GUIDED INCREMENTALISM: INFORMAL SPATIAL ADAPTATION AND THE FUTURE OF MIGRANT HOUSING IN BANGLADESH

BY

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A thesis submitted to the Department of Architecture in partial fulfillment of the requirements for the degree of Master in Disaster Management.

Department of Architecture

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Declaration

It is hereby declared that:

1. The thesis submitted is my original work while completing my degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through complete and accurate referencing.
3. The thesis does not contain material accepted or submitted for any other degree or diploma at a university or other institution.
4. I have acknowledged all primary sources of assistance.

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Approval

The thesis titled "Guided Incrementalism: Informal Spatial Adaptation and the Future of Migrant Housing in Bangladesh," submitted by Rakesh Sharma (Student ID: 23168002) of Spring 2023, has been accepted as satisfactory in partial fulfillment of the requirements for the degree of Master in Disaster Management on September 15, 2025.

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Ethics Statement

Throughout the research process, I adhered to rigorous ethical standards to uphold the dignity, rights, and well-being of all participants. Informed consent was obtained from each research participant, ensuring they clearly understood the objectives of the study, procedures, and their right to withdraw at any stage without consequence. Strict measures were taken to safeguard confidentiality and anonymity; all personal data was anonymized and securely stored to prevent any breach of privacy. The research framework was carefully designed to avoid causing harm, fostering a safe, respectful, and inclusive environment for all participants. Particular attention was given to cultural sensitivity, with deliberate efforts to honor the diverse cultural backgrounds and lived experiences of the migrant communities. The study received formal approval from the relevant ethical review board, affirming its compliance with ethical standards and potential to yield meaningful and constructive outcomes for engaged communities.

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Abstract

Environmental migration is transforming the built environment of cities in the Global South. As a universal adaptation strategy, migration often arises when other forms of adaptation fail in response to socioeconomic uncertainty and environmental pressure. However, migration to major cities often contributes to the proliferation of substandard housing within informal settlements, raising a housing question. Although formal initiatives to rehabilitate the landless, homeless, and displaced population are not uncommon, such top-down, neoliberal developments frequently lead to gentrification. Furthermore, traces of informality in the planned housing environment indicate a necessity for a bottom-up approach.

In this background, this study examines the morphogenesis of the settlements and how migrant communities in vulnerable settlements adapt their housing environments to cope with social dynamics, economic pressure, and environmental change. The study presents lessons from the housing transformation and spatial adaptation at *Sri Krishnapur Ashrayan Project* (planned resettlement as sample site) and *Jogen Babur Maath* (informal settlement as target site), in the Dinajpur district of Bangladesh. In doing so, the study has undertaken a mixed-methods approach combining non-participant observation (n=4), semi-structured interviews (n=14), and focus group discussions (n=2). The morphologies are classified, themes are identified, and their spatial patterns are analyzed.

Findings reveal incremental and heterogeneous housing development across sites. The typologies of *setback, aligned, setback-aligned*, *setforward,* and *aligned-setforward* are dominant forms. While these small-scale adaptations allow for greater household adaptability and multifunctionality, they also limit sociability and accessibility.

Sri Krishnapur Ashrayan Project displays limited but structured adaptations, while *Jogen Babur Maath* demonstrated organic growth with stronger socioeconomic adaptation outcomes. Emerging themes, such as social adaptations, included horizontal and vertical extensions, appropriation of space for multifunctionality, and independent access to services. Economic adaptations included multifunctional spaces for livestock, small shops, and home-based enterprises. Environmental adaptations stressed structural upgrades using permanent materials. Some strategies overlapped, such as toilets and tubewells, which serve both social benefits (privacy) and environmental needs (water, sanitation, and hygiene during flood).

Spatial analysis shows that highly integrated households displayed grid layouts (ring-like), while households with low integration followed a linear (tree-like) spatial arrangement. Central rooms, foyers, verandas, and circulation nodes are highly integrated, while peripheral toilets, storage, and wash areas are less integrated. Incremental development hinges on transitional spaces such as central rooms, verandas, and stairs, which support expansion but often create circulation bottlenecks. Although most transformed houses showed well-integrated spatial evolution, many lack spatially sound layouts.

Focus group discussions revealed infrastructure gaps, including poor drainage, waste management, and failing toilets, worsened by seasonal flooding. Residents also face social challenges such as drug abuse and weak law enforcement. Moreover, the limited success of institutional interventions at *Jogen Babur Maath* highlights the need for community participation in the decision-making process.

Overall, the study critiques top-down resettlement policies and proposes a quasi-formal approach with an *adaptive formal-informal continuum* for housing development in marginalized communities. The findings underscore the agency of the inhabitants in shaping resilient urban morphologies and offer insights for participatory, sustainable adaptation planning in secondary cities of the Global South.

Keywords: *Environmental Migration, Informality, Affordable Housing, Community Participation, Urban Resilience, Sustainable Development*

Dedication

I dedicate this study to all those who live in transience—the homeless, the migrant, and the displaced—who continue to fight for their right to something fundamental yet profound: *home*.

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List of Acronyms

CCTF	Climate Change Trust Fund
FGD	Focus Group Discussion
GoB	Government of Bangladesh
HBFC	House Building Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
JBM	Jogen Babur Maath
MD	Mean Depth (Space Syntax metric)
RA	Relative Asymmetry (Space Syntax metric)
SDG	Sustainable Development Goal
I	Integration (Space Syntax metric)
SS01	Sample Site Section 01
TH1-TH12	Target House 1-12
TS01	Target Site Section 01
TS02	Target Site Section 02
TS03	Target Site Section 03
SH1-SH2	Sample House 1-2

Glossary

Climate-Resilient Housing	Housing is designed to withstand climate impacts while supporting livelihoods.
Environmental Migration	The movement of individuals or communities caused by sudden or gradual changes in the environment, such as riverbank erosion, floods, droughts, or other climate-related hazards, that compromise their livelihood, safety, or habitability of their place of origin.
Guided Incrementalism	A hybrid approach combining state support with resident-led housing upgrades.
Housing Transformation	Incremental changes made to dwellings in informal settlements, such as material upgrades, spatial expansion, or elevation, to adapt to environmental, economic, or social pressures.
Informal Settlement	Self-organized housing, which lacks formal planning or tenure security.
Morphogenesis	Urban morphogenesis studies the formation and development of urban structures and patterns, emphasizing the transformation of spatial configurations over time.
Planned Resettlement	Government-built housing for displaced populations.
Spatial Adaptation	Modification and flexible use of built space are needed to meet changing needs due to environmental challenges, income-generating activities, or growing household size.

CHAPTER ONE
INTRODUCTION

"Informal settlements are the most pervasive modes of urbanization on the planet, housing up to 2 billion people and absorbing most rural-to-urban migration worldwide."

(Dovey et al., 2023)

Recent studies have shown that a near-term increase of 1.5°C in atmospheric temperature would inevitably exacerbate several environmental disasters and threaten ecosystems and humans. The parallel short-term trends in exposure, vulnerability, development, and adaptation measures will determine the degree of risk (IPCC, 2023c). As cyclones, drought, sea level rise, erratic precipitation, and related flooding intensify, displacement will also rise. This could lead to involuntary migration from areas with high exposure and inadequate adaptation capacity to regions with relatively reduced hazard risks and better livelihood opportunities (IPCC, 2023c). Migration to major cities contributes to the proliferation of substandard housing within informal settlements. Informal settlements are home to nearly 1 billion urban poor people (World Bank, n.d.). Despite a deficiency in infrastructure and services, informal settlements continue to absorb new generations of inhabitants as the world's fast-growing urban population outpaces access to affordable formal housing (Salazar Miranda et al., 2022).

Figure 1: Karail: the largest informal settlement in Dhaka. (Source: Author)

1.1 Background

Climate change, a buzzword in recent development discourse, generally refers to *"sustained, detectable alterations in the state of the climate concerning average conditions and/or variability"* (Solomon et al., 2007). These shifts may result from natural processes or modifications in atmospheric composition due to human activities, such as energy consumption and deforestation, collectively known as anthropogenic climate change. In the 1980s, physical scientists started to voice concerns about the possible worldwide impact of human-caused climate change, specifically concerning precipitation, extreme weather, sea level, land, and glaciers. The Intergovernmental Panel on Climate Change published in 1990 that the most significant effect of climate change would be on human migration since many people might be uprooted due to agricultural disturbances, coastline erosion, and coastal floods (Brown, 2008). Numerous investigations since then have stressed that environmental degradation, especially climate change, is becoming widely regarded as a significant factor in human displacement, indicating an impending disaster.

Many key frameworks have acknowledged Climate change as a major mobility driver. These include the Agenda for Humanity (2016), UN Summit for Refugees and Migrants (2016), Global Compact for Migration (2018), and Global Compact on Refugees (2018). The Sustainable Development Goals (SDGs) also address migration. For example, target 10.7 of SDG 10 aims to "facilitate orderly, safe, and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies," along with a separate SDG 13 focused on climate action. Moreover, media outlets have frequently portrayed migration as the "human face" of climate change (Klepp, 2017; Gemenne, 2011a). Simplistically stated, climate change could make some areas of the world less suitable for living. It may also lead to more frequent and intense natural disasters, making food and water supplies less reliable. It is generally expected that if the average global temperature rises by 2°C or more compared to pre-industrial levels, there will be a notable increase in migration in the forthcoming decades (Biermann & Boas, 2010; Myers, 2002), a view which the World Bank endorses (Clement et al., 2021; Rigaud et al., 2018). However, this perspective is yet to be supported by sound research and empirical evidence (Boas et al., 2019). Although strong evidence is still limited, concerns about a possible sharp increase in migration caused by large-scale climate-related events have continued to grow. These concerns have led to the inception of a research field focused on exploring the impacts of climate hazards on human mobility.

According to the International Organization for Migration (IOM), Climate migration is defined as *"the movement of a person or groups of people who, primarily due to sudden or progressive environmental change caused by climate change, are obliged to leave their habitual place of residence or choose to do so, either temporarily or permanently, within a State or across an international border"* (IOM, 2019). Several studies have referred to this kind of migration as "climate-induced migration" (Baldwin et al., 2014), "climate-induced internal displacement" (Siddiqui et al., 2015), "climate-driven displacement" (McDonnell, 2019), "environmental migration" (Priovashini & Mallick, 2022) or "human displacement" (B. Mallick & Vogt, 2014). The act of migrating in reaction to ecological or climate-related "push" and "pull" factors is as old as human civilization. However, climate change alters and increases human migration patterns (Wright et al., 2021). For both the migrants and the communities they arrive in, migration could be a beneficial and required response to environmental pressures or risks (Wright et al., 2021; Adger et al., 2020; Black, Adger, et al., 2011; Barnett & Webber, 2010).

Although a noteworthy amount of research has been conducted to help us understand climate-driven migration, comparatively less focus has been placed on how receiving communities will be affected by this mobility and what they can do to better prepare. According to Marandi & Main (2021), addressing issues like housing and homelessness remains challenging for both cities directly affected by disasters and those that may absorb displaced populations, due to the unpredictability of extreme events and limited resources. The concerning aspect is that a shortage of affordable housing could soon be a catastrophe for local governments. Therefore, it is essential to ensure that people who need to move have access to affordable housing, employment, and transportation choices outside of vulnerable, hazardous zones (Marandi & Main, 2021).

1.2 Rationale of the Research

This research is driven by the need to address the vulnerabilities of migrant populations who lack culturally adequate and affordable housing environments in Bangladesh. Particularly, the northwestern part of Bangladesh has often been overlooked in academic literature. The region's marginalized socioeconomic conditions and environmental vulnerabilities are continually exacerbated due to a lack of appropriate infrastructure planning and policies. This study highlights the community resilience and sustainable adaptation of informal settlements, through which a sustainable and affordable housing framework may be developed. It provides critical insights into housing schemes' design and policy landscape for homeless, landless, and migrant populations. Given the scarcity of research on informal housing adaptations in the built

environment discipline, this study offers a timely contribution. It enhances our understanding of how these communities can provide broader housing solutions for marginalized populations worldwide.

1.3 Significance of Research

The present study is significant for its emphasis on the adaptation strategies adopted by the communities of informal settlements and planned resettlement in Bangladesh in response to environmental and socioeconomic stressors, such as flooding and economic instability. By highlighting these community-driven adaptations, the research underscores the contrasts between grassroots resilience and government-led rehabilitation interventions' rigid, often inadequate responses. Additionally, critical examination of existing policies aims to inform and improve transitional shelters and housing schemes for the displaced populations, making them more responsive to the needs of vulnerable populations.

In addition, the study strives to establish a hypothesis by finding casual-link between user-initiated informal adaptations and sustainable development, which makes the research reliable to carry forward by the built environment scholars, academics, and practitioners. By aligning with Sustainable Development Goal (SDG) 11, this research advocates for accessible, responsive, and inclusive urban development strategies. Finally, it strives to contribute to realizing sustainable and equitable housing solutions that empower vulnerable communities and foster resilience in the face of climate change.

1.4 Statement of the Problem

There is growing empirical data to support that migration is an efficient adaptation mechanism in reducing the impacts of environmental shocks and stressors (ADB, 2012; Black, Adger, et al., 2011; Tacoli, 2009; WEBBER et al., 2008; McLeman & Smit, 2006). Climate change is already prompting vulnerable and exposed populations globally to adopt various modes of adaptation for survival and to protect their livelihoods. Among the various socioeconomic adaptation strategies, involuntary migration is prioritized, particularly for vulnerable communities in emerging economies (C. L. Gray & Mueller, 2012). Vulnerable households choose their adaptation approaches, frequently opting for migration to cities when local administrations struggle to manage environmental hazards (Ahsan et al., 2016a). However, environmental migrants require support when they relocate, and their needs increasingly challenge the status quo of cities receiving large numbers of such migrants (ibid). Environmental migrants typically settle either in slums near central urban areas for easy access

to employment or on the city outskirts for lower housing costs (G. A. Parvin & Shaw, 2011). Unplanned and unlawful occupation of land has adverse effects on urban land use, city expansion, and the economy. Socioeconomic disparities often increase in these cities. Migrants, having experienced significant losses due to environmental changes, often become confined in a cycle of economic marginalization upon reaching their destination.

Addressing this new trend in migration and providing shelter, services, and economic opportunities has become challenging. Given their limited resources, developing countries (e.g., Bangladesh) are already vulnerable to climate change due to their inadequate urban infrastructure, which is unprepared for rapid and unplanned urban growth. Despite a downward trend over the past five years, 18.9% of urban residents still live in poverty. By 2030, there will be an 8.5 million shortfall in urban housing. (UN-Habitat, n.d.). This is bound to increase the demand for social amenities, sanitation, housing, water, and land. According to the Cities Alliance, more than 500,000 people migrate to Dhaka annually from rural and coastal areas. Bangladesh is among the countries where natural disasters significantly contribute to migration (E. Piguet, 2008). However, the World Bank (2007) reported that 70 percent of households living in the slums of Dhaka remain below the poverty line, earning nearly $2.50 a day, and these households also lack access to piped water (Rana & Ilina, 2021a). Consequently, the migrant communities continue to struggle as they live in informal settlements with minimal access to essential services and resources. Most climate migrants first move to slums and squatter settlements because they are easily accessible. However, these destinations fail to bring meaningful improvements to housing, as formal housing is not affordable (Ahsan et al., 2016b). The migrant populations are being forced into many different economic activities to survive. The city has little to offer them because they usually have little skill other than farming and fishing (ibid). Consequently, resettlement affects the migrants' livelihood regarding shelter, occupation, food security, utilities and services, and social life.

Researchers studying climate migrants in Khulna City revealed that 55% of migrants have shifted professions and are working as day laborers. Only 11% have access to safe drinking water, about 5% lack any toilet facilities, and over 20% use open toilets, while toilets with only a slab are used by 11% of the migrant population. Furthermore, 31% of migrant dwellings have no drainage, 56% have open drainage, and 45% of respondents dispose of their waste in open areas (Arif et al., 2010).

The Government of Bangladesh (GoB) endeavored to manage urban population growth by relocating thousands of migrants to specially designated villages. The cluster villages project

(1988) was planned for implementation across all sub-districts in the country. According to the Immigration and Refugee Board of Canada, approximately 50 percent of the beneficiaries resettled in the cluster villages, returned to urban informal settlements (IRB, 1994). Landowners opposed the government's land distribution plan from the very beginning, claiming these lands were distributed through bribery or private militias, preventing people experiencing poverty from receiving land (IRB, 1994). No source confirms the existence of cluster villages with the intended beneficiaries.

The Climate Change Trust Fund (CCTF), established by the government in 2009, has authorized forty-three government projects totaling USD 70 million and thirty-two NGO initiatives totaling USD 3.5 million (Martin et al., 2013a). Many government initiatives, such as Cluster Village (1972), Ashrayan (1997), Adarsha Gram (1998), Abashan (2001),

Figure 2: Typical designs of Ashrayan houses. (Source: GoB, 2024)

Gucchagram I and II (2009, 2015), Ashrayan-2, and others, have been constructed to date to address the increasing housing demand of climate migrants. However, the success of these projects (e.g., Ashrayan) can be questioned in terms of livability, cultural suitability, and sustainability factors (see Figure 2).

Additionally, the Bangladesh Government's (GoB) Ashrayan (shelter) Prakalpa is accused of corruption. This project aims to reduce poverty through rehabilitation and income generation. According to an article in The Financial Express, Ashrayan homes in several locations were damaged, collapsed, or washed away by rain within months of their completion. Waterlogging resulted from improper landfilling, and the inhabitants were at risk from the deteriorating pillars and parts of the dwellings. It is claimed that the dwellings' degradation or collapse in such a short period was partly caused using subpar building materials or incorrect ratios of sand to cement (The Financial Express, 2021). Investigations are also being conducted into allegations of irregularities and financial embezzlement (ibid). In many developing countries, these neoliberal growth and prosperity models could lead to gentrification (The Daily Star, 2020). Consequently, more segregation follows as the increase in property value displaces low-income demographics and small enterprises (ibid), trapping the migrant communities in a vicious cycle of poverty and relocation.

1.5 Research Aim and Objectives

The study assumes that social dynamics, economic pressures, and environmental stress are the primary factors influencing housing transformation and spatial adaptation in vulnerable communities. The research aims to establish a conceptual framework for affordable housing solutions tailored to marginalized groups, including migrants, the homeless, landless populations, and displaced individuals. The specific objectives of the study are as follows:

i. To understand how the morphology of a settlement of vulnerable communities evolves.

ii. To explore the incremental transformation process of homesteads through informal spatial adaptations, driven by environmental changes, social dynamics, and economic needs.

iii. To provide insights into building environment professionals and policymakers, contributing to developing a sustainable housing scheme for the demographics above.

1.6 Research Questions

The study is grounded on the hypothesis that even within formally planned housing schemes, informal practices emerge, playing a crucial role in enhancing the resilience of communities. Additionally, the author thinks that informal adaptations contribute to the sense of belonging to the home and the broader community. Hence, lessons from morphological transformations can be instrumental in designing and delivering future housing schemes for marginalized communities. In light of this, the study intends to address the following research questions:

i. How to explain traces of informality in formal housing projects for homeless, landless, and migrant populations?
ii. How does the morphological transformation of a settlement influence the built environment and social system?
iii. What primary spatial adaptation strategies do migrant communities adopt in response to environmental and socioeconomic challenges?
iv. Are these informal adaptations sustainable? If so, how can it inform current housing schemes for marginalized populations to enhance resilience?

1.7 Scope of the Study

While exploring morphological changes of a homestead or a settlement, an ethnographic approach with longitudinal observations is the best. However, this is not realistic within the short timeframe of a graduate thesis. Hence, the research scope is limited to the findings from cross-sectional research (case study in the northwestern part of Bangladesh) employing a mixed-method approach. Additionally, although the study intends to contribute to an overall framework of a housing scheme for migratory and/or displaced populations, the scalability and replicability depend on many other variables, which may be overlooked in this focused study.

CHAPTER TWO
REVIEW OF LITERATURE

The global temperature is projected to rise until the middle of the century, with a 1.5°C to 2°C rise unless significant reductions in carbon dioxide and other greenhouse gas emissions occur (IPCC, 2023b). Consequently, large delta systems such as Bangladesh are at particular risk of compound and cascading environmental disasters. It is widely accepted that human behavioral and mobility patterns can be impacted by environmental change due to both natural and anthropogenic factors, particularly climate change (Gemenne, 2011b; Moniruzzaman et al., 2018). Recent scholarly works have viewed migration as a climate change adaptation strategy (IPCC, 2023a; Bettini, 2014) and a formal policy action that provides advantages and mitigates adverse effects (Eriksen et al., 2015). However, "migration as an adaptation strategy" was scrutinized, as many climate migrants failed to obtain places with livable conditions and services because of maladaptation (Warner & Afifi, 2014). Therefore, it is crucial to plan and construct urban housing landscapes that provide adequate social and environmental services for migrants who are maladaptive to the urban climate (Vinke, 2020).

2.1 Why do People Migrate: A Context of Vulnerability

Migration behavior is not linear and has multifaceted drivers and reasons. However, migration is essentially a strategy for adaptation.

2.1.1 Drivers of Migration

There are five main drivers of migration: social, political, economic, environmental, and demographic (Foresight, 2011) (see Figure 3). These factors can interact or overlap depending on the context. Climate change mainly affects the "environmental driver" of migration, but it also impacts the "economic driver" by influencing occupation, income, and overall well-being (Foresight, 2011).

In Bangladesh, climate change can impact migration in several ways. Disasters such as cyclones and heavy rain may destroy homes, livelihoods, and infrastructure, while floods and the salinity intrusion could make these effects last longer (A. A. Rahman et al., 2007). However, unpredictable or diminished rain could result in water shortages and lower crop production (Martin et al., 2013b). More erosion or coastal flooding could result from rising sea levels and increasing river flow (Brown, 2008). Exposure to climatic processes and events,

including hazardous occurrences, may lead to migration (Brown, 2008).

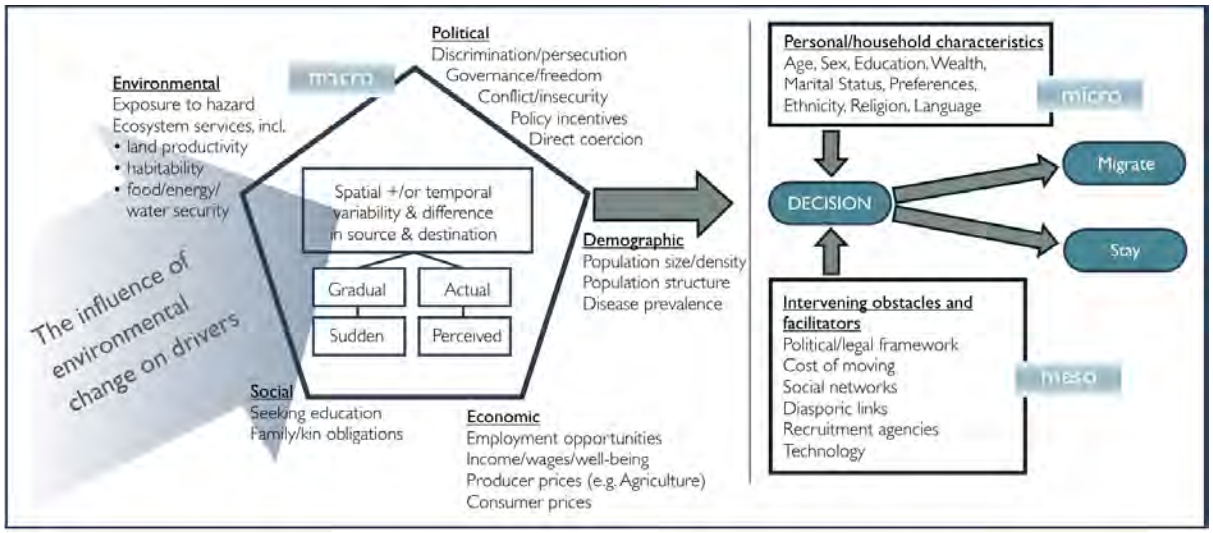


Figure 3: Conceptual framework of the drivers of migration. (Source: Black et al., 2011)

When people migrate, they affect both the place they leave and the place they move into, and relocation might be temporary or permanent (B. Mallick & Siddiqui, 2015; Black et al., 2013). Landlessness is one of the leading causes of migration (B. Mallick & Sultana, 2017). Short-term and short-distance migration are common after disasters. Following river erosion and home loss due to flooding in Bangladesh, for example, 88 percent of migratory agricultural groups were found to be living within two miles of their past habitation (Zaman, 2008). Because individuals lack the resources to go further, such rapid-onset disasters result in temporary displacement to surrounding locations, and many people return to rebuilding their houses (É. Piguet et al., 2011). People also want to be with family and kin and are connected to social networks (Webber & Barnett, 2009) and live in familiar ways (L. Perch-Nielsen et al., 2008). It should be highlighted, however, that migration is typically not the first response to a disaster, particularly when humanitarian relief addresses the damage incurred (Kniveton et al., 2009). In fact, seasonal and circular migration is a common source of livelihood for communities, allowing them to access resources at their destination while reducing the burden at home. Climate change-induced mobility is anticipated to be short-term and internal, occurring across limited distances, particularly in economically disadvantaged countries (Sward & Codjoe, 2012; Gemenne, 2011c). Rural-to-rural migration is widespread among the poorest people, most susceptible to alterations in climate. In contrast, moving to a city often necessitates new skills and more capital (Martin et al., 2013c).

While "climate-induced displacement and migration" implies a causal relationship between climate change and displacement and migration, the evidence does not support this (Kniveton

et al., 2008). As a result, it's critical to comprehend how environmental change affects the drivers of displacement and migration, both directly and indirectly. The causes, effects, and forms of migration are heavily influenced by the socioecological situations in which people migrate to and from (Locke, 2000). Experts believe migration decisions are context-specific and rely on various factors (Kolmannskog, 2008). For example, after Cyclone Aila, poor governance during the response and recovery process, a political factor, worsened the situation. This led to environmental issues, such as food and drinking water shortages, which forced people to migrate.

2.1.2 Can Climate Induce Migration?

There is a growing consensus that climate hazards, including extreme events and variability, directly drive involuntary migration and displacement, and indirectly influence it by undermining climate-sensitive livelihoods (Pachauri, 2014). The majority of climate-induced displacement and migration occur within a country, with international mobility typically limited to neighboring countries. Since 2008, over 20 million people have been internally displaced annually by weather-related extreme events, with storms and floods being the most frequent causes (IPCC, 2023a)**.** Droughts, tropical storms, erratic rainfall, flooding, and erosion are the most common climatic drivers of migration and displacement. These extreme weather events can act as direct triggers, such as devastating cyclones, or as indirect pressures, such as income loss in rural areas due to extended droughts, contributing to forced migration and displacement.

While there is significant consensus that climate change will lead to widespread population displacement (Pachauri, 2014), data on global human migration remains controversial (Bose, 2016). A few analysts, such as Norman Myers, have attempted to estimate how many people are forced to migrate because of climate change. Professor Myers suggests, *"There could be as many as 200 million people overtaken by disruptions of monsoon systems and other rainfall regimes, by droughts of unprecedented severity and duration, and by sea level rise and coastal flooding by 2050"* (Norman Myers cited in Brown, 2008). However, this projection is still quite uncertain.

Climate change-related fast-onset extreme weather events impact migration directly and suddenly, resulting in short-term movements over limited distances (McLeman & Gemenne, 2018). One area of research looked at how floods affected migration, with mixed results. Mueller et al. (2014), for instance, discovered that floods reduce the likelihood of migration to Pakistan, whereas Gray & Mueller (2012) and Bohra-Mishra et al. (2014) found no appreciable

impact of floods on migration in Ethiopia and the Philippines, respectively. According to (Koubi et al., 2016), rapid-onset disasters are more likely to induce migration in Vietnam, but long-term environmental changes (e.g., salinity intrusion) lessen the probability of migration.

