THIRD LANDSCAPES FOR FLOOD-RESILIENCE: LOCATING THE MISSING SCALE OF GREEN INFRASTRUCTURE IN NEIGHBORHOODS IN KHULNA, BANGLADESH

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ABSTRACT
This paper examines an opportunity to address recurring urban flooding within neighborhoods in Khulna, Bangladesh. Urban flooding has been intensifying in Khulna with sea-level rise and chronic waterlogging. Over the past decade, professional and academic planning studies have prioritized upgrades to large-scale infrastructure and drainage systems. Although well-intentioned, these infrastructure redevelopments alter landforms, change flow directions, and trap water in streets and basements, which exacerbates localized flooding. This paper investigates the gaps between traditional flood-mitigation planning and actual on-the-ground flooding conditions in Khulna neighborhoods. It uses document review, interviews with professionals and residents, and fieldwork documentation, and reveals three key findings: flooding impacts at the neighborhood scale are largely absent from mitigation planning, professionals' and residents' knowledge and attitudes differ regarding flooding and adaptation, and interstitial spaces within neighborhoods offer opportunities to function as intentionally designed retention areas. Building on these findings, the paper argues for local-scale, landscape-based adaptations that align with community concerns, and for integration of professional and residential knowledge to achieve effective adaptations. The paper draws from and extends Gilles Clément' "Third Landscapes" theory, which posits the value of overlooked landscapes as spaces to address local needs and bridge the performance gaps created by large-scale planning. The paper underscores the role of knowledge sharing and landscape research in designing flood-resilient neighborhoods in flood-prone cities in Southeast Asia and around the world.

Keywords
Urban Flooding, Adaptation, Engagement, Fieldwork, Third Landscapes

1 INTRODUCTION

Urban flooding is among the major concerns of cities around the world, in which rapid development reduces the landscape's capacity to handle extreme weather, precipitation events, and threats of rising sea levels (World Bank 2012, Houston et al. 2011, Gill et al. 2007). Extensive imperviousness and altered drainage pathways contribute to recurring flooding events (Huang et al. 2008, Liu et al. 2014, Miller et al. 2014, Li et al. 2019). Large flood control infrastructures, such as floodwalls, floodgates, levees, dams, and polders, are inefficient during extreme weather events, degrade ecological processes, and are unable to adapt to climate change fluctuations and effects (White 1942, Mount 1995, Philippi 1996, Nienhuis and Leuven 2001, Smits et al. 2006, Gurnell et al. 2007, Liao 2014). Landscape architecture approaches, in contrast, utilize multi-scale, site design techniques to manage flooding; unlike conventional planning and engineering that offer resistance and control to flooding, landscape-based designs embrace, capture, and manage water locally (Lister 2016). Landscape-based design for stormwater, frequently termed green stormwater infrastructure (GSI), creates multifunctionality by slowing and storing water, providing infiltration, filtering pollutants, and improving the health of the environment, especially when integrated with gray infrastructure throughout urban areas to the extent possible (Mertens 2021). Understanding potential spaces and places for GSI integration in urban areas is one of the significant adaptation opportunities in the climate crisis (Gill et al. 2007).

South Asian countries are particularly vulnerable to frequent disasters. Rapid urbanization is worsening urban flooding, and modeling, data, and design are lagging. A recent review of 105 articles across South Asia, analyzed urban flood management and concluded that most hydraulic models lack short-duration rainfall data and high-resolution site-scale information, limiting their accuracy in the urban context (Manandhar et al. 2023). For example, in Dhaka, Bangladesh models such as MIKE Urban, GeoSWMM and Personal Computer Stormwater Management Model (PCSWMM) use 10 m and 25m DEMs to create location specific maps; however, reliance on gray infrastructure remains dominant, and limited efforts toward low-impact development (LID) practices such as rain gardens and detention basins have only recently begun (Manandhar et al. 2023). Several studies have highlighted specific challenges and opportunities in Khulna, the third-largest business center in Bangladesh. A paper examined Wards 29, 30, and 31 and documented ecosystem services provided by urban blue ecosystems (BEs), such as thermal cooling, carbon absorption, and biodiversity support (Haque et al. 2022). Although the existing quality of ponds and water bodies and their ecosystems is degrading, a majority of residents expressed willingness to pay for their improvement, emphasizing the importance of community participation in sustainable management (Haque et al. 2022). Another recent study assessed Ward 30’s drainage system using PCSWMM, DEM, and LULC maps, showing that reducing imperviousness (currently 70%) and increasing slopes significantly lowered outfall discharge and improved infiltration, pointing to the need for green infrastructure (GI) integration (Fahim et al. 2024). A doctoral study explored Traditional Ecological Knowledge (TEK) in two Khulna riverbank communities, discussing existing local water management practices and recommending their knowledge integration into Khulna’s urban planning and design through community engagement, policy reform, and neighborhood-scale water management networks (Asad 2025). Those studies reflect growing concerns about urban flooding as well as recent efforts to find alternatives to large gray infrastructure solutions. This paper further contributes to those research efforts through neighborhood engagement opportunities and field observations to identify potential sites for appropriate interventions and solutions, focused on a neighborhood in Khulna, Bangladesh, as a case study.

