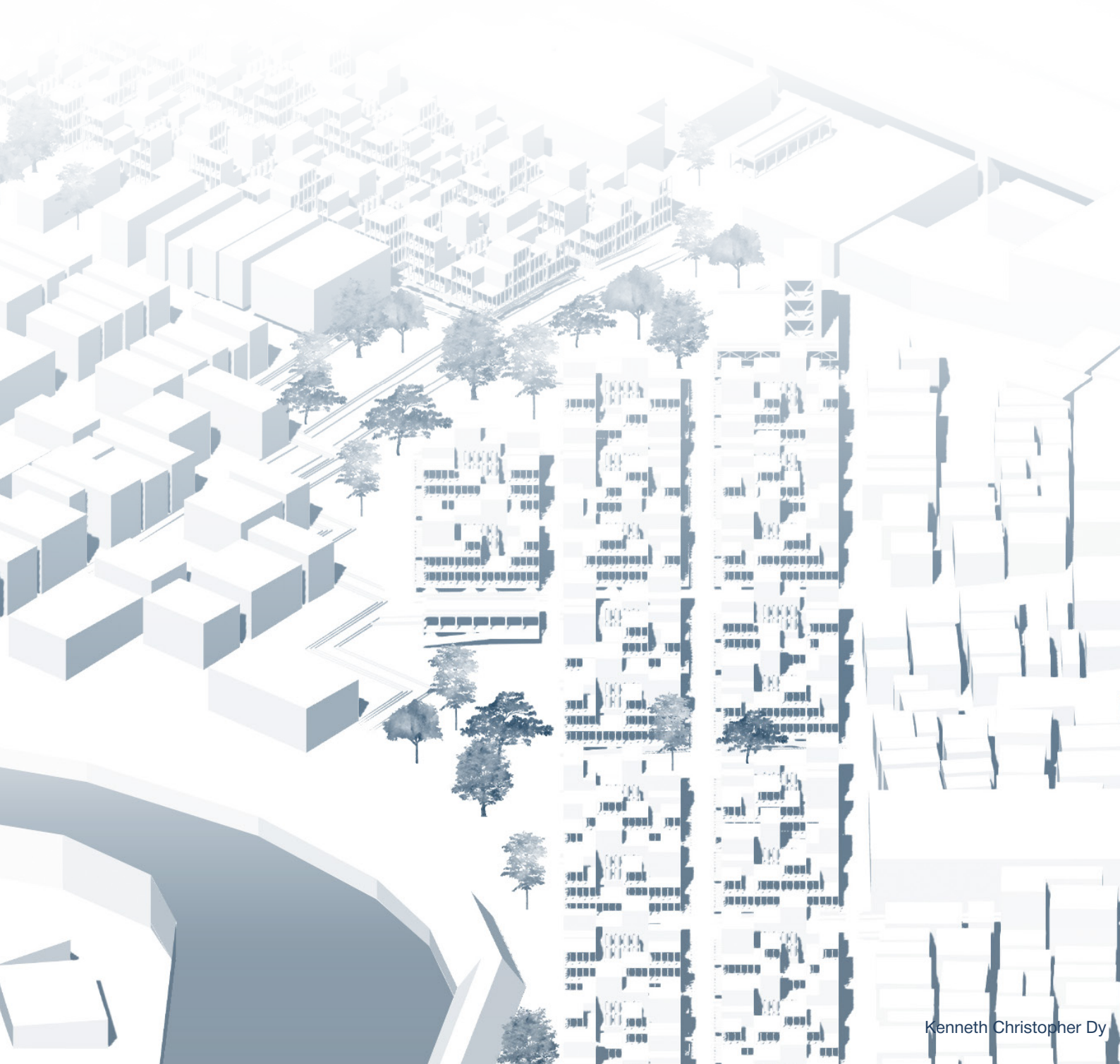


Pockets of Change

Flood Resilience Strategies in Dense Low-Income Neighborhoods in Metro Manila



Preface

MSc Graduation Thesis Report
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This report presents the final outcomes of the graduation research and design project conducted as part of the MSc Urbanism programme at Delft University of Technology. The project, titled Pockets of Change: Flood Resilience Strategies in Dense Low-Income Neighborhoods in Metro Manila, is submitted in partial fulfilment of the requirements for the assessment within the City of the Future graduation studio.

Acknowledgements

This project would not have been possible without the guidance, support, and generosity of many people who have helped me throughout this graduation project.

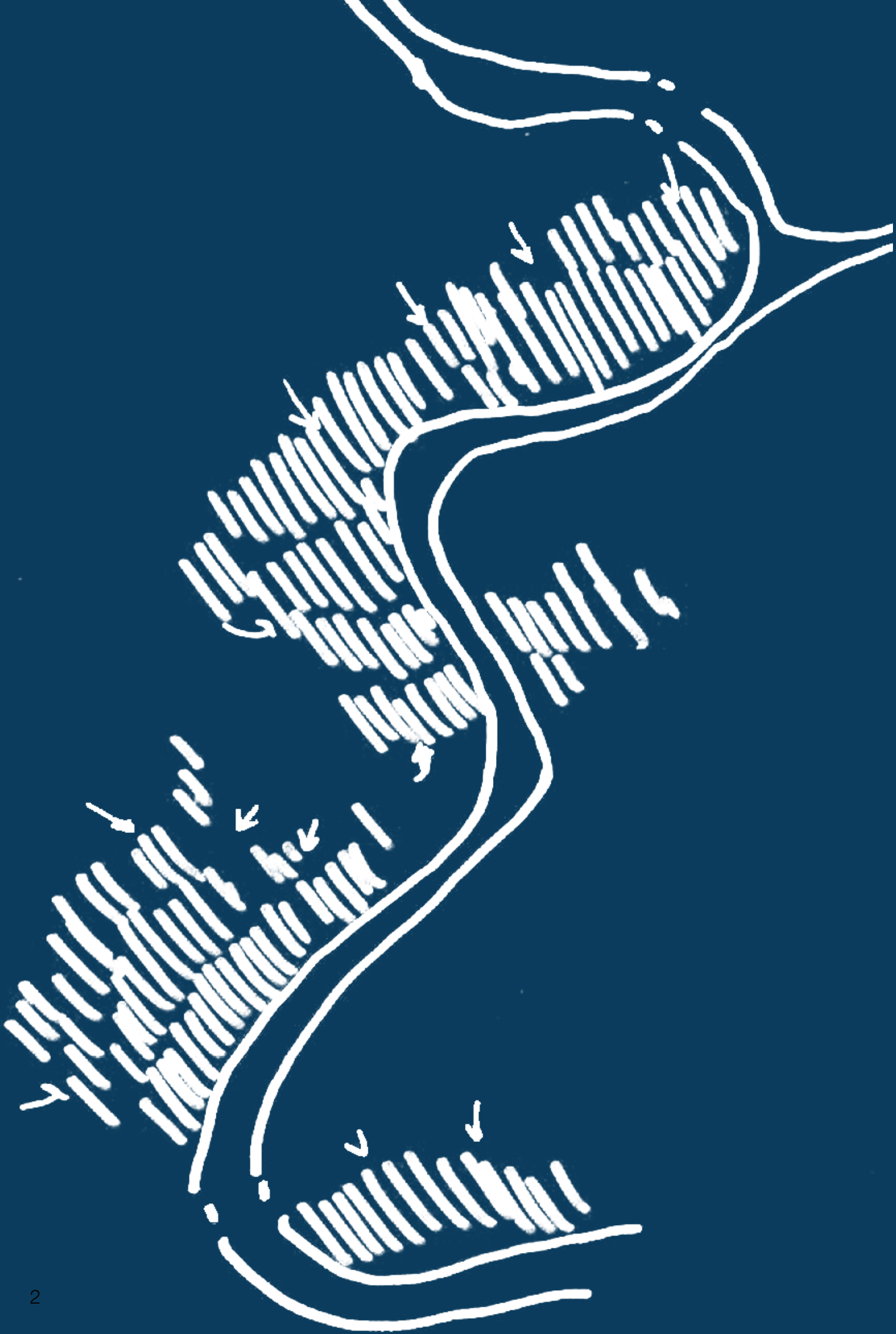
I would first like to thank my mentors, Marco and Mark, for their guidance and extensive knowledge in their specific fields. Your feedback consistently pushed the project beyond what it could have been. Your willingness to understand the complexities of a context far from the Netherlands was greatly appreciated.

To my mom, thank you for your constant support and encouragement throughout this process. To the residents of Barangay Tatalon, thank you for your time and willingness to share your experiences in the settlements. Your perspectives have grounded this project. To my friends, Anika, Danae, Martin, Michele, Raul, Rian, Ula, Wouter, and Youjin, thank you for making the long months of thesis work both bearable and enjoyable. My entire master’s journey would not have been the same without your company. To Alberto and Joëla, thank you for your support and patience throughout the many stressful nights at home. To Cata, thank you for sharing your knowledge on flood risk management; your insights have significantly informed the design process. To Catalina, thank you for your support and assistance, especially during the final weeks; I could not have finished without your help. To Isabel, thank you for your company and assistance with the physical model. To Alcen, thank you for being there for me and providing emotional support during this journey.

Finally, this project is dedicated to the informal settler communities of Metro Manila, whose resilience in the face of challenging conditions continues to inspire me. I hope this work initiates a meaningful conversation about creating better, more livable conditions for these communities.

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01

Introduction

1.1 Background

1.1.1 A land of vulnerability

The Philippines faces extreme vulnerability to climate-related disasters due to its geographical location in the Pacific Typhoon Belt (Lagmay et al., 2023). Because of climate change, the frequency and intensity of these extreme weather events have increased eighteenfold since the 1970s (Porio, 2014). This vulnerability is reflected in the country's ranking as the highest disaster-risk country in the world, where the impacts of climate change are predicted to intensify over the next few decades (Bundnis Entwicklung Hilft & IFHV, 2025).

Metro Manila is the most densely populated region in the Philippines, where its inhabitants experience around six to seven typhoons every year, which cause severe flooding, disrupting daily life and economic activities (Edelman, 2016). Its low-lying terrain and location at the Pasig-Marikina-Laguna Lake catchment along with its impervious surfaces also contribute to its vulnerability (Dulawan et al., 2024). Flooding in the region comes from multiple sources, which include pluvial flooding from intense rainfall, fluvial and flash flooding from typhoons and monsoons causing overflowing rivers, and tidal flooding from the increased high tides from Manila Bay (Dulawan et al., 2024). In 2009, one of the most intense and catastrophic weather events hit Metro Manila, called Typhoon Ondoy, which resulted in widespread flooding across the region, with damage to property and infrastructure, and left millions homeless (Abon et al., 2011).

Metro Manila is one of the most hazard-prone cities in Southeast Asia, where the majority of informal settler families suffer from constant flooding during the rainy season (Quetulio-Navarra, 2023). Their population is approximately 500,000 households, or 1 in 4 of the region's residents (Department of Human Settlements and Urban Development, 2022). These informal households, having limited capacity to adapt, are disproportionately affected by the risk of flooding. Out of the 500,000 households who reside in Metro Manila, 100,000 live in high-risk areas including coasts, rivers, and creeks (Lauer et al., 2024). Urban informality in Metro Manila is a result of economic conditions that drive these low-income households to spaces not suitable for housing, which are often in areas prone to flooding, earthquakes, and landslides (Aguilar, 2021). The government has responded by focusing on resettlement programs, relocating informal households in high-risk areas to state-owned land (Lauer et al., 2024). However, these relocation projects have paradoxically increased their vulnerability by decreasing access to livelihood, basic services, and social networks (Quetulio-Navarra, 2023).

1.2 Problem Statement

According to the World Risk Report (Bundnis Entwicklung Hilft & IFHV, 2025), the Philippines ranks first as the highest disaster risk country in the world. In Metro Manila, the most densely populated region, severe flooding is a recurring problem that has affected millions of residents over the past years. (Dulawan et al., 2024). Moreover, a significant percentage of the region's population resides in flood-prone areas, where low-income households are the most vulnerable (Porio, 2011). Despite ongoing flood mitigation projects, several factors further contribute to flooding, including high levels of impervious surfaces, settlement encroachment, and unregulated urban expansion. In addition, low income, flood prone communities have limited participation over disaster planning (Domingo, 2017).

The general problem is that dense low-income flood-prone neighborhoods are insufficiently equipped to address the increasing risks of these extreme disasters, resulting in disruptions to mobility and daily life, repeated damage to housing and livelihood, and a disproportionate impact on vulnerable communities.

Problem Framing

What happened: recurring and intensifying flooding

Where: dense low-income neighborhoods

When: increasing over the past decades

How: hydrology, urban form, infrastructure

Why: climate change, rapid urban growth

With Whom: low-income informal settlement households

1.3 Relevance

1.3.1 Flooding and its effects on the vulnerable

The relevance of this research is based on the focus on the significant impact of flooding on low-income communities in densely populated and rapidly growing cities. The effects of climate change have been increasingly evident in the past few years, and the severity of its impacts will only increase in the future (IPCC, 2023). Moreover, the impacts of climate change are felt most strongly in developing countries despite contributing less to climate change (Wu et al., 2021).

Being the most disaster-risk country in the world (Bundnis Entwicklung Hilft & IFHV, 2025) as illustrated in Figure 1.1, this research aims to provide strategies for flood resilience, especially for the most vulnerable. Flood risk in Metro Manila is both an environmental and spatial inequality issue where policies disproportionately focus on relocating vulnerable communities while increasing their vulnerability and decreasing their resilience (Valenzuela et al., 2023). Studies show that vulnerable communities are most likely to reside in high-risk areas prone to flooding and landslides, exposing them to a recurring cycle of destruction and loss of life (Aguilar, 2021). These communities, which are mostly urban poor households living in informal settlements, lack adequate access to potable water, electricity, health, sewage, and sanitation facilities, which affects their capacity to recover from these disasters (Porio, 2011).

Rapid urban growth and the ongoing socio-economic transformation has further intensified flood risk in Metro Manila, where 31% of its land is prone to flooding (Regmi, 2018). Similar to Southeast Asia’s megacities, Metro Manila attracts migrants to seek employment and economic opportunity. The region has experienced constant migration from different parts of the country, which has significantly increased its population and has largely filled vacant land (Yulu, 2021). This has caused increased pressure on land, housing, and infrastructure. Informal settlement communities are the backbone of the urban economy, where they work in trading businesses under challenging conditions (Yulu, 2021) and microentrepreneurs who provide services despite frequent flooding (Manegdeg et al., 2024). However, these areas are often disregarded and spatially marginalized through middle-class perceptions that favor their eviction (Valenzuela et al., 2023). It is essential, then, to understand the rhythms of their everyday lives to further develop flood-resilience strategies that do not disrupt their livelihoods.

Moreover, this research seeks to contribute to discussions on flood resilience, the informal sector, and climate adaptation by focusing on neighborhood-scale spatial interventions that are often overlooked in conventional flood management approaches. Metro Manila has traditionally and recently focused on large-scale infrastructure projects, such as the Metro Manila Flood Management Project, which includes hard infrastructure such as pumping stations and floodwalls (Department of Public Works and Highways, 2017). However, these interventions often fail to address the impacts of these floods at the neighborhood scale and how these communities can respond and adapt to these increasing risks. In Metro Manila, informal settler families continue to experience frequent flooding (Gray & Ocampo, 2017), indicating that large-scale infrastructure is insufficient and fails to protect vulnerable communities.

The gap between large-scale infrastructure and neighborhood-scale interventions shows a broader and more global challenge in urban flood management. While large-scale water management interventions address city-wide drainage capacity, they often fail to consider local knowledge, practices, and patterns of vulnerable communities (Prana et al., 2024). Neighborhood scale approaches offer opportunities to integrate spatial design and community planning processes, which generate interventions that cater to the local needs and that support daily life (Prana et al., 2024).

This research also aims to address climate adaptation and resilience at the neighborhood scale, specifically in highly dense, constrained environments, through spatial analysis and design. This project seeks to contribute knowledge by focusing on spatial conditions in the daily life of these communities and how these can lead to more inclusive and adaptable cities in the future by emphasizing on spatial responses that are grounded in the community, this research aligns with approaches that prioritize both spatial justice and resilience strategies during times of uncertainty rather than large-scale redevelopment interventions.

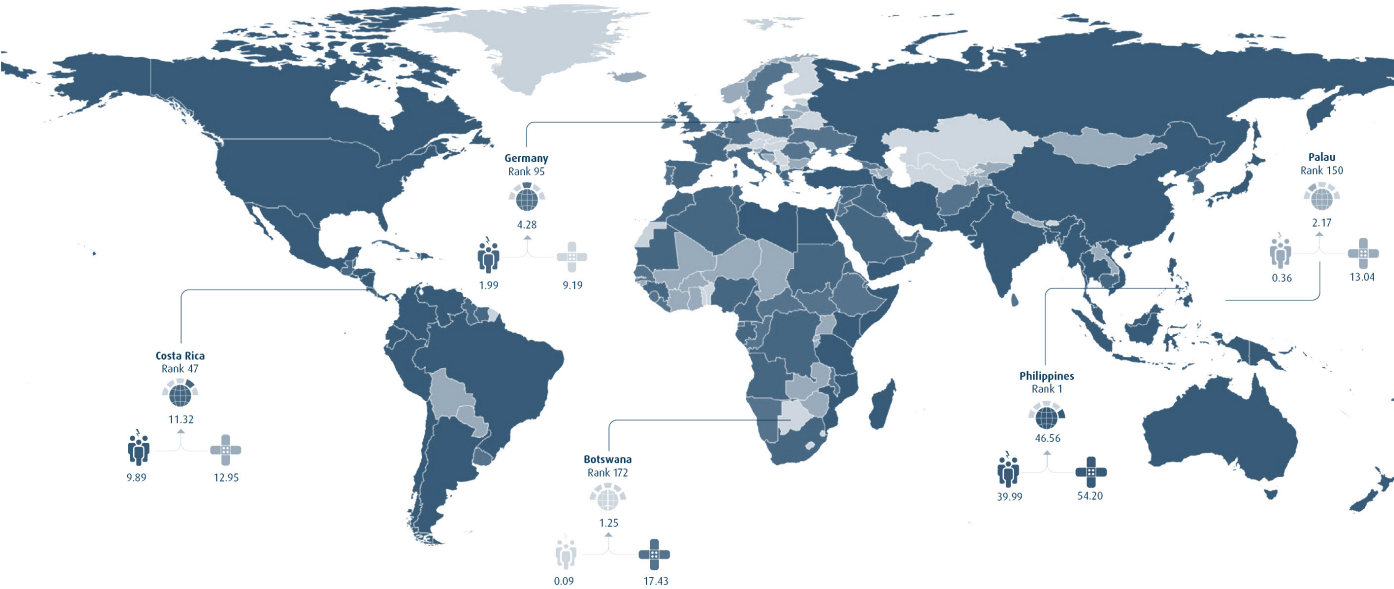


Figure 1.1 World Risk map 2025

Note. Adaoted from World Risk Report (2025)

1.4 Objective and Motivation

Project Goal

The goal of the project is to translate research into neighborhood-scale spatial design explorations that test how flood resilience strategies can be integrated into highly dense and constrained urban environments. Through a research-by-design approach, it develops an understanding of flood risk conditions and applies this knowledge through design interventions

Research Objective

The research objective of this project is to understand the specific spatial, social, and environmental conditions that influence flood risk and the capacity of highly dense, low-income communities in Metro Manila.

Design Objective

The design objective of this project is to test how flood resilience strategies can be spatially embedded at the neighborhood scale to reduce flood impacts while maintaining everyday functionality in dense, low-income environments

Motivation

The motivation for the project is rooted from an academic and personal interest in understanding how flood resilience can be addressed through spatial design in the context of spatial constraint and informality. Existing flood management approaches in Metro Manila focus mostly at the regional and infrastructural scale, leaving a gap in flood resilience can be integrated into the neighborhood level. The project is motivated by the potential to bridge research and spatial design by translating spatial analysis into context sensitive interventions that respond to flood risk and urban inequality.

Expected Outcome

The project does not aim to eliminate flooding in Metro Manila completely or to propose a comprehensive flood management plan. Instead, it seeks to generate two proposed design outcomes. The primary focus is a neighborhood-scale design exploration where interventions are made to test and contribute to flood resilience. The second outcome is a replicable, condition-based framework derived from lessons learned through the design process

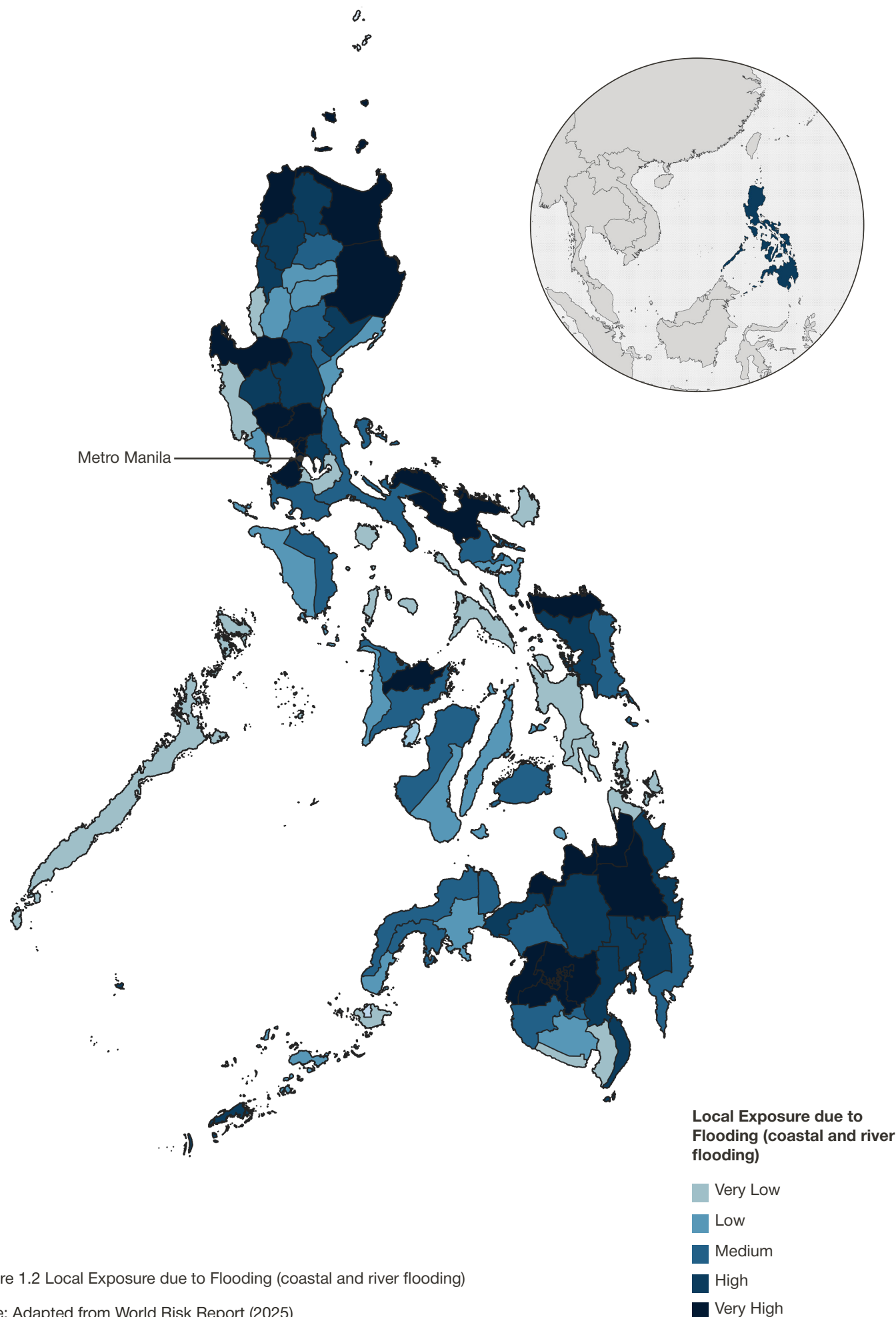


Figure 1.2 Local Exposure due to Flooding (coastal and river flooding)

Note: Adapted from World Risk Report (2025)

1.5 Scope

The project focuses on the neighborhood scale. In this scale, the project will demonstrate spatial analysis and design. Analysis will first be conducted on a large scale to present data systematically. The location will be in Metro Manila, known to be one of the most hazard-prone cities in Southeast Asia and the most populated region in the Philippines (Quetulio-Navarra, 2023). Within Metro Manila, Barangay Tatalon in Quezon City was chosen as a pilot case that represents fluvial and pluvial flooding in a high-density, low-income neighborhood.

Barangay Tatalon was selected based on being one of the most flood-prone neighborhoods that has a high density and contains low-income informal communities. It is located in a low-lying basin that is adjacent to the San Juan River, which contributes to flooding in the area. The neighborhood is frequently affected by flooding, disrupting daily life (Figure 3). Additional challenges have contributed to flooding, such as garbage blocking drains, and infrastructure, such as an elevated highway, has further worsened this situation. The neighborhood scale provides an opportunity to explore spatial design interventions that can enhance flood resilience with existing urban constraints. By focusing on this scale, it becomes possible to examine the relationship between the urban fabric, community practices, drainage patterns, and flood vulnerability. The focus on a specific neighborhood allows for in-depth spatial analysis and design that can inform for more broader applications through a replicable framework.

The project's scope focuses on spatial analysis, field observations, and scenario-based exploration. The scope is limited to identifying and testing spatial measures. It does not aim to produce flood simulations, a participatory planning process, or a regional flood management solution.



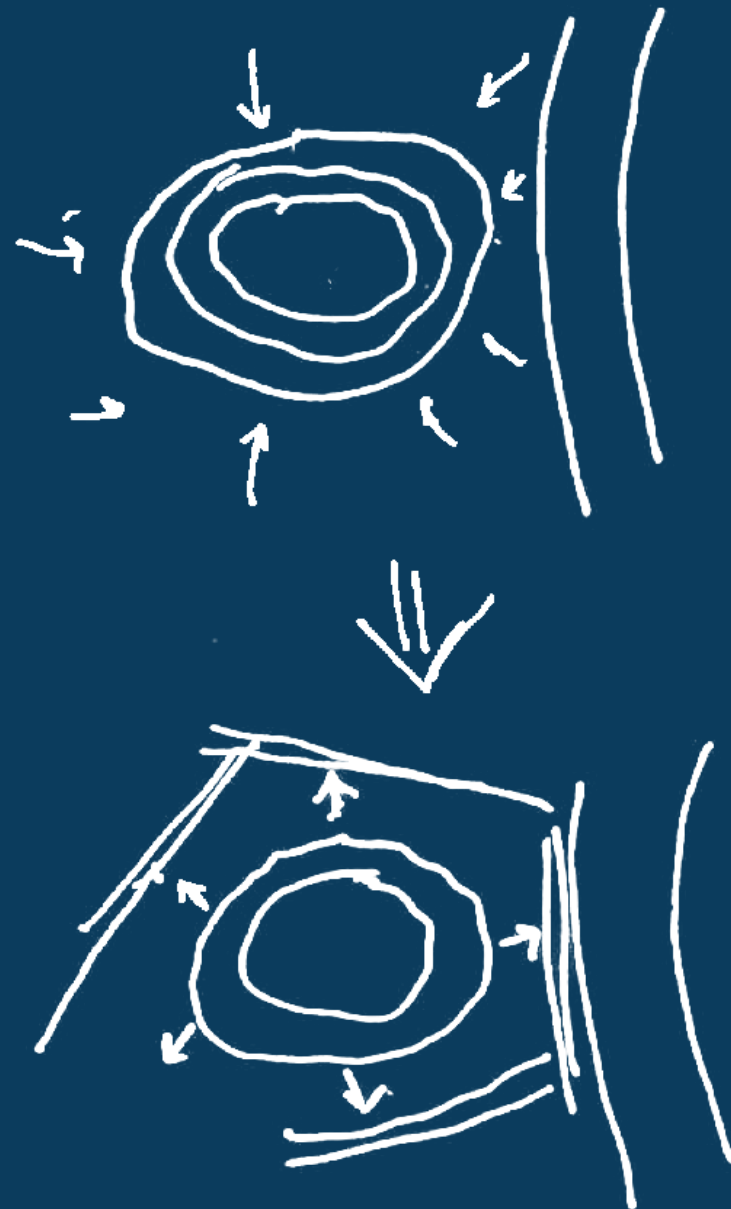
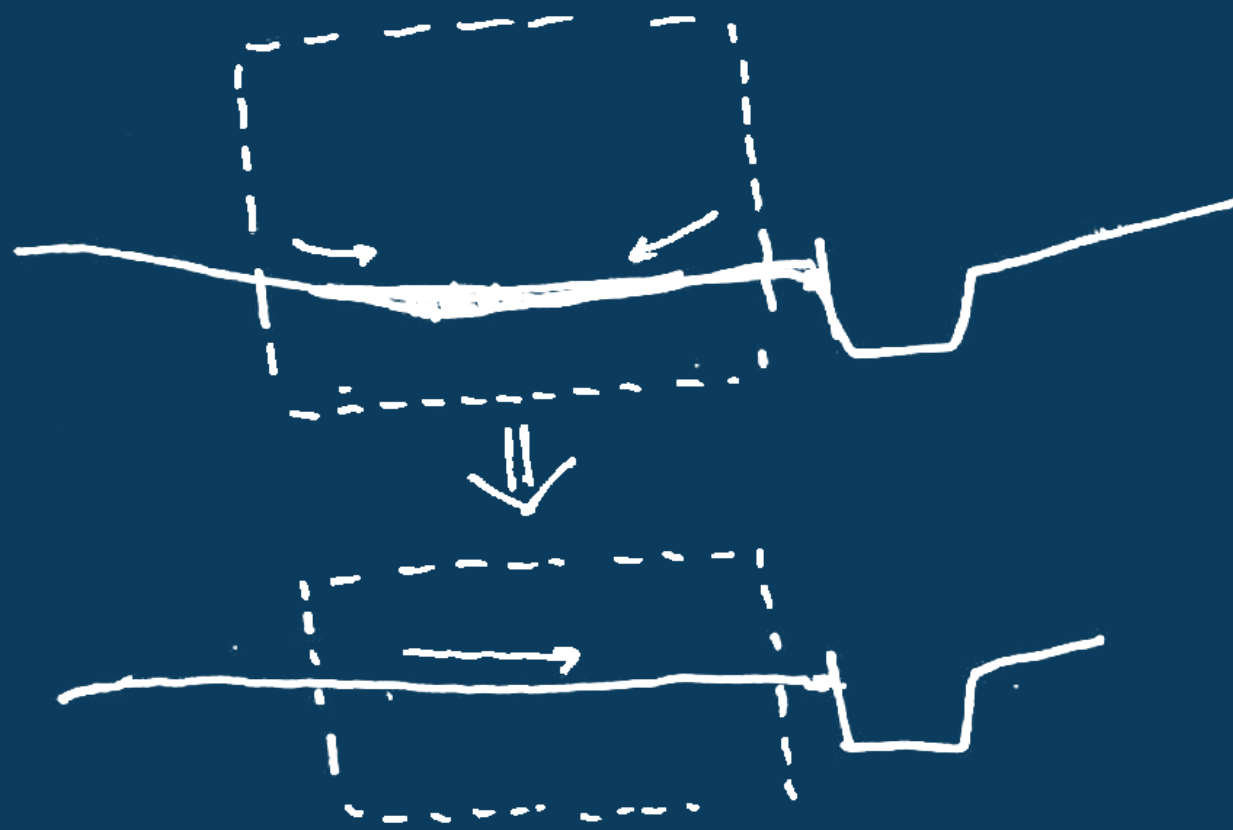
Figure 1.3 Metro Manila Flooding during Tropical Depression Dante

Note. From Philippine STAR (2025)



Figure 1.4 Barangay Tatalon Flooding Following Heavy Monsoon Rains

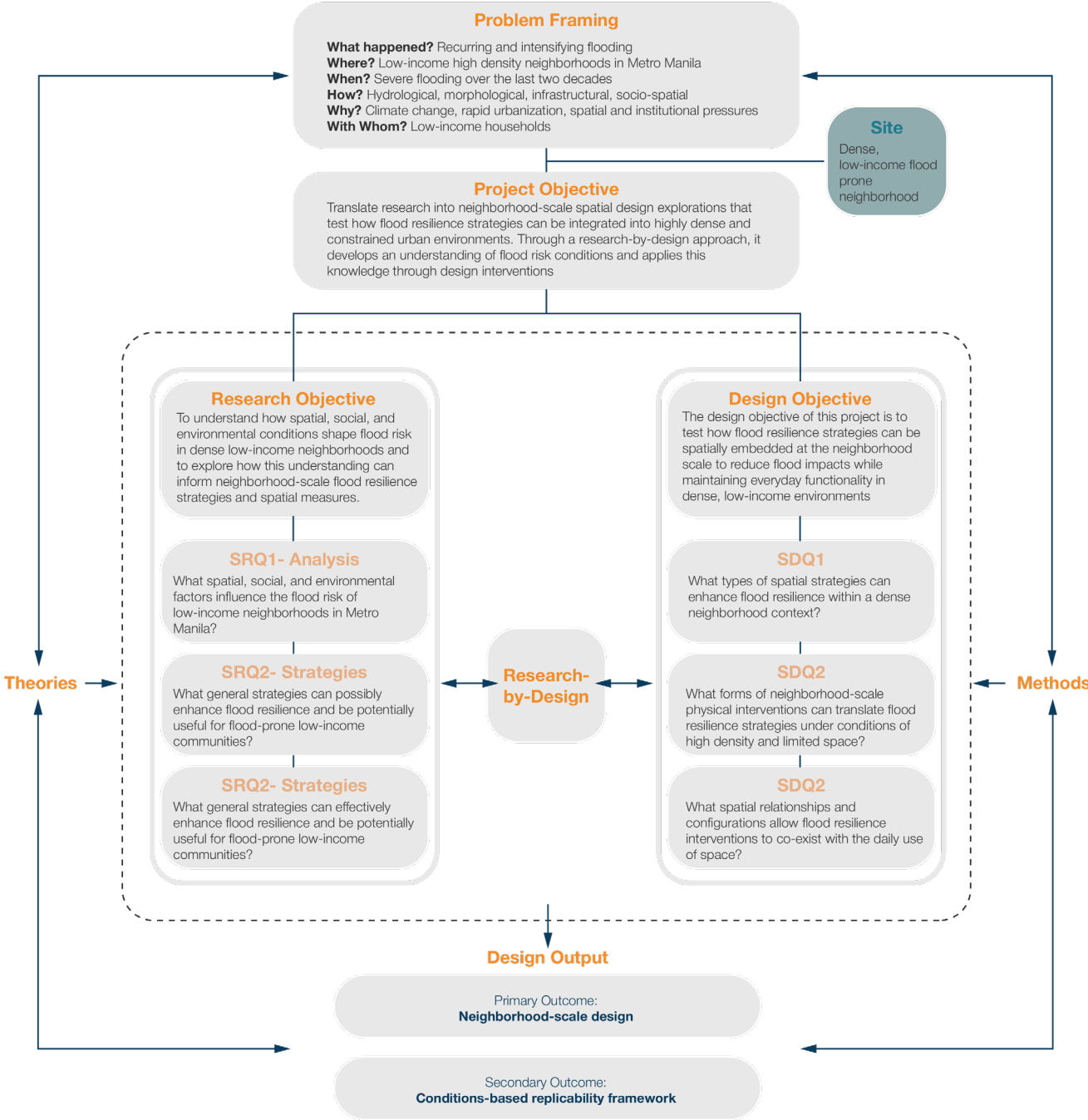
Note. From Manila Times (2023)



02

Methodology

2.1 Research Diagram



2.2 Research and Design Questions

Main Research Question:

How can understanding flood risk factors in dense low-income neighborhoods in Metro Manila guide the development of flood resilience strategies and measures that are effective and replicable?

- Sub Research Questions:**
1. What spatial, social, and environmental factors influence the flood risk of low-income neighborhoods in Metro Manila?
 2. What general strategies can potentially enhance flood resilience and be potentially useful for flood-prone low-income communities?
 3. What specific measures can realize these strategies, and under what specific conditions could these measures be replicated?

- Design Questions:**
1. What types of spatial strategies can enhance flood resilience within a dense neighborhood context?
 2. What forms of neighborhood-scale physical interventions can translate flood resilience strategies under conditions of high density and limited space?
 3. What spatial relationships and configurations allow flood resilience interventions to co-exist with the daily use of space?

Figure 2.1 Research Diagram
Note. Made by Author

2.3 Methods

The methodological research approach is primarily qualitative and spatial, which is then supported by quantitative data where available. The project focuses on spatial conditions and patterns that influence flood risk at the neighborhood scale. A method of scaling is used to relate regional environmental systems to neighborhood-scale spatial conditions. This ensures that the larger processes, such as climate change and urban growth, are taken into account. This multi-scalar approach considers various spatial scales, including regional, city, neighborhood, and block levels, and requires analysis at each level to fully understand the system.

In addition, the project adopts a research-by-design approach to test and explore spatial strategies that address complex challenges and generate new insights (Roggema, 2016). Rather than a linear sequence of stages, the methodological approach uses a feedback process wherein research feeds into design options and the design itself generates new knowledge. The methodology is structured in such a way that it directly responds to each sub-research question.

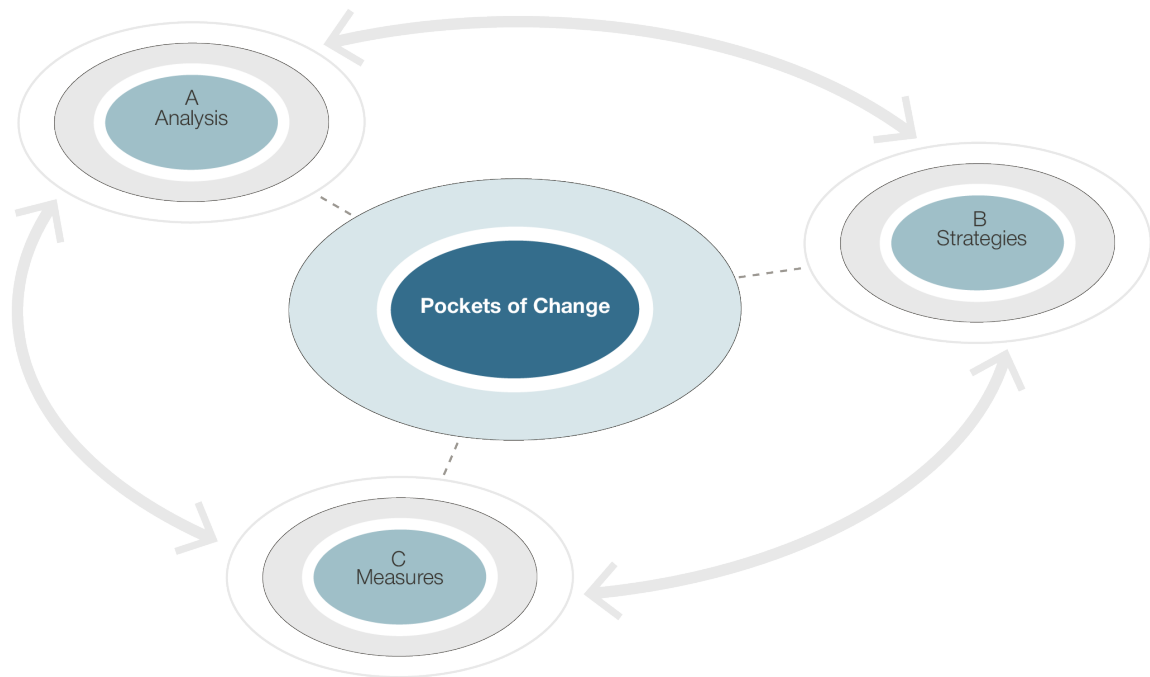


Figure 2.2 Methodological Framework

Note. Made by Author

A. Spatial and Environmental Analysis

Related sub-research question 1: What spatial, social, and environmental factors influence the flood risk of low-income neighborhoods in Metro Manila?