Castells-Quintana et al. (2021) investigates the macro-scale relationship between shifts in weather trends and the geographic distribution of people and economic activities using a global dataset that indirectly measures rural-urban migration by accumulating census, climatic, and night-light data. They discovered that higher urbanization is linked to worse climatic conditions. The findings indicate that abrupt onset events are mostly linked to short-term migration to neighboring urban areas and temporary displacements. Still, slow-onset climate changes may result in longer-distance and more permanent moves. Using cross-country survey data from Cambodia, Nicaragua, Peru, Uganda, and Vietnam, Koubi et al. (2022) show that there is significant variation in the migration response: post-exposure to fast-onset shocks, those with lower incomes and less education are less likely to migrate than those with more substantial economic resources and higher levels of education. The behavioral and human mobility implications of Mahasen (2013) cyclone in Bangladesh were examined by retrieving users' geographical whereabouts and movements using anonymized call detail records from a telecommunications provider (Lu et al., 2016b, 2016a). Overall, the researchers found minimal evidence of long-term changes in the spread of people across locations, despite the anticipation of discovering significant evacuations and displacement from coastal areas post-disaster. Research has shown that migration is exacerbated by slow-onset changes and rising temperatures (Jessoe et al., 2018; Bohra-Mishra et al., 2017; Dallmann & Millock, 2017; R. Cai et al., 2016; Mastrorillo et al., 2016; Mueller et al., 2014; Hunter et al., 2013; C. Gray & Mueller, 2012; C. L. Gray & Mueller, 2012; Dillon et al., 2011; Feng et al., 2010).

In summary, despite the apparent agreement that disasters amplify migratory flows, there are cases where the opposite happens, keeping affected communities in immobility. Migration is more likely to result from slow-onset changes than rapid-onset disasters; however, scholarly work has paid less attention to the consequences of gradual changes than sudden disasters (Kaczan & Orgill-Meyer, 2020). This is partly due to slow onset changes that impact people more slowly than floods, landslides, hurricanes, and other comparable disasters, which are not considered severe enough to induce migration. Furthermore, migratory fluxes are more likely to be challenging to track, staggered, and subject to measurement error. Finally, in most cases, migration is only marginally linked to slow-onset changes and is far more dependent on political and economic variables.

It is contended that framing migration as an impact of climate change (climate reductive translation) may be misleading, as this may disrupt public debate on rural development and governance (Dewan, 2023a). A study in coastal Bangladesh suggests that even though climate reductionist views of migration capture global interest, they correspondingly lead to concerning misconceptions of the socio-ecological landscape. For example, associating migration with climate change misinterprets coastal vulnerabilities and the significance of migration as a gendered approach to livelihood (Dewan, 2023b)**.** Hence, the link between climatic hazards and migration cannot be anticipated beforehand because the direction will depend on local circumstances. Overall, given the complexity of the factors of migration, it is ultimately an empirical issue.

2.1.3 Migration as an Adaptation

According to (Noble et al., 2015), adaptation is adjusting to the current or future climate and its consequences on humans to mitigate, prevent harm, or take advantage of favorable opportunities. Migration, as a universal adaptation strategy, often arises when other forms of adaptation fail due to economic pressure, political instability, and environmental stressors (IPCC, 2023a). The idea that migration represents a set of choices within the larger category of adaptation and coping mechanisms has some empirical evidence (G. M. Alam et al., 2016; Black, Bennett, et al., 2011; Kattumuri et al., 2017; McNamara et al., 2018). However, migration is thought to be more expensive than other in-situ adaptation techniques; hence, relocation may be the last alternative for households (Wodon et al., 2014). Notwithstanding an increasing amount of research, there are still significant gaps in our knowledge of the intricate and multifaceted interaction between migration and climate change, necessitating further study on slow-onset environmental changes, internal mobility, immobility, context-specific responses, and the relationship between migration and in situ adaptation (Letta et al., 2024).

2.2 Migration Patterns in Bangladesh

According to (Foresight, 2011), economic, environmental, social, demographic, and political issues are all at play in the migration situation of Bangladesh. However, migration appears to be driven mainly by economic factors. Economic and environmental drivers are frequently intertwined, particularly in rural areas. According to the Internal Displacement Monitoring Centre (IDMC), the 117 documented disaster events in Bangladesh resulted in a total of 18.8 million internal displacements from 2008 until the end of 2023 (IDMC, 2024) (see Figure 4). Furthermore, more than half a million people will be internally displaced (IDP) between 2019 and 2023 (IDMC, 2024). Apart from disasters, income diversification is a significant

motivator for this group of migrants (Afsar, 2005). In effect, the countryside has evolved into a source of labor for cities (Toufique & Turton, 2002).

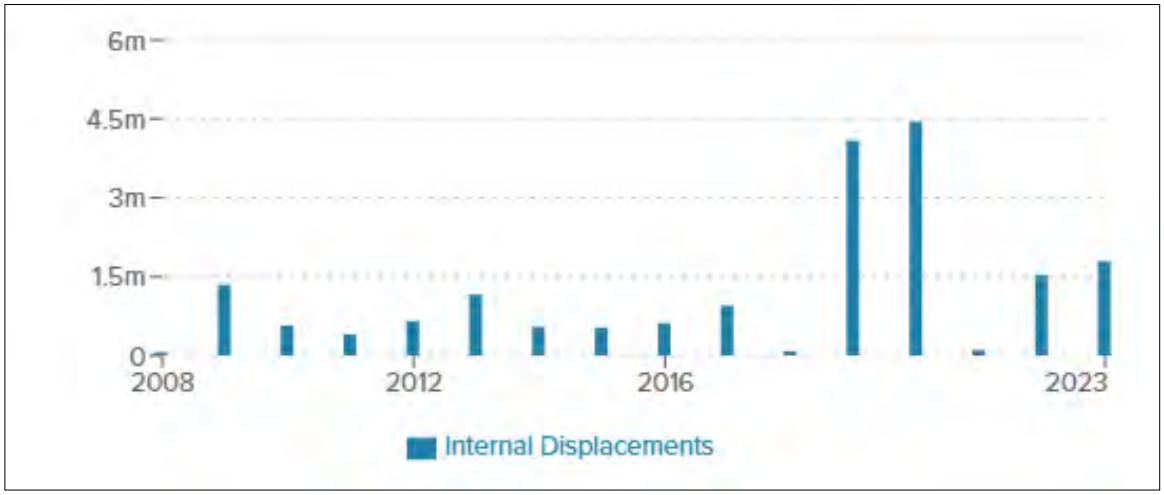


Figure 4: Distribution of total number of disaster-induced internal displacements. (Source: IDMC, 2024)

Rural-urban migration is a common survival strategy, especially in the aftermath of environmental shocks. It is also possible that it is a more proactive adaptation method. Water stress and climate variability, on the other hand, are reducing agricultural output and encouraging rural-urban migration. Landless people are often trapped in poverty in drought-prone northwestern districts such as Rangpur, Gaibandha, Kurigram, and Nilphamari, where alternative sources of income are limited during the low-yield season (September-December) (Siddiqui, 2009). Young men and boys from these communities seek work in cities and better-off towns every year. Moreover, every year in Bangladesh, riverbank erosion displaces 50,000 to 200,000 people (Mehedi et al., 2010). Not only does erosion take away people's homes, but it also takes away their farming land (Zaman, 1989). One of the main motivations for migration is the occurrence of cyclones regularly. Following Cyclone Aila in 2009, many individuals migrated to neighboring cities due to a lack of livelihood opportunities in the devastated districts, according to (Mehedi et al., 2010). However, not all Bangladeshi districts are equally targeted by migrants. According to the UNFPA report on urbanization and migration in Bangladesh, nearly two-thirds of migrants relocate to the districts of Dhaka and Chittagong, with Dhaka alone accounting for 42% of all in-migrants during their lifetime (UNFPA, 2016).

2.3 Impact of Migration on Cities

Bangladesh ranked sixth globally in terms of the number of slum dwellers, with a population of 30.4 million living in informal settlements (M. Davis, 2006). According to the (Bangladesh Bureau of Statistics (2015), there are 13,938 slums in Bangladesh. On top of that, projections

indicate that around 13 million people could be displaced by 2050, migrating to Dhaka and other major (divisional) cities (Rigaud et al., 2018). According to Dana (2011), Dhaka is one of the megacities with the fastest growth rate in the world, with roughly 300,000 to 400,000 people migrating there annually. Urban development authorities in Bangladesh struggle to provide adequate support, with studies showing that slum dwellers often lack access to essential services like housing, safe water, and sanitation (Rana & Piracha, 2020; Dana, 2011; Uddin & Baten, 2011; Z. Islam & Rahman, 2002). Additionally, climate hazards disproportionately impact populations in slums, which are often in hazard-prone areas, leading to heightened vulnerabilities (Diep, n.d.). Based on empirical data in Bangladesh, migration impact on cities can be categorized into three areas: (i) the spatiotemporal growth of urban informal settlements, (ii) impacts on infrastructure and services, and (iii) the growth of informal economy and city governance challenges (Rana & Ilina, 2021b). Although many studies have focused on issues such as attitudes toward climate-induced migrants, societal impacts of migration, justice, and human rights (Castellano et al., 2021; Ahsan, 2019; Kolstad et al., 2019; Naser et al., 2019), and health conditions of migrant communities in slums (Koly et al., 2021; Rahaman et al., 2018), as well as migration driven by sea level rise, flooding, riverbank erosion, and economic opportunities (K. F. Davis et al., 2018; Stojanov et al., 2016), the nexus between housing and environmental migration remains underexplored.

In informal settlements, limited adaptive capacity relates to substandard housing, lack of risk mitigation infrastructure, insecure tenure, and inadequate access to basic services, all increasing vulnerability. (Diep, n.d.). The IPCC's Sixth Assessment Report highlights the urgent need to address these vulnerabilities (Dodman et al., 2023). The Global Alliance for Buildings and Construction underscores that climate adaptation and emission reduction in buildings are mutually reinforcing goals (GlobalABC, 2021). Prioritizing adaptation capacity for the most vulnerable, particularly slum dwellers, is essential as these populations face low-quality housing, inadequate infrastructure, insecure tenure, and poor access to basic services. In African cities, residents of informal settlements spend 15-30% of their income on housing repairs (Frediani et al., 2023). Research conducted in the informal communities of the Philippines revealed that community vulnerability is influenced by four main factors: geography, economy, housing, and land tenure (Usamah et al., 2014). Research also indicates that slum inhabitants in urban areas lack access to adequate environmental services, including housing, safe water, sanitary facilities, and others (Rana & Piracha, 2020; Dana, 2011; Uddin

& Baten, 2011; Z. Islam & Rahman, 2002). Khan & Kraemer (2014) found that migrants from rural to urban areas reside in subpar houses constructed of subpar materials.

As urban populations grow globally, inclusive adaptation strategies in settlement upgrading plans can address infrastructure and service needs while offering social, political, and economic benefits (Dodman et al., 2023; Wolff et al., 2023). A recent study suggests that improving conditions in informal settlements essentially benefits society at large (Frediani et al., 2023). Slum upgradation represents a quintessential attempt to improve "pathological" spaces (Kamete, 2013) through technological and design interventions. It is premised on the belief that slum environments can be enhanced with appropriate technology and design (Cirolia, 2017). Complementing this perspective, Habraken introduced support-infill theory in the sixties, which provides a framework for distinguishing construction components by their life spans, decision levels, and building levels (urban tissue, support, infill), and their adaptability (fixed or variable components) (Habraken, 2021).

2.4 Maladaptation and Sustainable Adaptation

The word "maladaptation" refers to the possibility that actions to prevent or lessen vulnerability could raise the probability of unfavorable climate-related consequences, such as more significant greenhouse gas emissions, increased susceptibility to climate change, or decreased well-being (Masson-Delmotte, 2018). According to (Juhola et al., 2016), maladaptation is the adverse effect that an adaptation policy or measure has on the intended beneficiaries. Conversely, O'Brien & Leichenko (2007) suggest that sustainable adaptation interventions can improve long-term resilience and lessen vulnerability in a changing environment. Vinke et al. (2020) argue that *"migration does not necessarily lead to increased adaptation capacities for households in all contexts but can also have detrimental consequences, leading to increased impoverishment and deepened vulnerabilities."* For example, in Bangladesh, state-implemented initiatives do not adhere to environmental integrity, whereas NGO-implemented interventions suffer from recipient selection bias (S. M. Rahman, 2021).

However, outcomes of environmental migration vary significantly and are influenced by socioeconomic drivers and domestic assets. Particularly, migration is more successful when migrants have greater agency, meaning more voluntary movement, yielding better outcomes for both sending and receiving areas. Conversely, forced displacement or migration often leads to health challenges, reduced well-being, and socioeconomic disadvantages for the migrants, offering limited benefits to their origin or destination communities. Involuntary migration occurs when adaptation options are exhausted or unviable, reflecting non-climatic drivers that

limit adaptive capacity and heighten exposure and vulnerability. Additionally, planning and policy decisions influence these outcomes in terms of housing, infrastructure, services, education, and healthcare, which are crucial to integrating migrants into host communities.

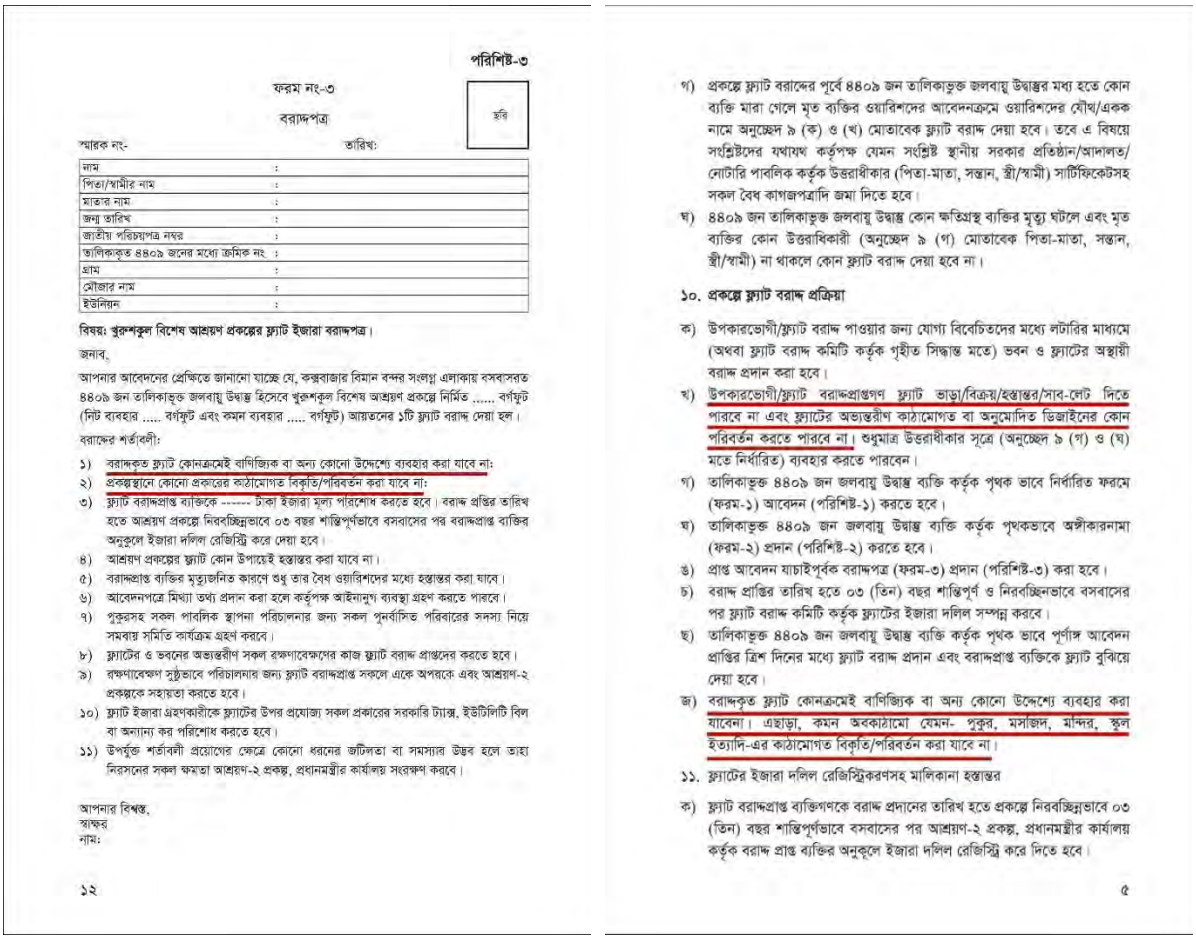
According to the Intergovernmental Panel on Climate Change, increasing adaptive capacities can minimize climate-related migration and forced displacement impacts, improving migration decisions and ensuring orderly movements. Despite progress in adaptation planning and implementation across relevant sectors, gaps exist between current and needed levels (IPCC, 2023a). Maladaptive responses can create vulnerability lock-ins and exacerbate existing inequalities. Hence, flexible, cross-sectoral, inclusive, and long-term planning and implementation of sustainable adaptation measures are fundamental to mitigating these issues.

2.5 Lessons from the Planned Precedents

In 1997, the Bangladesh Government (GoB) launched Ashrayan, a fully subsidized resettlement scheme to reduce poverty through the rehabilitation of homeless, landless individuals, including disaster-displaced people (GoB, 2024). The project is divided into four phases: Ashrayan I (phase I) from 1997 to 2002; Ashrayan I (phase II) from 2002 to 2010; Ashrayan II from 2010 to 2022; and Ashrayan III, which aims to provide 100,000 homes for Forcibly Displaced Myanmar Nationals (FDMN). Ashrayan, which means 'to shelter', has remained the greatest resettlement initiative by the Government of Bangladesh.

In a broader international literature, such top-down relocations often struggle to translate housing provision into sustained resilience when not accompanied by participatory planning, context-sensitive design, and robust governance (Klöck & Fink, 2019). International examples of incremental housing provide important lessons for planned housing initiatives. Ünlü and Baş (2017) argue that residential forms in Turkish cities emerge through incremental plot-based transformations, where successive small-scale changes (e.g., subdivisions, extensions, and redevelopments) accumulate into distinct morphogenetic types shaped by social practices, planning regulations, and state interventions. Projects such as Quinta Monroy in Chile and Ciudad Bachué in Colombia illustrate that providing residents with basic housing structures and the autonomy to expand over time encourages personalized, culturally appropriate solutions and strengthens community ownership (ELEMENTAL, 2003; E. Silva, 2016). However, no rules and regulations may become harmful as uncontrolled expansions might decline livability standards (Carrasco & O'Brien, 2021).

The 'Khurushkul Special Ashrayan Project' is a part of the ‘Ashrayan Project-2’ by the GoB. About 4,409 homeless climate-hit families were identified in and around the region, and they were planned to be resettled at Khurushkul Mouza, near the Bakkhali River of Cox’s Bazar Sadar. The government of Bangladesh allocated over 250 acres of land and planned to build 139 five-story buildings with modern amenities for the listed beneficiaries (GoB, n.d.a). Although the Khurushkul Ashrayan project houses numerous landless, homeless, and migrant people, but it lacks schools, prayer spaces, and healthcare facilities. Despite modern accommodation, income opportunities are limited. The lack of transport infrastructure makes it difficult for beneficiaries to join the fishing fleet and fish in the sea. Additionally, the villagers of neighboring Monupara are not accepting of the project beneficiaries, with young goons stalking girls and women and insulting them when protesting (The Business Standard, 2020).



পরিশিষ্ট-৩

ফরম নং-৩

বরাদ্দপত্র

ছবি

স্মারক নং- তারিখ:

নাম	:
পিতা/স্বামীর নাম	:
মাতার নাম	:
জন্ম তারিখ	:
জাতীয় পরিচয়পত্র নম্বর	:
তালিকাকৃত ৪৪০৯ জনের মধ্যে ক্রমিক নং	:
গ্রাম	:
মৌজার নাম	:
ইউনিয়ন	:

বিষয়: খুরুশকুল বিশেষ আশ্রয়ণ প্রকল্পের ফ্ল্যাট ইজারা বরাদ্দপত্র।

জনাব,

আপনার আবেদনের প্রেক্ষিতে জানানো যাচ্ছে যে, কক্সবাজার বিমান বন্দর সংলগ্ন এলাকায় বসবাসরত ৪৪০৯ জন তালিকাভুক্ত জলবায়ু উদ্বাস্তু হিসেবে খুরুশকুল বিশেষ আশ্রয়ণ প্রকল্পে নির্মিত ..... বর্গফুট (নিট ব্যবহার ..... বর্গফুট এবং কমন ব্যবহার ..... বর্গফুট) আয়তনের ১টি ফ্ল্যাট বরাদ্দ দেয়া হল।

বরাদ্দের শর্তাবলী:

১) বরাদ্দকৃত ফ্ল্যাট কোনক্রমেই বাণিজ্যিক বা অন্য কোনো উদ্দেশ্যে ব্যবহার করা যাবে না;
২) প্রকল্পস্থানে কোনো প্রকারের কাঠামোগত বিকৃতি/পরিবর্তন করা যাবে না;
৩) ফ্ল্যাট বরাদ্দপ্রাপ্ত ব্যক্তিকে ------ টাকা ইজারা মূল্য পরিশোধ করতে হবে। বরাদ্দ প্রাপ্তির তারিখ হতে আশ্রয়ণ প্রকল্পে নিরবচ্ছিন্নভাবে ০৩ বছর শান্তিপূর্ণভাবে বসবাসের পর বরাদ্দপ্রাপ্ত ব্যক্তির অনুকূলে ইজারা দলিল রেজিস্ট্রি করে দেয়া হবে।
৪) আশ্রয়ণ প্রকল্পের ফ্ল্যাট কোন উপায়েই হস্তান্তর করা যাবে না।
৫) বরাদ্দপ্রাপ্ত ব্যক্তির মৃত্যুজনিত কারণে শুধু তার বৈধ ওয়ারিশদের মধ্যে হস্তান্তর করা যাবে।
৬) আবেদনপত্রে মিথ্যা তথ্য প্রদান করা হলে কর্তৃপক্ষ আইনানুগ ব্যবস্থা গ্রহণ করতে পারবে।
৭) পুকুরসহ সকল পাবলিক স্থাপনা পরিচালনার জন্য সকল পুনর্বাসিত পরিবারের সদস্য নিয়ে সমবায় সমিতি কার্যক্রম গ্রহণ করবে।
৮) ফ্ল্যাটের ও ভবনের অভ্যন্তরীণ সকল রক্ষণাবেক্ষণের কাজ ফ্ল্যাট বরাদ্দ প্রাপ্তদের করতে হবে।
৯) রক্ষণাবেক্ষণ সুষ্ঠুভাবে পরিচালনার জন্য ফ্ল্যাট বরাদ্দপ্রাপ্ত সকলে একে অপরকে এবং আশ্রয়ণ-২ প্রকল্পকে সহায়তা করতে হবে।
১০) ফ্ল্যাট ইজারা গ্রহণকালীকে ফ্ল্যাটের উপর প্রযোজ্য সকল প্রকারের সরকারি ট্যাক্স, ইউটিলিটি বিল বা অন্যান্য কর পরিশোধ করতে হবে।
১১) উপর্যুক্ত শর্তাবলী প্রয়োগের ক্ষেত্রে কোনো ধরনের জটিলতা বা সমস্যার উদ্ভব হলে তাহা নিরসনের সকল ক্ষমতা আশ্রয়ণ-২ প্রকল্প, প্রধানমন্ত্রীর কার্যালয় সংরক্ষণ করবে।

আপনার বিশ্বস্ত,
স্বাক্ষর
নাম:

১২

গ) প্রকল্পে ফ্ল্যাট বরাদ্দের পূর্বে ৪৪০৯ জন তালিকাভুক্ত জলবায়ু উদ্বাস্তুর মধ্য হতে কোন ব্যক্তি মারা গেলে মৃত ব্যক্তির ওয়ারিশদের আবেদনক্রমে ওয়ারিশদের যৌথ/একক নামে অনুচ্ছেদ ৯ (ক) ও (খ) মোতাবেক ফ্ল্যাট বরাদ্দ দেয়া হবে। তবে এ বিষয়ে সংশ্লিষ্টদের যথাযথ কর্তৃপক্ষ যেমন সংশ্লিষ্ট স্থানীয় সরকার প্রতিষ্ঠান/আদালত/নোটারি পাবলিক কর্তৃক উত্তরাধীকার (পিতা-মাতা, সন্তান, স্ত্রী/স্বামী) সার্টিফিকেটসহ সকল বৈধ কাগজপত্রাদি জমা দিতে হবে।

ঘ) ৪৪০৯ জন তালিকাভুক্ত জলবায়ু উদ্বাস্তু কোন ক্ষতিগ্রস্থ ব্যক্তির মৃত্যু ঘটলে এবং মৃত ব্যক্তির কোন উত্তরাধিকারী (অনুচ্ছেদ ৯ (গ) মোতাবেক পিতা-মাতা, সন্তান, স্ত্রী/স্বামী) না থাকলে কোন ফ্ল্যাট বরাদ্দ দেয়া হবে না।

১০. প্রকল্পে ফ্ল্যাট বরাদ্দ প্রক্রিয়া

ক) উপকারভোগী/ফ্ল্যাট বরাদ্দ পাওয়ার জন্য যোগ্য বিবেচিতদের মধ্যে লটারির মাধ্যমে (অথবা ফ্ল্যাট বরাদ্দ কমিটি কর্তৃক গৃহীত সিদ্ধান্ত মতে) ভবন ও ফ্ল্যাটের অস্থায়ী বরাদ্দ প্রদান করা হবে।

খ) উপকারভোগী/ফ্ল্যাট বরাদ্দপ্রাপ্তগণ ফ্ল্যাট ভাড়া/বিক্রয়/হস্তান্তর/সাব-লেট দিতে পারবে না এবং ফ্ল্যাটের অভ্যন্তরীণ কাঠামোগত বা অনুমোদিত ডিজাইনের কোন পরিবর্তন করতে পারবে না। শুধুমাত্র উত্তরাধীকার সূত্রে (অনুচ্ছেদ ৯ (গ) ও (ঘ) মতে নির্ধারিত) ব্যবহার করতে পারবেন।

গ) তালিকাভুক্ত ৪৪০৯ জন জলবায়ু উদ্বাস্তু ব্যক্তি কর্তৃক পৃথক ভাবে নির্ধারিত ফরমে (ফরম-১) আবেদন (পরিশিষ্ট-১) করতে হবে।

ঘ) তালিকাভুক্ত ৪৪০৯ জন জলবায়ু উদ্বাস্তু ব্যক্তি কর্তৃক পৃথকভাবে অঙ্গীকারনামা (ফরম-২) প্রদান (পরিশিষ্ট-২) করতে হবে।

ঙ) প্রাপ্ত আবেদন যাচাইপূর্বক বরাদ্দপত্র (ফরম-৩) প্রদান (পরিশিষ্ট-৩) করা হবে।

চ) বরাদ্দ প্রাপ্তির তারিখ হতে ০৩ (তিন) বছর শান্তিপূর্ণ ও নিরবচ্ছিন্নভাবে বসবাসের পর ফ্ল্যাট বরাদ্দ কমিটি কর্তৃক ফ্ল্যাটের ইজারা দলিল সম্পন্ন করবে।

ছ) তালিকাভুক্ত ৪৪০৯ জন জলবায়ু উদ্বাস্তু ব্যক্তি কর্তৃক পৃথক ভাবে পূর্ণাঙ্গ আবেদন প্রাপ্তির ত্রিশ দিনের মধ্যে ফ্ল্যাট বরাদ্দ প্রদান এবং বরাদ্দপ্রাপ্ত ব্যক্তিকে ফ্ল্যাট বুঝিয়ে দেয়া হবে।

জ) বরাদ্দকৃত ফ্ল্যাট কোনক্রমেই বাণিজ্যিক বা অন্য কোনো উদ্দেশ্যে ব্যবহার করা যাবেনা। এছাড়া, কমন অবকাঠামো যেমন- পুকুর, মসজিদ, মন্দির, স্কুল ইত্যাদি-এর কাঠামোগত বিকৃতি/পরিবর্তন করা যাবে না।

১১. ফ্ল্যাটের ইজারা দলিল রেজিস্ট্রিকরণসহ মালিকানা হস্তান্তর

ক) ফ্ল্যাট বরাদ্দপ্রাপ্ত ব্যক্তিগণকে বরাদ্দ প্রদানের তারিখ হতে প্রকল্পে নিরবচ্ছিন্নভাবে ০৩ (তিন) বছর শান্তিপূর্ণভাবে বসবাসের পর আশ্রয়ণ-২ প্রকল্প, প্রধানমন্ত্রীর কার্যালয় কর্তৃক বরাদ্দ প্রাপ্ত ব্যক্তির অনুকূলে ইজারা দলিল রেজিস্ট্রি করে দিতে হবে।

৫

Figure 5: Ashrayan policy documents restricting user participation. (Source: GoB, n.d.)

A study on three Ashrayan Projects in Khulna revealed that the failure of the projects was caused by inappropriate site selection, lack of community engagement, and limited provision for future expansion (P. Mallick & Islam, 2019). Another study found that resettled populations face challenges in adjusting to Barrack housing, while the one-size-fits-all design contradicts

the rural settlement pattern, highlighting the need for reconsideration of Ashrayan policy, procedure, and design approaches (A. Parvin et al., 2022). A recent newspaper report reflects on the grim reality of an Ashrayan intervention at Sunamganj Sadar, indicating gentrification, corruption, violation of building code, and susceptibility to various disasters such as frequent floods (The Business Standard, 2024).