1.1 Flooding in Khulna and Key Climate Challenges

Khulna City sits between the western bank of the Rupsha-Bhairab River and the eastern bank of the Mayur River, in the southwestern region of Bangladesh (Figure 1). To protect the lowlands of the region from floods and salinization and agricultural lands from tidal influence, a polder system and sluice gates were introduced (Figure 1) in the 1960s, which is a very traditional flood-mitigation approach for low-lying regions (Datta 2020, Khulna City Corporation 2011). The city drains through the polders, then passes through the Mayur River, before draining to the Rupsha River (Nillesen et al. 2021). After the completion of the Farakka Dam (Figure 1) in the Murshidabad district in West Bengal in the 1970s, a reduced flow of water comes from the Ganges and its tributaries to the Bhairab-Rupsha River during the monsoon (June-September) (Jakia et al. 2016).

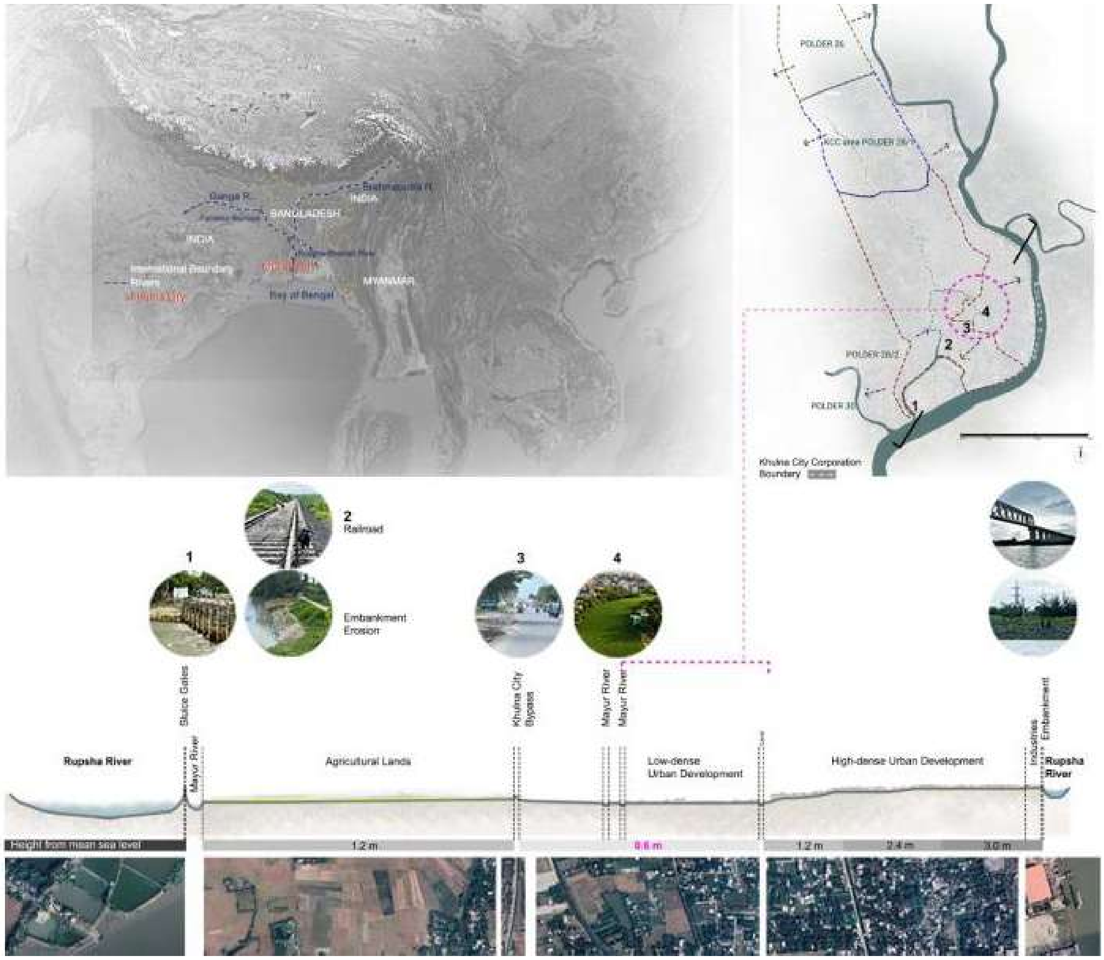

Figure 1. Top left: Geographic location of Khulna, Bangladesh; Top right: Polder systems and flow directions of Khulna; Bottom: Topographic elevation differences across Khulna. The Rupsha Riverbank is ~3m above mean sea level, whereas the central area is ~0.6m. Photos by the author.