1. Mapping and Spatial Analysis

The spatial analysis is conducted at three various scales to fully understand the urban flood system

a. Regional Analysis

Regional analysis examines Metro Manila’s flood risk zones, hydrological flow patterns and drainage systems at the metropolitan scale. This analysis identifies how regional and environmental factors such as watershed boundaries, river basins, major waterways, and large-scale infrastructure shape flood risk across the region (Sukri et al., 2025). The analysis maps current and projected flood-prone areas along with existing and future infrastructure.

b. City Analysis

City analysis focuses on demography, land use patterns, and vulnerability indicators at the city level (Dulawan et al., 2024). This analysis examines how Quezon City’s urban development and land use contribute to flood risk. Flood vulnerability is also analyzed to determine how it varies across the city. This analysis connects regional flood systems and neighborhood-scale conditions, identifying how city infrastructure and development affect flooding.

c. Neighborhood Analysis

Neighborhood analysis investigates existing infrastructure, waterways, and urban form in Barangay Tatalon. This analysis consists of identifying land uses, connections, block arrangements, and street characteristics to determine how they influence flood risk in the neighborhood (Mabrouk et al., 2024). Morphological analysis supports the identification of potential locations for spatial strategies within the dense neighborhood. The analysis examines how the neighborhood’s location in a low-lying basin adjacent to the San Juan River, combined with a high density of informal settler families, contributes to flood vulnerability.

Tools

QGIS, OpenStreet Map, Google Earth, Hazard Maps, Demographic Data

2. Site observations and documentation

The fieldwork is done to complement the spatial analysis through observations and community engagement. This approach, through recognizing local knowledge, can further inform flood risk in the neighborhood (Prana et al., 2024).

The documentation consists of mapping street networks, building footprints, low-lying areas, informal settlements, and drainage paths. An analysis of patterns and community interventions shows how the locals currently respond to flooding both in their homes and in the neighborhood.

Documenting spatial constraints and challenges identifies physical barriers to flood adaptation, such as limited space and restricted access to waterways. Informal interviews and conversations with residents and government leaders provide insight into the causes of flood vulnerability. These interactions can also inform how various factors influence decisions to remain in flood risk areas (Dulawan et al., 2024).

Tools

Photography, Sketching, Interviews

B. Strategy Identification and Evaluation

Related sub-research question 2: What general strategies can effectively enhance flood resilience and be potentially useful for flood-prone low-income communities?

1. Literature Review

In the literature review, scientific articles, journals, research papers, and books are collected, and selected strategies are extracted, such as flood-risk management, water-sensitive design, nature-based solutions, and spatial adaptability. This review provides a theoretical basis for identifying general resilience strategies beyond site-specific solutions.

The review examines the various factors that influence flood risk across regions, cities, and neighborhoods. It examines how resilience-based approaches can enhance adaptability in the face of uncertainty. There is a focus on strategies applicable to the context of urban informality and spatial constraints. The review also examines existing flood management approaches in Metro Manila and their effects on the region. Research from similar contexts in the Southeast Asia region is also taken into consideration for its insights on flood-resilience strategies.

2. Catalogue of Formal and Informal Practices

In this section, selected case studies are reviewed and analyzed. The goal is to create a catalogue presenting formal and informal flood management practices and how they would be applied as strategies for the project. The catalogue focuses on current responses to flooding and documents their spatial characteristics, scale, and limitations. This documentation examines both formal engineered interventions, such as flood walls and pumping stations, and informal community solutions, such as raised platforms and elevated walkways.

The catalogue analyzes practices from various contexts, including other Southeast Asian cities facing similar high-density situations. Based on this documentation, general flood resilience strategies are selected and applied to the project. These strategies are spatial principles rather than specific design solutions, which allows for their flexibility in their application across different neighborhood conditions.

3. Strategy Evaluation

The strategies are then evaluated based on their feasibility, adaptability, and compatibility with the existing environment.

Feasibility: This assessment examines the technical aspects, implementation costs, and maintenance requirements. This can help determine which strategy can be implemented in the context of informal settlements.

Adaptability: This assessment identifies which strategies can be modified in various spatial conditions, typologies, and scenarios. Adaptability is essential for ensuring the effectiveness of these strategies in times of uncertainty due to climate change

Compatibility: This assessment tests which strategies align with the community’s existing patterns and practices. Strategies that work with the existing conditions are more likely to be accepted by the community.

These strategies are also evaluated on their relevance to future flood scenarios. This evaluation considers how these strategies might perform under various pressures from the city, such as urban growth, increasing land pressure, and climate change impacts (Reimuth et al., 2023). This evaluation results in a selection of strategies that are most relevant for further spatial exploration.

C. Identifying Measures and Replication

Related sub-research question 3: What specific measures can realize these strategies, and under what specific conditions could these measures be replicated?

1. Spatial Measures

The identified strategies are then translated into spatial measures, defined as specific, concrete, neighborhood-scale design interventions. The measures are explored through drawings and scenarios in identified locations where these interventions could take place. These measures are integrated with spatial analysis, community input, and technical considerations.

The measures explore how strategies can be physically translated under site conditions, including constraints such as limited open space, existing building footprints, property boundaries, and infrastructure. The process recognizes that addressing flooding in informal settlements presents unique challenges for which conventional measures may not be applicable

2. Conditions Mapping and Scenario Testing

Conditions mapping is done to test the effectiveness of these measures under different future scenarios (Abbas et al., 2025). Instead of predicting one single outcome, scenario testing allows for multiple possible futures, addressing the uncertainty associated with climate change and urban development (Puntub et al., 2024).

Scenario testing explores possible future conditions in the years 2050-2100, reflecting projected climate change impacts such as rainfall intensity and frequency, continued urban growth, including densification of informal settlements, and increasing land pressure, such as limited open space for flood mitigation.

This method combines the exploratory and normative approaches to examine both possible futures for flood-resilience neighborhoods. This is done through scenario sketches and helps identify limitations and conditions where measures remain effective. By testing different scenarios, robust and effective measures are revealed and thus adapted

3. Replicability Assessment Testing

This section identifies specific conditions where these measures can be replicated beyond the pilot site. Replicability assessment examines the transferability of these interventions into other similar contexts in which certain spatial and social conditions recur.

Conditions that enable replication may include spatial and typological characteristics such as density, street networks, and proximity to waterways (Mabrouk et al., 2024). In addition, demographic and institutional conditions may also be considered when identifying contexts. Demographic factors, such as household income levels and community organization and patterns, along with institutional structures, such as government capacity, can help determine which contexts are likely to succeed with these measures.

The replicability assessment produces a framework that describes the conditions under which specific measures fit in the given context. This provides a guide for their application in other similar neighborhoods, taking into account that adaptation to the local context remains essential.

2.4 Theoretical Framework

The theoretical framework supports the project’s methodological approach by providing concepts for analyzing flood risk, spatial inequality, and urban form. The selected theories inform methods and design decisions, which make it applicable to both academic and practical settings. The framework is organized into four key theories that address different aspects of this research namely urban flood resilience, spatial justice and urban informality, urban morphology, future scenarios, and socio-spatial resilience.

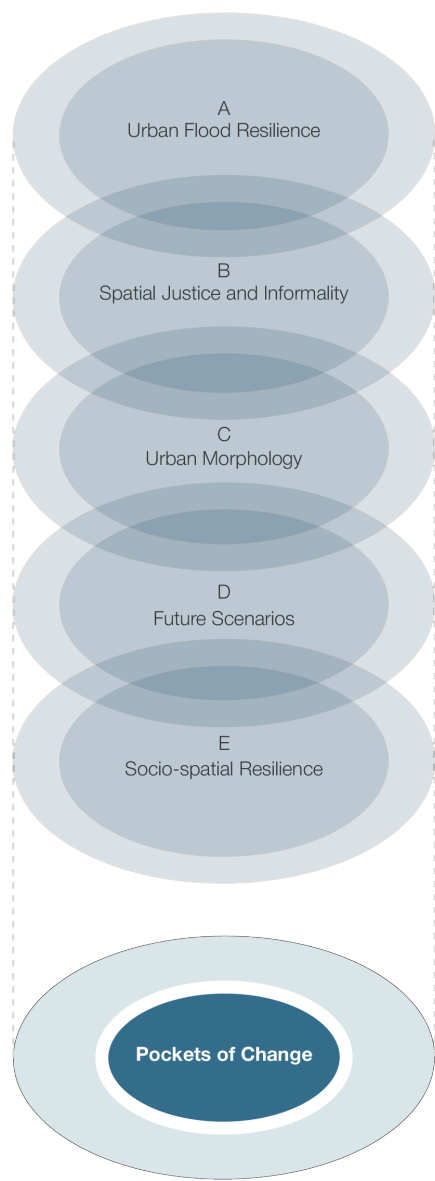


Figure 2.3 Theoretical Framework

Note. Made by Author

A. Urban Flood Resilience

Related sub-research question: SRQ1, SRQ2, SRQ3 | Related sub-design question: SDQ1

In urban flood resilience theory, there is a shift in how flooding is addressed. Instead of preventing floods, urban systems are designed to adapt and recover from flooding disasters. This shift recognizes that complete flood prevention is neither feasible nor economically viable, especially under conditions of climate uncertainty (Kabisch et al., 2016).

There is a focus on resilience-based approaches which emphasize adaptability, multifunctionality, (bio and social) diversity, multi-scale networks and connectivity, and redundancy, especially in conditions of uncertainty due to climate change (Ahern, 2011). These approaches recognize that urban systems must be flexible to challenges that cannot be precisely predicted (Reimuth et al., 2023).

Urban flood resilience can be defined as the capacity of a city to tolerate flooding and to reorganize while preventing physical damage and disruptions to socioeconomic activity (Liao, 2012). This definition emphasizes both the physical capacity to withstand flood impacts and the social-institutional capacity to function even after flood events. This theory involved five phases, namely: preparedness, response, recovery, adaptation, and transformability (Prashar et al., 2023). Preparedness is an action taken before flooding to reduce impacts, response is an immediate action during the flood event, recovery is the return to functionality after the flooding, adaptation is a response to reduce future impacts, and transferability is about changing systems when adaptation is insufficient.

Effective flood resilience is about moving beyond physical interventions into the social dimensions, where community perspectives and practices are understood (Dulawan et al., 2024). In Metro Manila, urban flood resilience theory informs both the strategies and their evaluation. This theory suggests that effective interventions have multiple dimensions of resilience, including infrastructure capacity, social adaptive capacity, and institutional coordination (Prana et al., 2024).

B. Spatial Justice and Urban Informality

Related sub-research question: SRQ1, SRQ2 | Related sub-design question: SDQ2

Spatial justice and urban informality are theories that show how socioeconomic inequality and spatial organization shape access to land, infrastructure, and safety in flood-prone areas. Both theories inform the research by incorporating equity and inclusion into flood mitigation strategies.

Spatial justice theory explains how justice and injustice are shaped by how spaces are organized (Wang & Gu, 2023). It can be defined as a continuous process for the just distribution of resources across scales (Dadashpoor & Dehghan, 2025). Climate change impacts, and urban development patterns can increase the existing socio-spatial inequalities (Dulawan et al., 2024). Without a focus on spatial justice, flood resilience strategies may risk reinforcing inequality rather than addressing it. This theory highlights how the physical urban environment shapes different levels of exposure to flood hazards (Dulawan et al., 2024). The patterns of vulnerability in Metro Manila are not organic but rather a result of planning decisions and unequal resource distribution.

On the other hand, urban informality complements spatial justice by explaining the process that produces these informal settlements. Urban informality is a result of systematic exclusion of low-income populations by urban developments rather than a transitional or temporary condition (Roy, 2005). Furthermore, urban informality should not be seen as a separate or illegal part of the city but rather a condition that exists because of formal systems (Chattopadhyay, 2024).

This theory shifts the perspective of how informal settlements are perceived in flood risk contexts. Rather than viewing informal settlements as problems to be eliminated through relocation (Quetulio-Navarra, 2023), this theory suggests working with existing settlement patterns to enhance their resilience. Studies show that the decision of informal settlement households to remain in flood-prone areas is influenced by attachment to homes, accessibility to amenities, livelihood independence, and economic opportunities, which all outweigh possible flood damage (Dulawan et al., 2024).

C. Urban Morphology

Related sub-research question: SRQ1, SRQ3 | Related sub-design question: SDQ2, SDQ3

When analyzing the urban form, it is essential to have the tools to examine it. Urban morphology theory is the study of the physical form of cities and how it has developed and changed over time. It focuses on understanding the patterns, structures, and elements of the built environment (Oliveira, 2022).

In the context of recurring flooding in cities, urban morphology explains how water moves through the city and how urban form affects and influences its vulnerability. When analyzing highly dense neighborhoods, morphological analysis can help identify and locate potential locations for spatial measures that could be implemented. Urban form affects flood resilience at various scales.

Morphological analysis enables the understanding of the urban fabric to identify patterns related to flooding (Mabrouk et al., 2024). This includes analysis of street networks, building footprints, block patterns, and lot configurations. When analyzing a highly dense neighborhood like Barangay Tatalon, morphological analysis helps identify potential areas for spatial measures. This analysis reveals opportunities, such as underutilized spaces, unnecessary circulation paths, and locations where small interventions could significantly improve flood mitigation.

The multiscale approach, which is part of the morphological analysis, is essential for this research (Aragonez et al., 2025). This approach recognizes that flood resilience must work across scales from urban systems to neighborhoods and to blocks. Measures that are implemented at one scale may require a complementary intervention at another scale to be effective.

Urban morphology theory can also help explain how some strategies and measures may work in some contexts but not in others. Characteristics such as street width, open spaces, and plot sizes provide opportunities for different types of interventions (Mabrouk et al., 2024). Understanding these morphological conditions is important when developing context-specific measures that can be implemented.

D. Future Scenarios

Related sub-research question: SRQ2, SRQ3 | Related sub-design question: SDQ1

In order to address future uncertainties and challenges in cities, scenario-based approaches will be used. Scenario planning allows for multiple possible futures instead of predicting one single outcome (Puntub et al., 2024). This theory is essential where there is deep uncertainty and future conditions cannot be precisely forecasted but possible futures can be explored (Reimuth et al., 2023).

There are three main scenario categories: exploratory explores possible future developments, normative develops what should happen on desired outcomes, and predictive predicts future outcomes based on probability. Additionally, there are two possible approaches: forecasting or backcasting (Jaoude et al., 2022).

Scenario methods are powerful tools that explore specific desirable or feared outcomes that could impact resilience, regenerative qualities, and sustainability of cities (Sedrez et al., 2024). They enable exploration of various combinations of different factors such as urban growth, climate change, and future policies.

In this research, future scenarios are used to test and explore possible outcomes from the proposed spatial measures. This theory explored possible future condition in the years 2050-2100 which projects and predicts climate change impacts, continued urban growth, and increasing land pressure (Reimuth et al., 2023). This timeline was chosen because it aligns with climate projection timeframes (Monachese et al., 2025).

The scenario approach recognizes that the effects of climate change will only intensify. An understanding of how cities are growing within these hazard-prone areas is essential for making informed decisions in the future (Reimuth et al., 2023). For this project, scenarios incorporate both climate predictions, such as increased rainfall intensity, and urban growth, such as densification of informal settlements. These scenarios are not intended to be precise but rather a possible future that tests the proposed measures (Puntub et al., 2024). By simulating implementation of these measures under certain scenarios, the project can identify which interventions are robust enough for the future (Reimuth et al., 2023). This could enhance the development of strategies and measures that can be adjusted accordingly.

E. Socio-spatial resilience

Related sub-design question: SDQ2, SDQ3

Flood resilience in dense urban neighborhoods must be understood not just in the technical and infrastructural aspects but also in the capacity of a community to withstand, adapt, and recover from flooding (Neves & Espling, 2025). In this theory, space can be more than a medium for flood mitigation but also a place for social cohesion (Ludin et al., 2018).

This theory is further explained through the work documented in Mission Neighbourhood: (Re)forming Communities (Pagh & Cook, 2023). This publication explains how neighborhood scale spatial interventions can actively form more social and environmentally sustainable neighborhoods. The work demonstrates a strategic design approach to urban development essentially subdivided into four parts that will be used for the project: neighborhood fundamentals, social infrastructure, reclaim the streets, and naturehood. For this project, Mission Neighbourhood serves as a key reference for understanding how socio-spatial design principles can be translated into a dense, constrained, and informally organized neighborhood.

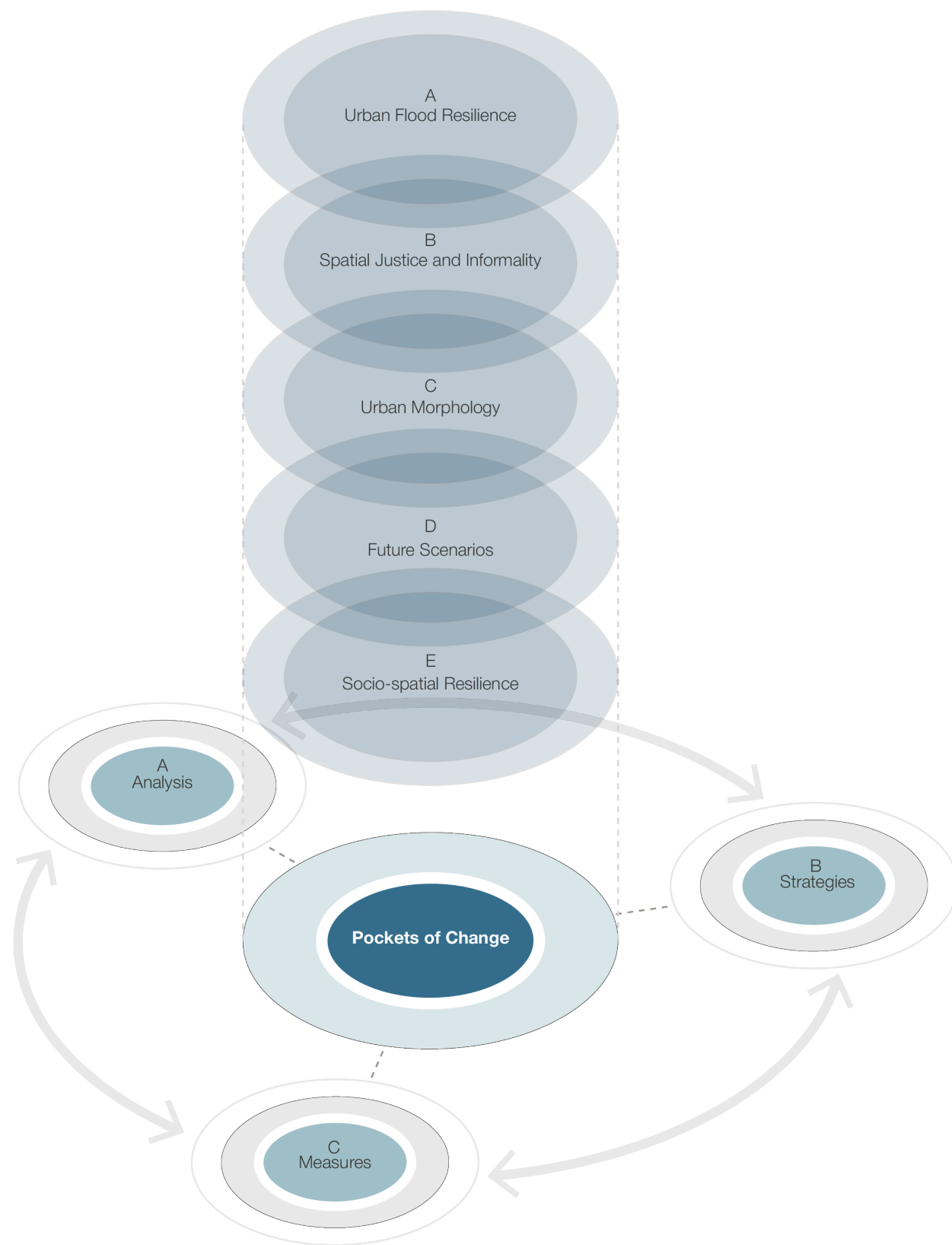
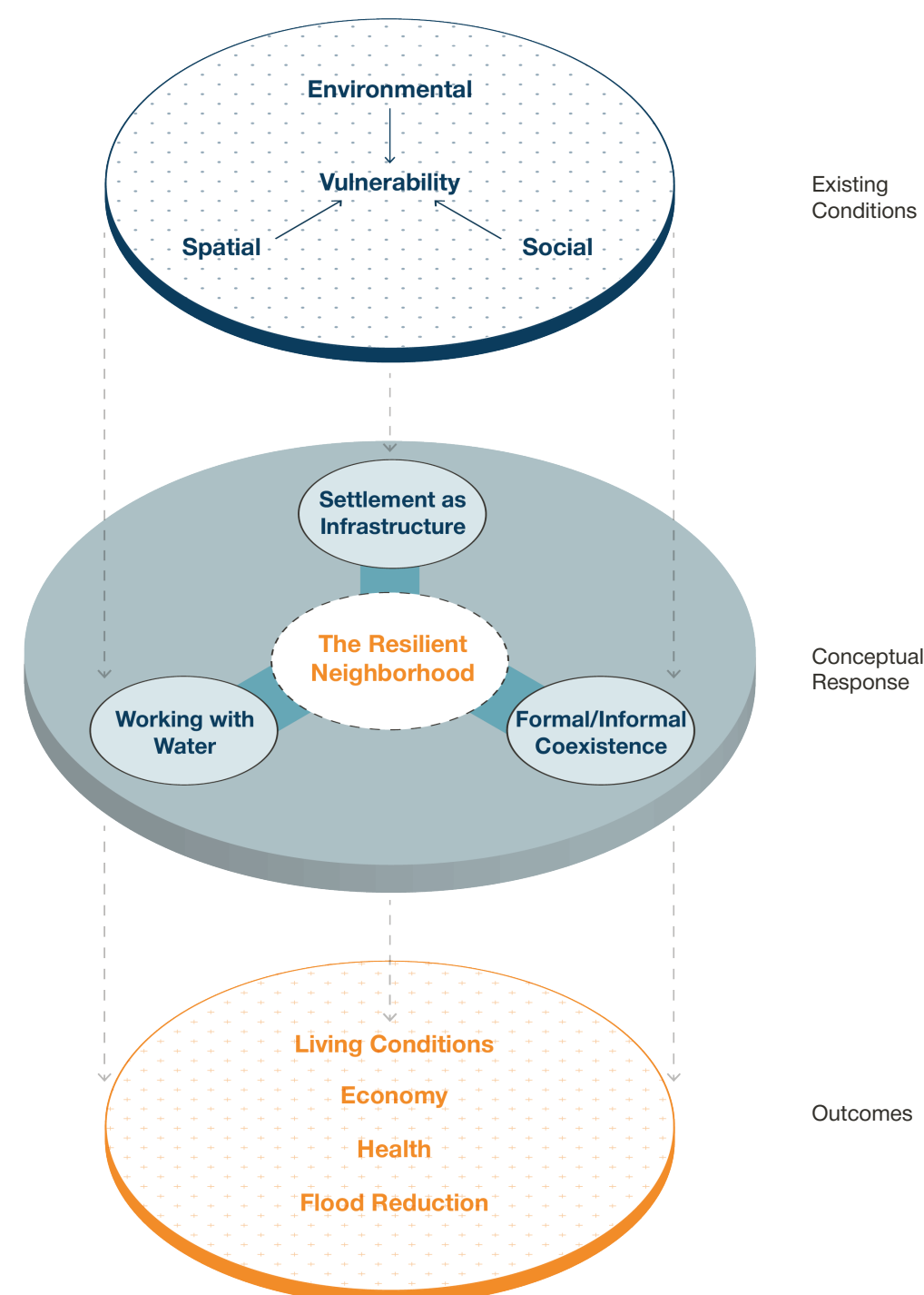


Figure 2.4 Methodological and Theoretical Framework

Note. Made by Author

2.5 Conceptual Framework



The conceptual framework consists of three parts namely: existing conditions, conceptual response, and outcomes. Flood vulnerability in dense low-income settlements emerges from three dimensions that intersect: environmental, spatial, and social. These dimensions are answered by three interconnected conceptual responses:

- 1. Settlement as Infrastructure**
This position challenges the idea that neighborhoods should only rely on large scale flood infrastructure. This position proposes that informal settlements can be its own flood infrastructure and mitigate flooding rather than be a recipient of these extreme disasters.
- 2. Working with Water**
The second position is a response to traditional flood management where water is to be kept out and resisted. This position proposes an alternative where floodwater can be accepted and managed
- 3. Formal and Informal Coexistence**
The third position addresses the tensions between the formal and informal in the city. Flood risk is an inequality issue where informal settlements are disproportionately exposed. This position proposes that the formal and informal could have a negotiated relationship.

With the integration of these three concepts, they form an interdependent system that produces the resilient neighborhood. The convergence of these three is expected to generate short to long term outcomes across different scales.

Figure 2.5 Conceptual Framework
Note. Made by Author



03

Analysis

The analysis chapter investigates the environmental, spatial, and social conditions that produce and sustain flood vulnerability in Barangay Tatalon. The analysis moves from the macro to the micro, from systematic causes of flooding in Metro Manila to the living conditions of the neighborhood. Each of the eight parts builds layers of evidence that inform the design response.

The historical analysis traces the development of Metro Manila and examines how current flood conditions repeat past patterns. Understanding history is essential to avoid these mistakes. The contextual analysis provides a macro-level idea for understanding flooding as a systematic phenomenon in Metro Manila. The environmental analysis examines the physical and climatic drivers of flood risk. The spatial analysis investigates how the built environment has intensified flood risk and vulnerability. The social analysis examines the social and political dimensions of flood vulnerability and evaluates existing flood control efforts. The neighborhood analysis brings all these dimensions together at the neighborhood scale. The fieldwork grounds this reading in on-site observations and community perspectives. Finally, the chapter closes with the understanding of disaster risk, establishing the framework of hazard, exposure, and vulnerability that sets the terms for the response.

3.1 Historical Analysis

3.1.1 Trends in flooding

Flooding is not a new phenomenon in Metro Manila. Flash floods have already occurred during the Spanish colonial period (1800s) (Liongson et al., 2000). The authors of “Pressures of Urbanization: Flood Control and Drainage in Metro Manila” delve into the historical accounts of flooding in Metro Manila from the 1950s through the 1990s.

In the 1950s, regions such as Tondo, Sta. Cruz, Sampaloc, and Sta. Mesa in Manila was frequently devastated by floods, primarily due to natural factors such as the city’s flat terrain, high rainfall intensity, tropical depressions and typhoons, and high tides in Manila Bay. Activities resulting from modernization have affected the city’s flooding patterns since the late 1950s.

In the 1960s, the areas affected by floods expanded, with nearly 70 percent of Manila submerged in floodwaters reaching depths of 3.6 to 4.5 meters. Floodwaters rose to nearly 6.1 m in Tatalon, an informal settlement community near Espana Boulevard Extension and Quezon Boulevard Extension, exacerbated by southwest monsoon rains, storm surges, high tides in Manila Bay, and the effects of urban development. The number of paved roads and building complexes had contributed to increased flash flood events. Despite the implementation of flood-control structures such as river walls, floodgates, main interceptors, and outfalls, deficiencies in funding

allocation, financial mismanagement, and inadequate resources hindered effective flood control. The era also witnessed significant financial losses of P13 million to 100 million pesos annually to private properties, coupled with health hazards such as respiratory and gastrointestinal diseases due to compromised water quality and sanitation.

In the 1970s, cities like Pasay, Manila, Quezon City, San Juan, Malabon, and Navotas experienced severe flooding, with murky, contaminated floodwaters caused by upstream soil erosion and pollutants. The degradation of water bodies such as the Pasig River and its tributaries, due to waste accumulation and unauthorized construction, further worsened the situation. The decade was marked by issues such as watershed deforestation, incomplete dike construction, siltation of waterways, and inadequate flood control strategies, leading to widespread family displacement, disruptions to vital services, and economic challenges, including soaring commodity prices and transportation costs. People increasingly resorted to rafts and small boats as modes of transportation on flood-prone streets.

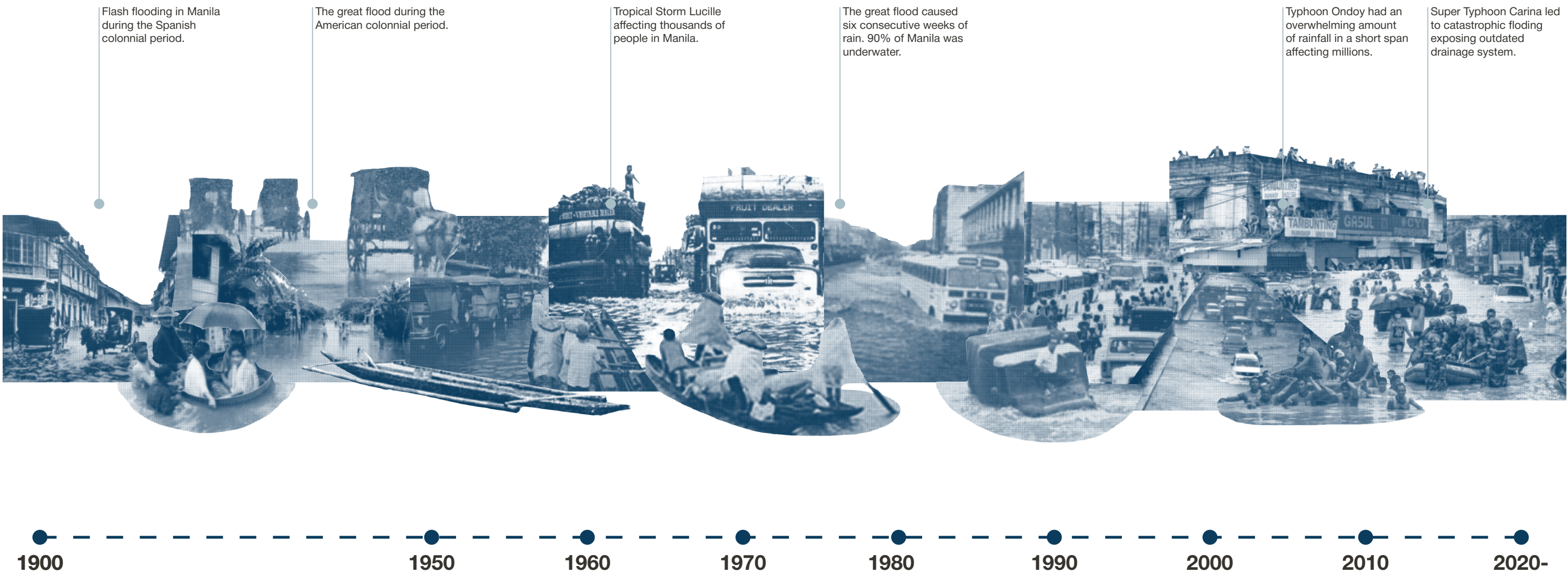
In the 1980s, newly developed residential areas in Marikina, Cainta, Pasig, Pateros, and Taguig faced inundation, with flood depths reaching 1.8 to 2.4 meters. The financial toll from flood-related damage and the devaluation of real estate, particularly in upscale residential enclaves, was substantial. Runoff from deforested watersheds contributed to rising water levels, prompting extensive relief and rehabilitation efforts costing millions of pesos.

In the 1990s, floodwater depths in subdivisions with substandard drainage and sewer facilities increased, affecting a growing number of informal settler families. Hundreds of thousands of people were evacuated to higher places. The escalation of traffic congestion and disruptions in daily activities, compounded by disease outbreaks and power failures, further compounded the challenges faced by the population. Annual property losses from floods were estimated at P900 million.

In the 21st century, similar trends persist. During the 2000s, due to Metro Manila’s rapid urbanization, the lack of development and maintenance of adequate drainage systems was the primary cause of flooding (Cal, 2021). Metro Manila failed to develop proportional stormwater drainage systems to meet the growing population’s demand (Cal, 2021). With the continued population growth and migration, informal settlements expanded into flood-prone areas. This decade culminated in the 2009 Tropical Cyclone Ketsana (Ondoy), which caused extensive, exceptionally high flooding (Abon et al., 2011). This event affected about 800,000 individuals in Metro Manila alone (Sato & Nakasu, 2011).

In the 2010s, the government made efforts to invest in reconstruction and flood-control infrastructure. Despite this, Metro Manila continued to experience annual flooding. Existing infrastructure was still unable to manage increasing flood risks, driven by population growth, urbanization, environmental degradation, and anticipated climate change (Liongson, 2012). Flood control projects were planned but faced funding constraints, resulting in their incompleteness by the end of the decade (Liongson, 2012). Rapid urbanization continued, creating dense settlements in flood-prone areas.

3.1 Historical Analysis



Timeline of Major Flood Events in Metro Manila

Figure 3.1 Timeline of Major Flood Events in Metro Manila

Note. Made by Author

3.2 Contextual Analysis

3.2.1 Definition of flooding

Flooding occurs when large amounts of water overflow and submerge normally dry land. This can happen in various ways, such as heavy or persistent rainfall that can cause bodies of water to exceed their normal capacity or surface rainwater to accumulate due to poor drainage. According to Alcoforado (2018), flooding may be caused by many factors, such as intense rainfall, strong winds over water, unusually high tides, tsunamis, or dam failures. Flooding occurs when lakes, riverbeds, soil, and vegetation cannot absorb all the water (Hendrasari & Wicaksana, 2025).

There are three main types of floods: fluvial, pluvial, and coastal. Each type is triggered by different factors. Fluvial floods occur due to an overflow from rivers, pluvial floods result from extreme rainfall where existing drainage systems cannot adequately handle the excess water, and coastal floods happen when low-lying land is submerged by seawater (Jafar et al., 2023).

3.2.2 Drivers of flooding in Metro Manila

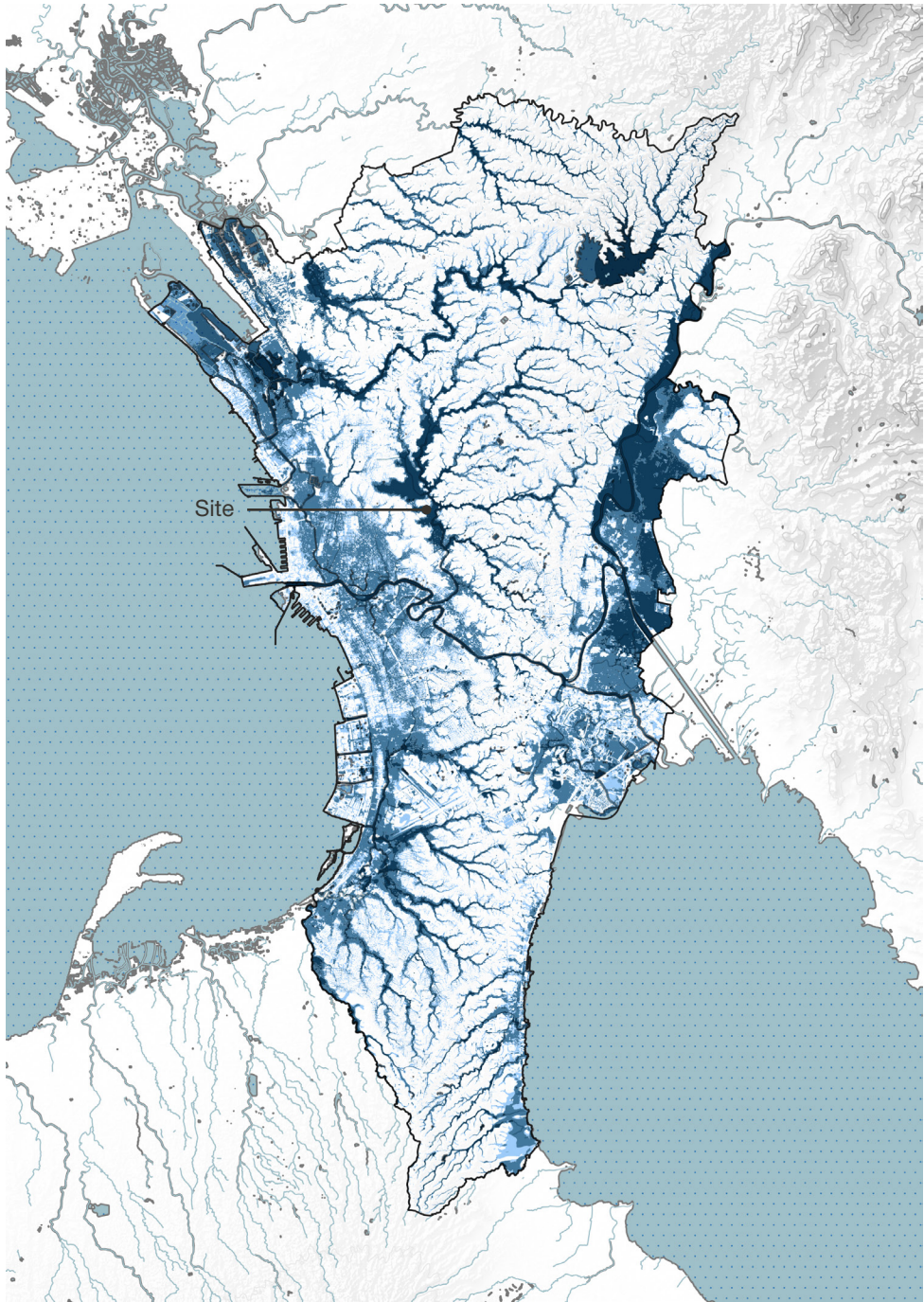
Metro Manila experiences different types of flooding due its complex hydrological and urban characteristic. According to Dulawan et al. (2024), the region experiences fluvial, pluvial, and coastal flooding. Fluvial floods occur as a of the overflow of the tributaries of the Pasig River, pluvial floods is associated with the inadequate drainage capacity, and coastal floods comes from storm surges and high tides that affect low-lying areas.

The challenges of flooding in Metro Manila result from a compounded effect of different factors. Natural rainfall events such as typhoons and monsoon rain are the primary triggers. Extreme flood events in the region are usually caused by these heavy rainfall events lasting 1 to 3 days (Regmi, 2018). The southwest monsoon also known as Habagat brings prolonged and intense rainfall usually during the months of June and September, leading to flash floods in urbanized areas such as Metro Manila (Rivera & Vega, 2025). Furthermore, a significant increase in rainfall over Metro Manila by approximately 78 mm per decade was documented from 1901-2018 (Villarin et al., 2024)

In addition to these natural factors, human activities also influence the severity and frequency of these events. Rapid urbanization is the fundamental driver of this. As the region expands, it disrupts the natural water cycle through impervious surfaces and overburdening the already outdated drainage system (Bundnis Entwicklung Hilft & IFHV, 2025).

3.2.3 Flood hazard areas in Metro Manila

This map (Figure 3.2) illustrates the inundation extents in an area if rainfall exceeds that of a 100-year return period event, meaning there is a 1% probability of such a flood occurring in any given year. Flood hazard considers both the height and velocity of the water. The map presents models of fluvial and pluvial flooding.



100 year Flood Hazard Map

- Low Hazard (0-0.5 meters)
- Medium Hazard (>0.5-1.5 meters)
- High Hazard (>1.5 meters)

Figure 3.2 100 year Flood Hazard Map

Note. Adapted from NOAH Studio (2025)

3.2.4 Flooding and its effects in Barangay Tatalon

During a study on community based disaster risk reduction in Barangay tatalon by Martinez et al., (2025), several factors were identified that contribute to flood risk. Barangay tatalon experiences pluvial and fluvial flooding that affects the community. Low-lying barangays like Tatalon, Santo Doming, Roxas, and Bagong Pag-asa are all located downstream from La Mesa Dam. During heavy rainfall events, the water level can exceed its spilling level and cause floodwater to overflow into these low-lying areas (Quezon City Government, 2021).

The barangay is also vulnerable to river and creek overflow caused by the backflow from the Pasig River (Quezon City Government, 2022). Because of its low-lying characteristic and shallow riverbed, flooding is further intensified especially during extreme rainfall (Martinez et al., 2025; see figure 3.3). Residents have noted that slow drainage and water stagnation are usually the warning signs of flooding in the area (Martinez et al., 2025). This is worsened by the lack of proper drainage routing and clogged pipes, which lead to ineffective water flow (Quezon City Government, 2025).

