SHIFTING SKIN

stories of humans and homes

Interim Progress Report

01/01/2024-21/03/2025

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Overview

Project Brief

Climate-impacted populations often face ecosystem stress and are forced to migrate in a phenomenon often termed as 'forced migrations', where they settle in informal housing. However, the uncertainty surrounding their housing and livelihoods exacerbates vulnerabilities often cascading impacts. It increases risk of exposure to other secondary and tertiary issues like gender violence, physical and mental health, and stunted growth in children.

This research aims to understand how these populations survive-migration as a survival strategy, the role of housing inadequacy in predicting their vulnerabilities, and how to design resilient adaptation and mitigation strategies.

Objectives

1. Develop and test a rapid risk assessment process examining the causal factors behind the vulnerability of climate-displaced families and the housing ecosystem in their new settings.
2. Design and demonstrate a pathway model for reducing the risk of displaced families, originating with their housing ecosystems. This is followed by scaling the model to address their comprehensive resilience needs through local action and governance frameworks.

Activities

Research and learning	Communications and outreach	Policy engagement and advocacy
Intent: Build a deeper understanding of the causal links between the climate vulnerability/resilience, housing ecosystem and migration tendencies Literature review Rapid Participatory Risk Assessments Technology Applications Workshops Field Testing Evidence Capture	Intent: Create more visibility around the issue in accessible formats, and spark conversations that can change minds Articles on LinkedIn highlighting key findings A set of conversations in new-age formats like podcasts Short clips/reels developed by trained community members Open-source data through a range of interactive maps and AI enabled information agents Publishing peer reviewed research	Intent: Create linkages to policies and policymakers for possibilities of longer-term solutions Ongoing dialogue with policymakers at different levels (in-person and online events) Policy Brief - How can policies better take account of realities?

Impact

The project would culminate in determining evidence-based approaches to measurably reduce disaster risks for families, especially women and girls, displaced by climate change in their new environments. This will be achieved through locally driven assessments and scaling piloted interventions, through targeted policy change to support more vulnerable families through replication.

The impact both tangible as well as intangible, of the project shall be captured through analysis against key indicators developed as a part of the action research.

Literature Review

The Literature review is conceived a as live document where we are parking all the possible knowledge resources that are relevant to the action research.

The knowledge source including papers, news etc are being trained manually over excel which can be used as feed to fine tune an AI agent which would be an expert in climate migration and cascading vulnerabilities in the Southern Asia.

We generated the following for each listed literature and this is being parked in a master excel.

- Brief summary,
- Key insights,
- Key challenges addressed,
- Key learning,
- Citation

Click here to access the selected list of literature

Link: of the master excel

The paper “Environmental Change and Forced Migration: A State-of-the-Art Review” by James Morrissey (2009) provides a comprehensive analysis of the debates, empirical evidence, and methodological challenges surrounding the relationship between environmental change and forced migration. The paper is structured to address the historical development of the concept of "environmental refugees," the politicisation of the term, the current state of the debate, and the methodological considerations in studying this complex relationship. This review will summarise the key themes, findings, and contributions of the paper to gather a holistic understanding of the theme.

Conceptualisation of Environmental Refugees

The term "environmental refugee" was first formally used in the 1970s by Lester Brown of the World Watch Institute, influenced by neo-Malthusian concerns about resource scarcity and population growth (Black, 2001). The concept gained prominence in the 1980s, particularly through the work of Essam El-Hinnawi, who provided a formal definition of environmental refugees and recognised the heterogeneity of environmentally displaced persons (El-Hinnawi, 1985). El-Hinnawi’s work laid the foundation for subsequent research by proposing typologies of environmentally motivated migrants, distinguishing between those displaced by natural disasters, development projects, and gradual environmental degradation.

Jacobson (1988) operationalised El-Hinnawi’s definition, estimating that 10 million people were displaced by the Sahelian droughts of the 1980s, and introduced the idea that climate change could generate future flows of environmental refugees. This marked a shift from purely theoretical discussions to empirical attempts to quantify the phenomenon. Norman Myers, one of the most prolific writers on the topic, expanded on Jacobson’s work, predicting that climate change could displace up to 200 million people by 2050 due to sea-level rise, desertification, and extreme weather events (Myers, 1993; Myers, 2005). Myers’ estimates, while influential, have been criticised for their reliance on Malthusian logic and lack of empirical rigor (Black, 2001).

Politicisation of the Term

The debate on environmental refugees has been highly politicised, with different actors using the term to advance their agendas. Environmental lobbyists and climate justice groups have employed the term to advocate for conservation and climate action, often citing Myers’ high estimates to emphasise the urgency of addressing climate change (Friends of the Earth, 2008; Christian Aid, 2008). Conversely, anti-asylum groups and governments have used the concept to justify restrictive immigration policies, arguing that environmental refugees do not qualify for protection under the 1951 Refugee Convention (Black, 2001; McGregor, 1994).

The term has also been linked to security concerns, with some authors hypothesizing that environmental scarcity could drive conflict and migration. For example, Kaplan (1994) argued that environmental degradation could lead to resource wars and mass displacement, while Myers (2005) suggested that climate change could exacerbate existing refugee flows. However, these claims have been criticised for their lack of empirical evidence and for oversimplifying the complex relationship between environmental change, conflict, and migration (Barnett & Adger, 2007).

Maximalist vs. Minimalist Schools

The debate on environmental refugees is characterised by two main schools of thought: the maximalist and minimalist schools. The maximalist school, represented by authors like Norman Myers, predicts large numbers of environmental refugees due to climate change, with estimates ranging from 25 million to 200 million by 2050 (Myers, 1993; Myers, 2005). These predictions are based on scenarios of sea-level rise, desertification, and increased frequency of extreme weather events, which are expected to render large areas uninhabitable.

In contrast, the minimalist school, including authors like Bilsborrow (1992) and Black (2001), critiques the simplistic causal link between environmental change and migration, emphasizing the role of socio-economic and political factors in mediating migration decisions. Bilsborrow (1992) argues that environmental change is rarely the sole driver of migration, and that factors such as poverty, land tenure, and access to resources play a significant role in determining whether people migrate. Black (2001) goes further, arguing that the concept of environmental refugees is a myth, as it oversimplifies the complex interplay of environmental, social, and economic factors that influence migration.

Empirical Evidence

The paper reviews a wide range of empirical studies on the relationship between environmental change and migration, focusing on specific environmental stressors such as drought, flooding, sea-level rise, and land degradation. These studies highlight the complexity of the relationship and the importance of context in shaping migration outcomes.

Drought and Migration: Studies on drought in the Sahel (e.g., Swift, 1973; Findley, 1994) show that migration patterns vary depending on the severity of drought, household vulnerability, and existing livelihood strategies. For example, Swift (1973) found that drought led to increased migration among nomadic pastoralists, while Findley (1994) observed that drought reduced international migration and increased short-term cyclical migrations. These findings suggest that migration is not a uniform response to environmental stress but is shaped by local socio-economic conditions.

Flooding and Migration: Research on flooding in South Asia (e.g., Kayastha & Yadava, 1985; Haque & Zaman, 1989) indicates that flooding can both force people to migrate and make land more attractive for settlement, depending on the context. For example, Kayastha and Yadava (1985) found that flooding in the Ghaghara Zone of India led to both temporary and permanent migration, with people moving to higher ground or resettling within the floodplain. These studies highlight the dual role of environmental change as both a push and pull factor in migration.

Sea-Level Rise: Sea-level rise is identified as a clear driver of forced migration, particularly for small island states. Nicholls (2004) estimates that rising sea levels could displace millions of people in low-lying coastal zones, with the most severe impacts expected in developing countries. However, the social and political context plays a significant role in determining the nature and extent of migration. For example, Arenstam Gibbons and Nichols (2006) found that the abandonment of Holland Island in the Chesapeake Bay was driven more by social factors than by the physical impacts of sea-level rise.

Methodological Considerations

The paper highlights the methodological challenges in studying the relationship between environmental change and migration, including the difficulty of defining and quantifying environmental change, the reliance on emission scenarios, and the complexity of non-linear responses. Both qualitative and quantitative approaches have their merits, with qualitative studies providing insights into the character of migrations and quantitative studies offering broader correlations. A mixed-methods approach is recommended to better understand the mechanisms linking environmental change and migration.

For example, qualitative studies have been useful in exploring the lived experiences of migrants and the role of environmental change in shaping migration decisions (Mese-Hausken, 2000; Morrissey, 2008). Quantitative studies, on the other hand, have been used to identify correlations between environmental stressors and migration patterns, although they often struggle to account for the complex interplay of social, economic, and political factors (Henry et al., 2004; Massey et al., 2007).

Conclusion

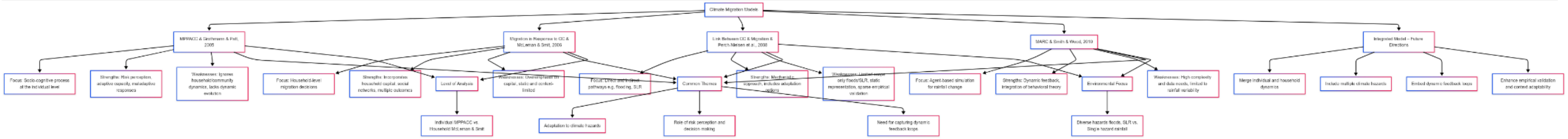
In conclusion, while there is evidence of a link between environmental change and migration, the relationship is complex and mediated by socio-economic and political factors. The debate on environmental refugees remains highly politicised, with maximalist predictions continuing to influence popular discourse despite critiques from the minimalist school. Further empirical research is needed to better understand the mechanisms by which environmental change drives migration and to inform policy responses that protect the rights of migrants and address the human insecurity generated by climate change.

Critical Review of Climate-Related Migration Models

The paper “A Critical Review of Human Migration Models" by Rahmati and Tularam (2017) provides a comprehensive overview of various migration models, including those specifically addressing climate-related migration. Below is a detailed and nuanced critical review of the climate-related migration models discussed in the paper.

Model	Overview	Strengths	Weaknesses
Model of Private Proactive Adaptation to Climate Change (MPPACC) *(Grothmann & Patt, 2005)*	Socio-cognitive model focusing on individual decision-making in response to climate change. It incorporates risk perception, adaptive capacity, and appraisal of climate change impacts. Differentiates between adaptive (e.g., migration) and maladaptive (e.g., denial) responses.	- Behavioural Focus: Emphasises individual cognition and decision-making, crucial for understanding personal risk perception and adaptive capacity. - Risk and Adaptation Appraisal: Captures why some individuals migrate while others do not by including risk perception and adaptive capacity. - Maladaptive Responses: Highlights psychological barriers to adaptation, which are often overlooked in other models.	- Limited Scope: Focuses on individual decision-making, neglecting household or community-level dynamics, which are crucial in collectivist societies (Black et al., 2011). - Lack of Empirical Validation: Conceptually robust but lacks extensive empirical testing, limiting its applicability across diverse contexts. - Static Nature: Fails to account for the dynamic and evolving impacts of climate change on migration (McLeman & Smit, 2006).
Model of Migration in Response to Climate Change *(McLeman & Smit, 2006)*	Household-level model that examines how families adapt to climate change through migration. It considers physical impacts (e.g., drought, flooding) and non-physical factors (e.g., household capital, social networks) influencing migration decisions.	- Household-Level Analysis: Reflects real-world migration dynamics by considering household-level decision-making. - Capital Endowments: Includes financial resources and social networks, providing a comprehensive view of migration drivers. - Multiple Outcomes: Recognises migration as a spectrum, including in-situ adaptation and return migration.	- Simplistic Representation: Overemphasises household capital while overlooking broader socio-economic and political factors (Black et al., 2011). - Limited Generalisability: Based on a case study of rural Eastern Oklahoma during the 1930s, limiting its relevance for contemporary contexts. - Lack of Dynamic Feedback: Does not account for feedback loops between migration and climate change, overlooking how migration may alter future vulnerabilities.

Exploring the Link Between Climate Change and Migration *(Perch-Nielsen et al., 2008)*	Conceptual model exploring the relationship between climate change (flooding, sea-level rise) and migration. Considers direct (e.g., land loss) and indirect (e.g., income reduction) pathways, as well as adaptation options influencing migration outcomes.	- Mechanistic Approach: Clearly defines how climate impacts (flooding, sea-level rise) drive migration through direct and indirect pathways. - Adaptation Options: Highlights how adaptation measures (e.g., flood protection) influence migration decisions. - Vulnerability Focus: Recognises that migration can both reduce and increase vulnerability.	- Limited Scope: Focuses only on flooding and sea-level rise, excluding other significant factors (e.g., drought, heatwaves). - Static Representation: Fails to capture the evolving and dynamic nature of climate-related migration over time. - Lack of Empirical Validation: Lacks robust testing across diverse geographic and socio-economic contexts, limiting its generalisability.
Model of Agent Migration Adaptation to Rainfall Change (MARC) *(Smith & Wood, 2010)*	Agent-based model simulating individual migration decisions in response to rainfall variability. Uses the Theory of Planned Behavior, incorporating attitudes, subjective norms, and perceived behavioral control.	- Agent-Based Approach: Simulates complex interactions between individuals, households, and environmental factors, offering realistic migration dynamics. - Behavioural Theory Integration: Incorporates cognitive processes behind migration decisions, enhancing its theoretical robustness. - Dynamic Feedback: Includes feedback loops between migration and environmental changes, capturing long-term impacts.	- Complexity: Computationally intensive and difficult to implement in data-scarce regions. - Data Requirements: Requires detailed data on individual and household characteristics, posing a barrier in many regions. - Limited Scope: Focuses only on rainfall variability, overlooking other climate factors (e.g., temperature, sea-level rise), reducing its applicability in broader contexts.