In the official Flat Transfer and Maintenance Policy document for Ashrayan-2 Project, section 10. B dictates that beneficiaries/flat allottees cannot rent/sell/transfer/sublet the flat and cannot make any changes to the internal structure or approved design (Figure 5). Additionally, section 10. H prohibits the beneficiaries from utilizing the flat for commercial or other purposes. Finally, section 19. A portion of the policy document declares that if it appears that the flat allottees have violated the terms of the lease, the leasing authority may cancel their lease (GoB, n.d.). Since these top-down projects fail to satisfy the beneficiaries' dynamic spatial needs, many project occupants modify or transform their houses to accommodate specific space requirements (see Figure 6). These modifications are made informally and in violation of government policy regulations enforced by the government.

Figure 6: A makeshift grocery shop on the ground floor of a building at Khurushkul Special Ashrayan Project. (Source: The Business Standard, 2020)

Similar spatial behaviors were observed in many other Ashrayan projects. For example, a study conducted at Bhandarpara Ashrayan found that residents were increasingly changing the housing units provided by the government. Indicators that were effectively employed in the

housing sector included direct labor, locally accessible materials, and a self-help strategy that did not require building plans or permits during the housing transformation process (P. Mallick & Mostafa, 2022). Such practices highlight a fundamental tension between centralized policy decisions and on-the-ground realizations that sustain livelihoods and household resilience. This highlights the need for more flexible and context-sensitive design and governance arrangements in resettlement programs.

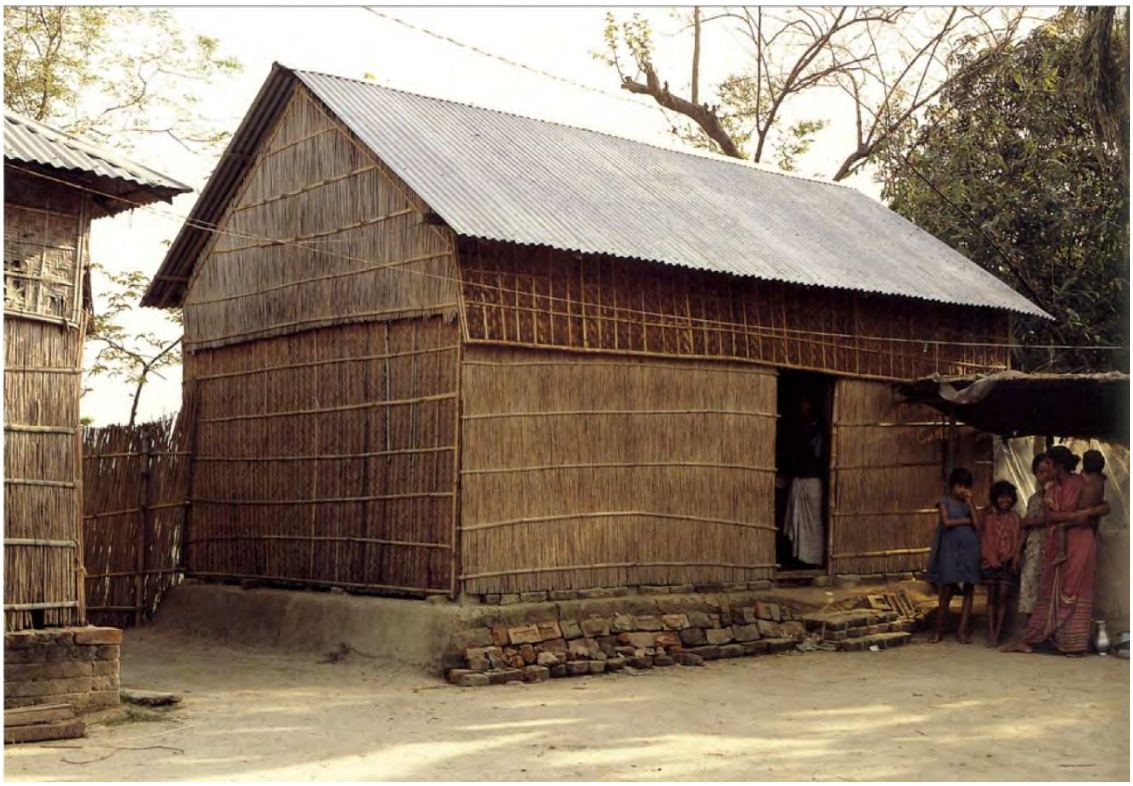


Figure 7: A household under the Grameen Bank Housing Programme. (Source: AKAA, 2013)

In contrast, the Government of India has approved the Delhi Development Authority's (DDA) extensive policy and procedure, which permits additions, modifications, and additional covered space in DDA apartments (DDA, n.d.). In a similar spirit of participation, the Grameen Bank Housing Programme (launched in 1984) provided small, low-interest loans and basic structural frames, enabling poor households, especially women borrowers, to build cyclone-resistant core units and expand them incrementally based on needs and resources (Aga Khan Award for Architecture, 2013). This model of incrementalism combined institutional support with community-led spatial adaptation. The scheme was one of the most successful examples of scalable, sustainable housing in Bangladesh and was awarded the Aga Khan Award for Architecture in 1989 (Figure 7).

2.6 Towards Climate Resilient Migrant Friendly Towns

Marandi & Main (2021) suggest that climate-driven migration is expected to affect American cities, which are divided into three categories: "vulnerable cities," "recipient cities," and "climate destinations." Vulnerable cities face high climatic risk, population declines, and declining tax bases, while "recipient cities" are slightly less vulnerable, despite the proximity to dangerous locations. However, they too are dealing with their fair share of environmental, economic, and social stressors. Climate destinations have better control over climate effects, freshwater availability, surplus housing, and proactive efforts to attract new businesses and residents. In Bangladesh, most rural-to-urban migration ends in Dhaka, the world's fastest-growing megacity, which will struggle to absorb even more migrants (Huq, 2017). Despite clear migration trends, governments lack guidance to manage these shifts, which disproportionately affect marginalized communities. A study conducted in the coastal district of Khulna, (Aziz & Podder, 2023) found that the peri-urban zones of the city have a distinct morphology, supporting migrant adaptability and symbiotic interactions with the core urban region. However, the historically formed pro-migrant character may be lost if growing infrastructure development is not carefully sensitized (Aziz & Podder, 2023).

Bangladesh has experienced rapid urban development over the past four decades, with most of this growth concentrated in Dhaka. By 2011, nearly 44% of the urban population of the country resided in Dhaka, placing immense stress on the city's housing, transport, and other essential infrastructure and services (GED, 2015). This strain intensifies due to a significant influx of people seeking livelihood opportunities, primarily driven by climatic stresses. Projections suggest that approximately 13 million people may be forced to relocate within Bangladesh by 2050, with many migrating to Dhaka and other major cities (Rigaud et al., 2018). Climate migrants are expected to surpass other internal migrants, posing a significant challenge for cities like Dhaka to accommodate this surge (Rigaud et al., 2018).

Within the framework of climate resilience, the 7th Five-Year Plan of Bangladesh highlights the importance of focusing on “transformative adaptation” rather than solely on “climate resilience,” signaling the need for changes from local to national levels (GED, 2015). The growing trend of migration towards metropolitan areas (e.g., Dhaka) exacerbates the urban population challenge (Huq, 2017). As a solution, (Huq, 2022) suggests investing in and attracting migrants to secondary towns to alleviate the pressure on major cities. The most crucial factor in attracting migrants to secondary towns is the availability of livelihood

opportunities, along with basic services such as housing, education, healthcare, water, and sanitation (S. S. Alam et al., 2018).

2.7 Formal or Informal: An Answer to the Housing Question?

Housing for migrants is not only about affordability; it is primarily about cultural and spatial adequacy that allows households to adapt to changing social, economic, and environmental conditions. Affordable housing can simultaneously be relative and subjective (Z. Cai, 2017) and has no universal definition. However, in simple terms, affordable housing means access to adequate housing affordable to the maximum demographics with a mix of various income groups (Mia & Zull, 2020). Historically, top-down design has been crucial for urban infrastructure, but it loses effectiveness while considering individual neighborhoods, allowing spontaneous order to create a fine-grained urban fabric (Bertaud, 2016). In contrast to the top-down process, the bottom-up approach is more likely to successfully overcome the obstacles that prevent the provision of affordable housing, even though governments have implemented enabling policies in their National Action Plans in a top-down manner (Muraya, 2006). In his seminal book titled *Architecture Without Architects,* Rudofsky (1987) also presented a critique of conventional, top-down architectural practices, advocating for the recognition and appreciation of vernacular, community-driven building traditions.

"Informal housing" generally describes an urban settlement that does not follow the rules and laws established by the city in which it takes place. This can happen in various ways, such as non-compliance with building codes, construction on land not owned by the occupier without consent, or development on land designated for other use. Furthermore, without obtaining legal authorization or meeting building requirements, any addition or modification to formal housing can lead to its transformation into an informal dwelling (Calor & Alterman, 2017; Durst & Wegmann, 2017; Potsiou, 2014).

The term "informal" was originally used to characterize labor market and city development practices that took place outside of the structured regulations of society (Portes et al., 1989) and were therefore seen as representative of the global south. However, political economists and urban geographers contest the idea that "informal" is the opposite of "formal" and, therefore, seldom found in the organized cities of the global north. In contrast, they contend that informality should be viewed as "a generalized mode of metropolitan urbanization" (Roy, 2005), created by state institutions that determine what is lawful while overlooking poverty and disparity in cities. Scholars suggest that informality emphasizes a significant power

dynamic between the state and society; therefore, the term cannot be just linked to illegal activity or violating laws or regulations (Yiftachel, 2009; Roy, 2005).

Although informal settlement is frequently perceived as disorderly rather than self-organized, it is considered a kind of urban planning and design that represents a complicated system of insufficiently understood logic (Dovey et al., 2020). A study in Jakarta revealed that factors like market affordability, job opportunities, and social relationships among family members influence self-help incremental housing (Puspita et al., 2024). A study in Australia found that digital platforms have allowed property owners to advertise unlawful rentals and unauthorized homes. However, they have also made it easier for those with a lower income to find affordable housing (Gurran et al., 2024). Another study reveals that despite legal pathways for informal housing development, unauthorized and illegal dwelling units still constitute a significant portion of low and very-low-income housing in Sydney (Gurran et al., 2022).

In Bangladesh, urban planning bodies fail to address informal settlement issues due to policy constraints, recognizing informality as illegal housing activities, making it challenging to incorporate the structural adaptation into formal planning and development efforts (A. Parvin et al., 2016). Jenkins & Andersen (2011) reveal that Maputo's urban development is a blend of formal and informal practices, with complex interactions between the state and residents blurring the lines. It suggests that the formal-informal binary does not help understand urban development and that informal institutions and social values significantly influence it in the Global South. Akinwande & Hui (2024) argue that informal adaptation strategies of the marginalized urban populations can influence the housing supply chain for adequate affordable housing provision, suggesting that modifying and institutionalizing these approaches can improve their suitability.

A case study on Bastuhara Housing in Mirpur found that user-initiated extension activities improve local living conditions rather than "building slums." Additional space for each household and individual, extra services, increased privacy, and more adaptability in room usage are all improvements. The increase in home value that comes after transformation activities is not the result of ongoing shortages or deteriorating conditions; instead, it is a sign of better housing conditions (A. G. Tipple & Ameen, 1999a). Heikkila & Lin (2014) suggest that instead of existing separately, the formal and informal sectors are two dimensions of a single market phenomenon. Informality, for instance, is directly caused by the inadequate absorption capacity of the public sector.

2.8 Urban Morphogenesis and Assemblages

The urban form is not static; it emerges, evolves, and adapts over time through the process of urban morphogenesis. Morphogenesis refers to the incremental processes by which urban form develops, often in ways that are bottom-up, spontaneous, and responsive to local conditions. In informal settlements, these processes are typically driven by small-scale, household-level decisions (e.g., extensions, infills, or rearrangements of rooms and plots that accumulate over time, and generate dense, fine-grained, and path-dependent urban forms. Rather than resulting from rigid master plans, these patterns emerge from the continuous co-evolution of buildings, pathways, and social practices, reflecting the dynamic interplay between people and their environment.

As Alexander (2004) emphasizes, true sustainability arises not from technological fixes but from morphogenetic processes in which buildings and settlements grow organically, like living structures, in harmony with both people and nature. Whitehand et al. (1999) further note that by observing individual houses and small-scale alterations over time, we can see how incremental, owner-driven changes shape the evolution of entire neighborhoods. Similarly, Türkmen (2025) argues that morphogenetic design enables buildings and settlements to adapt, self-renew, and engage symbiotically with their surroundings, suggesting a biologically inspired approach to architecture and urban form. In the context of frequent environmental hazards, these concepts are particularly relevant for understanding the spontaneous and inherent dynamics of city growth.

Assemblage theory, as described by Kamalipour and Peimani (2015) provides a complementary lens for studying these processes. It views cities as dynamic, heterogeneous, and interdependent systems, emphasizing the relationships between social, material, and infrastructural elements. This perspective aligns closely with urban morphogenesis, highlighting that city growth and transformation are not linear or predetermined, but emerge from the interactions and adaptations of diverse actors within the urban fabric. By combining morphogenetic thinking with assemblage theory, we gain a framework for understanding cities as living, evolving assemblages. This lens can be applied in migrant settlements (e.g., informal settlements, and mass housing programs), where residents' everyday adaptations shape both the form and function of the housing environment.

2.9 Incremental Spatial Adaptations in Housing Environment

Housing is a multifaceted concept, often described as a noun and a verb, encompassing both a product and a process (Ruonavaara, 2018; J. F. Turner & Fichter, 1972). Abrams (1964) asserts that housing extends beyond mere shelter to become integral to neighborhood life and social context. The term "informal housing practices" acknowledges the diverse and imprecise range of practices related to residential spaces that fall outside formal legal or regulatory frameworks (Shrestha et al., 2021) In both formal and informal housing environments, morphological transformation is a common strategy among households with low incomes, frequently driven by necessity (G. Tipple, 2005). Avi (2002) highlights that the desire to personalize one's space is as vital as resisting external constraints, reflecting the fundamental human need to create a personal and autonomous environment. Habraken (2021) argues that genuine identification with a space involves personal contributions through construction or modification, fostering a sense of belonging. Informal settlements demonstrate adaptability through mechanisms like adding new structures, expanding settlements, changes in occupancy, family growth, and evolving rental markets (J. F. Turner & Fichter, 1972). Tipple & Ameen (1999b) define any user-initiated extension or alteration of a building or neighborhood as a transformation, emphasizing the dynamic nature of housing adaptation.

Furthermore, humans must have appropriate space to determine which physical locations to use and how to use them. In doing so, people either embrace the intended ideas and regulations established by those who built the space or reframe it to meet their needs and goals (Lange, 2007; Zeiher, 1983, 1990). This process of spatial appropriation is especially significant in informal settlements, where environmental, social, and economic factors sometimes cause residents to adapt or change areas in ways that diverge from their original design or use. According to Dovey et al. (2020), informal settlements are defined by the co-evolution of architecture and urban design, with structures created along existing paths and new avenues emerging among dwellings.

Housing transformation and adaptation to climate change are critical yet understudied areas, especially within informal settlements. These areas, often characterized by their unplanned nature and limited resources, face considerable challenges. Extreme climatic events and environmental changes can lead to significant structural alterations, exacerbating already precarious conditions (Shrestha et al., 2021). Thus, it is vital to understand how these communities adapt their housing in response to migration and environmental pressures. There is a pressing need to investigate sustainable architecture and housing solutions that can

withstand climate impacts while improving residents' quality of life. Developing a comprehensive framework to assess and enhance the adaptation capacity of informal settlements is essential for preventing resource wastage and ensuring that migrated populations achieve a sustainable standard of living.

Cities evolve through a combination of formal and informal processes (Dovey et al., 2017; P. Silva, 2016). The morphology of informal settlements is dense, irregular, and fine-grained, with housing transformation often occurring through micro-scale, socio-physical adaptations by the inhabitants (Kamalipour & Dovey, 2019a). These transformations are usually incremental, involving changes such as dividing rooms for privacy, adding floors, inserting balconies, or reducing setbacks to accommodate new rooms or external stairs. Researchers like (Kamalipour & Dovey, 2019b; Dovey, 2016; Kamalipour, 2016a, 2016b; Rapoport, 1988) have noted that informal settlements expand through generative processes of incremental adaptation and self-organization, addressing immediate necessities rather than long-term outcomes. Parvin et al. (2023) found that households of informal settlements have developed adaptive upgrading strategies to reduce disaster risks, including vertical extension, the use of durable materials, and community-based initiatives. Another study in Mohakhali, Dhaka, Bangladesh, revealed that the housing environment has been modified by adding more floors and dividing ground floors into commercial and residential spaces (Awal & Reza, 2017). Furthermore, incremental, self-built housing allows for sustainable choices in design and materials, enabling residents to adapt their homes over time to incorporate climate-resilient features (Diep, n.d.).

Despite growing interest, the housing adaptation process in informal settlements remains underexplored. Current literature identifies 21 climate-adaptation measures, categorized into passive design, construction technologies, and performance evaluation tools (Raneses et al., 2021). However, research has largely concentrated on broader policy, governance, and characteristics of the ‘informal city’ (Neuwirth, 2016; Roy & AlSayyad, 2004). Micro-scale forms and transformative processes of housing adaptation, however, have received less attention (Kamalipour & Dovey, 2019a; McCartney & Krishnamurthy, 2018; Kamalipour, 2017, 2016a, 2016b). The physical characteristics of informal settlements are often poorly documented, with many areas omitted from official maps and plans (Patel & Baptist, 2012; Suhartini & Jones, 2019). Despite their potential for housing upgrading schemes, unique morphological features have been largely overlooked (Kamalipour, 2016b; Dovey & King, 2011; Duarte, 2009). Current methods fail to address incremental adaptations, fluid property

lines, usage rights, and access to services. Understanding informal settlements requires focusing on their fine-grain, micro-scale morphology rather than adhering strictly to formal land use plans and legal restrictions (McCartney & Krishnamurthy, 2018).

In light of current literature, this avenue of studying informality highlights a critical research niche across multiple scales, bridging urban form, housing practices, and adaptation. This thesis specifically focuses on spatial adaptations within the housing environment, examining how households respond to environmental, economic, and social pressures through incremental and resident-led transformations. By sitting at the intersection of morphogenesis, adaptation behavior, and incrementalism, it provides a focused lens to understand the micro- and meso-scale dynamics that underpin adaptive capacity in low-income settlements.

CHAPTER THREE
RESEARCH METHODOLOGY

This chapter describes the methodology adopted to conduct the research. The research has undertaken a case study design with mixed methods. The first section presents the theoretical influences and philosophical standpoint of the study, followed by a conceptual framework of the research. Further sections describe the research design in detail and establish how the adopted approach satisfies the investigation of the research questions. This chapter also includes sections on the study area(s), rationale for the selection of study area(s), research participants, research methods, and data collection tools.

3.1 Theoretical Influences

The research had certain theoretical influences, such as the assemblage theory by (Deleuze & Guattari, 1987), theory of place by (Canter, 1997), space syntax theory by (Hillier & Hanson, 1984), among others.

3.1.1 Assemblage Theory

The concept of ‘assemblage’ was first introduced in a book by (Deleuze & Guattari, 1987), *A Thousand Plateaus*, which has since been expanded by (DeLanda, 2019) and others into a pragmatic social theory. Assemblage is a socio-spatial network of linkages in which the characteristics and roles of both components and wholes develop from the flows that connect them. Assemblage thinking has the potential to shift architecture away from an emphasis on rigid structure and toward process and transformation. It is a useful way of thinking about ‘place’ theories in terms of process, identity formation, and becoming, without relying on essentialism (Dovey, 2013). Creating space through socio-material dwelling, including transforming spatialities or mobile forms of dwelling, represented through plans, policies, models, and migration, posits space in the center─how it is created, experienced, structured, and reconfigured (McFarlane, 2011).

The theory of Rhizomes is a closely connected topic to this theory. The terms "rhizome" and "rhizomatic" are used by Deleuze and Guattari to define theory and research that allows for multiple, non-hierarchical entry and exit points in data representations and interpretation. An understanding of the topic or phenomenon is that it can occur from multiple, simultaneous entry and exit points since each location on a rhizome can be connected to any other point. The traditional hierarchical models that follow a linear path and give preference to some viewpoints over others are challenged by this. Rhizome theory strongly emphasizes diversity, multiplicity,

and the rejection of rigid systems. It implies that a network of links should be considered rather than approaching issues through discrete categories. This viewpoint makes a more dynamic and comprehensive understanding of complex systems possible, which recognizes the interdependence between components in ways that conventional models can overlook. The theory has influenced several academic fields, such as education, cultural studies, sociology, and planning. According to (Mohammed et al., 2024). By employing the Rhizome approach, slums can be reintegrated into the city's wider urban system through enhancing the entanglements between the pre-existing and newly incorporated structures. The most crucial of these strategies is to use suitable pattern-generation mechanisms and take advantage of the slums' natural growth over time to lessen the discernible structural segregation.

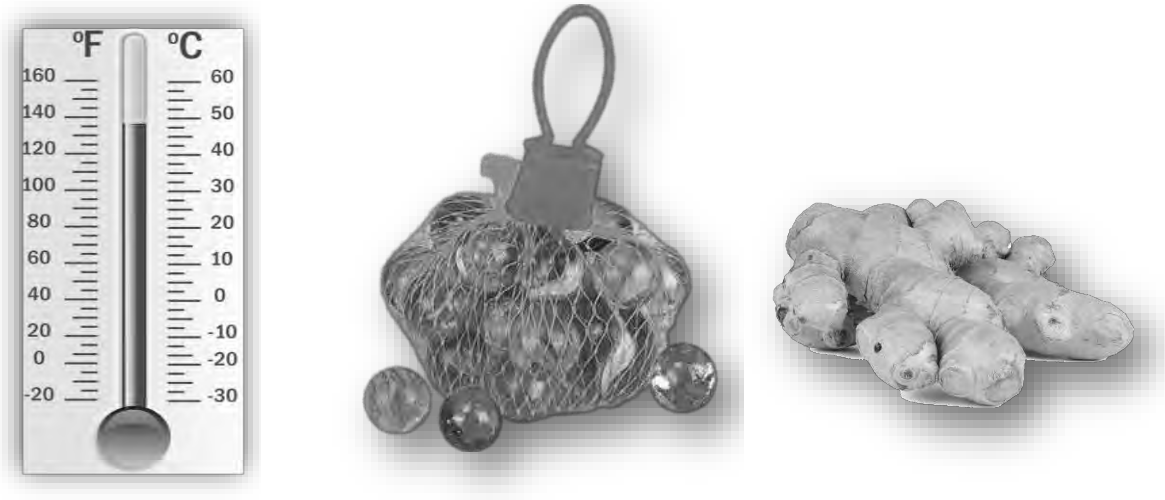


Figure 8: Analogies for a conceptual model of Rhizome theory. (Source: Web)

The key concepts of rhizomes are the following:

i. Non-linear: The concept suggests a non-linear rhizomatic system. For instance, the growth of ginger. One cannot figure out where it started from or where the focus is, nor does it disrupt the system if any portion is cut off (see Figure 8).
ii. Connectivity: Any point can be connected to another in a rhizomatic model.
iii. Heterogeneity: The connection between two points is emphasized here, regardless of similarities or differences.
iv. Multiplicity: Magnitude and dimensions cannot increase without changing their nature. The term multiplicity refers to a qualitative measure that can be illustrated

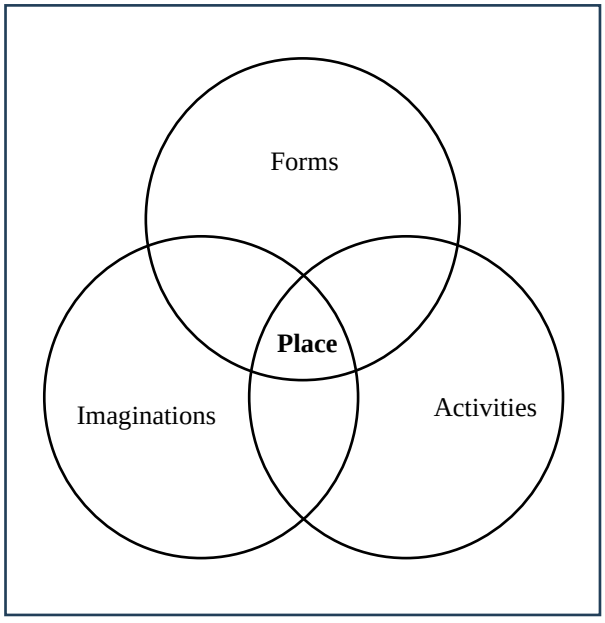
with the use of a thermometer and a bag of marbles example. When it comes to a thermometer, 100 degrees Fahrenheit has a distinct feel, and adding or removing from it alters that sense. On the other hand, adding or subtracting from a bag of marbles does not change the fact that it is still a bag of marbles (see Figure 6). The first is a quantitative measurement, whereas the second is qualitative.

v. Asignifying Rupture: The system can be broken at any point and started up again, referring to its resilience.

vi. Cartography and Decalcomania: These are philosophical concepts related to mapping or understanding rhizomes. Rhizomes are always open and can be entered from any point.

3.1.2 The Theory of Place

David Canter's (1977) concept of place heavily influences the sense of place. This concept is a theoretical framework for understanding the elements of a sense of place. According to Canter (1977), a place includes three dimensions: forms, imaginations, and activities (Canter, 2023). The place is the result of the relationship among (1) forms (object and physical attributes), (2) activities (human activities that occur there), and (3) imaginations (spatial meaning to the user) (Canter, 2023).



Based on the Structuralist school of thought, the Place Model aims to understand the interrelationships between factors that shape place experience. Changes in a single dimension may have resulted in changes in the overall quality of place experience. Canter's Place Model provides an inclusive framework for design research and professional design practice (see Figure 9).

Figure 9: The place model. (Source: Canter, 1977)

3.1.3 Ethnography and Architectural Anthropology

Anthropology is the foundation of ethnography. While ethnography is mainly employed to examine culture, it also demonstrates utility for the sociocultural examination of architectural environments (Sparkes & Howell, 2003). Data collection through ethnography involves systematically observing environmental behavior and physical evidence. This method produces a vast and diverse array of datasets. Ethnographic data can subsequently be examined using content analysis or different interpretive approaches such as semiology, hermeneutics, or psychological interpretation (Karnchanaporn, 2004; Korosec-Serfaty, 1984; Marcus & Francis, 1997; Sparkes, 2005). In sociocultural studies of architectural settings, ethnography proves to be a valuable data collection tool. This is because of its sensitivity to meaning and its ability to detect the comprehensive view of actual lived experiences (Groat & Wang, 2013). The desire to understand humans in a manner distinct from their self-perception is fundamental to both fields. Therefore, architectural anthropology holds significance not only for investigations of vernacular architecture but also for the modern urban environments (Stender, 2019). As Architect Momoyo Kaijima states, '*Life exceeds architecture, yet at the same time, it is the basis and essence of architecture. Understanding its different forms, as ethnography shows, is the precondition of engaging with it.'* This perspective underlines the deep connection between human experience and the built environment. Hence, an ethnographic approach is perhaps crucial for a genuine understanding of interaction with architectural spaces within their sociocultural contexts.

3.1.4 Space Syntax Theory

Space Syntax, a structuralist tool, describes the spatial organization of an architectural setting or settlement, similar to the Place Model (Canter, 1997). The main distinction is in their focus and application. Unlike the Place Model, which emphasizes all three components, Space Syntax focuses solely on two: activities and physical attributes (Groat & Wang, 2013).

Originally developed by (Hillier & Hanson, 1984), Space Syntax is a theory and method based on two assumptions. The first is that a social aspect of space exists, implying that society requires space to express itself. Second, there is an understanding of the social logic of space that can be expressed through mathematical computation. According to the Space Syntax theory, when space is perceived as being made up of distinct entities, the people's social structure depends on how these relationships and connections relate to the system as a whole. With its emphasis on exploring syntactic codes involving spatial types, the Space Syntax method provides a sensitive tool for describing spatial connectivity and demonstrates how

effective it is at elucidating the hidden cause behind a built structure. The socio-cultural aspects of homes, complex structures, and city planning have all been successfully studied using the study of space syntax and other methodologies like architectural semiology (Bafna, 2001; Hillier et al., 1986; Hillier & Hanson, 1998; Lara, 2001).