During the 100 year flood scenario, 89.45% of Barangay Tatalon will be flooding with waters higher than 0.5 meters where around 4,930 buildings may be reached by flood waters. (Quezon City Government, 2022; see Figure 3.4 and Figure 3.5). During this event, almost 11% of the total city population could be displaced, wherein Barangay Tatalon has the larger number of of people affected (Figure 3.6) Another factor contributing to flooding in the area is improper waste management, in which garbage clogs canals and waterways (Martinez et al., 2025). Moreover, when large scale floods, fecal coliform may be present and can cause health risks such as gastrointesimal infection (Quezon City Government, 2022; see Figure 3.7). Additionally, Tatalon has one of the highest fatality rates with values that area greater than 0.02% of the population at risk (Quezon City Government, 2021; see Figure 3.8). Historically, six disasters have caused flooding in the neighborhood where informal settlers face the highest risk of vulnerability and potential displacement during extreme flood events (Martinez et al., 2025).



Figure 3.3: Barangay Tatalon Flooding Following Heavy Monsoon Rains

Note. From Manila Times (2023)

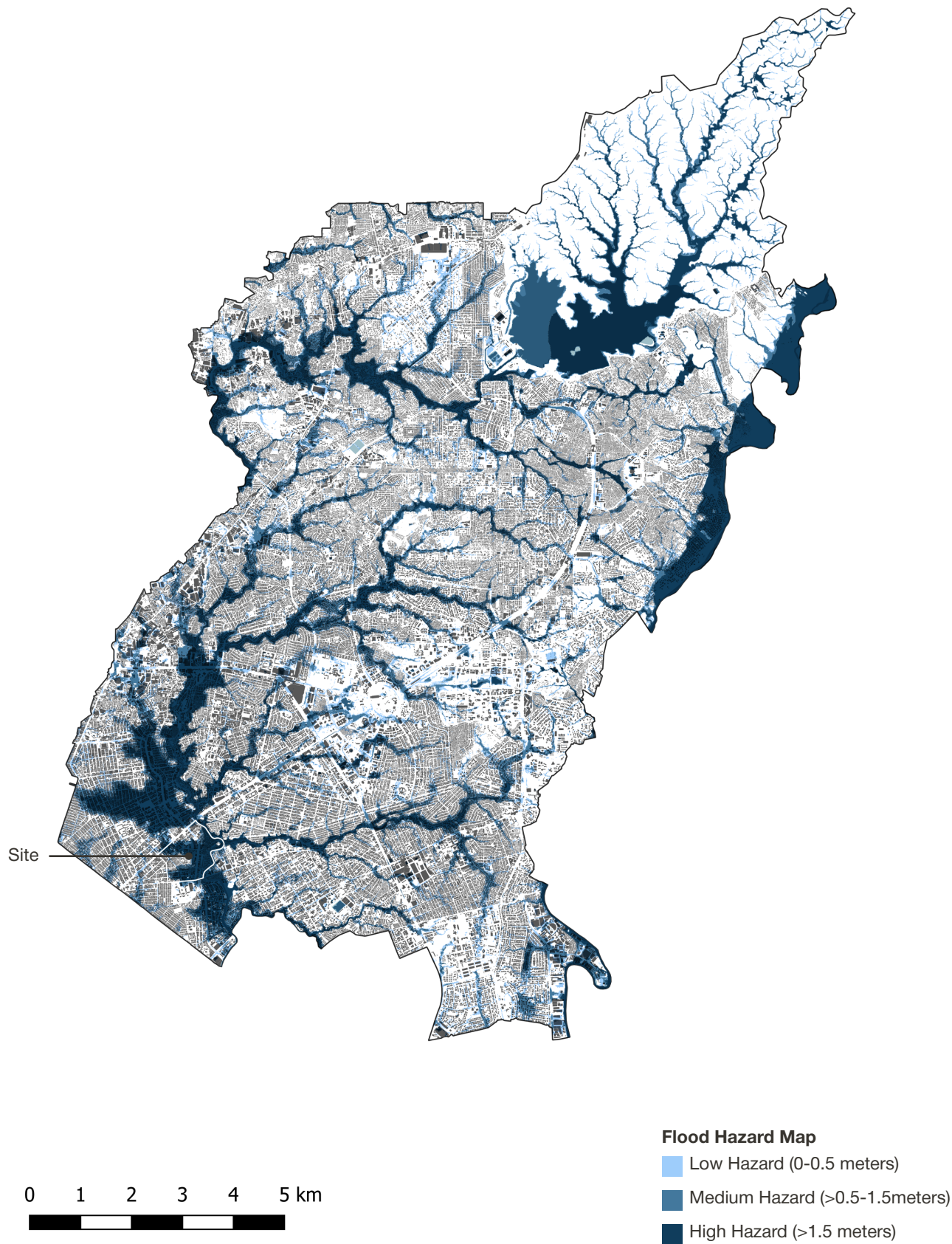


Figure 3.4 Quezon City Flood Hazard Map

Note. Adapted from NOAH Studio (2025) and building footprint data from openstreet map. Made by Author

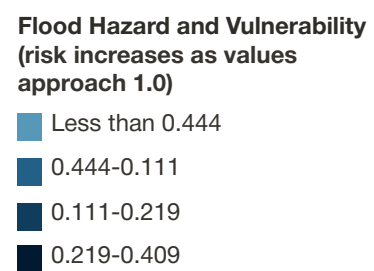
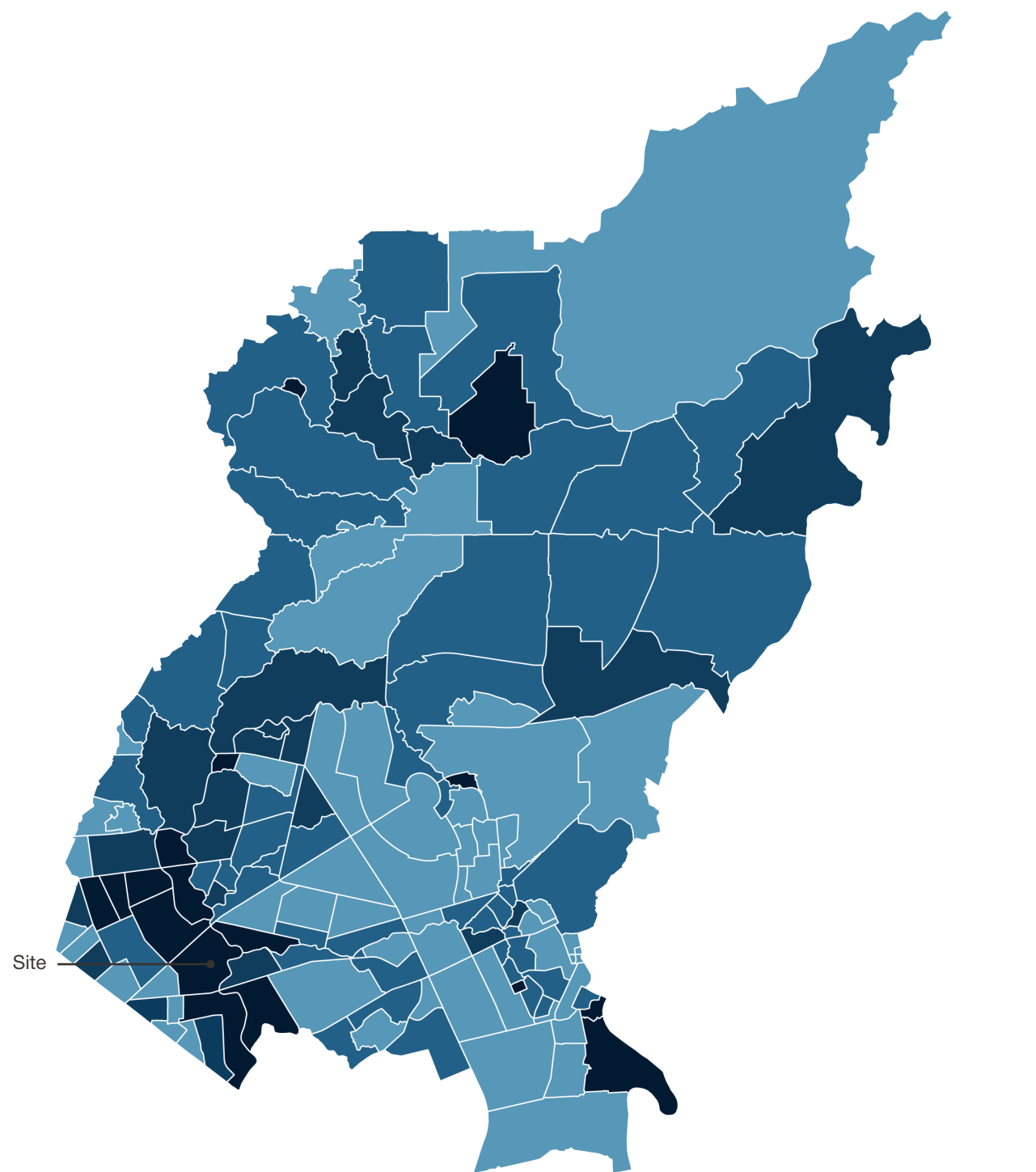


Figure 3.5 Flood Hazard and Vulnerability

Note. Adapted from Quezon City Disaster Risk Reduction and Management Office (2018)

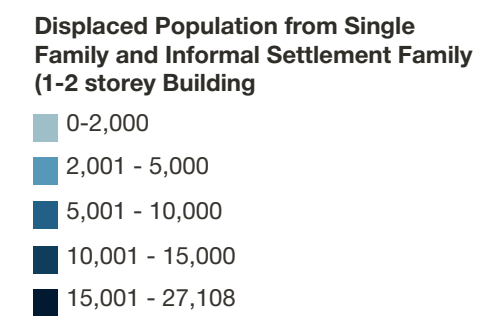
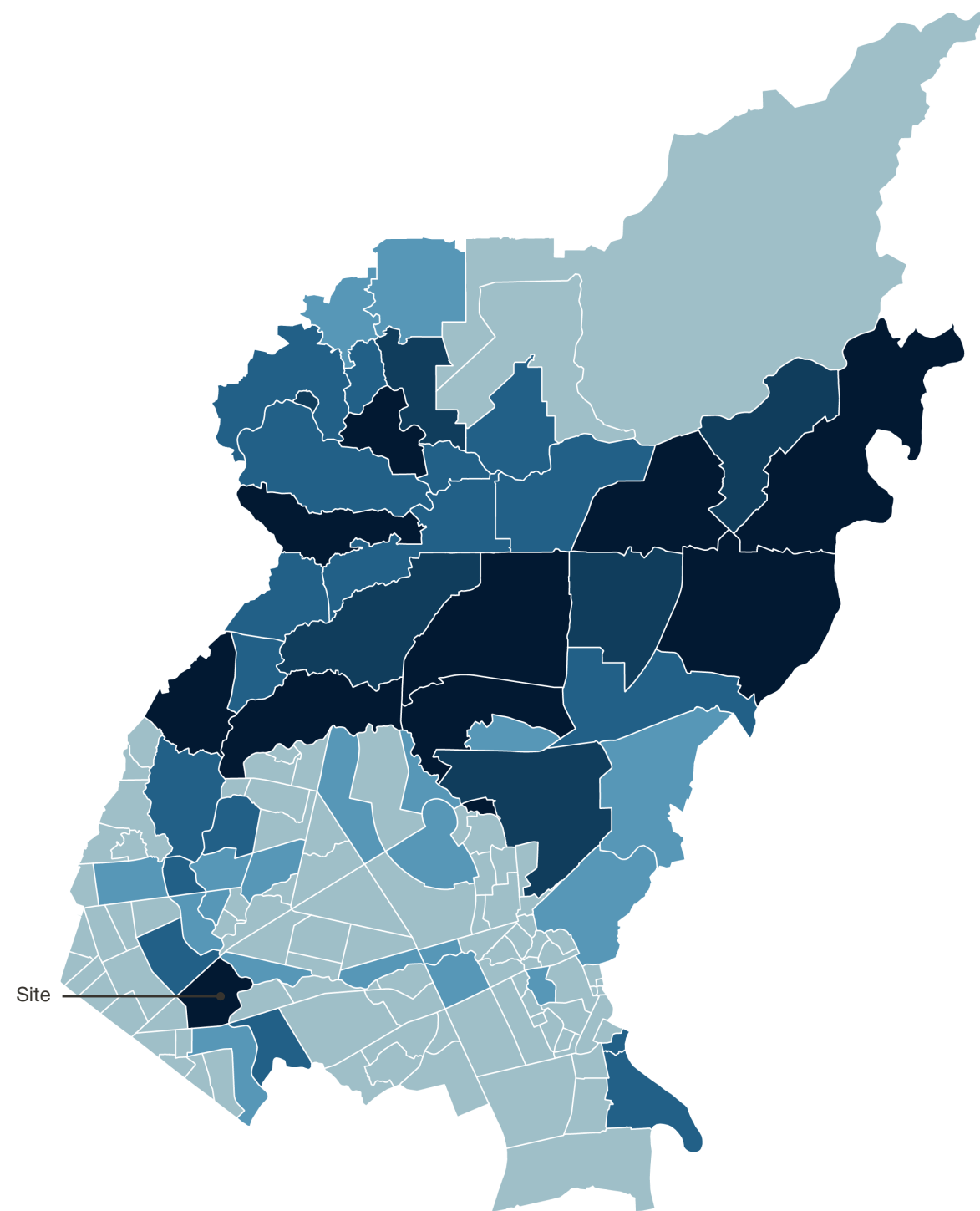


Figure 3.6 Flood Displaced Population Map

Note. Adapted from Quezon City Drainage Master Plan (2022)

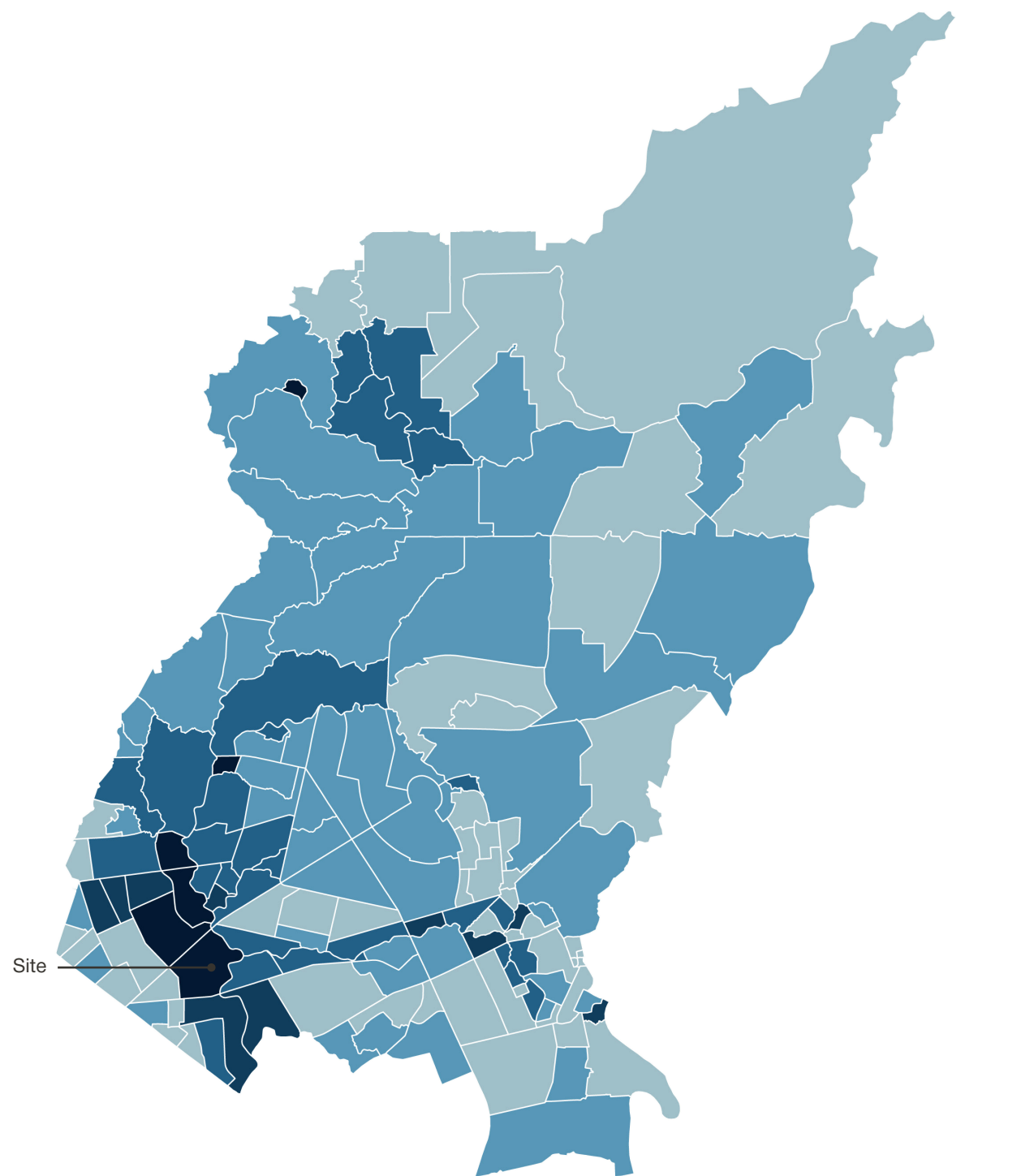


Figure 3.7 Gastro-enteritis Risk of Infection

Note. Adapted from Quezon City Drainage Master Plan (2022)

**Infection rate (per 1000 population) to
Gastro-Enteritis**

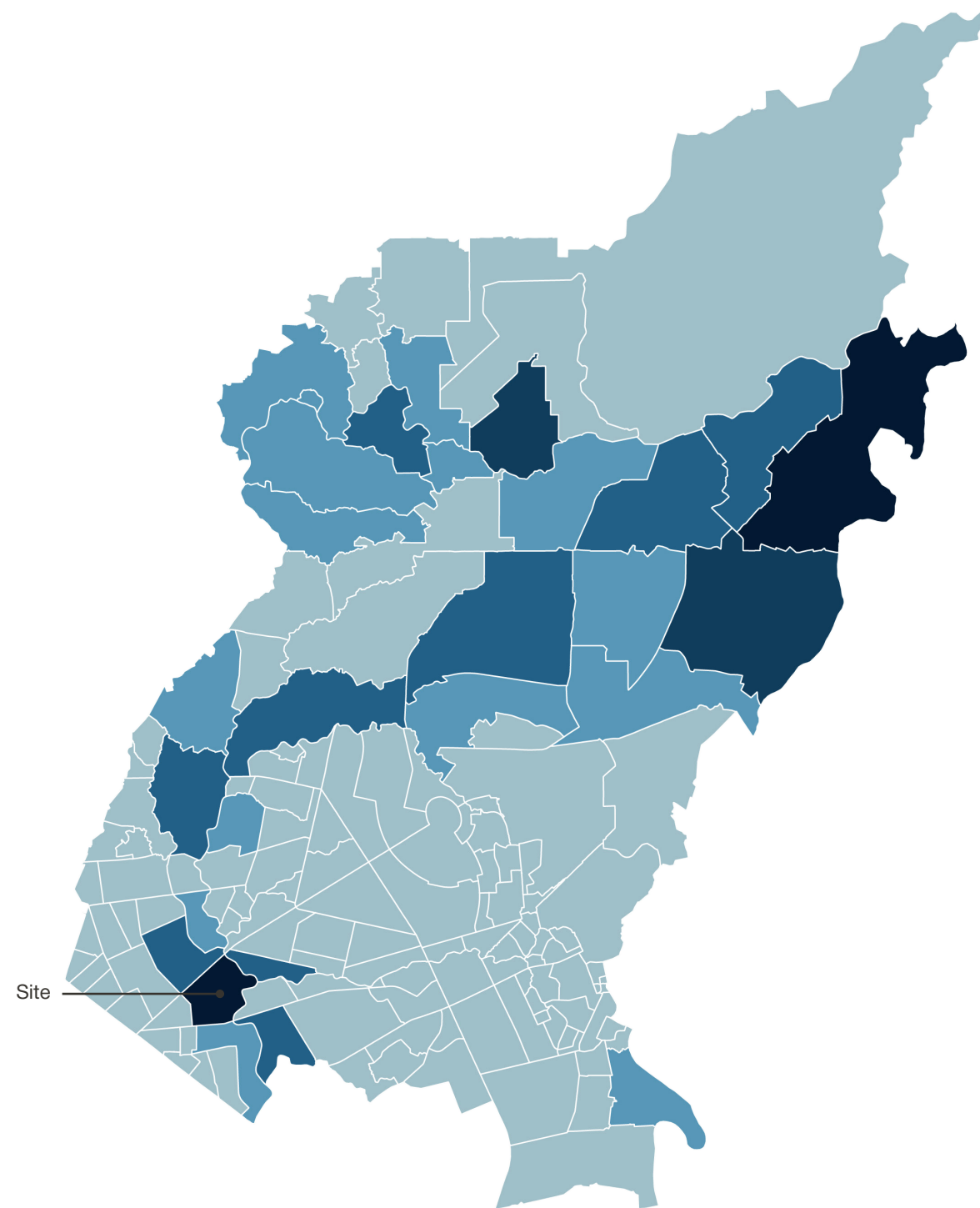
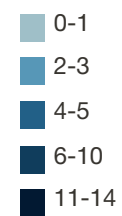
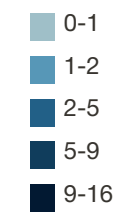


Figure 3.8 Projected Casualties in 100 year flood forecast

Note. Adapted from Quezon City Disaster Risk Reduction and Management Office (2018)

**Projected Casualties in 100 year
flood forecast**



3.3 Environmental Analysis

3.3.1 Watershed degradation

Flood vulnerability in Metro Manila reflects alterations in the region’s hydrology caused by improper land use and watershed degradation (Figure 3.9). One of the main issues on the environment is deforestation, especially in the upper catchment area of the Marikina River, which results in river capacity reduction due to erosion and lower absorption capacity of soil. (Asian Infrastructure Investment Bank, 2017). Deforestation has numerous harmful effects on the region, including increased landslides and disruption of the water cycle. This increases flood magnitude due to shorter runoff times (Center for Excellence in Disaster Management and Humanitarian Assistance, 2025). The loss of forest cover in the surrounding mountains has reduced the retention capacity of these watersheds and caused large volumes of water to flow into the low-lying areas (Liongson et al., 2000).

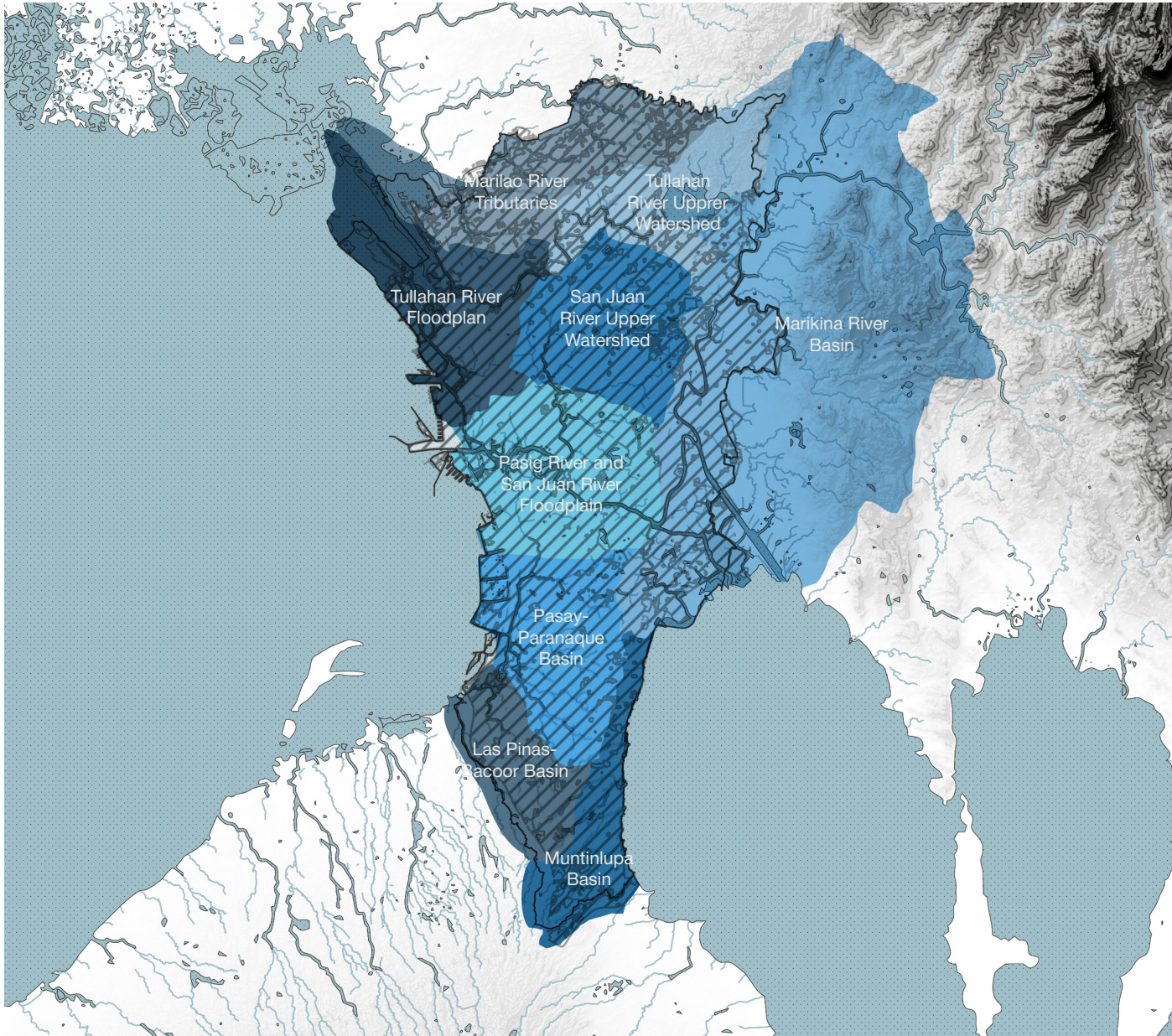


Figure 3.9 Metro Manila Watershed and Built Area

Note. Adapted from Lagmay et al., (2017) and land use data from Geoportal Philippines. Made by Author

3.3.2 Urbanization challenges

Urbanization has further disrupted the natural water cycle through land conversion and surface sealing (Bundnis Entwicklung Hilft & IFHV, 2025). This conversion of agricultural land to built-up and developed areas, with the use of concrete and other impervious materials, has reduced ground permeability, making it more difficult for surface runoff to infiltrate (Regmi, 2018; see Figure 3.10). This is not a new problem; its transformation and effects have been observed since the 1960s, when floods reached depths of 3.6 to 4.5 meters, and congested neighborhoods along waterways are most susceptible (Bankoff, 2003). Moreover, the limited amount of open and green space in the region has worsened flooding by limiting natural water absorption (Dulawan et al., 2024).

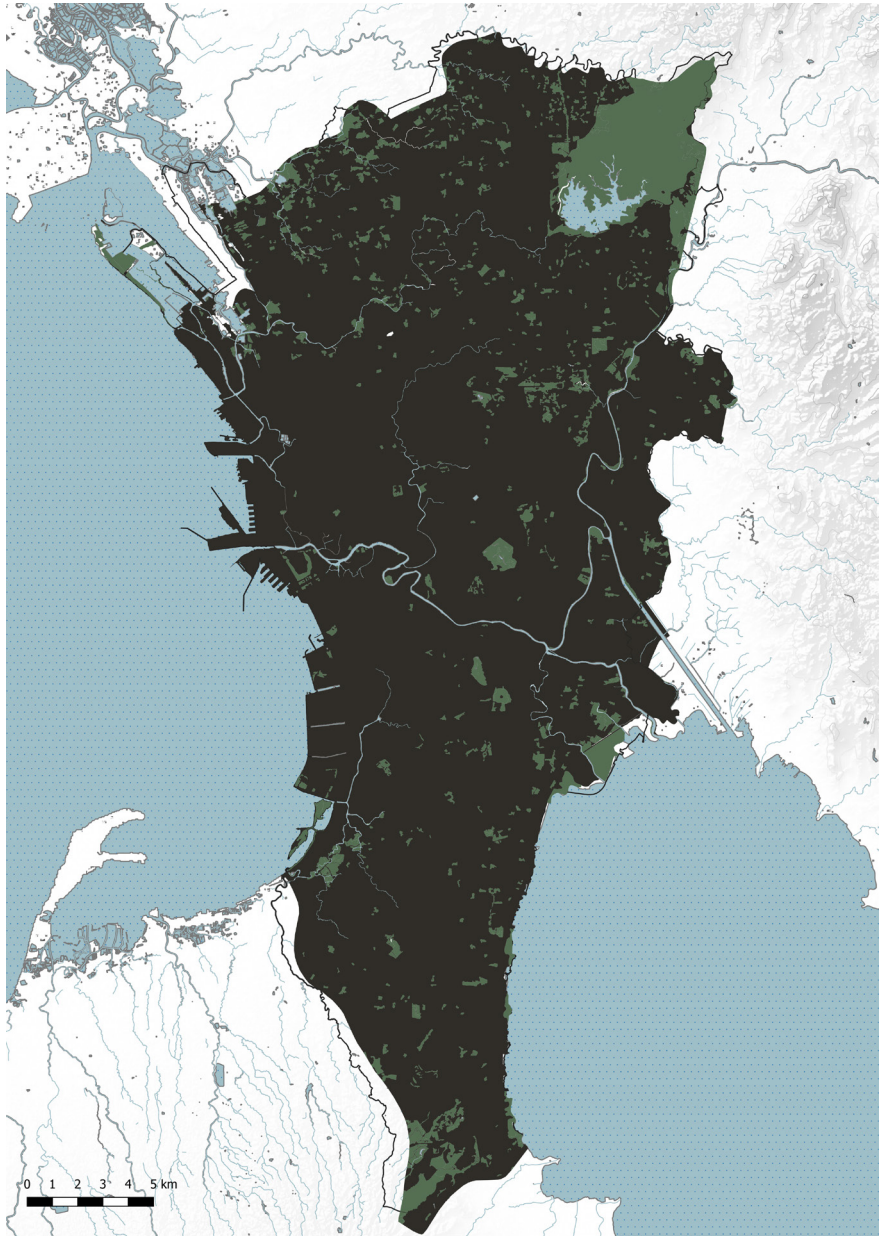


Figure 3.10 Built Area vs. Open Green Space in Metro Manila

Note. Land use data from Geoportal Philippines. Made by Author

Built Area vs Open Green Space

- Built-up area
- Open green space
- Water

Since the 1970s, Metro Manila’s population has grown from 4 million residents (Quezon City Government, 2022) to more than 15 million today and may reach 18 million by 2045 (Figure 3.11; Cal, 2021). Despite this, the infrastructure development has lagged. According to the Quezon City government (2025), drainage pipes, which are mostly concrete pipes and culverts, often fail when there is not enough drop inlets and when drainage pipes are too small. This results in flash flooding and backflow flooding.

Urban densification, obstruction of waterways, silting of riverbeds and canals, narrowing of rivers, and encroachment by concrete have intensified flooding in the region (Lagmay et al., 2017). These physical effects, compounded by more frequent rainfall events and outdated, failing pumping stations, have made flooding even more severe (Asian Infrastructure Investment Bank, 2017).

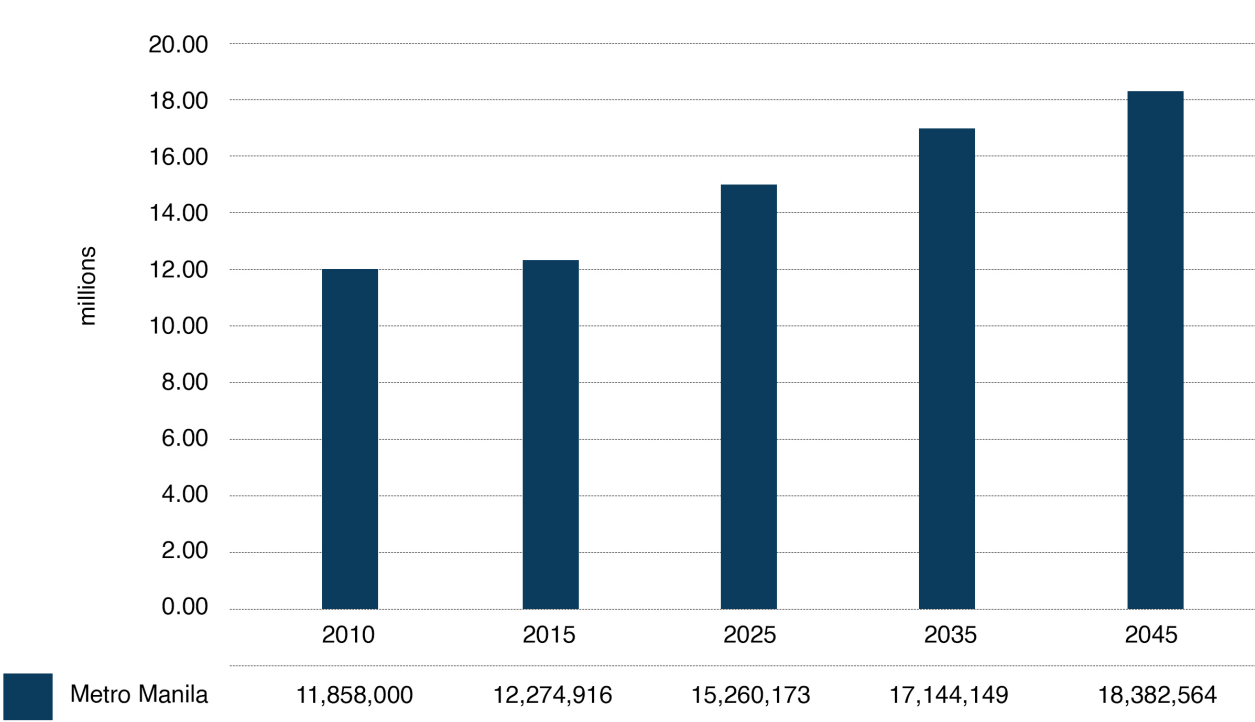


Figure 3.11 Population Forecast

Note. Adapted from Cal (2021)

3.3.3 Climate change amplification

Climate change has altered and intensified precipitation patterns. In the Philippines, the average number of typhoons that hit the country is 20, of which 5 are categorized as destructive (Rivera & Vega, 2025, see Figure 3.12). The combination of these typhoons and prolonged monsoon rain has caused devastating flooding, intensifying the flood risk for low-lying populated areas (Rivera & Vega, 2025). Future climate projections show the intensification of these climate-related effects. For every 1°C of warming, rainfall events are projected to intensify by around 7%, while tropical cyclones are projected to become more frequent (Villarin et al., 2024). According to the Quezon City Government (2018), rainfall will increase in 2050, especially during the wet season (June, July, August), while heavy daily rainfall events (exceeding 300mm) will become more frequent (Figure 3.13). Scientists agree that climate change will intensify typhoons, leading to more severe floods and affecting more communities (Lagmay et al., 2023).

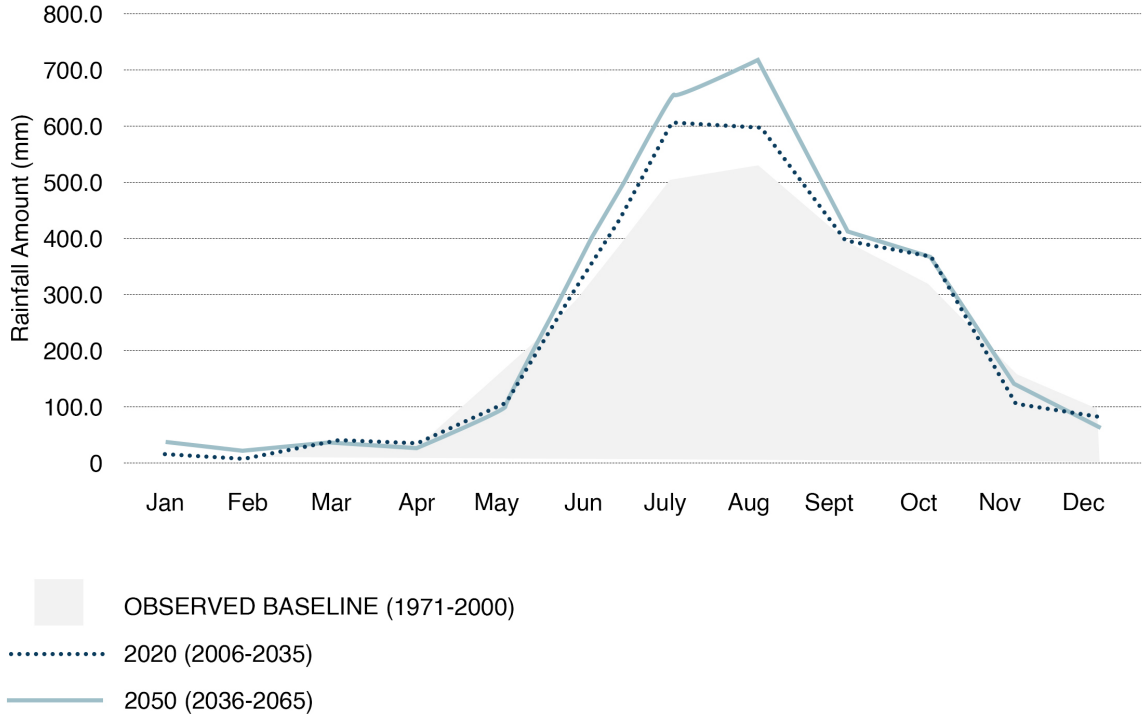


Figure 3.12 Projected Change in Monthly and Average Rainfall

Note. Adapted from Quezon City Government (2022)

3.4 Spatial Analysis

3.4.1 Geographic location and topography

The spatial distribution of low-income informal settlements in Metro Manila is determined by its geography and the constraints that make it flood-prone. Metro Manila is located in a low-lying, semi-alluvial plain that serves as a vast drainage basin and experiences frequent flooding during heavy rainfall (Porio, 2011; see Figure 3.15). It has a land area of 636 kilometers, stretching 22 kilometers from Manila Bay on the west and Laguna Lake on the east, which makes it susceptible to repeated overflow from rivers and stormwaters (Bankoff, 2003). This geographic characteristic ensures that informal settlements clustered in flat, low-lying areas experience greater exposure to floodwaters.

The elevation differences within Metro Manila create an uneven distribution of flood vulnerability. According to the Quezon City government (2025), the southern part of the city has more areas susceptible to flooding than the northern half because of the lower terrain in the south, where low-lying regions also become flooded by backflow at the junction of the San Juan and Pasig Rivers (Figure 3.16).