As lands in the Khulna region were reclaimed through the development of the polder system, the Rupsha-Bhairab River increasingly delimited the movement of river sediment into the floodplains. Moreover, siltation raises the elevation of the riverbed, which often causes overflows during the monsoon. Due to the higher elevation at the riverbanks, the middle part of the Khulna landscape sits lower, creating a bowl landscape (Figure 1). For this reason, stormwater does not naturally drain from the city center to the Rupsha River in the monsoon. Further, the sluice gates at the confluence of the Mayur and Rupsha rivers are under capacity to carry a high volume of runoff. Over time, with those dysfunctions, waterlogging has become more frequent in Khulna, and the rivers have almost lost their ability to drain water from the urban landscape (Nillesen et al 2021, Kamer et al 2021).

The Intergovernmental Panel on Climate Change (IPCC) predicts that Khulna will have a 0.5 m sea level rise in future monsoons (IPCC 2014, Nillesen et al 2021). Moreover, according to the Climate Service Center Germany (GERICS), rainfall will increase by 15% by 2050 (Kamer et al 2021). With a 15% increase in rainfall, Khulna will observe a new daily 10-year maximum of 243 mm within less than three decades (Nillesen et al 2021). Also, the population growth rate of the city corporation area is more than 93% and that indicates the city's expansion in the future as well as the increase in impervious surface, which will likely increase waterlogging (Li et al 2019, Hu et al 2020, Bangladesh Bureau of Statistics 2022).

1.2 Research Objectives

Since Khulna City suffers recurring urban flooding during the rainy season, this paper explores new strategies to address shortfalls of the centralized flood mitigation infrastructure. It asks three research questions: 1. What are the gaps between current flood mitigation planning and local on-the-ground flooding in Khulna neighborhoods? 2. What knowledge is missing regarding urban flooding at the neighborhood scale that will better bridge those gaps? 3. How might landscape-based interventions respond to that knowledge to make the city more flood-resilient?

1.3 Third Landscape Theory and Framework

This research draws on the concept of "Third Landscapes" – defined as abandoned, leftover, and interstitial landscapes, generally located in vacant lots, rights-of-way, and informal patches in our cities (Clément 2004). Third Landscape theory critiques urban planning and design practices for not integrating underused urban landscapes into formal or performative consideration, and advocates for the inclusion of these spaces in the development of ecological corridors and the promotion of biodiversity in interstitial zones of post-industrial cities (Clément 2004, 2006). Overall, Third Landscapes help to bridge the gaps between formal planning approaches and informal design adaptations. In the context of Khulna, this paper borrows the Third Landscape concept as a framing device to link gaps in flood mitigation planning to local-scale opportunities within interstitial urban landscapes.

2 METHODS

The research process for this study integrated three interdependent methods: 1. a review of planning documents related to flooding issues and flood-mitigation in Khulna; 2. 25 days of fieldwork consisting of semi-structured interviews across two participant groups; and 3. documentation of site observations covering approximately six miles of infrastructure and urban conditions which included conceptual mapping and visualization of flooding conditions in neighborhoods combining photography, drone-based mapping at street scale, and cross-sectional drawings.

2.1 Document Review

Document review consisted of publicly available online documents to understand the planning context of flooding. Among those documents, Bangladesh Delta Plan 2100, and Water as Leverage (WaL): Design Studies for Khulna, Chennai, and Semarang were selected as the most recent public studies that address the larger context of flooding in the region and discuss future planning. Two additional documents, The Drainage Master Plan 2011, and The Feasibility Study in Khulna Including Climate Risk Assessment and Environment and Social Impact Assessment, are not publicly available but were provided by Group One interviewees (Section 2.2.1) for the purpose of this research. Those documents discuss recent planning actions, approaches of different organizations towards this issue, analyze flood-vulnerable areas, and recommend future actions. All documents were reviewed and analyzed in terms of their studied scales, methods, and recommendations.

2.2 Fieldwork

Following document review, primary fieldwork, using methods of first-person observations, photographs, tracing, mapping, and representation defined by Girot (2009) as stages of landing and grounding, was conducted at different scales: city, neighborhood, and site. The fieldwork was needed in the absence of publicly available data sources of information. Twenty-five days in Khulna (July 18-August 4, 2023, and January 6-12, 2024) consisted of interviewing academics, professionals, and residents and observing large-scale infrastructures as well as local flooding conditions.