The analytical space syntax methods strongly emphasize quantitative modeling to reveal the behavioral and sociological dimensions of formal features and the spatial organization of the constructed environment. According to (Pearson & Richards, 1994), space syntax analysis frequently views the unit of analysis only in two dimensions. Syntax and semantics research should be combined to address the aforementioned limitations of space syntax analysis by incorporating knowledge about the usage and meaning of spaces. Researchers consistently use quantitative and statistical analyses to identify spatial patterns in the built environment when assessing the social implications of a house and its spatial configuration (Asriana et al., 2024; Abdullah & Abdullah, 2024; Rihane, 2023; Bustard, 1999; Orhun et al., 1995; Nevett, 1994; Plimpton & Hassan, 1987; Hillier et al., 1986).

3.2 Conceptual Framework

The conceptual framework of the research revolves around the effects of climate change on housing systems, specifically environmental changes and migration. These factors (as independent variables) contribute to a housing challenge that includes both informal settlements and formal planned housing.

The framework identifies three primary forces (moderating variables) driving housing transformations into informal settlements: social dynamics, economic pressures, and environmental stressors. These forces are translated into user-initiated spatial adaptations, representing the inhabitants' adaptive strategies for modifying and optimizing their living environments in response to the aforementioned challenges. Furthermore, the framework recognizes the impact of current policies (controlling variable) on these spatial adaptations. Finally, the framework acknowledges that a quasi-formal approach (as a mediating variable) to planned housing design and delivery can enhance community-led adaptations. These adaptations and interventions collectively contribute to morphological transformations within settlements, causing changes in physical and spatial characteristics (see Figure 10).

In short, the framework connects these transformation activities and spatial strategies to the broader goals of fostering resilient communities and achieving sustainable development.

Further, the research emphasizes the critical role of user-end adaptive interventions in mitigating the vulnerabilities of communities affected by climate-induced challenges.

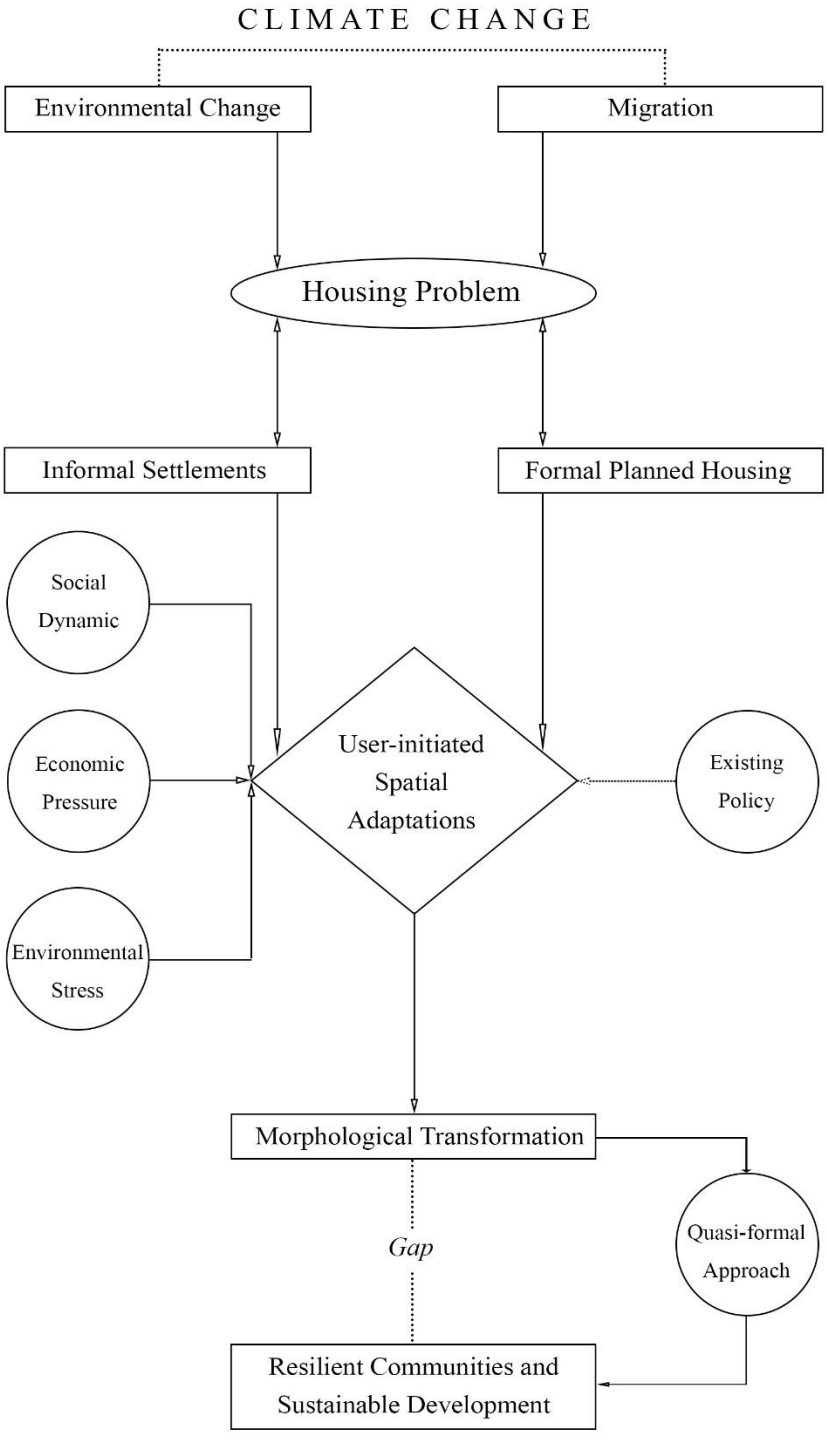


Figure 10: Conceptual framework of the research. (Source: Author)

3.3 Study Area

The research is focused on the northwestern part (cross-sectional) of Bangladesh. It experiences extreme weather, recurring drought, irregular precipitation, and riverbank erosion (Kabir & Kamruzzaman, 2022; S. M. Rahman et al., 2020), which is also consistent with the evidence published by the Intergovernmental Panel on Climate Change about global warming and climate change (Edenhofer, 2015; Stocker et al., 2013). The research concentrates on two study sites in the *Dinajpur* district that are in close proximity to one another. The first site is in *Bijora Union* of *Biral Upazila* (sub-district). This site is situated in a peri-urban area and explores the first research question about informality in formally planned settlements and their characteristics. Furthermore, the data collected from this site helps to establish the first section of the study's hypothesis, which assumes that informal adaptations are residents' responses to sociocultural dynamics, environmental pressures, and economic reality. This site is assumed to be a *sample site* for research. The second is in *Dinajpur Paurasava* (municipality) in *Dinajpur Sadar Upazila*, about six kilometers from the *sample site* and an urban area. This site expands on research to test the hypothesis utilizing a combination of qualitative and quantitative methods. This will be referred to as the *target site* (see Figure 11).

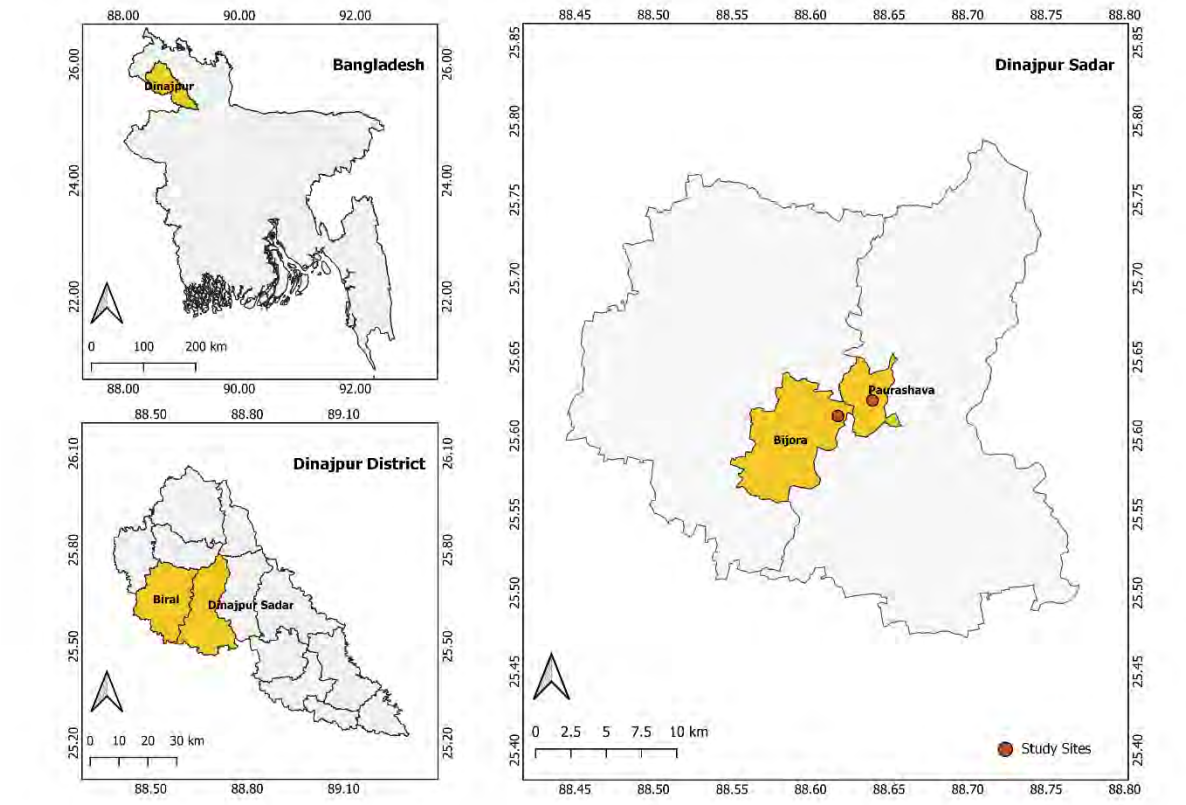


Figure 11: Study area map. (Source: Author)

The coordinates of the *sample site* are 25°36'38.2" N 88°37'10.6" E, and the community is called *Sri Krishnapur Ashrayan Community* after the name of the housing project provided by the Government of Bangladesh in 2001 (Figure 12). The settlement is designed as barrack-style housing, with ten houses in each barrack. There are ten barracks for 100 families, each with a land lease of *two shotok* (approximately 850 square feet). The houses are *kutcha* (temporary materials), with shared services such as one toilet per barrack. There is an electricity provision and other ecosystem services, such as two ponds.

Figure 12: Sri Krishnapur Ashrayan Project (sample site). (Source: Author)

Figure 13: Jogen Babur Maath (target site). (Source: Author)

The *target site* is located in *Dinajpur* city, with coordinates 25°38'02.3" N, 88°38'54.4" E. The community is called Jogen Babur Maath (Figure 13). The land was originally owned by *Jogen Babu*, a Hindu landowner who emigrated to India during the partition in 1947. The government has de facto ownership of the land at present. Although households lack individual title deeds, many do have 'right to stay' documents from the local government. The area has been established for many years, and with the threat of eviction low, many residents have invested in pucca (permanent) housing. *Jogen Babur Maath* is home to both Hindus and Muslims. They came from various parts of northwest Bangladesh, primarily for environmental and economic reasons. They pursue various jobs, including TV repairmen, day laborers, and rickshaw pullers, earning between Tk.350 and Tk.400 daily. Although some women work outside the area, most stay home and earn extra money through home-based activities like *poppadom* rolling or handicrafts.

3.4 Rationale for Selection of the Study Area

According to the Census of Slum Areas and Floating Population, Dinajpur district contains the highest number of informal settlements, with around *34,000* people living in these settlements (BBS, 2014), indicating greater livelihood opportunities and higher rates of immigration. These

factors make it an ideal location for studying the patterns of informality in migrant settlements. Regarding the study sites, the *Sri Krishnapur Ashrayan Project* is an outcome of the Bangladesh government's project that aims to rehabilitate homeless, landless individuals, including disaster-displaced people. Although the community is in a peri-urban area, it has a good communication system with the city center. Additionally, the community has been residing there for nearly 25 years, which makes it ideal for researching the residents lived experiences across space and time. On the other hand, the *Jogen Babur Maath* area is relatively low compared to the surrounding area, making it particularly vulnerable to water clogging. In 2017, the site was severely inundated, with ground floor levels submerged for several days, resulting in significant damage. Many people were displaced during this event, seeking shelter in relatives' homes or renting short-term accommodations. This context is critical for studying the informal housing paradigm in vulnerable communities because it highlights the challenges environmental forces pose in their socioeconomic contexts.

3.5 Sampling Technique and Research Participants

A combination of theoretical sampling techniques, such as convenience sampling and snowball sampling guides the selection of suitable data sources and the necessary number of samples (Auerbach & Silverstein, 2003). The study adopts three distinct techniques to gather data: non-participant observation, semi-structured interviews, and focus group discussions (see section 3.6). Initially, sample households were selected with the assistance of community leaders and local informants; later, samples were located utilizing references and social networks. As a result, fourteen households were ultimately chosen for the study. The following criteria were used to select the sample: (a) the sample must have come from a different administrative district than the one they currently reside in and have a history of internal migration; (b) the sample household must have a home of their own or a space that was negotiated for the sole purpose of providing shelter for the sample; and (c) given the high vulnerability of riverbank erosion in northwest Bangladesh, migrants resulting from river erosion were sought out and given priority. A number of areas from the study area were chosen for mapping and observations because they represented 10–15% of the entire settlement and had different formal characteristics. To maintain gender balance during focus group discussions, separate arrangements with male and female participants were given priority. The information about the study participants and sample sections is detailed in Table 1.

Table 1: Study sample description. (Source: Author)

Methods	Nos	Participant/Section Nos	Participant Nature
Non-participant Observation	04	Four zones across two study sites	The specified sections at *Sri Krishnapur Ashrayan* and *Jogen Babur Maath*
Semi-structured interviews	14	14 households across two study sites	Household heads, family members, and relatives at *Sri Krishnapur Ashrayan* and *Jogen Babur Maath*
Focus group discussion	2	Male = 11 Female= 20	Community members of *Jogen Babur Maath*

3.6 Research Methods

Methodologically, most studies draw on the case study method using documents and interviews as primary data sources. However, a few studies suggested that ethnography and video analysis might also be suitable for analyzing the everyday work practices of those creating space (Knoblauch and Heath 2006).

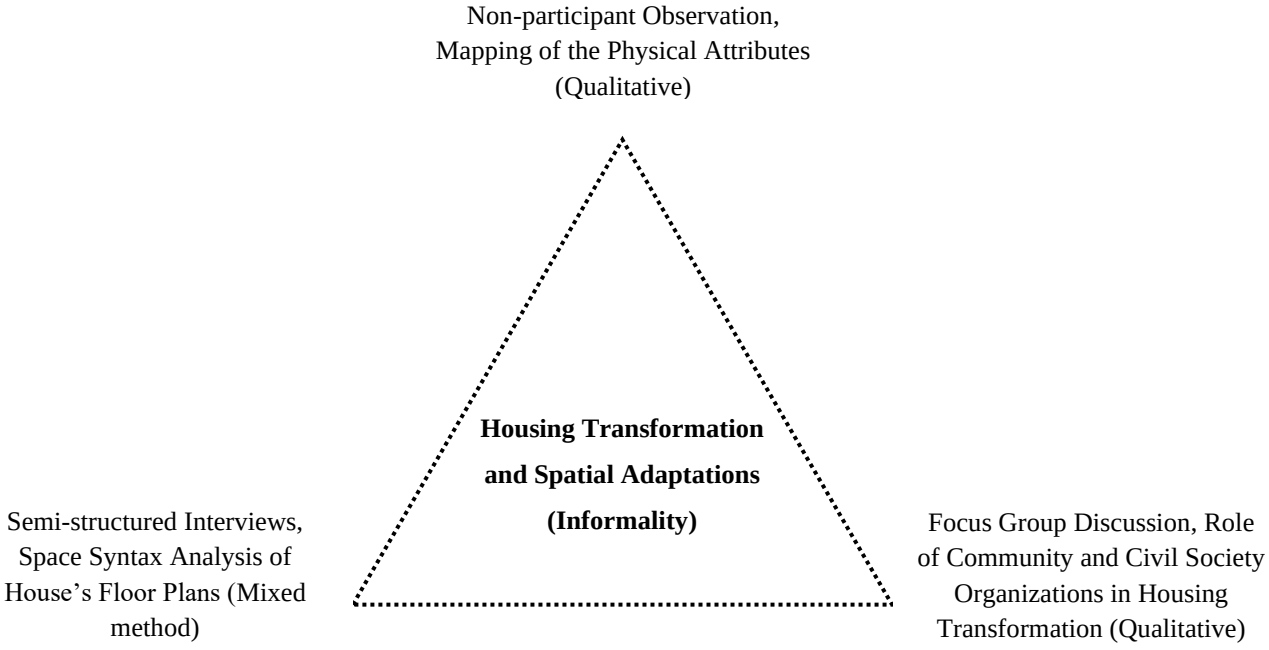


Figure 14: Triangulation of research methods. (Source: Author)

The research adopts a mixed-methods approach and incorporates both qualitative and quantitative data. Non-participant Observation was used to map the morphogenesis of the settlements. Additionally, semi-structured interviews and focus group discussions were conducted to understand the individual and collective behavior of the community, respectively. (see Figure 14).

3.6.1 Non-participant Observation

Non-participant observation is when an observer does not engage in human interaction in the field (Ciesielska et al., 2018). This approach allows for systematically observing and documenting physical transformations without actively engaging with the residents of a community. The observations were partially structured with predefined attributes and typologies adopted from (Jones, 2021). However, the typologies were expanded where necessary, considering the research question and context.

In the observations of the *sample site*, a single specified section containing 20 households was selected for mapping. In the case of the target site, three sections were chosen to record observations: (a) one section adjacent to a vehicle-dominant road, (b) a section of an intimate, pedestrian-dominated road with houses on both sides, and finally, (c) an internal road adjacent to an open space. At the *target site*, there are roughly 70 households in all three sections. The observer documented each observation on a hard copy of the observation tool for each section by following predetermined guidelines (see Appendix A). Additionally, an important principle of this kind of observation is taking field notes, realizing the fact that observation is a selective endeavor (Emerson et al., 2011).

3.6.2 Semi-structured Interviews

A total of 14 in-depth interviews were conducted (see Figure 15): two at the *sample site* (Sri Krishnapur Ashrayan) and the remaining twelve at the *target site* (Jogen Babur Maath). The interviews are the primary data source for matters such as the historical evolution of the dwelling, daily activities, occupant perception of their housing environment, and historical and socioeconomic accounts of migration.

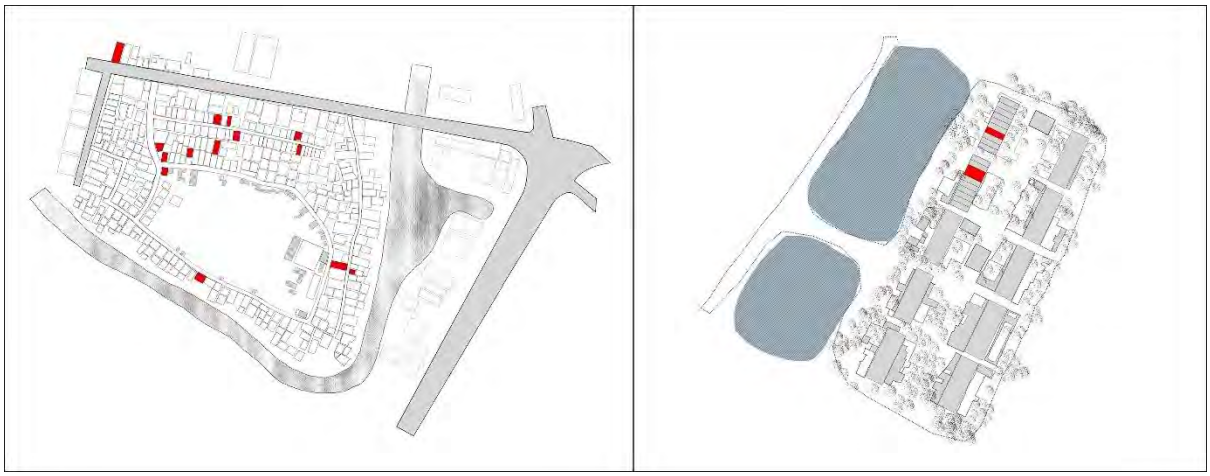


Figure 15: Location of the study households. (Source: Author)

During each visit, local contacts and community members guided the researcher into the house. The researcher then explained the purpose of the study to the family members and also requested consent from the interviewees. In most cases, the head of the household attended the interview alone after providing written consent to participate in the study. The participants were also asked for approval to photograph/videotape the homestead and record the interview (Figure 16).

Figure 16: Data collection through interviews. (Source: Author)

The whole interview was conducted in Bangla language as it is native to the research participants. Each interview (often multiple sessions) lasted around an hour on average, including some walk-along sessions when necessary. The questions were based on several predefined household profile information and some open-ended questions to better understand their lived experience, particularly focusing on the spatial adaptation behavior of the residents (see Appendix B). During the interviews, the author took field notes and drew annotated hand sketches to document occupant behavior. All interviews were audiotaped on researchers' mobile phones and later transcribed in English for data analysis.

3.6.3 Focus Group Discussions

Two separate focus group discussions, one with men and the other with women, were conducted at *Jogen Babur Maath* (Figure 17). The discussions were guided by an open-ended questionnaire (see Appendix C) and were conducted in Bangla. Community members were invited to meet at the community center to discuss their living situations, perceptions of hazardous living conditions, and collective efforts to mitigate vulnerabilities. The FGDs included more than twenty female and ten male participants of varying ages (see Table 1). The discussants answered questions, engaged in debate, and mapped together. The entire discussion was recorded as audio data and later transcribed for analysis.

Figure 17: Focus group discussions with male and female groups at JBM. (Source: Author)

3.7 Data Collection Tools

The study has employed several data collection tools to ensure a representative dataset. While conducting semi-structured interviews, responses were initially recorded on paper (e.g., texts, sketches, drawings) and then captured as audio data on the researcher's mobile phone. These recordings were later transcribed and analyzed. The current spatial arrangement and use of the households were documented using *LiDAR 3D scanning* technology via *Polycam* on an iPad and videotaped on a mobile phone (Figure 18).

Figure 18: Samples from flattened 2D house plan sketches from 3D scans. (Source: Author)

Mapping was used as a tool for gathering data on urban morphogenesis while observations were being documented. Many contributions to urban morphology studies can be interpreted, synthesized, and mapped using a basic Cartesian grid (Gauthier & Gilliland, 2006). Additionally, mapping was adopted as a tool to engage in focus group discussions. Lastly, many photographs and video footage were taken while making observations to examine, verify, and interpret the data.

CHAPTER FOUR
DATA ANALYSIS

This chapter describes the analytical methods and techniques used in the study. The three separate analytical processes are (a) settlement morphogenesis analysis, (b) spatial meaning analysis, and (c) spatial organization analysis. These procedures lead to typology analysis, thematic analysis, and space syntax analysis, respectively.

4.1 Analysis of Settlement Morphogenesis

The data in this section primarily comes from the non-participant observations in the specified sections of the study sites. The predefined typologies to observe were building forms that expanded further compared to their initial negotiated state, thus creating fluid property lines while accommodating varying support services. The collected field data were first processed, transcribed, and translated. Later, the data were analyzed to develop typologies that emerged from the observations.

4.1.1 Data Preparation

The collected field data (mapping) were reproduced in *Adobe Photoshop* with reference to recorded videotapes to enhance accuracy and understanding. The observer comments and field notes were then compiled to produce plausible interpretations. Each predefined typology was assigned specific symbols or legends, and new typologies were identified.

4.1.2 Typology Analysis

In order to obtain a deeper comprehension of how the physical form and spatial organization of the city are evolving, the typology analysis is situated within the larger field of urban morphology studies (Carmona, 2010; Moudon, 1997). Socio-physical forms define settlement, streets, alleyways, plot patterns, and typologies, which are supported by their connections to space, time, and function, as well as social-cultural and economic forces that shape change (Jones, 2021). First, maps were created based on the household's story levels and building materials. Furthermore, user-initiated expansion/extension and spatial negotiations were mapped providing critical insights into boundary fluidity and settlement morphology. Among the households of the *sample site*, typologies of *setback*, *aligned*, and *setback-aligned* were found to be dominant types, whereas at the *target site*, in addition to the typologies mentioned above, *setforward* and *aligned-setforward* were dominant forms (see Section 5.1 and 5.2).

4.2 Analysis of Spatial Meaning

The study carried out fourteen in-depth interviews in total. These semi-structured interviews included some structured information in the first section, which was analyzed to create a household profile. The interviews provided raw data on the historical evolution of home arrangements and household spatial adaptations. Furthermore, the interviews provided detailed information about how households respond to environmental challenges, economic pressures, and family growth. After compiling these qualitative data, themes were identified, and user responses were cross-examined to determine effective adaptation strategies.

4.2.1 Data Preparation

First, transcripts from qualitative interviews with 14 migrant households were transcribed and coded, resulting in themes such as environmental adaptation, economic adaptation, and social adaptation. Then, in Google Sheets, snippets from interview transcripts, architectural drawings, 3D scans, and photographs were organized by broad theme. Cross-referencing spatial data with interview responses will allow for a more comprehensive analysis of how physical changes in space relate to the residents' lived experiences and adaptation strategies. This structured data preparation will serve as the foundation for a deductive process, making it easier to identify dominant patterns and themes in the adaptation and appropriation of space in migrant settlements.

4.2.2 Thematic Analysis

The thematic analysis identifies three overarching themes—environmental, economic, and social adaptation motivated by existing literature (Jabeen et al., 2010; Olgyay, 2015; Pachauri, 2014; Priemus, 1986; J. F. C. Turner, 1976). The sub-themes of environmental adaptation—natural hazards, rainfall and water management, heat and insulation, energy efficiency, vegetation, and sustainability—emphasize climate resilience strategies like raising floor levels, improving insulation, and integrating vegetation. The sub-themes of economic adaptation, which include alternative income sources and access to credit and financing options, focus on how households diversify their sources of income and secure financial resources. Finally, social adaptation documents formal changes in response to household growth, social dynamics, and privacy, displaying how spaces are negotiated to accommodate the changing needs of expanding families and communities. Table 2 summarizes the thematic analysis; details of the analysis using household data can be found in Appendix D.

Table 2: Thematic analysis of adaptation behavior. (Source: Author)

Themes	***Sub Themes***	***Adaptation Tools***	***Abbreviation***	***Adaptation Measures***
Environmental Adaptation	Natural Hazards, Rainfall, and Water Management	Structural integrity and building materials	SBM	Incremental construction using permanent/semi-permanent materials for durability.
		Construction of protective measures	CPM	Raising the plinth level
				Masking with permanent materials
				Wall/Roof bracings
		Dismountable facade	DMF	Removable facades for flexibility
		Repair/renovation	REN	Repair works of the foundation/wall/roof
		Independent access to services	IAS	Installing tubewell
				Construction of a toilet
	Heat and Insulation	Natural ventilation	NVT	Conservation of open spaces
				Cross ventilation with windows/doors
		Technical	TEC	Shading mechanism
				Suspended ceiling as insulation
	Energy Efficiency	Spatial adaptations for efficient technologies	SET	Adapted cooking space for electric *Magic Chula*
	Vegetation	Productive gardening, shady trees	PGT	Small-scale gardening, planting shady trees
	Sustainability	Sustainable materials	SUM	Recycling old materials for construction
Economic Adaptation	Alternative Income Source	Multifunctional buildings/units	MFB	Common space appropriated for business
				The living area transformed into a small shop (adjacent)
				An income-generating space is adapted (isolated)
				The living area was transformed to accommodate cattle/husbandry
	Access to Credit and Financing Options	Agency	AGY	Involvement in a cooperative
				Support from external forces GoB/NGOs/INGOs
Social Adaptation	Household Growth and Social Dynamics	Horizontal extensions	HEX	Room extension horizontal for additional sleeping space
				Room addition horizontal for additional sleeping space
				Room addition horizontal for additional service space
				Room division for additional separate sleeping space
		Vertical extensions	VEX	Room addition vertical for additional sleeping space
				Room addition vertical for additional service
		Multifunctional buildings/units	MFB	Service spaces appropriated as additional sleeping space
				Sleeping space converted into other functional spaces
				Common area appropriate for services
	Privacy, Health, and Hygiene Needs	Independent access to services	IAS	Installing tubewell
				Electric motor water supply
				Construction of a toilet

4.3 Analysis of Spatial Organization

This section describes the analytical procedure of spatial organization and the use of interior spaces or genotypes motivated by the work of (Nanta, 2009). The frameworks used to compare spatial organization are 1) relative position and 2) spatial integration. The materials for the analysis and discussion are obtained from fieldwork data (drawings, measurements, 3D scans, etc.), and interviews with house occupants. Spatial metrics, including Relative Asymmetry (RA), Mean Depth (MD), and Integration (I), were computed using the space syntax method on *depthmapX*. Appendix E contains details on the procedure and calculations.