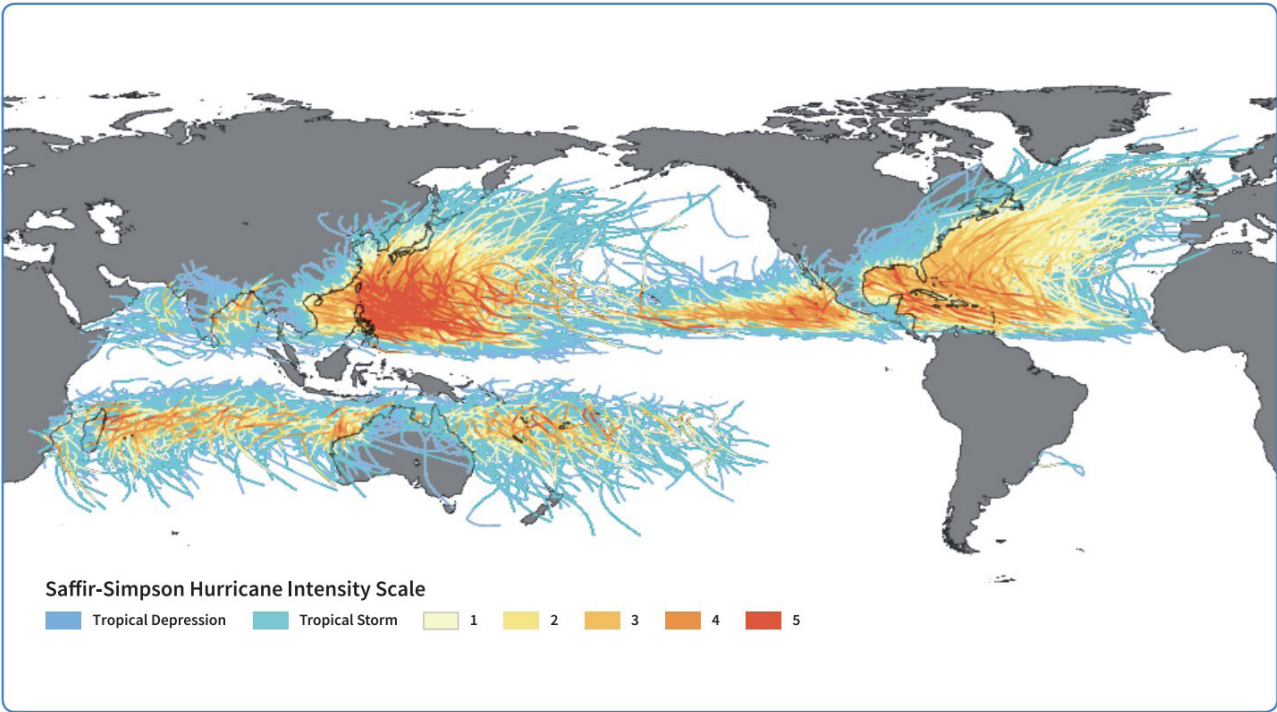


Figure 3.13 Worldwide Historical Tropical Cyclone Tracks

Note. From NASA Earth Observatory (2006)



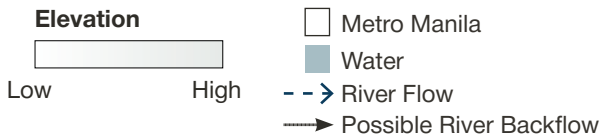
Figure 3.14 Aerial View of Flooding in Manila Caused by Typhoon Ulysses

Note. From GMA News Online (2020)



Figure 3.15 Metro Manila Topographic Map

Note. From Opentopograppgy. Made by Author



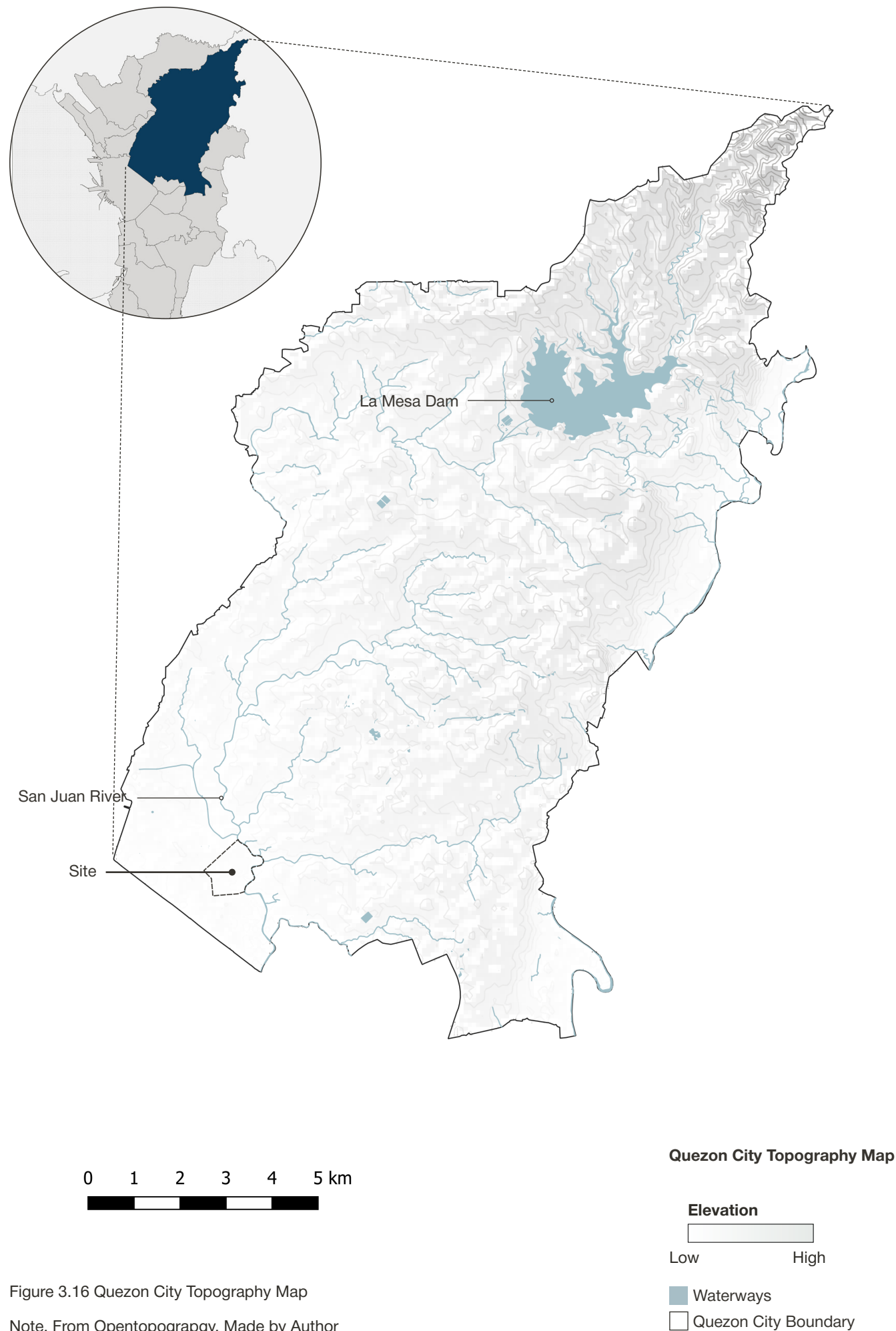


Figure 3.16 Quezon City Topography Map
 Note. From Opentopograppgy. Made by Author

3.4.2 High-density development and rapid urbanization

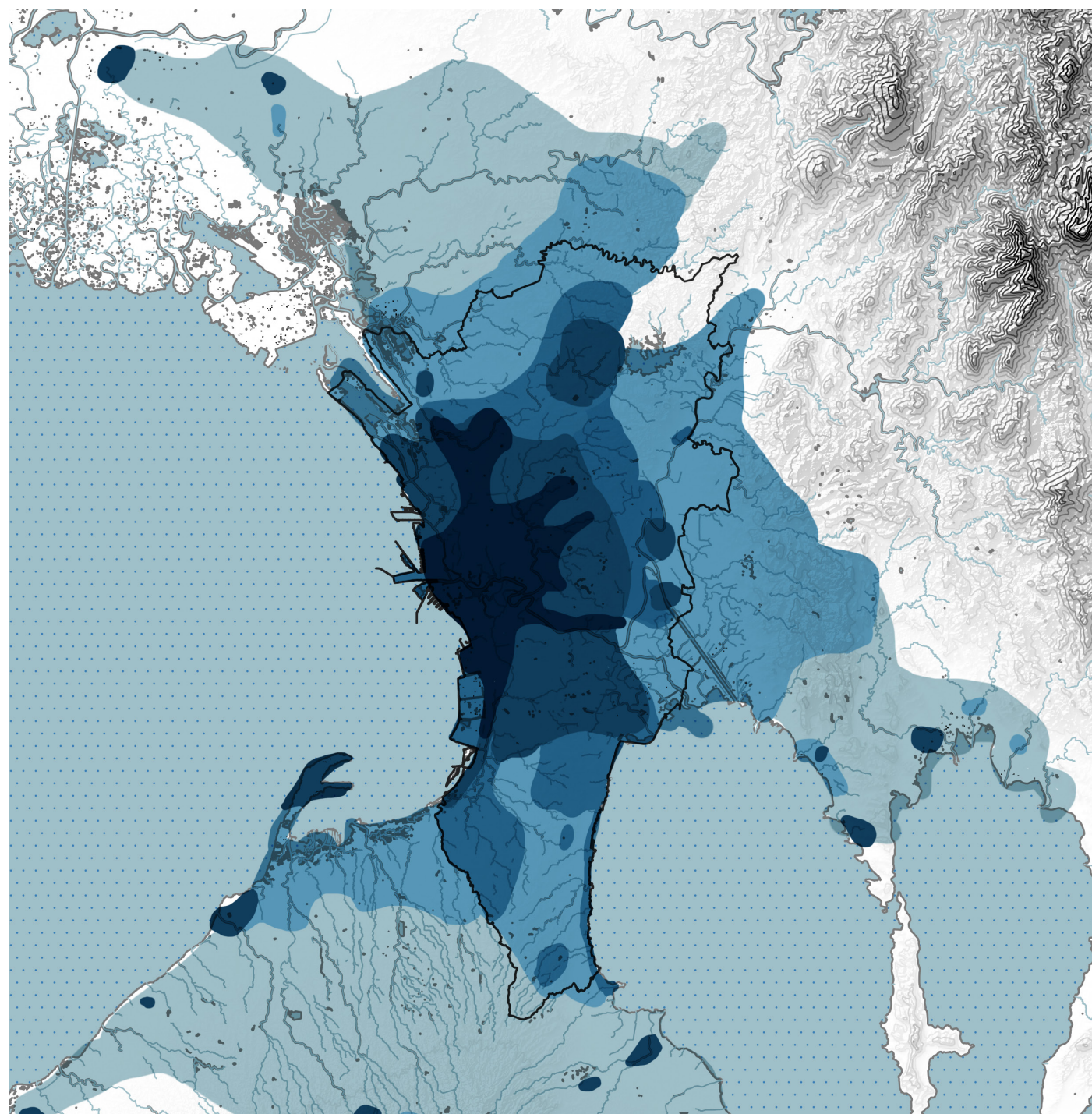
Metro Manila is the most populated region in the country, where most of its population faces challenges from rapid urbanization and migration. In Metro Manila, there is a constant flow of migrants from rural areas in the Philippines to seek for more opportunities (Figure 3.17; Yulu, 2021). This rapid urbanization has made it challenging to find adequate housing (Yulu, 2021). Moreover, it has led to the expansion and habitation in risky areas. Although this urbanization process has generated income for the region, it has, however, created an uneven distribution of risk.

Because of rapid urbanization (Figure 3.18), Metro Manila has limited open green space, which worsens flooding by reducing its natural water absorption (Dulawan et al., 2024; see Figure 3.17). According to the Quezon City government (2018), their analysis reveals that 81% of the area is currently impervious which increases surface runoff.



Figure 3.17 Metro Manila Migrants
 Note. Adapted from Yulu (2021)

■ Metro Manila



Trend in Urban Expansion of Metro Manila

2015
1996
1975
1966
1948

Figure 3.18 Trend in Urban Area Expansion of Metro Manila

Note. Adapted from JICA Study Team (2014)



Figure 3.19 Satellite Image of Metro Manila

Note. From ESRI World Imagery

3.4.3 Location of informal settlements along high-risk Areas

In the Philippines, Metro Manila has the largest concentration of informal settlements, which makes up about 40% of the total informal settlement population (World Bank, 2017; see Figure 3.21). Approximately 2.8 million people live in Metro Manila, with many of them living along drainage channels and waterways (Asian Infrastructure Investment Bank, 2017). Informal settlers living along waterways are vulnerable to flooding, which results from the accumulation of solid waste (Molnar-Tanaka & Surminski, 2024). Despite these hazards, these households, especially microentrepreneurs, still choose to remain in these areas for economic and socio-spatial reasons (Manegdeg et al., 2024).

Formal and informal segregation are among the most urgent barriers to flood management. In Metro Manila. There is an obvious contrast between the formal and informal sectors, in which high-rise buildings are home to middle- to high-income citizens, while informal settlements are home to those living in poverty (Edelman, 2016). This organization reflects patterns of informal settlements densifying in the city center while upper-income residential subdivisions develop toward the peripheries (Regmi, 2018). This segregation shows that the formal sector develops in more suitable locations while informal settlements remain in hazard-prone areas.



Figure 3.20 High-rise towers next to low income neighborhoods

Note. From Unequal scenes: Manila, by J. Miller

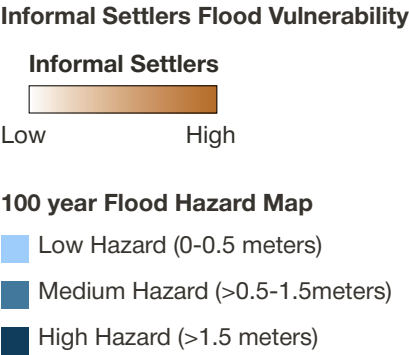
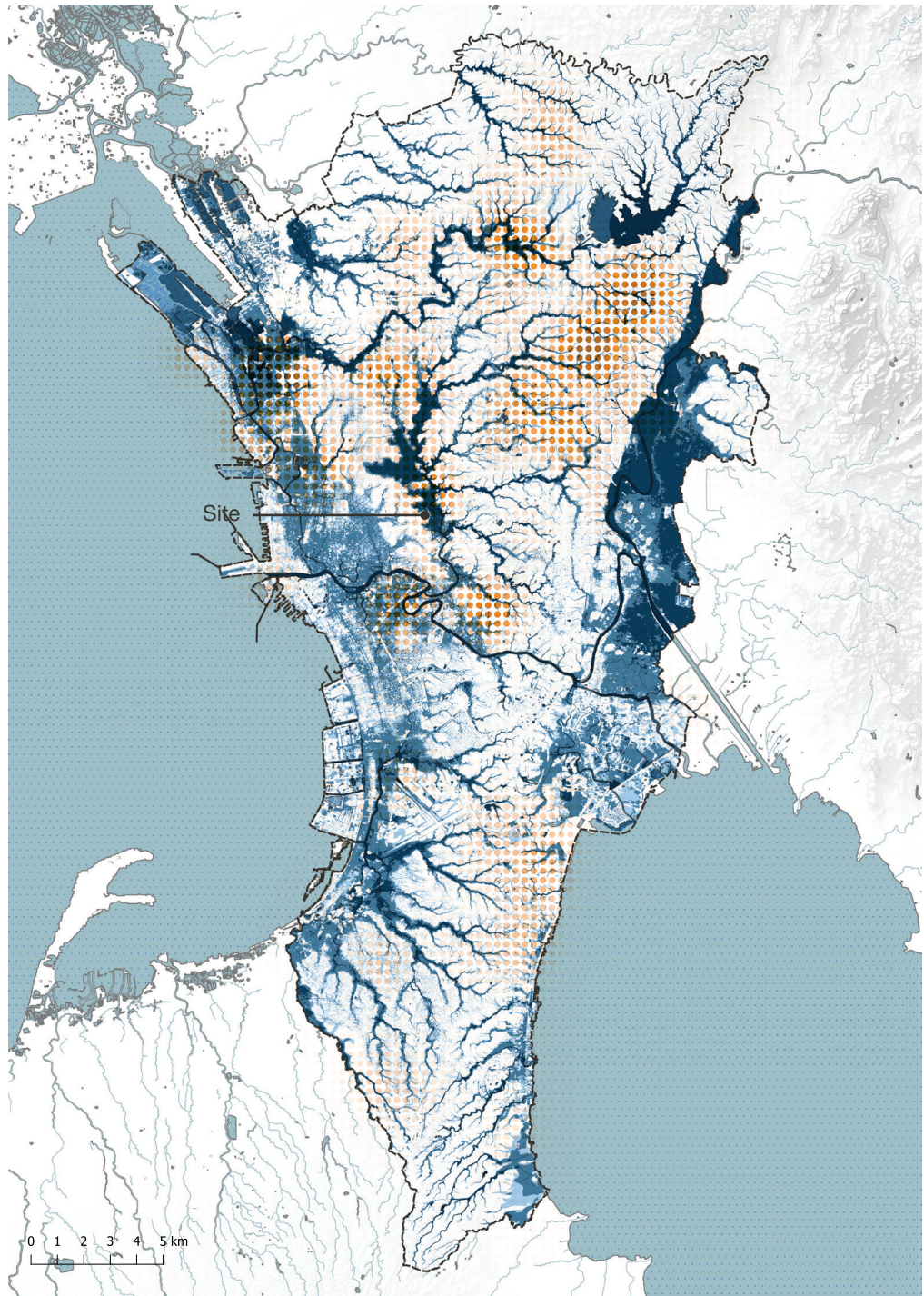


Figure 3.21 100 year Flood Hazard Map with Informal Settlements Heat Map

Note. Flood hazard map adapted from NOAH Studio (2025) and informal settler locations adapted from Singh et al. (2017). Made by Author

3.5 Social Analysis

3.5.1 Existing flood control efforts by the government

The Philippine government has developed strategies to address the recurring problem of flooding in Metro Manila. Because of the disastrous Tropical Cyclone Ketsana (Ondoy) which affected millions of residents, the government prepared a Flood Management Master Plan (Asian Infrastructure Investment Bank, 2017).

The most concrete effort of this Master Plan is the Metro Manila Flood Management Project. It was initiated in 2017 and assisted financially by the World Banks and the Asian Infrastructure Investment Bank (Molnar-Tanaka & Surminski, 2024). According to the project summary information by the Asian Infrastructure Investment Bank (2017), the project comprises of four components. The first and primary is modernizing drainage infrastructure with the construction of 20 new pumping stations while rehabilitating the existing ones along with the connected waterways and. The second component focuses on solid waste, which blocks waterways, by implementing systems that minimize its accumulation in water bodies. The third component addresses housing and resettlement for informal settlers living in high-risk areas. And the fourth supports the operation of these systems. The Department of Public Works (DPWH) and the Metropolitan Manila Development Authority (MMDA) coordinate the implementation of this project. However, the project has experienced significant delays as of 2024, only 4 of the 36 pumping stations had completed rehabilitation, and none of the 20 planned new pumping stations have been constructed (Subingsubing, 2024; see Figure 3.22).



Figure 3.22 Satellite Image of Metro Manila
Note. From Philippine News Agency (2024)

3.5.2 Disproportionate exposure and physical impacts on Metro Manila’s marginalized communities

The marginalized communities of Metro Manila face a disastrous impact of flooding greater than the rest of the population. The city of Manila recorded the highest incidence of flooding among informal settlements, followed by Muntinlupa and Quezon City (Singh & Gadgil, 2017). Poverty has limited the flood adaptation capacity of these communities. Most of these communities live in makeshift housing constructed with weak materials that cannot withstand floodwaters (Porio, 2014). Around 32% of the urban poor households have low-quality construction materials, making them vulnerable to structural damage and destruction (Singh & Gadgil, 2017). This housing condition comes from the limited availability of affordable housing and the lack of stable land tenure. Poverty has reduced their available options and forces them to live in high-risk areas, substandard drainage, poor infrastructure, and environmental degradation (Alcoforado, 2018). Thousands of people are living on land illegally, where they are in continuous fear of being displaced (Cash, 2021). Unlike wealthier communities that can easily relocate, these informal settlements lack this capacity. As a result, a cycle of poverty traps the poorest residents in the most flood-prone areas.

Flooding significantly impacts the livelihoods of these people. Due to flooding, residents are unable to travel to work, which prevents children from attending school and causes damage to homes (Figure 3.23; Singh & Gadgil, 2017). These informal settlers constantly suffer from the effects of flooding, which disrupts income, deteriorates health, and damages housing and household appliances (Porio, 2011). Due to the flooding, access to basic services such as potable water, toilets, electricity, and sanitation facilities is limited, worsening their vulnerability. Only 3% to 24% receive aid following devastating disasters (Porio, 2011).

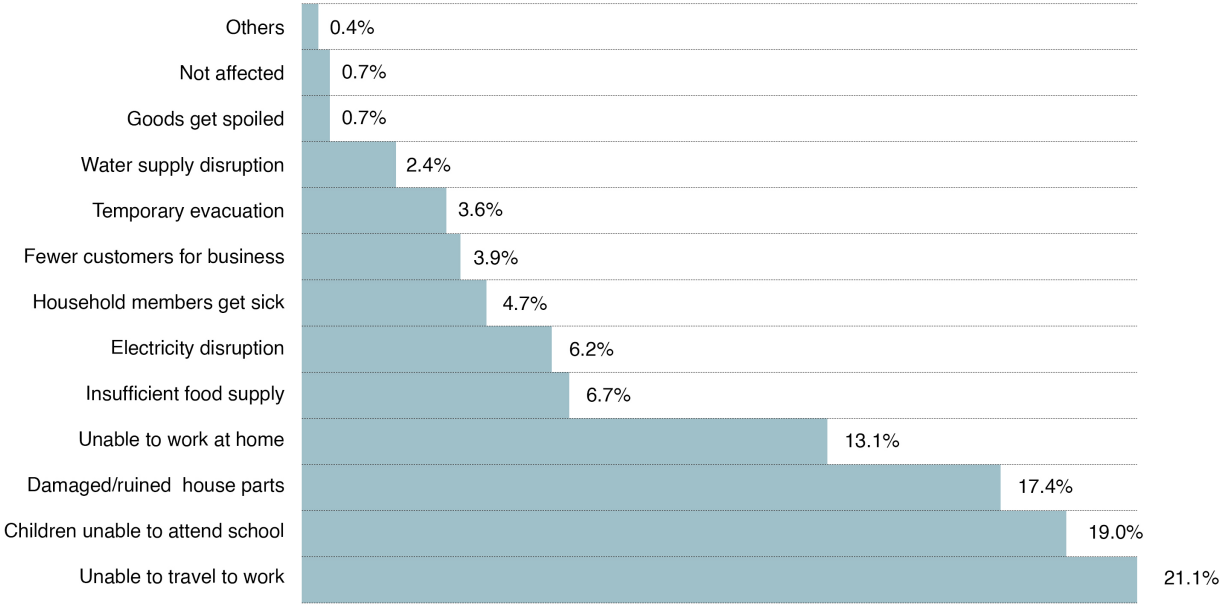


Figure 3.23 Issues Faced with Flooding by Informal Settler Families in Metro Manila
Note. Adapted from Singh & Gadgil, 2017)

3.5.3 Governance failures

The governance challenges of Metro Manila’s flood crisis reveal the historical marginalization of poorer communities, who are often seen as a socio-economic hazard rather than as communities in need of protection (Pante, 2016). This perspective has shaped the policies and priorities for certain areas, leaving out informal settlements. This can reduce flooding in certain wealthier areas but may redirect floodwaters towards lower-income neighborhoods (Middleton et al., 2018).

This governance crisis included inadequate disaster management planning. People living in poverty are systematically excluded from disaster management planning along with their concerns and knowledge (Center for Excellence in Disaster Management and Humanitarian Assistance, 2025). These marginalized families often reside in flood-prone areas without a choice. When disasters arrive, due to their limited capacity to recover, their livelihoods are disrupted, and their family displaced, which just worsens this cycle of poverty (Center for Excellence in Disaster Management and Humanitarian Assistance, 2025). This recurring pattern indicates that despite decades of investment, government flood-management infrastructure still fails to protect vulnerable populations.

Government policies addressing informal settlement relocation present an unresolved dilemma. Since the 1960s and 1970s, the government has focusing on relocating informality (Lauer et al., 2024). Although necessary for flood protection, resettlement programs severely affect the displaced populations through the loss of livelihood and community networks Quetulio-Navarra, 2023)



Figure 3.24 Flooded Residential Area Caused by Typhoon Gaemi and Monsoon Rains

Note. From CNN International (2024)

3.5.4 Inadequate housing

The compounded effect of inadequate housing and flood vulnerability has worsened the situation for Metro Manila’s urban poor. An estimated 500,000 informal settler families are without secure tenure (Department of Human Settlements and Urban Development, 2022). The informal settlement population is increasing at an annual rate over 3.5% compared to the urban population growth of 2.3%. There are projections that Metro Manila’s informal settlement population could reach over 9 million by 2050 (Aguilar, 2021).

The housing situation directly affects people who are renting or in transient housing since they have limited control over improvements for flood resilience (Dulawan et al., 2024). Therefore, the quality of these houses have the possibility of collapsing and may harm occupants. These houses are majorly located along flood paths and thus increasing their vulnerability (Dulawan et al., 2024; see Figure 3.24).

3.5.5 Contradiction between infrastructure and resilience

The governance challenges of Metro Manila’s flood crisis reveal the historical marginalization of poorer communities, who are often seen as a socio-economic hazard rather than as communities in need of protection (Pante, 2016). This perspective has shaped the policies and priorities for certain areas, leaving out informal settlements. This can reduce flooding in certain wealthier areas but may redirect floodwaters towards lower-income neighborhoods (Middleton et al., 2018).

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3.6 Neighborhood Analysis

The neighborhood analysis brings together the environmental, spatial, and social dimensions of flood vulnerability at the neighborhood scale. While the previous chapters have established the broader systematic factors for flooding in Metro Manila, this section narrows to the specific characteristics of the neighborhood itself. It is a site specific part of the report and serves as the bridge between the large scale analysis and design.

3.6.1 Barangay Tatalon

Barangay Tatalon is a highly dense administrative neighborhood located in District 4 of Quezon City in the Philippines. It is characterized by its large population of informal settlers and flood vulnerability. It has an area of around 96 hectares and subdivided into 107 puroks or neighborhood subdivisions (Martinez et al., 2025). It is the largest barangay in District 4 in terms of its population, among those 3,823 are informal settler families with 2,026 informal structures (Quezon City Government, 2025). This concentration of informal settlement families within a single barangay in already one of the most densely populated ones in Quezon City, produces a neighborhood that has the compounded effects of spatial constraints, informality, and flood exposure leaving the residents with limited capacity to deal with the recurring disasters of flooding.

3.6.2 Topography and soil conditions

An analysis of Barangay Tatalon’s topographic profile reveals one of the most critical factors in its flood vulnerability: its basin-like configuration. The barangay ranges from around 18 meters above sea level to between 4 and 6 meters at its lowest, with the informal settlements concentrated in the lowest-lying zone. This low-lying area is surrounded by higher ground on all sides, creating a bathtub effect in which water has no natural escape. Water flows towards the informal settlements regardless of rainfall intensity.

In addition, topographic vulnerability depends on the soil type beneath the neighborhood. The dominant soil type in the area is Novaliches clay loam, a heavy clay soil with very low hydraulic permeability. Under heavy rainfall, the infiltration rate is extremely low, so rainfall that reaches the ground immediately becomes runoff.



Figure 3.25 Figure Ground Map and Topography of the Neighborhood

Note. Buildings from openstreetmap and topography from opentopography. Made by author

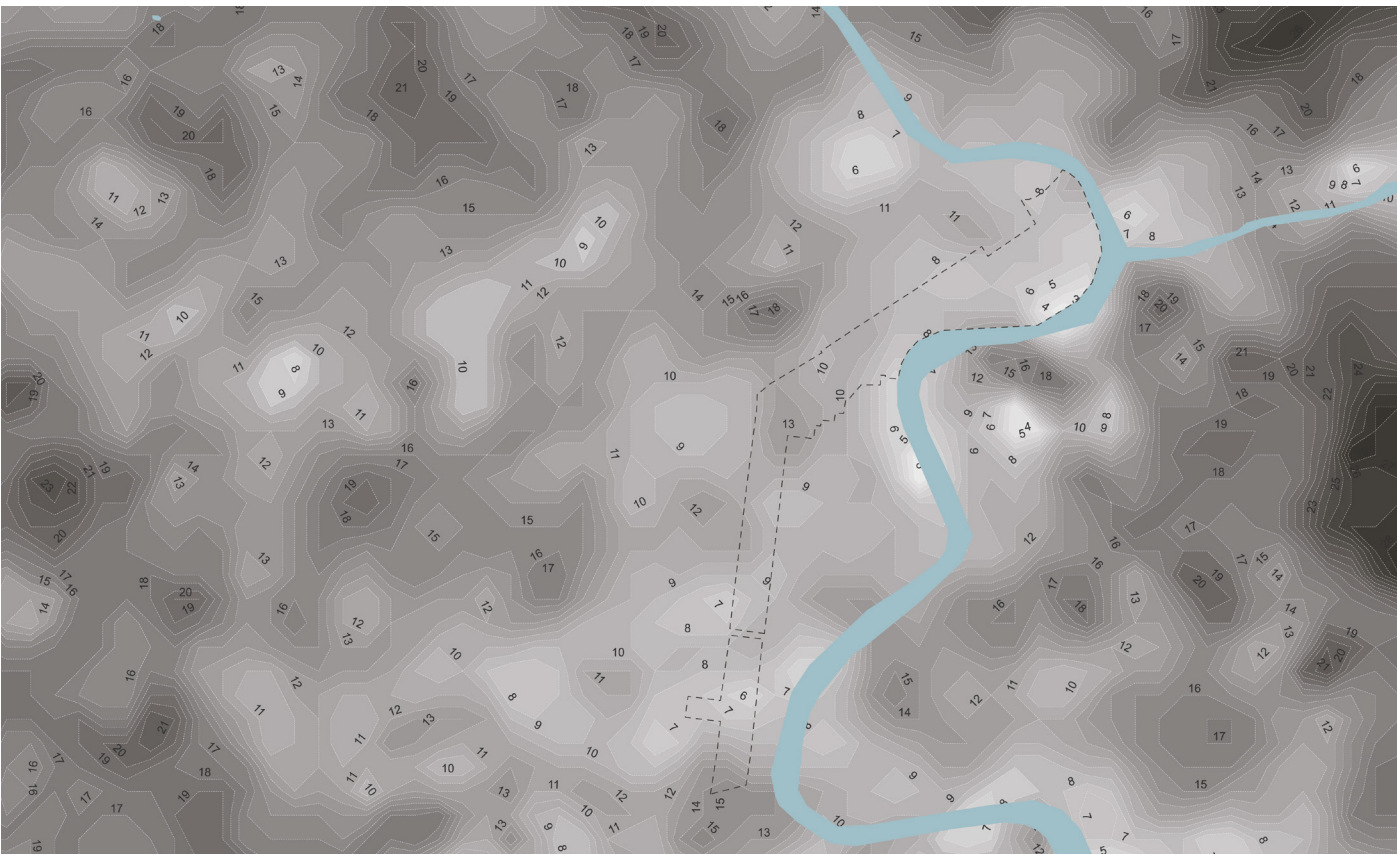
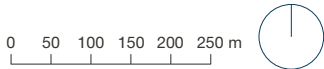


Figure 3.26 Topography of the Neighborhood

Note. From opentopography. Made by author



3.6.3 Flood vulnerability

The flood hazard profile of Barangay Tatalon is defined by the convergence of two types of flooding: pluvial flooding from accumulated rainfall across impervious surfaces, and fluvial flooding from the overflow and backflow of the San Juan River during heavy rainfall events. This compounded flooding is the neighborhood’s challenge. When both types occur simultaneously, which normally happens during typhoon or monsoon seasons, flood conditions become more severe. When floodwater arrives in the neighborhood, it has nowhere to go. The results are flooding that could reach 1.5 meters high.

Overlaying the locations of informal settlements, flood hazard zones, and low-elevation zones reveals the uneven spatial distribution of vulnerability across the neighborhood. The most vulnerable areas are those that combine all three. These areas experience flooding even during normal rainfall.

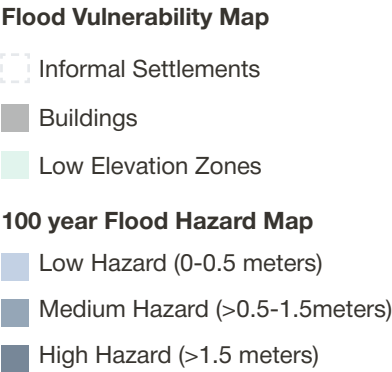
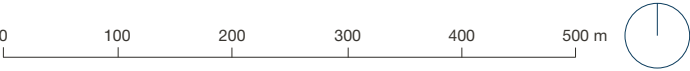


Figure 3.27 Flood Vulnerability Map

Note. Flood hazard map adapted from NOAH Studio (2025) and low zones from opentopography. Made by Author



3.6.4 Characteristic map

The characteristic analysis maps the distribution of formal residential, informal residential, commercial, and institutional areas across Barangay Tatalon, with their spatial relationships a driver of flood vulnerability. The neighborhood is not a homogeneous informal settlement but rather a complex urban fabric in which informal residential areas are constrained by the busy commercial zone, gated communities, and the San Juan River.

The commercial strip and the gated community that runs on the border of the informal settlements represent the hydraulic inequality. Formal land generates large volumes of rainwater runoff from its own impervious surfaces, which, when unmanaged, discharges into the low-lying informal settlements. The formal area increases the overall area’s imperviousness without contributing to the drainage capacity of the informal settlement. This imposes a burden whose consequences are borne by the informal residents. This relationship establishes the challenge of the neighborhood: residents with the least capacity to cope with flooding bear the greatest burden

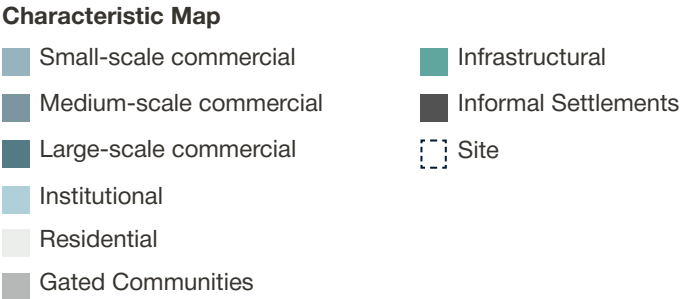
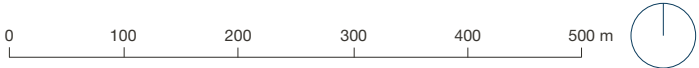


Figure 3.28 Characteristic Map

Note. From openstreetmap. Made by Author



3.6.5 The formal and informal divide

The characteristic analysis maps the distribution of formal residential, informal residential, commercial, and institutional areas across Barangay Tatalon, with their spatial relationships a driver of flood vulnerability. The neighborhood is not a homogeneous informal settlement but rather a complex urban fabric in which informal residential areas are constrained by the busy commercial zone, gated communities, and the San Juan River.

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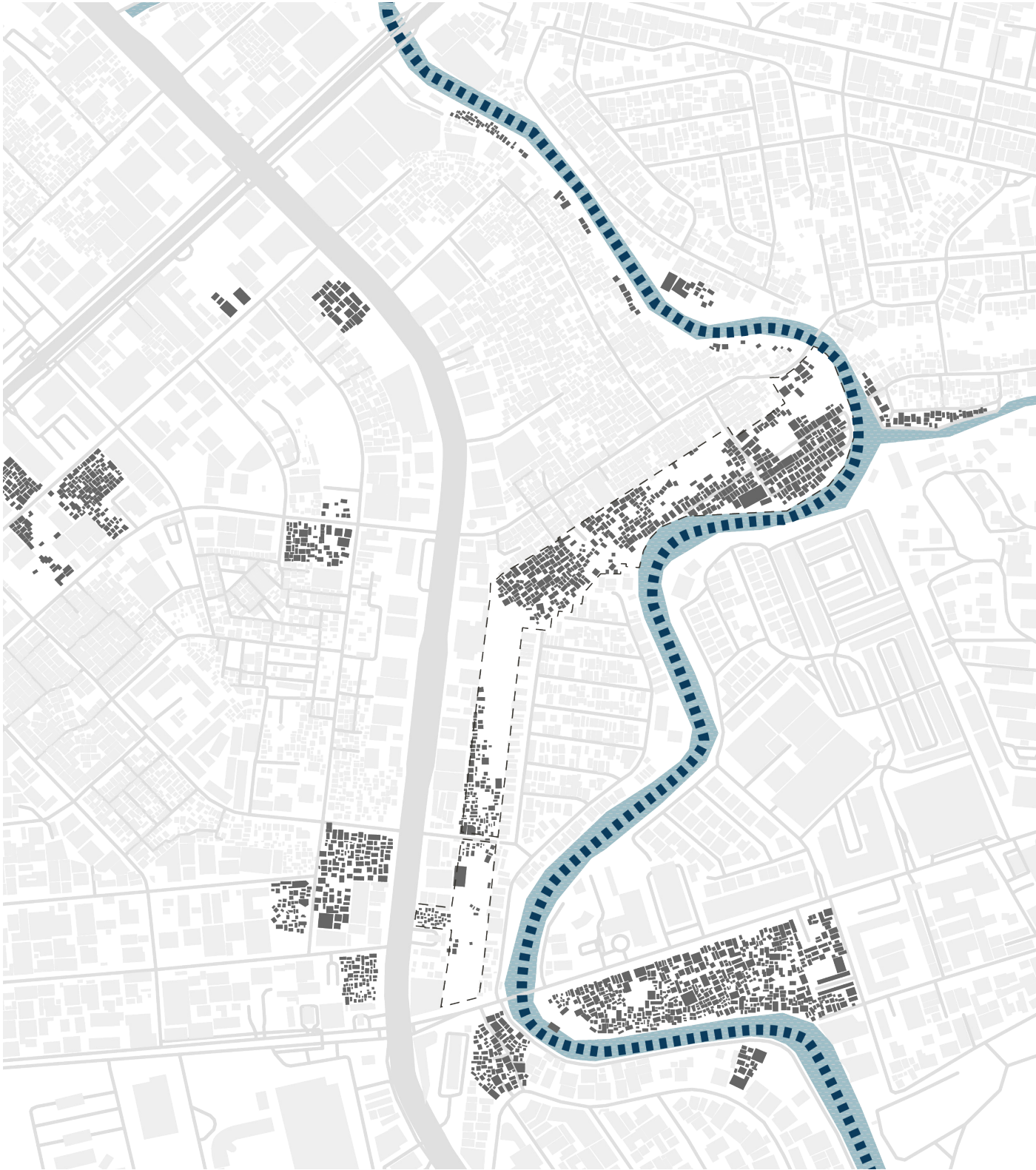
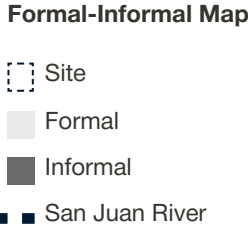
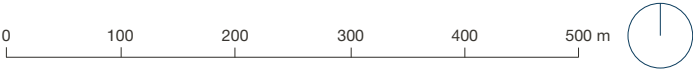


Figure 3.29 Formal-Informal Map

Note. From openstreetmap. Made by Author



3.6.6 Legibility analysis

The legibility analysis of the neighborhood examines how it is structured by its edges, nodes, streets, and amenities. This reveals how the built environment is organized and how accessible it is for residents, especially for those living within the informal settlement

The edges of the informal settlement are defined by two dominant physical boundaries: the elevated highway or skyway and the San Juan River. The elevated highway is a massive structural barrier that cuts through the neighborhood, while the San Juan River, the primary drainage outlet, runs along the eastern edge. The primary node of the neighborhood is the public market, which generates activity and social gathering. However, the public market's potential to bring people together is affected by the elevated highway. This creates fragmentation, where this node is only easily accessible to some residents. Beyond the public market, there are no clearly defined gathering spaces or community anchors that serve the informal settlement. The distribution of amenities across the neighborhood reveals that schools, churches, health centers, and the public market are located outside the informal settlement, positioned beyond the edges. Therefore, access to these amenities is hindered. Under normal conditions, these may cause inconvenience, but when it floods, they become a major barrier to accessing these services. The absence of amenities in informal settlements is an expression of the evident inequality.