2.2.1 Interviews

At the beginning of the fieldwork, the study required understanding the varying perspectives and voices of responsible agencies and affected residents. Those participants were sorted as: a) Group One - consisting of 20 professionals with roles in planning analysis, academic research, development of new residential neighborhoods, and flood mitigation infrastructures in Khulna, and b) Group Two - consisting of 28 adult residents who have lived a minimum of five years in Khulna Development Authority (KDA)-developed residential areas (R/A) that experience flooding every year during the rainy season.

Interview questions were slightly different between Group One and Group Two, yet they shared common themes: the causes of flooding and their frequency, identification of vulnerable areas, observed landscape changes, issues of accessibility, and potential adaptations. Group One interviews were scheduled for one hour with a set of twelve open-ended semi-structured questions and recorded with their permission. Group Two interviews varied between 20 and 40 minutes per participant, to respect their time, and were also recorded.

Questions asked of Participant Group One:

1. Causes of Flooding: What do you think are the reasons behind frequent flooding in Khulna City?
2. Frequency: How often do flood surges occur? Are there different types of flooding, and how are they different?
3. Identification of Vulnerable Areas: Which residential areas do you think suffer most during floods? How does flooding affect the everyday life of the residents?
4. Observed Landscape Changes: What are the impacts and changes occurring in the landscape due to flooding? - - For example, are vegetation, pavements, or soils affected? Do you want to share any of your personal experiences that you noticed regarding these changes?
5. Accessibility Issues: Are there any accessibility or mobility issues during flooding?
6. Adaptations: Are there any adaptation strategies that have been taken by the authorities or by residents? How do development authorities currently respond to urban flooding in Khulna?

Questions asked of Participant Group Two:

1. Causes of Flooding: What do you think is the reason behind the flooding in your neighborhood and other areas in Khulna?
2. Frequency: How often does flooding occur, and for how long?
3. Identification of Vulnerable Areas: Are there any areas that are more vulnerable to flooding in the city? What are the vulnerable areas in your community?
4. Observed Landscape Changes: How do you commute when flooding occurs in your neighborhood?
5. Accessibility Issues: Are there any accessibility or mobility issues during flooding? Adaptations: What do you do when there is flooding? Are there any adaptations you make to your home or daily routine in response to the flooding?
6. Adaptations: What do you do when there is flooding? Are there any adaptations you make to your home or daily routine in response to the flooding?

2.2.2 Direct Field Observations and Site Documentation Methods

Photographs were taken to document the conditions of large-scale flood-mitigation infrastructure and the impacts of recent drainage development constructions in neighborhoods. Observations were documented through mapping and cross-sectional drawings. Flooding patterns in landscapes at street-scale were documented. Road 21 within Nirala R/A was documented as several interview participants are from this area, and the street is connected with the Nirala Park, Nirala Adarsha School, and connected to the Mayur River with several outfalls. Street observations from within Nirala were also important because KDA plans to develop another R/A southwest of this neighborhood, an area that is also flood-prone. Drone shots were taken for five days in July to observe the locations of flooding 24 hours after 1-2 hours of rainfall. Images from a constant height (30m) recorded how water moves across and through the landscape at street scale, and in particular, where water ponds for a longer period.

3 RESULTS

Through the document review process, interviews, and fieldwork, this paper finds conceptual, spatial, and knowledge gaps between the current flood-mitigation planning approaches and actual on-the-ground flooding conditions in Khulna neighborhoods. It highlights that critical knowledge of the residents about local urban flooding is not integrated or addressed in the planning documents. Research documentation of the local flooding areas appears to be opportunities for flood-mitigation within the streets of the KDA-developed neighborhoods.

3.1 Current Planning Approaches

The *Bangladesh Delta Plan 2100* describes long-term goals for sustainable management of water, ecology, environment, and resources throughout the country. It highlights that future development project proposals should ensure safety from floods, climate change disasters, water security, waterlogging, and inefficiency of drainage infrastructure in the southwest. However, the study only discusses macro-scale challenges, opportunities, national-level strategies, and calls for effective institutional development to achieve its goals. (Bangladesh Planning Commission 2018). Another study, *Water as Leverage (WaL): Design Studies for Khulna, Chennai, and Semarang,* investigates flood risks and assesses that one-third of Khulna City's land is prone to flooding. It proposes decentralizing the sewage system to collect and reuse waste, with community stakeholder involvement, although it does not provide strategies for engagement (Nillesen et al 2021). In contrast to those publicly available documents, The *Drainage Master Plan 2011* by Khulna City Corporation (KCC) reveals that the waterlogging in Khulna has been caused by the dysfunctional drainage system, and the higher water level of the Bhairab-Rupsha River during high tide causes backflow from the Mayur River. It also suggests that the polder system of the city could tolerate several days of flooding and could therefore improve its drainage networks and own pumping system (Khulna City Corporation 2011). The *Feasibility Study in Khulna Including Climate Risk Assessment and Environment and Social Impact Assessment* provides a city-wide climate vulnerability study and prioritization of adaptation options, and a detailed analysis of existing drainage infrastructure. Feasibility assessment of the KCC's stormwater drainage improvement, strategies for implementation projects, capital cost estimation, and maintenance recommendations have been discussed in the report. It has a comprehensive overview of increasing urban development challenges in Khulna, analysis of flooding-vulnerable areas across the city, and proposals of nine sub-projects–river embankment controls, pumping station rehabilitation, ponds revitalization, drainage infrastructure improvements, and extensions. (Kamer et al 2021). Since flooding in Khulna has only been understood at the city scale and, at times, in specific vulnerable neighborhoods, this study intended to use interviews as a method to highlight residents' stories and lived experiences during flooding.