4.3.1 Data Preparation

To perform the Space Syntax analysis, *Autodesk AutoCAD* was used to create simplified homestead plans, which were then saved as DXF files. The DXF file was then imported into *depthmapX* to perform a convex graph analysis for each house. Convex maps were generated for both floors as a single spatial system, particularly for two-story dwellings, and stair connections were manually linked in DepthmapX environment.

4.3.2 Space Syntax Analysis

The 'relative position' concept examines how spaces are related and connected. This refers to placing spaces within a building and their relationship to the surrounding environment. According to (Hillier & Hanson, 1984), spatial "integration" and "segregation" refer to the measurable spatial metrics mathematically generated through space syntax analysis. Spatial integration is described based on three metrics: mean depth (MD), mean relative asymmetry (RA), and mean integration value (I). The Mean Depth scales how shallow or deep an individual space is relative to other spaces and the entire complex. A lower mean depth indicates a space is easily accessible and well-connected, while a higher value suggests isolation and limited connectivity. Relative Asymmetry reflects spatial integration; lower RA values indicate well-integrated spaces, while higher values suggest segregation. Integration (I) is a normalized measure that compares built settings. Higher I value represent easily accessible, interconnected spaces, while lower values indicate deeper, more hierarchical layouts. Appendix E contains formulas and a thorough explanation of these analyses.

CHAPTER FIVE
RESULTS AND FINDINGS

This chapter describes the results and findings of the research. The findings are presented in two parts. The first part presents the findings from the *sample site*, a planned settlement, while the second part describes the findings from the *target site*, an informal settlement. Specifically, the first section describes the findings from the primary data collected at the *Sri Krishnapur Ashrayan Project*, such as morphogenesis, schedule of spatial adaptations, and results from the quantitative analyses of spatial configuration. The second part performs the same function as the first section for *Jogen Babur Maath*. Finally, the second section includes findings from the focus group discussions at *Jogen Babur Maath* at the end of this chapter.

5.1 Findings from the Planned Settlement (Sri Krishnapur Ashrayan Project)

Sri Krishnapur Ashrayan (sample site) is a barrack-style housing in a peri-urban setting. There are 10 barracks and some community facilities and spaces, with a few areas built nearby. About 100 families live on this housing project. The government provided each family with a 300 sqft (10 feet x 30 feet) dwelling. However, field observations and data (see Table 3) indicate that many of these units have been expanded over time. For instance, household SH1 expanded its homestead area to 570 square feet. Similarly, household SH2 increased its space to 1,090 square feet, more than triple the original area. Most homesteads in this community are well above the original allocation, reflecting adaptation to household needs and socio-economic drivers.

Table 3: Profile of Sri Krishnapur Ashrayan Project community. (Source: Author)

ID	No. of People in HH	Monthly Income (BDT)	Per Capita Income (BDT)	Total Area (sqft)	Space Per Person (sqft)
SH1	5	15500	3100	570	114.0
SH2	6	12500	2083	1090	181.7
Mean	**5.5**	**14000**	**2592**	**830.0**	**147.9**

The overall site is adequate, providing open spaces and two ponds. The section chosen for observation is in the north of the whole settlement, comprising two sheds among the ten (see Figure 19).

Figure 19: The sample site at Sri Krishnapur Ashrayan Project. (Source: Author)

Figure Description: (a) Map of Sri Krishnapur Ashrayan showing the observed area; (b, c) open spaces in front of the HHs utilized for interaction; (d) open space behind the HHs designated for services.

5.1.1 Morphogenesis at Sri Krishnapur Ashrayan Project

Findings from the selected section SS01 (n=20) reveal that all the houses are one story in height. Additionally, while most of them are *Kutcha (75%)* in terms of structure and materials, some houses were observed with *semi-pucca* (25%) built forms (Figure 20).

Figure 20: Housing typologies at sample site based on structural quality and materials. (Source: Author)

Figure Description: (a) Physical structure of section SS01; (b) a government-provided kutcha house; (c) outdoor seating in front of HH; (d) open space in front of HH; (e) passage between barracks.

The primary typologies of spatial adaptations were observed *setback, aligned,* and *aligned setback,* comprising *20%, 25%,* and *55%,* respectively. Further, some activities activate a certain space for a temporary period, for instance, drying straws in front of the house, making and selling *pithas* (a kind of rice cake) in winter, and leaving the cattle tied to a tree in front of the house. These activities and spaces play an important yet invisible role in shaping the sense of boundary and territory. Finally, detached formal extensions to the main house are primarily services, such as toilets, tubewells, etc. (see Figure 21).

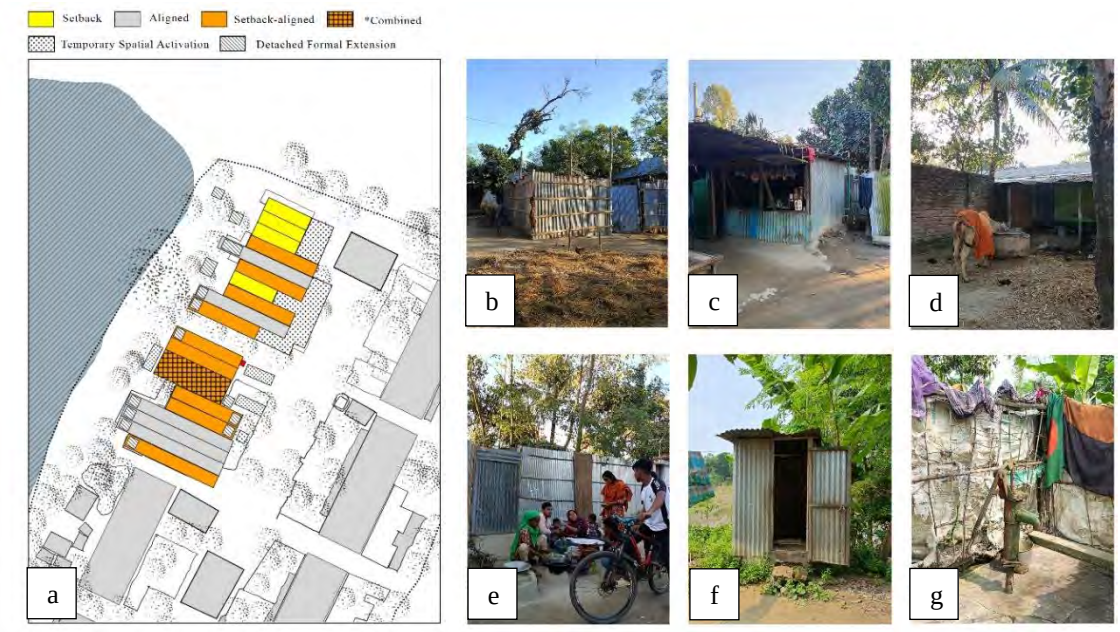


Figure 21: Housing typologies at sample site based on morphogenesis. (Source: Author)

Figure Description: (a) House typologies by morphogenesis; (b) temporary hay drying; (c, d, e) spatiotemporal economic activities: shop, livestock, and seasonal business; (f–g) adapted services: a kutcha toilet, and tubewell.

In this planned settlement, the lots are allocated to the lessees by the government, and relatively better tenure security is present here. Hence, boundaries here are defined through spatial negotiations among community members. While recording the observation, *setbacks were defined as houses with setbacks on both sides,* considering their initial form. *Aligned* types are drawn from observing spatial behavior in which each barrack resident defined fluid boundaries for their households, which the inhabitants claimed through constructing a physical envelope or locating various services within their defined boundary for extensions and spatial negotiations. Finally, *setback-aligned* houses have one side aligned with the other houses, and the other side has a clear setback. Although the individual home lots are small (300 square feet), the overall site area is quite large, with front-to-back open spaces and two ponds, characterizing the peri-urban context.

5.1.2 Spatial Adaptations at Sri Krishnapur Ashrayan Project

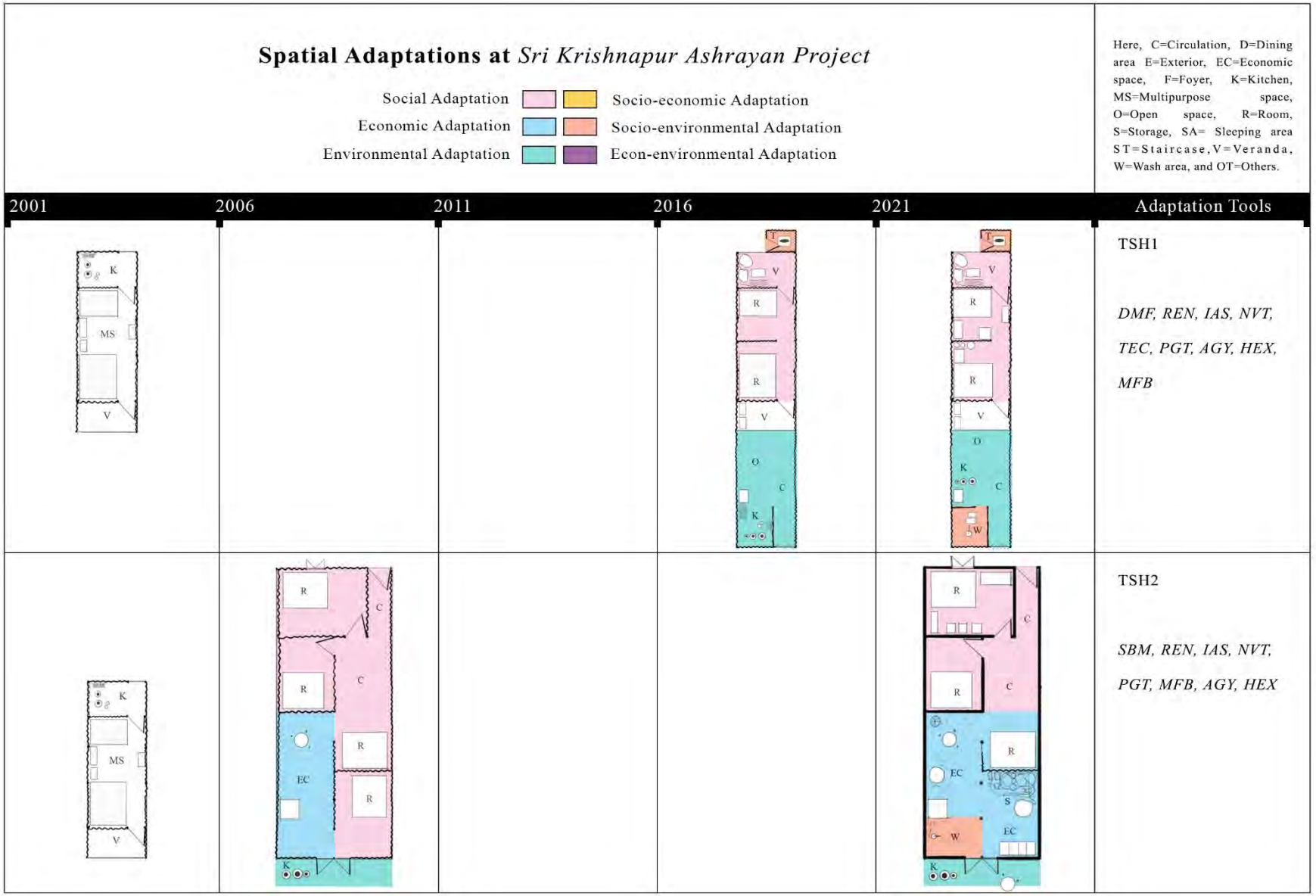
The Government of Bangladesh provided the beneficiaries with a plot of *2 shotok* and a 10-foot by 30-foot dwelling. In this row housing, 80% of the dwellings within each barrack are blocked on two sides, excluding those located at the terminal plots. Two sample households were identified and documented. The researcher emphasized oral histories and drawings of spatial arrangements and adaptations in the documentation process. One interviewee said, *"When it rains, water seeps into my house, flooding everything—including our beds. To keep the floor dry, I've spread plastic sheets over the bare earth. The only light and air we get is through a hole in the front wall. And for the toilet, we share a single government-provided one with five other families."*

Thematic analysis revealed three primary categories of adaptation: social, economic, and environmental. Additionally, overlapping themes emerged, such as socio-economic adaptations, where interventions supported social and economic functions. Similarly, adaptations offering both social and environmental benefits were categorized as socio-environmental, while those combining economic and environmental functions were identified as econ-environmental. These overlapping themes were derived from empirical data, tracing specific strategies and interventions of the community members to adapt their living environments.

The *sample site* displays that most adaptation interventions were influenced by social dynamics, followed by economic and environmental adaptations of spaces (see Figure 15). One of the participants explained, *"At first, we had just one bedroom with a small kitchen attached. Later, we moved the kitchen outside and extended the room slightly. There was open space on both sides, and a shared government toilet stood at the back. As our children grew, we divided the large room into two smaller ones. When our daughter got married and moved out, our son took her room. Now, he's married and lives here with his wife."*

Economic adaptation highlighted cattle rearing and husbandry, while environmental interventions were mostly the conservation of open space and planting shady trees. Overlapping themes, such as socio-environmental adaptation, were noticed, such as installing individual tubewells and toilets; however, the prime reason here is privacy. One of the interviewees elaborated, *"We raise cows, goats, ducks, and chickens for our livelihood. Over time, we gradually upgraded our kutcha house to a semi-pucca one using money from selling livestock. We converted the front part of our house into cattle shed. But our income is unpredictable—sometimes we have plenty, other times, nothing at all"* (see Figure 22).

Figure 22: Spatial adaptations at sample site. (Source: Author)



In summary, the adaptation strategies in the sample households were shaped by social, economic, and environmental factors. Socially, families reorganized spaces for privacy and functionality. Economically, livestock rearing supported livelihoods, while environmental adaptations focused on conserving open space and planting trees.

5.1.3 Degree of Spatial Integration at Sri Krishnapur Ashrayan Project

It is essential to understand spatial dynamics within the built environment to enhance functionality and adaptive capacity. Within the planned context of the sample site, two sample households (SH1 and SH2) were selected, and their spatial data were analyzed for different phases (see Table 3). The following value bands were assumed based on site-specific observed distribution:

High Integration: ≥ 0.70

Moderate Integration: $0.60 \leq I < 0.69$

Low Integration: < 0.60

Low Asymmetry: $RA < 0.45$

Moderate Asymmetry: $0.45 \leq RA < 0.55$

High Asymmetry: $RA \geq 0.55$

Initially, both SH1 and SH2 shared a similar spatial configuration. They had a Mean Integration (I) of 0.63, a Mean Depth (MD) of 2.00, and a relatively high Relative Asymmetry (RA) of 0.67. It indicates that the original layouts were moderately connected but still had a degree of spatial separation between rooms. This is typical of the standardized Ashrayan layout provided (see Table 4).

In Phase Two, the two houses began diverging in their spatial adaptation. SH1's integration value dropped to 0.59 while its depth increased to 3.24. It implies that the house grew more complex with additional rooms. However, the RA improved to 0.56, suggesting that even though some areas became harder to reach, the overall balance of the layout was marginally better than before. Meanwhile, SH2 showed significant improvement. Its integration rose to 0.71, falling under the high integration category. Additionally, the RA dropped to 0.48, indicating a more balanced and accessible spatial hierarchy. Although its depth also increased to 2.91, the layout changes led to improved connectivity rather than separation.

Table 4: Results of space syntax analysis at sample site. (Source: Author)

	Phase One			Phase Two			Phase Three		
Household ID	Mean I	Mean Depth	Mean RA	Mean I	Mean Depth	Mean RA	Mean I	Mean Depth	Mean RA
SH1	0.63	2.00	0.67	0.59	3.24	0.56	0.64	3.27	0.51
SH2	0.63	2.00	0.67	0.71	2.91	0.48	0.70	3.21	0.44

In Phase Three, SH1 improved slightly, with a moderate integration value of 0.64. The RA value improved to 0.51, even though the depth increased again to 3.27. It reflects a continued expansion but with improved organization and access. On the other hand, SH2 continued to optimize its space. Its integration remained high at 0.70, and RA decreased to 0.44. It means an increasingly integrated and efficient layout. Though the depth reached 3.21, the internal spatial logic was sound (see Table 4).

The houses are categorized in terms of their degree of integration in Table 5.

Table 5: Categories of spatial integration of sample houses. (Source: Author)

Category	HH Codes	Characteristics
High Integration	SH2 (Phase 2, Phase 3)	Highly connected and accessible spaces, with easy access between rooms.
Moderate Integration	SH1 (Phase 3)	Spaces are moderately connected, with some degree of spatial fragmentation.
Low Integration	SH1 (Phase 1, Phase 2), SH2 (Phase 1)	Spaces are deep, isolated, and less accessible.

Convex Maps illustrate the spatial depth and integration of housing units. *Red* represents high integration, indicating highly accessible and central zones within the settlement. *Green* implies moderate integration, suggesting balanced accessibility and somewhat connected spaces. *Blue* represents low integration, which indicates peripheral or isolated areas with less connectivity. *Yellow*, *Orange, Cyan,* and other hues indicate varying levels of integration in the whole spectrum. The Justified Plan Graphs further complement the analysis by displaying the spatial layout and arrangement of spaces. Figure 16 reveals the evolution of spatial relationships within the house, where C=Circulation, D=Dining area, E=Exterior, EC=Economic space, F=Foyer, K=Kitchen, MS=Multipurpose space, O=Open space, R=Room, S=Storage, ST=Staircase, V=Veranda, W=Wash area, and OT=Others (Figure 23).

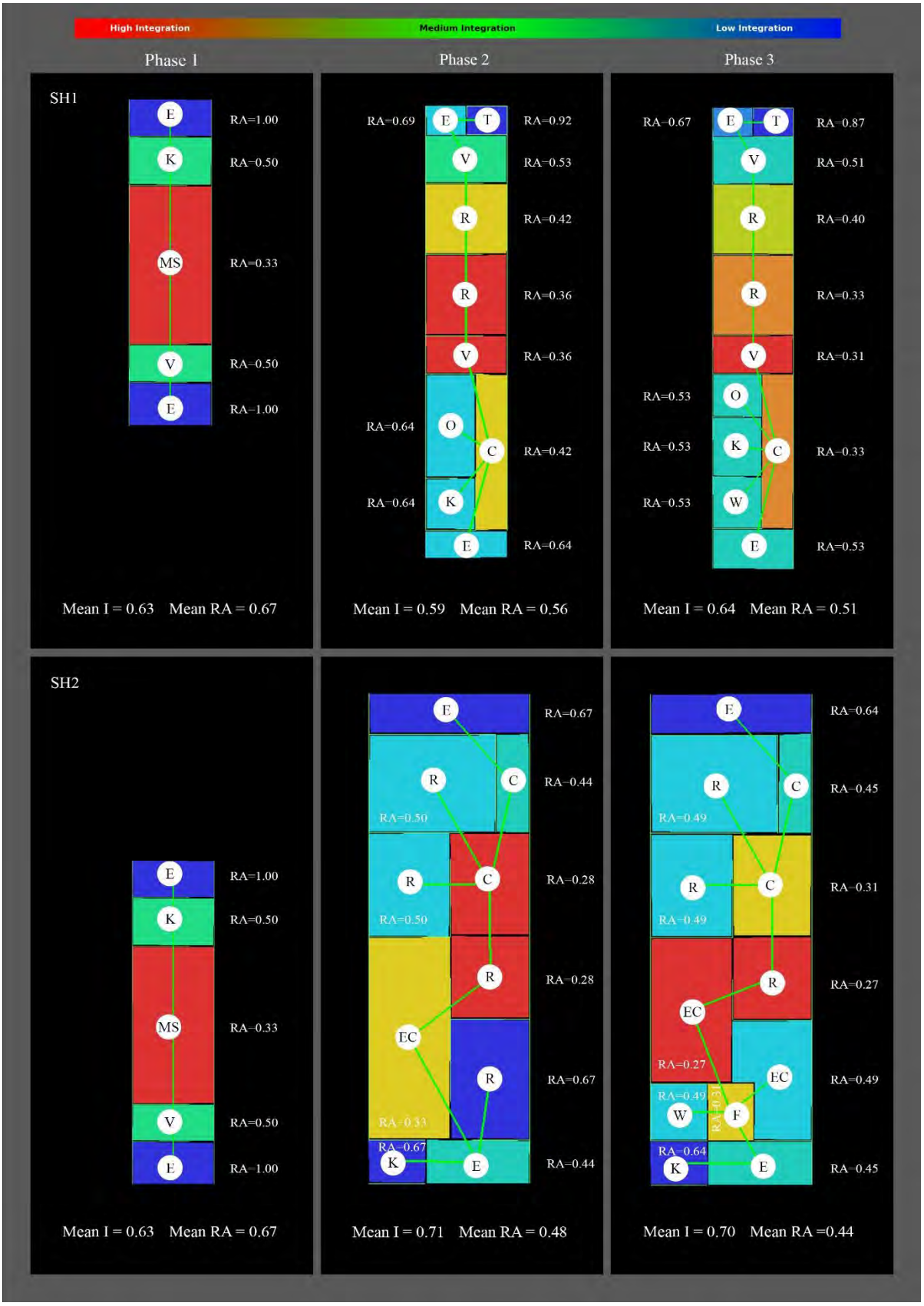


Figure 23: Convex map and justified plan graph (JPG) of spatial configuration over time of sample houses. (Source: Author)

In summary, the morphogenesis of the settlements and the transformation of the dwellings were attributed to informal spatial adaptations of the inhabitants. Overall, the transformed sample houses demonstrated a better balance in spatial relationships, considering privacy, interconnectedness, and accessibility.

5.2 Findings from the Informal Settlement (Jogen Babur Maath)

Household profiles of the Jogen Babur Maath community are presented in Table 6. Household sizes range from 2 to 5 members. Monthly household incomes vary from BDT 4,500 to BDT 12,500, with a mean income of BDT 8,667. Per capita income reflects this diversity, ranging from BDT 1,300 to BDT 4,167. The total built-up area per household spans from 250 to 1,000 square feet, with a mean of 514.2 square feet. Consequently, space per person varies significantly, from just 67.5 to 333.3 square feet, averaging 153.3 square feet across all households.

Table 6: Profile of Jogen Babur Maath community. (Source: Author)

ID	No. of People in HH	Monthly Income (BDT)	Per Capita Income (BDT)	Total Area (sqft)	Space Per Person (sqft)
TH1	4	8500	2125	270	67.5
TH2	5	12500	2500	550	110.0
TH3	3	12500	4167	950	316.7
TH4	3	12500	4167	1000	333.3
TH5	3	9500	3167	330	110.0
TH6	3	10500	3500	860	286.7
TH7	3	4500	1500	370	123.3
TH8	2	5500	2750	250	125.0
TH9	4	9500	2375	390	97.5
TH10	5	6500	1300	350	70.0
TH11	2	5500	2750	280	140.0
TH12	4	5500	1375	300	75.0
Mean	**3.3**	**8667**	**2637**	**514.2**	**153.3**

The findings are delineated from field observations of three sections at Jogen Babur Maath, namely TS01, TS02, and TS03 (see Figure 24). The sections were selected as one section adjacent to the main road, one section of an internal alleyway, and one section of an internal access road adjacent to open space. Additionally, 12 household interviews were conducted, and their historical spatial evolution was documented and analyzed.

Figure 24: The target site at Jogen Babur Maath. (Source: Author)

Figure Description: (a) Map of Jogen Babur Maath displaying observed areas; (b) main road in observed section TS01; (c) internal alleyway showing section TS02; and (3) alley adjacent to open space displaying section TS03.

5.2.1 Morphogenesis at Jogen Babur Maath

Data from section TS01 (n=16) reveal that all the built structures are one story high. Approximately 37% of the structures are *Kutcha*, and the rest 63% are *semi-pucca* (Figure 25).

Figure 25: Housing typologies at target site (TS01) based on structural quality and materials. (Source: Author)

Figure Description: (a) Physical structure of section TS01; (b) a semi-pucca single-story house

The primary typologies of spatial adaptations were observed *setback, aligned,* and *aligned setback,* comprising *62%, 7%,* and *31%,* respectively. Further, some built forms were unused, and interface creeps were a noticeable element of many structures (see Figure 26).

Figure 26: Housing typologies at target site (TS02) based on morphogenesis. (Source: Author)

Figure Description: (a) House typologies of section TS01; (b) adapted shops facing the main road and livestock.

In the observation of section TS02, more diversity in terms of structure height and materials was noticed. Among the observed houses or structures (n=20), about 39% were *Kutcha* single-story, and around 19% were *Kutcha* double-story. Approximately 27% were *semi-pucca* single-story structures, and 3% were *semi-pucca* double-story. Lastly, 6% of the structures were *pucca* single-story, and 6% were unoccupied or abandoned (see Figure 27).

Figure 27: Housing typologies at target site (TS02) based on structural quality and materials. (Source: Author)

Figure Description: (a) Physical structure of section TS02; (b) a pucca single-story house; (c) a kutcha two-story house

The main typologies of spatial adaptations in section TS02 (n=34) were observed *aligned, aligned-setback, setforward,* and *aligned-setforward,* comprising *35%, 6%, 29%, and 21%,* respectively. Further, some built forms were unoccupied (6%) or service infrastructure (3%), and interface creeps were a noticeable element of many of those structures, often with certain

functions or sometimes just to serve as an intermediate space between private and public realm (see Figure 28).

Figure 28: Housing typologies at target site (TS02) based on morphogenesis. (Source: Author)

Figure Description: (a) House typologies of section TS02; (b, c) interface creep as steps and open porch

Observations of section TS03 (n=20) reveal that about 25% were *Kutcha* single-story, and approximately 70% were *semi-pucca* single-story structures. Lastly, 5% of the structures were *pucca* single-story (see Figure 29).

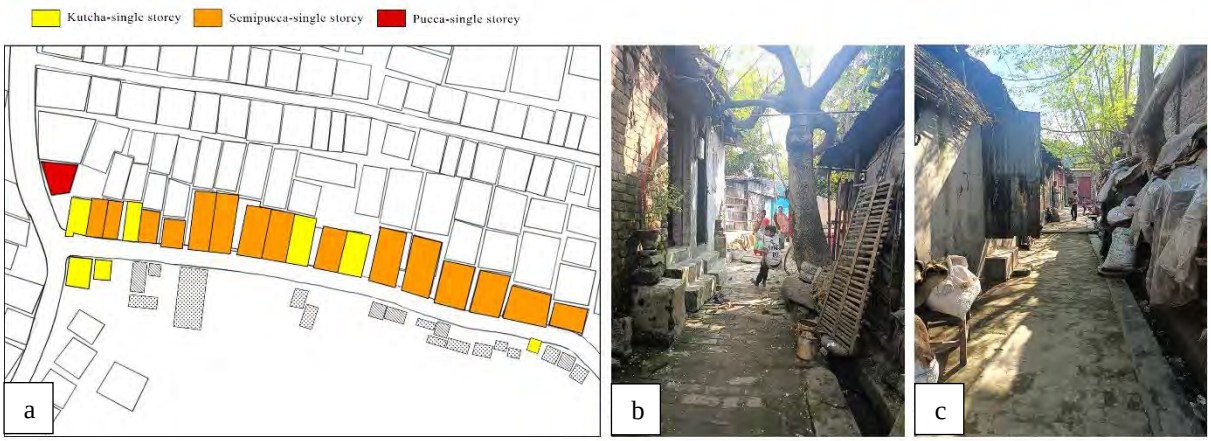


Figure 29: Housing typologies at target site (TS03) based on structural quality and materials. (Source: Author)

Figure Description: (a) Physical structure of section TS03; (b) interface creep as steps and planter; (c alleyway used for goods storage.

The main spatial typologies in section TS03 (n=20) were observed *aligned, setforward,* and *aligned-setforward,* comprising *20%, 75%, and 5%,* respectively. Further, some built forms were detached formal extensions of the main house, and interface creeps were a noticeable

element of many of those structures. Also, temporary activities that activate spaces were noticed (see Figure 30).

