,000 people homeless' after slum destroyed*, *The Independent*. Independent Digital News and Media. Available at: https://www.independent.co.uk/news/world/asia/bangladesh-fire-slum-destroyed-homeless-blaze-dhaka-capital-a9063871.html (Accessed: November 1, 2022).

DWASA. (2018). Annual Report. Dhaka Water Supply and Sewerage Authority (2018)

Field, C. B., & Barros, V. R. (Eds.). (2014). *Climate change 2014–Impacts, adaptation and vulnerability: Regional aspects*. Cambridge University Press.

Fröhlich, C. J. (2016). Climate migrants as protestors? Dispelling misconceptions about global environmental change in pre-revolutionary Syria. *Contemporary levant*, *1*(1), 38-50.

Füssel, H. M. (2007). Vulnerability: A generally applicable conceptual framework for climate change research. *Global environmental change*, *17*(2), 155-167.

Gain, A. K., Mojtahed, V., Biscaro, C., Balbi, S., & Giupponi, C. (2015). An integrated approach of flood risk assessment in the eastern part of Dhaka City. *Natural Hazards*, *79*(3), 1499-1530.

GIZ. (2022): Urban Management of Internal Migration due to Climate Change (UMIMCC) / Urban Management of Migration and Livelihoods (UMML). Retrieved February 19, 2022, from https://www.giz.de/en/worldwide/31936.html

Goosen H., Hasan T., Saha S., Rezwana N., Rahman R., Assaduzzaman M., Kabir A., Dubois G. & Van Scheltinga C., (2018). Nationwide Climate Vulnerability Assessment in Bangladesh. Final Draft. Dhaka.

Hasnat, M. A., Chowdhury, M. A., & Abdullah-Al-Mamun, M. M. (2022). Perception of people on climate-induced migration issues in coastal areas of Bangladesh. *Migration and Development*, *11*(1), 142-162.

Hahn, M. B., Riederer, A. M., & Foster, S. O. (2009). The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change—A case study in Mozambique. *Global environmental change*, *19*(1), 74-88.

Hasan, M. M., Hosain, S., Poddar, P., Chowdhury, A. A., Katengeza, E. W., & Roy, U. K. (2019). Heavy metal toxicity from the leather industry in Bangladesh: a case study of human exposure in Dhaka industrial area. *Environmental monitoring and assessment*, *191*, 1-9.

Helbling, M., Rybski, D., Schewe, J., Siedentop, S., Glockmann, M., Heider, B., ... & Stroms, P. (2023). Measuring the effect of climate change on migration flows: Limitations of existing data and analytical frameworks. *PLOS Climate*, *2*(1), e0000078.

Hernandez, V., Roman, J. E., & Vidal, V. (2005). SLEPc: A scalable and flexible toolkit for the solution of eigenvalue problems. *ACM Transactions on Mathematical Software (TOMS)*, *31*(3), 351-362.

Hoffmann, R. (2022). Contextualizing climate change impacts on human mobility in African drylands. *Earth's Future*, *10*(6), e2021EF002591.

Hoffmann, R., Dimitrova, A., Muttarak, R., Crespo Cuaresma, J., & Peisker, J. (2020). A meta-analysis of country-level studies on environmental change and migration. *Nature Climate Change*, *10*(10), 904-912. https://doi.org/10.1038/s41558-020-0898-6

Horn, J. L. (1965). A rationale and test for the number of factors in factor analysis. *Psychometrika*, *30*(2), 179-185. https://doi.org/10.1007/BF02289447

Hossain, S. (2008). Rapid Urban Growth and Poverty in Dhaka City. *Bangladesh e-journal of sociology*, *5*(1).

Huang, D., Zhang, R., Huo, Z., Mao, F., & Zheng, W. (2012). An assessment of multidimensional flood vulnerability at the provincial scale in China based on the DEA method. *Natural hazards*, *64*(2), 1575-1586.

Huong, N. T. L., Yao, S., & Fahad, S. (2019). Assessing household livelihood vulnerability to climate change: The case of Northwest Vietnam. *Human and Ecological Risk Assessment: An International Journal*, *25*(5), 1157-1175.

IBM (2021a). *Kaiser-Meyer-Olkin measure for identity correlation matrix*. Ibm.com. Retrieved 3 October 2022, from https://www.ibm.com/support/pages/kaiser-meyer-olkin-measure-identity-correlation-matrix.

IBM Documentation. Ibm.com. (2021b). Retrieved 8 October 2022, from https://www.ibm.com/docs/en/spss-statistics/28.0.0?topic=analysis-factor-rotation.

Icddrb. (2016). Baseline Population and Socioeconomic Census Slums of Dhaka (North and South) and Gazipur City Corporations, 2015-16 Urban Primary Health Care Services Delivery Project Local Government Division Ministry of Local Government, Rural Development & Cooperative. Dhaka. Available from: http://uphcp.gov.bd/cmsfiles/files/Baseline-PopulationandSocioeconomicCensus.pdf.

Islam, M. S., Swapan, M. S. H., & Haque, S. M. (2013). Disaster risk index: How far should it take account of local attributes?. *International journal of disaster risk reduction*, *3*, 76-87.

Imran, H. M., Hossain, A., Islam, A. K. M., Rahman, A., Bhuiyan, M. A. E., Paul, S., & Alam, A. (2021). Impact of land cover changes on land surface temperature and human thermal comfort in Dhaka City of Bangladesh. *Earth Systems and Environment*, *5*(3), 667-693.

Internal Displacement Monitoring Center (IDMC). (2022). *Global Internal Displacement Database (GIDD) 2022*. Geneva: IDMC. https://www.internal-displacement.org/database/displacement-data

Ishtiaque, A., & Nazem, N. I. (2017). Household-level disaster-induced losses and rural–urban migration: Experience from world's one of the most disaster-affected countries. *Natural hazards*, *86*(1), 315-326.

Islam, S. S., Parvin, M. M., Fagun, A. N., & Sarker, M. M. R. (2021). Determinates of Migration from and Within Bangladesh: A Household Level Analysis. *International Journal of Agricultural Economics*, *6*(4), 193-197.

Jackson, D. A. (1993). Stopping rules in principal components analysis: a comparison of heuristical and statistical approaches. *Ecology*, *74*(8), 2204-2214. https://doi.org/10.2307/1939574

Jacobson, C., Crevello, S., Chea, C., & Jarihani, B. (2019). When is migration a maladaptive response to climate change?. *Regional Environmental Change*, *19*(1), 101-112.

Jamshed, A., Rana, I. A., Mirza, U. M., & Birkmann, J. (2019). Assessing relationship between vulnerability and capacity: An empirical study on rural flooding in Pakistan. *International Journal of Disaster risk reduction*, *36*, 101109.

Kaczan, D. J., & Orgill-Meyer, J. (2020). The impact of climate change on migration: a synthesis of recent empirical insights. *Climatic Change*, *158*(3), 281-300.

Kaiser, H. F. (1960). The application of electronic computers to factor analysis. *Educational and psychological measurement*, *20*(1), 141-151.

Kaiser, H. F. (1974). An index of factorial simplicity. *psychometrika*, *39*(1), 31-36. https://doi.org/10.1007/BF02291575

Kaiser, H. F., & Rice, J. (1974). Little Jiffy, Mark Iv. Educational and Psychological Measurement, 34(1), 111–117. https://doi.org/10.1177/001316447403400115

Kangmennaang, J., Bisung, E., & Elliott, S. J. (2020). 'We are drinking diseases': Perception of water insecurity and emotional distress in urban slums in Accra, Ghana. *International journal of environmental research and public health*, *17*(3), 890.

Kangmennaang, J., & Elliott, S. J. (2021). Linking water (in) security and wellbeing in low-and middle-income countries. *Water Security*, *13*, 100089.

Karim, M. F., & Mimura, N. (2008). Impacts of climate change and sea-level rise on cyclonic storm surge floods in Bangladesh. *Global environmental change*, *18*(3), 490-500.

Kaur, R., & Pandey, P. (2021). Air pollution, climate change, and human health in Indian Cities: A brief review. *Frontiers in Sustainable Cities*, *3*, 705131.

Kaźmierczak, A., & Cavan, G. (2011). Surface water flooding risk to urban communities: Analysis of vulnerability, hazard and exposure. *Landscape and urban planning*, *103*(2), 185-197.

Khan, M. A. (2022). Livelihood, WASH related hardships and needs assessment of climate migrants: evidence from urban slums in Bangladesh. *Heliyon*, *8*(5), e09355.

Khan, M. R., Huq, S., Risha, A. N., & Alam, S. S. (2021). High-density population and displacement in Bangladesh. *Science*, *372*(6548), 1290-1293.

Kherif, F., & Latypova, A. (2020). Principal component analysis. In *Machine Learning* (pp. 209-225). Academic Press.

Kim, J., & Gim, T. H. T. (2020). Assessment of social vulnerability to floods on Java, Indonesia. *Natural Hazards*, *102*(1), 101-114.

Kita, S. M. (2017). Urban vulnerability, disaster risk reduction and resettlement in Mzuzu city, Malawi. *International journal of disaster risk reduction*, *22*, 158-166.

Klopp, J. M., & Petretta, D. L. (2017). The urban sustainable development goal: Indicators, complexity and the politics of measuring cities. *Cities*, *63*, 92-97. https://doi.org/10.1016/j.cities.2016.12.019

Koop, S. H., & van Leeuwen, C. J. (2017). The challenges of water, waste and climate change in cities. *Environment, development and sustainability*, *19*(2), 385-418.

Kresta, J. V., Macgregor, J. F., & Marlin, T. E. (1991). Multivariate statistical monitoring of process operating performance. *The Canadian journal of chemical engineering*, *69*(1), 35-47.

Labib, S. M., Bhuiya, M. M. R., & Rahaman, M. Z. (2013). Location and size preference for apartments in Dhaka and prospect of real estate market. *Bangladesh Research Publications Journal*, *9*(2), 87-96.

Leal Filho, W., Balogun, A. L., Olayide, O. E., Azeiteiro, U. M., Ayal, D. Y., Muñoz, P. D. C., ... & Li, C. (2019). Assessing the impacts of climate change in cities and their adaptive capacity: towards transformative approaches to climate change adaptation and poverty reduction in urban areas in a set of developing countries. *Science of the Total Environment*, *692*, 1175-1190.

Levada, A. L. (2020). Parametric PCA for unsupervised metric learning. *Pattern Recognition Letters*, *135*, 425-430.

Lever, J., Krzywinski, M., & Altman, N. (2017). Points of significance: Principal component analysis. *Nature methods*, *14*(7), 641-643.

Linting, M., Meulman, J. J., Groenen, P. J., & van der Koojj, A. J. (2007). Nonlinear principal components analysis: introduction and application. *Psychological methods*, *12*(3), 336.

Liu, J., Brouwer, R., Sharmin, D. F., Elliott, S., Govia, L., & Lindamood, D. (2022). Industry Perspectives on Water Pollution Management in a Fast Developing Megacity: Evidence from Dhaka, Bangladesh. *Sustainability*, *14*(24), 16389.

Long, J., & Rice, J. L. (2019). From sustainable urbanism to climate urbanism. *Urban Studies*, *56*(5), 992-1008.

Maharjan, A., de Campos, R. S., Singh, C., Das, S., Srinivas, A., Bhuiyan, M. R. A., ... & Vincent, K. (2020). Migration and household adaptation in climate-sensitive hotspots in South Asia. *Current Climate Change Reports*, *6*(1), 1-16.

Maharjan, S. K., Maharjan, K. L., Tiwari, U., & Sen, N. P. (2017). Participatory vulnerability assessment of climate vulnerabilities and impacts in Madi Valley of Chitwan district, Nepal. *Cogent Food & Agriculture*, *3*(1), 1310078.

Mallick, B., Rogers, K. G., & Sultana, Z. (2022). In harm's way: Non-migration decisions of people at risk of slow-onset coastal hazards in Bangladesh. *Ambio*, *51*(1), 114-134.

Marotzke, J., Semmann, D., & Milinski, M. (2020). The economic interaction between climate change mitigation, climate migration and poverty. *Nature Climate Change*, *10*(6), 518-525.

Mavhura, E., Manyena, B., & Collins, A. E. (2017). An approach for measuring social vulnerability in context: The case of flood hazards in Muzarabani district, Zimbabwe. *Geoforum*, *86*, 103-117.

McFarlane, C. (2008). Sanitation in Mumbai's informal settlements: State,'slum', and infrastructure. *Environment and planning A*, *40*(1), 88-107.

McLaughlin, S., & Cooper, J. A. G. (2010). A multi-scale coastal vulnerability index: A tool for coastal managers?. *Environmental Hazards*, *9*(3), 233-248.

Miceli, R., Sotgiu, I., & Settanni, M. (2008). Disaster preparedness and perception of flood risk: A study in an alpine valley in Italy. *Journal of environmental psychology*, *28*(2), 164-173.

Mishra, S. V., Gayen, A., & Haque, S. M. (2020). COVID-19 and urban vulnerability in India. *Habitat international*, *103*, 102230.

Mitchell, D., Hawker, L., Savage, J., Bingham, R., Lord, N. S., Khan, M. J. U., ... & Testut, L. (2022). Increased population exposure to Amphan-scale cyclones under future climates. *Climate Resilience and Sustainability*, e36. https://doi.org/10.1002/cli2.36

Montgomery, M. A., & Elimelech, M. (2007). Water and sanitation in developing countries: including health in the equation. *Environmental science & technology*, *41*(1), 17-24.

Moore, M., & Wesselbaum, D. (2022). Climatic factors as drivers of migration: a review. *Environment, Development and Sustainability*, 1-21. https://doi.org/10.1007/s10668-022-02191-z

Mortoja, M. G., & Yigitcanlar, T. (2020). How does peri-urbanization trigger climate change vulnerabilities? An investigation of the dhaka megacity in Bangladesh. *Remote Sensing*, *12*(23), 3938.

Nahian, M. A. (2023). Public Health Impact and Health System Preparedness within a Changing Climate in Bangladesh: A Scoping Review. *Challenges*, *14*(1), 4.

Ngugi, P., Babic, A., Kariuki, J., Santas, X., Naanyu, V., & Were, M. C. (2021). Development of standard indicators to assess use of electronic health record systems implemented in low-and medium-income countries. *PloS one*, *16*(1), e0244917.

Nguyen, T. A., Nguyen, B. T., Van Ta, H., Nguyen, N. T. P., Hoang, H. T., Nguyen, Q. P., & Hens, L. (2021). Livelihood vulnerability to climate change in the mountains of Northern Vietnam: comparing the Hmong and the Dzao ethnic minority populations. *Environment, Development and Sustainability*, *23*(9), 13469-13489.