Pulicat Lake
CHENNAI

Chennai, India

Introduction

Chennai, the capital of Tamil Nadu, India, is a coastal metropolis increasingly vulnerable to climate-induced disasters, particularly flooding. The city's low-lying topography, rapid urbanisation, and proximity to the Bay of Bengal exacerbate its exposure to climate hazards such as sea-level rise (SLR), cyclones, and erratic monsoonal rainfall (Khan et al., 2019). These environmental stressors have triggered a climate migration crisis, characterised by displacement, internal migration, and socio-economic instability. This section examines the interplay between climate change, flooding, and migration in Chennai, focusing on critical locations, migration patterns,

Figure 1: Chennai Seaside Fishermen Livelihood

and compounding factors such as urbanisation and governance failures.

Climate Change and Environmental Challenges

Rising Sea Levels and Coastal Erosion

Chennai faces significant threats from SLR, with projections indicating a rise of 36.87 cm by 2100 (Khan et al., 2019).

Chennai's coastline is subsiding at 0.52 mm/year, with projections of 36.87 cm SLR by 2100 (Khan et al., 2018). SLR exacerbates saltwater intrusion, contaminates groundwater, and submerges coastal settlements. Pallikaranai marsh, a natural flood sink, has lost 21.75 km^2 to urbanisation, displacing communities reliant on its ecosystem (Khan et al., 2018).

The city's average elevation of 6.7 meters above sea level makes it susceptible to inundation, particularly in areas like Ennore Creek and the Pallikaranai wetlands. SLR intensifies saltwater intrusion, degrading freshwater resources and agricultural land, which disproportionately affects coastal communities (Rostini et al., 2020). The loss of protective ecosystems, such as mangroves and wetlands, further diminishes resilience to storm surges.

Erratic Rainfall and Cyclonic Activity

Chennai's climate is marked by the Northeast Monsoon, contributing 60% of its annual rainfall. However, climate change has amplified rainfall variability, leading to extreme events like the 2015 floods, which delivered 1,049 mm of rain in November alone—the highest recorded since 1918 (Ramasamy et al., 2018). Cyclones like Vardah (2016) and Gaja (2018) have intensified, with winds exceeding 160 km/h destroying homes and infrastructure. Coastal migrants, often living in informal settlements, face disproportionate risks due to inadequate disaster warnings and relief (Keerthy & Praveen Sam, 2018).

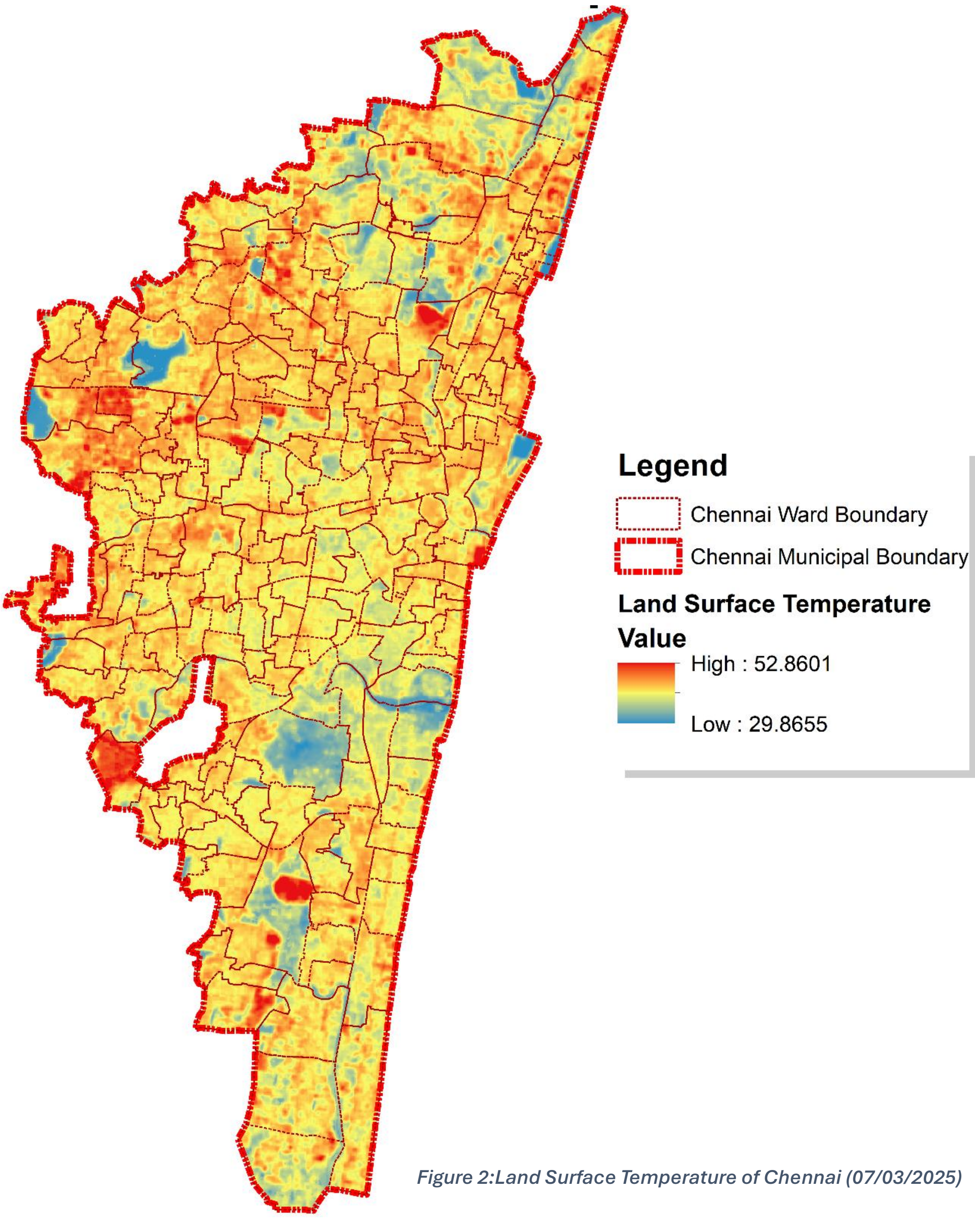


Figure 2:Land Surface Temperature of Chennai (07/03/2025)

Figure 3: Temperature and Humidity recorded at Saidapet versus seaside

Indexed heat and high land surface temperature

Chennai, a major Indian metropolis, faces escalating heat stress due to climate change, with temperatures exceeding 40°C annually. Rising urban heat island effects, driven by rapid urbanisation and deforestation, exacerbate vulnerabilities (Indian Meteorological Department, 2023). Extreme heat disrupts livelihoods, particularly in labor-intensive sectors, pushing low-income populations to migrate temporarily or permanently. A 2020 study linked Chennai's heatwaves to increased rural-to-urban migration, as agricultural losses force workers to seek informal urban jobs (Mishra et al., 2020). Conversely, some residents relocate to cooler regions, reflecting "climate out-migration" trends observed in South Asia (World Bank, 2018).

Migration patterns strain Chennai's infrastructure, amplifying housing and water scarcity. The Tamil Nadu State Action Plan on Climate Change (2019) highlights heat resilience as a policy priority, yet implementation gaps persist. Addressing heat-induced migration requires integrating climate adaptation with urban planning, ensuring equitable resource access.

Flooding and Its Impacts on Migration

The 2015 Floods: A Catalyst for Displacement

Chennai's low-lying coastal geography and dense urban sprawl make it prone to catastrophic flooding. The 2015 floods, triggered by 1,049 mm of rainfall in November–December, submerged 51%of the Pallikarnai wetlands and displaced over 2 million people and claimed 421 lives (Ramasamy et al., 2018). Recurrent floods in 2016 (Cyclone Vardah) and 2017 further eroded livelihoods, pushing marginalised groups, particularly migrant laborers, to relocate. Flood-prone zones like Pallikaranai marsh and Adyar Riverbanks, where migrants often reside, face annual inundation due to poor drainage and wetland encroachment (Keerthy & Praveen Sam, 2018).

Informal settlements along the Cooum and Adyar rivers, home to 18% of Chennai's population, were hardest hit due to their proximity to floodplains (Khan et al., 2019). Post-disaster surveys revealed that 40% of affected households relocated temporarily, while 12% migrated permanently (Ramasamy et al., 2018).

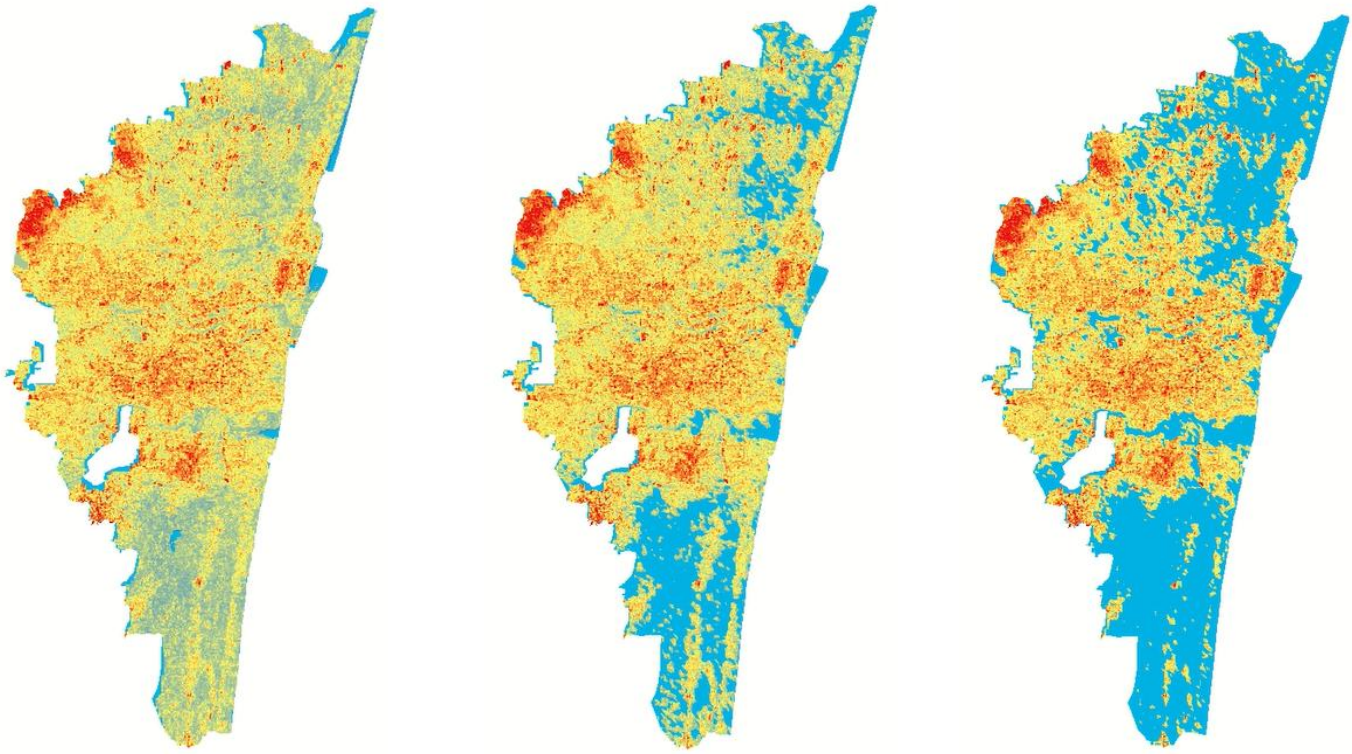


Figure 4: Flood Map of Chennai (120mm in 24 hr duration)

Chronic Flooding and Livelihood Loss

Recurrent floods disrupt livelihoods, particularly in fishing and agriculture. For instance, saltwater intrusion in Ennore has reduced fish stocks by 30%, compelling fisherfolk to seek alternative incomes in urban informal sectors (Khan et al., 2019). Agricultural communities in peri-urban areas, such as Thiruvallur, face crop failures due to saline soils, pushing rural-urban migration.

Migration Patterns in Chennai

Internal Migration: Urban Poor in Vulnerable Zones

Chennai's population has surged from 4.6 million in 2011 to over 8 million in 2023, driven by rural-urban migration (Khan et al., 2019). Migrants often settle in informal settlements on encroached wetlands or floodplains, perpetuating a cycle of vulnerability. For example, the Velachery neighborhood, built on reclaimed water bodies, houses 120,000 residents per km^2, many of whom are climate migrants from drought-prone districts like Ramanathapuram (Ramasamy et al., 2018).