3.2 Interview Results

Interviews with Group One and Group Two demonstrate varying knowledge, attitudes, and experiences between the groups across six key themes (Table1). Group One participants provided theoretical knowledge focused on system-wide issues, whereas Group Two offered experiential knowledge grounded in daily encounters with flooding. The interview sorting process captures the knowledge of two participant groups under themes to find their voices in flooding narratives, understand their relationship with flooding, and their contribution to adapting to flooding.

Table 1. Sorting of the two participant groups' responses under six themes; selective responses provide insights into different perspectives.

Themes	Group 1 - Professionals Theoretical Knowledge	Group 2 - Residents Experiential Knowledge
Causes/ Factors	- "The periphery is at a higher elevation than the center of the city. Where does the water go in this situation?" - "..The problem we have is waterlogging. And, It is important to know how you define waterlogging here." - The illegal encroachment of water bodies, lack of maintenance, and waste dumping - are the main reasons behind the problem. - The natural drainage system has failed. - "...So, the development pressure is there. It is low land, and the Mayur River backflows water during heavy rainfall events." - During high tide, water flows back from the Rupsha River to the Mayur River through the floodgate.	- "If it rains for 2 or 3 hours, our whole area goes under water." - "Lack of maintenance of KCC drains is a reason for flooding." - "...Also there are some areas where flooding happens if it rains for 2/3 day. Basically, it depends on the quality of drainage system in that particular area…" - "There are some areas where if it rains for 2 hours, the whole area goes under water." - "...Once all the roads of this neighborhood will be raised, most of the ground floors in this area will have clogged water during the rainy season."
Frequency	- "We experience this problem from June/ July, and it lasts till September."	- "…mainly we have this problem during all over the rainy season, every year." - "...4 - 5 inches water, it goes away after one hour." - "…we mainly face water logging problem here. In rainy season, - we face problem in daily commute due to this problem." - "...it doesn't happen frequently; it gets worse once or twice a year, rainwater comes over the plinth." - "...and heavy rainfall events submerge our ground floor eventually."
Vulnerable Areas	- "...for people who don't live in a planned apartment building, their ground floor usually goes underwater during the rainy season."	- "This is a KDA-planned residential area. We don't have much problem except the drainage system."
Landscape Changes	- "...because of waterlogging, the soil structure changes." - "Soakable area has been decreasing due to rapid urbanization..."	- "...we see mud in our park and open public areas." - "I noticed small plants and vegetation sometimes die due to heavy rainfall and flooding. Also, moss is seen on the ground floor and the walls at that period of time."
Accessibility	- " Even the impact on the landscape reduces outdoor gatherings even a few days after a heavy rain event."	- "...we don't even feel comfortable to go outside. We can see waste in the water.So, we avoid going out and prefer to stay at home."
Adaptations	- "Now, we are reconstructing drains and maintaining the slope to the Mayur River because the west part of the city is lower than the east part." - "We are working with a German consultant, who is proposing some drainage outlet to the Sholmari River."	- "We use bricks to make raised steps for walking into our house." - "I always check weather updates to be prepared for rain events. I need to wear my rain boots and do the groceries before rain comes."

3.3 Site Observation Results

Site photographs and mapping documented the conditions of flood control infrastructures (Figure 2) and the impacts of recent developments (Figure 3) on local flooding. Areas along the Rupsha River are densely developed with shipping trade businesses, brick and cement industries, and transportation businesses. Khan Jahan Ali Bridge and Rupsha Railway Bridge were built on the Rupsha River, altering land use, contributing to siltation, and changing the ecosystem of this area. There are two confluences of the Mayur and the Rupsha River–one (Alutola) has ten floodgates that are not functioning well in discharging water during high tide, and another one has been blocked by aquaculture and landfills. Along the Mayur River, recent infrastructure developments such as city bypasses, railroads, and bridges have created blocks for water to pass through from the middle part of the city (Figure 1). In the southwest part of the city, adjacent to the Mayur River, where urban development has accelerated recently, most of the residents own and manage rice fields, other agricultural lands, and aquaculture areas. Rice fields work as natural retention areas during the rainy season. This part of the city is dependent on natural and organic drainage, which is healthy for some agricultural practices. Since Khulna city does not have a separate stormwater drainage network, these photographs provide evidence of neighborhood drainage outfalls at various intersections that are clogged with waste and overflowing directly into the Mayur River.