Nhuan, M. T., Tue, N. T., Hue, N. T. H., Quy, T. D., & Lieu, T. M. (2016). An indicator-based approach to quantifying the adaptive capacity of urban households: the case of Da Nang city, Central Vietnam. *Urban Climate*, *15*, 60-69.

Notenbaert, A., Karanja, S. N., Herrero, M., Felisberto, M., & Moyo, S. (2013). Derivation of a household-level vulnerability index for empirically testing measures of adaptive capacity and vulnerability. *Regional Environmental Change*, *13*(2), 459-470.

Nuwematsiko, R., Nabiryo, M., Bomboka, J. B., Nalinya, S., Musoke, D., Okello, D., & Wanyenze, R. K. (2022). Unintended socio-economic and health consequences of COVID-19 among slum dwellers in Kampala, Uganda. *BMC public health*, *22*(1), 1-13.

OECD/WHO (2020), "Water and sanitation", in Health at a Glance: Asia/Pacific 2020: Measuring Progress Towards Universal Health Coverage, OECD Publishing, Paris, https://doi.org/10.1787/f6a5d600-en.

Panthi, J., Aryal, S., Dahal, P., Bhandari, P., Krakauer, N. Y., & Pandey, V. P. (2016). Livelihood vulnerability approach to assessing climate change impacts on mixed agro-livestock smallholders around the Gandaki River Basin in Nepal. *Regional environmental change*, *16*(4), 1121-1132.

Perez-Escamilla, R., Gubert, M. B., Rogers, B., & Hromi-Fiedler, A. (2017). Food security measurement and governance: Assessment of the usefulness of diverse food insecurity indicators for policy makers. *Global Food Security*, *14*, 96-104. https://doi.org/10.1016/j.gfs.2017.06.003

Piguet, E. (2022). Linking climate change, environmental degradation, and migration: An update after 10 years. *Wiley Interdisciplinary Reviews: Climate Change*, *13*(1), e746.

Plummer, R., de Loë, R., & Armitage, D. (2012). A systematic review of water vulnerability assessment tools. *Water resources management*, *26*(15), 4327-4346. https://doi.org/10.1007/s11269-012-0147-5

Pörtner, H. O., Roberts, D. C., Adams, H., Adler, C., Aldunce, P., Ali, E., ... & Birkmann, J. (2022). Climate change 2022: Impacts, adaptation and vulnerability. *IPCC Sixth Assessment Report*.

Poudel, S., Funakawa, S., Shinjo, H., & Mishra, B. (2020). Understanding households' livelihood vulnerability to climate change in the Lamjung district of Nepal. *Environment, Development and Sustainability*, *22*, 8159-8182.

Preacher, K. J., & MacCallum, R. C. (2003). Repairing Tom Swift's electric factor analysis machine. *Understanding statistics: Statistical issues in psychology, education, and the social sciences*, *2*(1), 13-43.

Rahman, M. M., Ahmad, S., Mahmud, A. S., Hassan-uz-Zaman, M., Nahian, M. A., Ahmed, A., ... & Streatfield, P. K. (2019). Health consequences of climate change in Bangladesh: an overview of the evidence, knowledge gaps and challenges. *Wiley Interdisciplinary Reviews: Climate Change*, *10*(5), e601.

Rahaman, M. A., Rahman, M. M., Bahauddin, K. M., Khan, S., & Hassan, S. (2018). Health disorder of climate migrants in Khulna City: an urban slum perspective. *International Migration*, *56*(5), 42-55.

Rana, I. A., & Routray, J. K. (2018). Integrated methodology for flood risk assessment and application in urban communities of Pakistan. Natural Hazards, 91(1), 239-266.

Rashid, S. F. (2009). Strategies to reduce exclusion among populations living in urban slum settlements in Bangladesh. *Journal of health, population, and nutrition*, *27*(4), 574.

Rashid, S. F., Gani, S., & Sarker, M. (2013). Urban poverty, climate change and health risks for slum dwellers in Bangladesh. In *Climate change adaptation actions in Bangladesh* (pp. 51-70). Springer, Tokyo.

Richmond, A., Myers, I., & Namuli, H. (2018). Urban informality and vulnerability: A case study in Kampala, Uganda. *Urban science*, *2*(1), 22.

Rigaud, K. K., de Sherbinin, A., Jones, B., Bergmann, J., Clement, V., Ober, K., Schewe, J., Adamo, S., McCusker, B., Heuser, S., Midgley, A. (2018). *Groundswell : Preparing for Internal Climate Migration.* World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/29461 *License: CC BY 3.0 IGO.*

Ringnér, M. (2008). What is principal component analysis?. Nature biotechnology, 26(3), 303-304. https://doi.org/10.1038/nbt0308-303

Rosengärtner, S. K., De Sherbinin, A. M., & Stojanov, R. (2022). Supporting the agency of cities as climate migration destinations. *International Migration*.

Roy, M. (2009). Planning for sustainable urbanisation in fast growing cities: Mitigation and adaptation issues addressed in Dhaka, Bangladesh. *Habitat international*, *33*(3), 276-286.

Roy, S., Bose, A., Singha, N., Basak, D., & Chowdhury, I. R. (2021). Urban waterlogging risk as an undervalued environmental challenge: An Integrated MCDA-GIS based modeling approach. *Environmental Challenges*, *4*, 100194.

Salem, N., & Hussein, S. (2019). Data dimensional reduction and principal components analysis. *Procedia Computer Science*, *163*, 292-299.

Schewel, K. (2020). Understanding immobility: Moving beyond the mobility bias in migration studies. *International Migration Review*, *54*(2), 328-355

Schipper, E. L. F. (2020). Maladaptation: When adaptation to climate change goes very wrong. *One Earth*, *3*(4), 409-414.

Selod, H., & Shilpi, F. (2021). Rural-urban migration in developing countries: Lessons from the literature. *Regional Science and Urban Economics*, *91*, 103713.

Shahid, S., Wang, X. J., Harun, S. B., Shamsudin, S. B., Ismail, T., & Minhans, A. (2016). Climate variability and changes in the major cities of Bangladesh: observations, possible impacts and adaptation. *Regional Environmental Change*, *16*, 459-471.

Sahana, M., Rehman, S., Paul, A. K., & Sajjad, H. (2021). Assessing socio-economic vulnerability to climate change-induced disasters: evidence from Sundarban Biosphere Reserve, India. *Geology, Ecology, and Landscapes*, *5*(1), 40-52.

Shrestha, N. (2021). Factor analysis as a tool for survey analysis. *American Journal of Applied Mathematics and Statistics*, *9*(1), 4-11.

Singh, A. (2019). Managing the uncertainty problems of municipal solid waste disposal. *Journal of environmental management*, *240*, 259-265.

Sorg, L., Medina, N., Feldmeyer, D., Sanchez, A., Vojinovic, Z., Birkmann, J., & Marchese, A. (2018). Capturing the multifaceted phenomena of socioeconomic vulnerability. *Natural Hazards*, *92*, 257-282.

Sowgat, T., & Roy, S. (2022). Throwntogetherness in Dhaka: rethinking urban planning: A visual essay. *City*, *26*(2-3), 422-432.

Spielman, S. E., Tuccillo, J., Folch, D. C., Schweikert, A., Davies, R., Wood, N., & Tate, E. (2020). Evaluating social vulnerability indicators: criteria and their application to the Social Vulnerability Index. *Natural hazards*, *100*(1), 417-436.

Subrina, S., & Chowdhury, F. K. (2018). Urban Dynamics: An undervalued issue for water logging disaster risk management in case of Dhaka city, Bangladesh. *Procedia engineering*, *212*, 801-808.

Tabachnick, B. G., Fidell, L. S., & Ullman, J. B. (2007). *Using multivariate statistics* (Vol. 5, pp. 481-498). Boston, MA: pearson.

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in science education*, *48*(6), 1273-1296. https://doi.org/10.1007/s11165-016-9602-2

Tacoli, C. (2009). Crisis or adaptation? Migration and climate change in a context of high mobility. *Environment and urbanization*, *21*(2), 513-525.

Tate, E. (2012). Social vulnerability indices: a comparative assessment using uncertainty and sensitivity analysis. *Natural Hazards*, *63*, 325-347.

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International journal of medical education*, *2*, 53–55. https://doi.org/10.5116/ijme.4dfb.8dfd

The World Bank. (2020, January 14). *Data Catalog: Dhaka (Bangladesh) - Flood Maps*. Data Catalog. Retrieved September 24, 2022, from https://datacatalog.worldbank.org/search/dataset/0042071

Trimmer, J. T., Lohman, H. A., Byrne, D. M., Houser, S. A., Jjuuko, F., Katende, D., ... & Guest, J. S. (2020). Navigating Multidimensional Social–Ecological System Trade-Offs

across Sanitation Alternatives in an Urban Informal Settlement. *Environmental Science & Technology*, *54*(19), 12641-12653

Turhan, E., & Armiero, M. (2019). Of (not) being neighbors: cities, citizens and climate change in an age of migrations. *Mobilities*, *14*(3), 363-374.

Twinomuhangi, R., Sseviiri, H., Mulinde, C., Mukwaya, P. I., Nimusiima, A., & Kato, A. M. (2021). Perceptions and vulnerability to climate change among the urban poor in Kampala City, Uganda. *Regional Environmental Change*, *21*(2), 1-13.

Ullah, F., Shah, S. A. A., Saqib, S. E., Yaseen, M., & Haider, M. S. (2021). Households' flood vulnerability and adaptation: Empirical evidence from mountainous regions of Pakistan. *International Journal of Disaster Risk Reduction*, *52*, 101967.

UNFPA. (2016). Urbanization and migration in Bangladesh 2016 UNFPA Urbanization and migration in Bangladesh. United Nations Population Fund. Bangladesh Country Office, Dhaka (2016)

United Nations Framework Convention on Climate Change (2019), "Adaptation Fund". Retrieved February 19, 2022, from https://unfccc.int/Adaptation-Fund.

Vaske, J. J., Beaman, J., & Sponarski, C. C. (2017). Rethinking internal consistency in Cronbach's alpha. *Leisure sciences*, *39*(2), 163-173.

Vinke, K., Bergmann, J., Blocher, J., Upadhyay, H., & Hoffmann, R. (2020). Migration as adaptation?. *Migration Studies*, *8*(4), 626-634. https://doi.org/10.1093/migration/mnaa029

Vivek H, P., Singh, S. N., Mishra, S., & Todd Donavan, D. (2017). *Parallel Analysis Engine to Aid in Determining Number of Factors to Retain using R [Computer software]*. Retrieved 3 October 2022, from https://analytics.gonzaga.edu/parallelengine/.

Wang, Z., Xu, N., Wei, W., & Zhao, N. (2020). Social inequality among elderly individuals caused by climate change: Evidence from the migratory elderly of mainland China. *Journal of Environmental Management*, *272*, 111079.

Wiegel, H., Boas, I., & Warner, J. (2019). A mobilities perspective on migration in the context of environmental change. *Wiley Interdisciplinary Reviews: Climate Change*, *10*(6), e610. https://doi.org/10.1002/wcc.610

Williams, D. S., Máñez Costa, M., Sutherland, C., Celliers, L., & Scheffran, J. (2019). Vulnerability of informal settlements in the context of rapid urbanization and climate change. *Environment and Urbanization*, *31*(1), 157-176.

Yong, A. G., & Pearce, S. (2013). A beginner's guide to factor analysis: Focusing on exploratory factor analysis. *Tutorials in quantitative methods for psychology*, *9*(2), 79-94.

Zakour, M. J., & Swager, C. M. (2018). Vulnerability-plus theory: the integration of community disaster vulnerability and resiliency theories. In *Creating Katrina, Rebuilding Resilience* (pp. 45-78). Butterworth-Heinemann.

Zhou, Y., Liu, Y., Wu, W., & Li, N. (2015). Integrated risk assessment of multi-hazards in China. *Natural hazards*, *78*(1), 257-280.

Zuhra, S. S., Tabinda, A. B., & Yasar, A. (2019). Appraisal of the heat vulnerability index in Punjab: a case study of spatial pattern for exposure, sensitivity, and adaptive capacity in megacity Lahore, Pakistan. *International journal of biometeorology*, *63*, 1669-1682.

Chapter 4

Abimbola, O., Aikins, J. K., Makhesi-Wilkinson, T., & Roberts, E. (2021). Racism and climate (in) justice. *Heinrich Böll-Stiftung, Washington, DC*.

Adisa, T. A., Gbadamosi, G., & Adekoya, O. D. (2021). Gender apartheid: The challenges of breaking into “man's world”. *Gender, Work & Organization*, *28*(6), 2216-2234.

Agadjanian, V. (2020). Double gendered: public views on women’s and men’s migration in Armenia. *Journal of Ethnic and Migration Studies*, 1-24.

Ahmed, I., Alam, M., Jimmy, A., Fatema, K., Islam, M., Ahsan, G., & Khan, N. (2019). Climate change induced migration: empirical evidences from the southwest coastal region of Bangladesh. *Int J Environ Sustain Dev*, *3*(4), 116-126.

Ahmed, S., & Eklund, E. (2021). Climate change impacts in coastal Bangladesh: migration, gender and environmental injustice. *Asian Affairs*, *52*(1), 155-174.

Akter, K., Dey, S., & Hasan, S. (2019). Riverbank erosion and its impact on rural women: Case study of Ulania village in Bangladesh. *Asian Journal of Women's Studies*, *25*(1), 76-95.

Al Mamun, M. A., & Hoque, M. M. (2022). The impact of paid employment on women's empowerment: A case study of female garment workers in Bangladesh. *World Development Sustainability*, *1*, 100026.

Alam, A., & Khalil, M. B. (2022). Gender,(im) mobility and social relations shaping vulnerabilities in coastal Bangladesh. *International Journal of Disaster Risk Reduction*, *82*, 103342.

Alesina, A., Giuliano, P., & Nunn, N. (2013). On the origins of gender roles: Women and the plough. *The quarterly journal of economics*, *128*(2), 469-530.

Althor, G., Watson, J. E., & Fuller, R. A. (2016). Global mismatch between greenhouse gas emissions and the burden of climate change. *Scientific reports*, *6*(1), 1-6. https://doi.org/10.1038/srep20281

Amelina, A., & Lutz, H. (2019). Gender and Migration. Transnational and Intersectional Perspectives. London and New York: Routledge.

Amjad, K. (2019). Mental stress of climate migrant’s poor women living in slums of Dhaka city. *Mental*, *6*(8).

Andrijevic, M., Crespo Cuaresma, J., Lissner, T., Thomas, A., & Schleussner, C. F. (2020). Overcoming gender inequality for climate resilient development. *Nature Communications*, *11*(1), 6261.

Aromataris, E., & Pearson, A. (2014). The systematic review: an overview. *AJN The American Journal of Nursing*, *114*(3), 53-58.