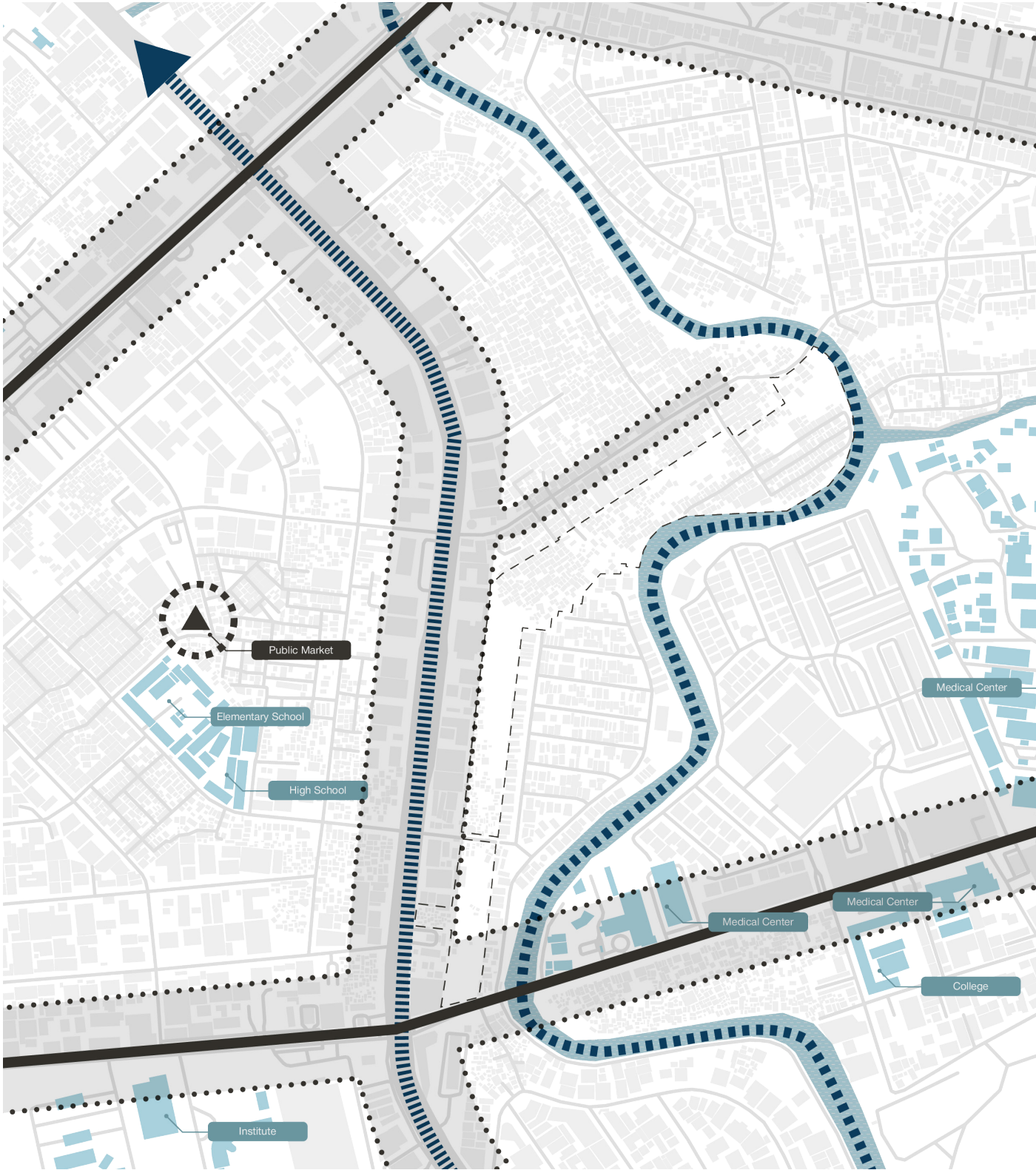
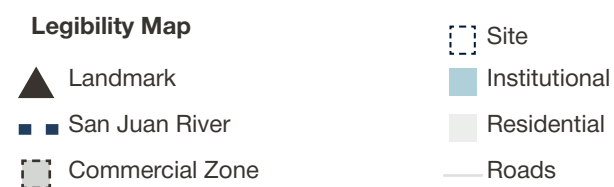
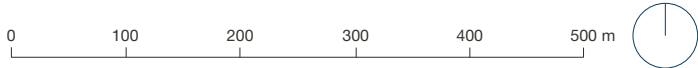


Figure 3.30 Legibility Map

Note. From openstreetmap. Made by Author



3.6.7 Barriers and accessibility

An analysis of the barriers and accessibility reveals that the settlement is not just constrained but also is hindered by multiple factors. This enclosure restricts movement and limits access. The informal settlement is defined by a series of physical barriers that function as a perimeter of enclosure. The walls and fences of the fated communities form the immediate boundary; these continuous impermeable structures serve as a division between the formal and informal fabric. The second barrier is an elevated highway that fragments the neighborhood, making it difficult and uncomfortable to cross on foot. In addition, this infrastructure generates noise, reduces natural light, and leaves residual ground. The sheet pile installed along the San Juan River is the third barrier, especially in terms of flood vulnerability. Instead of acting as a flood protection measure, the sheet pile eliminates the settlement’s ability to drain water back to the river. The sheet pile has trapped surface water within the settlement, significantly extending the duration of flooding. The transport network is concentrated at the edges of the informal settlement. There is no formal public transport that penetrates the interior of the informal settlement. This absence of vehicular access has consequences for infrastructure maintenance and emergency response.

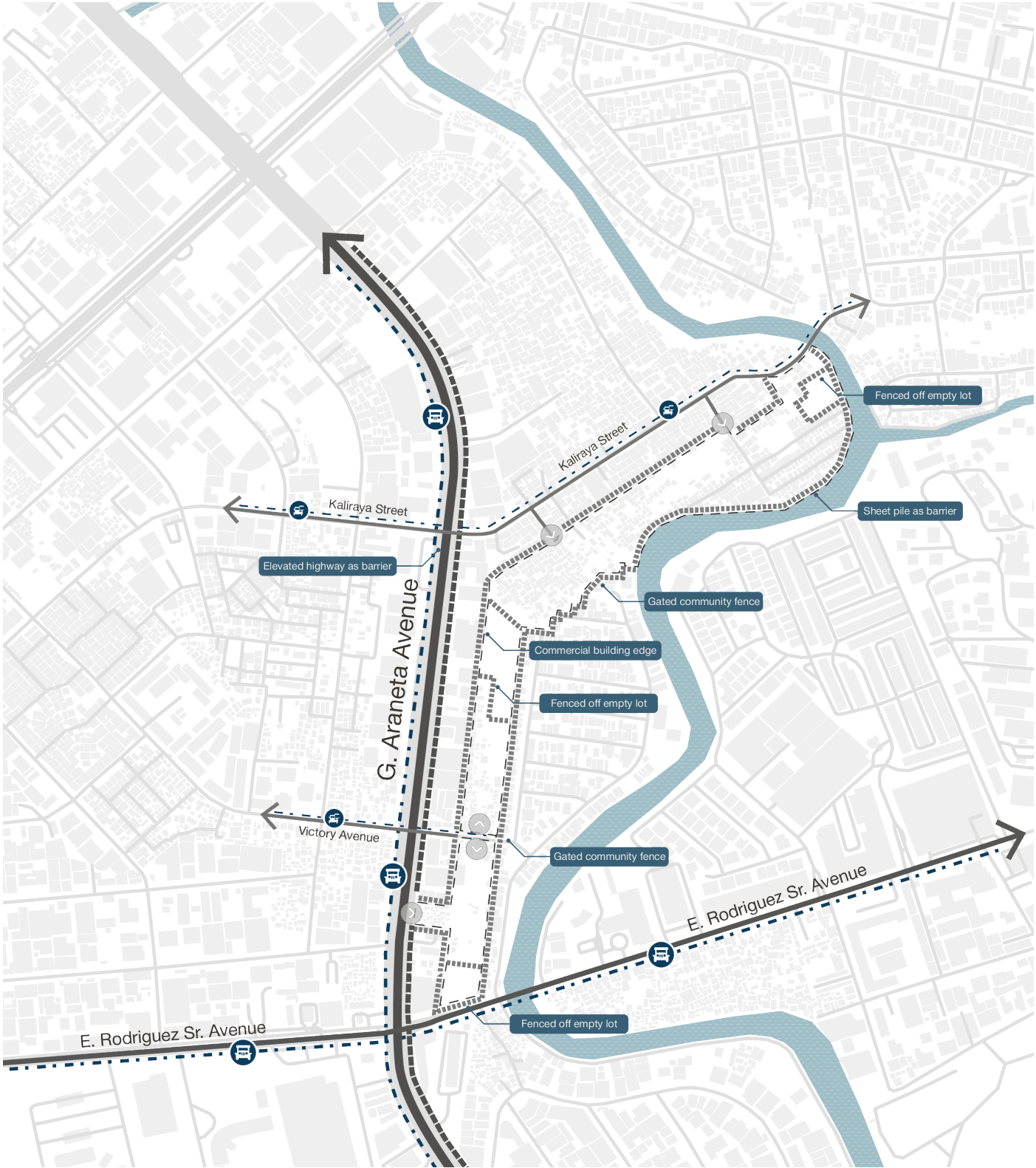
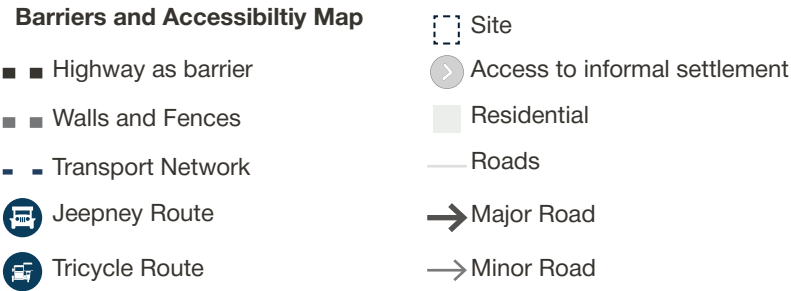
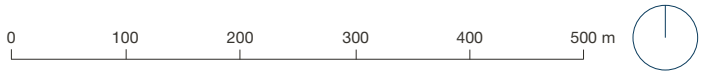


Figure 3.31 Barriers and Accessibility Map

Note. From openstreetmap. Made by Author



3.6.8 Open green spaces

An analysis of green and permeable surfaces within Barangay Tatalon reveals an almost complete absence of open, accessible, and permeable ground. Concrete is the dominant surface material across streets, pathways, and open areas. The consequence of these is the accelerated runoff and elimination of capacity for natural absorption.

Green spaces do exist within the neighborhood, but are inaccessible and sparse. The larger green spaces are concentrated in private establishments on higher ground and far from flood-risk zones. These spaces are typically fenced off, enclosed by private or institutional boundaries, and are unavailable as flood buffers. The only publicly accessible park serving the entire neighborhood is small in scale and insufficient to make a meaningful ecological or social contribution. The spatial distribution of green spaces is therefore not a quantity problem but one of access.

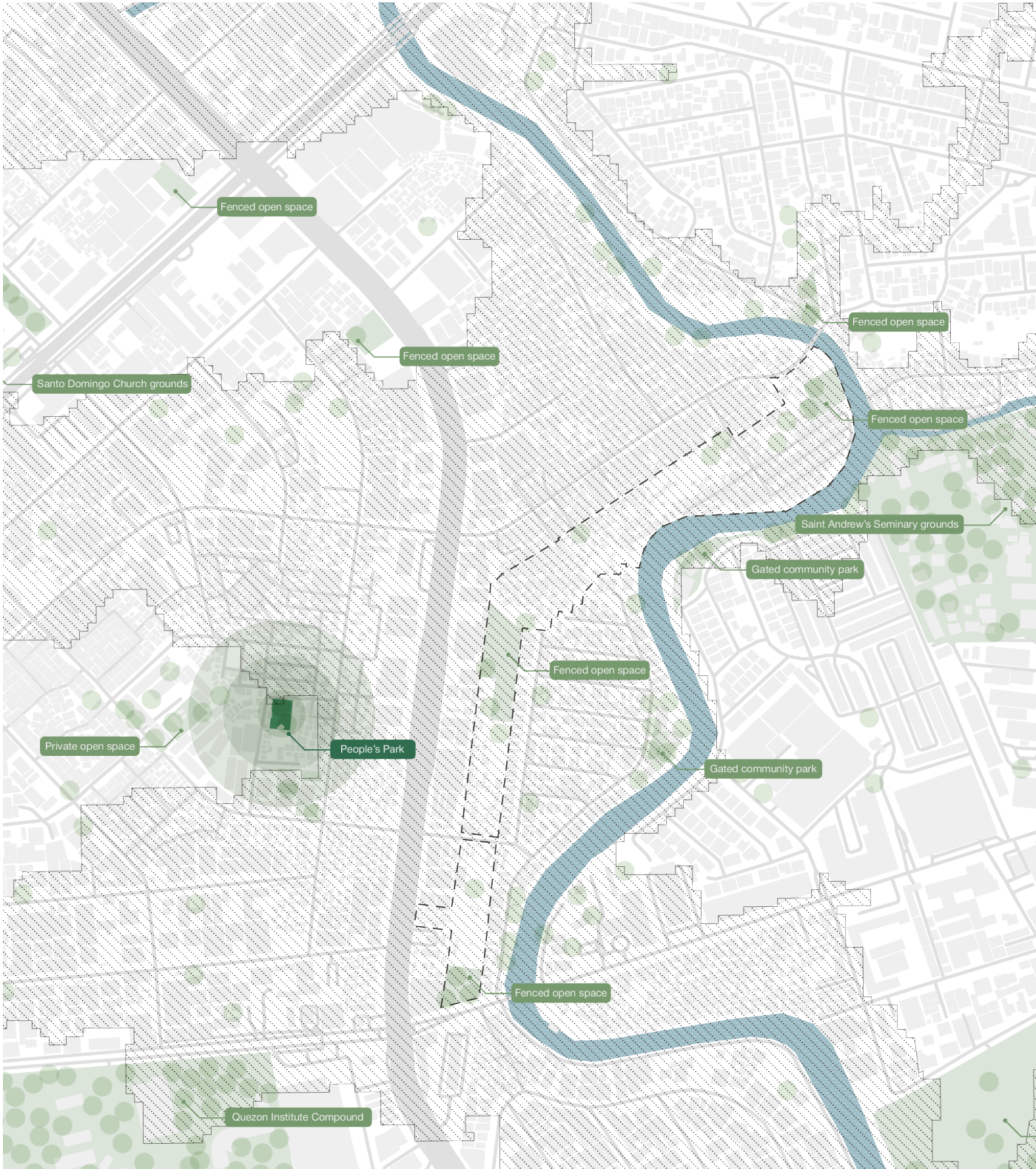
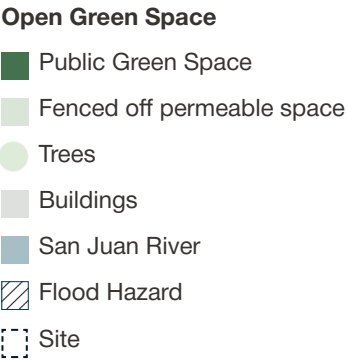
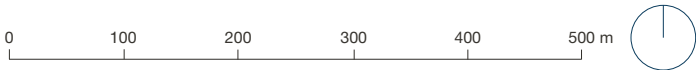


Figure 3.32 Open Green Spaces Map

Note. Flood hazard map adapted from NOAA Studio (2025) and open green spaces from openstreetmap. Made by Author



3.6.9 Existing drainage infrastructure

An analysis of the neighborhood’s existing drainage infrastructure reveals the spatial deficiencies that drive its flood vulnerability: the absence of an organized drainage hierarchy within the informal settlement. Within the informal settlement, drainage is not a planned system but an improved one. Road surfaces serve as the primary drainage mechanism for stormwater. This is a direct consequence of the absence of channels and catch basins within the settlement. Water flows across concrete streets and pools in low-lying areas. This disconnection between the formal and informal drainage systems is evident. There is a misalignment between the existing grey infrastructure and the settlement’s actual drainage needs. This reflects the broader pattern of inequality in Metro Manila.

- Existing Drainage Infrastructure
- Residential
 - Roads
 - Drainage lines
 - Pumping station
 - Sheet pile
 - Site

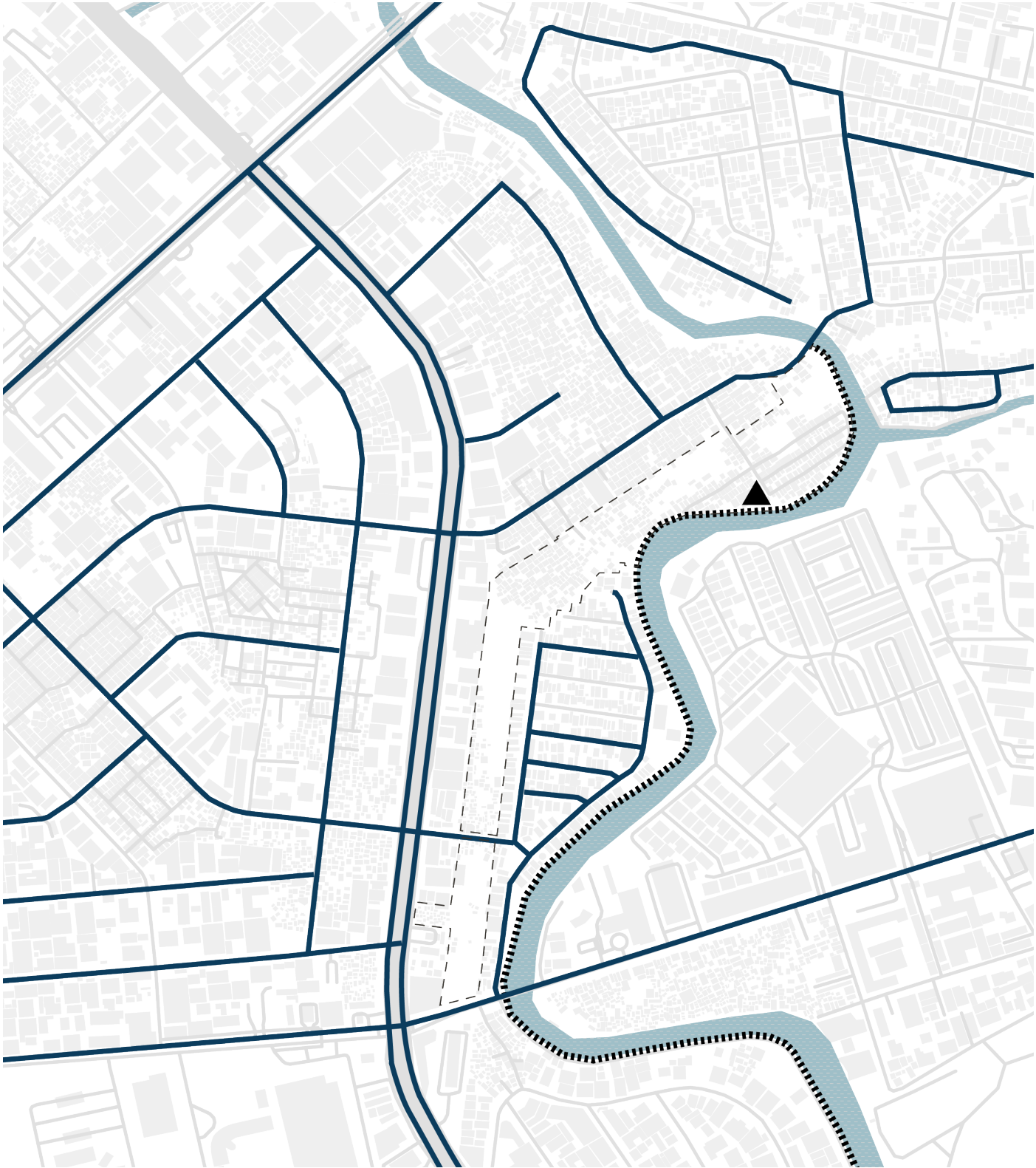
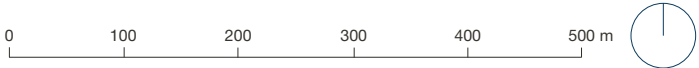


Figure 3.33 Existing Drainage Infrastructure

Note. Drainage lines form Quezon City Government (2025).
Made by Author



3.6.10 Opportunities and constraints

All these analytical layers produce a synthesized map of the neighborhood’s opportunities and constraints. The primary constraints on the neighborhood are structural and physical. The walls of the gated communities, the elevated highway, and the river edge.

Against these constraints, several opportunities emerge from the analysis. Because of the numerous barriers around the site, new access points and potential open spaces can be created to improve access. Potential connections can be made, such as a new spine that connects two existing busy streets while enhancing mobility, drainage, and community life. Green corridors can emerge as opportunities to introduce permeable surfaces and vegetation and to connect fragmented green spaces.

All in all, these opportunities inform a possible design response that works with existing conditions and transforms constraints into strategies that improve the neighborhood’s living conditions.

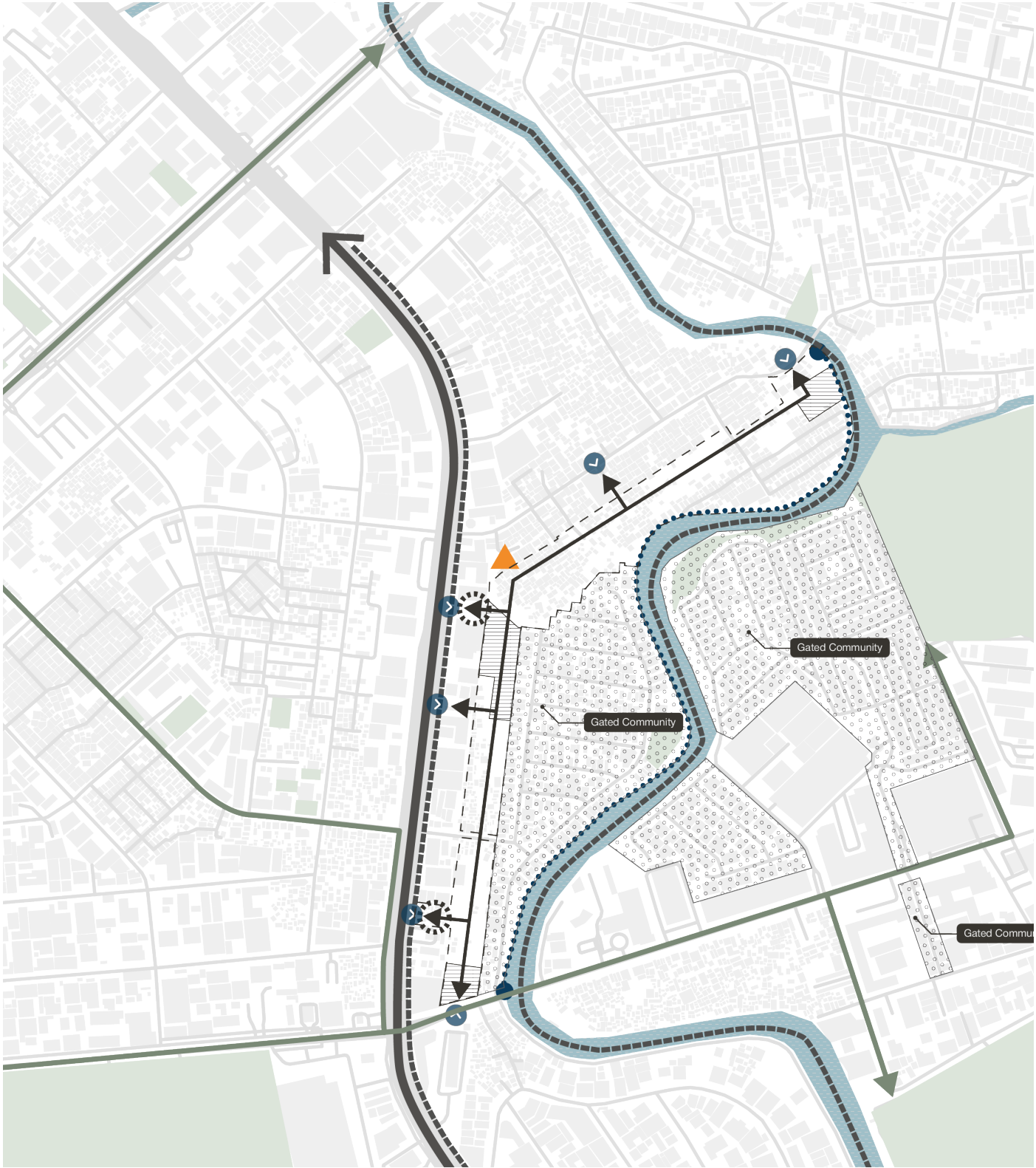
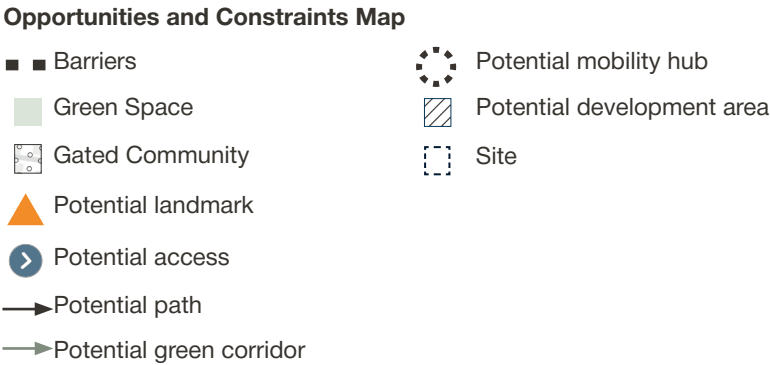
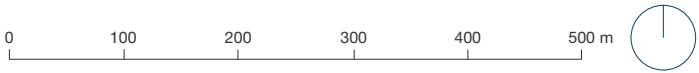


Figure 3.34 Opportunities and Constraints Map

Note. From openstreetmap. Made by Author



3.6.11 Existing situation

The following figures (Figure 3.35 and Figure 3.36) illustrate cross-sections of the existing conditions during a regular flood event. The sections reveal how the natural topography concentrates flood depth in the lowest-lying areas of the settlement, where informal housing is most densely clustered. However, the sections also demonstrate that flooding is not exclusive to informal areas but also affects higher-elevation zones, such as gated communities and commercial zones, which are similarly flooded. This suggests that flooding in Barangay Tatalon is a shared neighborhood condition, yet its consequences are unequal: informal residents, with less flood protection and limited capacity, are disproportionately affected by the same flood event.

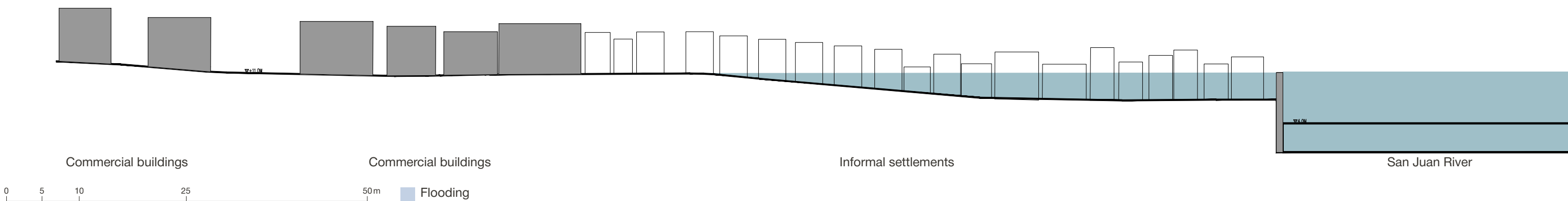


Figure 3.35 Existing section showing regular flooding

Note. Made by Author

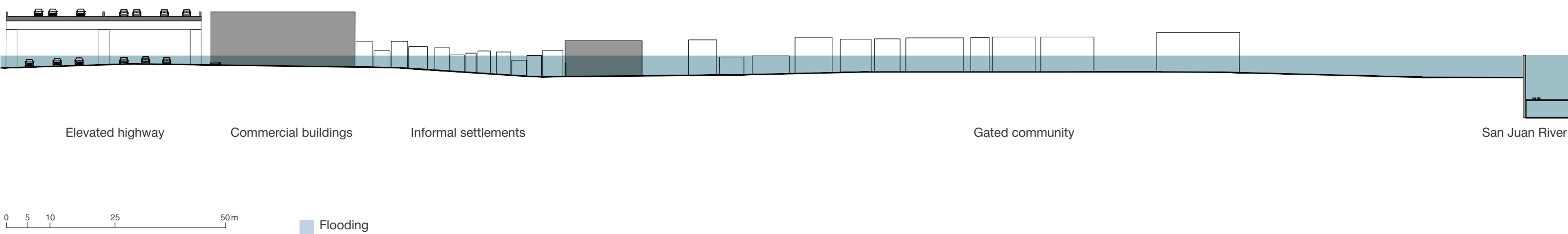


Figure 3.36 Existing section showing regular flooding

Note. Made by Author

3.6.12 SWOT Analysis

Strengths

- Proximity to San Juan River provides natural drainage outlet
- Access to major roads and streets

Weaknesses

- Low-lying basin enclosed on multiple sides
- Low soil infiltration rate
- Limited permeable surfaces
- Absence of drainage hierarchy
- Lack of amenities within the informal settlement
- No vehicular access within the settlement
- Absence of public open space

Opportunities

- Natural catch basin
- Formal and informal boundary
- Potential negotiation of open space
- Potential access points

Threats

- Rapid urbanization of Metro Manila
- Climate change intensification
- Government resettlement policies



Figure 3.37 Satellite Image of Barangay Tatalon
Note. From Google Satellite

3.7 Fieldwork

A fieldwork was conducted in Barangay Tatalon through direct site observation, spatial documentation, and informal conversations with residents and barangay officials. The fieldwork aimed to complement the socio-spatial analysis by understanding flood risk in the lived condition of the neighborhood

3.7.1 Physical conditions of the informal settlements

The informal settlements of Barangay Tatalon are characterized by extreme density and the absence of planned drainage infrastructure. Streets within the settlements are narrow and are barely wide enough for a single motorcycle to pass. These surfaces are entirely made of concrete, leaving no permeable ground for water absorption. These makeshift houses are constructed of lightweight materials, with roofs that slope directly toward the ground without gutters or catch basins. This means that rainwater is discharged immediately into the street. The absence of a drainage hierarchy leaves water with no clear path of escape, resulting in pooling across the settlement.

Stagnant water was observed throughout the site, which was mostly dirt and contaminated. This stagnant water continued even outside rain events. Garbage was present throughout the whole settlement, mostly in the streets and drainage channels, which further obstructs the little water movement that exists. The combination of standing water, solid waste, and limited access to sanitation facilities makes these residents vulnerable to health risks.

Water infrastructure within the settlements is informal. Water lines are embedded directly into concrete ground surfaces rather than protected systems, making them vulnerable to damage and contamination. A significant number of residents lack formal connections to utilities and therefore tap into neighboring households. Sanitation facilities are similarly lacking for many residents, further worsening their public health vulnerability.

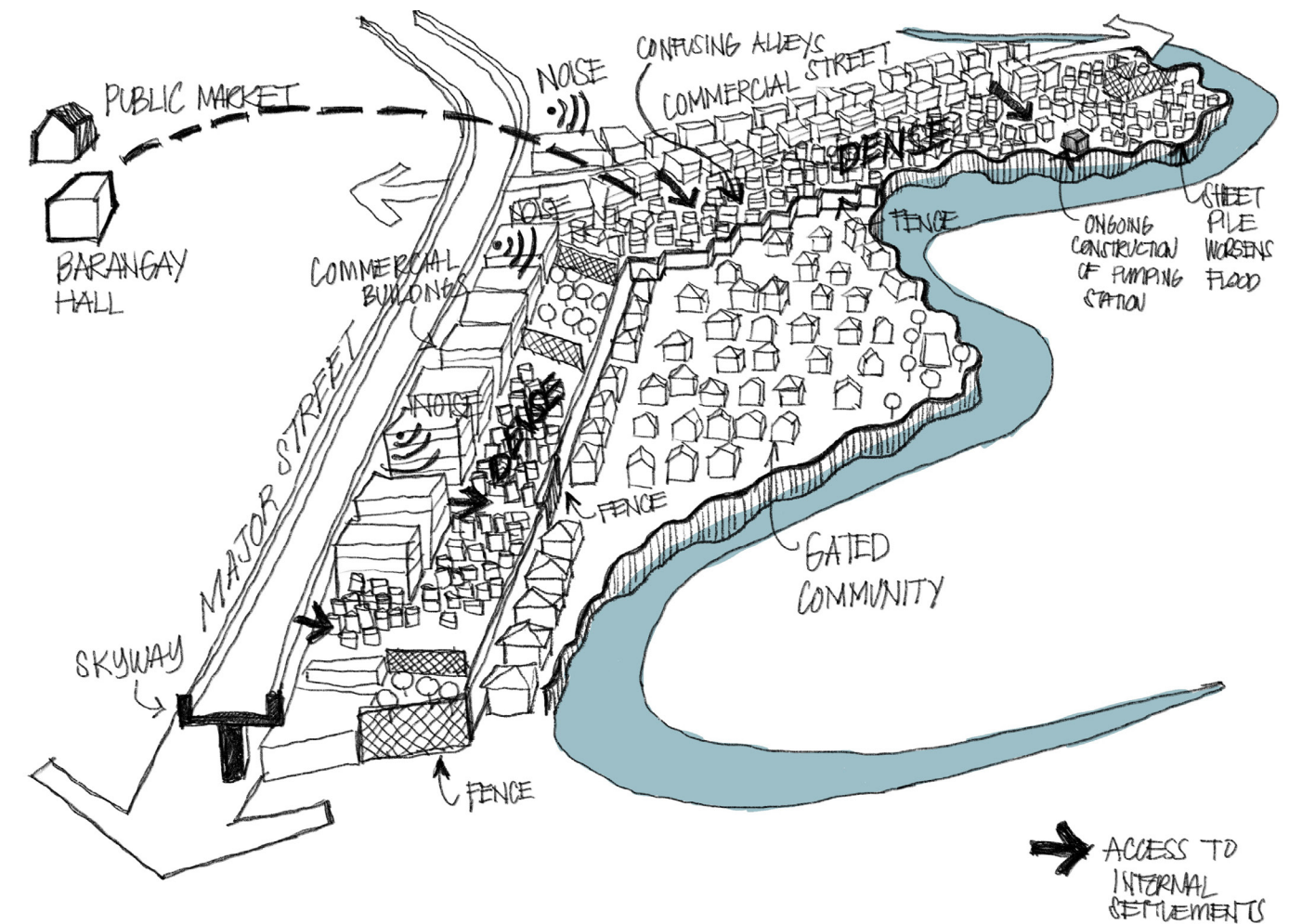


Figure 3.38 Mind Map of the Neighborhood

Note. Made by Author

3.7.1 Adaptive practices and responses

Residents have developed a range of informal adaptive strategies in response to the recurring nature of flooding. Several households have constructed second floors using light materials, providing elevated refuge during flooding. For those without a second floor, a common response was to relocate temporarily to their neighbor's house.

Small neighborhood retail stores, known as sari-sari stores, serve as reminders of the economic and social factors within the settlement. During flooding, store owners are forced to physically carry their goods to higher ground or other elevated surfaces to prevent damage resulting in repeated economic disruptions. Additionally, the presence of chicken coops in some households indicates that animal management is integrated into the spatial organization of homes.

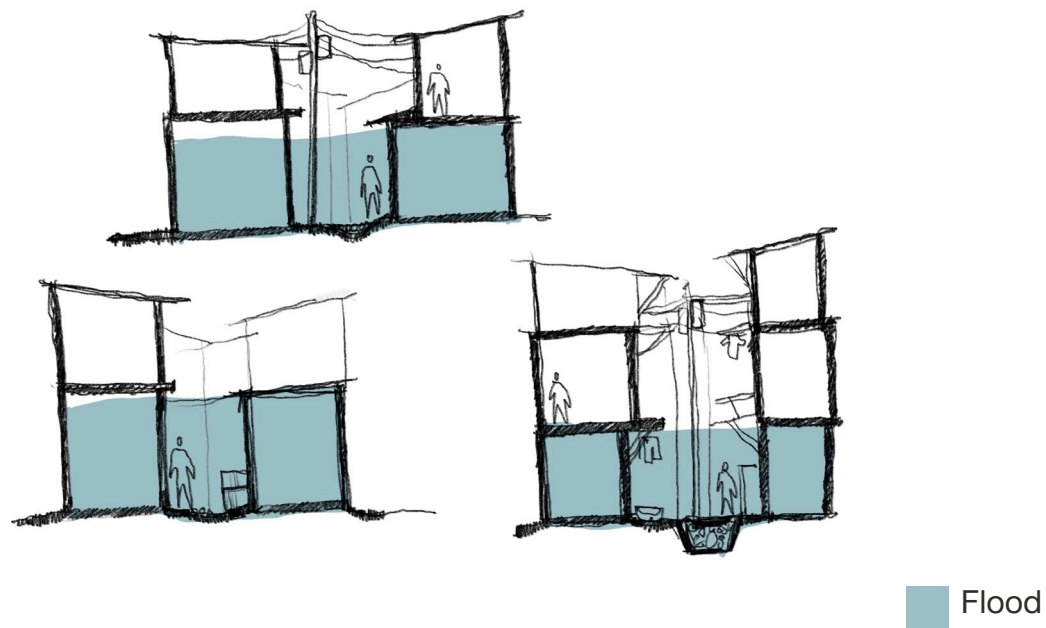


Figure 3.39 Conceptual Sketch of the Streets and Structures

Note. Made by Author

3.7.2 The formal-informal boundary

Field observations revealed a sharp boundary between the informal settlement and the surrounding formal urban fabric. Adjacent formal establishments have responded to flood risk by elevating ground floors and constructing solid perimeter walls. These barriers obstruct drainage paths and disrupt connections between the informal settlements and the broader neighborhood, increasing the isolation and vulnerability of these communities.

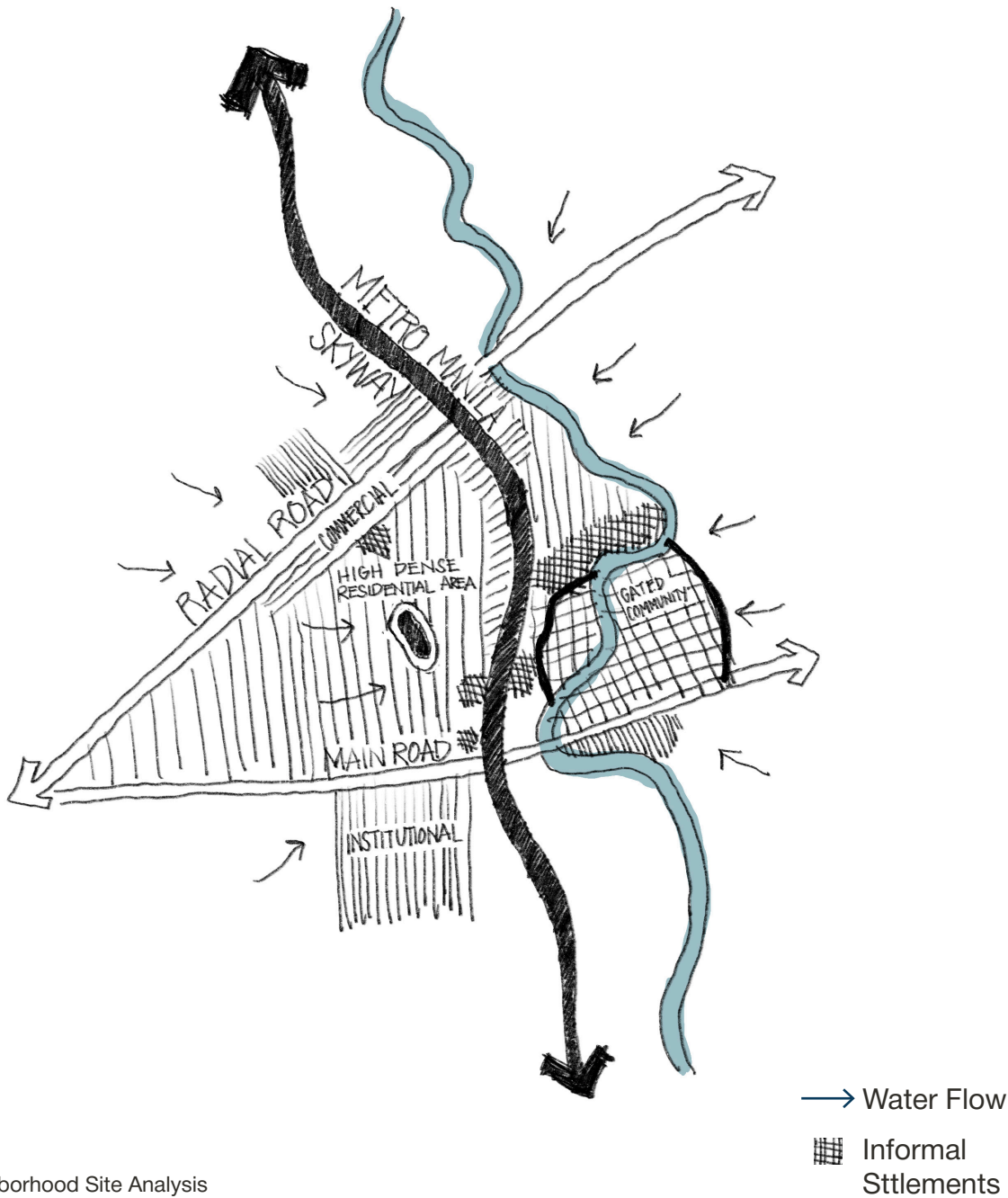


Figure 3.40 Neighborhood Site Analysis

Note. Made by Author

3.7.3 Community perspectives

Informal conversations with residents and barangay officials revealed a community that is aware of its flood conditions and deeply frustrated by the government’s lack of response. Residents reported that flooding occurs even during normal rainfall events, not just during typhoons and monsoons. Several people attributed this to the recent installation of sheet piling along the riverbank. This has created consequences of preventing floodwater from draining back into the San Juan River.