Out-Migration: Displacement to Peri-Urban and Neighboring States

Repeated flooding has spurred out-migration to peri-urban areas like Sriperumbudur and neighboring states such as Karnataka. A 2020 study noted that 15% of families in North Chennai relocated to suburban regions after Cyclone Vardah (Khan et al., 2019). Long-distance migration to cities like Bengaluru and Hyderabad is also rising, driven by the collapse of coastal economies.

In-Migration: Labor Dynamics and Urban Sprawl

Paradoxically, Chennai continues to attract migrants due to its economic opportunities in IT and manufacturing. However, this in-migration strains infrastructure, with 35% of newcomers residing in high-risk zones like the Buckingham Canal corridor (Ramasamy et al., 2018). The city's unplanned expansion—its urban footprint grew by 50% between 2000 and 2020—has encroached on 60% of its water bodies, exacerbating flood risks (Khan et al., 2019).

Critical Locations and Vulnerability Hotspots

1. Pallikaranai Wetlands: Once spanning 50 km^2, this critical flood buffer has shrunk to 16.6 km^2 due to urbanisation. Encroachment by IT parks and settlements has increased flooding in southern Chennai (Ramasamy et al., 2018).

2. Ennore Creek: Industrialisation and thermal power plants have degraded this estuarine ecosystem, displacing 10,000 fishers since 2010 (Khan et al., 2019).

3. Cooum and Adyar River Basins: Over 70% of these rivers' floodplains are occupied by informal settlements, with 30% of residents displaced annually during monsoons (Ramasamy et al., 2018).

4. Marina Beach: SLR has eroded 300 meters of this iconic coastline since 2004, threatening 20,000 households (Khan et al., 2019).

Compounding Factors Beyond Climate Change

Urbanisation and Governance

Chennai's population grew 26-fold since 1871, with 19 lakhs added in suburbs between 2001–2011 (Keerthy & Praveen Sam, 2018). Expansion into floodplains (e.g., IT corridors on Buckingham Canal, airports on Adyar River) disrupted natural drainage. Over 60% of wetlands were lost to real estate, forcing low-income migrants into hazardous zones like Mudichur and Tambaram (Ramasamy et al., 2018).

Chennai's urbanisation has been marked by lax enforcement of zoning laws. The 2015 floods were exacerbated by the construction of the Chennai Metro Rail on the Buckingham Canal, a colonial-era drainage channel (Ramasamy et al., 2018). Over 3,500 water bodies have been lost since 1980, reducing the city's water storage capacity by 65% (Khan et al., 2019).

Socio-Economic Inequities

Marginalised groups, including Dalits and fishing communities, constitute 60% of flood-affected populations (Khan et al., 2019). Slum dwellers in North Chennai, earning less than $2/day, lack resources to rebuild post-disaster, perpetuating cycles of displacement.

Inequitable Infrastructure and Policy Gaps

Migrants, constituting 34% of Chennai's population, are excluded from disaster relief due to lack of local IDs, language barriers, and bureaucratic neglect. In 2015, 92% of surveyed migrants received no flood aid, and 96% lacked early warnings (Keerthy & Praveen Sam, 2018). Anti-migrant sentiment further marginalises this group, blaming them for job competition and resource strain.

Economic Disparities

Migrants from Bihar, Uttar Pradesh, and Odisha dominate unskilled sectors (construction, domestic work), earning <₹10,000/month. Limited affordable housing forces 88% to rent in flood-prone areas (Keerthy & Praveen Sam, 2018). Meanwhile, SEZs and metro projects prioritise high-income groups, deepening spatial inequalities.

Mitigation and Adaptation Strategies

The Community-Based Adaptation for Chennai City to Climate Change and Sea-Level Rise (CBACCS) framework emphasises participatory resilience-building (Khan et al., 2019). Key measures include:

1. Restoring Ecosystems: Rejuvenating Pallikaranai wetlands and enforcing Coastal Regulation Zone (CRZ) laws.

2. Affordable Housing: Relocating vulnerable communities to elevated zones like the OMR IT Corridor.

3. Early Warning Systems: Implementing COREDAR (Communicating Risk of Climate Change) tools for real-time flood alerts (Khan et al., 2019).

Statistical Insights

- Migrant Demographics: 70% of male migrants move for employment; 42% of females migrate post-marriage (Keerthy & Praveen Sam, 2018).

- Health Impacts: 88% of flood-affected migrants reported waterborne diseases; 74% received delayed political aid (Keerthy & Praveen Sam, 2018).

- Economic Losses: The 2015 floods caused ₹100 billion in damages, hitting migrant-informal sectors hardest (Ramasamy et al., 2018).

- Housing: 65% of Chennai’s slums are in low-lying coastal zones, housing 120,000 people/km^2 (Khan et al., 2018).

River Shifting Patterns and Flood Vulnerability

The 2015 Chennai floods highlighted the complex interplay between natural geodynamic processes and anthropogenic activities, particularly along the Adyar and Cooum rivers. These rivers, shaped by tectonic forces and human encroachment, have rendered communities along their banks highly vulnerable to flooding. The river shifting

Figure 5: Pallikarnan Wetlands, bird watching point being cleaned

patterns, exacerbated by Chennai's rapid urbanisation, have disrupted natural drainage systems, while unplanned infrastructure and housing developments have further amplified flood risks. Below is a detailed analysis of these dynamics and the specific locations most prone to flooding.

The Adyar and Cooum rivers exhibit migratory behavior influenced by post-collision tectonics affecting the Indian plate. The study identifies tectonic arching (e.g., the Mangalore-Chennai arch) and subsidence as key drivers of river migration. These processes have created palaeochannels (abandoned river courses) and anomalies like deflected drainages and compressed meanders, which disrupt natural water flow.

Adyar River

The river's southerly migration, influenced by tectonic uplift along the Mangalore-Chennai arch, has left behind palaeochannels in zones now densely urbanised. For instance, the Minambakkam International Airport, built on the Adyar's floodplains, lies in an area historically prone to channel shifts. During heavy rains, the river reclaims these old pathways, inundating settlements.

- Compressed meanders near Egmore and the airport create bottlenecks, slowing water flow and causing overflow. The 2015 floods submerged the airport, highlighting how tectonic-induced river geometry exacerbates flooding.

Cooum River

The Cooum's northerly migration, guided by subsidiary tectonic deeps, has resulted in annular and deflected drainages. Areas like Koyambedu, where the bus terminus was built on a reclaimed water body, now face flooding as the river attempts to reoccupy its palaeochannels.

Fragmented drainages due to infrastructure projects (e.g., the Mass Rapid Transit System) disrupt the river's natural flow, forcing water into residential areas during monsoons.

Encroachment on Critical Zones:

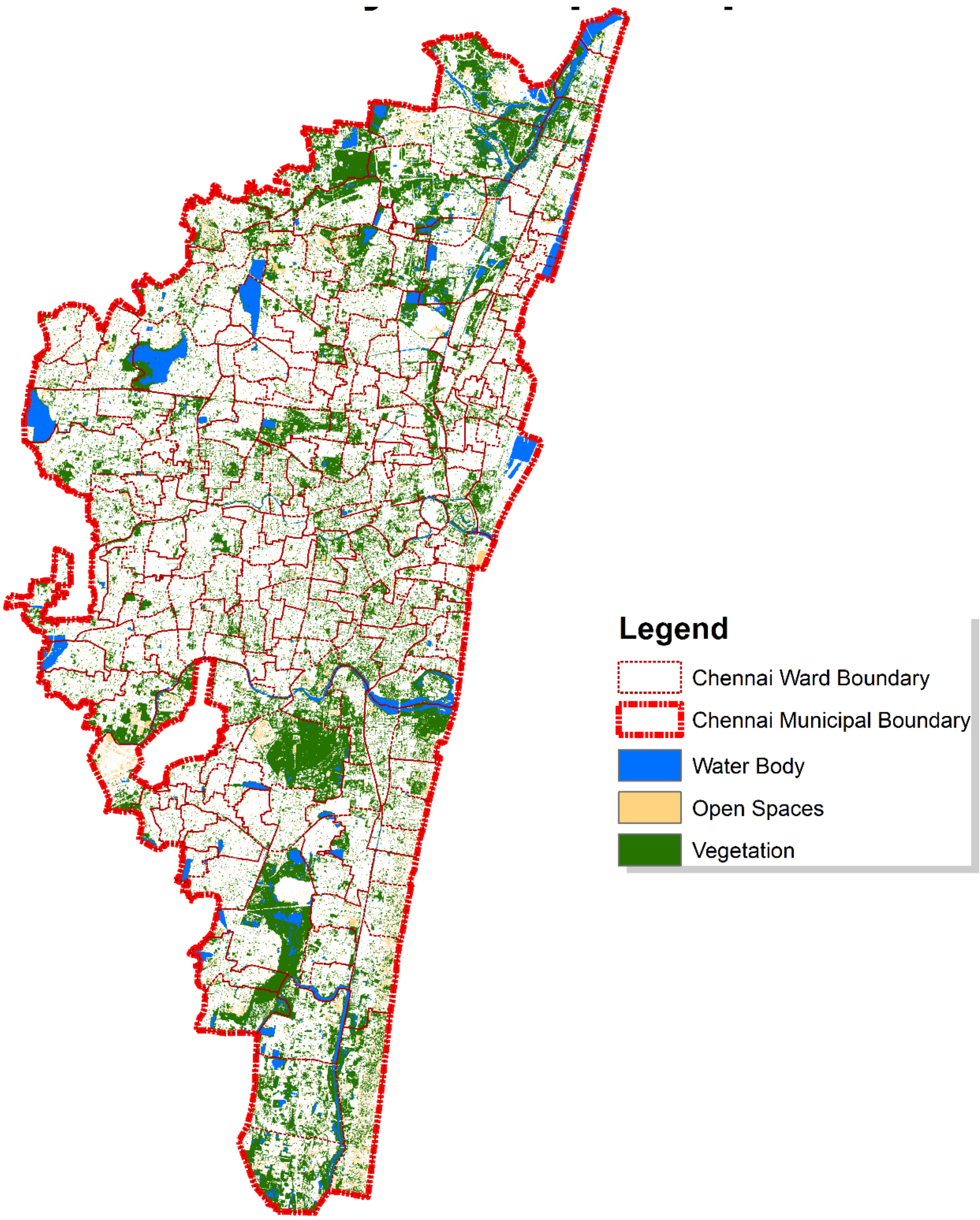


Figure 6:Blue Green Open Spaces of Chennai

Palaeoswales and Tidal Flats

These clay-rich depressions, such as Pallikaranai swamp, naturally absorb floodwaters. However, settlements like Velachery Township now occupy these zones. During the 2015 floods, water from 96 upstream tanks funnelled into the encroached swamp, flooding homes and IT parks.

Palaeobeach Ridges

While sandy ridges (e.g., areas near Marina Beach) have better drainage, haphazard construction has blocked infiltration pathways. For example, the IT corridor along the Old Mahabalipuram Road (OMR) sits on ridges, but adjacent swales remain waterlogged.

Obstructed Drainage Systems:

Buckingham Canal, originally a British-era floodway, is now narrowed by highways and settlements. Its reduced capacity forces stormwater into neighborhoods like Mylapore and Thiruvanmiyur.

Fragmented Drains: In zones like Nungambakkam and T. Nagar, stormwater drains are blocked by illegal constructions, turning streets into rivers during rains.

Figure 7: Pallikarnan Wetlands intercepted by road

High-Risk Housing:

Low-income settlements in Saidapet and Jafferkhanpet are built on tectonic deepening zones where land subsidence increases flood retention. These areas lack elevated foundations, leaving residents stranded during floods.

Luxury apartments in OMR and Adyar, though elevated, disrupt natural gradients, diverting floodwaters into poorer downstream communities.