Ayeb-Karlsson, S. (2020). ‘When we were children we had dreams, then we came to Dhaka to survive’: urban stories connecting loss of wellbeing, displacement and (im) mobility. *Climate and Development*, *13*(4), 348-359.

Ayeb-Karlsson, S., Kniveton, D., & Cannon, T. (2020). Trapped in the prison of the mind: Notions of climate-induced (im) mobility decision-making and wellbeing from an urban informal settlement in Bangladesh. *Palgrave Communications*, *6*(1), 1-15.

Bertrand, M. (2020, May). Gender in the twenty-first century. In *AEA Papers and proceedings* (Vol. 110, pp. 1-24).

Bhatta, G. D., Aggarwal, P. K., Poudel, S., & Belgrave, D. A. (2015). Climate-induced migration in South Asia: Migration decisions and the gendered dimensions of adverse climatic events. *Journal of Rural and Community Development*, *10*(4).

Bhopal, K. (2019). *Gender,'race'and patriarchy: a study of South Asian women*. Routledge. https://doi.org/10.4324/9780429456305

Bircan, T., & Yilmaz, S. (2022). A critique of gender-blind migration theories and data sources. *International Migration*.

Birkmann, J., Liwenga, E., Pandey, R., Boyd, E., Djalante, R., Gemenne, F., ... & Wrathall, D. (2022). Poverty, livelihoods and sustainable development.

Black, R., Adger, W. N., Arnell, N. W., Dercon, S., Geddes, A., & Thomas, D. (2011). The effect of environmental change on human migration. *Global environmental change*, *21*, S3-S11.

Black, R., Natali, C., & Skinner, J. (2005). Migration and inequality. https://openknowledge.worldbank.org/handle/10986/9172

Boas, I., de Pater, N., & Furlong, B. T. (2022b). Moving beyond stereotypes: the role of gender in the environmental change and human mobility nexus. *Climate and Development*, 1-9.

Boas, I., Schapendonk, J., Blondin, S., & Pas, A. (2020). Methods as moving ground: Reflections on the 'doings' of mobile methodologies. *Social Inclusion*, 8(4), 136–46, https://doi.org/10.17645/si.v8i4.3326

Boas, I., Wiegel, H., Farbotko, C., Warner, J., & Sheller, M. (2022a). Climate mobilities: Migration, im/mobilities and mobility regimes in a changing climate. *Journal of Ethnic and Migration Studies*, 1-15.

Booth, A., Moore, G., Flemming, K., Garside, R., Rollins, N., Tunçalp, Ö., & Noyes, J. (2019). Taking account of context in systematic reviews and guidelines considering a complexity perspective. *BMJ global health*, *4*(Suppl 1), e000840.

Boyack, K. W., & Klavans, R. (2010). Co-citation analysis, bibliographic coupling, and direct citation: Which citation approach represents the research front most accurately?. *Journal of the American Society for information Science and Technology*, *61*(12), 2389-2404.

Carling, J., & Schewel, K. (2018). Revisiting aspiration and ability in international migration. *Journal of Ethnic and Migration Studies*, *44*(6), 945-963.

Carrico, A. R., Donato, K. M., Best, K. B., & Gilligan, J. (2020). Extreme weather and marriage among girls and women in Bangladesh. *Global Environmental Change*, *65*, 102160.

Castelli, F. (2018). Drivers of migration: why do people move?. *Journal of travel medicine*, *25*(1), tay040.

Chowdhury, J. R., Parida, Y., & Goel, P. A. (2021). Does inequality-adjusted human development reduce the impact of natural disasters? A gendered perspective. *World Development*, *141*, 105394.

Clement, V., Rigaud, K. K., de Sherbinin, A., Jones, B., Adamo, S., Schewe, J., ... & Shabahat, E. (2021). *Groundswell part 2: Acting on internal climate migration*. World Bank.

Connelly, J. L., & Barriteau, P. (2000). Theoretical perspectives on gender and development. IDRC.

Covidence Systematic Review Software. (2022). Veritas health innovation (2022). Melbourne, Australia. Available at www.covidence.org

Debnath, M., & Kumar Nayak, D. (2021). Rural out-migration as a coping strategy in the drought-prone areas of Rarh region of Eastern India. *International Migration*, *60*(3), 209-227.

de Haas, H. (2021). A theory of migration: the aspirations-capabilities framework. *Comparative Migration Studies*, *9*(1), 1-35.

Djoudi, H., Locatelli, B., Vaast, C., Asher, K., Brockhaus, M., & Basnett Sijapati, B. (2016). Beyond dichotomies: Gender and intersecting inequalities in climate change studies. *Ambio*, *45*(3), 248-262. https://doi.org/10.1007/s13280-016-0825-2

Donkor, F. K., & Mazumder, R. K. (2021). Women and the environment: Southern perspectives and global implications. In *Gender Equality* (pp. 1118-1129). Cham: Springer International Publishing.

Eckstein, D., Künzel, V., Schäfer, L., & Winges, M. (2020). *GLOBAL CLIMATE RISK INDEX 2021: Who Suffers Most from Extreme Weather Events? Weather-Related Loss Events in 2019 and 2000 to 2019.* Bonn: Germanwatch e.V.

Emirbayer, M., & Mische, A. (1998). What Is Agency? *American Journal of Sociology*, *103*(4), 962–1023. https://doi.org/10.1086/231294

Erdal, M. B., & Hagen-Zanker, J. (2022). Migration decision-making. In *Routledge Handbook of Immigration and Refugee Studies* (pp. 63-72). Routledge.

Eriksen, M. B., & Frandsen, T. F. (2018). The impact of patient, intervention, comparison, outcome (PICO) as a search strategy tool on literature search quality: a systematic review. *Journal of the Medical Library Association: JMLA*, *106*(4), 420.

Evertsen, K. F., & van der Geest, K. (2020). Gender, environment and migration in Bangladesh. *Climate and Development*, *12*(1), 12-22.

Fanelli, D., Costas, R., & Ioannidis, J. P. (2017). Meta-assessment of bias in science. *Proceedings of the National Academy of Sciences*, *114*(14), 3714-3719.

Fanelli, D., & Glänzel, W. (2013). Bibliometric evidence for a hierarchy of the sciences. *PLoS one*, *8*(6), e66938.

Garcia, A., Tschakert, P., & Karikari, N. A. (2020). 'Less able': how gendered subjectivities warp climate change adaptation in Ghana's Central Region. *Gender, Place & Culture*, *27*(11), 1602-1627.

Gautam, Y. (2017). Seasonal migration and livelihood resilience in the face of climate change in Nepal. *Mountain Research and Development*, *37*(4), 436-445.

GCM (Global Compact on Safe, Orderly, and Regular Migration). 2018. New York: UN General Assembly. https://refugeesmigrants.un.org/sites/default/files/180713_agreed_outcome_global_compact_for_migration.pdf.

Gioli, G., Khan, T., Bisht, S., & Scheffran, J. (2014). Migration as an adaptation strategy and its gendered implications: A case study from the Upper Indus Basin. *Mountain Research and Development*, *34*(3), 255-265.

Gioli, G., & Milan, A. (2018). Gender, migration and (global) environmental change. *Routledge Handbook Of Environmental Displacement And Migration*, 135-150. doi: 10.4324/9781315638843-11

Gray, C. L., & Mueller, V. (2012). Natural disasters and population mobility in Bangladesh. *Proceedings of the National Academy of Sciences*, *109*(16), 6000-6005.

Harari, M. B., Parola, H. R., Hartwell, C. J., & Riegelman, A. (2020). Literature searches in systematic reviews and meta-analyses: A review, evaluation, and recommendations. *Journal of Vocational Behavior*, *118*, 103377.

Hasnat, M. A., Chowdhury, M. A., & Abdullah-Al-Mamun, M. M. (2022). Perception of people on climate-induced migration issues in coastal areas of Bangladesh. *Migration and Development*, *11*(1), 142-162.

Heise, L., Greene, M. E., Opper, N., Stavropoulou, M., Harper, C., Nascimento, M., ... & Gupta, G. R. (2019). Gender inequality and restrictive gender norms: framing the challenges to health. *The Lancet*, *393*(10189), 2440-2454.

Hoffmann, R., Dimitrova, A., Muttarak, R., Crespo Cuaresma, J., & Peisker, J. (2020). A meta-analysis of country-level studies on environmental change and migration. *Nature Climate Change*, *10*(10), 904-912.

Homar, A. R., & Cvelbar, L. K. (2021). The effects of framing on environmental decisions: A systematic literature review. *Ecological Economics*, *183*, 106950.

Hummel, D. (2021). 12 The Nexus Between Climate Change, Migration and Gender. *Gender, Climate Change and Livelihoods: Vulnerabilities and Adaptations*, 159.

IDMC & UNFCCC. (2018, August). *Synthesizing the state of knowledge to better understand displacement related to slow onset events, Task Force on Displacement*. https://unfccc.int/sites/default/files/resource/WIM%20TFD%20I.2%20Output.pdf

Ingham, V., Rabiul Islam, M., & Hicks, J. (2019). Adaptive flood mobilities in Bangladesh. *Mobilities*, *14*(2), 158-172.

IOM, 2015, IOM GENDER EQUALITY POLICY 2015–2019 https://www.iom.int/sites/default/files/about-iom/gender/C-106-INF-8-Rev.1-IOM-Gender-Equality-Policy-2015-2019.pdf

International Labour Organization. (2020, March 6). These occupations are dominated by women. ILOSTAT. https://ilostat.ilo.org/these-occupations-are-dominated-by-women/

IPCC. (2019, May 12). *REPORT FROM THE IPCC TASK GROUP ON GENDER* . IPCC. Retrieved December 17, 2022, from https://www.ipcc.ch/site/assets/uploads/2019/01/110520190810-Doc.-10-Rev.1TG-Gender.pdf

Islam, M. R., & Shamsuddoha, M. (2017). Socioeconomic consequences of climate induced human displacement and migration in Bangladesh. *International Sociology*, *32*(3), 277-298.

James, K. L., Randall, N. P., & Haddaway, N. R. (2016). A methodology for systematic mapping in environmental sciences. *Environmental evidence*, *5*(1), 1-13.

Jayachandran, S. (2021). Social norms as a barrier to women's employment in developing countries. *IMF Economic Review*, *69*(3), 576-595. https://doi.org/10.1057/s41308-021-00140-w

Jerneck, A. (2018). What about gender in climate change? Twelve feminist lessons from development. *Sustainability*, *10*(3), 627.

Kabeer, N. (1999). Resources, agency, achievements: Reflections on the measurement of women's empowerment. *Development and change*, *30*(3), 435-464.

Kaczan, D. J., & Orgill-Meyer, J. (2020). The impact of climate change on migration: a synthesis of recent empirical insights. *Climatic Change*, *158*(3-4), 281-300.

Kaijser, A., & Kronsell, A. (2014). Climate change through the lens of intersectionality. *Environmental politics*, *23*(3), 417-433.

Kajikawa, Y., Ohno, J., Takeda, Y., Matsushima, K., & Komiyama, H. (2007). Creating an academic landscape of sustainability science: an analysis of the citation network. *Sustainability Science*, *2*(2), 221-231.

Kajikawa, Y., Tacoa, F., & Yamaguchi, K. (2014). Sustainability science: the changing landscape of sustainability research. *Sustainability science*, *9*(4), 431-438.

Kelman, I., Orlowska, J., Upadhyay, H., Stojanov, R., Webersik, C., Simonelli, A. C., ... & Němec, D. (2019). Does climate change influence people's migration decisions in Maldives?. *Climatic change*, *153*, 285-299.

Khan, F. N., Collins, A. M., Nayak, P. K., & Armitage, D. (2018). Women's perspectives of small-scale fisheries and environmental change in Chilika lagoon, India. *Maritime Studies*, *17*, 145-154.

Khosravi, S. (2018). Afterword. Experiences and stories along the way. *Geoforum*, *116*, 292-295. https://doi.org/10.1016/j.geoforum.2018.05.021

King-Dejardin, A. (2019). The social construction of migrant care work. At the intersection of care, migration and gender. *International Labour Organization: Geneva, Switzerland*, 5-6.

Lama, P. D. (2018). Gendered consequences of mobility for adaptation in small island developing states: case studies from Maafushi and Kudafari in the Maldives. *Island Studies Journal*, *13*(2), 111-128.

Lama, P., Hamza, M., & Wester, M. (2021). Gendered dimensions of migration in relation to climate change. *Climate and Development*, *13*(4), 326-336.

Lau, J. D., Kleiber, D., Lawless, S., & Cohen, P. J. (2021). Gender equality in climate policy and practice hindered by assumptions. *Nature climate change*, *11*(3), 186-192.

Lawson, V. A. (1998). Hierarchical households and gendered migration in Latin America: feminist extensions to migration research. *Progress in Human Geography*, *22*(1), 39-53.

Leal Filho, W., Will, M., Shiel, C., Paço, A., Farinha, C. S., Orlovic Lovren, V., ... & Skouloudis, A. (2021). Towards a common future: revising the evolution of university-based sustainability research literature. *International journal of sustainable development & world ecology*, *28*(6), 503-517.

Maharjan, A., de Campos, R. S., Singh, C., Das, S., Srinivas, A., Bhuiyan, M. R. A., ... & Vincent, K. (2021). Migration and household adaptation in climate-sensitive hotspots in South Asia. *Current Climate Change Reports*, *6*, 1-16.

Mallick, B. (2019). The nexus between socio-ecological system, livelihood resilience, and migration decisions: Empirical evidence from Bangladesh. *Sustainability*, *11*(12), 3332.

Mallick, B., Rogers, K. G., & Sultana, Z. (2022). In harm's way: Non-migration decisions of people at risk of slow-onset coastal hazards in Bangladesh. *Ambio*, *51*(1), 114-134.

Mallick, B., & Vogt, J. (2012). Cyclone, coastal society and migration: empirical evidence from Bangladesh. *International Development Planning Review*, *34*(3).

McLeman, R. (2020). How Will International Migration Policy and Sustainable Development Affect Future Climate-Related Migration?. *Migration Policy Institute https://www. migrationpolicy. org/sites/default/files/publications/tcm-climate-migrationmcleman_final. pdf*.

Memon, R. A. (2021). A Comparative Study on Women Perception and Condition In the Event of Natural Disaster and Migration: A Qualitative Study from Sindh–Pakistan Flood 2010. *Journal of Governance Risk Management Compliance and Sustainability*, *1*(1), 50-61.

Mueller, V., Gray, C., & Kosec, K. (2014). Heat stress increases long-term human migration in rural Pakistan. *Nature climate change*, *4*(3), 182-185.

Munn, Z., Peters, M. D., Stern, C., Tufanaru, C., McArthur, A., & Aromataris, E. (2018a). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC medical research methodology*, *18*(1), 1-7.