Residents have accepted this flooding as a s regular condition of their life. Their adaptive response involves waiting for floodwaters to recede as part of a routine cycle. The residents are aware of the role of garbage in blocking drainage, yet solid waste continues to accumulate, indicating that collection efforts are needed rather than individual awareness.

Barangay officials have tried to manually clear the drainage channels, but these blockages return the next day.

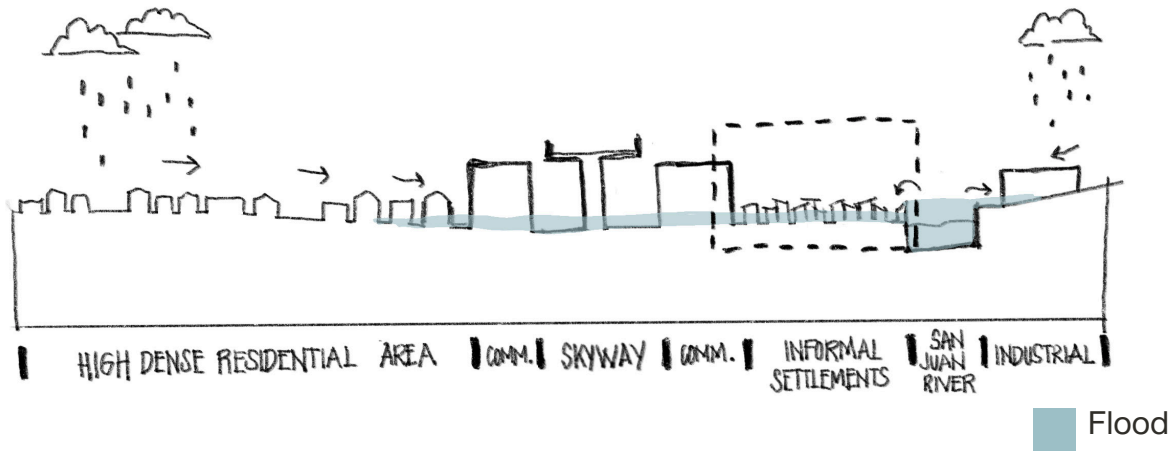


Figure 3.41 Conceptual Section Sketch of the Neighborhood

Note. Made by Author

3.7.4 Persistent elements



Figure 3.42 Concrete ground, exposed water line, and garbage

Note. From Author



Figure 3.43 Exposed utilities

Note. From Author



Figure 3.44 Stagnant water

Note. From Author



Figure 3.45 Stairs for refuge

Note. From Author



Figure 3.46 Formal sector on raised ground floors

Note. From Author

3.7.5 Findings

The fieldwork confirmed and deepened several conditions identified through spatial analyses: the absence of a drainage hierarchy, the impermeability of ground surfaces, the informal nature of utilities, the sharp formal-informal divide, and the government's intended worsening of flood conditions. At the same time, the adaptive responses of residents point to an existing gap and social logic that a design intervention must work with.

3.8 Understanding Risk

According to United Nations Office for Disaster Risk Reduction (2017), Disaster Risk is defined as the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity.

In simple terms, it’s a combination of the severity and frequency of a hazard, the numbers of people and assets exposed to the hazard, and their vulnerability to damage (UNNDR, 2025).

Risk = Hazard x Exposure x Vulnerability

Hazard is defined as “a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation”. Hazards may be single, sequential or combined in their origin and effects. Each hazard is characterized by its “location, intensity or magnitude, frequency, and probability” (UNNDR, 2017).

Exposure is defined as “the situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas”. Measures of exposure can include the number of people or types of assets in an area (UNNDR, 2017).

Vulnerability is defined as “the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards”. Examples include, but are not limited to: poor design and construction of buildings, inadequate protection of assets, lack of public information and awareness, high levels of poverty and education, limited official recognition of risks and preparedness measures, disregard for wise environmental management or weak institutions, and governance (e.g. including corruption etc.) (UNNDR, 2017).

Sendai Framework and its Four Priorities (2015)

Priority 1: Understanding the risk

Priority 2: Strengthening disaster risk governance to manage disaster risk

Priority 3: Investing in disaster risk reduction for resilience

Priority 4: Enhancing disaster preparedness for effective response, and to ‘Build, Back, Better’ in recovery, rehabilitation, and reconstruction

In the Dutch and European context, flood risk can be defined as the probability that a flood incident will occur in relation to the consequences in terms of casualties and economic damage (Doorn-Hoekveld et al., 2022).

Risk =Probability x Consequences

Different strategies address reducing flood risk through decreasing probability of flooding or mitigating its consequences (Doorn-Hoekveld et al., 2022).

- 1. Prevention
Preventing damage caused by floods in present and future flood prone areas by avoiding construction of houses and industries. Additionally, by adapting future developments to the risk of flooding
- 2. Protection
Taking structural and non-structural measures to reduce likelihood of floods and the impact.
- 3. Preparedness
Informing authorities, organizations, and population about flood risks.

Both defintions align as they account for the probability of hazards and the consequences that are associated with it such as people, assests, infrastructure that are present in the affected area and their susceptibilty to damage or loss (Kolen & Nicolai, 2025).

Flood hazard which are determined by rainfall intensity, river behaviour, and catchment conditions beyond the settlement’s boundary cannot be controlled at the neighbourhood scale. The proposal instead reduces vulnerability and exposure through spatial reorganisation, creating conditions under which residents can safely remain during flood events that currently displace them.



04

Design

4.1 Design Vision

The design vision reimagines the neighborhood as the critical scale for strengthening flood resilience through spatially embedded interventions. By rethinking how dense communities organize ground, water, and everyday life, the project proposes a model that is locally grounded in Barangay Tatalon but replicable and adaptable across similarly constrained, flood-prone, low-income neighborhoods in Metro Manila and beyond.

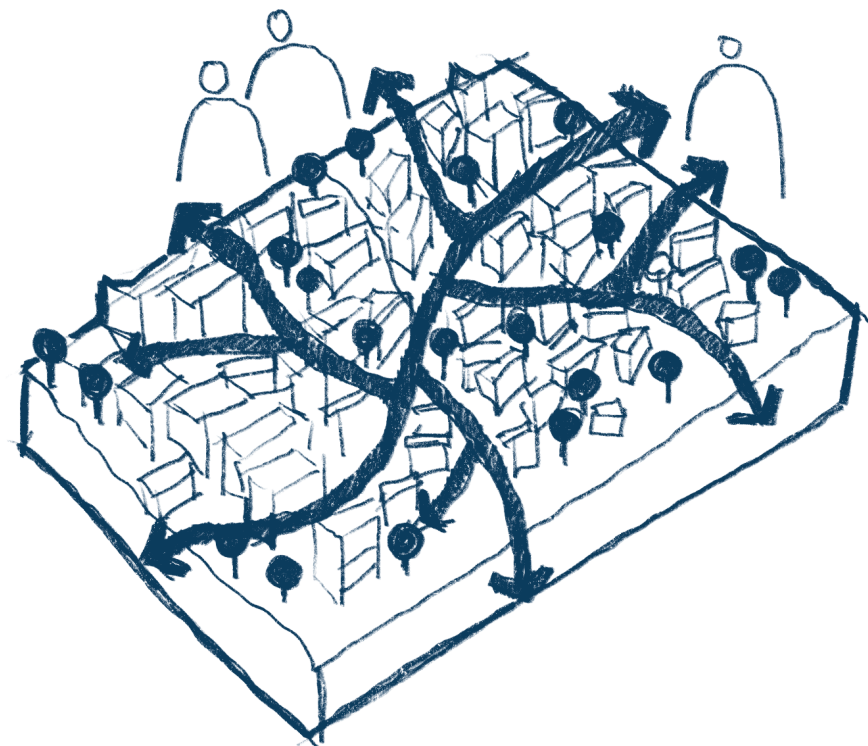


Figure 4.1 Conceptual Sketch of Design Vision

Note. Made by Author

4.2 What if Scenario

4.2.1 What if flood resilience is co-produced by the formal and informal sectors?

The persistent flood vulnerability in the neighborhood results from both technical and political factors. Informal settlements across Metro Manila occupy an unclear position in the eyes of the government, which sees their struggles yet does not include them in its planning priorities. Investment in these communities is rarely about creating better living conditions, but rather an economic decision.

The what-if scenario proposes a co-production model in which the government invests in flood-resilience infrastructure at the neighborhood scale, not out of concern for informal settlers, but because it represents the lowest-cost, highest-impact intervention available. By addressing flooding at its source through proper drainage and ground-level water management, the government spends significantly less than on repeated disaster responses, infrastructure repair, and the failed resettlement programs that have characterized the government’s approach to date. Within this framework, improved living conditions for residents are not the stated goal of the government’s investment, but they are an inevitable consequence. By fixing the drainage, opening access, and reorganizing the ground, the neighborhood becomes safer, more legible, and more functional. These outcomes result not from prioritizing informal settlers, but from recognizing that robust infrastructure can simultaneously serve both governmental and community interests. In this context, co-production represents the convergence of the government’s flood risk management objectives with the community’s need for a livable environment.

This position does not ask the government to abandon its existing priorities or treat informal settlements as equal to formal ones, but rather argues that when it does, there is a possibility of a transformation of a neighborhood.

4.2.2 The gradient negotiation

Co-production does not happen uniformly across the entire neighborhood. It happens at thresholds where the formal investment and informal community meet. To make this legible, the design proposes a gradient of negotiation. It defines who controls what and under what terms. This gradient represents an intentional spatial organization of responsibility.

1. The Formal Layer

At the ground level, the government takes full responsibility for the structural and infrastructural foundation of the neighborhood. This includes the drainage hierarchy, the ground, and the structural elements of flood infrastructure. These interventions are permanent, solid, and non-negotiable. The neighborhood’s hydraulic and structural performance depends on this consistency and durability. This is the layer where the government investment is most evident.

2. The Negotiated Layer

Above this ground layer is the negotiation zone. This middle ground is where the formal and informal overlap. Here, the government supplies the materials, the structural framework, and the spatial rules, while the community does the building. This is where co-production is spatially seen. This framework enables residents to assemble, adapt, and claim it as their own. This is the layer where the visual gradient between formal and informal is legible. Materials transition from heavy and permanent at the base to lighter and more varied above.

3. The Informal Layer

Above this negotiation zone, the community retains full autonomy. The household layer, extensions, additions, and personal modifications remain entirely within the informal settler’s domain. This is the layer that the government does not control. It is where residents exercise the freedom to adapt their homes to the existing conditions. The household above is free to adapt without the constant threat of flooding.



3. Informal (freedom above)

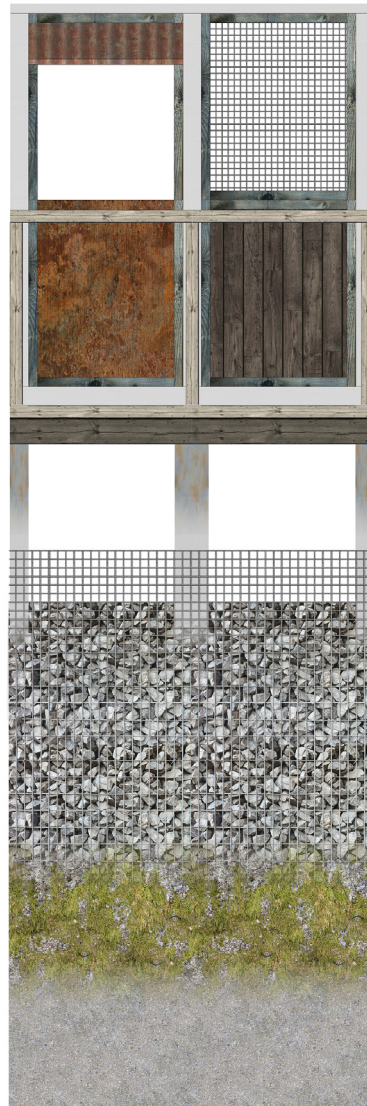
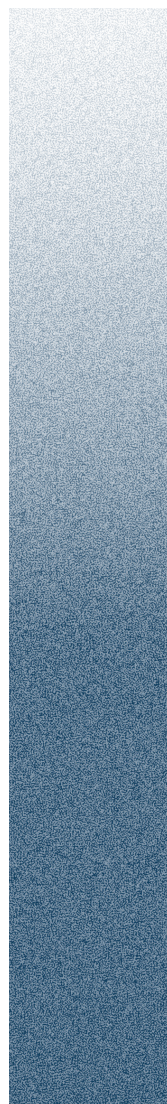
household adaptation

2. Negotiation

co-produced; materials provided by government; built by community

1. Formal (ground control)

structured intervention and maintenance by government



Informal (flexible)

Formal (solid, stable)

Figure 4.2 Materiality Gradient

Note. Made by Author

4.2.3 Formal-informal coexistence in art

The following art references document conditions of formal and informal coexistence. These are examples of visual negotiation and tension. They established the aesthetic foundation of the project.

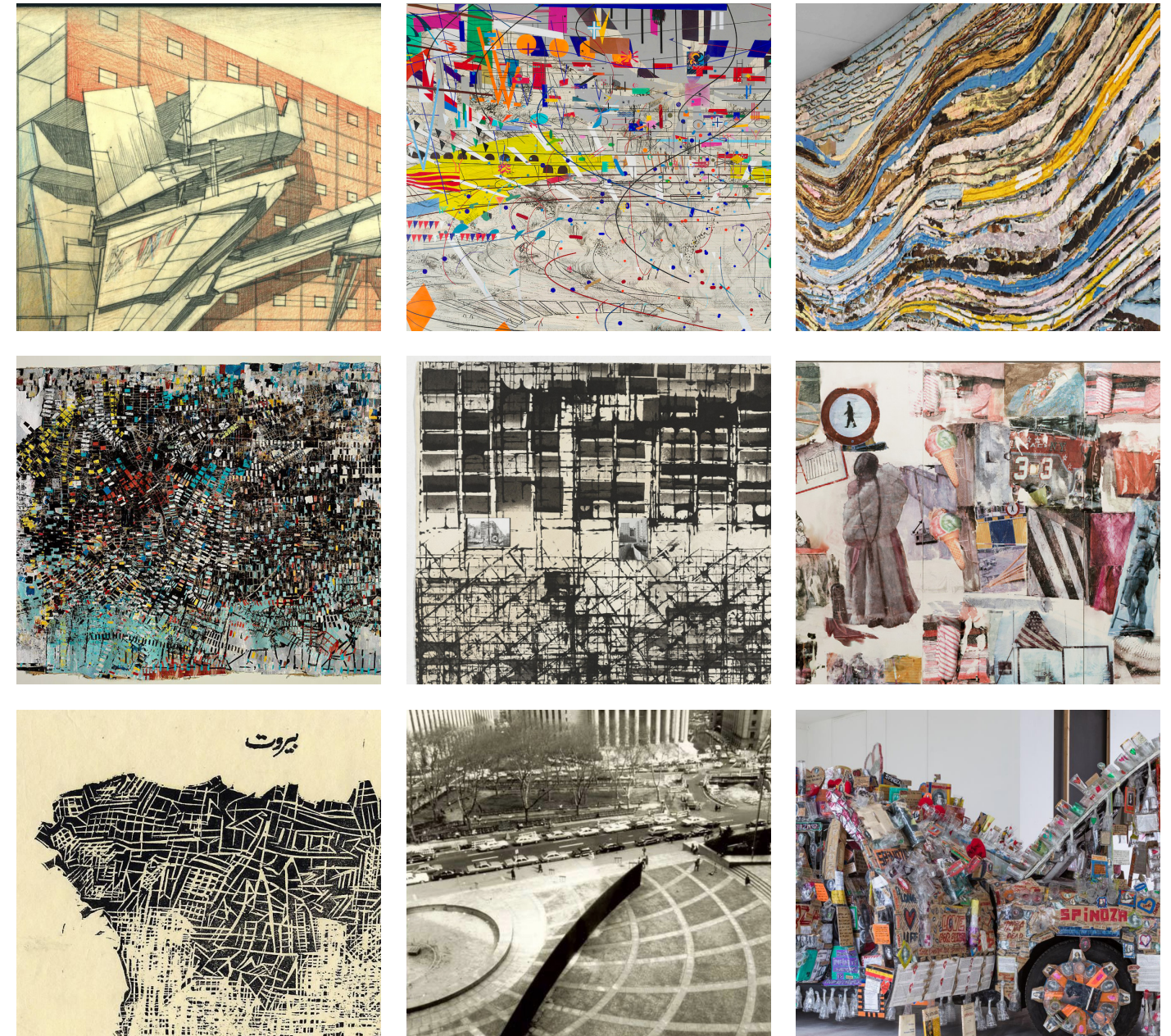


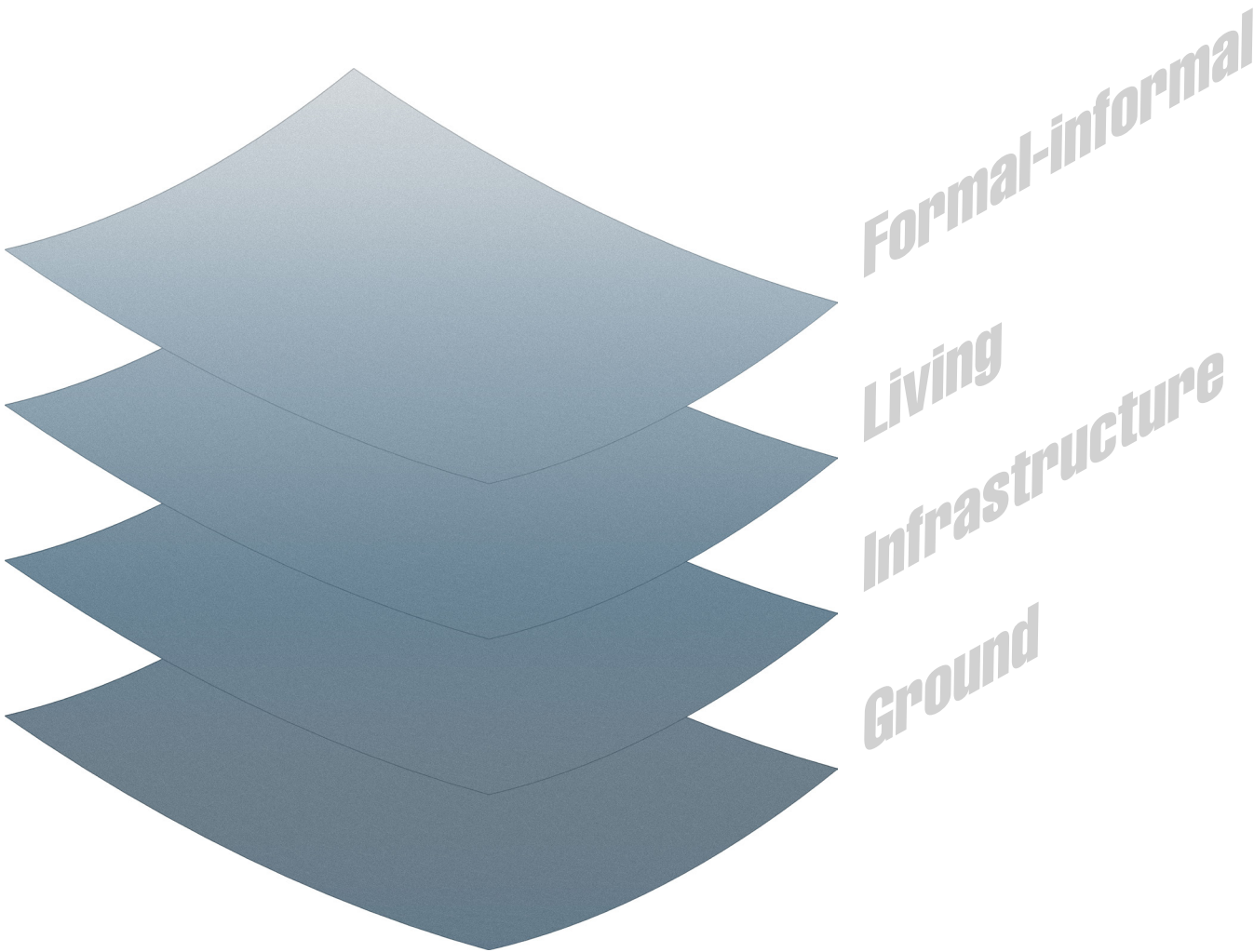
Figure 4.3 Art references

Note. Top left: Lebbeus Woods, Sarajevo, from War and Architecture, 1993. Top center: Julie Mehretu, Stadia II, 2004. Top right: Mark Bradford, Pickett's Charge, 2017. Center left: Mark Bradford, Black Venus, 2005. Center center: Brion Gysin, Plateau Beaubourg, 1974. Center right: Robert Rauschenberg, Port of Entry, 1998. Bottom left: Zarina, Map of Beirut, 2013. Bottom center: Richard Serra, Tilted Arc, 1981. Bottom right: Thomas Hirschhorn, Spinoza Car, 2012.

4.3 Design Concept

The layered basin

The design concept of the layered basin emerges directly from the neighborhood’s defining condition: a low-lying topographic area where water accumulates from multiple directions. The concept reframes the basin as the organizing logic of the design, wherein every layer of the neighborhood, from the ground, infrastructure, living, and formal-informal, could operate and coexist as an integrated whole and be designed to work together in managing water, movement, and community life, therefore reducing vulnerability



4.4 Catalogue of Formal and Informal Practices

To translate the layered basin concept into concrete spatial action, a catalogue of formal and informal flood resilience practices is assembled drawing from local and international case studies. To organize the catalogue, two sections are distinguished: Formal Strategies and Measures and Informal Strategies and Measures. Each section is then subdivided into five resilience strategy categories: : Avoid/Reduce Exposure, Defend/Protect, Accommodate/Live with Water, Recover/Maintain Continuity, and Transform/Adapt the System. These categories are used as a framework from flood adaption theory (Peck et al., 2022) and resilience theory (Ahern, 2011).

The framework draws on the flood adaptation hierarchy, which organizes responses according to degrees of exposure reduction, protection, accommodation, and systemic transformation (Peck et al., 2022). These are further enhanced by resilience based strategies of multifunctionality, redudancy and modularization, bio and social diversity, multi-scale networks and connectivity, and adaptive planning and design (Ahern, 2011).

In this catalogue, strategies are defined as broader spatial logics while measures are concrete actions. This catalogue makes it possible to compare formal and informal practices.

The categories are grouped into the following main strategy categories:



1. Avoid / Reduce Exposure

Focuses on preventing new development or relocating assets away from flood-prone areas.



2. Defend / Protect

Focuses on mitigating floodwater through physical control, drainage, and protective infrastructure.



3. Accommodate / Live with Water

Focuses on adapting the built environment so water can enter, pass through, or be tolerated with limited damage.



4. Recover / Maintain Continuity

Focuses on keeping daily life, access, and services functioning during and after flooding.



5. Transform / Adapt the System

Focuses on long-term spatial, institutional, and ecological change that improves resilience over time.

After the measures have been divided into the five main categories, each measure is described on its characteristics, type of flooding it addresses, effects on flooding, context, scale, advatanges, and limitations. The measures per category is presented in Table 4.1 (Formal Practices) and Table 4.2 (Informal Practices)

4.4.1 Formal Practices

Strategy Category	Strategy	Measure	Type of Flooding	Description	Effects on Flooding	Context	Scale	Advantages	Limitations	Citation
 Avoid / reduce exposure	Land Use Planning & Zoning	Zoning regulations	Fluvial, Coastal	Zoning regulations that restrict development in flood-prone areas; floodplain mapping and designation.	Reduces exposure through prevention of new vulnerable development	Floodplain areas, low-elevation coastal zones, river edge, formal infrastructure corridor	City/regional	Prevents future exposure; cost-effective long-term	Difficult enforcement in existing formal and informal settlements; requires political will; addresses only future development	(Aerts & Botzen, 2011)
		Grid-based urban layout	Pluvial, Fluvial	Spatial planning approaches that establish well-interconnected street systems with grid patterns allow for efficient water runoff through multiple drainage paths, including street surfaces	Reduces runoff accumulation; enables efficient water drainage; decreases flood risk during heavy precipitation; improves emergency evacuation routes; facilitates multiple water flow pathways	Urban neighborhoods, city-wide planning zones, residential and commercial districts	City/district/neighborhood	Facilitates efficient runoff flow and effective flood management during flooding events; promotes better water drainage through frequent intersections	Retrofitting existing irregular urban layouts is challenging; requires comprehensive urban planning and political will; land acquisition issues in densely settled areas;	(Leta et al., 2024)
	Relocation/Managed Retreat	Relocation programs	Pluvial, Fluvial, Coastal	Voluntary or assisted relocation of communities from high-risk areas to safer locations. Government-supported or market-driven movement away from flood zones.	Eliminates physical exposure	Low-lying street, floodplain, low-elevation coastal areas	Household to neighborhood	Eliminates risk; improves long-term resilience	High social costs; displacement trauma; gentrification risks; equity concerns	(Lauer et al., 2024)
	Building Code Enforcement	Building code standards	Pluvial, Fluvial, Coastal	Implementation of flood-resistant construction standards during permitting and inspection. Mandatory design features that reduce building vulnerability.	Reduces vulnerability through design	Urban residential and commercial areas, formal infrastructure corridor	Building/neighborhood	Protects assets; reduces damage; creates co-benefits; prevents poor construction practices	Expensive; requires continuous training; weak enforcement in informal contexts; unequal enforcement; excludes informal builders; documentation requirements	(Richardson, 2025)
	Upstream Watershed Management	Reforestation programs	Pluvial, Fluvial	Forest conservation and reforestation in catchment areas to increase water retention. Protects and restores vegetation that absorbs rainfall.	Reduces peak discharge; reduces runoff volume; improves infiltration	Upland and urban-upland interface zones, river edge	Watershed/catchment	Reduces runoff; provides ecosystem services; long-term benefit; biodiversity support; multiple benefits	Slow implementation timeline; tenure security issues; deforestation pressures; displacement	(Purboseno et al., 2024)
	Water Retention in Headwaters	Headwater rehabilitation	Fluvial	Treating headwaters as sponge zones for water absorption. Manages upper catchment areas to retain and infiltrate water rather than rapidly conveying it.	Reduces downstream flooding; delays peak flow; improves baseflow	Upper catchment areas, river edge	Catchment	Reduces peak flows; improves water supply; low-cost implementation; ecosystem co-benefits; long-term sustainability	Requires large land areas; land rights issues; slow recharge times; slow implementation; upland-urban equity concerns	(Pena, 2025)

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Table 4.1 Catalogue of Formal Practices

Note. Made by Author

4.4.1 Formal Practices

Strategy Category	Strategy	Measure	Type of Flooding	Description	Effects on Flooding	Context	Scale	Advantages	Limitations	Citation
 Defend / Protect	Natural Grading & Gravity Drainage	Sloped surfaces; gravity channels	Pluvial	Sloped surfaces and channels designed to direct water by gravity without pumping. Uses topography to naturally convey water downslope.	Reduces localized ponding; no energy required; reduces peak discharge	Street networks, open spaces, slopes, hillside areas, low-lying street	Street/neighborhood	Cost-effective; no pumping needed; passive system; multiple co-benefits; low maintenance; operates without power	Requires adequate slope; may cause erosion; creates visible channels; may conflict with pedestrian/vehicle access	(Ohara & Yamatani, 2019)
	Reduce Velocity	Street-level check dams	Pluvial	Measures designed specifically for urban pluvial flooding that slow water velocity and dissipate energy rather than storing water	Reduces flow velocity; dissipates flood energy; reduces downstream damage	Street networks, open spaces, slopes, hillside areas, dense urban blocks	Street	Reduces erosion; protects downstream areas; improves infiltration opportunity; protects infrastructure; immediate relief	Requires maintenance; can accumulate sediment; may be overtopped in extreme events; clogging potential; impacts flow conveyance capacity	(Wu et al., 2023)
		Check dams; riparian buffers	Fluvial	Speed reduction through check dams, riparian buffers, flow restrictions, terraced surfaces. Slows water movement to reduce erosion and downstream damage.	Reduces flow velocity; dissipates flood energy; reduces downstream damage	Street networks, open spaces, slopes, hillside areas, low-lying street	Reach/catchment	Reduces erosion; protects downstream areas; improves infiltration opportunity; protects infrastructure	Requires maintenance; can accumulate sediment; may be overtopped in extreme events; clogging potential; impacts flow conveyance capacity	(Najafi et al., 2025)
	Permeable Surfaces & Infiltration-Based Infrastructure	Permeable Pavements	Pluvial	Porous asphalt, permeable concrete, paving stones with open joints, stone grids. Allows water to infiltrate through paving surface into underlying storage/infiltration layer.	Reduces runoff at site scale; allows infiltration; reduces peak discharge	Streets, parking areas, sidewalks, public spaces, formal infrastructure corridor	Neighborhood/street-level	Cost-effective when integrated with construction; multiple co-benefits; improves walkability; reduces heat island effect; distributed approach; filters pollutants	Performance degrades with maintenance; soil compaction issues; requires well-drained soils; clogging problems with sediment/debris; durability concerns; costs higher than conventional	(Franco et al., 2025)
		Green Roofs	Pluvial	Engineered systems consisting of waterproofing membranes, drainage layers, growing media, and vegetation that cover building rooftops	Reduces peak discharge from individual buildings; reduces total runoff volume when integrated across multiple structures	Urban residential and commercial areas, rooftops in dense urban districts, formal infrastructure corridors.	Building/Neighborhood	Uses existing vertical space without consuming ground-level land	limited effectiveness in extreme rainfall events due to substrate saturation; performance degrades if maintenance is inconsistent	(De Araújo et al., 2025)
		Bioswales	Pluvial	Vegetated channels for stormwater conveyance and infiltration; planted linear features with engineered soil. Plants slow water and enhance infiltration. Water filters through soil for pollutant removal.	Reduces runoff; provides infiltration and filtration; improves water quality	Parks, street medians, corridor edges, neighborhood green spaces, low-lying street	Neighborhood/district	Multiple co-benefits; distributed approach; low maintenance when established; improves landscape quality; green employment; community engagement	Requires sustained watering during establishment; needs appropriate soil; performance varies with design; maintenance dependent; space requirements	(Grgich et al., 2024)
		Infiltration Trenches	Pluvial	Underground perforated trenches filled with gravel, designed to infiltrate runoff. Water enters through surface opening and infiltrates through soil. Stores water below ground for infiltration.	Reduces runoff at site; stores and infiltrates rainfall	Beneath parking areas, green spaces, along streets, formal infrastructure corridor	Neighborhood/site-level	Underground; effective in sandy soils; can be retrofitted; doesn't compete for surface area	Requires good drainage; clogging risks; maintenance challenging higher cost than bioswales; soil-dependent performance; access for maintenance difficult	(De Araújo et al., 2025)

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Table 4.1 Catalogue of Formal Practices

Note. Made by Author

4.4.1 Formal Practices

Strategy Category	Strategy	Measure	Type of Flooding	Description	Effects on Flooding	Context	Scale	Advantages	Limitations	Citation
 Defend / Protect	Storage-Based Infrastructure (Retention & Detention)	Detention Ponds (Temporary Storage)	Pluvial	Engineered temporary storage facilities designed to hold water during storms and release slowly afterward.	Stores rainfall; reduces peak discharge; extended release reduces downstream flooding	Parks, green spaces, canal edges, flood plains, formal infrastructure corridor	District/neighborhood	Multiple uses; cost-effective land use; natural aesthetics possible; can be community-managed; provides habitat	Large land area requirements; maintenance needs; can become waste dumping sites; safety concerns if not fenced; aesthetic challenges; mosquito breeding potential	(Terêncio et al., 2020)
		Retention Ponds (Permanent Water)	Pluvial	Permanent water bodies with controlled outlets maintained at constant level. Stores floodwater and controls release. Provides ecological and recreational benefits year-round.	Reduces runoff volume; improves water quality through sedimentation; provides water supply	Parks, green spaces, ecological reserves, integrated landscapes, low-lying street	District/neighborhood	Aesthetic; wildlife habitat; water supply; evaporative cooling; recreation; community gathering; improves property values	Large permanent land requirement; water quality management complex; mosquito breeding potential; safety concerns; equity of access; maintenance intensive; requires skilled management	(Nagare & Supekar, 2024)
		Bioretention Cells (Rain Gardens)	Pluvial	Shallow planted basins with engineered soil mix designed for infiltration and plant uptake. Water ponds temporarily in basin, infiltrates through soil, and is taken up by plants. Combines detention and infiltration.	Reduces runoff; filters pollutants; improves water quality; reduces peak discharge	Parking lots, median strips, green spaces, neighborhood areas, low-lying street	Neighborhood/site-level	Aesthetic; biodiversity; filtration; community-visible; scalable; multiple plantings possible; educational value	Requires good soil; establishment watering needed; maintenance dependent; performance highly variable; clogging in high-sediment areas; overflow risk	(De Araújo et al., 2025)
		Underground Cisterns & Reservoirs	Pluvial	Subsurface storage tanks and aquifer storage systems for capturing and storing stormwater. Collects floodwater for later use. Combines flood reduction with water supply.	Stores rainfall; provides water supply; reduces peak discharge	Beneath buildings, parks, plazas, formal infrastructure corridor	Building/neighborhood/district	Water supply provision; distributes storage; doesn't consume visible land; can serve multiple purposes; long-term water security	High construction cost; maintenance access challenges; land ownership issues; water quality management required; technical expertise needed; clogging risks	(Toronto and Region Conservation Authority, 2016)
	Structural Flood Defenses & Barriers	Levees & Embankments	Fluvial	Engineered earth or concrete embankments designed to block flood waters. Raises protection level by creating barrier between flood source and protected area.	Provides protection during design storm events; reduces flood; protects developed area	Perimeter of protected areas, river corridors, polder embankments, formal infrastructure corridor	City/district	High protection for designed events; immediate implementation; proven technology; visible protection; enables development in protected areas	Restricts floodplain connectivity; creates false security if maintained poorly; maintenance intensive; expensive; can increase downstream flooding; environmental impacts; creates urban-rural divide	(Prominski, 2012)
		Levees with Flap Valve	Fluvial	Engineered embankments with one-way tidal/backflow prevention valves. Prevents water from backing up into protected area while allowing internal drainage. Automates flood exclusion during high tides.	Provides protection during design storm events; reduces flood height; protects developed areas; enables water flow to river	River mouths, estuary areas, protected perimeters, formal infrastructure corridor	City/district	Enables permanent habitation in low areas; protects developed land; one-way valve automates operation; no manual intervention needed; complete protection from backwater	Technical maintenance required; valve clogging possible; high operational costs; displacement effects	(U.S. Army Corps of Engineers, 2025)
		Drainage System Improvements	Pluvial, Fluvial	Expansion and rehabilitation of drainage networks, dredging, and maintenance programs. Increases system capacity through infrastructure upgrades. Removes blockages and sediment accumulation.	Increases conveyance capacity; reduces localized flooding	Urban street networks, river channels, primary/secondary drains, formal infrastructure corridor	Neighborhood to city	Well-established technology; visible improvements; creates employment; straightforward to implement; addresses congestion	Limited effectiveness during extreme events beyond design capacity; maintenance costs continuous; land acquisition issues for expansion; displacement during construction; sediment management challenges	(Azir, 2025)

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Table 4.1 Catalogue of Formal Practices

Note. Made by Author

4.4.1 Formal Practices

Strategy Category	Strategy	Measure	Type of Flooding	Description	Effects on Flooding	Context	Scale	Advantages	Limitations	Citation
 Defend / Protect	Structural Flood Defenses & Barriers	Pumping Stations	Pluvial, Coastal	Installation of mechanical pumps for active water discharge against gravity. Enables continued occupation in very low areas by actively removing water. Requires energy input.	Actively removes water; enables continued occupation in very low areas; works against gravity	Low-lying areas, behind embankments, polder interiors, coastal zones, formal infrastructure corridor	District	Extends protection to very low areas; flexible operation; can be mobile; rapid response capability; enables development in otherwise uninhabitable areas	Energy-dependent; maintenance requirements extensive; reliability issues; environmental discharge impacts; break-down risks during events	(Seo & Jo, 2025)
		Secondary Backup Dikes	Fluvial, Coastal	Secondary protection layers and redundant systems that ensure continued flood management capability after primary system failure	Maintains protection if primary system fails; ensures continued drainage operation	River corridors, protected areas, polder embankments, drainage infrastructure	District/City	Prevents cascading failures; maintains service continuity; provides defense-in-depth; reduces system fragility	High capital cost; maintenance requirements; complex coordination; requires skilled management	(Sjödahl & Kalantari, 2005)
		Floodgates & Storm Surge Barriers	Coastal	Mechanical gates at river mouths or inlets; barrier systems against surge. Blocks water entry to protected areas by closing during surge events. Provides complete protection from external water.	Prevents tidal/surge penetration entirely during closure; complete protection of protected area	Estuary areas, canal mouths, coastal barriers, formal infrastructure corridor	Reach/district	High protection during surge events; controllable operation; complete exclusion possible; protects large areas	Extremely expensive; very high technical complexity; maintenance intensive; can trap water behind barrier; environmental impacts on estuarine ecology; requires sophisticated management	(Mooyaart et al., 2014)
	Early Warning Systems	Rainfall gauge; forecasting models	Pluvial, Fluvial, Coastal	Rainfall monitoring, flood forecasting, automated alerts, real-time warning dissemination. Uses technical infrastructure to predict floods and communicate risks. Enables preparedness and evacuation.	Provides advance warning; enables preparedness and evacuation; reduces casualties	Citywide, district level, reach-scale, formal infrastructure corridor	City	Enables preparedness; low-cost technology option; can be community-based; improves response timing; saves lives; provides data for planning	Requires technical capacity; data infrastructure needs; electricity dependence; communication barriers; coverage gaps; accuracy challenges; access barriers for vulnerable	(Ashruri et al., 2025)
 Accommodate / Live With Water	Flood-Resistant Architecture	Elevated ground floors	Pluvial, Fluvial, Coastal	Buildings designed with raised ground levels and protective materials to withstand flood impacts	Reduces structural damage; allows continued habitation; minimizes downtime	Low-lying streets, formal infrastructure corridors, river edges	Building	Enables habitation in flood zones; cost-effective when integrated into design; local artisans capable; reduces repair costs; enables business continuity	Reduces usable floor space; cultural resistance; requires ongoing maintenance; may increase water velocity at neighboring properties; can be expensive for retrofits	(Pasquier et al., 2024)
		Waterproof construction materials	Pluvial, Fluvial	Construction using materials specifically engineered for water resistance and durability during inundation	Reduces structural and contents damage significantly	Urban residential and commercial areas, formal infrastructure corridors	Building	Protects assets; reduces damage; creates co-benefits (improved quality); prevents poor construction practices	Expensive; requires continuous training; weak enforcement in informal contexts; unequal enforcement; excludes informal builders	(Mustafa, 2023)
		Adjustable interior fixtures	Pluvial, Fluvial	Design strategies that minimize damage through adaptive interior layouts and fixture selection that accommodates temporary water presence	Reduces contents damage; enables continued use; minimizes downtime	Residential and commercial buildings in flood-prone areas	Building	Maintains habitability; reduces repair timescales; culturally sensitive; enables business continuity	Requires specialized expertise; initial investment; may reduce floor functionality; not suitable for all building types	(Vuscan & Muntean, 2025)
		Amphibious Housing	Pluvial, Fluvial, Coastal	Structures that float vertically on guide posts or rise with water; buoyant design. Buildings move up and down with flood levels; eliminates structural damage while allowing continued habitation.	Eliminates structural damage completely; allows continued use during and after floods; enables permanent residency	Low-lying street, river edge, formal infrastructure corridor	Building/neighborhood	Innovative approach; allows permanent residence without damage; no reconstruction needed post-flood; maintains functionality; enables livelihoods	Very expensive; complex maintenance; technical expertise required; cultural acceptance uncertain; requires specialized contractors; rare implementation; limited real-world examples	(Mustafa, 2023)
	Multi-functional Infrastructure	Floodable Public Spaces	Pluvial, Fluvial	Parks and public spaces deliberately designed to store floodwater temporarily while serving recreation, markets, and social functions during dry season	Reduces peak discharge; extends release; stores rainfall temporarily	formal infrastructure corridors, floodplain areas	District/neighborhood	Multiple uses; cost-effective land use; natural aesthetics; can be community-managed; provides habitat; seasonal livelihood opportunities	maintenance needs; can become waste dumping sites; safety concerns; aesthetic challenges; mosquito breeding potential	(Dor et al., 2025)