Key Flood-Prone Locations

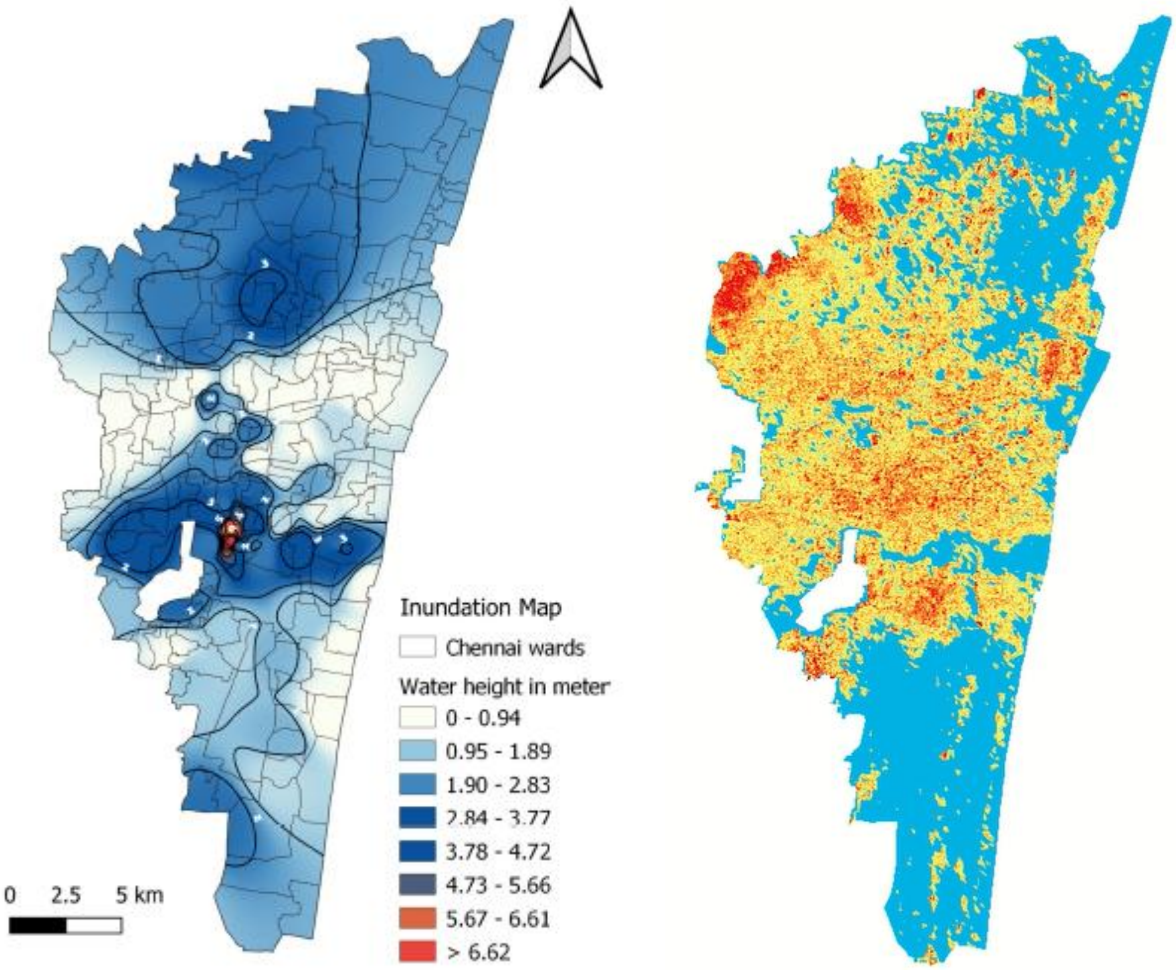


Figure 8: Flood map of Chennai simulation versus actual flooded areas

Velachery: Built on the Pallikaranai swamp, this area acts as a sink for upstream runoff. Encroachments on the Velachery Tank and swamp reduced storage capacity, leading to catastrophic flooding in 2015.

Koyambedu: The bus terminus and surrounding markets occupy a reclaimed water body, disrupting the Cooum's palaeochannels. During rains, the area becomes a lake, paralyzing transportation.

Minambakkam-Adyar Belt: The airport and IT parks on the Adyar's floodplains face recurrent flooding due to compressed meanders and subsidence. The 2015 floods submerged runways, causing economic losses.

Pallikaranai: Once a vast swamp, it is now a mix of garbage dumps and residential colonies. Tectonic uplift has disconnected it from the sea, turning it into a stagnant pool during monsoons.

Ennore Creek and North Chennai: Industrial zones here encroach on tidal flats, obstructing drainage into the Bay of Bengal. The 2015 floods caused chemical spills, compounding health risks.

Conclusion

The Adyar and Cooum rivers' shifting patterns, driven by tectonic forces, have created inherently unstable floodplains. However, Chennai's unchecked urbanisation—marked by encroachments on wetlands, flawed drainage systems, and high-risk infrastructure—has turned natural vulnerabilities into disasters. Communities in Velachery, Pallikaranai, and Koyambedu epitomise this crisis, where tectonic subsidence and anthropogenic neglect converge. Addressing these issues requires restoring natural buffers, enforcing zoning laws, and integrating geodynamic insights into urban planning. Without such measures, Chennai's flood-prone communities will remain trapped in a cycle of displacement and loss.

In-Migration in Chennai: Demographics and Migration Patterns

Chennai, a major economic hub in Tamil Nadu, attracts a diverse migrant population primarily from other Indian states. As of 2018, 34% of migrants originated from outside Tamil Nadu, while 62% migrated from other parts of the state (World Population Review, 2017). Skilled workers, employed in IT, engineering, and automobile sectors, predominantly hail from Karnataka, Kerala, Andhra Pradesh, and Maharashtra. Unskilled laborers, working in construction, hospitality, and manufacturing, migrate from Assam, Bihar, Odisha, West Bengal,

Figure 9: Government rehabilitation housing of Kannagi Nagar, Chennai for slums affected by 2004 Tsunami

and Uttar Pradesh (Dutta, 2016). Women constitute a significant portion, with 42% migrating for marriage and 34% accompanying families (Kanjamala, 2007).

Migration patterns reveal gender disparities: 47% of men migrate for employment, while only 4.1% of women cite education or business as reasons (Kalyanaraman, 2011). The city's suburbs, such as Mudichur and Pallikaranai, have witnessed a 19-lakh population surge since 2001 due to migration-driven urban sprawl (Kalyanaraman, 2011). Migrants often settle in flood-prone, low-cost settlements near industrial zones, driven by proximity to workplaces and affordable housing (Keerthy & Praveen Sam, 2018). Despite contributing to Chennai's economy, migrants face systemic exclusion, with limited access to disaster relief and social integration, perpetuating cycles of vulnerability (Mariaselvam & Gopichandran, 2016).

Migration to Chennai is driven by a combination of economic, social, and cultural factors. According to the study by Keerthy and Praveen Sam (2018), 88% of migrants cited employment or business opportunities as their primary motivation. Skilled workers from states like Karnataka, Kerala, Andhra Pradesh, and Maharashtra dominate sectors such as information technology (IT), automobile manufacturing, and engineering. In contrast, unskilled laborers from Assam, Bihar, Odisha, West Bengal, and Uttar Pradesh work in construction, domestic services, and brick kilns (Dutta, 2016).

Education and healthcare also play significant roles. Chennai's reputed educational institutions and multi-specialty hospitals attract families seeking better academic and medical facilities (TNN, 2010). Additionally, 4% of female migrants relocate post-marriage, often due to familial obligations (Kanjamala, 2007).

Demographic Trends

Chennai's migrant population is characterised by gender-specific migration motives. While 47% of men migrate for employment, only 4.1% of women do so. Conversely, 42% of women migrate for marriage, reflecting entrenched socio-cultural norms (Keerthy & Praveen Sam, 2018). The 2011 Census highlighted that 34% of Chennai's migrants originated from other Indian states, with a significant concentration in suburban areas like Tambaram, Pallikaranai, and Koyambedu (World Population Review, 2017). These regions, situated near water bodies like the Adyar River and Pallikaranai marshlands, are prone to annual flooding, forcing migrants into precarious living conditions.

Socio-Economic Conditions

Employment and Livelihood

Migrants contribute significantly to Chennai's economy but face stark disparities in job security and wages. Skilled migrants in IT and manufacturing often reside in suburban housing projects near Special Economic Zones (SEZs), benefiting from proximity to workplaces (Keerthy & Praveen Sam, 2018). However, unskilled laborers endure informal employment with no social security. For instance, construction workers earning daily wages lack access to healthcare or insurance, exacerbating their vulnerability during crises (Daksham, 2016).

Housing and Settlement

Chennai's city center, with its dense infrastructure, is largely inaccessible to migrants due to high rents. Consequently, 98% of migrants settle in unplanned suburban colonies near floodplains and wetlands (Keerthy & Praveen Sam, 2018). These areas lack proper drainage, sanitation, and disaster-resilient housing. The 2015–2017 floods submerged homes in Mudichur and Tambaram, displacing thousands and destroying livelihoods (Lakshmi, 2015).

Challenges Faced by Migrants

Environmental Vulnerabilities

Chennai's geographic location on the Coromandel Coast makes it susceptible to cyclones and monsoon floods. Migrants in low-lying suburbs face disproportionate risks due to inadequate infrastructure. During the 2015 floods, 92% of migrants reported receiving no timely warnings or relief, as alerts were issued only in Tamil, excluding non-Tamil speakers (Keerthy & Praveen Sam, 2018). Contaminated floodwater caused widespread health crises, with 88% of respondents suffering from waterborne diseases (Keerthy & Praveen Sam, 2018).

Figure 10: Fishermen livelihood components including preparation, selling and housing for fishermen community

Socio-Political Marginalisation

Migrants encounter systemic exclusion from welfare schemes. Relief packages, such as the ₹5,000 cash aid post-2015 floods, were inaccessible to migrants lacking local ration cards or bank accounts (Daksham, 2016). Political apathy further compounds their plight; 74% of migrants received aid only after native residents, reflecting bureaucratic neglect (Keerthy & Praveen Sam, 2018).

Anti-migrant sentiment exacerbates social exclusion. Locals often blame migrants for job scarcity and resource strain, leading to discrimination in housing and employment (Denyer, 2008). During floods, this prejudice translates into delayed rescue efforts, as relief teams prioritise native-majority areas (Vaishnavi, 2018).

Government and Policy Response

Legislative Gaps

While Tamil Nadu has labor laws and disaster management policies, migrants remain excluded due to jurisdictional ambiguities. For instance, the Tamil Nadu Public Works Department's flood warnings fail to account for linguistic diversity, leaving migrants uninformed (Keerthy & Praveen Sam, 2018). The Gadgil Committee Report (cited in Vetriselvan, 2018) criticised the state's lack of rehabilitation policies for disaster-affected migrants, urging urgent reforms.

Recent Initiatives

In 2018, the Tamil Nadu government allocated ₹100 crore for flood mitigation, focusing on sewage management and slum resettlement (Mani, 2018). Proposed measures include migrant registries and multilingual disaster communication. However, implementation remains sluggish, with no significant reduction in suburban encroachments (Jayaraman, 2017).

Recommendations

1. Comprehensive Migrant Database: Chennai Corporation should maintain annual records of migrant populations, including temporary residents, to streamline relief distribution (Keerthy & Praveen Sam, 2018).

2. Inclusive Welfare Schemes: State-issued identity cards, akin to ration cards, would ensure access to subsidies and healthcare for migrants (Keerthy & Praveen Sam, 2018).

3. Language-Inclusive Disaster Communication: Flood alerts and relief instructions must be disseminated in Hindi, Bengali, and other regional languages to bridge linguistic gaps.

4. Affordable Housing: Relocating migrants to elevated, non-flood-prone zones with affordable rents can reduce environmental risks.

5. Community Integration Programs: Public awareness campaigns to combat anti-migrant bias and promote social cohesion are critical (Keerthy & Praveen Sam, 2018).

Conclusion

Chennai’s migrant population is integral to its economic growth yet remains marginalised due to systemic neglect and environmental precarity. Addressing their vulnerabilities requires policy reforms that prioritise inclusive disaster management, equitable resource distribution, and socio-political integration.

Chennai’s climate-related migration is a crisis shaped by intersecting environmental and systemic failures. While cyclones and SLR amplify risks, unchecked urbanisation and policy neglect force migrants into vulnerable peripheries. Addressing this requires integrating climate adaptation (e.g., wetland restoration, flood-resilient housing) with inclusive governance (e.g., migrant registries, multilingual warnings). Without equitable development, Chennai’s growth will remain a paradox—driven by migrants yet exclusionary in its resilience.

Figure 11: Flow Chart depicting the current climate migration status in Chennai derived from above Literature Review

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CHANAUTE BAZAAR, MELAMCHI

Chanaute Bazaar, Nepal

Introduction

Nepal, a landlocked country nestled in the Himalayas, is among the world's most climate-vulnerable nations. Its unique topography—ranging from the high-altitude Himalayas to the lowland Terai plains—exposes it to diverse climate threats, including glacial lake outburst floods (GLOFs), landslides, droughts, and erratic monsoon patterns. These hazards disproportionately impact rural and marginalised communities, driving internal and cross-border migration as a coping mechanism.

Figure 12:A human habitation stoppage at Melamchi Helambu Road

Climate-induced migration—defined as the movement of people driven by environmental stressors such as floods, landslides, and droughts—has become a critical issue in the country. This review examines climate migration patterns in Nepal, focusing on the impacts of the 2015 earthquakes and the 2021 Melamchi floods, particularly in the Melamchi districts of Sindhupalchowk. By analyzing in-migration and out-migration trends, this study highlights how environmental disasters exacerbate existing vulnerabilities and reshape population dynamics. Data from the 2011 Census, post-disaster assessments, and localised surveys are synthesised to underscore the socio-economic and environmental drivers of migration.