Munn, Z., Stern, C., Aromataris, E., Lockwood, C., & Jordan, Z. (2018b). What kind of systematic review should I conduct? A proposed typology and guidance for systematic reviewers in the medical and health sciences. *BMC medical research methodology*, *18*(1), 1-9.

Nielsen, L., & Faber, M. H. (2021). Impacts of sustainability and resilience research on risk governance, management and education. *Sustainable and Resilient Infrastructure*, *6*(6), 339-384.

Obokata, R., Veronis, L., & McLeman, R. (2014). Empirical research on international environmental migration: a systematic review. *Population and environment*, *36*, 111-135.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *International journal of surgery*, *88*, 105906.

Page, M. J., Moher, D., & McKenzie, J. E. (2022). Introduction to PRISMA 2020 and implications for research synthesis methodologists. *Research Synthesis Methods*, *13*(2), 156-163.

Partey, S. T., Dakorah, A. D., Zougmoré, R. B., Ouédraogo, M., Nyasimi, M., Nikoi, G. K., & Huyer, S. (2020). Gender and climate risk management: evidence of climate information use in Ghana. *Climatic Change*, *158*(1), 61-75.

Paaske, D. M. (2021). Impact of Climate Justice and Climate Change Cost Distribution on SDGs. *Peace, Justice and Strong Institutions*, 391-399.

Patel, A., & Giri, J. (2019). Climate change, migration and women: analysing construction workers in Odisha. *Social Change*, *49*(1), 97-113.

Petrongolo, B., & Ronchi, M. (2020). Gender gaps and the structure of local labor markets. *Labour Economics*, *64*, 101819.

Piguet, E., Pécoud, A., & De Guchteneire, P. (2011). Migration and climate change: An overview. *Refugee Survey Quarterly*, *30*(3), 1-23.

Prati, G., Cazcarro, I., & Hazra, S. (2022). Gendered dimensions of the migration, sustainability and care nexus: The case study of the Mahanadi delta, India. *Current Research in Environmental Sustainability*, *4*, 100104.

Rabbani, M. G., Cotton, M., & Friend, R. (2022). Climate change and non-migration—exploring the role of place relations in rural and coastal Bangladesh. *Population and Environment*, *44*(1-2), 99-122.

Rao, N., Lawson, E. T., Raditloaneng, W. N., Solomon, D., & Angula, M. N. (2019). Gendered vulnerabilities to climate change: insights from the semi-arid regions of Africa and Asia. *Climate and Development*, *11*(1), 14-26.

Rethlefsen, M. L., Kirtley, S., Waffenschmidt, S., Ayala, A. P., Moher, D., Page, M. J., & Koffel, J. B. (2021). PRISMA-S: an extension to the PRISMA statement for reporting literature searches in systematic reviews. *Systematic reviews*, *10*(1), 1-19.

Rigaud, K. K., De Sherbinin, A., Jones, B., Bergmann, J., Clement, V., Ober, K., ... & Midgley, A. (2018). Groundswell.

Risman, B. J. (2018). *Gender as a social structure* (pp. 19-43). Springer International Publishing.

Sams, I. S. (2019). Impacts of Climate Change Induced Migration on Gender: A Qualitative Study from the Southwest Coastal Region of Bangladesh. *Int'l J. Soc. Sci. Stud.*, *7*, 57.

Schardt, C., Adams, M. B., Owens, T., Keitz, S., & Fontelo, P. (2007). Utilization of the PICO framework to improve searching PubMed for clinical questions. *BMC medical informatics and decision making*, *7*(1), 1-6.

Siddaway, A. P., Wood, A. M., & Hedges, L. V. (2019). How to do a systematic review: a best practice guide for conducting and reporting narrative reviews, meta-analyses, and meta-syntheses. *Annual review of psychology*, *70*, 747-770.

Singh, C. (2019). Migration as a driver of changing household structures: Implications for local livelihoods and adaptation. *Migration and Development*, *8*(3), 301-319.

Singh, C., & Basu, R. (2020). Moving in and out of vulnerability: Interrogating migration as an adaptation strategy along a rural–urban continuum in India. *The Geographical Journal*, *186*(1), 87-102.

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of business research*, *104*, 333-339.

Sovacool, B. K., Axsen, J., & Sorrell, S. (2018). Promoting novelty, rigor, and style in energy social science: Towards codes of practice for appropriate methods and research design. *Energy Research & Social Science*, *45*, 12-42.

Sultana, F. (2021). Climate change, COVID-19, and the co-production of injustices: a feminist reading of overlapping crises. *Social & Cultural Geography*, *22*(4), 447-460. https://doi.org/10.1080/14649365.2021.1910994

Tejedor, G., Segalàs, J., & Rosas-Casals, M. (2018). Transdisciplinarity in higher education for sustainability: How discourses are approached in engineering education. *Journal of cleaner production*, *175*, 29-37.

Teke Lloyd, F. A. (2019). Intersectional power dynamics and extended households: Elderly and widowed women's international migration from Armenia. *Gender, Place & Culture*, *26*(3), 362-383.

The University of Notre Dame. (2022). ND-GAIN index 2020. Rank Countries by ND-GAIN Country Index, Vulnerability and Readiness. Retrieved December 1, 2022, from https://gain.nd.edu/our-work/country-index/rankings/

Thorne, N., Yip, A. K. T., Bouman, W. P., Marshall, E., & Arcelus, J. (2019). The terminology of identities between, outside and beyond the gender binary–A systematic review. *International Journal of Transgenderism*, *20*(2-3), 138-154.

Tiwari, P. C., & Joshi, B. (2015). Gender processes in rural out-migration and socio-economic development in the Himalaya. *Migration and Development*, *5*(2), 330-350.

Tripathy Furlong, B., Adams, H., Boas, I., Warner, J., & Van Dijk, H. (2022). Gendered (im) mobility: emotional decisions of staying in the context of climate risks in Bangladesh. *Regional Environmental Change*, *22*(4), 1-15.

United Nations. (2015). Transforming our world: the 2030 agenda for sustainable development, 21 October 2015 (Vol. 16301). A/RES/70/1.

Unterhalter, E., Longlands, H., & Peppin Vaughan, R. (2022). Gender and intersecting inequalities in education: Reflections on a framework for measurement. *Journal of Human Development and Capabilities*, 1-30.

UN Women (2018). Turning promises into action: *gender equality in the 2030 agenda for sustainable development*. New York: United Nations Women

van Daalen, K. R., Kallesøe, S. S., Davey, F., Dada, S., Jung, L., Singh, L., ... & Nilsson, M. (2022). Extreme events and gender-based violence: a mixed-methods systematic review. *The Lancet Planetary Health*, *6*(6), e504-e523.

Van Eck, N. J., & Waltman, L. (2022). *VOSviewer* (1.6.18). Leiden University. https://www.vosviewer.com/

Van Eck, N. J., & Waltman, L. (2020). VOSviewer manual: Manual for VOSviewer version 1.6. 15. *Leiden: Centre for Science and Technology Studies (CWTS) of Leiden University*.

Van Praag, L., Ou-Salah, L., Hut, E., & Zickgraf, C. (2021). Migration and environmental change in Morocco: In search for linkages between migration aspirations and (perceived) environmental changes (p. 188). Springer Nature.

Vij, S., Moors, E., Ahmad, B., Arfanuzzaman, M., Bhadwal, S., Biesbroek, R., ... & Wester, P. (2017). Climate adaptation approaches and key policy characteristics: Cases from South Asia. *Environmental Science & Policy*, *78*, 58-65.

Weinreb, A., Stecklov, G., & Arslan, A. (2020). Effects of changes in rainfall and temperature on age-and sex-specific patterns of rural-urban migration in sub-Saharan Africa. *Population and Environment*, *42*(2), 219-254.

Winker, G., & Degele, N. (2011). Intersectionality as multi-level analysis: Dealing with social inequality. *European Journal of Women's Studies*, *18*(1), 51-66.

Yates, O. E., Manuela, S., Neef, A., & Groot, S. (2022). Reshaping ties to land: a systematic review of the psychosocial and cultural impacts of Pacific climate-related mobility. *Climate and Development*, *14*(3), 250-267.

Zickgraf, C., Ali, S. H., Clifford, M., Djalante, R., Kniveton, D., Brown, O., & Ayeb-Karlsson, S. (2022). Natural resources, human mobility and sustainability: a review and research gap analysis. *Sustainability Science*, *17*(3), 1077-1089.

Appendix

Supplementary material A: Household survey questionnaire – Dhaka, Bangladesh

Knowledge, Attitudes & Practices Towards Freshwater in Dhaka

Hello, my name is …. I'm an interviewer in a survey that is part of an independent research project on water management in Dhaka. INSTRUCTION: SHOW ID CARD

We interview 2000 households like yours in Dhaka.
The survey is conducted by the University of Waterloo in Canada.

We would like to ask you some questions related to water in and around your house.
The interview lasts no longer than 15-20 minutes.

We are interested in your opinion. There are no right or wrong answers.
All information you provide will be treated confidential and not shared with anyone else.

SCREENING QUESTIONS:
Are you willing to participate in the survey? IF YES >> CONTINUE
Do you feel authorized to answer some questions on behalf of your household? IF YES >> CONTINUE

Survey ID		Thana name		Road no.	
Name interviewer		Ward no.		House no.	
Date interview	….. /….. /2019	Slum name		GPS coordinates	

Section A – Socio-Demographic Household Characteristics

1. **Are you the head of the household?** no=0; yes=1
2. **If not, what is your relationship to the household head?** 1=spouse; 0=other, namely ……
3. **Gender respondent?** 0=female; 1=male
4. **What is your age?** …….. years
5. **What is the primary religion practiced in your household?** 1=Muslim**;** 2=Hindu**;** 3=Christian**;** 4=Buddhist**;** 5=Other, namely ……..
6. **Respondent's education level**:

0	Cannot read or write	6	Graduate of University or College
1	Can read & write but no formal education	7	Postgraduate of University
2	Primary school (class 1-5)	8	Medical/engineering
3	High school (class 6-10)	9	Diploma
4	Secondary School Certificate (SSC)/equivalent	10	Other, namely……
5	Higher Secondary School Certificate (HSC)/equivalent		

7. **Main occupation of the respondent (A-J) and the head of the household (1-10):**

A-1	Unemployed	H- 8	Garments worker
B-2	Student	I- 9	Small business owner (for example fruit/vegetables/meat/fish vendor)
C-3	Full-time employee government sector	J- 10	Transporter (rickshaw/cart puller, taxi/bus/truck driver)
D-4	Full-time employee private sector	K-11	Domestic worker
E-5	Professional (doctor, engineer, lawyer)	L-12	Daily laborer (construction, garbage/waste collector)
F-6	Business	M-13	Other, namely…….
G-7	Retired	N-14	Dependent on rent, remittance and savings

8. House characteristics:

House type (A)	House ownership	No. of rooms	Electricity connection?	Supply Piped Water connection?	Main source(s) of Water PLEASE LIST ALL RELEVANT SOURCES (B)	Sewer connection
1= Jhupri 2= Tong 3= Tin/ Kachan 4= Semi-pacca 5= Pacca 6= Flat/apartment 7= Other, namely …….....	0= Own 1= Rented 2= Rent-free		0= no 1= yes	0= No 1= Yes 2= Yes shared	1=Tap water 2=Tube well 3=Pond/river 4=Well 5=Bottled mineral water 6=Rain water 7=Other, namely …….	0 = No 1 = Yes 3= Don't know
Latrine type (C)		**Method of household solid waste disposal? (D)**				
1= Flush toilet connected to sewer 2= Flush toilet connected to septic tank 3= Pakka latrine (water seal) 4= Pakka latrine (pit) 5= Permanent kacha latrine 6= Temporary kacha latrine 7= Hanging 8= Open field/river 9= Other, namely ……. 10= Don't know		1= Managed dustbin 2= Burry inside pit 3= Burn 4= Unmanaged dump side 5= Other, namely…….. 6= Don't know				

9. How long have you lived in this house?

0=Since birth [GO TO QUESTION 16]

1= ……. months / years [CIRCLE APPROPRIATE CATEGORY]

10. If "1" in previous question, from where did you move to this neighborhood?

0=From another neighborhood in Dhaka, namely …….

1=From outside of Dhaka, namely ……

11. Why did you move to this neighborhood in Dhaka?
INSTRUCTION: PLEASE LIST THE MOST IMPORTANT REASON ONLY

1	Work/Employment	6	Marriage
2	Education	7	Conflict., please specify ……..
3	Better Healthcare	8	Environmental concerns/degradation (for example lack of water poor/degraded soils/, crop failure, arsenic contamination, or water pollution) >> GO TO QUESTION 13
4	Poverty, no income where I lived before	8	Natural disasters, such as cyclones, riverbank erosion, flooding, waterlogging, sea level rise, salinity intrusion, or droughts >> GO TO QUESTION 13
5	Moving together with family	10	Other,namely……

12. If the respondent does not mention environmental concerns/degradation or natural disasters in the previous question 11, then ask: did risk of environmental degradation or natural disasters such as cyclones, flooding, or riverbank erosion play a role in your decision to migrate to Dhaka?
0= no [GO TO QUESTION 14]
1= yes [GO TO QUESTION 13]

13. Please specify which concern played the most important role in your migration decision?
1=Freshwater scarcity
2=Groundwater level decline/groundwater depletion
3=Poor/degraded soils
4=Groundwater contamination with arsenic
5=Surface water pollution
6=Crop failure
7=Cyclone Sidr (2007), Cyclone Aila (2009), Cyclone Mora (2017) (CIRCLE THE APPROPRIATE REPLY)
8=Riverbank erosion
9=Flooding
10=Waterlogging
11=Sea level rise
12=Salinity intrusion in water/soil
13=Drought
14=Other, namely ……

14. If you moved from outside Dhaka, what was your main occupation and source of income in your place of origin?
0=I was unemployed
1=I did not work because I still went to school
2=Farmer
3=Fisherman/Fish salesperson [CIRCLE THE APPROPRIATE CATEGORY]
4=Petty business
5=Land laborer
6=Housewife
7=Day laborer
8=Other, namely……

15. If you moved from outside Dhaka, please rate how much you agree or disagree with the following statements:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree	Don't know
a. We have better earning opportunities in Dhaka than in our place of origin/there is more work in Dhaka						
b. Our living conditions are better in Dhaka than in our place of origin						
c. We are less exposed to natural disasters like floods in Dhaka						
d. We have better water and sanitation facilities in Dhaka than in our place of origin						
e. Our health was better in our place of origin than in Dhaka/we get more sick than before						
f. We had a higher social status and better network in our place of origin than in Dhaka						

16. Household Characteristics: INSTRUCTION: TAKE INFORMATION FOR ALL HOUSEHOLD MEMBERS LIVING WITH THE RESPONDENT IN DHAKA (NOT ELSEWHERE), STARTING WITH THE RESPONDENT

Household member	**Age** (years)	**Gender** (M/F)	**Income earner?** (Y/N)	**If child <16 attend school**? (Y/N)	**If child <16 not in school, explain why not**?	**Suffer from health issue(s)? (Y/N)**	**Name health issue** Examples: diarrhea/skin rash/hepatitis/ typhoid/dengue/breathing problems If respondent cannot name the disease: list "don't know"	**Receive treatment? (Y/N)**	**Estimated total medical costs** (checkup/medicines and so on) (BDT/week/month/year) CIRCLE APPROPRIATE CATEGORY
Respondent									
1									
2									
3									
4									
5									
6									
7									
8									

17. If the respondent mentions that members of their household suffer from health problems: Do you think if any of those health problems are related to your household water supply?