To better understand the impact of their new drainage redevelopments on existing flooding conditions in Khulna neighborhoods, the construction sites in different neighborhoods were documented through photographs and mapping. Figure 3 shows drainage constructions, impacts on the sites, and landscape conditions in three different KDA-developed residential areas–Khalishpur R/A, Mujgunni R/A, and Nirala R/A.

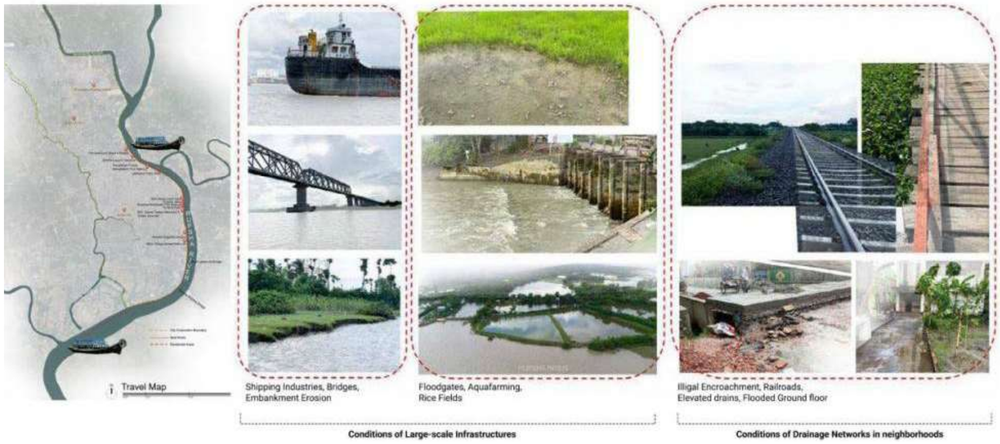

Figure 2. Left: Travel route, and Right: the documentation of large scale flood-mitigation and drainage infrastructures at different scales. Photos by the author.

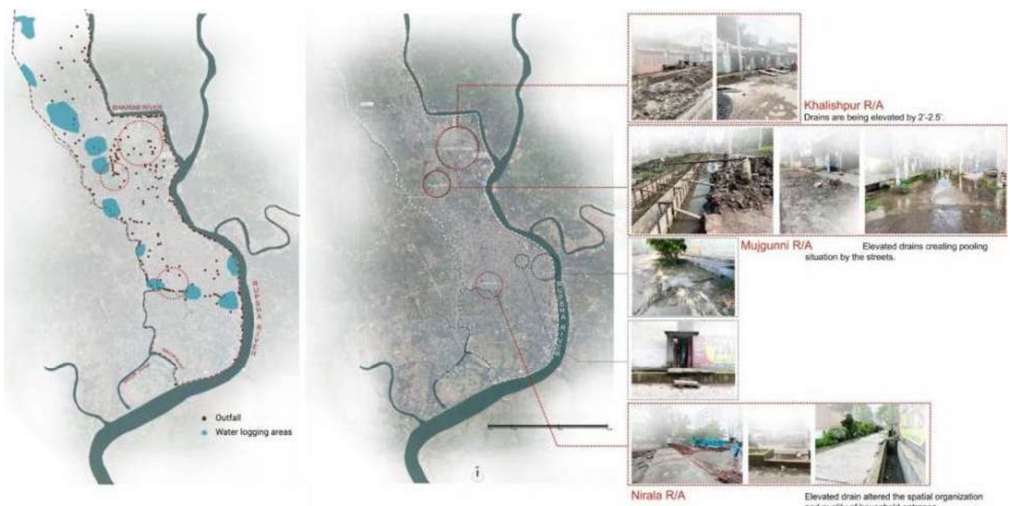

Figure 3. Left: Waterlogging areas and location of three residential neighborhoods; Right: Drainage constructions' impacts on sites and landscapes in different areas. Photos by the author. Source: KCC, 2011

3.4 Flooding Locations at the Site Scale

Drone images were taken of Nirala Road 21 from a constant height (30m) over five days in the last two weeks of July 2023, and were helpful when stitched together to trace how water moves across and through the landscape at this scale, and in particular, where water ponds for a longer period. Figure 4 illustrates flooding locations highlighted by residents under the "Experiential Knowledge" column in Table 1 at the scale mentioned in Table 2; those locations include rights-of-way, vacant lots, open public spaces, and basements along the street in Nirala R/A. Figure 4 also shows those areas that remain wet, hold stagnant water, or are pooled with water 24 hours after rainfall. The cross-sections show how the raised drains have altered landforms along the street and created new flooding conditions on this street. These conditions connect back to the interview participants' comments about their neighborhood park becoming inaccessible due to waterlogging. This has become a common scenario in most of the Khulna neighborhoods where drain construction is ongoing.