Climate Threats in Nepal

Nepal's geographical diversity—spanning the Himalayas, hills, and Terai plains—exposes it to diverse climate risks. The 2015 earthquakes (magnitude 7.8 and 7.3) displaced over 2.8 million people, destroyed 800,000 homes, and caused $7 billion in damages (Government of Nepal, 2015). Similarly, the June 2021 Melamchi flood, triggered by intense rainfall and glacial lake outbursts, devastated the Melamchi River Basin, displacing thousands and causing economic losses exceeding $500 million (Parajuli et al., 2023; Maharjan et al., 2021). These events highlight Nepal's susceptibility to cascading hazards, where natural disasters compound pre-existing socio-economic challenges, driving internal and external migration.

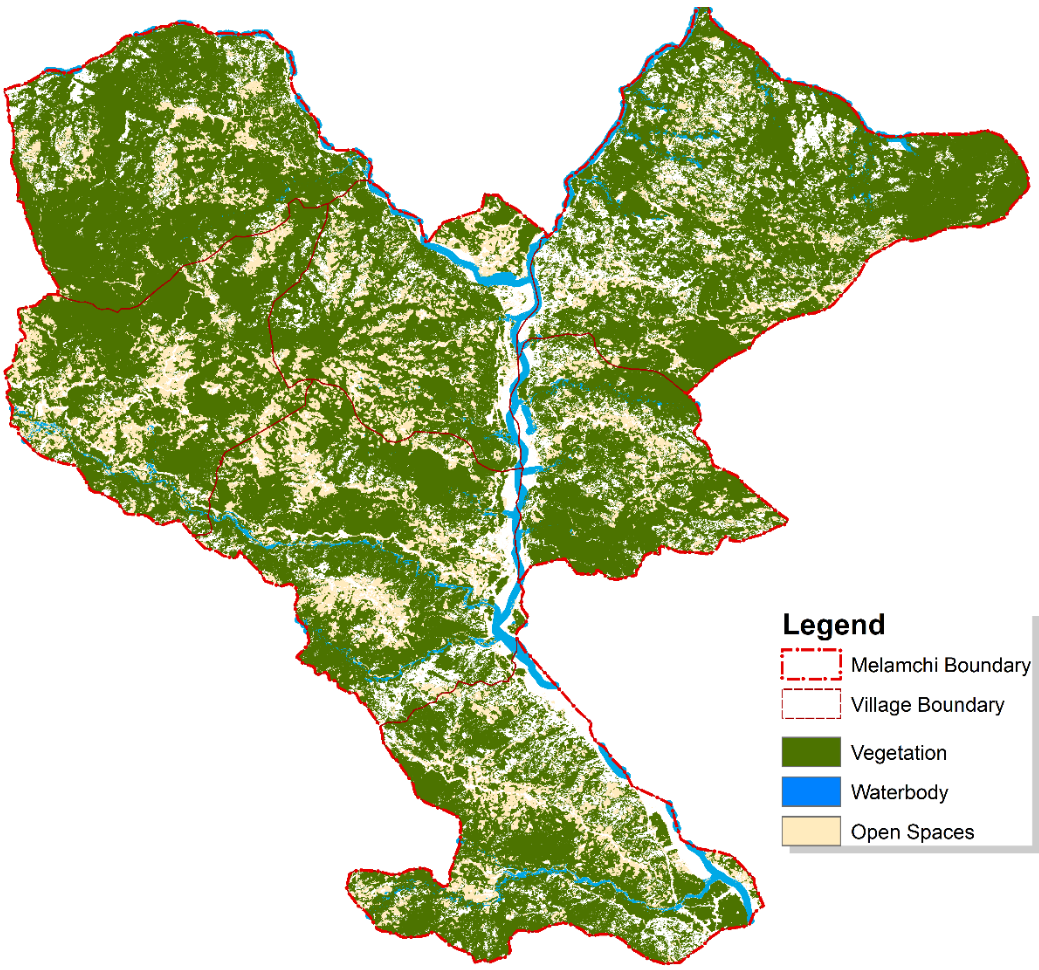

Figure 13: Blue Green Open Space of Helambu

Glacial Lake Outburst Floods (GLOFs)

Nepal's Himalayan region hosts over 2,000 glacial lakes, 21 of which are classified as high-risk for outbursts (ICIMOD, 2021). Rising temperatures accelerate glacial melt, increasing the volume and instability of these lakes. For example, the Tsho Rolpa Lake in the Rolwaling Valley has expanded by 150% since the 1950s, threatening downstream communities (Maharjan et al., 2021). GLOFs can obliterate infrastructure, agricultural land, and settlements, as seen in the 1985 Dig Tsho outburst, which caused USD 3 million in damages (Byers et al., 2019).

Landslides and Floods

Intense monsoon rains and deforestation exacerbate landslides and flash floods. The 2021 Melamchi flood, triggered by a combination of extreme rainfall and riverbank collapse, displaced over 539 households and caused USD 498 million in economic losses (Parajuli et al., 2023). Similarly, the 2014 Jure landslide in Sindhupalchowk killed 156 people and displaced 1,200 families (Van der Geest, 2018).

Figure 14: Debri hit and ground floor demolished house at Chanaute Bazaar with some flood water remaining amidst boulders

Droughts and Erratic Rainfall

The mid-western and far-western regions face prolonged droughts, reducing agricultural productivity. Between 2015 and 2020, rainfall variability in the Terai decreased crop yields by 30%, pushing smallholder farmers into debt and migration (MoFE, 2021).

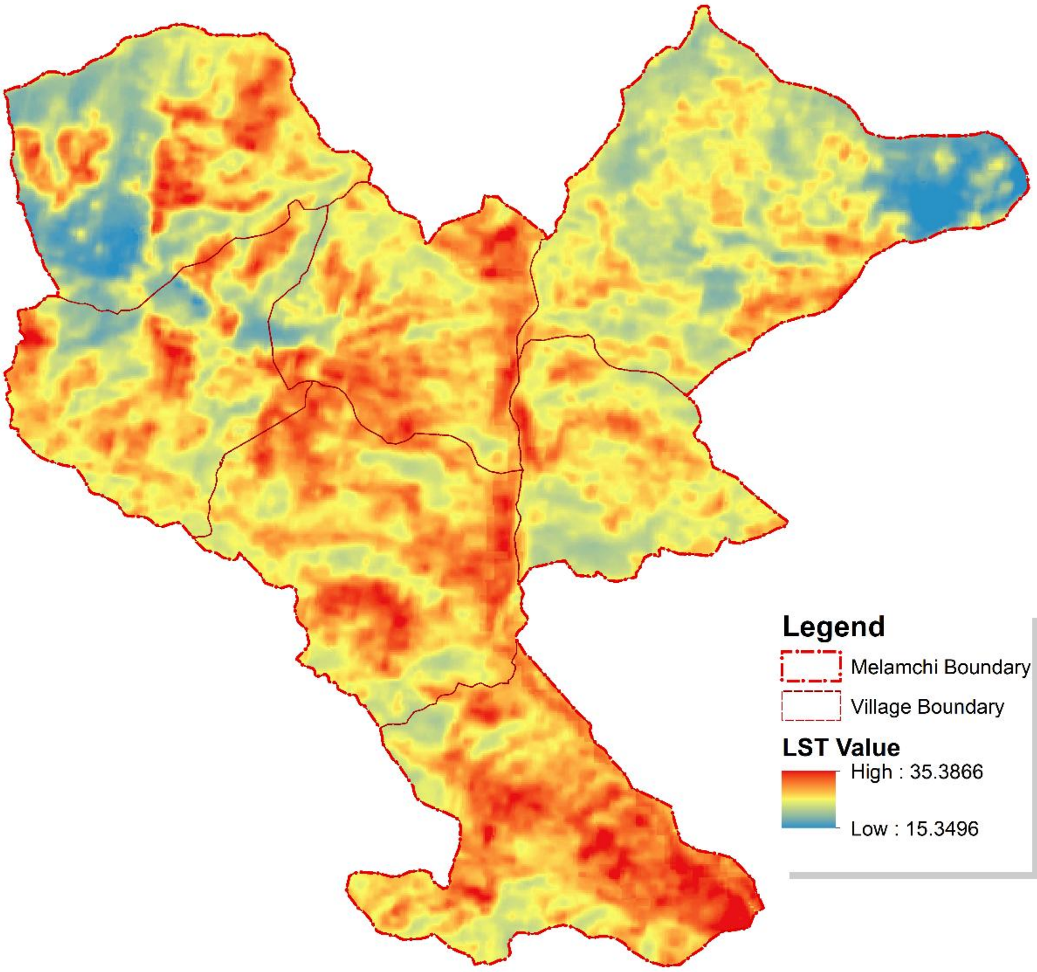

Figure 15: Land surface Temperature of Helambu (13/03/2024)

Temperature Rise

Nepal’s average temperature has increased by 0.056°C annually since 1971, with high-altitude regions warming faster (DHM, 2017). This disrupts snowmelt patterns, affecting water availability for irrigation and hydropower.

Vulnerable Regions

High Mountain Regions

Districts like Solukhumbu, Dolakha, and Rasuwa are susceptible to GLOFs and landslides. Melamchi Municipality and Helambu Rural Municipality, situated along the Melamchi River, experienced catastrophic flooding in 2021, destroying 91.57 hectares of farmland (Parajuli et al., 2023).

Mid-Hills

The Siwalik and Mahabharat ranges face soil erosion and landslides. Sindhupalchowk, Kavrepalanchowk, and Gorkha report high out-migration due to recurring disasters (Suwal, 2014).

Terai Plains

The southern Terai, home to 50% of Nepal's population, suffers from flooding and droughts. Districts like Saptari and Bardiya face annual inundation, displacing 15,000 people yearly (CBS, 2021).

Vulnerable Populations

Smallholder Farmers

Agriculture employs 60% of Nepal's workforce but contributes only 27% to GDP (World Bank, 2022). Farmers in Sindhupalchowk lost 30% of their crops to the 2021 floods, forcing 53% to take loans or sell assets (Parajuli et al., 2023).

Indigenous Communities

Ethnic groups like the Hyolmo, Tamang, and Sherpa in mountainous regions rely on climate-sensitive livelihoods (e.g., trout farming, agroforestry). The Melamchi flood displaced 41% of Hyolmo households, eroding cultural ties to land (Parajuli et al., 2023).

Figure 16: A lone family living in an otherwise deserted habitation in Helambu Melamchi Road affected by floods

Women constitute 46% of surveyed flood victims in Melamchi and reported increased caregiving burdens and mental health issues (85% anxiety, 40% workload spikes) (Parajuli et al., 2023). School disruptions affected 73% of children, limiting long-term opportunities.

Urban Poor

Internal migrants often settle in informal settlements in Kathmandu and Pokhara, where 60% lack access to clean water and sanitation (UN-Habitat, 2020).

Migration Patterns

Internal Migration

Rural to Urban: Kathmandu Valley hosts 48% of Nepal's internal migrants, driven by climate shocks and employment opportunities (Suwal, 2014). Post-2015 earthquake, 70,000 families migrated to urban centers (NRRC, 2016).

Cross-Regional: Hill communities migrate to the Terai for fertile land. Between 2001–2011, 14.8% of Nepal's population relocated internally, with 4.2% moving in the preceding five years (KC, 2003; CBS, 2012).

International Migration

Over 3.5 million Nepalis work abroad, primarily in Gulf countries and Malaysia (MoLE, 2022). Climate stressors compound economic motives; 20% of Melamchi flood survivors migrated internationally for livelihoods (Parajuli et al., 2023).

Figure 17: Chanaute Bazaar settlement (up), debris filled interiors of the affected houses (down)

Adaptation Techniques

Traditional Practices

Agroforestry: Communities in Kavre practice mixed cropping to stabilise slopes and retain soil moisture.

Water Management: Kul irrigation systems in Mustang channel glacial meltwater to fields.

Government-Led Initiatives

National Adaptation Plan (NAP): Prioritises climate-resilient infrastructure and early warning systems (MoFE, 2021).

Disaster Risk Reduction (DRR): The 2017 DRR Act established local committees, yet only 8–9% of municipal budgets are allocated to disaster management (Parajuli et al., 2023).

Community-Based Adaptation

Early Warning Systems: In Chitwan, community radios broadcast flood alerts, reducing casualties by 40% (Practical Action, 2019).

Microinsurance: Programs like Index-Based Livestock Insurance in Dolakha compensate herders for climate-related losses (UNDP, 2021).

Figure 18: Temporary transit shelters on hills for the people affected by floods

The 2015 Earthquakes and Displacement

The 2015 earthquakes primarily affected central Nepal, including Sindhupalchowk District, which recorded the highest death toll (3,500 fatalities). While Melamchi was not the epicenter, the earthquakes exacerbated vulnerabilities in the region by damaging infrastructure and livelihoods. Post-disaster assessments revealed that 39% of displaced households migrated temporarily, while 8% relocated permanently (CBS, 2015). Migration was driven by:

1. Loss of Housing and Infrastructure: Over 90% of homes in Sindhupalchowk were damaged, forcing families to seek shelter in urban centers like Kathmandu (Government of Nepal, 2015).