0=no
1=yes
2=don't know

18. If yes, can you specify why? ……..

19. Total estimated MONTHLY income of the WHOLE household:
INTERVIEWER INSTRUCTION: remind the respondent that all information provided will be kept confidential and will not be shared with anyone else

A	Lower than BDT 2,500	H	BDT 75,001 – BDT 100,000
B	BDT 2,501- BDT 5,000	I	BDT 100,001 – BDT 150,000
C	BDT 5,001 – BDT 10,000	J	BDT 150,001 – BDT 200,000
D	BDT 10,001 – BDT 15,000	K	BDT 200,001 – BDT 250,000
E	BDT 15,001 – BDT 25,000	L	BDT 250,001 – BDT 300,000
F	BDT 25,001 – BDT 50,000	M	BDT 300,001 – BDT 350,000
G	BDT 50,001 – BDT 75,000	N	More than BDT 350,001 namely BDT ……..

Section B – Water and Sanitation Characteristics

20. Approximately how many liters of water do you use in your household every day?

0=Best guess: …….liters/day
1=Best guess: …….buckets/day
INSTRUCTION: MEASURE BUCKET SIZE: height: …… cm
width at top ……..…… cm
width at bottom …… cm (IF NOT EQUAL TO TOP]
2=According to my water bill: …….liters/day
3=Don't know
4=Refused

21. How much do you pay on average for your household drinking water?

0=I don't pay anything for my household water
1=the cost of water is included in my rent >> I pay …… BDT/month in rent
2=the cost of water is included with my electricity and gas bill >> I pay …… BDT/month in total for water, electricity and gas
3=I pay BDT…….per day/week/2 weeks/month for my water bill [CIRCLE APPROPRIATE CATEGORY]
4= I pay BDT…….per day/week/2 weeks/month for my drinking water **<u>from other sources</u>** than piped household water supply like bottled water [CIRCLE APPROPRIATE CATEGORY]
5=Refused

22. Do you think the water you use is safe for drinking?

0=no 1=yes 2=don't know

23. If not, why not? INSTRUCTION: DO NOT READ LIST, MULTIPLE ANSWERS POSSIBLE

1=Looks muddy/dirty/ not clean
2=Smells
3=Tastes bad
4= insects/bugs come with water
5=Contaminated by germs
6=Other, namely.....

24. How would you rate the quality of your household water supply?

0=don't know 1=poor 2=moderate 3=good 4=very good

25. Do you treat your water before drinking? INSTRUCTION: DO NOT READ LIST

0=no
1=yes, I boil the water
2=yes, I use chlorine
3=yes, I use a filter
4=yes, other namely.....

26. Is the toilet you use shared by multiple families?

0=no [GO TO QUESTION 28]
1=yes [GO TO QUESTION 27 FIRST AND THEN TO QUESTION 28]

27. If yes, by how many families? ……

28. Who is responsible for maintaining and cleaning the toilet?

INSTRUCTION: THIS QUESTION IS ANSWERED BY EVERY RESPONDENT, WHETHER THEY SHARE THE TOILET OR NOT

1=me
2=someone else in my household, namely …….
3=this rotates among family members
4= this rotates among the families who share the toilet
5=someone else from outside is paid to clean the toilet
6=I don't know
7=Other, namely …….

29. What happens to the waste from the toilet/latrine?

0= we pay for collection

1=I/other household members collect and remove the waste

2=the waste goes to the sewer pipe

3=I don't know

4=Other, namely ……..

30. Does the neighborhood where you live have a drainage network for storm water?

0=no 1=yes 2=don't know

31. How often do you face flooding in your home?
0=never
1=sometimes
2=regularly
3=often
4=all the time there is heavy rainfall

32. Do you and your family members have health insurance?
0=no 1=yes 2=don't know

33. If yes, how much do you pay for this for your entire household?
BDT …… week / 2 weeks / month / 6 months / 12 months [CIRCLE APPROPRIATE CATEGORY]

99 =I don't know

34. How far is the nearest health clinic or pharmacy to your home? …… meters

[CIRCLE APPROPRIATE CATEGORY: CLINIC/PHARMACY]

99=I don't know

35. In the past 30 days, ….

	No	**Yes**	**Don't know**
a. Did you worry that your household would not have enough water?			
b. Did you or any household member drink unsafe water?			
c. Did you or any household member drink less than needed because there was not enough water?			
d. Was there ever no water at all in your household?			

36. How often do members of your household suffer from diarrhea?
INSTRUCTION: PUT A CHECKMARK FOR CHILDREN AND ADULTS

	Never	**Rarely**	**Sometimes**	**Often**	**Very often**	**Don't know**
Children						
Adults						

37. How often do members of your household suffer from water-related health problems?

	Never	Rarely	Sometimes	Often	Very often	Don't know
Children						
Adults						

38. What do you do when someone in your household is ill?

1=See a doctor

2=Go to the pharmacy to buy medication

3=Use own medication

4=Other, namely …….

39. If you do not seek medical treatment, can you explain why not?

1=too costly

2=nearest health clinic or pharmacy is too far away

3=other, namely……

Section C – Environmental Characteristics

40. Is there any open water near your house?
0=don't know >> GO TO QUESTION 50
1=no >> GO TO QUESTION 50
2=yes >> GO TO QUESTION 41
41. How far is this water from your home? …… meters
99=don't know
42. What type of water is it?
1=river
2=canal/khal
3=lake
4=pond
5=other, namely ……
6=don't know

43. Do you use water from this open water for any purpose? INSTRUCTION: do NOT read list
0=no
1=yes, bathing
2=yes, washing clothes

3=yes, household use

4=yes other, namely……

44. How would you rate the quality of this open water?

0=don't know 1=poor 2=moderate 3=good 4=very good

45. Do you have any concern(s) about this open water?
0=no 1=yes

46. What is your main concern? INSTRUCTION: do NOT read list
1=smell
2=colour
3=danger to children
4=health impacts [INSTRUCTION: ONLY CROSS IF RESPONDENT MENTIONS HEALTH]

5=other, namely……

47. Are you in any way concerned about your health or that of your family members related to this water?

0=no 1=yes 2=don't know

48. If yes, can you explain why? ……

49. Have you ever considered moving because of this open water?

0=no 1=yes 2=don't know 3=I never thought about this

50. What do you think is the main source of water pollution in Dhaka?

INTERVIEWER: do not read list; encourage respondent to name the most important one only; if they insist on more than one, rank them

1=residential households
2=hospitals
3=industry:
- 0 tanneries
- 0 dying textile
- 0 food industry
- 0 other namely ……

4=other, namely ……

51. Do you think that water bodies in Dhaka should be better protected than currently is the case?

0=no >> GO TO QUESTION 52
1=yes >> GO TO QUESTION 52
2=don't know >> GO TO QUESTION 53

52. Can you explain why (not)? ……

53. Who do you think is responsible for protecting the quality of the open waters in Dhaka?

1=Individual households
2=Government/department of Environment
3=WASA
4=Dhaka North City Corporation (DNCC)
5=Dhaka South City Corporation (DSCC)
6=NGO's
7=Other, namely ……..
8= Don't know

54. To what extent do you agree or disagree with the following statements?

INTERVIEWER – read each statement one at a time

	Strongly agree	**Somewhat agree**	**Neither agree nor disagree**	**Somewhat disagree**	**Strongly disagree**	**Don't know**

a. Environmental protection such as water and air quality should receive more priority in Dhaka						
b.Employment is more important than the protection of open waters in Dhaka						
c.The polluter should pay for water pollution						
d.I am willing to pay for improved water quality in Dhaka						

Section D – Choice Experiment

INTERVIEWER INSTRUCTION: READ THE TEXT BELOW OUT LOUD

I will now show you 6 cards with different possible future situations related to the quality of your indoor household water supply and the outdoor rivers and lakes in Dhaka. In order to improve indoor and outdoor water quality, investments are needed in both household water supply and collection and treatment of wastewater from households and industry The construction of additional underground sewer pipes to collect wastewater from households like yours and industry also allows for the capturing and discharge of storm water during excessive rainfall, better protecting houses and buildings in Dhaka from future flooding.

Currently, indoor and outdoor water quality is poor. Many households in Dhaka do not have access to good quality household water supply. They need to filter and boil their water before it is drinkable. And rivers and lakes are so polluted that fish cannot live in them.

The quality of household water supply can be improved
- a little bit to "**moderate**" quality where the water is already clearer and cleaner but still needs to be filtered and boiled before drinking,
- further to "**good quality**" where the water does not have to be filtered anymore to take out any pollution but needs to be boiled still, or to
- "**very good**" quality where it does not have to be filtered and boiled anymore to kill germs and bacteria, and it can be drunk right away.

The quality of outdoor rivers and lakes can also be improved to
- "**moderate**" quality where fish can just survive,
- "**good**" quality where both fish quantity and diversity increases, and
- "**very good**" where different types of fish survive in large quantities.

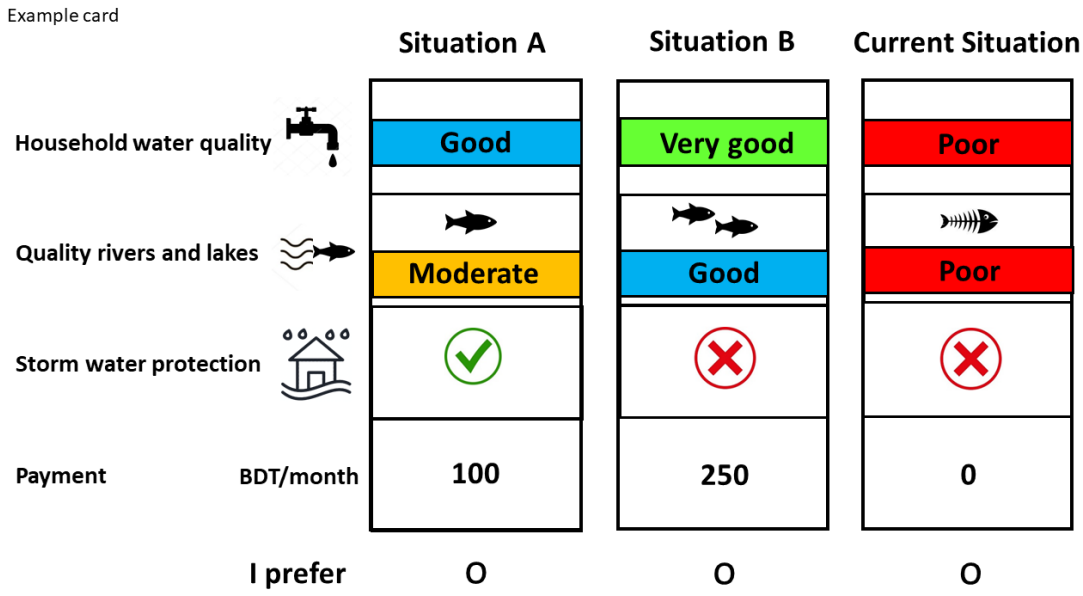
All households in Dhaka, including yours, will be asked to financially contribute to the improvement of indoor and outdoor water quality You can either pay an increase in your income tax to cover the costs or a water development fee if you prefer not to pay any extra tax or you do not pay any income tax. In return, you will benefit from improved household water supply quality, cleaner rivers and lakes in Dhaka city, and reduced flood risks in the near future.

55. How do you prefer to pay?

1=Income tax
2=Water Development Fee
3=I don't want to pay [SKIP CHOICE EXPERIMENT, GO TO QUESTION 62]

INTERVIEWER INSTRUCTION: SHOW EXAMPLE CARD AND EXPLAIN THE CARD

I will show you an example card first.



- In the example card, you see 2 possible future situations, situation A and situation B.

- Each situation is an improvement from the current situation where indoor household water supply quality and outdoor water quality in rivers and lakes in Dhaka is poor, and there is no storm water protection.

- In situation A, household water supply quality is improved from poor to good, meaning that you still need to boil your water but you don't need to filter it, outdoor water quality in rivers and lakes has improved a little bit and fish can just survive, and there is storm water protection

- To achieve this situation, your household will have to pay 100 Taka per month (either in extra income tax or as a monthly water development fee)

- In situation B, household water supply quality is highest and directly drinkable, outdoor water quality is good and various fish can live in rivers and lakes, but there is no extra storm water protection

- To achieve this situation, your household will have to pay 50 Taka per month (either in extra income tax or as a monthly water development fee)

- Hence, the two situations differ in the indoor and outdoor water quality levels and storm water protection, and therefore have different prices. All you have to tell me is which situation you prefer

- You can also choose none of the two new situations. In that case you stay with the current situation and you pay nothing extra. You will also not receive any of the water quality improvement or storm water protection benefits

56. Is this explanation of the example card clear?
0=no >> EXPLAIN ONCE AGAIN
1=yes >> CONTINUE WITH THE NEXT 6 CARDS

Please look at the next 6 cards carefully and choose in every card the alternative you prefer most. Every card shows a completely new situation and the cards you are shown have to be evaluated independently of each other. The results of this survey will inform policy and decision-making whether or not to invest in future water quality improvements and storm water protection in Dhaka, so please answer as truthfully as possible and imagine you will actually be asked to pay the income tax or water development fee for the alternative you prefer most.

INTERVIEWER INSTRUCTION: INDICATE WHICH SET OF CHOICE CARDS YOU USED:
1=version 1
2=version 2
3=version 3
4=version 4

57. Indicate in the table below which situation the respondent preferred in each card

Card	Situation A	Situation B	Current Situation
1			
2			
3			
4			
5			
6			

58. If you chose in <u>the last card</u> either situation A or B, how much would you be willing to pay maximum per month on behalf of your entire household for this specific situation?