Table 2. Findings show scale differences between the two interviewee groups–Group 1 possesses more central, homogenous knowledge about the city's flooding issues and infrastructures, whereas Group 2 offers experiential knowledge of everyday life about local flooding.

Themes	Group 1 - Theoretical Knowledge	Vs.	Group 2 - Experiential Knowledge
Causes/Factors	Flood gates, polders, climate change, elevation change, illegal encroachment, failed natural drainage system, lack of maintenance, relationship between water and humans	Vs.	Submerging the ground floor, quality of drainage system
Frequency	June - Sept	Vs.	All through the rainy season
Vulnerable Areas	Walkability, less soakable areas	Vs.	Mobility on the water
Landscape Changes	Soil structure, dust	Vs.	Muddy Park, dead plants, thick layer of moss on the ground floor
Accessibility	Streets go underwater, ground floor in planned residential areas, fewer outdoor gatherings	Vs.	Ground floor goes 4-5 inch under water, lack of transportation, mud and waste everywhere
Adaptations	New pumps, elevated drains, water-inclusive planning	Vs.	Raised steps at the entrance, elevated beds for plants
Understanding of Urban Flooding	Global, centralized flood-mitigation model, homogenous, and centralized	Vs.	Everyday landscape, ephemeral, and personal adaptations

Table 2 further analyzes the responses from Table 1 and highlights the scale differences between the two knowledge systems. It shows that residents experience flooding at the street scale in their neighborhoods–landscapes they use daily and take their personal adaptation measures. In contrast, professionals discussed future actions to strengthen the current centralized flood control infrastructure.

Figure 4. Top Left: Mapping priority landscapes for flood adaptation design on Road 21, Nirala R/A. Top Right: Mapping five days of flooding conditions. Left Bottom: Types of pooling conditions in the section, due to elevation changes. Right Bottom: Section revealing a newly elevated drain in the middle of a street, trapping runoff on the sides. Photos by the author.

4 DISCUSSION

There are four areas of discussion and reflection based on the results of the research: integrating definitions of "urban flooding" into planning scale studies, reconciling gaps between planners' knowledge of flooding with that of local residents, positing Third Landscapes as an opportunity for adaptation as well as some challenges, and next steps needed in the discovery process. Limitations of the research are also discussed.

4.1 Integrating Urban Flooding into the Planning Narrative

None of the policy and planning documents reviewed in Section 3.1 identify the issues in Khulna as "urban flooding," despite the problem being related to impervious surfaces, saturated soil, and failed gray infrastructures. Those documents primarily focus on large-scale infrastructure solutions without addressing the residents' everyday experiences or their own desperate short-term adaptation measures. This indicates that considerations for addressing flooding through urban design, landscape interventions, or retrofitting existing flooding conditions have not yet been incorporated into the planning approach. Recognizing these omissions opens up opportunities for landscape design interventions at both site and neighborhood scales, which are essential for developing effective adaptation strategies in urban areas.

4.2 Reconciling the Two Knowledge Systems

The contrast between professional and resident knowledge systems (Table 1) further emphasizes the inefficiencies and challenges in Khulna's flood mitigation planning practice. Residents' knowledge about flooding in landscapes they use every day reveals the value of their experiential knowledge on living with water. However, this missing narrative has the potential to conserve local adaptations (some are mentioned in Table 2) and build on cultural and social relationships with water bodies in communities. Studies acknowledge the importance of integrating residents' knowledge and participation in planning and policy of flood mitigation (Haque et al. 2022, Asad 2025). Whereas Asad (2025) recommended integration of traditional water knowledge in urban areas in Khulna, this study shows in Tables 1 and 2 that residents have already adopted small measures as their adaptations. However, their knowledge is yet to be acknowledged in design research and planning documents. This paper calls for the reconciliation of professionals' and residents' knowledge systems.

4.3 Third Landscapes as Sites for GSI

As first introduced in Section 1.3, interstitial landscapes, termed Third Landscapes by Gilles Clement (2004), play roles in integrating functions, developing ecological networks, and contributing to the multi-scale planning and design. Third Landscapes, as a concept, seeks to assign functions within urban leftover landscapes in different contexts, and this lens provides a new method of looking at neglected landscapes in Khulna neighborhoods as site-specific opportunities for flood adaptation. Jan Kamer, the Team Leader for the "Feasibility Study in Khulna Including Climate Risk Assessment and Environmental and Social Impact Assessment", discussed the possibilities for nature-based adaptations in Khulna neighborhoods based on his experiences in other South Asian cities. He conceded that this is a vital and viable approach to managing flooding. Figure 4 highlights Third Landscapes that are commonly found in neighborhoods, are of an intermediate nature, and can function as retention areas during the rainy season. The diagram also reveals that runoff remains trapped on both sides of the concrete drains within most of the streets in the rainy season. If the landscape fragments along the streets remain neglected, the local flooding conditions will become more complex and cause further damage to ground floors and properties of individuals. Highlighted in Tables 1 and 2, these interstitial landscapes have always been heavily used by inhabitants and hold stories of everyday environmental and social life; hence, they are spaces that can continue to adapt to changes.