2. Livelihood Collapse: Agriculture, the primary livelihood for 74% of the population, was disrupted due to landslides and destroyed terraces (KC et al., 2016).

3. Access to Services: Schools and health facilities were destroyed, prompting families to migrate for education and healthcare (Childs et al., 2014).

While the earthquakes triggered immediate displacement, long-term migration trends were influenced by Nepal's existing drivers, such as urbanisation and labor migration. By 2017, Kathmandu Valley hosted 48% of inter-district migrants, many from earthquake-affected regions (Suwal, 2014).

The 2021 Melamchi Flood: A Case Study in Climate Migration

The Melamchi flood of June 2021, caused by extreme rainfall and glacial melt, offers a stark example of climate-induced migration. The disaster displaced 539 households, destroyed 1,600 hectares of agricultural land, and caused $52,113 in average economic losses per household (Parajuli et al., 2023). Below, we analyse out-migration and in-migration patterns post-flood.

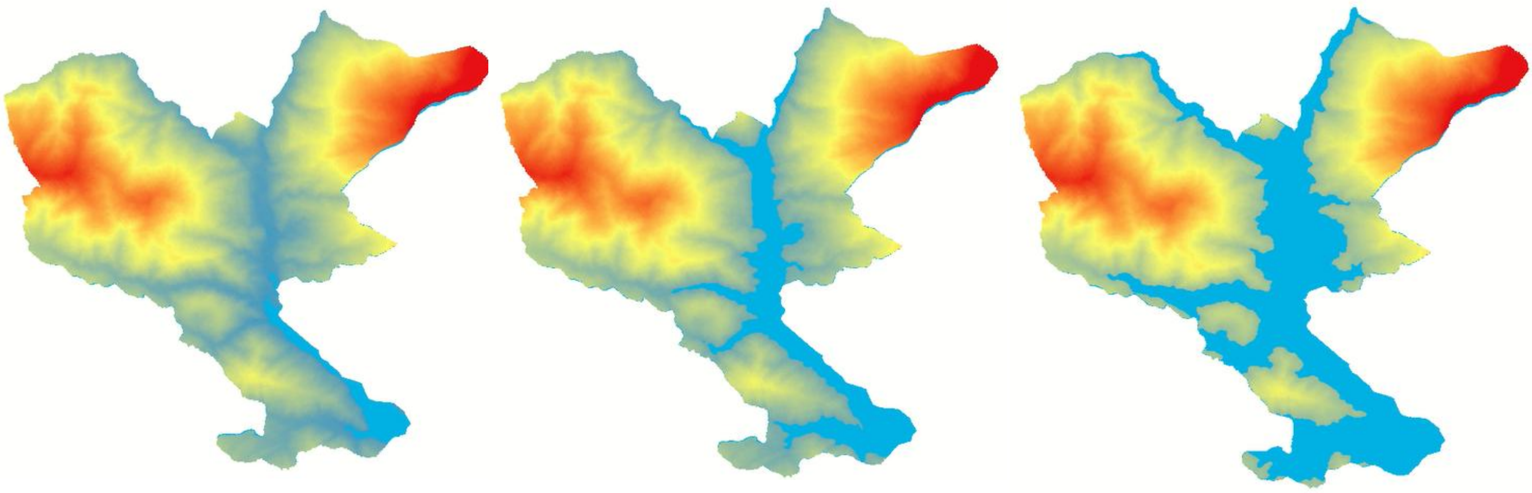

Figure 19: Flood simulation map of Melamchi (75 mm in 24 hr)

Out-Migration: Drivers and Patterns

1. Livelihood Loss: Agriculture and tourism, the backbone of Melamchi's economy, were decimated. Over 53% of households lost crops and livestock, while trout farms—a $61,000 investment for some—were obliterated (Parajuli et al., 2023). This forced 20% of affected families to migrate, primarily to Kathmandu and other parts of Sindhupalchowk, in search of wage labor (Parajuli et al., 2023).

2. Psychological Distress: Mental health crises, reported by 85% of respondents, compounded migration decisions. Families unable to cope with trauma sought relocation as a coping mechanism (Parajuli et al., 2023).

3. Infrastructure Collapse: Damage to roads and bridges isolated communities, cutting access to markets and services. Over 40% of households reported disrupted mobility, pushing them to urban areas (Parajuli et al., 2023).

In-Migration: Limited Resettlement

In-migration to Melamchi was minimal post-flood due to the scale of destruction. However, temporary in-migration occurred among aid workers and NGOs providing relief. The government's resettlement efforts were inadequate: only 14% of households received relocation support, and most were forced to rebuild in high-risk zones (Parajuli et al., 2023). This highlights a critical gap in climate adaptation policies.

Melamchi Flood (2021)

The Melamchi flood exemplifies compound climate-disaster impacts. Intense rainfall (168 mm/day) triggered landslides, displacing 1,200 households. Economic losses averaged USD 52,113 per household, but government compensation covered only USD 380, leaving a 98% financial gap (Parajuli et al., 2023). Non-economic losses—mental trauma (85%), cultural site destruction (58%)—highlight multidimensional vulnerability.

Sindhupalchowk District

A hotspot for landslides, Sindhupalchowk lost 0.08% of its GDP annually to disasters pre-2015 (MoFE, 2021). Post-earthquake, 30% of households migrated to Kathmandu, straining urban resources (NRRC, 2016).

Gender and Social Dimensions of Migration

Climate migration in Nepal is gendered. Women, who constitute 46% of migrants in Melamchi, face unique challenges (Parajuli et al., 2023). Post-flood, 42% reported increased psychological stress, while 40% shouldered greater caregiving burdens (Parajuli et al., 2023). Cultural norms often restrict women's decision-making power, limiting their access to resources. Conversely, men migrate for labor opportunities, perpetuating a cycle of remittance dependency.

Marriage remains a key driver of female migration, accounting for 41% of women's moves nationally (KC, 2003). However, disasters like the Melamchi flood disrupt traditional patterns, as families prioritise economic survival over cultural practices.

Policy Gaps and Recommendations

Nepal's policy framework for climate migration remains fragmented. The National Climate Change Policy (2019) emphasises resilience but lacks provisions for displacement. The Disaster Risk Reduction and Management Act (2017) focuses on short-term relief, not long-term resettlement. Key gaps include:

1. Compensation Mechanisms: Only 34% of Melamchi households received government aid, averaging $380—far below the $52,113 loss per household (Parajuli et al., 2023).

2. Early Warning Systems: Informal alerts from relatives, not formal systems, enabled 77% of evacuations, leaving vulnerable groups like the elderly at risk (Parajuli et al., 2023).

3. Urban Planning: Kathmandu’s rapid urbanisation (63% urban population in 2018) strains resources, worsening migrants’ living conditions (Charles-Edwards et al., 2019).

4.Funding Shortfalls: Melamchi’s USD 498 million loss exceeds municipal budgets (USD 10.5 million annually), necessitating international aid (Parajuli et al., 2023).

5.Data Limitations: Only 22% of municipalities track non-economic losses, hindering targeted interventions (MoFE, 2021).

Figure 20: Melamchi Bazaar and Bus Stand, currently operational after flood events

Conclusion

The 2015 earthquakes and 2021 Melamchi floods underscore the complex interplay between climate disasters and migration in Nepal. Out-migration driven by livelihood loss, psychological distress, and infrastructure collapse contrasts with limited in-migration due to inadequate resettlement support. Gender disparities further complicate recovery, as women bear disproportionate caregiving and psychological burdens. Addressing these challenges requires robust policies that prioritise compensation, early warning systems, and inclusive urban planning. As climate change intensifies, Nepal’s ability to manage displacement will determine its socio-economic stability in the coming decades.

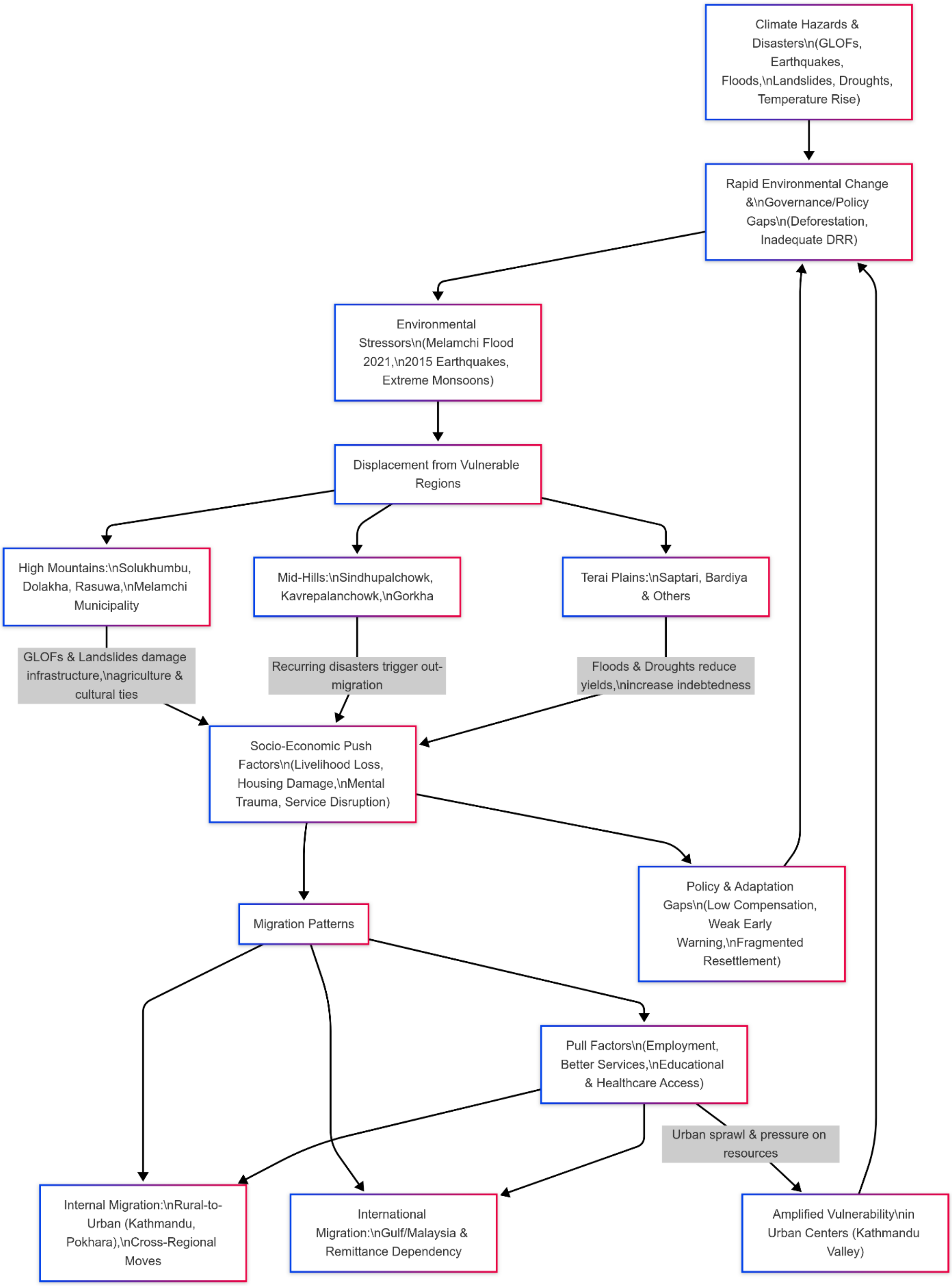

Figure 21:Figure 11: Flow Chart depicting the current climate migration status in Nepal, Mlamchi- Helambu derived from above Literature Review

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DHAKA
Padma River
Tetulia River

Dhaka, Bangladesh

Introduction

Bangladesh, a deltaic nation with a population exceeding 165 million, is among the most climate-vulnerable countries globally (IPCC, 2014). Its low-lying topography, dense population, and reliance on agriculture make it acutely susceptible to climate hazards such as sea level rise (SLR), flooding, cyclones, heatwaves, and droughts. Dhaka, the capital, has emerged as a primary destination for climate-displaced populations, exacerbating urban challenges like slum proliferation and strained infrastructure. This section examines climate-induced migration in Bangladesh, focusing on Dhaka, by analysing climate threats, vulnerable populations, migration patterns, and adaptation strategies. Quantitative data from recent studies underscore the urgency of addressing these interconnected issues to achieve sustainable urban resilience.

Climate Threats Driving Migration

Sea Level Rise (SLR) and Coastal Inundation

Bangladesh's coastal zone, home to 35 million people, faces existential threats from SLR. By 2050, 19 coastal districts risk losing 16–25% of their land to inundation under a 0.3–0.74 m SLR scenario (Davis et al., 2018). By 2100, up to 2.1 million people could be displaced, with districts like Barisal, Chandpur, and Shariatpur losing 3–17% of their land (Davis et al., 2018; Rana & Ilina, 2021). SLR exacerbates saltwater intrusion, rendering agricultural lands infertile and freshwater scarce, which disproportionately affects rural livelihoods.