Maximum: …….. BDT/month

59. Which of the characteristics was <u>most</u> important each time you chose your most preferred situation?
1=Indoor household water supply quality
2=Outdoor water quality
3=Storm water protection
4=Monthly payment
5=All characteristics were equally important in my choices

60. Which of the characteristics was <u>least</u> important each time you chose your most preferred situation?

1=Indoor household water supply quality

2=Outdoor water quality

3=Storm water protection

4=Monthly payment

5=None of the characteristics were important in my choices

INSTRUCTION: ASK THIS QUESTION ONLY IF RESPONDENT CHOOSES 6 TIMES THE CURRENT SITUATION AND DOES NOT WANT TO PAY EXTRA INCOME TAX

61. If you chose every time the current situation, can you explain why?

1=I don't care about water quality improvements or storm water protection

2=I don't have enough income to pay for the proposed water quality or storm water improvements

3=I prefer to spend my money on other things than water quality improvements or storm water protection

4=I don't believe these situations are real or achievable

5=I refuse to pay because the government should pay, not me

6= I refuse to pay because the polluter should pay, not me

7=Other, namely ……..

62. Is there anything else you would like to add related to water and sanitation issues in Dhaka that we haven't already talked about?

……..

THIS IS THE END OF THE INTERVIEW

THANK YOU VERY MUCH FOR HELPING US WITH OUR RESEARCH

Supplementary material B: Some important migration theories and their strengths and limitations

Theory	Strengths	Limitations
Neoclassical macroeconomic approach (Harris & Todaro, 1970; Todaro, 1977)	▪ It views migration as an individual's decision to move to a place where labor markets and associated wages are or are perceived to be better than the migrant's place of origin to improve their wages.	▼ One-directional flow: This theory assumes that migration is a one-way flow from origin to destination. However, migration is often a complex and dynamic process that involves multiple movements and returns. ▼ Labor market focus: This approach emphasizes the role of labor markets in shaping migration patterns. While this is important, other factors, such as family ties, cultural ties, and personal preferences, also shape migration decisions. ▼ Simplistic view of economies: This approach tends to view economies as homogeneous, ignoring regional differences and the role of institutions in shaping migration patterns.
Neoclassical microeconomic approach (Sjaastad, 1962)	▪ Emphasis on economic factors: This perspective recognizes the role of economic factors, including wages and employment opportunities, in shaping migration decision-making. ▪ Explanation of rational choice: It views migration as an investment decision of individuals to maximize their economic well-being. Individuals make a rational cost and benefit analysis of anticipated discounted future returns of migration over future periods and only decide to migrate if the estimated returns are positive.	▼ Individualistic perspective: This theory primarily focuses on individual-level decision-making, ignoring the role of households and communities in migration decisions. ▼ Over-simplification: This theory assumes that individuals make rational decisions about migration based solely on economic factors, ignoring the influence of social, cultural, political, and psychological factors, such as conflict and inequality. ▼ Lack of recognition of institutional constraints: This theory assumes that individuals have perfect information about job opportunities and wages, but individuals are often limited by institutional factors such as immigration policies, discrimination, and lack of information.
Push-Pull theory (Lee, 1966)	▪ Explains that migration is driven by a combination of factors, including positive (e.g., better life, employment opportunity) and negative (e.g., poverty, conflict) that are associated with place of origin and destinations, intervening obstacles (e.g., immigration policy) and personal.	▼ This theory is more of a collection of elements that influence migration rather than a comprehensive view of the causal mechanisms.
The migration systems and networks theory (Fawcett, 1989; Gurak & Caces, 1992)	▪ Emphasis on connectedness: This theory recognizes the interconnectedness of migration systems and networks, both within and between countries, and their impact on migration patterns and decisions. ▪ Incorporation of social networks: This theory incorporates the role of social networks, including family and community connections, in shaping migration decisions and experiences.	▼ Neglect of structural factors: This theory may neglect the impact of broader structural factors, such as economic, political, and social structures, on migration patterns and decisions. ▼ Difficulty in measuring networks: Measuring migration systems and networks can be challenging, and this perspective may struggle to fully capture the complexities of migration decisions and experiences.

Theory	Strengths	Limitations
	▪ Explanation of collective migration: This perspective provides a helpful explanation of collective migration, including the role of social networks and communities in shaping migration decisions and experiences.	▼ Little explanation of individual agency: This theory may neglect the agency of individuals in shaping their migration decisions and experiences, focusing instead on the role of networks and systems.
The world systems theory (Wallerstein, 1974)	▪ It takes a macro and multidisciplinary perspective to explain migration as a product of the global economic and political systems and views migration as a means of disruptions and displacements in peripheral parts of the world due to colonialism and the capitalist expansion of neoclassical governments and international businesses. ▪ Emphasis on global structural factors: This perspective recognizes the role of global economic and political structures in shaping migration patterns and decisions, providing a helpful explanation of the root causes of migration. ▪ Explanation of global inequalities: This perspective provides a valuable explanation of global inequalities, the relationship between core and peripheral regions in the world economy, and how this affects migration patterns and decisions. ▪ Integration of historical factors: This perspective considers historical factors and the evolution of global economic and political structures, providing a long-term view of migration patterns and decisions.	▼ Reductionism: The theory reduces migration to a single cause, which is the economic structure of the world system. This ignores other factors, such as personal and social motivations, cultural differences, and the impact of state policies. ▼ Over-generalization: It tends to over-generalize migration as a uniform process that affects all regions and people in the same way, but migration experiences are highly diverse and vary significantly between different groups and regions. ▼ Lack of agency: It does not fully recognize the role of individual agency and decision-making in migration processes. People are often seen as passive victims of the world system rather than active agents making decisions about their own lives.
Structuralist views of migration (Bach & Schraml, 1982)	▪ This approach considers migration as a result of broader socio-economic and political structures and forces rather than just the result of individual choices. ▪ Historical and institutional context: Structuralists see migration as shaped by historical and institutional processes, including colonialism, globalization, and the development of capitalist systems. ▪ Power relations: Structuralists focus on the role of power relations in shaping migration, including the exploitation of migrant labor, discrimination, and unequal access to resources. ▪ Interconnections between countries: Structuralists emphasize the interconnectedness between countries and the role that	▼ Determinism: Structuralist views can be seen as deterministic, suggesting that individuals have little agency and are merely passive recipients of broader structural forces. ▼ Reductionism: Structuralist views can simplify complex migration processes and reduce the agency of individuals, communities, and states. ▼ Oversimplification: Structuralist views can oversimplify the complex and multidimensional causes of migration, neglecting other factors such as individual experiences, preferences, and motivations. ▼ Limited explanation of differential impacts: Structuralist views may struggle to fully explain why migration affects different groups in different ways and why some groups are more vulnerable to structural changes than others.

Theory	Strengths	Limitations
	transnational economic and political systems play in shaping migration patterns. ▪ Impact on origin and destination countries: Structuralists consider the effects of migration on both the countries of origin and destination, including the remittances sent back to the origin country, the labor market effects in the destination country, and the impact on social and cultural systems. ▪ Class and inequality: Structuralists view migration as being influenced by class and inequality, including the unequal distribution of resources and opportunities within countries and the exploitation of migrant labor in destination countries.	▼ Difficulty in predicting migration trends: Structuralist views can have difficulty in predicting future migration trends, as structural changes can have unexpected consequences, and individuals may respond differently to migration opportunities.
The agency theory of migration (Bakewell, 2010; Bakewell et al., 2012)	▪ Emphasis on individual agency: This theory acknowledges the role of individual choices and decision-making in the migration process, recognizing the agency of migrants in shaping their own migration experiences. ▪ Better explanation of differential impacts: The agency theory can better explain why some individuals or groups are more likely to migrate than others based on their level of agency and access to resources and information. ▪ Account for complexity: The agency theory recognizes that migration is a complex and multidimensional process, considering individual motivations, preferences, and experiences.	▼ Neglect of structural factors: This theory can neglect the impact of broader structural factors, such as economic, political, and social structures, which can shape the migration opportunities and experiences of individuals. ▼ Individualistic approach: The agency theory can be seen as overly individualistic, neglecting the impact of collective and societal factors on migration. ▼ Difficulty in predicting trends: Like structuralist views, the agency theory can have difficulty predicting migration trends as it does not account for unexpected changes in structural conditions or shifts in individual preferences. ▼ Limited explanation of collective action: This theory does not fully explain the phenomenon of collective migration or the impact of social networks and communities on migration decisions.
Behavioral theories of migration: Stress threshold model (Brown & Moore, 1970; Wolpert, 1965) Value-expectancy model (De Jong & Fawcett, 1981; De Jong et al., 1983)	▪ Emphasis on decision-Making processes: Behavioral theories shed light on the decision-making processes of individuals and households, considering the role of information, expectations, values, and attitudes. ▪ Incorporation of social and psychological factors: Behavioral theories incorporate social and psychological factors that influence migration decisions, such as the level of utility they aspire to have, place attachment, risk perceptions, residential dissatisfaction, or stress. ▪ Better explanation of household migration decisions: This perspective is instrumental in understanding the migration	▼ Neglect of structural factors: Behavioral theories can neglect the impact of broader structural factors such as economic, political, and social structures, which can shape the migration opportunities and experiences of individuals. ▼ Difficulty in predicting trends: Behavioral theories can have difficulty predicting migration trends, as changes in individual preferences, attitudes, and behaviors can be difficult to predict. ▼ Narrow focus on migration decisions: Behavioral theories may focus too narrowly on the migration decision, neglecting the impact of broader social, economic, and political structures on the migration process as a whole.

Theory	Strengths	Limitations
	decisions of households, which often involve multiple individuals with different motivations and preferences.	
The human capabilities perspective (Sen, 2001)	▪ Recognition of individual agency: The human capabilities perspective recognizes the agency of individuals in shaping their migration decisions and experiences, considering their abilities and capacities to act. ▪ Emphasis on human development: This perspective recognizes the importance of human development, including education and skill development, in shaping migration decisions and experiences. ▪ Integration of structural and individual factors: This perspective integrates structural and individual factors, recognizing that both can shape migration decisions and experiences.	▼ Difficulty in measuring capabilities: Measuring human capabilities can be challenging, and this perspective may struggle to fully capture the complexities of migration decisions and experiences. ▼ Neglect of psychological factors: This perspective may neglect critical psychological factors, such as risk perceptions and attitudes, that can influence migration decisions. ▼ Limited explanation of differential impacts: The human capabilities perspective may struggle to fully explain why migration affects different groups in different ways and why some groups are more vulnerable to structural changes than others.
The sustainable livelihood approach to migration (McDowell & de Haan, 1997; Scoones, 1998)	▪ Integration of livelihood and migration: This approach considers migration as a livelihood strategy in which individuals and households make migration decisions based on their livelihood assets and vulnerabilities. ▪ Consideration of differential impacts: This approach can better explain why migration affects different groups differently and why some groups are more vulnerable to structural changes than others. ▪ Recognition of multidimensionality: This approach recognizes the multidimensional nature of migration and its impact on livelihoods, considering economic, social, and political factors.	▼ Little explanation of individual agency: This approach may neglect the agency of individuals in shaping their migration decisions and experiences, focusing instead on broader factors. ▼ Difficulty in measuring livelihood assets: Measuring livelihood assets and vulnerabilities can be challenging, and this approach may struggle to fully capture the complexities of migration decisions and experiences. ▼ Limited explanation of psychological factors: This approach may neglect critical psychological factors, such as risk perceptions and attitudes, that can influence migration decisions. ▼ Difficulty in predicting trends: This approach can have difficulty predicting migration trends, as changes in livelihood assets and vulnerabilities can be difficult to predict.
The new economics of labor migration (NELM) theory (Massey et al., 1993; Stark & Bloom, 1985; Stark & Levhari, 1982)	▪ The NELM theory takes a holistic view of migration decisions, recognizing the important role played by households and families in shaping migration decisions. ▪ The NELM theory places the behavior of individual migrants within the context of the household or family and considers migration as a strategy to sustain and maximize income, diversify risks, leverage labor opportunities, and offset losses. ▪ Household/family context: This perspective considers the household or family as an appropriate decision-making unit, providing a more nuanced and comprehensive understanding of migration decisions.	▼ Neglect of non-economic aspects: This perspective may neglect the impact of non-economic factors, such as social, cultural, and political psychological aspects on migration decisions and experiences.

Theory	Strengths	Limitations
Family decision-making theory (Boyed, 1989; Harbison, 1981; Mincer, 1978)	▪ Emphasis on family context: This perspective recognizes the role of the family as an important decision-making unit, considering the interplay between individual and household migration decisions.	▼ This theory may overlook the significance of individuals' psychological, health and agency aspects in migration decision-making.
Gender perspective (De Jong, 2000; Morokvaśic, 1984)	▪ Consideration of gender differences: This perspective recognizes the importance of gender in shaping migration decisions and experiences and acknowledges the different ways in which men and women are affected by migration.	▼ Limited consideration of intersectionality: This perspective may neglect the impact of other important factors, such as race, class, and ethnicity, on migration decisions and experiences, particularly as they interact with gender. ▼ Difficulty in measuring gender dynamics: Measuring gender dynamics, such as gender roles and household dynamics, can be challenging, and this perspective may struggle to fully capture the complexities of migration decisions and experiences.

Supplementary material C: Mann-Whitney Test Statistics

Test Statistics[a]

	Exposure	Sensitivity	Adaptive Capacity	Total CVI IPCC
Mann-Whitney U	49439.000	37336.500	75993.000	34899.000
Wilcoxon W	208205.000	196102.500	234759.000	193665.000
Z	-11.216	-14.524	-3.936	-15.192
Asymp. Sig. (2-tailed)	.000	.000	.000	.000

a. Grouping Variable: Climate migrants and native residents

Test Statistics[a]

	Exposure	Sensitivity	Adaptive Capacity	Total CVI IPCC
Mann-Whitney U	46336.000	32545.000	76817.500	33422.000
Wilcoxon W	191327.000	171673.000	221808.500	172550.000
Z	-11.379	-15.042	-2.709	-14.788
Asymp. Sig. (2-tailed)	.000	.000	.007	.000

a. Grouping Variable: Climate migrants and other migrants

Test Statistics[a]

	Exposure	Sensitivity	Adaptive Capacity	Total CVI IPCC
Mann-Whitney U	143245.500	143476.000	142518.500	144393.000
Wilcoxon W	288236.500	282604.000	301284.500	283521.000
Z	-1.556	-.939	-1.693	-.762
Asymp. Sig. (2-tailed)	.120	.348	.090	.446

a. Grouping Variable: Native residents and other migrants

Supplementary material D: Preferred Reporting Items for Systematic Reviews and Meta-Analyses PRISMA 2020 item checklist[11]

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	

[11] Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. International journal of surgery, 88, 105906.

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	
Study characteristics	17	Cite each included study and present its characteristics.	
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	
	23b	Discuss any limitations of the evidence included in the review.	
	23c	Discuss any limitations of the review processes used.	
	23d	Discuss implications of the results for practice, policy, and future research.	
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	
Competing interests	26	Declare any competing interests of review authors.	
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	

From: Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi:10.1136/bmj.n71

For more information, visit: www.prisma-statement.org.