In Figure 5, the cross-section shows spatial opportunities for GSI along the street of Nirala R/A, and how water can be designed and managed through these Third Landscapes. Importantly, there is no single strategy or solution for a street. Residents would ideally collaborate with the professional design team to design the most feasible and desired alternative based on different factors, with the goal of supplementing their neighborhood-specific gray infrastructure. If transformed into a series of GSI networks at the neighborhood scale with rain gardens, bioswales, and retention areas, these spaces will contribute to the city's flood defense while serving the neighborhood residents. Consistent with the work of Haque et al. (2022) and Fahim et al. (2024), a series of GSI in Third Landscapes would further multiply the benefits of slowing runoff in neighborhoods and eventually develop a new method of adaptation design in Khulna neighborhoods.

Figure 5. Potential spatial organizations and types of green infrastructures to slow down, circulate, recharge into the ground, and store in possible locations in the interstitial "Third Landscapes" at the street scale. Diagram by the author. Background image: Google Street View.

4.4 Opportunities and Challenges in the Third Landscape Approach

The application of Clément's Third Landscape concept to manage local flooding offers both promises and some challenges. Addressing Khulna's urban flooding requires shifting from a solely large-scale mitigation model to incorporating small-scale, site-specific adaptations. This begins with identifying landscape fragments and leftover spaces to learn how the water moves and where it causes flooding. Third Landscapes in Khulna are landscape fragments that shift functionality as needed but still require retention areas and management strategies. Once identified and networked with gray infrastructure, Third Landscapes can soak water during 1-2 hours of rain and contribute to the residents' adaptation knowledge and the domain of urban flooding research in Khulna, where residents' participation has been highlighted for flood management.

However, the paper also acknowledges some critical limitations of adaptation design in Third Landscapes. First, the carrying capacity of leftover landscapes in any neighborhood is limited. Even though street-scale interventions in Third Landscapes have the potential of developing more retention areas, they will not be substituted for large-scale infrastructure. Rather, a network of green stormwater infrastructure will manage runoff during short-duration rain events. Second, Figure 5 requires in-depth analysis and survey data for implementation. Third, if the KDA, which holds authority over rights-of-way and other leftover spaces in residential neighborhoods, takes the initiative to manage these landscape fragments to enhance the city's flood resilience, a comprehensive plan must be developed. This plan should be led by an interdisciplinary team and must actively engage local communities—who are the daily users—from the very beginning of the process. Importantly, the Third Landscape approach requires specialized teams who will run workshops and start outreach programs to have an in-depth understanding of local flooding dynamics in each neighborhood. This is a bottom-up design approach, which is an iterative and long-term process and needs continuous active engagement and collaborative efforts to effect meaningful change.

4.5 Limitations of the Study

This study spanned one academic year, providing adequate time for research as well as limitations. From the beginning, it was clear that a lack of detailed, Khulna-specific secondary data was a limitation for the literature review and site analysis. Direct fieldwork observations were beneficial but restricted to July-August 2023 and January 2024, limiting the opportunity for more extensive observations. Moreover, the sample size for resident interviews was limited to 28 individuals across three neighborhoods, which may not adequately capture all of the residents' experiences and flooding-related challenges faced. Furthermore, while hydrological analyses and maps exist in some KCC reports, they lack the finer-scale

GIS data that is necessary for comprehensively understanding, modeling, and mapping flow accumulation at the neighborhood level and quantitatively evaluating stormwater capture potential in specific locations and identifying sites of adaptation design in Third Landscapes as discussed above.

5 CONCLUSION

This paper addresses the gaps between traditional flood mitigation planning efforts and recurring urban flooding in neighborhoods in Khulna, Bangladesh. Experiential knowledge of flooding, obtained through interviews with neighborhood residents, demonstrates that direct knowledge at the site scale is excluded from professional flood-mitigation planning. This knowledge, combined with site observation of local flooding, is a critical input into effective adaptation and resolution of urban flooding. It is precisely those things missing–engagement and local scale analysis–that are key to a solution. The “Third Landscapes" theory undergirds the thoughtful use of interstitial spaces within neighborhoods in an integrated and site-scaled approach. This paper, through its methods and discussion, invites professionals and residents to combine their knowledge and to design meaningful and effective adaptations throughout neighborhoods, which may serve as an engaged model for similar flood-prone cities and communities around the world that struggle to bridge knowledge systems and planning and design scales.

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