Coastal districts such as Khulna, Satkhira, and Bhola are acutely vulnerable to flooding and SLR. By 2050, a 0.3–0.74 m rise in sea levels could displace 0.9–2.1 million people, with 16–25% of coastal land submerged (Davis et al., 2018). Cyclones and storm surges exacerbate these risks; Cyclone Aila (2009) alone displaced 500,000 people, 70% of whom migrated to urban areas like Dhaka (Mallick & Vogt, 2014)

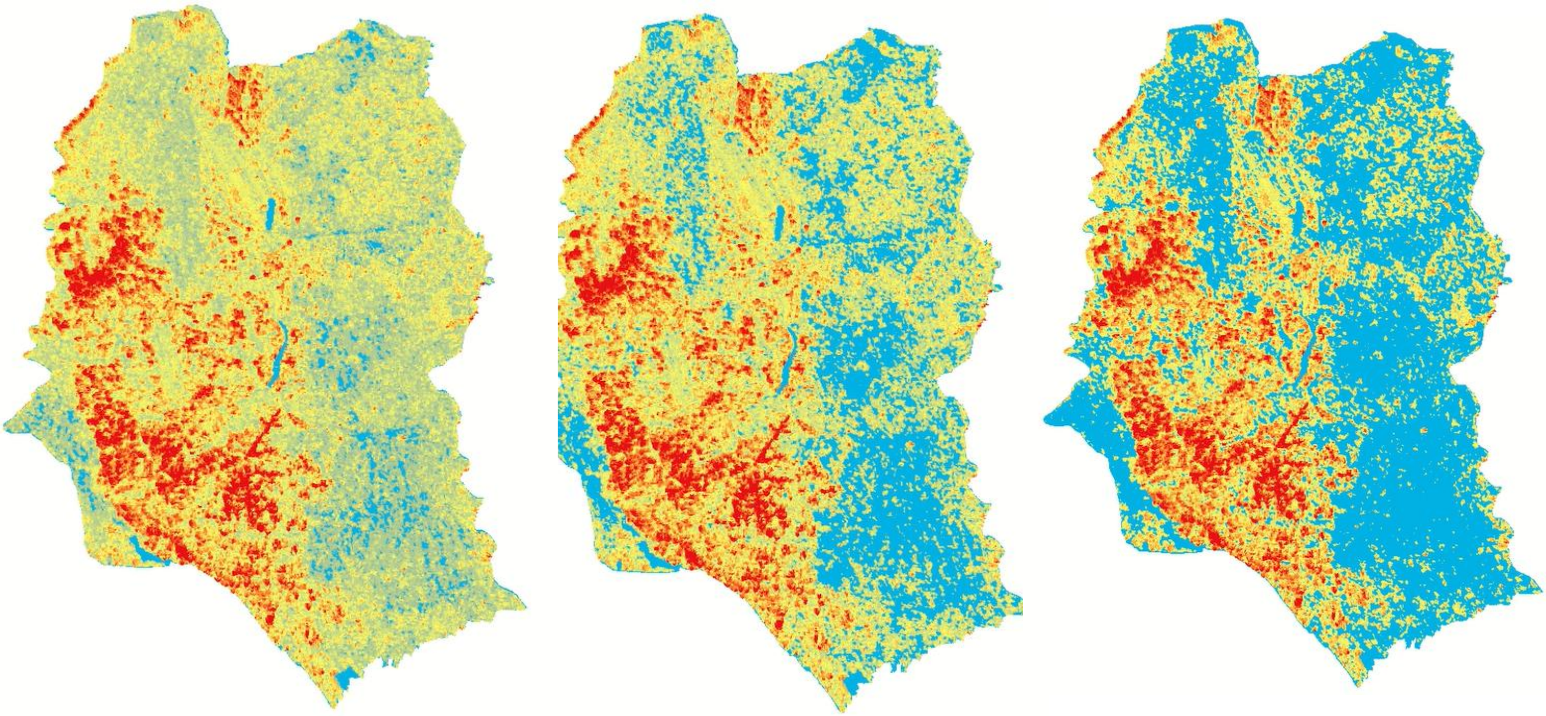

Figure 22: Flood Simulation Map of Dhaka (85mm in 24 hr)

Riverine Flooding and Erosion

Annual monsoon floods submerge 20–25% of Bangladesh, displacing 1 million people yearly (World Bank, 2020). Riverbank erosion along the Padma, Jamuna, and Meghna basins displaces 50,000–200,000 individuals annually, destroying homes and farmland (Rana & Ilina, 2021). Char dwellers—communities on river islands—are particularly vulnerable, with 60% migrating temporarily or permanently after losing land (Khatun et al., 2021).

Heatwaves and Urban Heat Islands (UHIs)

Dhaka's average temperature has risen by 1.5°C since 1970, with heatwaves exceeding 40°C becoming frequent (Yasumoto et al., 2019). Surface Urban Heat Island (SUHI) effects elevate temperatures in the city center by 3–5°C compared to rural areas. Suburban migrants working in Dhaka's core face higher heat exposure, with dynamic models showing a 2.01°C increase in maximum daily temperatures compared to static residential assessments (Yasumoto et al., 2019).

Dhaka's rapid urbanisation has intensified UHI effects, with inner-city temperatures 3–5°C higher than surrounding rural areas (Yasumoto et al., 2019). Suburban migrants working in Dhaka's core face elevated health risks, as dynamic exposure models reveal a 2.01°C increase in maximum daily temperatures compared to static assessments (Yasumoto et al., 2019).

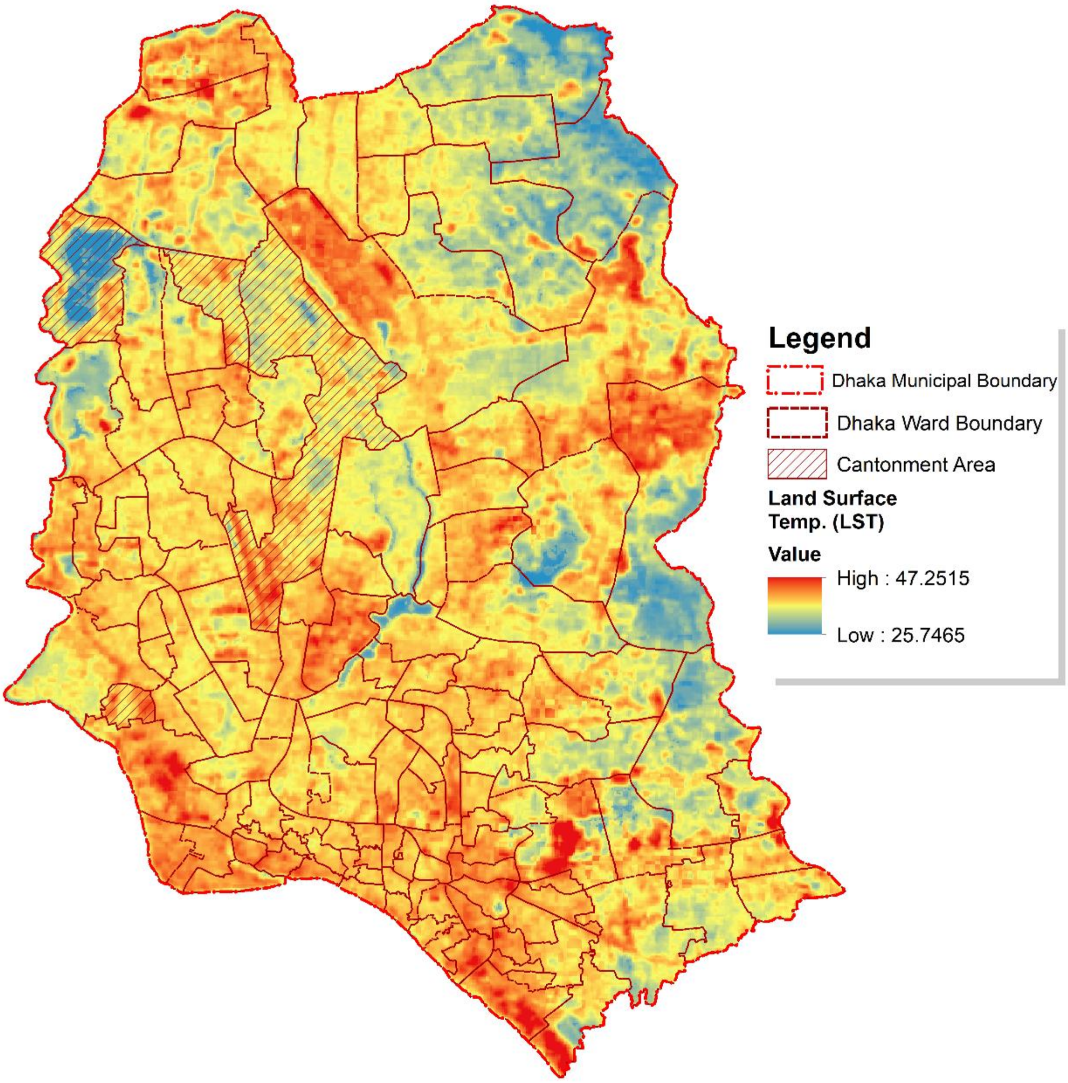

Figure 23: Land Surface Temperature Map of Dhaka (04/03/2025)

Cyclones and Storm Surges

Cyclones like Sidr (2007) and Aila (2009) displaced over 2 million people, with storm surges inundating 40% of coastal regions (Mallick & Vogt, 2014). Post-disaster surveys reveal that 70% of displaced households migrated to urban centers like Dhaka and Chattogram due to livelihood losses (Ahsan et al., 2014).

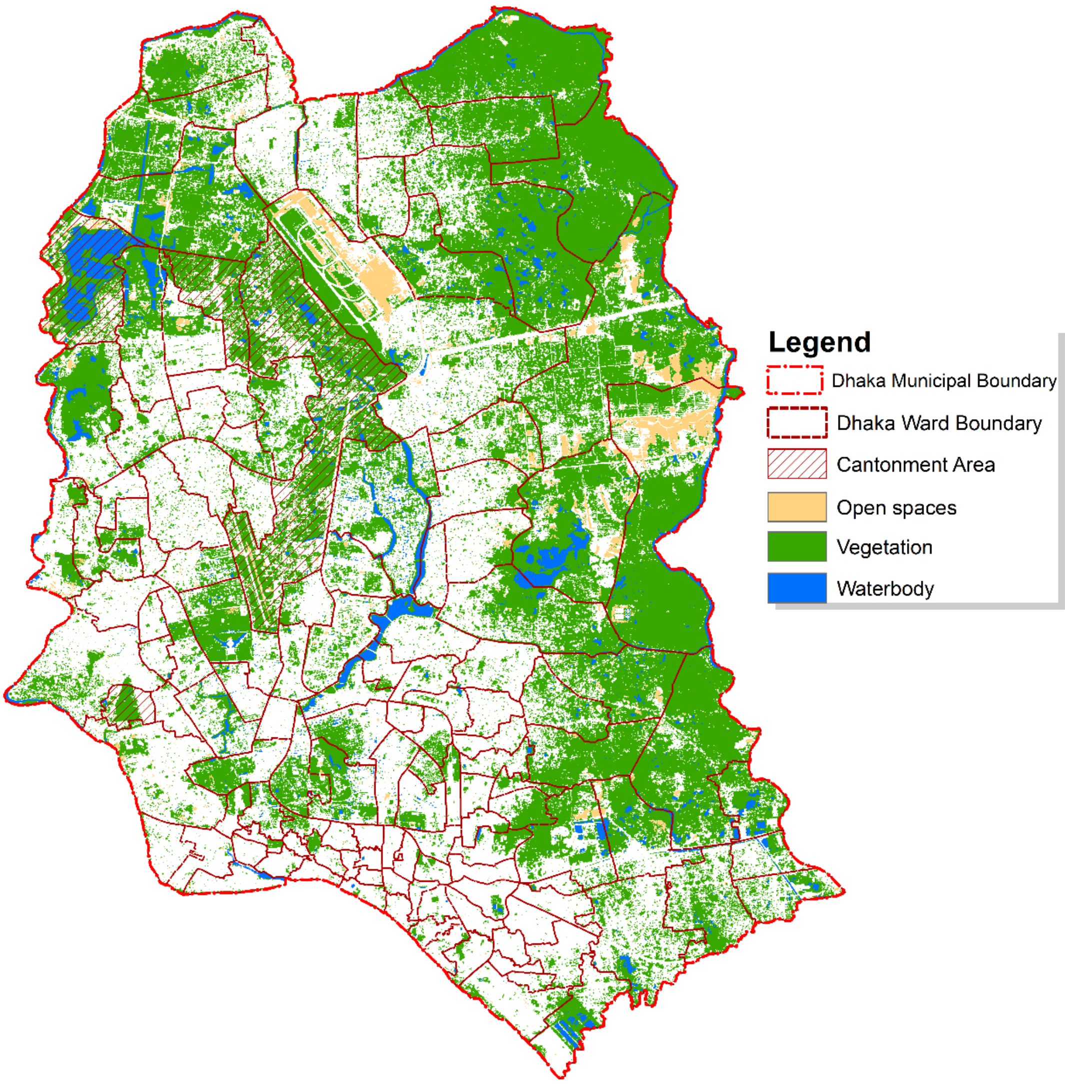

Figure 24: Blue Green Open Space of Dhaka

Droughts and Agricultural Stress

Northwestern districts (e.g., Rajshahi, Rangpur) face recurrent droughts, reducing rice yields by 15–30% (UNDP, 2021). Seasonal migration to cities increases during dry periods, with 25% of rural households relying on remittances from urban migrants (Gray & Mueller, 2012).