Supplementary material E: Systematic review search stretegy

Database	Search string
Web of Science Search Date: 12.03.2022 Total: 2796	“climate change” OR “climatic change*” OR “climate variability” OR “weather-related event*” OR “global warming” OR "greenhouse effect*" OR “weather event” OR “environmental change” OR “climate disaster” OR “natural hazard” OR “natural disaster” OR “slow onset” OR “slow-onset” OR “sudden onset” OR “sudden-onset” OR “rapid onset” OR “extreme weather” OR “flood*” OR “cyclone” OR “storm surge” OR “typhoon” OR “hurricane” OR “coastal erosion” OR “riverbank erosion” OR “drought” OR “heat*” OR “heat-wave” OR “temperature” OR “wildfire” OR “desertification” OR “sea level rise” OR “sea-level rise” OR “SLR” OR “rainfall*” OR “precipitation” OR “water stress” OR “water scarcity” OR “water insecurity” OR “water security” OR “water availability” OR “saline intrusion” OR “salinity” OR “warming ocean” OR “ocean acidification” OR “climate vulnerability” (Topic) and “gender” OR “woman*” OR “man*” OR “male” OR “female” OR “boy” OR “girl” OR “mother” OR “father” OR “wife*” OR “husband*” OR “femini*” OR “masculin*” OR “caregiver” OR “caregiving” OR “breadwinner” OR “breadwinning” OR “transgender” OR “intersex” OR “nonbinary” OR “non-binary” (Topic) and “migration” OR “human migration*” OR “displace*” OR “relocate” OR “relocation” OR “resettlement” OR “planned relocation” OR “move*” OR “mobility” OR “immobi*” OR “floating population” OR “trapped population” OR “population movement” OR “migrate” OR “migrant*” OR “refugee*” OR “immigra*” (Topic) not species OR animal* OR physics OR astronomy OR tree OR soil OR plant OR bird* OR pharmaceutical* OR parasite* OR forest OR clinical OR patient OR teach* OR energy OR transport* OR engineer OR engineering (All Fields) and Environmental Sciences or Environmental Studies or Ecology or Geography or Social Sciences Interdisciplinary or Sociology or Economics (Web of Science Categories)
Scopus Search Date: 12.03.2022 Total: 3719	(TITLE-ABS-KEY ("climate change" OR "climatic change*" OR "climate variability" OR "weather-related event*" OR "global warming" OR "greenhouse effect*" OR "weather event" OR "environmental change" OR "climate disaster" OR "natural hazard" OR "natural disaster" OR "slow onset" OR "slow-onset" OR "sudden onset" OR "sudden-onset" OR "rapid onset" OR "extreme weather" OR "flood*" OR "cyclone" OR "storm surge" OR "typhoon" OR "hurricane" OR "coastal erosion" OR "riverbank erosion" OR "drought" OR "heat*" OR "heat-wave" OR “temperature” OR “wildfire” OR "desertification" OR "sea level rise" OR "sea-level rise" OR "SLR" OR “rainfall*” OR "precipitation" OR "water stress" OR "water scarcity" OR "water insecurity" OR "water security" OR "water availability" OR "saline intrusion" OR "salinity" OR "warming ocean" OR "ocean acidification" OR "climate vulnerability") AND TITLE-ABS-KEY ("gender" OR "woman*" OR "man*" OR "male" OR "female" OR "boy" OR "girl" OR "mother" OR "father" OR "wife*" OR "husband*" OR "femini*" OR "masculin*" OR "caregiver" OR "caregiving" OR "breadwinner" OR "breadwinning" OR "transgender" OR "intersex" OR "nonbinary" OR "non-binary") AND TITLE-ABS-KEY ("migration" OR "human migration*" OR "displace*" OR "relocate" OR "relocation" OR "resettlement" OR "planned relocation" OR "move*" OR "mobility" OR "immobi*" OR "floating population" OR "trapped population" OR "population movement" OR "migrate" OR "migrant*" OR "refugee*" OR "immigra*") AND NOT ALL (species OR animal* OR bird* OR physics OR astronomy OR tree OR soil OR plant OR pharmaceutical* OR parasite* OR forest OR clinical OR patient OR teach* OR energy OR transport* OR engineer OR engineering)) AND (LIMIT-TO (

	SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "MULT"))
GenderWatch Date: 12.03.2022 Total: 282	noft("climate change" OR "climatic change*" OR "climate variability" OR "weather-related event*" OR "global warming" OR "greenhouse effect*" OR "weather event" OR "environmental change" OR "climate disaster" OR "natural hazard" OR "natural disaster" OR "slow onset" OR "slow-onset" OR "sudden onset" OR "sudden-onset" OR "rapid onset" OR "extreme weather" OR "flood*" OR "cyclone" OR "storm surge" OR "typhoon" OR "hurricane" OR "coastal erosion" OR "riverbank erosion" OR "drought" OR "heat*" OR "heat-wave" OR “temperature” OR “wildfire” OR "decertification" OR "sea level rise" OR "sea-level rise" OR "SLR" OR “rainfall*” OR "precipitation" OR "water stress" OR "water scarcity" OR "water insecurity" OR "water security" OR "water availability" OR "saline intrusion" OR "salinity" OR "warming ocean" OR "ocean acidification" OR "climate vulnerability") AND ("gender" OR "woman*" OR "man*" OR "male" OR "female" OR "boy" OR "girl" OR "mother" OR "father" OR "wife*" OR "husband*" OR "femini*" OR "masculin*" OR "caregiver" OR "caregiving" OR "breadwinner" OR "breadwinning" OR "transgender" OR "intersex" OR "nonbinary" OR "non-binary") AND noft("migration" OR "human migration*" OR "displace*" OR "relocate" OR "relocation" OR "resettlement" OR "planned relocation" OR "move*" OR "mobility" OR "immobi*" OR "floating population" OR "trapped population" OR "population movement" OR "migrate" OR "migrant*" OR "refugee*" OR "immigra*")
Wiley Online Library Date: 12.03.2022 Total: n = 395	“climate change” OR “climatic change*” OR “climate variability” OR “weather-related event*” OR “global warming” OR "greenhouse effect*" OR “weather event” OR “environmental change” OR “climate disaster” OR “natural hazard” OR “natural disaster” OR “slow onset” OR “slow-onset” OR “sudden onset” OR “sudden-onset” OR “rapid onset” OR “extreme weather” OR “flood*” OR “cyclone” OR “storm surge” OR “typhoon” OR “hurricane” OR “coastal erosion” OR “riverbank erosion” OR “drought” OR “heat*” OR “heat-wave” OR “temperature” OR “wildfire” OR “desertification” OR “sea level rise” OR “sea-level rise” OR “SLR” OR “rainfall*” OR “precipitation” OR “water stress” OR “water scarcity” OR “water insecurity” OR “water security” OR “water availability” OR “saline intrusion” OR “salinity” OR “warming ocean” OR “ocean acidification” OR “climate vulnerability”" in Abstract and ""“gender” OR “woman*” OR “man*” OR “male” OR “female” OR “boy” OR “girl” OR “mother” OR “father” OR “wife*” OR “husband*” OR “femini*” OR “masculin*” OR “caregiver” OR “caregiving” OR “breadwinner” OR “breadwinning” OR “transgender” OR “intersex” OR “nonbinary” OR “non-binary”" in Abstract and ""“migration” OR “human migration*” OR “displace*” OR “relocate” OR “relocation” OR “resettlement” OR “planned relocation” OR “move*” OR “mobility” OR “immobi*” OR “floating population” OR “trapped population” OR “population movement” OR “migrate” OR “migrant*” OR “refugee*” OR “immigra*”" in Abstract
CliMIg bibliographic database Date: 12.03.2022 Total: n = 82 Keywords are suggested by CliMig website https://climig.com/#keywords	“climate change” OR “global warming” OR “greenhouse effect” OR “flood” OR “flooding” OR “flash flood” OR “rainfall variability” OR “hurricane” OR “typhoon” OR “cyclone” OR “storm” OR “sea level rise” OR SLR OR “coastal erosion” OR “drought” OR “desertification” OR “heat waves” OR “dry” OR “rainfall variability” OR “land degradation” AND “gender” AND “migrate” OR “migration” OR migadapt OR “immobility” OR “trapped”

Supplementary material F: Detailed features and findings of the selected studies in the systematic review

Source	Country	Setting(s)	Climatic exposure (s)	Study Year(s)	Study Design	Theory/ Framework	Gender Data Analysis	Gender Aspect(s) / Associated Factor(s) – facilitators/ barriers	Findings: Agency involved in decision-making (Yes+, No-)	Findings: Migration types	Findings: Distance covered (Spatial)	Findings: Duration (Temporal)
Ingham et al. (2019)	Bangladesh	Rural	Flood Destroyed fisheries	2010-2015	Qualitative: 3 stage interviews In-depth and open-ended interviews Sample size (n=18)	N/A	Binary	Gender roles Gender norms Economic status Social status	Women (-) Men (-)	Women: non-migration trapped Men: migration (forced)	Men: internal, short distance, rural-urban	Men: Short-term, circular, long-term
Ahmed & Eklund (2021)	Bangladesh	Coastal	Sea-level rise Saline intrusion in croplands Food insecurity Cyclones Storm surge Coastal flooding Coastal erosion Rainfall variations	2017-2018	Mixed: Semi-structured interviews Key informant interviews Focus group discussions Sample size (n=250)	Intersectional	Binary	Gender norms Sociocultural norms and expectations Religion	Women (-) Men (+)	Women: non-migration (immobile/ trapped) Men: adaptive migration	Men: short distance, rural-urban	Men: seasonal, circular, temporary, long-term
Ahmad et al. (2019)	Bangladesh	Coastal	Cyclone Salinity Poor/ degraded soil	N/A	Qualitative: Semi-structured questionnaire Sample size (n=120)	N/A	Biological dichotomy	Gender roles Age Occupation Poverty Unemployment during the dry season	Unable to capture	Female: non-migration (immobile/ trapped) Male: migration (adaptive)	Male: short distance, rural-urban	Male: short-term, circular, long-term
Mallick & Vogt (2012)	Bangladesh	Rural and coastal	Cyclone	2010	Mixed: Observation survey Face-to-face interview Sample size (n=280)	N/A	Binary	Gender relations Loss of livelihood Income and asset distribution	Women (-) Men (-)	Women: non-migration (trapped/ immobile) Men: migration (adaptive/	Men: internal, rural-urban	Men: short-term, permanent

Source	Country	Setting(s)	Climatic exposure (s)	Study Year(s)	Study Design	Theory/ Framework	Gender Data Analysis	Gender Aspect(s)	Findings			
								Associated Factor(s) – facilitators/ barriers	Agency involved in decision-making (Yes+, No-)	Migration types	Distance covered (Spatial)	Duration (Temporal)
								Education Skills		forced migration)		
Hasnat et al. (2020)	Bangladesh	Coastal	Damage of natural resources Salinity intrusion Riverbank erosion Loss of agriculture and fisheries	N/A	Mixed: Household interviews (n=120) Focus Group Discussions [6 FGDs (n=10-12 each)]	N/A	Binary	Gender norms Livelihood diversification Political disturbance Social status Unemployment Poverty Conflict and crisis Family restriction Marital status	Women (-/+) Men (+/-)	Women: Non-migration (immobile/ trapped), migration (adaptive/ forced) Men: migration (adaptive/ forced)	Women: Internal, short distance, rural-urban, international, long distance Men: Internal, rural-urban, international, long distance	Women: short-term, long-term Men: short-term, circular, long-term
Carrico et al. (2020)	Bangladesh	Rural	Heat waves	1989-2013	Quantitative: Household survey Sample size (n=615)	N/A	Biological dichotomy	N/A Marriage Poverty Age	Unable to capture	Women/ Girls: migration	Women/ Girls: Internal	Women/ Girls: long-term, permanent
Evertsena & Geest (2019)	Bangladesh	Rural and urban	Cyclones Tidal changes Riverbank erosion Depletion of fish stock Loss of agricultural land Food insecurity	N/A	Qualitative: Semi-structured Open-ended interviews Sample size (n=26)	'Risk appraisal' 'Adaptation appraisal' Cognitive processes	Binary	Gender norms Poverty Asset (land, shelter) Income/livelihood diversification Garment industries	Women (+/-) Men (+/-)	Women: migration (adaptive or forced) Men: migration (adaptive or forced)	Women: internal, short distance, rural-urban Men: internal, short distance,	Women: long-term, permanent Men: long-term

Source	Country	Setting(s)	Climatic exposure (s)	Study Year(s)	Study Design	Theory/ Framework	Gender Data Analysis	Gender Aspect(s) / Associated Factor(s) – facilitators/ barriers	Findings: Agency involved in decision-making (Yes+, No-)	Findings: Migration types	Findings: Distance covered (Spatial)	Findings: Duration (Temporal)
											rural-urban	
Sams (2019)	Bangladesh	Coastal	Cyclones Tidal surges Flood Riverbank erosion	2017	Qualitative: In-depth interviews (n= 30) Focus group discussions (FGDs) (n=35)	N/A	Binary	Gender norms Gender roles / Poverty Illiteracy Unequal access to and ownership of resources (land, property) Unequal access to information Inadequate employment/ livelihood opportunities Loss of income from agriculture-based livelihoods age Class Ethnicity	Women (-) Men (+/-)	Women: migration (forced/ adaptive) Men: migration (forced/ adaptive)	Women: internal, short distance, rural-urban Men: internal, short distance, rural-urban	Women: long-term, permanent Men: short-term, long-term, permanent
Mallick et al. (2022)	Bangladesh	Coastal	Gradual salinization - Change in soil and water conditions	2018	Mixed: Household surveys (n = 200) Semi-structured interviews (n = 11)	Protection Motivation Theory (PMT)	Binary	Gender norms / Age Land inheritance and ownership Social network Place attachment	Women (+) Men (+)	Women: non-migration Men: migration	N/A	N/A