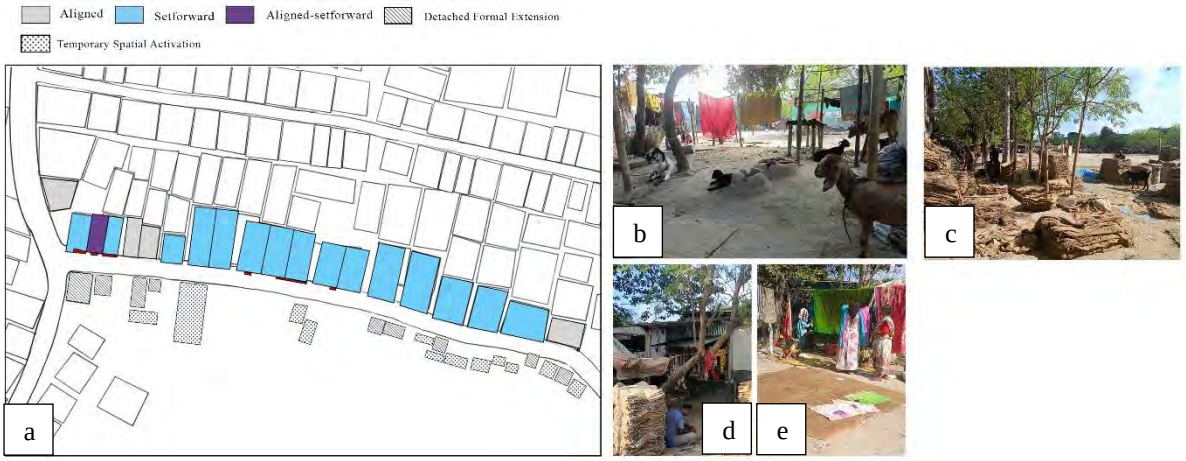


Figure 30: Housing typologies at target site (TS03) based on morphogenesis. (Source: Author)

Figure Description: (a) House typologies of section TS03; (b) spatial adaptation for outdoor cooking activity and livestock; (c, d) spatiotemporal activation for business; (e) spatiotemporal activation to dry clothes.

These micro-adaptations shape the morphology of informal settlements. Although small-scale adaptations allow for greater household adaptability and multifunctionality, they also pose an obstacle to economic modes of production, sociability, access, and efficiency with narrowing alleyways.

5.2.2 Spatial Adaptations at Jogen Babur Maath

Similar to the *sample site*, the *target site* displays most adaptation interventions such as social adaptations, such as horizontal and vertical extensions, multifunctionality of the building units, and independent access to services. One interviewee said,

In the beginning, we lived in a small, thatched house with just one room. We used to cook on the roadside veranda. The first change we made was extending the house to the north to create a kitchen and install a tubewell. Later, we added a pit latrine for privacy and converted the extended space next to the kitchen into a sleeping area for my mother-in-law. Before that, we had to collect water from our neighbors' tubewells and use either open spaces or others' toilets.

Economic adaptation interventions were few but intentional and planned primarily through the multifunctionality of the spaces. On the contrary, spatial adaptations solely for environmental benefits were fewer and often sporadic, such as shading and insulating mechanisms, small-scale gardening, etc. However, the most significant environmental adaptation was ensuring

structural integrity against hazardous events via incremental construction using more permanent materials. A participant says,

Initially, we only had a small 15-by-15-foot kutcha room, and our kitchen was across the road. But every year after the monsoon, the Ghaghra would overflow, making life miserable. We also needed a way to earn more. So, little by little, we built up our home—starting from kutcha, then semi-pucca, and finally a pucca house—to protect ourselves from water related disasters. Additionally, we converted our old kitchen into a shelter for livestock, and now we raise goats there as an alternative source of income.

Overlapping themes in this case were significant, installing individual tubewells and toilets were noticed. These interventions are not only for privacy but also to reduce the adverse effects of flooding and water clogging the community faced before in 2017, causing havoc, especially because of the lack of capacity in fecal sludge management and access to safe drinking water, imposing serious public health risks. A group of community members said,

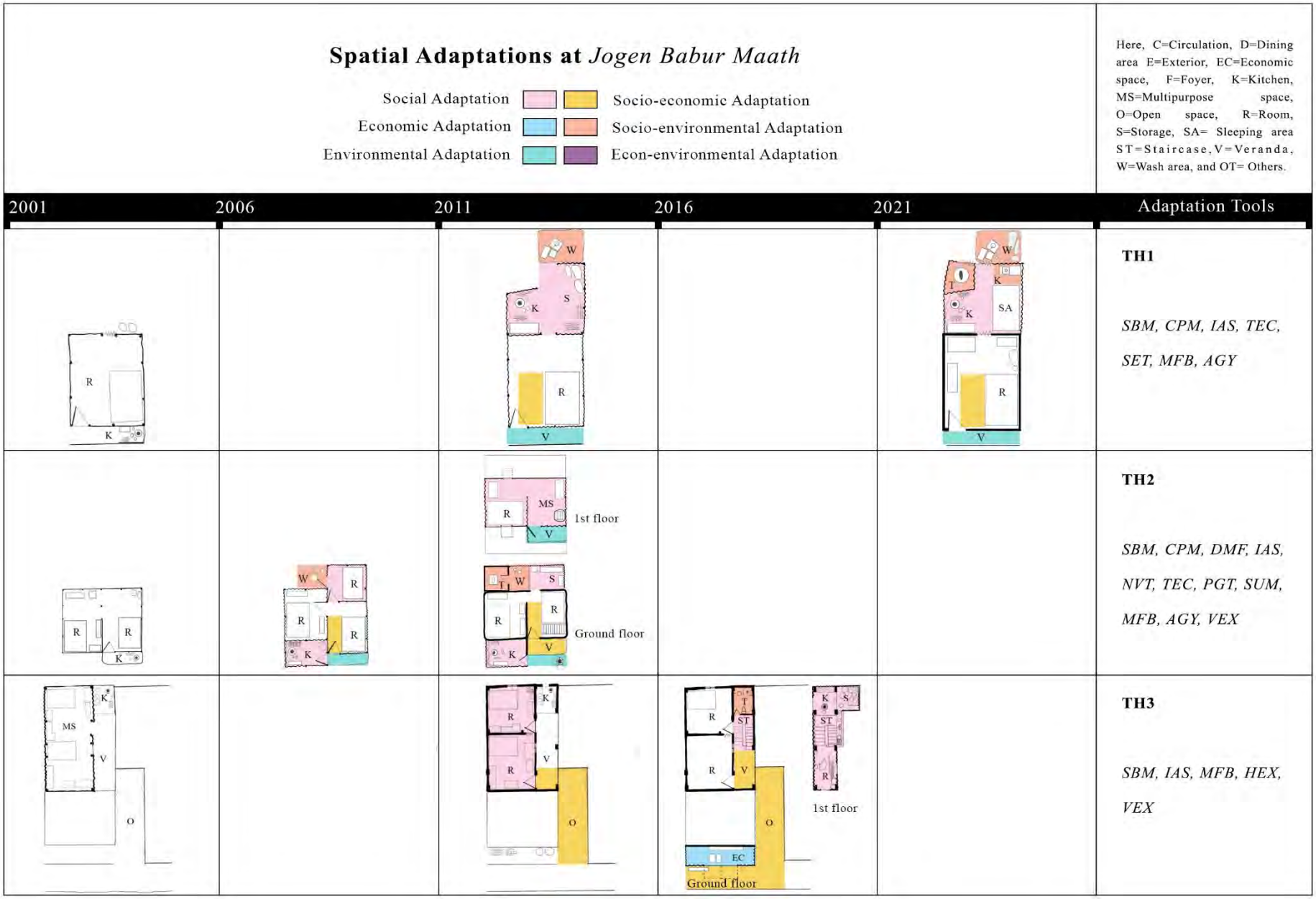
When it floods, everything gets clogged. In 2017, the water rose up to the municipal utility meter, submerging it. Waste, fecal sludge, and sharp objects floated around, making it dangerous. After that, we knew we needed a private toilet and a tube well, so we installed them.

Furthermore, spatial interventions and transformations to allow for both social and economic modes of functions were observed and documented. Major socio-economic adaptations were appropriation of living area to run business activities such as *poppadom rolling* enterprises by women. Further, an income-generating space is adapted, such as a small shop or cattle house, in varied proximity to the main house. A woman interviewee said,

I roll poppadoms for some extra income. I use the veranda and part of the living area to work. Sometimes, I dry them on the veranda, and other times, I dry them on the kitchen roof. I earn 20 taka for every 100 pieces I roll and can make around 2500-3000 taka a month. However, during the monsoon, there's less work from the Mahajan, so our income drops.

The *target site* shows adaptation interventions centered on social and economic functions. Social adaptations involve extensions, multifunctional units, and independent service access. Economic adaptations are planned through multifunctionality that can support economic activities such as shops, livestock, and so on. Finally, environmental adaptations such as tubewells and toilets are adapted to mitigate health consequences post-disaster and ensure privacy. Figure 31 presents a detailed picture of the 12 households at *Jogen Babur Maath*.

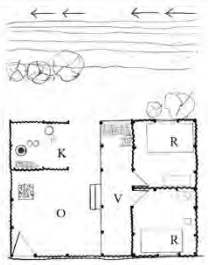
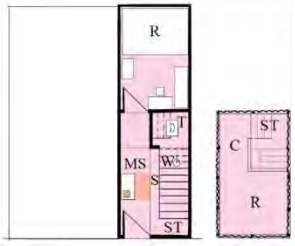
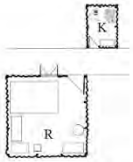
Figure 31: Spatial adaptations at target site. (Source: Author)



Spatial Adaptations at *Jogen Babur Maath*

Social Adaptation
Economic Adaptation
Environmental Adaptation
Socio-economic Adaptation
Socio-environmental Adaptation
Econ-environmental Adaptation

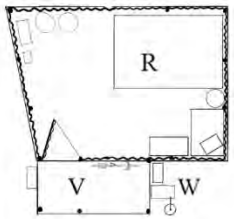
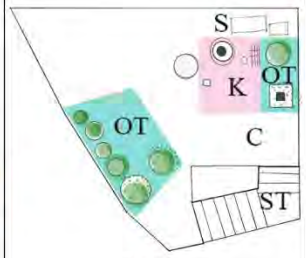
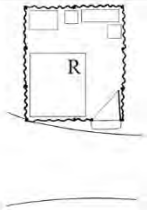
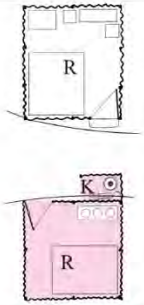
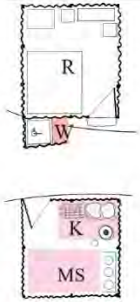
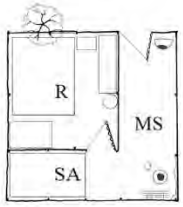
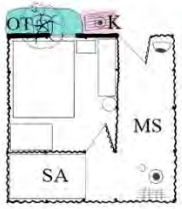
Here, C=Circulation, D=Dining area E=Exterior, EC=Economic space, F=Foyer, K=Kitchen, MS=Multipurpose space, O=Open space, R=Room, S=Storage, SA= Sleeping area ST=Staircase, V=Veranda, W=Wash area, and OT= Others.

2001	2006	2011	2016	2021	Adaptation Tools
					**TH4** *SBM, CPM, IAS, NVT, TEC, MFB, HEX*
					**TH5** *SBM, CPM, IAS, SET, MFB, VEX*
					**TH6** *SBM, IAS, SET, MFB, HEX*

Spatial Adaptations at *Jogen Babur Maath*

Social Adaptation
Economic Adaptation
Environmental Adaptation
Socio-economic Adaptation
Socio-environmental Adaptation
Econ-environmental Adaptation

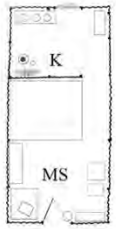
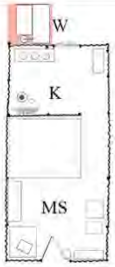
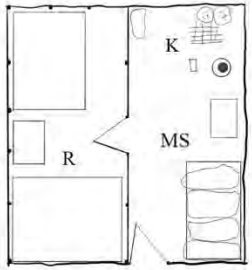
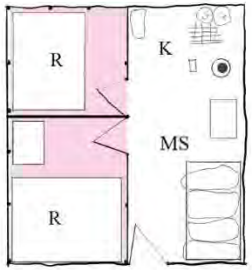
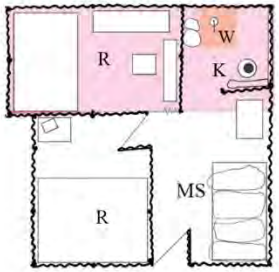
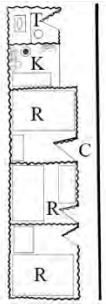
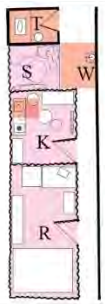
Here, C=Circulation, D=Dining area E=Exterior, EC=Economic space, F=Foyer, K=Kitchen, MS=Multipurpose space, O=Open space, R=Room, S=Storage, SA= Sleeping area ST=Staircase, V=Veranda, W=Wash area, and OT=Others.

2001	2006	2011	2016	2021	Adaptation Tools
			 Ground floor	 Rooftop	**TH7** *SBM, REN, IAS, PGT, VEX*
					**TH8** *SBM, CPM, DMF, REN, IAS, HEX, MFB*
					**TH9** *SBM, CPM, DMF, REN, IAS, SET, PGT, AGY, HEX, MFB*

Spatial Adaptations at *Jogen Babur Maath*

Social Adaptation
Economic Adaptation
Environmental Adaptation
Socio-economic Adaptation
Socio-environmental Adaptation
Econ-environmental Adaptation

Here, C=Circulation, D=Dining area E=Exterior, EC=Economic space, F=Foyer, K=Kitchen, MS=Multipurpose space, O=Open space, R=Room, S=Storage, SA= Sleeping area ST=Staircase, V=Veranda, W=Wash area, and OT=Others.

2001	2006	2011	2016	2021	Adaptation Tools
					**TH10** *SBM, DMF, REN, IAS, NVT, TEC, PGT, SUM, MFB, VEX*
					**TH11** *SBM, CPM, DMF, REN, IAS, MFB, HEX*
					**TH12** *CPM, REN, IAS, TEC, SET, SEM, MFB, HEX*

5.2.3 Degree of Spatial Integration at Jogen Babur Maath

The twelve target households (TH1–TH12) at *Jogen Babur Maath* reveal diverse patterns of spatial organization across the different transformation phases. The data from *Jogen Babur Maath* was provided for 12 households, and the findings are categorized according to the degree of spatial integration: high, moderate, and low. The spatial analysis method was modified to achieve meaningful results, particularly for multilevel dwellings[1]. Therefore, it is advised to consider the results not as an accurate representation but as an approximation. The following value ranges were established based on the site-specific observed distribution:

High Integration: $I \geq 1.00$

Moderate Integration: $0.70 \leq I < 1.00$

Low Integration: $I < 0.70$

Low Asymmetry: $RA < 0.30$

Moderate Asymmetry: $0.30 \leq RA < 0.45$

High Asymmetry: $RA \geq 0.45$

Among the twelve *target houses* at *Jogen Babur Maath*, several homesteads display a high degree of spatial integration with low to moderate levels of asymmetry. These include TH6 (I= 2.39, MD= 1.96, RA= 0.21), TH11 (I= 1.21, MD= 1.87, RA= 0.43), TH1 (I= 1.13, MD= 2.22, RA= 0.35), and TH4 (I= 0.99, MD= 2.62, RA= 0.32). The high integration values ($I \geq 1.00$) indicate that these houses are spatially cohesive, and their functional spaces are centralized and accessible. Low to moderate relative asymmetry values suggest a relatively even distribution of spatial depth with minimal segregation (see Table 5). Syntactically, these layouts exhibit shallow depth levels and strong connectivity across rooms. Spatially, they tend to form ring-like or grid-like configurations, allowing for better circulation. For example, TH1, TH4, and TH6 contain spaces arranged around a circulation space (like a ring) which connects many other spaces, allowing the circulation space to become the central space in the hierarchy. TH11 also exhibits grid-like formation, even though spatial behavior in this household is limited due to a small number of family members (see Figure 29).

[1] In space syntax analysis, the results are limited, where k<5 spaces. To analyze two-story households with fewer than five spaces on the upper floor (TH2, TH3, TH5, TH7, TH10) *, both levels were placed side by side in the DXF file with a 300 mm horizontal offset. Convex maps were drawn for both floors, and stair connections were manually linked in DepthmapX. This approach allowed DepthmapX to interpret both floors as a single spatial system. As a result, the values for Integration (I), Relative Asymmetry (RA), and Mean Depth (MD) reflect a more relational and system-wide understanding of spatial configuration.

In contrast, moderately integrated households are TH3 (I= 0.79, MD= 3.03, RA= 0.41), TH10 (I= 0.67, MD= 3.35, RA= 0.47), TH5 (I= 0.72, MD= 3.05, RA= 0.46), and TH8 (I= 0.76, MD= 2.29, RA= 0.51). They exhibit different spatial logic. These houses show integration values in the moderate range ($0.70 \leq I < 1.00$ or slightly below), coupled with moderate to high asymmetry (see Table 7). This combination suggests that while some rooms remain fairly accessible, others are more segregated or deeper in the spatial system. From a syntactic standpoint, these houses still support interaction, but with more emphasis on selective access or movement control. Spatially, they may lean toward a hybrid arrangement with linear or branched extensions, balancing accessibility with privacy.

Table 7: Results of space syntax analysis at target site. (Source: Author)

	Phase One			**Phase Two**			**Phase Three**		
Household ID	Mean I	Mean Depth	Mean RA	Mean I	Mean Depth	Mean RA	Mean I	Mean Depth	Mean RA
TH1	-	-	-	1.01	2.10	0.44	1.13	2.22	0.35
TH2*	-	-	-	0.82	2.07	0.53	0.75	3.36	0.39
TH3*	-	-	-	0.42	1.60	0.30	0.79	3.03	0.41
TH4	0.97	1.93	0.47	1.10	2.00	0.40	0.99	2.62	0.32
TH5*	-	-	-	0.84	2.39	0.46	0.72	3.05	0.46
TH6	-	-	-	0.86	2.19	0.48	2.39	1.96	0.21
TH7*	-	-	-	0.56	1.67	0.20	0.75	3.05	0.41
TH8	-	-	-	-	-	-	0.76	2.29	0.51
TH9	-	-	-	0.76	2.46	0.49	0.77	2.76	0.44
TH10*	-	-	-	0.93	1.80	0.53	0.67	3.35	0.47
TH11	-	-	-	0.70	1.60	0.30	1.21	1.87	0.43
TH12	-	-	-	0.73	1.71	0.24	0.94	2.25	0.42

Homesteads with low integration and low to moderate asymmetry include TH12 (I = 0.73, MD = 1.71, RA = 0.24), TH7 (I = 0.75, MD = 3.05, RA = 0.41), TH2 (I = 0.75, MD = 3.36, RA = 0.39), and TH9 (I = 0.77, MD = 2.76, RA = 0.44). These households exhibit deeper and more segregated spatial arrangements, where functional spaces are often deep, isolated, and linked indirectly. For instance, the circulation of TH9 and TH12 connects all the spaces of the house (see Figure 27). Syntactically, the lower integration values suggest weak spatial centrality, and the moderate RA scores reflect reduced balance in spatial access across the layout. Spatially, these homes tend to follow a linear or tree-like structure. Although this pattern supports greater privacy but reduces overall connectivity. However, metric values of TH2 and TH7 do not illustrate the whole picture. TH2 is fairly well integrated through its transformation, where the multipurpose space (R) of the ground floor allows for an integrated spatial hierarchy. Similarly, TH7 displays a ring-like spatial configuration, though the spaces are skewed and quite

segregated, which might be the reason for its lower integration value. The houses are categorized in terms of their degree of integration in Table 8.

Table 8: Categories of spatial integration of target houses. (Source: Author)

Category	HH Codes	Characteristics
High Integration	TH6, TH11, TH1, TH4	Cohesive layouts with central, accessible spaces (ring-like or grid-like arrangements), with minimal segregation.
Moderate (see Figure 25) Integration	TH3*, TH10*, TH5*, TH8	Mixed configurations with lower access; more privacy. Linear or branched extensions with moderate depth and asymmetry.
Low Integration	TH12, TH7*, TH2*, TH9	Segregated spaces with deeper, isolated rooms. Linear or tree-like structures with limited connectivity and higher asymmetry.

However, the results are not spatially precise for the multilevel houses (e.g., TH2, TH3, TH5, TH7, TH10). The increased average physical distance between levels raises mean depth, which in turn lowers integration values and inflates RA values. While this approach allows for analyzing both floors in a single graph, the spatial distortion must be acknowledged. For this reason, spaces may appear less integrated than they truly are, underestimating accessibility and real spatial configuration. Although these results do not reflect real vertical proximity (for multilevel units), the convex maps and JPGs imply important insights.

Across the 12 households, spaces marked in warm colors (red, orange), primarily Rooms (R), Foyers (F), Verandas (V), Multipurpose Spaces (MS), and Circulations (C), consistently appear at the center or front of the house, showing high integration and accessibility. In households such as TH6, TH11, and TH1, the presence of ring-like or interconnected paths enhances this spatial logic. Moderately integrated spaces (yellow/green), such as Rooms (R), Verandas (V), Kitchens (K), Stairs (ST), and occasionally Wash Areas (W), are often attached to these central spaces with slight isolation. Their location allows for privacy without compromising accessibility. In contrast, low-integration spaces (green/blue), such as Storages (S), Toilets (T), Wash Area, and some Rooms (R), tend to be peripheral with high spatial segregation. Interestingly, Economic Spaces (EC) are thoughtfully placed to maintain links with both the central living areas and the exterior (E), while they can range from being integrated to more isolated. Finally, emerging spaces such as Economic Spaces (EC), Wash Areas (W), Toilets (T), and Verandas (V) in Phase 3 illustrate growing spatial complexity in response to economic needs, family expansion, and environmental adaptation (see Figure 32).

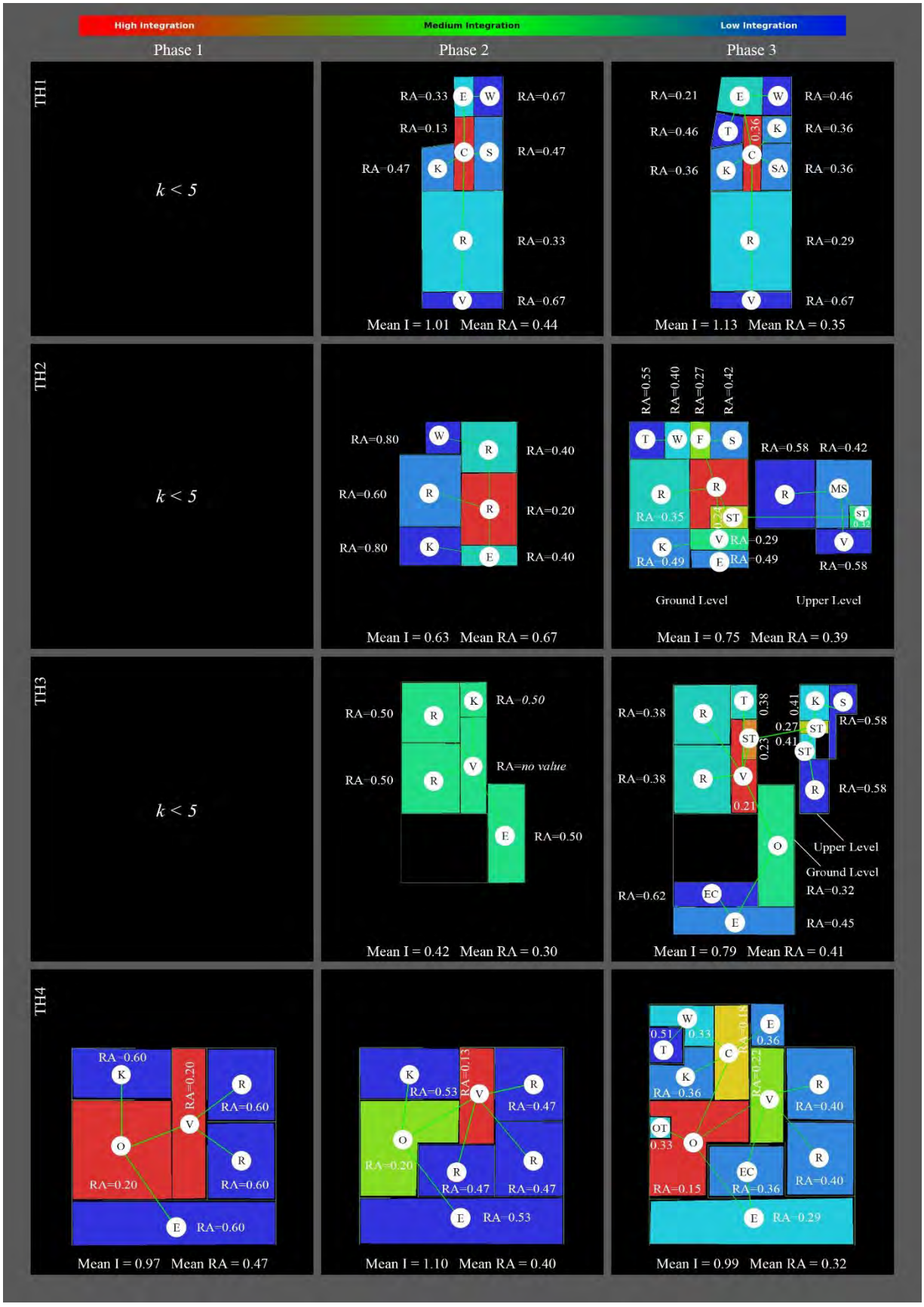
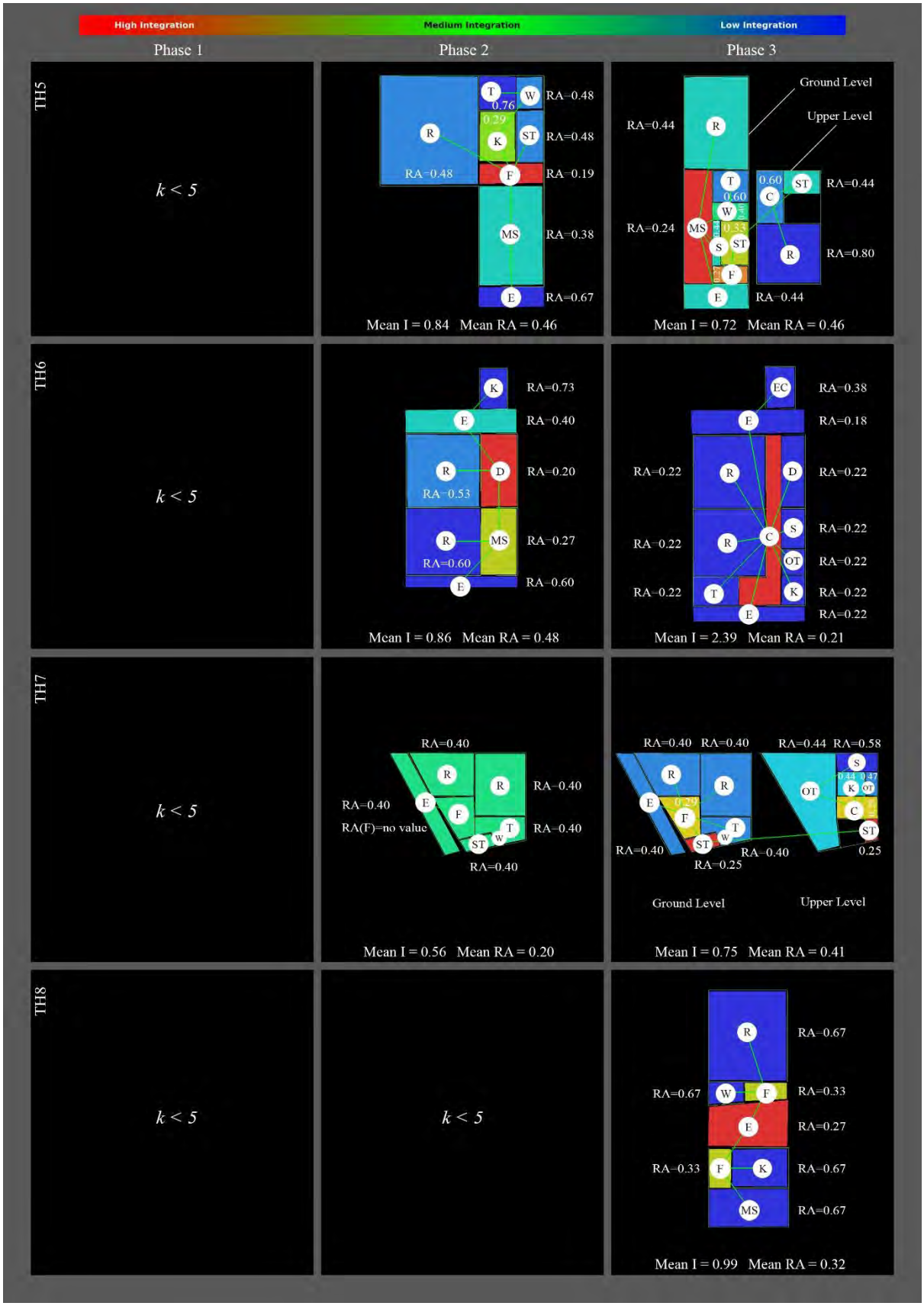
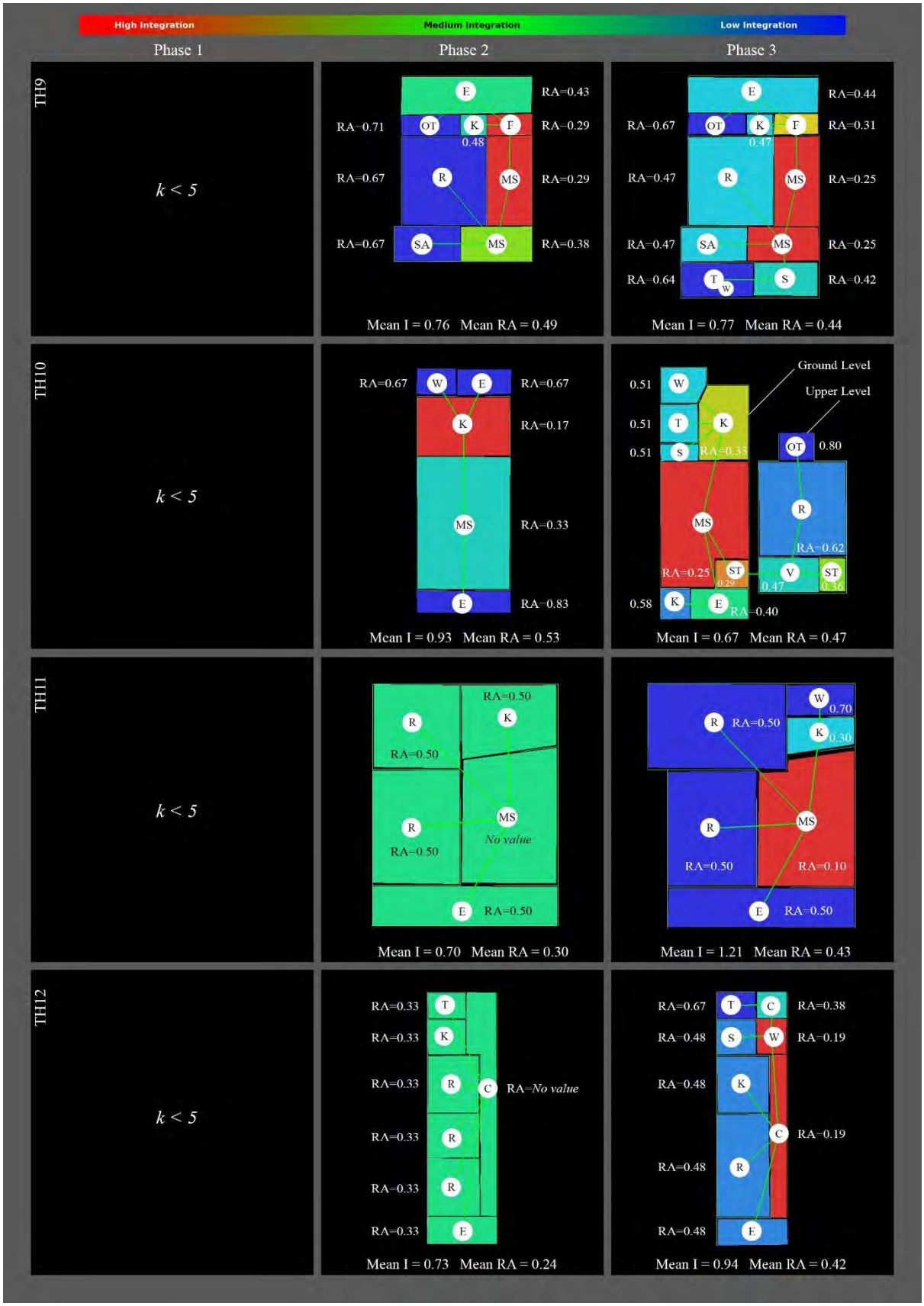