Geographies of Vulnerability

Coastal Zones

The southwestern coast (Khulna, Satkhira) and central coast (Barisal, Bhola) are SLR hotspots. By 2050, 12% of Khulna's population (142,968 people) could be displaced under a 1.5 m SLR scenario (Davis et al., 2018). Salinisation affects 1.2 million hectares, reducing rice production by 50% in affected areas (World Bank, 2020).

Riverine Chars

Chars in the Brahmaputra-Jamuna basin host 6.5 million people, with 30% losing land annually to erosion (Rana & Ilina, 2021). Migrants from chars often relocate to nearby towns like Sirajganj or Dhaka.

Dhaka's Periphery

Slums in Dhaka's periphery (e.g., Mirpur, Keraniganj) house 3.4 million people, with 70% living below the poverty line (BBS, 2015). These areas lack access to clean water (46% rely on unsafe sources) and sanitation (80% use shared latrines), amplifying health risks (Rana & Piracha, 2020).

Vulnerable Populations

The Urban Poor

Dhaka's slum dwellers, constituting 37% of the city's population, face dual vulnerabilities: climate risks in rural origins and urban marginalisation (Rana & Ilina, 2021). Women and children in slums are disproportionately affected, with 33% of children malnourished (UNICEF, 2020). Female-headed households constitute 45% of slum populations, often working in informal sectors like domestic labor (Ahsan et al., 2014).

Heat-related illnesses in Dhaka's slums have risen by 20% since 2010, with limited access to healthcare exacerbating vulnerabilities (Yasumoto et al., 2019).

Agricultural Workers

Coastal and riverine farmers, who constitute 40% of Bangladesh's workforce, lose livelihoods to salinisation and erosion. A survey in Bhola found 60% of households migrated after losing farmland to river erosion (Mallick & Vogt, 2014). Farmers in Satkhira report 60% income declines due to salinisation, pushing many into debt-driven migration (World Bank, 2020).

Women and Children

Women in climate-affected regions face increased domestic burdens due to water scarcity and crop failures. Women in coastal regions face increased domestic burdens, spending 4–6 hours daily collecting freshwater (Rana & Ilina, 2021).

Post-disaster, 45% of female-headed households migrate to cities for informal labor (Ahsan et al., 2014).

Migration Patterns and Urbanisation

Rural-to-Urban Migration

Between 1991–2011, rural-urban migration accounted for 52–57% of Dhaka's population growth (UNFPA, 2016). By 2050, Dhaka's population is projected to reach 30 million, with 300,000–400,000 new migrants annually (Rana & Ilina, 2021).

Secondary Cities as Emerging Destinations

Chattogram, Khulna, and Rajshahi are absorbing 20% of climate migrants, offering cheaper housing and labor opportunities (Davis et al., 2018). However, these cities lack infrastructure to support growth; Khulna needs 5,000 new jobs annually to accommodate migrants (Davis et al., 2018).

Translocal and Seasonal Migration

Seasonal migration to Dhaka's construction sector peaks during post-cyclone and post-harvest periods. Approximately 15% of migrants return to villages during planting seasons, maintaining dual residences (Gray & Mueller, 2012).

Coastal Districts: Out-Migration Hotspots

- Khulna and Satkhira: Salinisation affects 1.2 million hectares of farmland, reducing rice yields by 50% (World Bank, 2020). By 2100, Khulna could lose 5.2% of its population (142,968 people) to SLR-driven displacement (Davis et al., 2018).

- Bhola and Barisal: Riverbank erosion displaces 30% of char dwellers annually, with many relocating to Dhaka or Chattogram (Khatun et al., 2021).

- Permanent Displacement: After losing land to erosion or salinity, 60% of households in Bhola migrate permanently to cities (Mallick & Vogt, 2014).

- Seasonal Migration: During post-flood or drought periods, 15–20% of coastal residents engage in temporary migration to Dhaka's construction sector (Gray & Mueller, 2012).

Dhaka: The Epicenter of In-Migration

Dhaka's population, currently 23 million, grows by 300,000–400,000 migrants annually, 52–57% of whom originate from climate-affected rural areas (UNFPA, 2016). Slums like Korail and Mirpur house 3.4 million people, with population densities reaching 891 persons/acre (BBS, 2015). These areas lack basic services: 46% rely on unsafe water, and 80% use shared latrines (Rana & Piracha, 2020).

Urban pull factors like Dhaka's informal economy attracts migrants with daily wages of $3–5 in sectors like rickshaw-pulling and garment work (World Bank, 2020). Chattogram and Khulna absorb 20% of climate migrants, though inadequate infrastructure limits their capacity (Davis et al., 2018).

Return and Circular Migration

Despite urban hardships, 25% of migrants return seasonally to rural areas for farming, maintaining dual residences (Gray & Mueller, 2012). However, prolonged salinity intrusion and land loss are reducing return rates.

Adaptation Strategies

Community-Based Approaches

- Embankments and Polders: Coastal communities build 5,700 km of embankments, reducing flood risks by 30% (Gain et al., 2017).

- Floating Agriculture: In waterlogged areas, farmers grow crops on rafts, boosting yields by 40% (UNDP, 2021).

Government-Led Initiatives

- Bangladesh Delta Plan 2100: A $38 billion initiative to enhance flood resilience, restore wetlands, and promote climate-smart agriculture (Gain et al., 2017).

- Urban Resilience Projects: Dhaka's 2021 Master Plan aims to expand green spaces by 20% and relocate 500 slums to peri-urban areas (RAJUK, 2020).

Limitations of Adaptation

- Maladaptation: Migrants in Dhaka's slums face "risk displacement," exchanging rural hazards for urban precarity (Rana & Ilina, 2021).

- Funding Gaps: Only 15% of the Delta Plan's budget is allocated to migration support, limiting housing and job creation (World Bank, 2020).

- Policy Gaps: Lack of legal land tenure in slums hinders infrastructure investment, perpetuating cycles of poverty (Rana & Piracha, 2020).

Policy Recommendations

1. Decentralise Urban Growth: Invest in secondary cities to reduce Dhaka's migrant influx (Davis et al., 2018).

2. Enhance Rural Resilience: Scale up climate-smart agriculture and early warning systems to reduce displacement (UNDP, 2021).

3. Improve Slum Governance: Legalise land tenure in slums and expand access to water and healthcare (Rana & Piracha, 2020).

4. Data-Driven Planning: Integrate mobility data into climate models to predict migrant flows (Yasumoto et al., 2019).

Conclusion

Bangladesh's climate migration crisis underscores the need for holistic policies that address rural vulnerability and urban capacity. Dhaka's transformation into a megacity of slums highlights the costs of unplanned urbanisation. By prioritizing adaptive governance, equitable resource distribution, and multi-stakeholder collaboration, Bangladesh can mitigate the human toll of climate displacement.

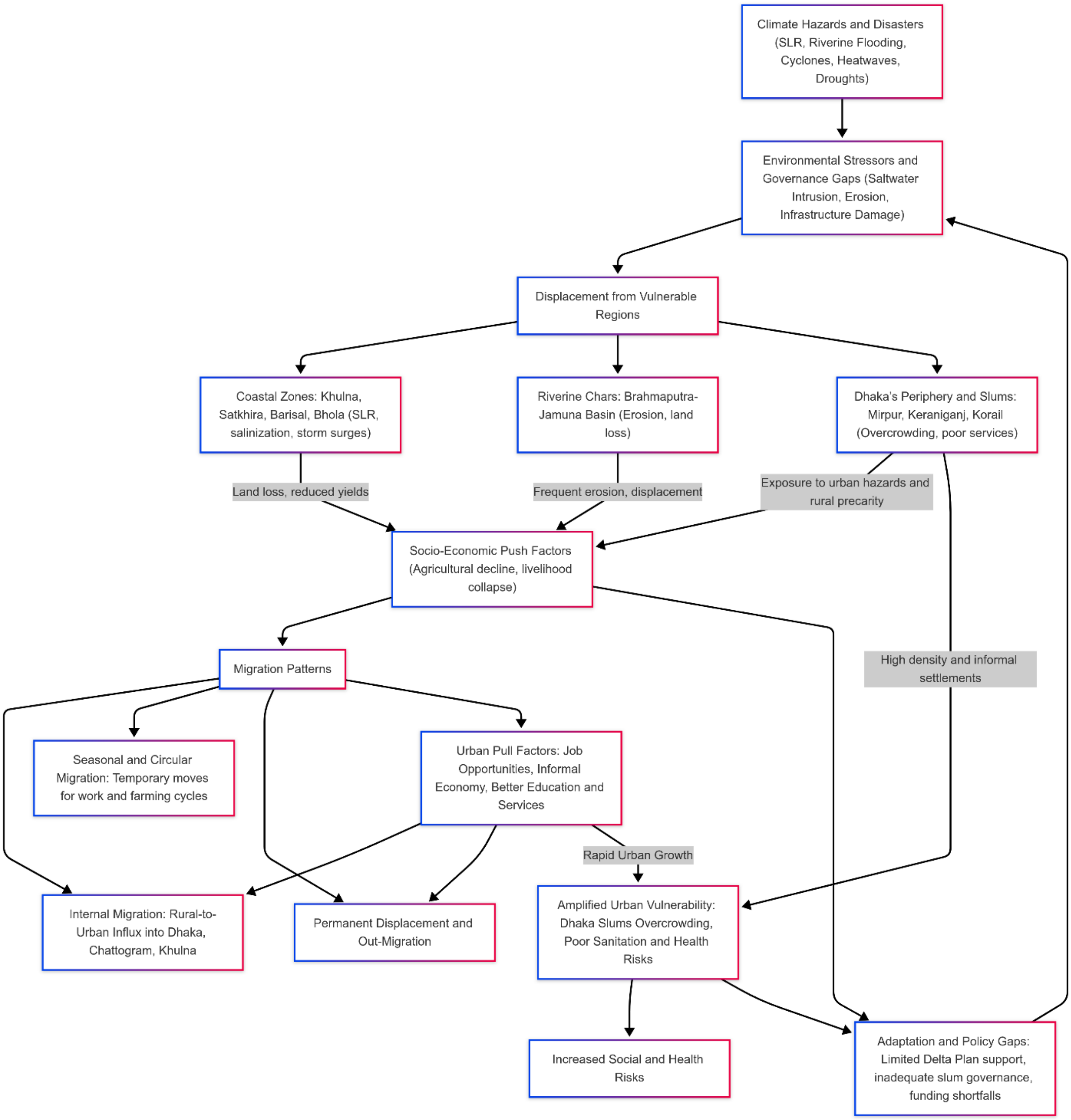

Figure 25:Figure 11: Flow Chart depicting the current climate migration status in Bangladesh, Dhaka derived from above Literature Review

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Annexure 1: Team

Name	Designation		Role in the project
Dr. David Sanderson	PhD, Professor and Inaugural Judith Neilson Chair in Architecture, has 30 years' experience working across the world in development and emergencies.	UNSW	UNSW will anchor the project, with research coordination capabilities hosted at the university to help the project convene, consult and consolidate across all the proposed activities.
Natalie Diane	Project Manager, How We Survive	UNSW	
Dr. Anshu Sharma	PhD, Co-founder and Director of SEEDS	STS	SEEDS Technical Services is an impact research advisory organisation based in India, that will partner to coordinate the field and will support in the management and logistics related to the project activities, including implementation of action research pilot projects.
Shreyasi Neogi	Project Manager, Disaster and Climate Advisory	STS	
Kh. Samuel Poumai	Project Manager, Assessment and Planning	STS	
Dr. Rajashree Kotharkar	PhD, Professor, Visvesvaraya National Institute of Technology	VNIT	They will anchor the research components of the respective countries, and the national consultations. They will also help design the field research and the pilots in the three countries.
Dr. Inu Pradhan Salike	PhD, Lecturer at Pulchowk Campus, Institute of Engineering, Tribhuvan University	TU	
Dr. Huraera Jabeen	PhD, Senior Research fellow, BRAC Institute of Governance and Development	BRAC	
Ms Gouthami	Independent practitioner who has worked in senior management in grassroots implementing organisations as well as international donor agencies.		Will explore the project through the gender lens.
Dr. Ronak Patel	PhD, Medical Doctor, Brigham & Women's Hospital, multiple decades of disaster and humanitarian medicine		Will explore the project from the health perspective.
Soura Manna	Pursuing PhD at IIT Kharagpur, Department of Infrastructure Design		Will contribute to making GIS maps
Shabin Paul	Independent Practitioner who has worked in the development sector		Will contribute to strengthening of the research activities