Source	Country	Setting(s)	Climatic exposure (s)	Study Year(s)	Study Design	Theory/ Framework	Gender Data Analysis	Gender Aspect(s)	Findings			
								Associated Factor(s) – facilitators/ barriers	Agency involved in decision-making (Yes+, No-)	Migration types	Distance covered (Spatial)	Duration (Temporal)
								Wealth and capital strength Education				
Amjad (2019)	Bangladesh	Urban	Riverbank erosion Cyclone Sudden loss of crops Drought	Dec 2018-Mar 2019	Quantitative: Dhaka Stress Scale-Adult (DSS-A) n = 60	N/A	Only women	Gender norms Gender relations	Unable to capture	Women: forced migration	Women: internal, rural-urban	N/A
Boas et al. (2022b)	Bangladesh	Coastal	Floods Riverbank erosion Sea-level rise Saltwater intrusion Floods Cyclones Tidal surges Loss of agricultural production	2016 - 2017	Qualitative: Individual interviews (n=104) Focus group discussion (FGDs) [n=7 (total 96 participants)]	Pluralism in studying gender dynamics	Binary	Gender norms Gender roles Gender relations	Women (+) Men (+)	Women: non-migration (immobile), sometimes adaptive migration with family, in few cases alone Men: migration (adaptive)	Women: internal short distance rural-urban Men: internal short distance rural-urban	Women: long-term permanent Men: circular seasonal short-term long-term permanent
								Age Socio-economic status Strong place attachment Male respondents felt it was not safe for a woman to move to the city alone				
Gray & Mueller (2012)	Bangladesh	Country	Flooding Crop failure	1994–2010	Quantitative longitudinal survey data Sample size (n=1700)	N/A	Biological dichotomy	N/A	Unable to capture	Women: migration Men: migration	Women: short distance Men: long distance	N/A
								Poverty				
Akter et al. (2019)	Bangladesh	Rural and riverside	Riverbank erosion	2016	Qualitative: Focus Group Discussions (FGDs)	Feminist standpoint epistemology	Only women	Gender norms Gender roles Gender relations	Women (+/-) Men (+/-)	Women: migration (adaptive/ forced)	Women: internal migration short	Women: long-term, permanent Men: short-

Source	Country	Setting(s)	Climatic exposure (s)	Study Year(s)	Study Design	Theory/ Framework	Gender Data Analysis	Gender Aspect(s)	Findings			
								Associated Factor(s) – facilitators/ barriers	Agency involved in decision-making (Yes+, No-)	Migration types	Distance covered (Spatial)	Duration (Temporal)
					(n=15 participants) In-depth interviews (n=15)			Loss of assets (e.g., house) Loss of income Cost of migration Place attachment		Men: migration (adaptive/ forced)	distance rural-urban Men: internal migration short distance rural-urban	term long-term permanent
Islam & Shamsuddoha (2017)	Bangladesh	Rural and urban	Cyclones Saline water intrusion Sea-level rise Drought Flooding River erosion	2012	Mixed: participatory rural appraisals (PRAs) (n=6) Focus group discussions (FGDs) (n=8) Key informant interviews (KIIs) (n=24) In-depth case studies (n=12)	N/A	Binary	Gender roles Gender relations Poverty Unemployment, Lack of income generation activities, Social insecurity and social chaos or conflict	Women (-) Men (+/-)	Women: non-migration (trapped), migration (forced/ adaptive) (with family) Men: migration (forced/ adaptive)	Women: short distance, internal, rural-urban (with family) Men: short-distance, internal, rural-urban	Women: long-term, permanent (with family) Men: short-term, circular, long-term, permanent
Mallick (2019)	Bangladesh	Coastal	Cyclones	2018	Qualitative: In-depth interviews (n=8) Group discussions (n=7)	Livelihood resilience in socio-ecological systems	Binary	Gender norms Gender roles Cultural Religious Socio-political conflicts	Women (-) Men (+/-)	Women: non-migration, sometimes migrate with family Men: migration (adaptive/ forced)	Women: short distance, rural-urban (migrate with family) Men: short distance, internal,	Women: long-term, permanent (with family) Men: seasonal, circular, short-term, long-term, permanent

Source	Country	Setting(s)	Climatic exposure (s)	Study Year(s)	Study Design	Theory/ Framework	Gender Data Analysis	Gender Aspect(s) / Associated Factor(s) – facilitators/ barriers	Findings: Agency involved in decision-making (Yes+, No-)	Findings: Migration types	Findings: Distance covered (Spatial)	Findings: Duration (Temporal)
											rural-urban, international (cross border India)	
Ayeb-Karlsson et al. (2020)	Bangladesh	Urban	Cyclone Riverbank erosion	2014-2015	Mixed: Individual interviews (n=30) Focus group discussion (FGDs) (n=250 participants)	Q-based Discourse Analysis	Binary	Gender relation Better education Better employment opportunity Landlessness Poverty Social network	Women (+/-) Men (+/-)	Women: migration (adaptive/ forced) Men: migration (adaptive/ forced)	Women: short distance, internal, rural-urban Men: short distance, internal, rural-urban	Women: long-term, permanent Men: seasonal, short-term, long-term, permanent
Ayeb-Karlsson (2020)	Bangladesh	Urban	Cyclone Riverbank erosion	2014-2016	Qualitative: Open-ended narrative interview (n=10) Group sessions (n=130 participants)	N/A	Binary	Gender roles Gender relations Gender norms Power relations Social hierarchies	Women (+/-) Men (+/-)	Women: migration (adaptive/ forced) Men: migration (adaptive/ forced)	Women: short distance, internal, rural-urban Men: short distance, internal, rural-urban	Women: long-term, permanent Men: seasonal, short-term, long-term, permanent
Patel & Giri (2019)	India	Urban	Flooding Cyclone Salinization Rainfall variation Crop loss	N/A	Qualitative Focus Group Discussions Sample size (n=135)	N/A	Only women	Gender roles Gender relations Strong networking avenues Low wages paid at local	Women (+/-) Men (+)	Women: forced migration Men: migration	Women: internal, rural-urban Men: internal, rural-urban,	Women: permanent

Source	Country	Setting(s)	Climatic exposure (s)	Study Year(s)	Study Design	Theory/ Framework	Gender Data Analysis	Gender Aspect(s)	Findings			
								Associated Factor(s) – facilitators/ barriers	Agency involved in decision-making (Yes+, No-)	Migration types	Distance covered (Spatial)	Duration (Temporal)
								worksites Limited resources and therefore the inability to acquire advanced skills for better employment opportunities			international (few instances)	
Singh & Basu (2020)	India	Semi-arid	Decreasing rainfall intensified by the drought Crop failure from land degradation and water scarcity	N/A	Mixed: Semi-structured household surveys (n = 825) Gender differentiated FGDs (n = 29) In-depth life histories (n = 16)	Migration through a livelihoods approach	Binary	Gender identities Gender norms (Patriarchal) Gender roles Existing livelihoods Available assets Distance and connectivity Social networks Lack of bargaining power Caste Asset ownership	Women (-) Men (+)	Women: migration (adaptive) (with family) Men: migration (adaptive)	Women: short distance rural-urban Men: short distance rural-urban	Women: long-term, permanent Men: seasonal, circular, permanent
Chowdhury et al. (2021)	India	Flood-affected areas	Flood	1983–2013	Quantitative: Gender-disaggregated flood mortality data Sample size (N/A)	N/A	Gender-disaggregated data	Gender norms Gender roles Gender responsibilities (e.g., childcare)	Women (-)	Women: non-migration Men: migration	N/A	N/A

Source	Country	Setting(s)	Climatic exposure (s)	Study Year(s)	Study Design	Theory/ Framework	Gender Data Analysis	Gender Aspect(s)	Findings			
								Associated Factor(s) – facilitators/ barriers	Agency involved in decision-making (Yes+, No-)	Migration types	Distance covered (Spatial)	Duration (Temporal)
								Dependence on climate-sensitive agriculture and Lack of alternate employment for women Structural constraints				
Prati et al. (2022)	India	River delta	Sea level rise Cyclones Floods Declining agricultural production Irregular rainfall patterns Saltwater intrusion	2015-2016	Mixed: Semi structure interviews Census data	Political ecology Intersectional Ecofeminist	Only women and sex-disaggregated census data	Gender role Gender relations Gender norms (Patriarchal) Cost of migration Social status High cost of living in the destination areas Social responsibility of taking care of the in laws Marriage	Women (-) Men (+)	Women: non-migration (immobile/ trapped) Men: migration (adaptive)	Men: internal rural-urban	Men: Short-term, long-term
Tiwari & Joshi (2015)	India	Watershed Catchment	Rainfall variability Temperature increase Low agricultural productivity Natural disasters	2010	Mixed: Household survey Observation Sample size (n=643)	Sustainable livelihood approach	Binary	Gender roles Poverty Loss of livelihood	Unable to capture	Women: non-migration Men: migration (adaptive/ forced)	Men: internal, short distance international, long distance	Men: short-term, permanent

Source	Country	Setting(s)	Climatic exposure (s)	Study Year(s)	Study Design	Theory/ Framework	Gender Data Analysis	Gender Aspect(s)	Findings			
								Associated Factor(s) – facilitators/ barriers	Agency involved in decision-making (Yes+, No-)	Migration types	Distance covered (Spatial)	Duration (Temporal)
Khan et al. (2018)	India	Rural, lagoon and coastal	Cyclone Storm surges Floods Depleting fishery resources	2015	Qualitative: Semi-structured interviews Focus groups Social map Seasonal calendar Activity profile Venn diagram Participant observation Sample size (n=103)	Intersectional	Binary	Gendered division of labor Gender roles (e.g., taking care children and elderly people) Gender identities Caste identities Age Income, Geographic location Employment status Risk perception	Women (-/+) Men (+)	Women: non-migration, adaptive migration (few instances) Men: migration (adaptive)	Women: internal, short distance, rural-urban Men: internal, short distance, rural-urban	Women: short-term Men: long-term
Singh (2019)	India	Rural and urban	Decreasing rainfall Repeated drought	N/A	Mixed: Structured household survey (n=825) Gender-differentiated focus groups discussions (FGDs) (n=26) in-depth life histories (n=16)	Intersectional	Binary	Gender norms Gender roles Gender relations Caste Age Livelihood opportunities	Women (-) Men (+/-)	Women: non-migration (immobile/ trapped), sometimes adaptive migration with family Men: migration (adaptive/ forced)	Women: rural-urban (with family) Men: internal rural-urban (alone or with family)	Women: permanent (with family) Men: seasonal long-term permanent (with family)
Debnath & Kumar	India	Rural	Droughts Crop failure Food insecurity	2018-2019	Mixed: Structured household interview	N/A	Only men	N/A	Unable to capture	Men: migration	Men: short distance internal	Men: seasonal

Source	Country	Setting(s)	Climatic exposure (s)	Study Year(s)	Study Design	Theory/ Framework	Gender Data Analysis	Gender Aspect(s)	Findings			
								Associated Factor(s) – facilitators/ barriers	Agency involved in decision-making (Yes+, No-)	Migration types	Distance covered (Spatial)	Duration (Temporal)
Nayak (2021)					Focus Group Discussions (FGDs) Sample size (n=82)			Landlessness, Social and personal network Age Caste composition Literacy		(adaptive migration)		short-term Circular
Memon (2021)	Pakistan	Urban	Flood	2020	Qualitative: semi-structured questionnaire interviews Sample size (n=94)	N/A	Only women	Gender norms Gender roles Gender relations Health concerns Employment opportunity	Women (-)	Women: migration (forced)	Women: internal, short distance, rural urban	Women: long-term (>10years), permanent
Mueller et al. (2014)	Pakistan	Rural	Temperature increase/ Heat stress Rainfall Flood	1991-2012	Quantitative: Longitudinal survey Sample size (n=44791)	N/A	Biological dichotomy	N/A Poverty Farm income losses Land ownership and wealth	Unable to capture	Women: migration Men: migration	Women: short distance Men: long distance	Men: long-term
Gioli et al. (2014)	Pakistan	River basin	Severe flood Massive landslide	2012	Mixed: Structured interview (n=210) Key informant interview (n=31) Gender-disaggregated focus group discussion FGDs [n = 6 (8-10 people)]	Relational	Binary	Gender roles Gender relations Livelihood diversification Education	Women (-) Men (+)	Women: non-migration (immobile/ trapped) Men: Migration (adaptive)	Men: internal short distance long distance rural-urban international long distance (a few)	Men: circular short-term long-term

Source	Country	Setting(s)	Climatic exposure (s)	Study Year(s)	Study Design	Theory/ Framework	Gender Data Analysis	Gender Aspect(s) / Associated Factor(s) – facilitators/ barriers	Findings: Agency involved in decision-making (Yes+, No-)	Findings: Migration types	Findings: Distance covered (Spatial)	Findings: Duration (Temporal)
Kelman et al. (2019)	Maldives	Small Island Developing States (SIDS)	Sea-level rise	2013	Qualitative: Semi-structured face-to-face interviews Sample size (n=113)	N/A	Biological dichotomy	N/A	Women (+) Men (+)	Women: adaptive migration Men: adaptive migration	Women: internal Men: internal	N/A
Lama (2018)	Maldives	Small Island Developing States (SIDS)	Decline in fish stocks	2016	Qualitative: In-depth interviews Semi-structured key informant interviews Sample size (n=35)	Intersectional	Binary	Gender roles Tourism industry	Women (-) Men (+)	Women: non-migration/ immobility Men: migration/ mobility (adaptive)	Men - internal (within the island context)	Men: temporary
Gautam (2017)	Nepal	Rural agroecological	Changing snow pattern A shift in the timing of annual precipitation Dry spell during spring Food insecurity	2013-2014	Mixed: Focus group discussions (FGDs) [n=10 (74 participants)] Household socio-economic survey (n=313)	Food security and sustainable livelihood	Binary	Gender roles Gender norms Poverty Economic condition Caste Ethnicity Livelihood diversification	Unable to capture	Women: non-migration Men: migration (adaptive)	Men: short distance Internal long distance international	Men: seasonal short-term long-term
Maharjan et al. (2021)	Pakistan India Nepal Bangladesh	River basins	Floods Extreme rainfall Cloud bursts	2017	Quantitative: Structured questionnaire Sample size (n=1987)	New Economics of Labor Migration (NELM)	Biological dichotomy	Gender relations Gender norms (Patriarchal) Livelihood diversification through remittance	Unable to capture	Women: majority non-migration, few migration Men: migration	Men: internal, short distance, long distance, international	Men: seasonal, circular, temporary, long-term
Bhatta et al. (2015)	India Nepal	Rural and coastal	Drought Flood	2011-2012	Mixed: Structured questionnaire	N/A		Gender norms	Women (-) Men (+)	Women: non-	Men: internal	Men: short-term,

Source	Country	Setting(s)	Climatic exposure (s)	Study Year(s)	Study Design	Theory/ Framework	Gender Data Analysis	Gender Aspect(s)	Findings			
								Associated Factor(s) – facilitators/ barriers	Agency involved in decision-making (Yes+, No-)	Migration types	Distance covered (Spatial)	Duration (Temporal)
	Bangladesh		Irregular rainfall Water stress Crop failure Sea-level rise Saline intrusion Cyclone		Focus group discussion (FGDs) with women Sample size (n = 2660)		Binary & Only women	Socio-economic, Cultural barriers Caste inequality Class Ethnicity Age Level of development of the society		migration (trapped/ immobile) Men: migration (adaptive/ forced migration)		seasonal, circular