Table 4.1 Catalogue of Formal Practices

Continues on next page

Note. Made by Author

4.4.1 Formal Practices

Strategy Category	Strategy	Measure	Type of Flooding	Description	Effects on Flooding	Context	Scale	Advantages	Limitations	Citation
 Recover / Maintain Continuity	Improved Sanitation/Hygiene During Floods	Portable sanitation facilities; water purification systems	Pluvial, Fluvial, Coastal	Prevents waterborne diseases during and after floods. Provides essential services to maintain health during displacement and recovery periods.	Reduces waterborne disease risk; prevents secondary health crises; saves lives	Formal infrastructure corridor, low-lying street, evacuation centers	Community/neighborhood	Prevents secondary health crises; cost-effective approach; saves lives; addresses health equity; improves dignity; prevents epidemics	Sustainability challenges post-event; requires consistent supply; cultural acceptance varies; stigma risks; maintenance demands; equity of access; coordination complexity	(Sari, 2026)
	Critical Infrastructure Protection	Elevated utility equipment	Pluvial, Fluvial, Coastal	Protects essential infrastructure systems (power, water, communications) from flood damage. Maintains service continuity during and after floods.	Maintains service continuity; reduces recovery time; prevents cascading failures	Formal infrastructure corridor, formal system, critical nodes	City/district	Maintains essential services; reduces cascading disruptions; improves overall system resilience; enables emergency response; protects dependent services	Expensive upfront investment; ongoing maintenance needs; may not address all infrastructure types; coordination challenges; gaps in coverage	(Rezvani et al., 2024)
	Business Continuity Planning	Emergency procedures; data backup systems	Pluvial, Fluvial, Coastal	Emergency procedures, data backup, alternative facilities, supply chain redundancy. Enables businesses to maintain operations or resume quickly after disruptions.	Reduces economic loss and recovery time; maintains employment; protects business assets; enables rapid restart	Formal infrastructure corridor, formal economy, business centers	Business/district	Reduces economic loss; maintains employment; protects market functionality; business resilience; competitive advantage	Not accessible to informal economy (majority in developing countries); requires technical capacity and capital; disproportionate benefits to large businesses; equity concerns; excludes vulnerable workers	(Lou et al., 2024)
	Environmental Education and Awareness	Educational programs for waste management	Pluvial, Fluvial	Environmental education integrating project-based learning, experiential learning, and community-based training to foster environmental awareness and pro-environmental behavior regarding waste management and recycling	Reduces environmental burden through sustained behavior change; minimizes waste generation at source; improves system acceptance and participation	Schools, universities, communities, digital platforms, cultural venues, faith institutions	Building/neighborhood	Builds long-term capacity for environmental stewardship; fosters environmental consciousness; accessible without requiring significant infrastructure; can reach marginalized populations	Requires sustained implementation and resources; knowledge-behavior gap often exists despite awareness; requires trained educators and facilitators; long-term outcomes uncertain	(De Feo, 2025)
	Post-Disaster Reconstruction Guidelines	Reconstruction standards; green building guidelines	Pluvial, Fluvial, Coastal	Standardized recovery procedures, green reconstruction protocols, inclusive rebuilding frameworks. Guides reconstruction to improve quality and reduce future risk.	Enables faster recovery; improves quality of rebuilt infrastructure; reduces future risk; prevents maladaptation	Formal infrastructure corridor, formal system, affected areas	Regional/city	Improves quality of rebuilt infrastructure; reduces future risk; standardization accelerates approval; consistency; resilience improvement	Requires political will and enforcement; can perpetuate inequities if not inclusive; may not account for local preferences; costly implementation; slow institutional adoption	(Singhal, 2025)
 Transform / Adapt the System	Integrated Urban Water Management	Multi-sector planning frameworks; integrated water governance	Pluvial, Fluvial, Coastal	Coordinated water resource planning across sectors (water supply, sanitation, stormwater, irrigation). Treats water as integrated system rather than separate concerns.	Optimizes water infrastructure; reduces conflicts; addresses scarcity and flooding together	Formal infrastructure corridor, formal water system, city-wide	City/region	Holistic approach; addresses both water scarcity and flooding; multiple benefits; improves coordination; cost-effective integration; system resilience	Requires institutional coordination; governance complexity; long implementation timelines; power imbalances between sectors; resistance to change; institutional fragmentation	(Lehmann, 2017)
	Sponge City Concept	City-wide green-blue infrastructure network, integrated water management, distributed storage and infiltration, multi-functional systems	Pluvial, Fluvial	Nature-based infiltration, retention, reuse, and purification integrated throughout urban areas. Mimics natural water cycle; treats city as water absorption and storage system.	Reduces runoff; restores water cycle; provides water supply and flood reduction simultaneously; improves quality	Formal infrastructure corridor, city-wide system, river edge, parks	City	Comprehensive approach; multiple co-benefits; scalable; addresses both flooding and scarcity; creates green jobs; improves livability; ecological restoration	Uncertainty of life cycle costs; requires sustained maintenance; land scarcity; challenges in public-private partnership	(Li et al., 2017)
	Nature-Based Solutions (NBS) Integration	Wetland creation/restoration, mangrove conservation; river dike removal; ecological corridor establishment; habitat restoration	Pluvial, Fluvial, Coastal	Wetland restoration, mangrove conservation, river naturalization, ecological corridors. Works with natural processes to provide flood reduction and ecosystem services.	Reduces flood peak; provides biodiversity; carbon sequestration; ecological restoration; water quality	River edge, formal infrastructure corridor, coastal areas, wetlands	City	Multiple ecosystem services; cost-effective; improves livability; improves public health; creates green jobs; carbon benefits; biodiversity; long-term resilience	Slow to establish; land rights conflicts; requires ecological knowledge; performance highly variable; institutional support needed; maintenance; land scarcity	(Baker et al., 2025)
	Climate-Adaptive Urban Planning	Climate scenario planning; adaptive land use zoning	Pluvial, Fluvial, Coastal	Integrated land use and water management under climate scenarios; anticipatory planning. Uses climate projections to guide long-term planning.	Builds long-term adaptive capacity; reduces future risk; aligns multiple objectives; enables proactive response	Formal infrastructure corridor, city-wide system, planning zones	City/region	Anticipatory; aligns multiple objectives; science-based; future-oriented; avoids maladaptation; long-term resilience	High complexity; requires long-term political commitment; cost uncertainty; modeling limitations; social resistance; implementation slow; uncertainty in projections	(Huang & Wang, 2024)

Table 4.1 Catalogue of Formal Practices

Note. Made by Author

4.4.2 Informal Practices

Strategy Category	Strategy	Measure	Type of Flooding	Description	Effects on Flooding	Context	Scale	Advantages	Limitations	Citation
 Avoid / reduce exposure	Indigenous / Traditional Settlement Patterns	Traditional settlement site selection	Pluvial, Fluvial, Coastal	Settlement site selection and design based on generations of local knowledge. Communities locate homes on higher ground, elevated areas, or traditionally-safe locations.	Reduces exposure through historical knowledge; lower risk where maintained	Traditional lands, indigenous territories, long-inhabited areas, shared courtyards	Household/community	Cost-free; culturally appropriate; proven over generations; low-tech; integrates indigenous rights	Under threat from modernization; lacks formal documentation; often excluded from formal planning; knowledge loss risk; power imbalances in land recognition	(Lestari et al., 2025)
	Community-Led Land Management	Community hazard awareness,	Pluvial, Fluvial, Coastal	Local awareness of hazard patterns guides community decisions about where to build. Communities establish informal no-build zones and enforce through social norms.	Informal compliance with unsafe areas; community norms regulate development	Narrow alleys, dense blocks	Neighborhood/community	Low-cost; uses local knowledge; community-driven; culturally embedded; immediate implementation	Lack of legal standing; vulnerable to encroachment; no formal enforcement power; can be overridden by desperate need for housing	(Barau & Wada, 2021)
	Livelihood Diversification	Occupational diversification; seasonal migration	Pluvial, Fluvial	Engagement in non-flood-dependent income activities and seasonal migration. Households develop multiple income sources not exclusively dependent on flood-prone livelihoods.	Reduces economic reliance on flood zone; spreads economic risk; improves survival capacity	Floodplain communities, seasonal economy areas, home edges	Neighborhood/community	Spreads economic risk; improves resilience; enables flexibility; cost-free; self-driven adaptation	Requires market access; social capital; information; not universally possible; individual initiative dependent; limited options in poor areas	(Nong et al., 2026)
 Defend / Protect	DIY Flood Protection	Sandbags; informal barriers; temporary structures, barricades	Pluvial	Community-assembled sandbags, informal barriers, manual gates, temporary structures. Provides immediate temporary protection during flood events using locally-available materials and community labor.	Provides temporary protection; blocks water entry; reduces localized inundation	Home edges, narrow alleys, dense blocks	Household	Immediately implementable; uses local materials; community-owned; low-cost; deployable on demand; accessible to all	Temporary only; ineffective against strong flows (>1 m/s); time-consuming; labor-intensive; creates obstacles for neighbors; displacement effects; not durable	(Laji & Ayonga, 2024)
	Informal Drainage Maintenance	Manual dredging; debris removal; channel clearing	Pluvial	Manual de-siltation and community drainage clearing. Community labor removes accumulated sediment and debris from local drainage channels and gutters.	Improves local conveyance; reduces localized flooding; removes physical obstructions	Narrow alleys, dense blocks	Neighborhood	Low-cost; community participation; visible results; immediate relief; builds solidarity; employment generation; responsiveness	Temporary (clogs again); ongoing labor burden; can cause downstream problems; no institutional support; inconsistent effort; equity concerns	(Laji & Ayonga, 2024)
	Community-Based Early Warning (Traditional)	Traditional observation systems; community messenger networks	Pluviall, Fluvial	Traditional environmental cues, observation, and community networks for informal alerts. Based on generations of local knowledge; individuals observe water levels, weather patterns, and communicate through informal networks.	Enables evacuation hours before flooding; reduces casualties	Shared courtyards, dense blocks, home edges	Community	Low-cost; culturally appropriate; builds on existing networks and trust; accessible without technology; immediate dissemination; community ownership	Limited advance notice; may be unreliable in changing climate; doesn't reduce physical hazard; limited communication range; weather dependency.	(Lestari et al., 2025)
	Informal Local Construction	Elevated structures; flood-resistant modifications by local builders	Pluviall, Fluvial	Local builders using elevated structures, flood-resistant design techniques, and informal improvement methods. Creates local employment while improving housing. Skills-based approach.	Reduces damage; enables habitation in flood zones	Home edges, dense blocks, narrow alleys	Building	Local employment; culturally appropriate; cost-effective; supports local economy; practical knowledge; accessible to poor households	Inconsistent quality; lack of formal standards; knowledge not codified; may not meet building codes; uneven effectiveness.	(Laji & Ayonga, 2024)
	Informal Water Harvesting & Storage	Roof tanks; collection containers, storage systems	Pluvial	Community-constructed or household-managed water collection and storage. Addresses both flood and water scarcity challenges.	Stores rainfall; provides dry season water; reduces external demands	Home edges, dense blocks	Household/community	Low-cost; addresses water scarcity; community-managed; immediate benefit; distributed approach; improves resilience	Maintenance challenges; water quality issues; limited storage; disease vectors possible; requires discipline in use; seasonal variation	(Domullodzhanov & Rahmatilloev, 2023)

Continues on next page

Table 4.2 Catalogue of Informal Practices

Note. Made by Author

4.4.2 Informal Practices

Strategy Category	Strategy	Measure	Type of Flooding	Description	Effects on Flooding	Context	Scale	Advantages	Limitations	Citation
 Accommodate / Live With Water	Temporary Relocation	Upper floor refuge; rooftop temporary shelter; item relocation procedures	Pluvial, Fluvial, Coastal	Moving household items to upper stories, rooftop refuge, temporary shelters within community. During floods, community members move possessions and take refuge on higher floors or roofs.	Protects lives and essential possessions; enables temporary displacement	Home edges, dense blocks, multi-story structures	Household	Immediate; requires no infrastructure; community-based; culturally acceptable; saves lives	Stressful; only temporary protection; may face resistance from landlords/owners; doesn't protect property/assets; repeated disruption; incomplete protection	(Francisco, 2014)
	Circulation/Mobility Adaptation	Elevated pedestrian networks,	Pluvial, Fluvial	Infrastructure systems designed to maintain human movement and emergency access during flood events through water-compatible pathways	Enables continued access during inundation; maintains emergency response capability; supports livelihood continuity	Neighborhood streets, community pathways, formal infrastructure corridors, dense blocks, narrow alleys	street/neighborhood	Maintains mobility during floods. enables emergency response; supports livelihood continuity; accessible infrastructure; community-based implementation possible	Requires specialized design; maintenance needs during extreme events; may conflict with vehicle traffic; capital investment required for construction; may not address extreme flood depths	(Malabayabas & Bacongus, 2017)
		Community-managed boat routes	Pluvial, Fluvial, Coastal	Community-organized and formal boat systems that enable access, evacuation, and supply distribution during flooding by using water channels as pathways	Enables continued access; supports evacuation; maintains supply chains	Delta areas, urban floodplains, water channel networks, low-lying areas	Neighborhood/Community/District	Uses existing water infrastructure; enables continued access and evacuation; utilizes existing community networks; relatively low-cost activation	Limited to water-accessible areas; requires boats and trained operators; seasonal applicability; may exclude non-swimmers; coordination challenges	(Malabayabas & Bacongus, 2017)
	Flood-Tolerant Livelihood Adaptation	Temporary business relocation; seasonal adjustments; floating market operations;	Pluvial	Street vending relocation, hawker adjustments. Informal economy workers adapt operations during and after floods. Demonstrates livelihood flexibility and resilience.	Maintains income during partial flood events; reduces loss; demonstrates economic resilience	Narrow alleys, home edges	Household/street	Quick adaptation; income protection; resourceful; no outside intervention needed; maintains livelihoods; pragmatic	Income reduction during floods; requires alternative space; limited during multiple events; no long-term security.	(Asmal et al., 2025)
 Recover / Maintain Continuity	NGO Recovery	NGO rebuilding support, counseling services; livelihood programs	Pluvial, Fluvial, Coastal	Non-governmental organization support for rebuilding, trauma counseling, livelihood restoration. External organizations provide specialized expertise and resources for recovery.	Accelerates recovery; provides social support; additional resources; technical assistance	Community level, dense blocks	Community/neighborhood	Professional support; specialized services; resources mobilized; reduces individual burden; external expertise; comprehensive approach	Temporary nature; dependency risks; may not address structural issues; external agenda risks; unequal access; sustainability after project ends	(Castaños et al., 2025)
	Informal Livelihood Recovery	Informal lending; informal employment; flexible income activities; community markets	Pluvial, Fluvial, Coastal	Informal credit, second-hand goods recycling, street work, informal economy activities. Informal economy participants use flexible strategies to rebuild income quickly. Utilizes existing informal networks.	Enables return to income generation; quick return to productivity	Narrow alleys, home edges	Household	Immediate; tailored to circumstances; uses existing networks; no documentation needed; accessible	Risky ventures; exploitative interest rates possible; limited growth potential; unregulated; precarious; poverty perpetuation	(Moulds et al., 2021)
 Transform / Adapt the System	Community-Based Disaster Risk Reduction	Community risk mapping; participatory planning; community-designed projects	Pluvial, Fluvial, Coastal	Community-led risk assessment, planning, and implementation. Communities identify risks and design solutions. Emphasizes local agency and decision-making. Bottom-up resilience approach	Builds capacity; improves risk awareness; enables community action; reduces vulnerability	Dense blocks, neighborhoods	Community	Community-led; capacity building; empowering; sustainable; locally appropriate; ownership; inclusive	Requires external support sometimes; limited resources; may lack technical expertise; sustainability dependent on engagement	(Francisco, 2014)
	Social Networks & Community Organizing	Community organizations, social movements; collective action forums	Pluvial, Fluvial, Coastal	Building social capital, community organizations, advocacy networks. Communities organize collectively for resilience and flood risk reduction. Strengthens social fabric and collective agency.	Builds collective capacity; enables advocacy; improves coordination	Dense blocks, neighborhoods, communities	Community/neighborhood/city	Empowering; builds solidarity; amplifies voice; enables collective action; sustainable; community-driven	Requires time and commitment	(Starkey et al., 2026)

Table 4.2 Catalogue of Informal Practices

Note. Made by Author

4.5 Evaluation Criteria

Not every measure in the catalogue is applicable to the project. The evaluation assesses each measure against its spatial feasibility, type of flooding addressed, local capacity, future relevance, secondary effects, local acceptability, and influence. Measures are retained, conditioned, or discarded based in the evaluation. This step ensures that the design proposal is grounded in contextual evidence rather than generic solutions.

4.5.1 Hard requirements

Before any scoring begins, two hard requirements must be met. The decision is then made to pass or fail.

Hard requirement 1- Spatial Feasibility

Spatial feasibility is the most fundamental constraint in this project. Before evaluating the performance, a measure must first establish whether it can exist in this context at all

Hard requirement 2- Flood type coverage

The site experiences compound flooding of pluvial and fluvial. A measure that doesn’t address either is not included. It is therefore also concluded that at least one measure from each flood type must be included in the selected measures

Formal Practices Measure	Hard requirement	
	Spatial Feasibility	Flood Type Coverage
Relocation programs	FAIL	
Reforestation programs	FAIL	
Headwater rehabilitation	FAIL	
Detention Ponds (Temporary Storage)	FAIL	
Retention Ponds (Permanent Water)	FAIL	
Floodgates & Storm Surge Barriers		FAIL
Multi-sector planning frameworks; integrated water governance	FAIL	
City-wide green-blue infrastructure network, integrated water management, distributed storage and infiltration, multi-functional systems	FAIL	
Wetland creation/restoration, mangrove conservation; river dike removal; ecological corridor establishment; habitat restoration	FAIL	
Climate scenario planning; adaptive land use zoning	FAIL	

Table 4.3 Hard Requirement Failed Measures

Note. Made by Author

4.5.2 Multi-criteria evaluation

MCE Criterion 1- Local capacity (30%)

An assessment of whether the measure can be implemented and maintained by the actors available in Barangay Tantallon’s context. Formal and informal actors have different capacities; therefore, they are distinguished and subdivided.

Formal strategies are scored only on formal capacity. Informal strategies are scored only on informal capacity.

Formal capacity sub-criterion

Evaluates if these factors are available: funding, technical expertise, and legal authority

Informal capacity sub-criterion

Evaluates if these factors are available: community labor, existing community knowledge, accessibility of materials

The rationale for its weight at 30% being the highest is because of the documented failures of the Metro Manila Flood Management Project, where delays and misalignments are evident. A measure that cannot be implemented or maintained by the government is not effective for this project. Moreover, measures that are maintainable by the community produce more resilient outcomes.

MCE Criterion 2- Future Relevance (25%)

An assessment of whether the measure remains effective under projected future conditions. This distinguishes between natural driving forces, such as climate and environmental changes, and human driving forces, such as population and economic changes

Natural future relevance sub criterion (12.5%)

Evaluates if measures remain effective under these conditions: projected rainfall intensity, flood frequency, loss of remaining green space

Human future relevance sub-criterion (12.5%)

Evaluates if measures remain effective under these conditions: population growth, land pressure, and available open space, changing government

The rationale for its weight at 25% is because of the rapidly changing environment and how these measures must be able to perform under these future conditions, and not just now.

MCE Criterion 3- Secondary Effects (20%)

An assessment of the unintended effects that a measure produces beyond its hydraulic function. These are effects on the immediate living environment that determine whether the measure improves or worsens the neighborhood’s quality of life. There are seven sub-effects weighted by

Evaluates if measures are tolerable by gated community residents, governance agencies, and commercial building owners

MCE Criterion 5- Influence (10%)

An assessment of the extent to which a measure generates positive effects within the boundaries of the site. It’s subdivided into hydraulic influence and replicability influence

Hydraulic Influence sub-criterion (6%)

Evaluates if the measure reduces flood burden on surrounding areas.

Replicability influence

Evaluates whether the measure demonstrates applicability to other similar settlements, contributing to the replicability framework

Influence is a significant evaluation dimension, but should not be more important than direct effects to the residents.

Scoring Guide

Each measure in the catalogue is evaluated across a set of criteria and assigned a score from 1 to 5, where 1 indicates the lowest performance or feasibility, and 5 indicates the highest. The scoring aims to provide a structured and comparable basis for assessing which measures are most appropriate for the neighborhood’s conditions.

Score	Indication
1	Not feasible
2	Limited feasibility
3	Moderately feasible
4	Largely feasible
5	Highly feasible

It is important to note that the results of this evaluation are inherently interpretive. This score reflects the author’s assessment based on the analytical findings established in the previous chapters. In practice, the evaluation would require validation through direct consultation with residents, barangay officials, technical engineers, and other stakeholders. The evaluation should therefore be read not as a definitive ranking but as a transparent and reasoned one. This makes the design process more legible while acknowledging that the final selection of measures is ultimately collaborative

Column Headers

Code	Criterion	Weight
LC	Local Capacity	30%
FRn	Future Relevance Natural	12.5%
FRh	Future Relevance Human	12.5%
San	Sanitation & Health	6%
Soc	Social Cohesion	4%
Liv	Livelihood	4%
Was	Waste & Pollution	3%
Acc	Accessibility	1.6%
Eco	Ecology	1%
Vis	Visual Amenity	0.4%
Com	Community Acceptability	10.5%
For	Formal Actor Acceptability	4.5%
Hyd	Hydraulic Influence	6%
Rep	Replicability	4%
WT	Weighted Total	

The Scoring Table

The table is divided into three parts

- 1. Formal measures- Table 4.4
- 2. Informal measures- Table 4.5
- 3. Summary ranking- Table 4.6

Formal Measures Scoring Table

Measure	LC (30%)	FRn (12.5%)	FRh (12.5%)	San (6%)	Soc (4%)	Liv (4%)	Was (3%)	Acc (1.6%)	Eco (1%)	Vis (0.4%)	Com (10.5%)	For (4.5%)	Hyd (6%)	Rep (4%)	WT
Zoning regulations	3	4	4	3	2	2	3	3	3	2	2	4	4	4	3.206
Grid-based urban layout	3	5	5	4	4	4	3	5	3	4	3	4	5	4	3.881
Building code standards	3	4	4	3	2	3	3	3	2	3	2	4	2	3	3.08
Sloped surfaces; gravity channels	4	5	5	4	4	4	3	4	4	4	4	5	5	4	4.325
Street-level check dams	3	4	3	3	3	3	3	3	3	3	3	4	3	3	3.17
Check dams; riparian buffers	3	4	3	3	3	3	3	3	4	4	3	4	3	3	3.184
Permeable Pavements	3	4	4	4	3	3	4	4	4	4	4	4	4	4	3.62
Green Roofs	3	4	4	4	4	3	4	3	4	5	3	4	4	4	3.543
Bioswales	3	5	4	4	4	3	4	3	5	5	4	4	4	4	3.783
Infiltration Trenches	2	3	3	3	2	2	2	2	3	2	3	3	2	3	2.51
Bioretention Cells (Rain Gardens)	3	5	4	4	5	4	4	4	5	5	5	4	4	4	3.984
Underground Cisterns & Reservoirs	2	3	3	3	2	2	3	3	2	3	3	3	3	3	2.61

Table 4.4 MCE Formal Scoring Table

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Note. Made by Author

Formal Measures Scoring Table

Measure	LC (30%)	FRn (12.5%)	FRh (12.5%)	San (6%)	Soc (4%)	Liv (4%)	Was (3%)	Acc (1.6%)	Eco (1%)	Vis (0.4%)	Com (10.5%)	For (4.5%)	Hyd (6%)	Rep (4%)	WT
Levees & Embankments	3	2	2	2	2	2	3	2	1	2	2	3	3	2	2.425
Levees with Flap Valve	4	4	4	3	3	3	3	3	2	3	3	4	4	4	3.685
Drainage System Improvements	4	4	4	4	4	4	4	4	3	3	4	4	4	4	3.986
Pumping Stations	1	2	2	2	1	2	2	2	1	1	2	2	2	1	1.606
Secondary Backup Dikes	3	3	3	2	2	2	3	2	1	2	2	3	3	2	2.675
Rainfall gauge; forecasting models	4	5	5	4	4	5	4	4	3	2	4	5	5	5	4.417
Elevated ground floors	4	5	4	5	4	5	3	3	2	4	4	4	4	4	4.159
Waterproof construction materials	3	4	4	4	3	4	3	3	2	3	4	4	3	4	3.53
Adjustable interior fixtures	3	3	3	3	3	4	3	3	2	3	4	3	2	3	3.075
Amphibious Housing	2	4	3	3	3	3	3	3	2	3	2	3	2	3	2.65
Floodable Public Spaces	4	5	5	4	5	5	4	5	5	5	5	4	4	5	4.505
Portable sanitation facilities; water purification systems	3	4	4	5	3	4	3	3	3	2	4	4	2	4	3.536

Table 4.4 MCE Formal Scoring Table

Continues on next page

Note. Made by Author

Formal Measures Scoring Table

Measure	LC (30%)	FRn (12.5%)	FRh (12.5%)	San (6%)	Soc (4%)	Liv (4%)	Was (3%)	Acc (1.6%)	Eco (1%)	Vis (0.4%)	Com (10.5%)	For (4.5%)	Hyd (6%)	Rep (4%)	WT
Elevated utility equipment	4	5	5	4	4	5	3	4	2	2	4	4	3	4	4.172
Emergency procedures; data backup systems	3	4	4	3	4	4	3	3	2	2	4	4	2	3	3.406
educational programs for waste management	4	4	4	5	4	3	5	3	4	4	4	5	3	5	4.059
Reconstruction standards; green building guidelines	3	4	3	4	3	4	4	3	4	4	5	4	3	4	3.564

Table 4.4 MCE Formal Scoring Table

Note. Made by Author

Informal Measures Scoring Table

Measure	LC (30%)	FRn (12.5%)	FRh (12.5%)	San (6%)	Soc (4%)	Liv (4%)	Was (3%)	Acc (1.6%)	Eco (1%)	Vis (0.4%)	Com (10.5%)	For (4.5%)	Hyd (6%)	Rep (4%)	WT
Traditional settlement site selection	3	3	3	3	5	3	3	2	4	4	5	2	2	2	3.143
Community hazard awareness,	4	4	5	4	4	4	4	4	3	3	3	4	3	3	3.906
Occupational diversification; seasonal migration	4	4	4	3	4	5	3	3	2	2	5	2	1	4	3.741
Sandbags; informal barriers	4	2	2	2	3	3	2	2	1	1	5	2	1	2	2.921

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Table 4.5 MCE Informal Scoring Table

Note. Made by Author

Informal Measures Scoring Table

Measure	LC (30%)	FRn (12.5%)	FRh (12.5%)	San (6%)	Soc (4%)	Liv (4%)	Was (3%)	Acc (1.6%)	Eco (1%)	Vis (0.4%)	Com (10.5%)	For (4.5%)	Hyd (6%)	Rep (4%)	WT
Manual dredging; debris removal; channel clearing	5	3	3	4	5	3	5	4	3	3	5	3	3	4	4.066
Traditional observation systems;	5	3	3	4	5	4	3	4	2	2	5	2	3	4	3.987
Elevated structures by local builders	5	4	4	5	4	5	3	3	2	4	5	3	3	5	4.374
Roof tanks; collection containers	4	4	4	4	3	3	3	3	3	2	5	3	3	4	3.856
Upper floor refuge; rooftop temporary shelter	5	3	3	3	4	4	3	2	1	2	5	2	1	3	3.685
Elevated pedestrian networks	3	5	4	3	4	4	3	5	3	4	3	4	3	4	3.576
Community-managed boat routes	3	3	3	3	4	3	3	4	2	3	4	2	1	3	2.986
Temporary business relocation; seasonal adjustments	5	4	4	3	4	5	3	3	2	2	5	2	1	4	4.041
NGO rebuilding support,; livelihood programs	3	3	3	4	5	5	3	3	2	3	5	3	2	3	3.36
flexible informal income activities; community markets	5	3	3	3	5	5	3	3	2	3	5	1	1	3	3.75
Community risk mapping; participatory planning	5	5	5	4	5	4	5	5	4	4	5	3	4	5	4.736
Community organizations, social movements; collective action forums	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Table 4.5 MCE Informal Scoring Table

Note. Made by Author

Summary Ranking Table

The measures are ranked according to the following;

Tier 1: selected (>3.5)

Tier 2: conditional (2.5-3.49)

Tier 3: rejected (<2.5)

Measure	WT	Category	Type	Tier
Community organizations, social movements; collective action forums	5	Informal	Non-physical	1
Community risk mapping; participatory planning	4.736	Informal	Non-physical	1
Floodable Public Spaces	4.505	Formal	Physical	1
Rainfall gauge; forecasting models	4.417	Formal	Non-physical	1
Elevated structures by local builders	4.374	Informal	Physical	1
Sloped surfaces; gravity channels	4.325	Formal	Physical	1
Elevated utility equipment	4.172	Formal	Physical	1
Elevated ground floors	4.159	Formal	Physical	1
Manual dredging; debris removal; channel clearing	4.066	Informal	Physical	1
Educational programs for waste management	4.059	Formal	Non-physical	1

Measure	WT	Category	Type	Tier
Temporary business relocation; seasonal adjustments	4.041	Informal	Non-physical	1
Traditional observation systems;	3.987	Informal	Non-physical	1
Drainage System Improvements	3.986	Formal	Physical	1
Bioretention Cells (Rain Gardens)	3.984	Formal	Physical	1
Community hazard awareness,	3.906	Informal	Non-physical	1
Grid-based urban layout	3.881	Formal	Physical	1
Roof tanks; collection containers	3.856	Informal	Physical	1
Bioswales	3.783	Formal	Physical	1
Flexible informal income activities; community markets	3.75	Informal	Non-physical	1
Occupational diversification; seasonal migration	3.741	Informal	Non-physical	1

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Table 4.6 MCE Summary Ranking Table

Note. Made by Author

Measure	WT	Category	Type	Tier
Levees with Flap Valve	3.685	Formal	Physical	1
Upper floor refuge; rooftop temporary shelter	3.685	Informal	Physical	1
Permeable Pavements	3.62	Formal	Physical	1
Elevated pedestrian networks	3.576	Informal	Physical	1
Reconstruction standards; green building guidelines	3.564	Formal	Non-physical	1
Green Roofs	3.543	Formal	Physical	1
Portable sanitation facilities; water purification systems	3.536	Formal	Physical	1
Waterproof construction materials	3.53	Formal	Physical	1
Emergency procedures; data backup systems	3.406	Formal	Non-physical	2
NGO rebuilding support,; livelihood programs	3.36	Informal	Non-physical	2
Zoning regulations	3.206	Formal	Non-physical	2
Check dams; riparian buffers	3.184	Formal	Physical	2
Street-level check dams	3.17	Formal	Physical	2

Measure	WT	Category	Type	Tier
Traditional settlement site selection	3.143	Informal	Non-physical	2
Building code standards	3.08	Formal	Non-physical	2
Adjustable interior fixtures	3.075	Formal	Physical	2
Community-managed boat routes	2.986	Informal	Non-physical	2
Sandbags; informal barriers	2.921	Informal	Physical	2
Secondary Backup Dikes	2.675	Formal	Physical	2
Amphibious Housing	2.65	Formal	Physical	2
Underground Cisterns & Reservoirs	2.61	Formal	Physical	2
Infiltration Trenches	2.51	Formal	Physical	2
Levees & Embankments	2.425	Formal	Physical	3
Pumping Stations	1.606	Formal	Physical	3

Table 4.6 MCE Summary Ranking Table

Note. Made by Author

Value-cost graph

While the MCE score indicates how well a measure performs, it does not determine whether that performance is worth the cost. Measures that were rejected in the MCE do not appear on the value-cost graph.

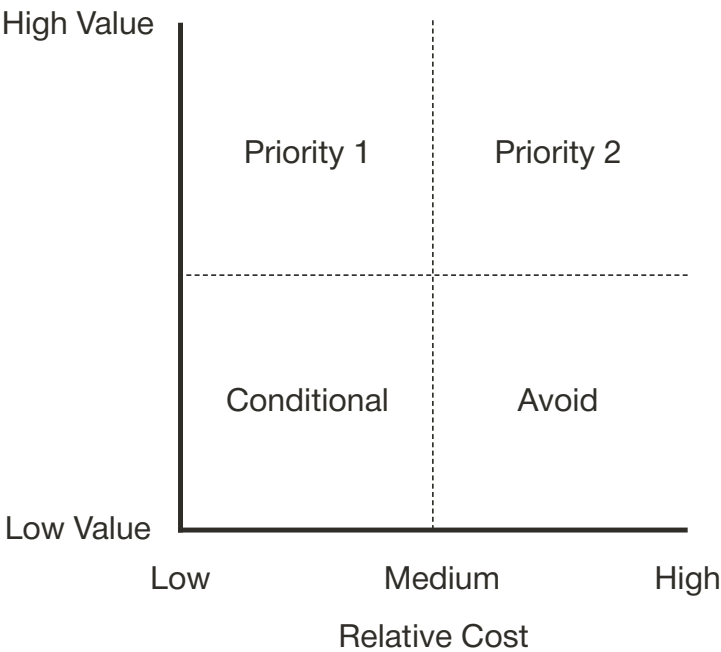
The Y-axis shows the MCE score (Value), and the threshold line is at 3.5. The X-axis shows the relative cost (low, medium, high). There are no precise points just how they are plotted within a band, the medium cost is the threshold line. The result is 4 quadrants. High Value and Low cost (Priority 1), High value and Medium cost (Priority 2), Low value and low cost (Conditional), and low value and high cost (Avoid)

Cost is represented as a relative and indicative value based on the nature and scale of each measure. Precise cost estimation would require detailed quantity analysis and is beyond the scope of the project

Low cost- represented by non-physical measures and informal physical measures that use local labor and materials

Medium cost- formal physical measures that require professional installation, but are standard infrastructure

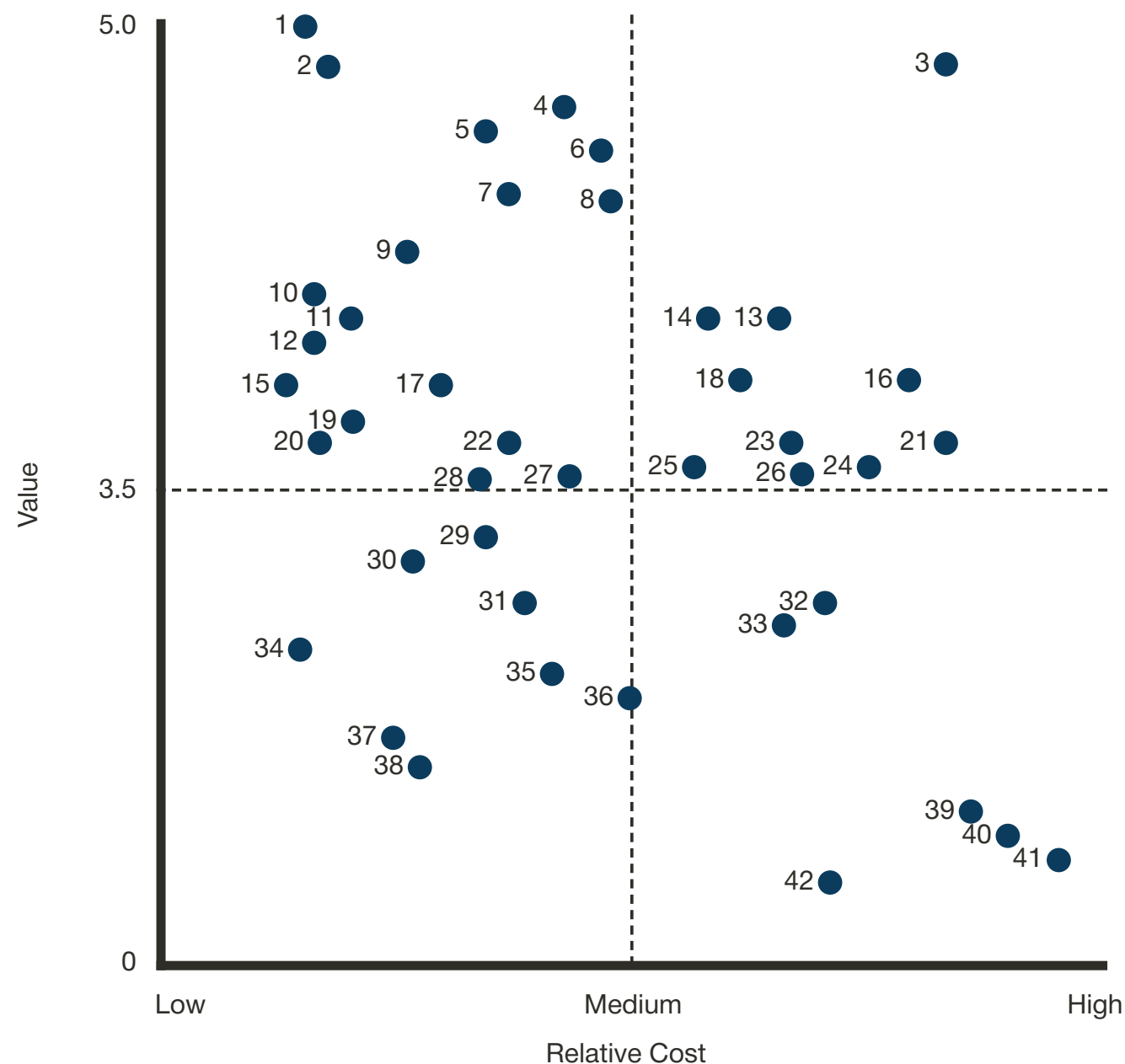
High cost- formal physical measures that require significant engineering, structural work, or large-scale construction



The following measures from the MCE, will be used for the graph:

- Tier 1
- 1. Community organizations, social movements; collective action forums
 - 2. Community risk mapping; participatory planning
 - 3. Floodable Public Spaces
 - 4. Rainfall gauge; forecasting models
 - 5. Elevated structures by local builders
 - 6. Sloped surfaces; gravity channels
 - 7. Elevated utility equipment
 - 8. Elevated ground floors
 - 9. Manual dredging; debris removal; channel clearing
 - 10. Educational programs for waste management
 - 11. Temporary business relocation; seasonal adjustments
 - 12. Traditional observation systems
 - 13. Drainage System Improvements
 - 14. Bioretention Cells (Rain Gardens)
 - 15. Community hazard awareness
 - 16. Grid-based urban layout
 - 17. Roof tanks; collection containers
 - 18. Bioswales
 - 19. Flexible informal income activities; community markets
 - 20. Occupational diversification; seasonal migration
 - 21. Levees with Flap Valve
 - 22. Upper floor refuge; rooftop temporary shelter
 - 23. Permeable Pavements
 - 24. Elevated pedestrian networks
 - 25. Reconstruction standards; green building guidelines
 - 26. Green Roofs
 - 27. Portable sanitation facilities; water purification systems
 - 28. Waterproof construction materials

- Tier 2
- 29. Emergency procedures; data backup systems
 - 30. NGO rebuilding support; livelihood programs
 - 31. Zoning regulations
 - 32. Check dams; riparian buffers
 - 33. Street-level check dams
 - 34. Traditional settlement site selection
 - 35. Building code standards
 - 36. Adjustable interior fixtures
 - 37. Community-managed boat routes
 - 38. Sandbags; informal barriers
 - 39. Secondary Backup Dikes
 - 40. Amphibious Housing
 - 41. Underground Cisterns & Reservoirs
 - 42. Infiltration Trenches



The numbers on the graph are directly correlated to the numbering of measures in the previous page

Figure 4.4 Value-cost graph

Note. Made by Author

4.5.3 Selection of measures

Priority 1 (High value, low cost)

These measures represent the strongest case for immediate implementation. They perform well across the MCE criteria and relatively low in financial investment

- Community organizations, social movements and collective action forums
- Community risk mapping and participatory planning
- Rainfall gauge and forecasting models
- Elevated structures by local builders
- Sloped surfaces and gravity channels
- Elevated utility equipment
- Elevated ground floors
- Manual dredging, debris removal and channel clearing
- Educational programs for waste management
- Temporary business relocation and seasonal adjustments
- Traditional observation systems
- Community hazard awareness
- Roof tanks and collection containers
- Flexible informal income activities and community markets
- Occupational diversification and seasonal migration
- Upper floor refuge and rooftop temporary shelter
- Portable sanitation facilities; water purification systems
- Waterproof construction materials

Priority 2 (High value, medium to high cost)

These measures perform strongly in the MCE but require greater financial investment, professional expertise, and large-scale spatial organization

- Floodable public spaces
- Drainage system improvements
- Bioretention cells and rain gardens
- Grid-based urban layout
- Bioswales
- Levee with flap valve
- Permeable pavements
- Elevated pedestrian networks
- Reconstruction standards and green building guidelines
- Green roofs

Conditional (Low value, low to medium cost)

These measures did not reach Tier 1 of the MCE but can still be included in the design under certain conditions, depending on the circumstances of the neighborhood. They are therefore retained as supplementary measures when conditions allow it.