Figure 32: Convex map and justified plan graph (JPG) of spatial configuration over time of target houses. (Source: Author)


High Integration
Medium Integration
Low Integration
Phase 1
Phase 2
Phase 3
TH5
k < 5
RA=0.48
RA=0.48
RA=0.19
RA=0.38
RA=0.67
Mean I = 0.84 Mean RA = 0.46
Ground Level
Upper Level
RA=0.44
RA=0.24
RA=0.44
RA=0.80
RA=0.44
Mean I = 0.72 Mean RA = 0.46
TH6
k < 5
RA=0.73
RA=0.40
RA=0.20
RA=0.53
RA=0.27
RA=0.60
RA=0.60
Mean I = 0.86 Mean RA = 0.48
RA=0.38
RA=0.18
RA=0.22
RA=0.22
RA=0.22
RA=0.22
RA=0.22
RA=0.22
Mean I = 2.39 Mean RA = 0.21
TH7
k < 5
RA=0.40
RA=0.40
RA=0.40
RA=0.40
RA(F)=no value
RA=0.40
Mean I = 0.56 Mean RA = 0.20
RA=0.40 RA=0.40
RA=0.44 RA=0.58
RA=0.40
RA=0.40
RA=0.25
0.25
Ground Level
Upper Level
Mean I = 0.75 Mean RA = 0.41
TH8
k < 5
k < 5
RA=0.67
RA=0.67
RA=0.33
RA=0.27
RA=0.33
RA=0.67
RA=0.67
Mean I = 0.99 Mean RA = 0.32


High Integration
Medium Integration
Low Integration
Phase 1
Phase 2
Phase 3
TH9
k < 5
RA=0.71
RA=0.67
RA=0.67
RA=0.43
RA=0.29
RA=0.29
RA=0.38
0.48
Mean I = 0.76 Mean RA = 0.49
RA=0.67
RA=0.47
RA=0.47
RA=0.64
RA=0.44
RA=0.31
RA=0.25
RA=0.25
RA=0.42
0.47
Mean I = 0.77 Mean RA = 0.44
TH10
k < 5
RA=0.67
RA=0.67
RA=0.17
RA=0.33
RA=0.83
Mean I = 0.93 Mean RA = 0.53
0.51
0.51
0.51
RA=0.33
0.80
RA=0.62
RA=0.25
0.58
RA=0.40
0.47
Ground Level
Upper Level
Mean I = 0.67 Mean RA = 0.47
TH11
k < 5
RA=0.50
RA=0.50
RA=0.50
No value
RA=0.50
Mean I = 0.70 Mean RA = 0.30
0.70
0.30
RA=0.50
RA=0.10
RA=0.50
Mean I = 1.21 Mean RA = 0.43
TH12
k < 5
RA=0.33
RA=0.33
RA=0.33
RA=0.33
RA=0.33
RA=0.33
RA=No value
Mean I = 0.73 Mean RA = 0.24
RA=0.67
RA=0.48
RA=0.48
RA=0.48
RA=0.48
RA=0.38
RA=0.19
RA=0.19
Mean I = 0.94 Mean RA = 0.42

Across the twelve case studies, the justified plan graphs reveal a three-phase trajectory of spatial evolution: in Phase 1, houses are fragmented with minimal connectivity. In Phase 2, layouts adopt more linear or shallow tree structures centered on connector spaces, such as verandas, kitchens, multipurpose spaces, or circulation nodes. In Phase 3, vertical expansion and clustering slightly increase integration but reduce efficiency, creating uneven accessibility. Within this progression, transitional nodes such as central rooms, verandas, kitchens, and stairs emerge as integrative hubs. Meanwhile, service functions such as toilets, storage, and water points remain peripheral with low integration, reflecting an underlying informal grammar where such utilities are treated as secondary add-ons rather than integral to the spatial core. Finally, the findings indicate that some households have evolved without coherent spatial planning, highlighting the need for professional designers to promote better spatial connectivity and minimize spatial segregation.

5.2.4 Community-based Adaptations and Institutional Interactions

In the informal settlement of Jogen Babur Maath, both men and women groups highlighted challenges and possibilities in focus group discussions (Figure 32). Among the identified concerns, the most pressing was the water-clogging situation posed by the overflow of the adjacent *ghaghra* (canal). *Ghaghra* is a 29-kilometer canal, of which about half is part of the Dinajpur urban area. Women described the impact of seasonal floods, stating,

"Once ghaghra was utilized for fishing and bathing. But now, when the monsoon comes, it turns against us. When the ghaghra overflows, everything gets submerged. We have to evacuate by swimming or on boats, leaving our homes behind. At that moment, the only thought was, 'What should we prioritize—life or our belongings?"

The canal overflow is caused by inadequate drainage infrastructure. Both men and women groups agreed that focusing on improving the canal and drainage system could help mitigate the crisis. However, previous government-led efforts to address the issue failed (see Figure 33). One woman recalled,

"The government started excavating the canal, evicting people from their homes, and then just left it incomplete. Instead of solving anything, they only created new problems for us. Soon, the evicted families had no choice but to rebuild their houses, encroaching on the land and water body again."

Waste management was another critical concern. Both men and women noted the absence of a formal waste disposal system, which has led to uncontrolled dumping into the canal.

One male participant explained, "Since there is no waste disposal system, people tend to dispose of domestic waste in the canal. It is concerning as this prevents monsoon rain from flowing away. On top of that, a shallow drain does not work properly, creating a clogging situation."

Figure 33: Community mapping of collective effort at JBM. (Source: Author)

The degrading condition of sanitation facilities was also a major issue. Initially, there were only two toilets for the entire community of about 500 families. Over time, two more were added. However, maintenance remains a challenge (Figure 34a, 34b). At present, one of the toilets is entirely out of order, and the other three suffer from technical issues. In response, the community has mapped out existing sanitation facilities and potential locations for waste disposal points, demonstrating their capacity to plan together (see Figure 33).

Beyond infrastructure and facilities, drug abuse has become a deep-rooted social issue (Figure 33). While both groups acknowledged the problem, the men noted the situation as a failure of law enforcement agencies. One participant explained,

"Law enforcement agencies only take custody of the drug abusers, not the drug lords. Even that can be disregarded as they take bribes to free the accused. However, the drug dealers are under the protection of powerful local politicians or businessmen. Members of the community

have taken many steps to solve this issue via local law enforcement agencies and political entities but failed."

Overall, although past community-led initiatives were hindered by mismanagement and lack of leadership, many I/NGO interventions were successful. One example is community-led housing design and build intervention (see Figure 33, 34c). Additionally, women emphasized the need for economic empowerment. Institutional interventions (government and I/NGO projects) have often failed to meet community needs. Both groups stressed that future interventions should be designed in consultation with the community members.

Figure 34: Current condition of the housing environment. (Source: Author)

Figure Description: (a) Poor condition of community toilet; (b) abandoned community toilet; (c) I/NGO-provided kutcha two-story house; (d) I/NGO-constructed drain; (e) Ghaghra canal behind households; (f) dilapidated road.

To conclude, key suggestions included re-excavating the *ghaghra*, introducing a waste disposal system, repairing sanitation facilities, improving roads and drainage infrastructure, and creating economic opportunities. The findings imply the importance of community-driven planning and effective institutional collaboration for the sustainable development of future cities.

CHAPTER SIX

DISCUSSION AND RECOMMENDATION

This chapter initiates discussions of results and their implications, followed by a conceptual framework for sustainable adaptation and resilience in marginalized housing environments. Finally, it presents several recommendations for built environment professionals and policymakers that are guided by this research.

6.1 Housing with the People, by the People

The evolution of housing in low-income settlements demonstrates a distinctly participatory process, where the residents themselves drive the design, construction, and adaptation of their homes in response to social, economic, and environmental pressures. This study examined fourteen migrant households (SH1-SH2, and TH1–TH12) across two sites in Dinajpur to understand how resident-led adaptation reshapes dwelling organization and settlement morphogenesis. Three consistent patterns emerge. First, social adaptations (room additions-divisions, vertical extension, appropriated service spaces, individual water/sanitation facilities) respond to household growth and privacy. Second, economic adaptations convert thresholds, fronts, and corners into income-generating micro-spaces (shops, husbandry, temporary economic activities). These spaces are proximal to the household but can be both adjacent to the dwelling or isolated. Third, environmental adaptations (plinth raising, bracing, material upgrading, dismountable facades) respond to flood risk and heat. They often improve durability while preserving flexibility.

Syntactic analysis clarifies the spatial consequences. Households with higher integration (I) and lower RA (e.g., TH6, TH11, TH1) exhibit ring-like, easily accessible layouts where everyday routes pass through or near multipurpose social spaces. Moderately integrated homes balance shallow and deeper spaces (e.g., TH3, TH10, TH5, TH8), using partitions and level changes to regulate access without compromising connectivity. Lower-integration houses (e.g., TH12, TH7, TH2, TH9) present more linear, tree-like sequences. They afford privacy and containment, but at the cost of longer movement paths and weaker functional efficiency.

These results align with and extend existing scholarships in four ways. (1) Morphogenesis as co-evolution. We find that building extensions follow emergent paths and edges, producing ring-like organization, where economic and social activities cluster. On the other hand, deeper tree-like syntax provides households with more privacy. (2) Resident agency and aspiration as the prime force. Echoing Turner, Tipple, and others, most performance gains (flood risk

management, thermal comfort, livelihood space) arise from resident-led adaptations. Households actively correct misfits through adaptation, underscoring the centrality of user agency. (3) Incrementalism works when guided and enabled. The comparative lens shows how secure tenure rights, access to basic services, and spatial negotiation correlate with higher syntactic integration around cores. Conversely, rigid housing schemes that prohibit modification often fail to foster a sense of belonging and lead to gentrification. (4) Syntax as evidence of connectivity and accessibility. Changes in I, RA, and MD are not merely geometric; they show how households govern the sequence and flow of spaces.

Many scholars have examined urban morphogenesis and housing adaptations, emphasizing the incremental and bottom-up processes that shape informal settlements (Alexander, 2004; Whitehand et al., 1999; Türkmen, 2025; Kamalipour & Peimani, 2015). Research highlights how housing functions as both a product and a process, where informal practices and user-driven transformations generate dynamic and fine-grained morphologies (Ruonavaara, 2018; J. F. Turner & Fichter, 1972; Shrestha et al., 2021; G. Tipple, 2005; Avi, 2002; Habraken, 2021). These adaptations (e.g., structural alteration, space personalization, incremental extensions, and commercial conversions) reflect strategies of resilience in the face of social, economic, and environmental pressures (Tipple & Ameen, 1999b; Dovey et al., 2020; Parvin et al., 2023; Awal & Reza, 2017). Recent studies demonstrate how spontaneous occupations and generative processes in favelas reveal the underlying logic of form-making and the genesis of informal settlement morphologies (Verniz & Duarte, 2021). Despite these insights, micro-scale housing transformations in informal settlements remain understudied, with much of the literature focused instead on broader policy and governance perspectives (Raneses et al., 2021; Neuwirth, 2016; Roy & AlSayyad, 2004; McCartney & Krishnamurthy, 2018; Patel & Baptist, 2012; Suhartini & Jones, 2019).

This study goes further by showing how specific changes in the household affect the urban fabric (meso scale), and connectivity of spaces (micro scale), and how these changes relate to social, environmental, and livelihood outcomes. By combining typology mapping with spatial analysis, we find that small modifications can change a house from a “deep-tree” layout to a more “ring-like” layout, improving accessibility and connectivity. Though many households showed a clear social logic of spatial adaptations and sound integration of spaces, some lacked accessibility and overall spatial quality.

The implications are clear. For design practice, housing should be conceived as a process for incremental change: resilient, flexible, and able to support both living and work. For policymakers, housing programs should provide security of tenure, basic infrastructure, and allow safe, incremental adaptations in a participatory process. Aligned projects, such as the Grameen Bank Housing Programme (1984), must be revisited and re-evaluated to identify bottlenecks and work out effective solutions to establish housing with the people, and by the people. Finally, the findings from focus group discussions support these ideas of collective housing.

6.2 Sustainable Cities and Societies

Cities make up only 2% of the planet's surface, yet they account for 55 % of the population, 75% of energy consumption, & 80 % of CO_2 emissions, says Carlo Ratti on (Bloomberg New Economy, 2022). Hence, cities are at the center of the future of human civilization and planet Earth. The Sustainable Development Goals (SDGs), introduced by the United Nations in 2015, are a shared global vision to end poverty, protect the planet, and ensure peace and prosperity by 2030. The 17 goals are deeply connected, reminding us of that progress in one area—like housing, health, or climate—can have ripple effects across others and that sustainable development must balance societal needs, economic opportunity, and the environment (United Nations, 2015).

This research connects to multiple SDGs by examining housing changes in informal settlements of environmentally displaced communities. Adaptations such as pit latrines, raised platforms, and home-based income activities like small retail or livestock rearing contribute to SDG 1 (No Poverty), SDG 3 (Good Health), SDG 6 (Clean Water and Sanitation), SDG 8 (Decent Work), and SDG 10 (Reduced Inequalities), highlighting the resilience of marginalized populations. The study particularly informs SDG 11 (Sustainable Cities and Communities) by showing how inclusive, adaptive, and community-led design builds resilient neighborhoods, and SDG 13 (Climate Action) by illustrating how housing adaptations help cope with environmental hazards.

As urban populations are expected to reach 68% by 2050 (UN, 2019), residents' rights to city services, participation, and control over urban space need to be emphasized. In Bangladesh, state-led housing programs have historically accelerated gentrification. It is evident in the diversion of House Building Finance Corporation (HBFC) plots to affluent buyers and the Bhasantek Project's market-driven redevelopment that displaced slum dwellers (Lata, 2020). These cases reveal how pro-poor initiatives often become vehicles of exclusionary urban

transformation and deprivation of the right to adequate housing, particularly for the marginalized urban communities. However, recent top-down neoliberal housing initiatives, such as the Ahrayan project, are being advanced under the guise of visible development. Yet, they ultimately represent another iteration of gentrification. Historically, this (provided) model of housing for marginalized communities has failed in different contexts as it deprives the recipient of their sense of belonging and encourages dependency. Beyond diverting critical resources in a nation transitioning from underdeveloped to developing status, such projects undermine efforts to adopt sustainable housing practices and equitable urban development. These insights underscore the relevance of bottom-up approaches in advancing sustainability and resilience at the intersection of urbanization, displacement, and environmental change.

6.3 Incremental Adaptations: A Quasi-formal Approach

In his book *Architecture Without Architects* (Rudofsky, 1987), the author emphasizes community-centered building practices and the organic growth and adaptability of vernacular architecture. Rudofsky argues that vernacular architecture is not a product of external designers or planners but is created collectively by the community's inhabitants who deeply understand their needs, climate, and available materials. This encourages housing environments to be created by the community instead of external designers or planners. In a similar sentiment, Alejandro Aravena, a Chilean architect and Pritzker laureate said, *"There's nothing worse than answering the wrong questions well. It is important to ask the right questions before we answer them in our cities. And then we must learn how not to discriminate and segregate people by our misguided design and development* (Dezeen, 2016)*."*

According to (Heikkila & Lin, 2014), the inadequate absorption capacity of the formal sector results directly in informality. Although the idea of "bottom-up," participatory methods for community development are frequently discussed in global development discourses, the strategies, procedures, and novel knowledge required to ensure a successful integration (Georgiadou et al., 2016). However, scholars such as (Mukhija, 2014) reveal how rigid formal/informal binaries fail urban poor communities, proposing instead a 'guided incrementalism' model where state infrastructure enables resident-driven housing improvements. This approach contrasts with more rigid models, such as Bangladesh's *Ashrayan* program, where standardized solutions often overlook the unique needs of individual communities. The Aranya Housing Project in Indore (Doshi, 1989, cited in (Awasarkar, 2021)) demonstrated how state-provided land and infrastructure frameworks could enable incremental, resident-led housing adaptations, a model of 'guided incrementalism'. Its success

underscores how quasi-formal systems, which marry tenure security with self-built agency, can sustainably house the urban poor while accommodating organic growth. Similarly, Delhi Development Authority has laid out a comprehensive policy permitting additions/alterations in DDA Flats (quasi-formal approach), applying to DDA housing schemes (LIG, MIG, HIG flats, etc.) that DDA allots to different income groups (DDA, n.d.).

Gentrification deprives the communities of their fundamental right to safe and adequate housing. Hence, the research findings resonate with the community and human-centric approaches and suggest an *adaptive informal-formal continuum* for housing development for marginalized communities, such as environmental migrants. The term "adaptive informal-formal continuum" describes the dynamic and changing interplay between formal and informal housing systems, especially in how communities adapt over time. Simply put, it implies that housing does not always fit into one of two categories: formal (planned, government-approved) or informal (unregulated, self-organized). Instead, housing frequently falls on a spectrum, with community-led initiatives, legislative changes, or infrastructure improvements helping informal settlements gradually adapt and take on formal characteristics. On the other hand, formal housing environments can evolve through informal adaptations, reflecting on community needs.

6.4 Sustainable Adaptation and Urban Resilience

Sustainable adaptation in contexts of climate-induced migration requires moving beyond technocratic or purely infrastructural solutions to recognize the agency and everyday strategies of marginalized urban communities. As Satterthwaite (2013) cautions, conventional resilience planning often overlooks the root causes of vulnerability—particularly tenure insecurity, exclusion from governance, and unequal access to resources. The research findings echo this critique: families adapt incrementally, raising plinths, repurposing rooms for livelihoods, and investing in self-built sanitation, not because of external interventions but through necessity-driven ingenuity. These practices demonstrate what Ziervogel et al. (2017) describe as a rights-based approach to resilience, where incremental improvements (e.g., self-built flood-resistant housing or community-managed drainage) in shelter and infrastructure are not merely strategies but also claims to dignity, equity, and belonging in the city.

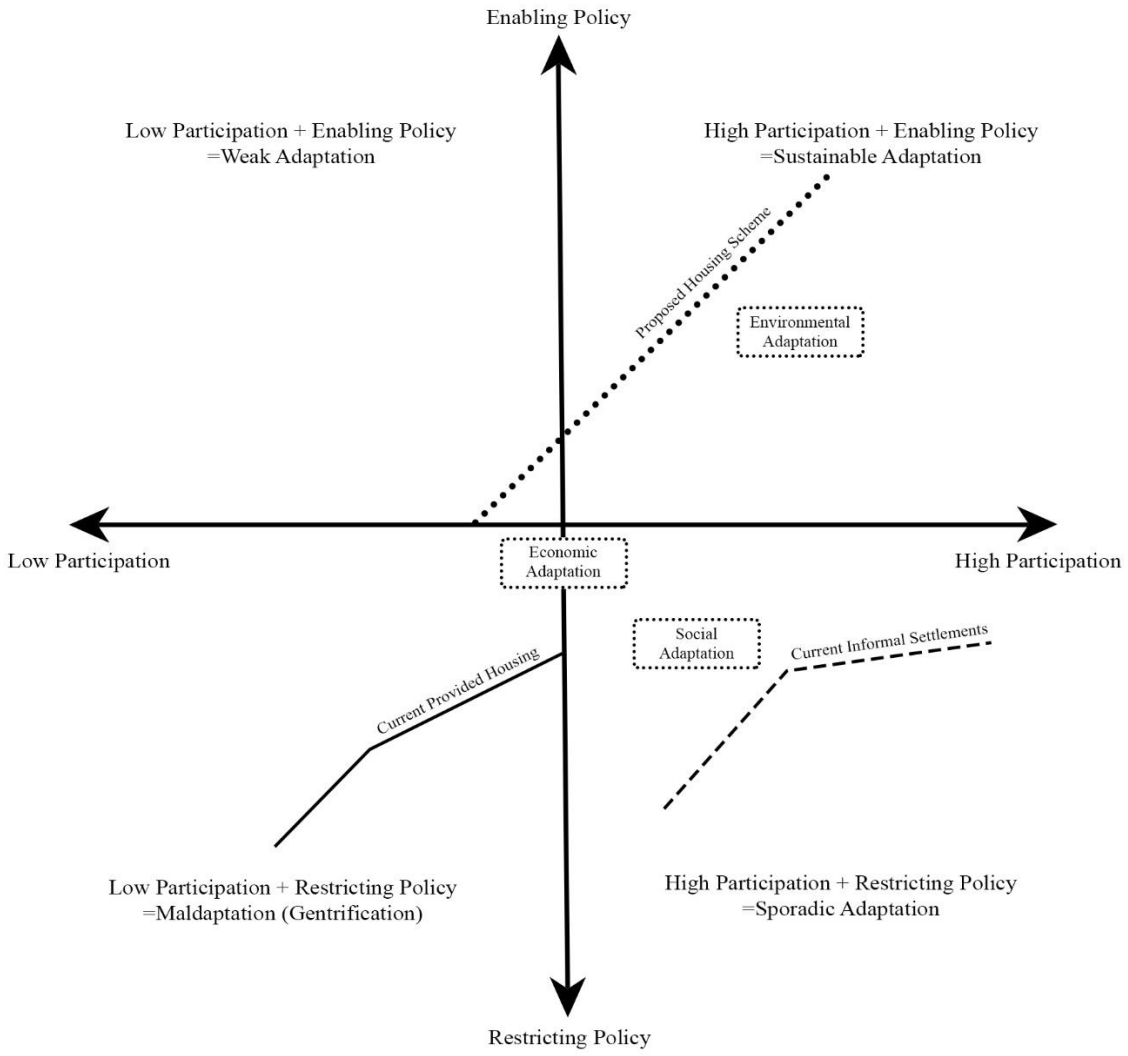


Figure 35: Interaction of participation and policy in shaping adaptation outcomes. (Source: Author)

Figure 35 represents a conceptual diagram for understanding housing adaptation outcomes by plotting the level of participation (low to high) against the policy landscape (restricting to enabling). The four quadrants illustrate different scenarios: low participation and restricting policy led to maladaptation (e.g., gentrification), high participation and restricting policy result in sporadic adaptation (as in current informal settlements), low participation and enabling policy produces weak adaptation, and high participation and enabling policy foster sustainable adaptation. The current (provided) housing model is placed in the maladaptive quadrant, while informal settlements fall in the sporadic adaptation zone. The diagram also recognizes social, economic, and environmental adaptations within these dynamics as catalysts to bridge the housing gap.

Global precedents reinforce this perspective. Yasmeen Lari's critique of the "Western colonial charity model" highlights how conventional aid often delivers costly, carbon-intensive, and

disempowering solutions that bypass community agency (Hurst, 2023). Instead, she advocates for low-cost, participatory approaches that treat communities as capable partners. This resonates strongly with the dynamics observed in Jogen Babur Maath, where residents collectively manage drainage, negotiate shared boundaries, and expand homesteads, reshaping the urban morphology.

Together, these insights suggest that sustainable adaptation and urban resilience in Bangladesh, and the Global South more broadly, hinge on recognizing informal, bottom-up strategies as legitimate forms of climate adaptation. Rather than imposing standardized housing schemes or rigid urban plans, policies and designs must create enabling conditions, such as secure tenure, flexible regulations, and support for community-led upgrading that allow migrant households to adapt and thrive. This paradigm shift is essential for sustainable adaptation while empowering the communities.

6.5 Recommendations

In the face of imminent climate risks and ongoing socio-economic challenges, integrated, inclusive, and locally led adaptation strategies are essential to enhance long-term urban resilience. Insights from the IPCC (2023a) highlight that climate-resilient development is most effective when decision-making prioritizes equity, risk reduction, and justice. In this context, the following recommendations will guide design professionals and policymakers in creating responsive, resilient, and dignified housing environments for marginalized and migrant communities. These recommendations draw directly from field evidence in Dinajpur, Bangladesh. The diagram in Figure 36 shows how recommended design strategies and policy measures converge towards the shared goal of sustainable, participatory, and adaptive housing.

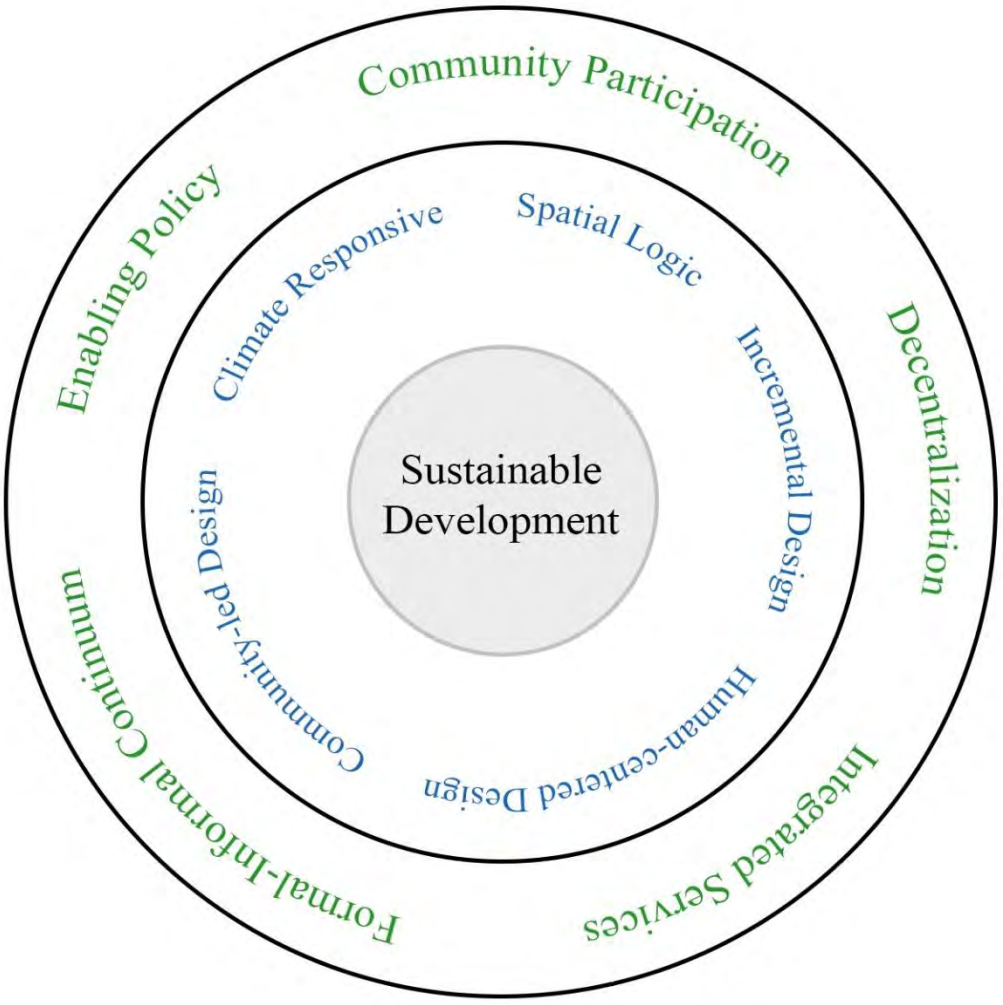


Figure 36: Recommendations for policymakers (green) and built environment professionals (blue). (Source: Author)

Recommendations for Policymakers

1. From Providing to Enabling: Top-down, one-size-fits-all schemes often fail in practice. Policies must recognize housing as a process, not a product. Adaptive support through sites and services, incremental subsidies, secure land tenure, and regulatory flexibility can enable safer and self-sustaining housing environments.
2. Adaptive Formal-Informal Continuum: Planning authorities should revisit land-use policies, building codes, and/or beneficiary policies to allow controlled, safe, and incremental changes. Rather than enforcing strict formalization, housing policies should encourage hybrid models that merge formal planning frameworks with informal innovations and spatial practices. This can bridge gaps in affordability, cultural appropriateness, and adaptation.

3. Integrated Infrastructure and Services: Findings reveal a lack of basic services (e.g., sanitation, water, roads) in both planned resettlement and informal settlements. A holistic approach is needed, where infrastructure and architecture are one integrated system.
4. Decentralized Urban Development Strategies: Concentrated migration to Dhaka highlights uneven development. Planning should focus on strengthening climate-resilient secondary cities and peri-urban areas with better housing, infrastructure, and economic prospects to absorb future migration pressure.
5. Participatory Process in Housing Development: Institutional rigidity in top-down systems often hinders sustainable adaptation. Policymakers should establish mechanisms for continuous dialogue between communities, local governments, and development partners to guide housing adaptation and transformation over time.

Recommendations for Built Environment Professionals

1. Design for Incremental Growth and Adaptation: Many households incrementally adapt their spaces in response to social, economic, and environmental pressures. Design strategies should support modular and scalable spatial configurations that allow for future adaptations without compromising structural safety.
2. Spatial Logics in Formal Design: The space syntax analysis revealed that homesteads with higher integration values and lower asymmetry offer greater accessibility, fluid movement, and functional efficiency. They are often configured in ring-like or semi-grid arrangements. However, the findings also suggest that not all households have developed in a spatially sound manner because of a lack of knowledge and skills. It highlights the need for professional designers to promote better spatial connectivity and reduce the deep segregation of rooms.
3. Climate-Responsive and Contextual Design: Many households adapt their dwellings to reduce flood risk, heat exposure, or seasonal hardship. Built environment professionals should prioritize climate-responsive materials and strategies (e.g., raised plinths, shaded outdoor areas, cross-ventilation, insulation) appropriate to the socio-ecological context of marginalized settlements.
4. Community-led Design Processes: Co-design workshops and participatory planning can compile lived knowledge and adaptive practices. Designers should collaborate with residents to develop housing finance plans, design layouts, select materials, and

implement other sustainable practices that reflect community values, needs, and aspirations.

5. Human-centered Design: As many units were adapted for economic activities (e.g., small businesses, animal husbandry), housing environments should integrate spatial provision for home-based enterprises. Moreover, the tendency to acquire private service areas reflects the real aspiration of the community that designers should consider as the core of the design process.

These recommendations call for concrete steps to support climate adaptation in marginalized settlements (e.g., slums, resettlements). For policymakers, this means prioritizing investments in basic infrastructure, enabling access to financial tools, and formally integrating informality in settlement planning. For designers, it involves using affordable, climate-responsive techniques, training residents in adaptive, incremental construction, and working closely with communities to co-create sustainable housing environments.

CHAPTER SEVEN
CONCLUSION

This chapter concludes the study. In doing so, it describes the key findings of the research, its limitations, and contributions along with a way forward for future research.

7.1 Overview of Key Findings

The study findings reveal distinct patterns of spatial adaptation and community dynamics between the planned settlement of *Sri Krishnapur Ashrayan Project* and the informal settlement of *Jogen Babur Maath*. In the planned settlement, the barrack-style housing exhibited primarily kutcha (75%) and semi-pucca (25%) structures, with morphogenesis following setback (20%), aligned (25%), and aligned-setback (55%) typologies. Residents adapted their spaces through social interventions such as room subdivisions, adapting individual service spaces, and multifunctionality of spaces. Economic adaptations include spaces such as shops, livestock rearing, and temporary home-based business spaces. Finally, environmental measures include open space conservation and upgrading to permanent materials. Space syntax analysis demonstrated how some households achieved high spatial integration (e.g., SH2 improved from I=0.63 to 0.71) through optimized layouts, while the other remained moderately or less integrated.

In contrast, Jogen Babur Maath displayed more organic growth with greater structural diversity. It ranges from kutcha to pucca constructions across its three sections. The settlement showed higher instances of semi-pucca structures (e.g., 63% in TS01) and more varied adaptation typologies, including setforward and aligned-setforward configurations. Social adaptations included horizontal and vertical extensions, appropriation of space for multifunctionality, and independent access to services. Economic adaptations included multifunctional spaces for livestock, small shops, and home-based enterprises (e.g., poppadom rolling). Environmental adaptations stressed structural upgrades using permanent materials. Some strategies overlapped, such as toilets and tubewells, which serve both social benefits (privacy) and environmental needs (water, sanitation, and hygiene during floods). Space syntax analysis revealed some households achieved exceptional integration (TH6, I=2.39) through ring-like spatial configurations, though multilevel dwellings presented analytical challenges. The community faced severe infrastructure shortages, particularly regarding drainage and sanitation, exacerbated by failed institutional interventions. However, they demonstrated

capacity for collective action, as seen in community-led mapping activities and discussions, pointing to the potential for a participatory approach to enhance resilience.

Incremental housing growth is shaped by transitional spaces such as central rooms, verandas, and stairs, which act as hinges for expansion and gateways to vertical growth. While this process slightly increases integration, it also creates shallow and uneven circulation patterns that often concentrate access through a single node. Such bottlenecks can become critical weaknesses during disasters, slowing down evacuation efforts in floods or fires. At the same time, service spaces such as toilets, storage, and water points remain pushed to the periphery, even though they are essential for health and overall resilience. Recognizing transitional nodes as infrastructural cores and integrating service spaces into the spatial center can therefore improve both everyday usability and disaster preparedness in incremental housing. The findings also suggest that not all households have developed in a spatially sound manner, which calls for professional designers to encourage spatial connectivity and reduce the deep segregation of rooms. Hence, a quasi-formal approach with an adaptive formal-informal continuum may be adopted for housing development in marginalized communities, such as environmental migrants.

7.2 Contribution to Knowledge

This study employs a case study approach, borrowing methods from multiple disciplines such as architecture and planning, anthropology, environmental management, disaster management, development studies, and other relevant social sciences. This study contributes to the existing body of knowledge by introducing a framework that links environmental migration challenges to housing transformations in informal settlements. The research identifies key moderating variables—such as social dynamics, economic pressures, and environmental stressors—and provides valuable insights into how communities adapt spatially to these challenges. Furthermore, the study emphasizes the importance of user-initiated spatial adaptations and their connection to broader goals of resilience and sustainable urban development. The inclusion of empirical findings and the concept of quasi-formal housing approaches enrich the discourse on community-led planning and the role of human-centered design interventions. This research contributes to theoretical understanding and practical solutions for improving the resilience of cities in the face of climate change.

7.3 Limitations of the Study

This study has several limitations. First, the findings are context-specific to Dinajpur, Bangladesh, which may limit their generalizability to other informal settlements with different socio-environmental dynamics. Although the collected data from the interviews (n=14) is rich in detail, it may not fully represent the varied forms of housing adaptation across regions. This study is limited in scope to two study areas, a planned settlement and an informal settlement at Dinajpur, which may not reflect the diverse experiences of climate-induced migrants across other urban or peri-urban settlements in Bangladesh. The findings are context-specific and may not be fully generalized to other geographic or socio-economic settings. Additionally, while the mixed-method approach provided rich insights, the reliance on self-reported data through semi-structured interviews may be subject to recall bias. Furthermore, in the space syntax analysis, the reliability of results is reduced where spatial systems contain fewer than five spaces, and the adopted combined system introduces interpretative assumptions that may affect accuracy. Finally, time constraints and limited access to historical planning data restricted a more comprehensive longitudinal analysis of spatial transformations.

7.4 Direction for Future Research

Future research could build on this study by adopting a longitudinal approach to document the evolution of spatial adaptations over time (shape grammar) in response to socioeconomic and environmental challenges. Expanding the geographical scope to include multiple informal and planned settlements across different climatic zones would enhance the comparative depth and generalizability of findings. Moreover, closer examination of governance, policy implementation, and community-led planning mechanisms could yield insights into how institutional frameworks enable or constrain adaptive capacity at different scales (meso and macro scales). Integrating advanced spatial tools such as remote sensing, GIS-based analytics, and space syntax and/or place syntax methods would allow for a deeper exploration of how settlement morphologies and spatial configurations influence accessibility, social interaction, and resilience.

In addition, extending the inquiry into the social dimensions, such as gendered use of spaces, cultural practices of dwelling, and the role of networks in fostering collective resilience, would help build a more holistic understanding of adaptation processes. Place syntax analysis, for example, could reveal how accessibility to services, resources, and opportunities is shaped by the built form, thereby influencing livelihood strategies, safety, and social cohesion. At the same time, the integration of emerging technologies, particularly Artificial Intelligence (AI),

presents a promising frontier for advancing housing and settlement research. AI-driven tools could support predictive modeling of environmental risks, providing scenario-based simulations of how flooding, heat stress, or riverbank erosion might reshape settlement patterns. Generative design algorithms could be employed to test adaptive housing typologies that respond to climate stresses while remaining affordable and culturally appropriate. Coupled with space syntax and place syntax analytics, AI could further identify optimal configurations for circulation networks, shared infrastructure, and community facilities that enhance accessibility and resilience. Future studies may also explore how AI can augment participatory design processes by translating local knowledge into computational models.

7.5 Conclusion

In conclusion, this research highlights the crucial role of adaptive spatial strategies in informal settlements, driven by social, economic, and environmental factors, in response to the challenges posed by climate change and migration. Through an in-depth examination of spatial transformations, the study highlights how households respond to climatic and livelihood pressures by reconfiguring space to balance accessibility, privacy, and functionality. The analysis of spatial syntax metrics further illustrates how different levels of integration and asymmetry reflect evolving priorities—whether improving service accessibility or accommodating growing household needs. These informal spatial adaptations by residents underscore the adaptive capacity embedded within informal urbanism and call for a quasi-formal approach. This thesis contributes to a nuanced understanding of resilience at the scale of the home and settlement, offering valuable insights for policy, planning, and design to better support vulnerable communities in building inclusive and sustainable urban futures.

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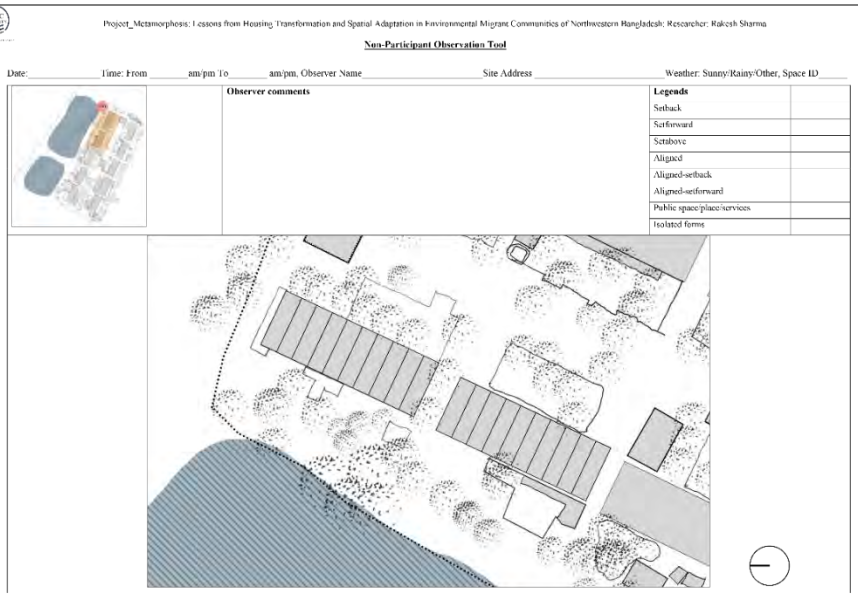
Appendix A.

Non-participant Observation Tool

The appendix contains observation tools that researchers used to map the morphogenesis of the settlements.

Observation Tool_SampleSpace01



Observation Tool_TargetSpace01

Observation Tool_TargetSpace02


Project_Metamorphosis: Lessons from Housing Transformation and Spatial Adaptation in Environmental Migrant Communities of Northwestern Bangladesh; Researcher: Rakesh Sharma

Non-Participant Observation Tool

Date:_____ Time: From _____ am/pm To _____ am/pm, Observer Name_____ Site Address _____ Weather: Sunny/Rainy/Other, Space ID

Observer comments

Legends	
Setback	
Setforward	
Setabove	
Aligned	
Aligned-setback	
Aligned-setforward	
Public space/place/services	
Isolated forms	

Observation Tool_TargetSpace03


Project_Metamorphosis: Lessons from Housing Transformation and Spatial Adaptation in Environmental Migrant Communities of Northwestern Bangladesh; Researcher: Rakesh Sharma

Non-Participant Observation Tool

Date:_____ Time: From _____ am/pm To_____ am/pm, Observer Name_____ Site Address _____ Weather: Sunny/Rainy/Other, Space ID_____

Observer comments

Legends	
Setback	
Setforward	
Setabove	
Aligned	
Aligned-setback	
Aligned-setforward	
Public space/place/services	
Isolated forms	

Appendix B.

Interview Questionnaire

Household ID_____

Section A. Migration and Demographic Information

1. Where were you originally from? _____
2. Why did your family move here?

☐ Natural disaster ☐ Job loss/poverty ☐ River erosion ☐ Marriage/family ☐ Other: _____

3. Total number of people in your household: ____
4. Number of adults earning: _____
5. Number of children (under 18): _____
6. Number of elderly (60+): _____
7. Number of dependents (not earning): _____

Section B. Household Income

1. Monthly household income (in BDT): _____
2. Main income source:

☐ Day labor ☐ Small business ☐ Rickshaw/Van ☐ Job ☐ Remittance ☐ Help from govt. ☐ Other: _____

3. Second income source (if any): _____

Section C. Housing Characteristics

1. Type of house:

☐ Katcha ☐ Semi-pucca ☐ Pucca ☐ Temporary

2. Roof material:

☐ Tin ☐ Plastic ☐ Concrete ☐ Thatched ☐ Other: _____

3. Wall material:

☐ Bamboo ☐ Tin ☐ Brick ☐ Other: _____

4. Floor material:

☐ Mud ☐ Cement ☐ Brick ☐ Other: _____

5. Total area of the household (in square feet): _____
6. Habitable space (in square feet): _____
7. Number of rooms used for sleeping/living: _____

Section D. Services and Access

1. Do you have electricity? ☐ Yes ☐ No
2. Main drinking water source:

☐ Tube well ☐ Piped ☐ River/pond ☐ Bottled ☐ Other: _____

3. Distance to water point:

☐ Inside house ☐ Less than 50m ☐ 50–100m ☐ Over 100m

4. Toilet type:

☐ Pit ☐ Hanging ☐ Flush ☐ Shared ☐ None

5. Where is the toilet?

☐ Inside ☐ Nearby/shared ☐ Far away

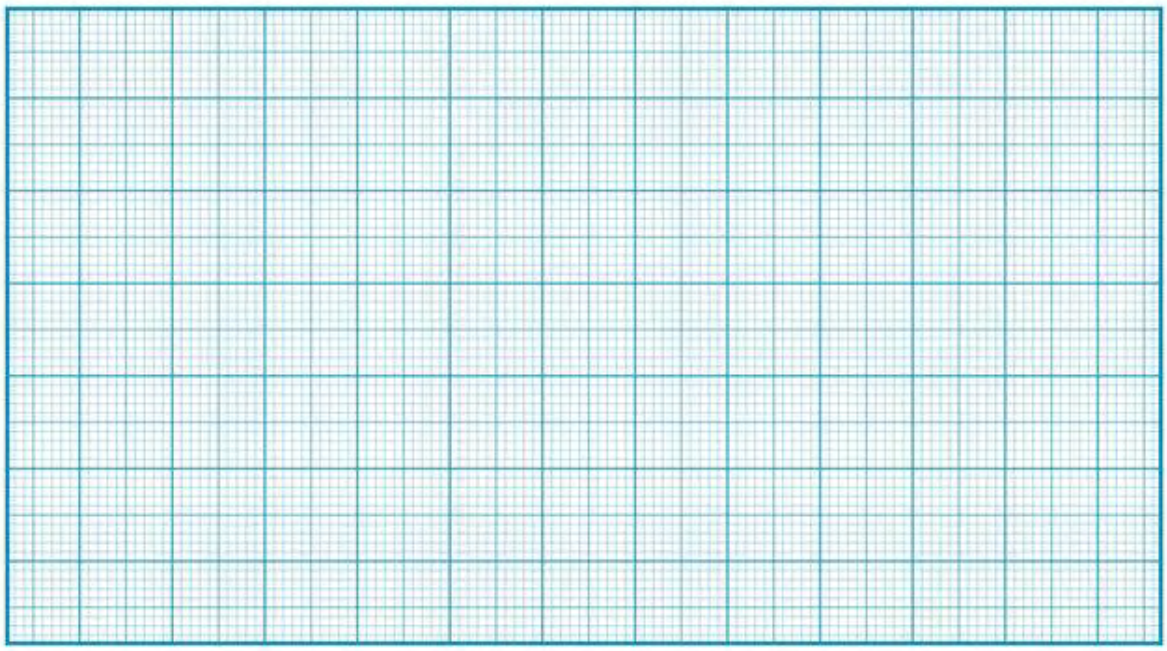
6. Main fuel for cooking:

☐ Firewood ☐ Cow dung ☐ Kerosene ☐ LPG ☐ Electricity ☐ Other: _____

Section E. Evolution of Housing

What were your initial housing arrangements when you first arrived, and how have they changed over time? Tell me like a story.

(Use scale 1 small square = 1 foot)



Appendix C.

Focus Group Discussion (FGD) Questionnaire

1. What are the main challenges your community faces in terms of housing and infrastructure? *(Neighborhood Challenges)*
2. What changes or adaptations have been made in the neighborhood to address these challenges? *(Community Adaptations)*
3. How have these neighborhood-level changes impacted the community's daily life and overall well-being? *(Impact of Interventions)*
4. What further neighborhood-level improvements or interventions would you like to see? *(Future Improvements)*

Map together

Notes

Appendix D.

The following table depicts the final version of the thematic analysis.

Themes	*Sub Themes*	*Adaptation Tools*	*Adaptation Measures*	*SH1*	*SH2*	*TH1*	*TH2*	*TH3*	*TH4*	*TH5*	*TH6*	*TH7*	*TH8*	*TH9*	*TH10*	*TH11*	*TH12*
Environmental Adaptation	Natural Hazards, Rainfall, and Water Management	**SBM**	Incremental construction using permanent/semi-permanent materials for durability.		**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	
		CPM	Raising the plinth level				**x**			**x**			**x**	**x**		**x**	**x**
			Masking with permanent materials			**x**	**x**							**x**			**x**
			Wall/Roof bracings						**x**								
		DMF	Removable facades for flexibility	**x**			**x**						**x**	**x**	**x**	**x**	
		REN	Repair works of the foundation/wall /roof	**x**	**x**							**x**	**x**	**x**	**x**	**x**	**x**
		IAS	Installing tubewell	**x**	**x**	**x**	**x**		**x**	**x**		**x**	**x**	**x**	**x**	**x**	**x**
			Construction of a toilet	**x**		**x**	**x**	**x**	**x**	**x**	**x**	**x**		**x**	**x**		**x**
	Heat and Insulation	**NVT**	Conservation of open spaces	**x**	**x**				**x**								
			Cross ventilation with windows/doors				**x**		**x**					**x**	**x**		
		TEC	Shading mechanism	**x**		**x**	**x**		**x**						**x**		
			Suspended ceiling as insulation	**x**			**x**								**x**		**x**
	Energy Efficiency	**SET**	Adapted cooking space for electric *Magic Chula*			**x**				**x**	**x**			**x**			**x**
	Vegetation	**PGT**	Small scale gardening, planting shady trees	**x**	**x**		**x**					**x**		**x**	**x**		
	Sustainability	**SUM**	Recycling old materials for construction				**x**								**x**		
Economic Adaptation		**MFB**	Common space appropriate for business			**x**	**x**	**x**		**x**					**x**	**x**	**x**
			Living area transformed into a small shop (adjacent)						**x**								
			An income generating space is					**x**									

			adapted (isolated)															
			Living area transformed to accommodate cattle/husbandry		**x**						**x**							
	Access to Credit and Financing Options	**AGY**	Involvement in a cooperative	**x**	**x**	**x**												
			Support from external forces GoB/NGOs/INGOs	**x**	**x**		**x**								**x**			
Social Adaptation	Household Growth and Social Dynamics	**HEX**	Room extension horizontal for additional sleeping space															**x**
			Room addition horizontal for additional sleeping space		**x**				**x**		**x**		**x**	**x**				
			Room addition horizontal for additional service space								**x**		**x**	**x**				
			Room division for additional separate sleeping space	**x**				**x**									**x**	
		VEX	Room addition vertical for additional sleeping space				**x**	**x**		**x**		**x**				**x**		
			Room addition vertical for additional service					**x**				**x**				**x**		
			Service spaces appropriated as additional sleeping space			**x**					**x**		**x**					
			Sleeping space converted into other functional spaces	**x**	**x**		**x**				**x**		**x**					
			Common area appropriate for services	**x**	**x**										**x**	**x**		
	Private Health and Hygiene Needs	**IAS**	Installing tubewell	**x**	**x**	**x**	**x**		**x**	**x**		**x**	**x**	**x**	**x**	**x**	**x**	
			Electric Motor Water Supply					**x**			**x**							
			Toilet	**x**		**x**	**x**	**x**	**x**	**x**	**x**	**x**		**x**	**x**			**x**

Appendix E.

Spatial Analyses and Calculations

Two types of Space Syntax variables, namely 'Integration' and 'Relative Asymmetry' (RA), which are the basis for Space Syntax calculation (Hillier & Hanson, 1984), have been used in describing spatial relationships within the dwellings in this study. The basic concept of Space Syntax concerns the relationship of the individual spatial points with each other and the individual to the whole system. It also concerns the pattern of connections, the adjacency of spaces, and how they relate to the outside system.

Mean Depth (MD)

The Mean Depth (MD) is an essential quantifiable spatial quality of an individual point in the habitation complex. For each point, the computation of its MD is derived from the summation of the multiplication of several points at different depth levels in the entire building complex. The method for calculation and the logic of MD is presented thoroughly in several publications (Hillier et al., 1986; Hillier & Hanson, 1984, 1998).

The relationship of space within a building complex *C* can be represented as a graph of points and connecting lines. The depth between points a and *b* of spatial complex *C* is noted as *D* (*a*, *b*), and is equal to the minimum number of connections that must be used to reach *b* from *a*, or a from *b*. Then.

The Mean Depth (MD) of point *a* in a complex *C*, where *K* = number of points in

C is defined by the expression:

$$\mathbf{MD}(\boldsymbol{a},\boldsymbol{C}) = \frac{\sum_{bi \in C} D(a,bi)}{K-1}$$

The MD value is localized and cannot be compared across the building complex. It can be calculated with and without the exterior. When the exterior is included in the calculation, the outside of the complex is simply counted as one additional point.

The Relative Asymmetry (RA) and the Real Relative Asymmetry (RRA)

Both the variable Relative Asymmetry (RA) and spatial Integration (I) express the degree to which the space is included or excluded in the whole dwelling complex. The relative asymmetry (RA) value indicates the relative position and the integration of the individual space

into the spatial categories that make up the whole building.

The Relative Asymmetry (RA) of point *a* in a complex *C* is defined by the expression:

$$\mathbf{RA}\ (a, C) = \frac{2[MD(a,C)-1]}{K-2}$$

The Relative Asymmetry (RA) values cannot be compared across buildings, but they are very useful for comparing spatial integration within the individual setting, especially in dwellings with very small numbers of spaces (k ≥ 5). The interpretation of the RA value is somewhat counterintuitive, the lower the RA value, the higher the degree of integration of that space.

The Real Relative Asymmetry (RRA) is a normalized version of RA, which allows it to be compared across the building systems. The RRA of a point *a* in a complex *C* (for all a, C; 0 ≤ RA (*a*, *C*) ≤1) is defined by the expression:

The RRA value ranges from 0 to 1. Its interpretation is similar to that of the RA: the lower the RRA value, the higher the degree of integration of that particular space.

$$\mathbf{RRA}\ (a, C) = \frac{6.644k.\log_{10}(k+2) - 3.17k + 2}{k^2 - 3k + 2}$$

Or

$$RRA = RA/D_k$$

Where D_k represents the D value of k number of spaces.

The Spatial Integration value (I)

The Integration value is more universal, and the interpretation is straightforward. The high Integration value coincides with the space with shallow and ringy quality, and the low Integration value is associated with deep and tree-like spatial quality. In simple terms, the higher the numbers indicate, the higher the level of integration of space with the whole unit. The Integration value is universal and normalized; therefore, it can be used for comparison across the built setting.

$$I = D_k/RA$$

$$\text{where } D_k = \frac{2\left\{k\left\{\log 2\left\{\frac{k+2}{3}\right\}-1\right\}+1\right\}}{(k-1)(k-2)}$$

or

$$I = 1/RRA$$

The Mean Integration value of a complex is derived from the average integration value of each point within the complex. The numerical consistency found among the Integration value of spatial types within the habitation complex, derived from samples of plans from a region or society, can be regarded as a 'cultural pattern'. (Hillier & Hanson, 1984) have borrowed this idea from the evolutionary biology concept of '*genotype*.'

The End