- Emergency procedures; data backup systems (dependent on institutional capacity of government)
- NGO rebuilding support; livelihood programs (valuable for post-flood recovery but dependent on presence of organization)
- Zoning regulations (applicable at formal-informal boundary)
- Traditional settlement site selection (relevant for new informal structures within the settlement)
- Building code standards (applicable for co-production framework)
- Adjustable interior fixtures (applicable as household adaptation measure)
- Community-managed boat routes (relevant but only for emergency mobility)
- Sandbags; informal barriers (relevant for short term coping measure during flood events)

Avoid (Low value, high cost)

Measures that are in those zones require large-scale engineering without demonstrable benefit for the community and are therefore not prioritized in favor of measures that perform better for their relative cost.

- Check dams; riparian buffers
- Street-level check dams
- Secondary Backup Dikes
- Amphibious Housing
- Underground Cisterns & Reservoirs (may be used for formal surrounding areas only, not applicable within informal settlement)
- Infiltration Trenches

4.5.4 Final selected measures

Final Selected Physical and Spatial Measures

Measure	Priority
• Sloped surfaces and gravity channels	1
• Elevated ground floors	1
• Elevated utility equipment	1
• Elevated structures by local builders	1
• Manual dredging and channel clearing	1
• Roof tanks and collection containers	1
• Portable sanitation and water purification	1
• Waterproof construction materials	1
• Upper floor refuge and rooftop shelter	1
• Drainage system improvements	2
• Bioretention cells and rain gardens	2
• Bioswales	2
• Permeable pavements	2
• Green roofs	2
• Levee with flap valve	2
• Elevated pedestrian networks	2
• Floodable public spaces	2
• Grid-based urban layout	2
• Adjustable interior fixtures	conditional
• Sandbags; informal barriers	conditional
• Underground cisterns and reservoirs	conditional

4.6 Design Elaboration

Final Selected Governance and Social Measures

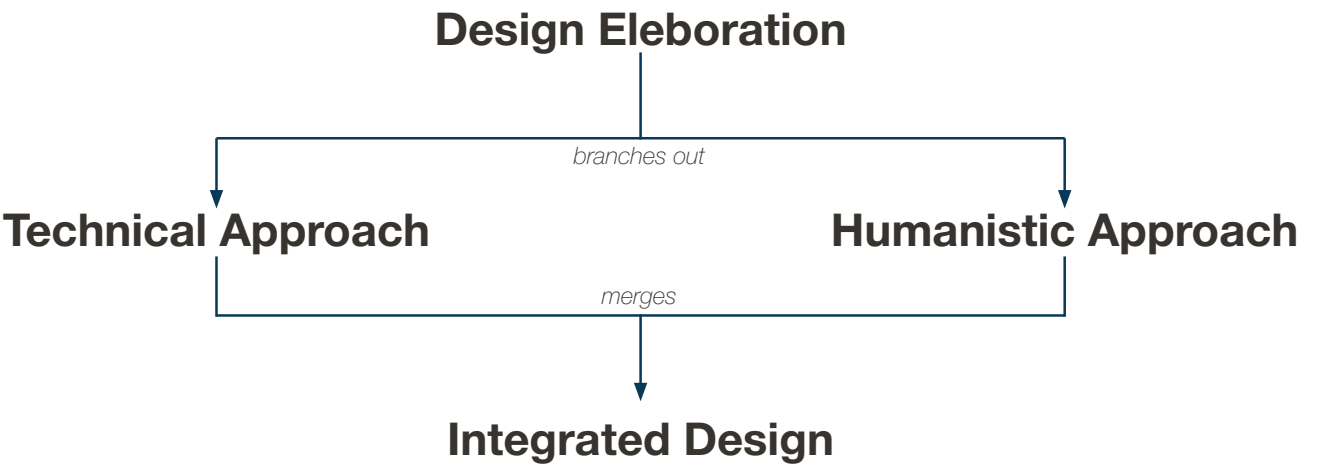
Measure	Priority
• Community organizations and collective action	1
• Community risk mapping and participatory planning	1
• Rainfall gauge and forecasting models	1
• Educational programs for waste management	1
• Traditional observation systems	1
• Community hazard awareness	1
• Temporary business relocation	1
• Flexible informal income activities	1
• Occupational diversification	1
• Reconstruction standards and green building	2
• Zoning regulations	conditional
• Building code standards	conditional
• Emergency procedures and data backup	conditional
• NGO rebuilding and livelihood programs	conditional
• Community-managed boat routes	conditional
• Traditional site settlement site selection	conditional

The design elaboration translates the vision, concept, and selected measures into a concrete spatial proposal for the neighborhood. It is organized across three interconnected approaches that together constitute the full design response. The technical approach addresses physical and infrastructural dimensions of flood resilience, a humanistic approach addresses the social and community dimensions, and an integrated design merges both into a coherent neighborhood-scale proposal

The two approaches do not operate independently. They branch from the same analytical and evaluative foundation before converging in the integrated design. The analysis established the neighborhood’s environmental, spatial, and social conditions. This shared analytical base informs both branches simultaneously: the technical approach responds to physical conditions, while the humanistic approach responds to socio-spatial conditions

The evaluation of measures reinforces both branches equally. Physical and spatial measures selected from the catalogue feed directly into the technical approach. Governance and social measures feed into the humanistic approach.

The humanistic approach additionally draws on the theory of socio-spatial resilience, which establishes design principles for how shared spaces and neighborhood anchors can reconstruct community life and strengthen social cohesion in the context of urban vulnerability.



4.6.1 Technical Approach

Addresses the physical and infrastructural dimensions of flood resilience through flood resilience strategies, a drainage hierarchy plan, a zoning map, and before-and-after mapping that demonstrates the spatial transformation proposed.

4.6.1.1 Flood Resilience Strategy Maps

The selected final physical measures from the evaluation are made visible through concrete design interventions presented in these flood resilience strategy maps showing where they are located within the neighborhood. Measures are grouped on the same strategy map based on similar qualities.

Physical and Spatial Measures

-  Sloped surfaces and gravity channels

 Elevated ground floors

 Elevated utility equipment

 Elevated structures by local builders

 Manual dredging and channel clearing

 Roof tanks and collection containers

 Portable sanitation and water purification

 Waterproof construction materials

 Upper floor refuge and rooftop shelter

 Drainage system improvements

 Bioretention cells and rain gardens
-  Bioswales

 Permeable pavements

 Green roofs

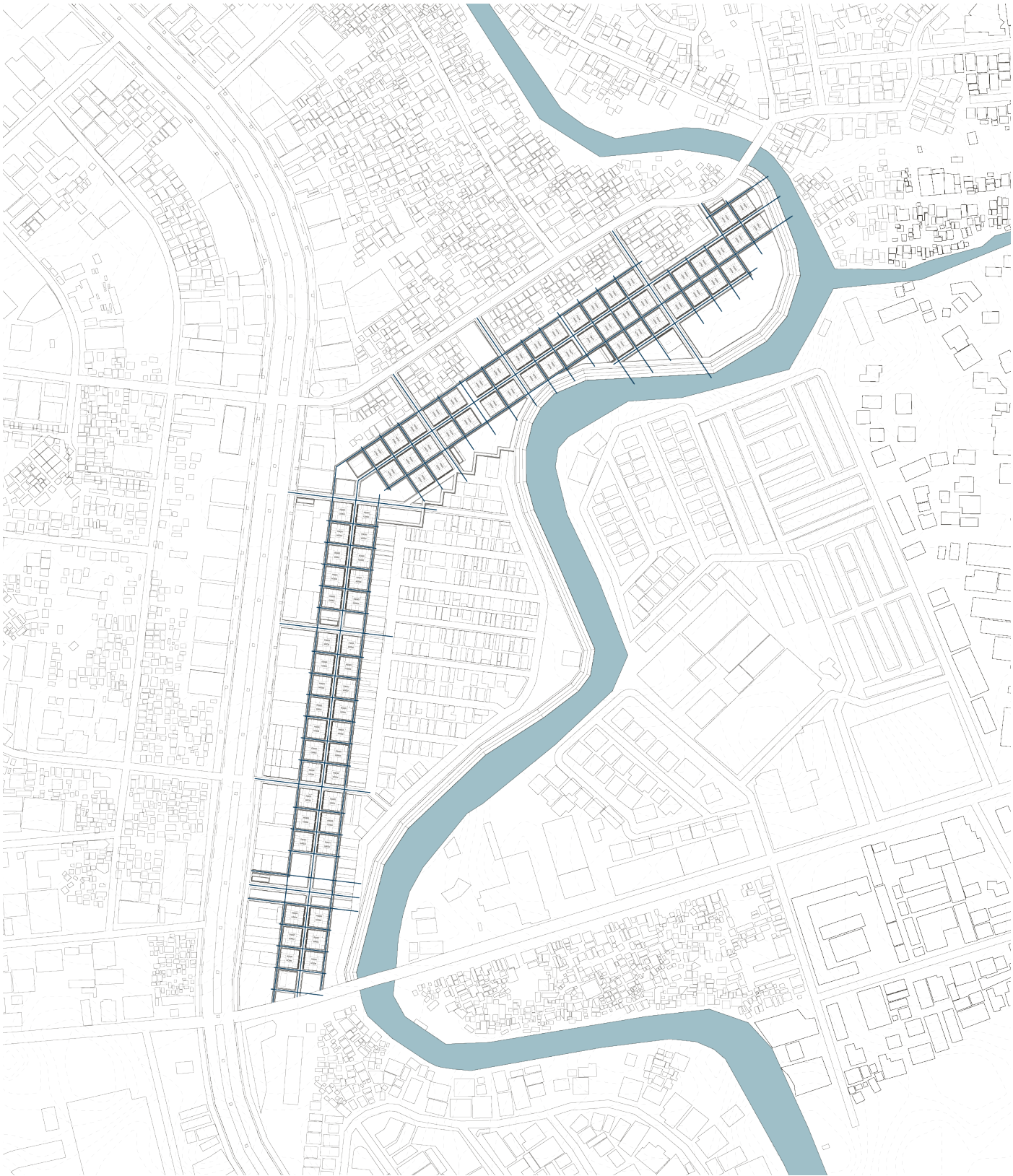
 Levee with flap valve

 Elevated pedestrian networks

 Floodable public spaces

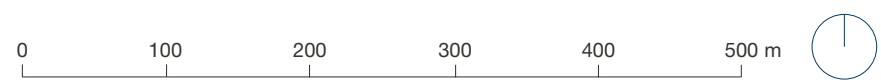
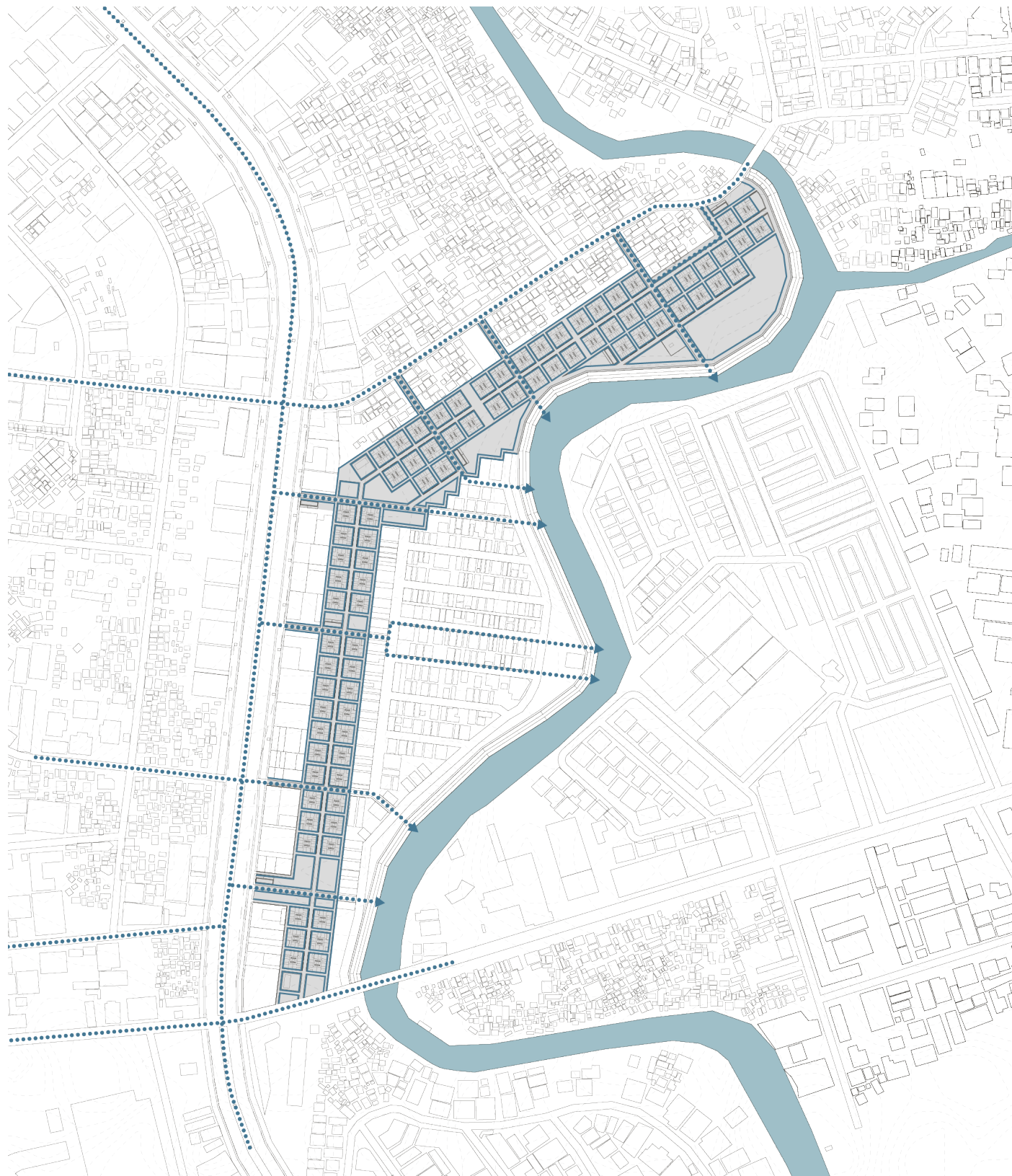
 Grid-based urban layout

 Underground cisterns and reservoirs



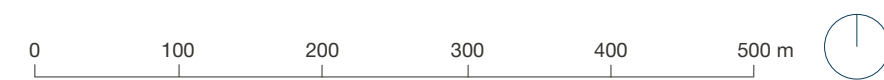
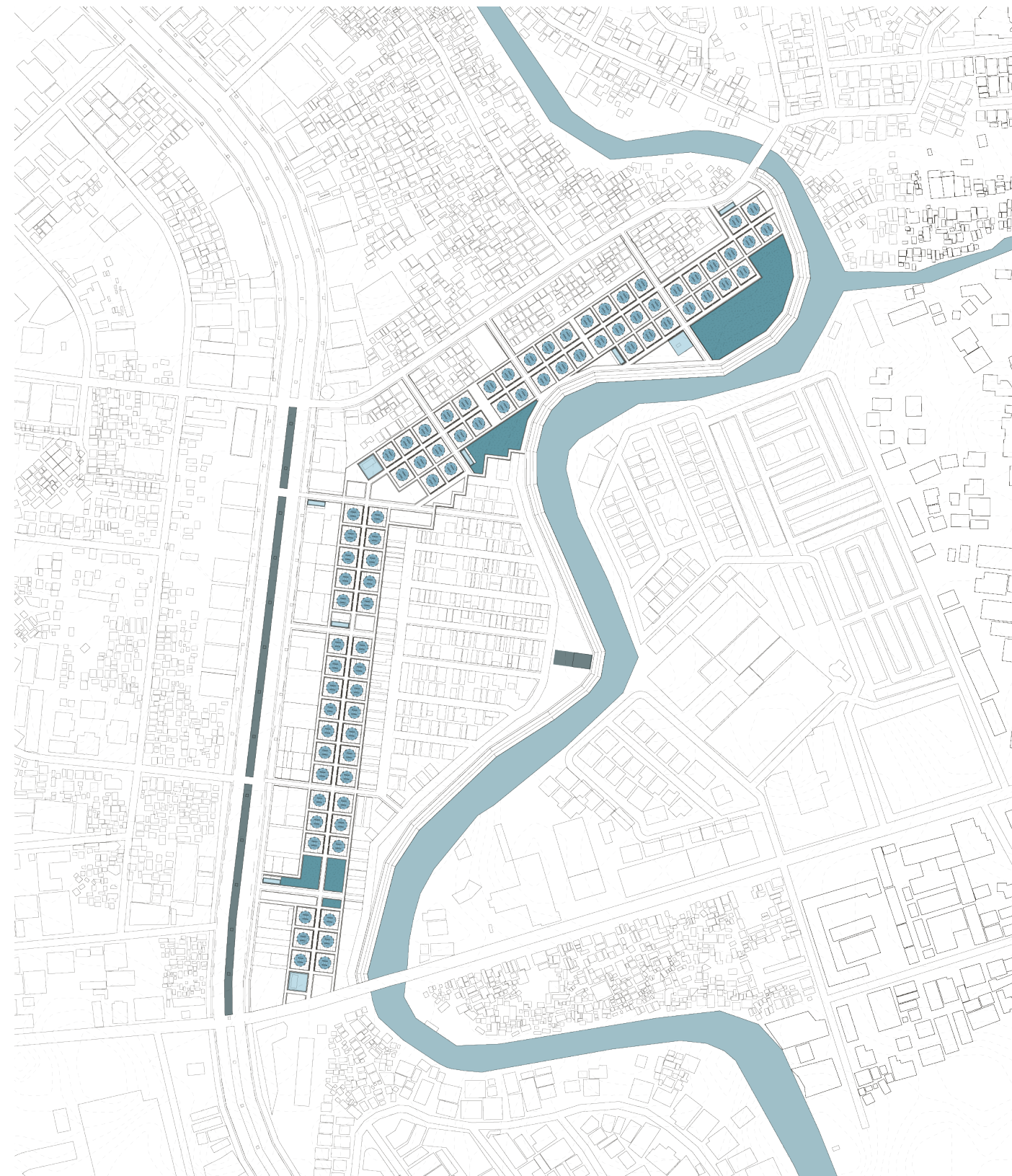
Upgrade urban layout

-  Grid-based urban layout
- 



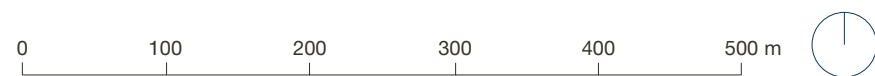
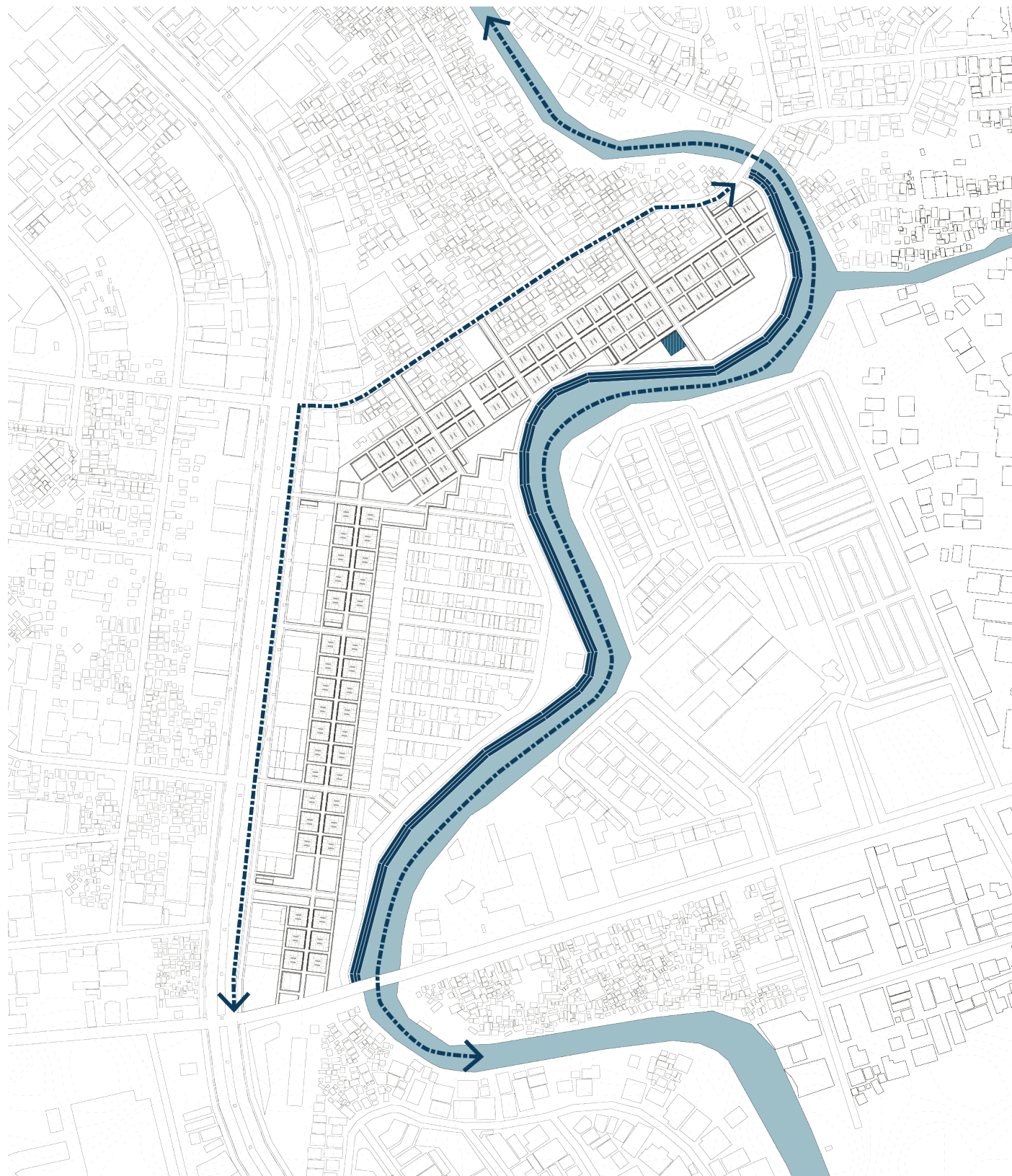
Enhance ground drainage

-  Sloped surfaces and gravity channels
-  Bioswales
-  Permeable pavements



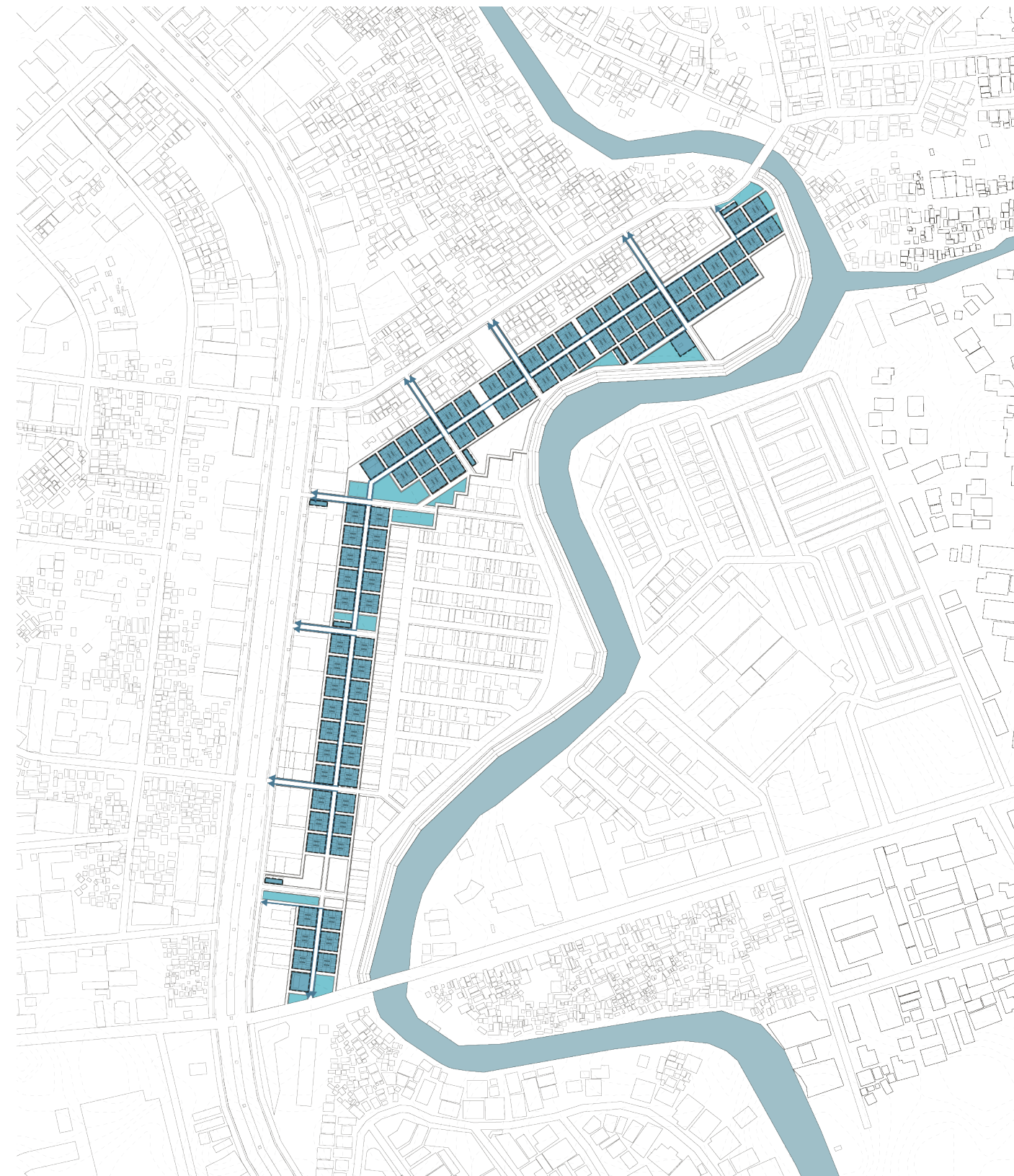
Store and absorb water

-  Bioretention cells and rain gardens
-  Roof tanks and collection containers
-  Underground cisterns and reservoirs
-  Green roofs



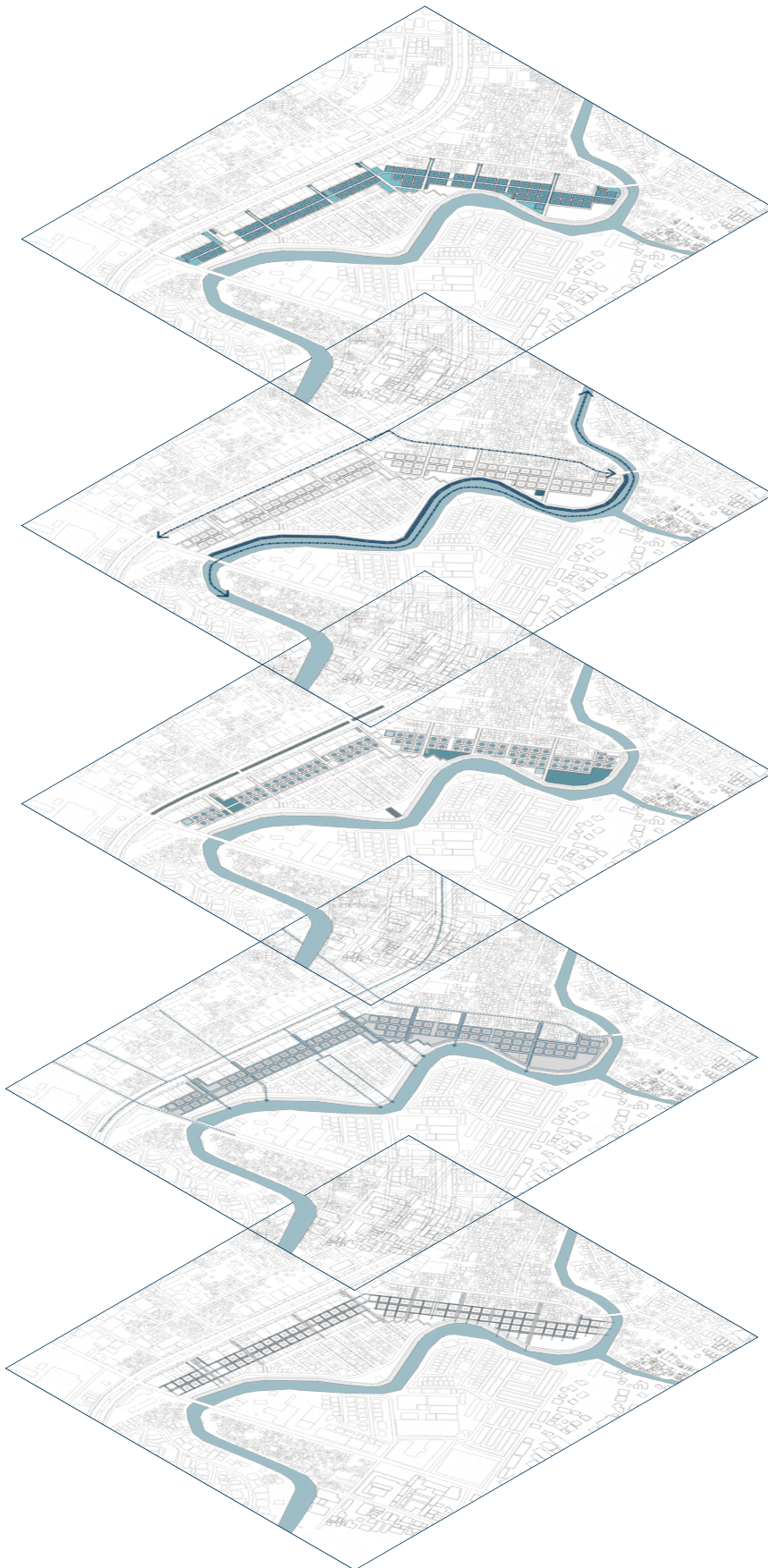
Structural defense

-  Levee with flap valve 
-  Drainage system improvements 



Accommodate water

-  Elevated ground floors 
-  Elevated utility equipment 
-  Elevated pedestrian networks 
-  Floodable public spaces 



Accommodate water



Structural defense



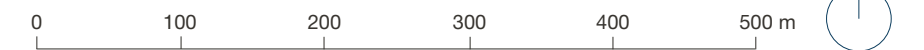
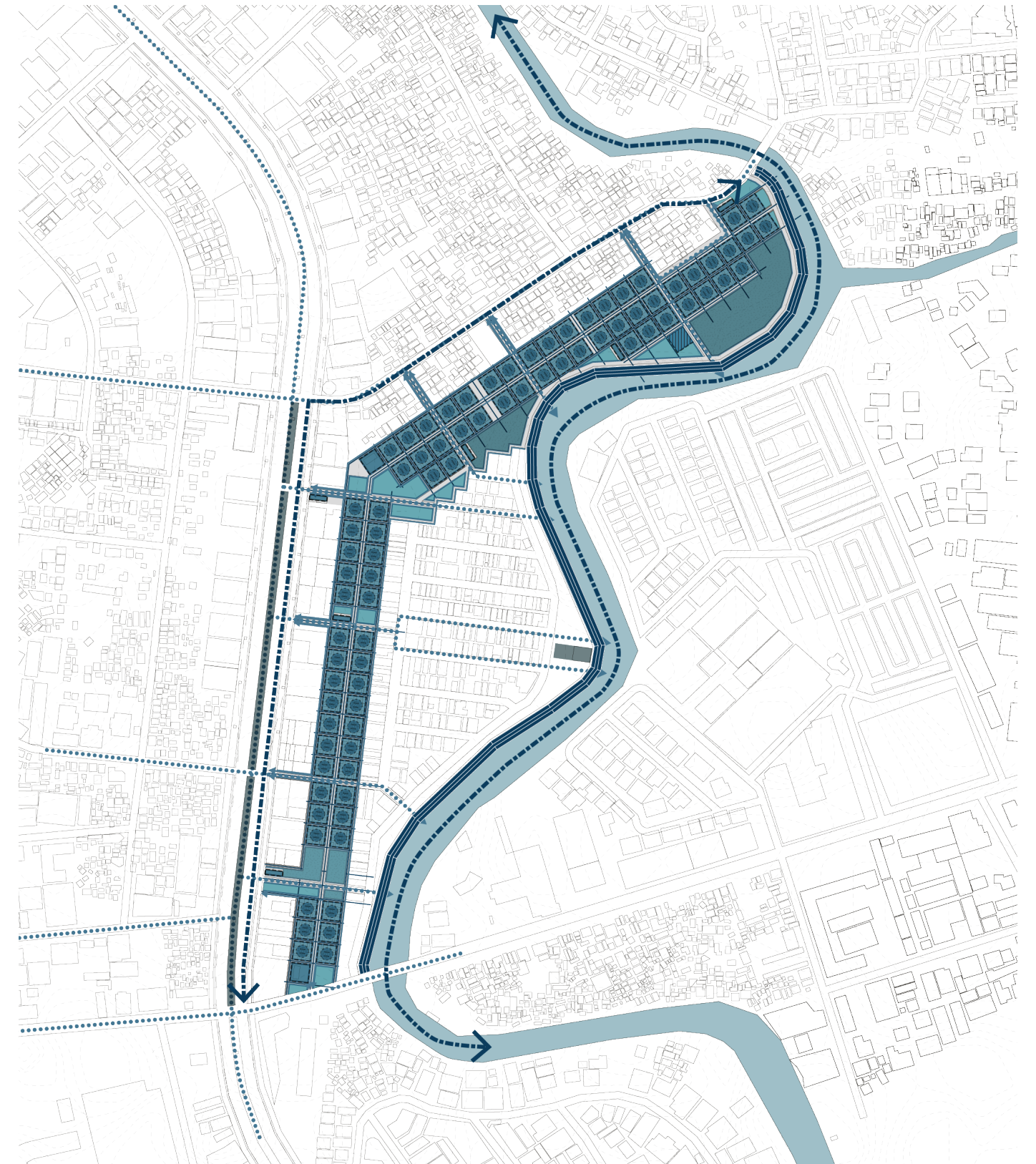
Store and absorb water



Enhance ground drainage



Upgrade urban layout



Layering of flood resilience strategies

Synthesized flood resilience strategy map

4.6.1.2 Drainage Hierarchy

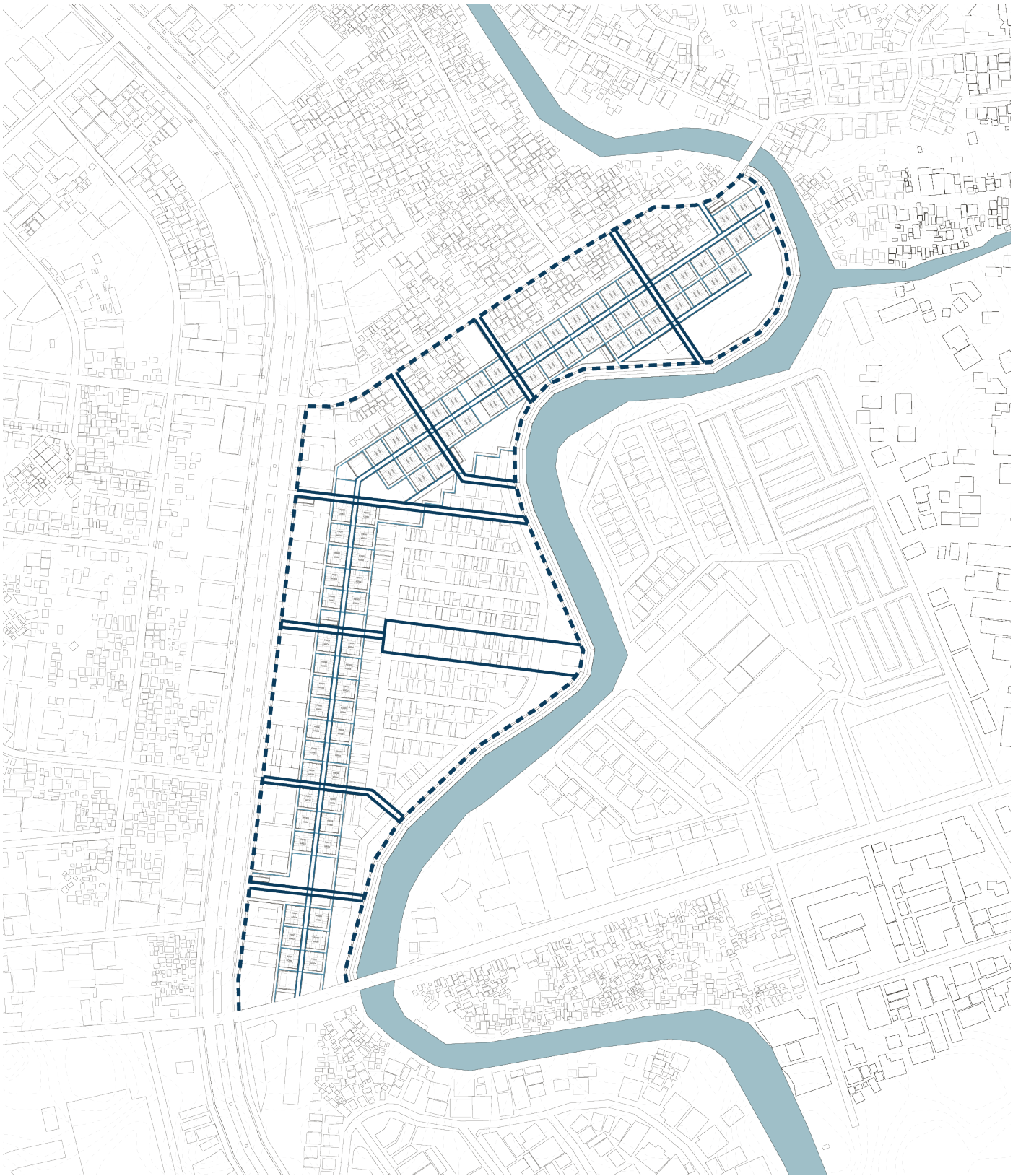
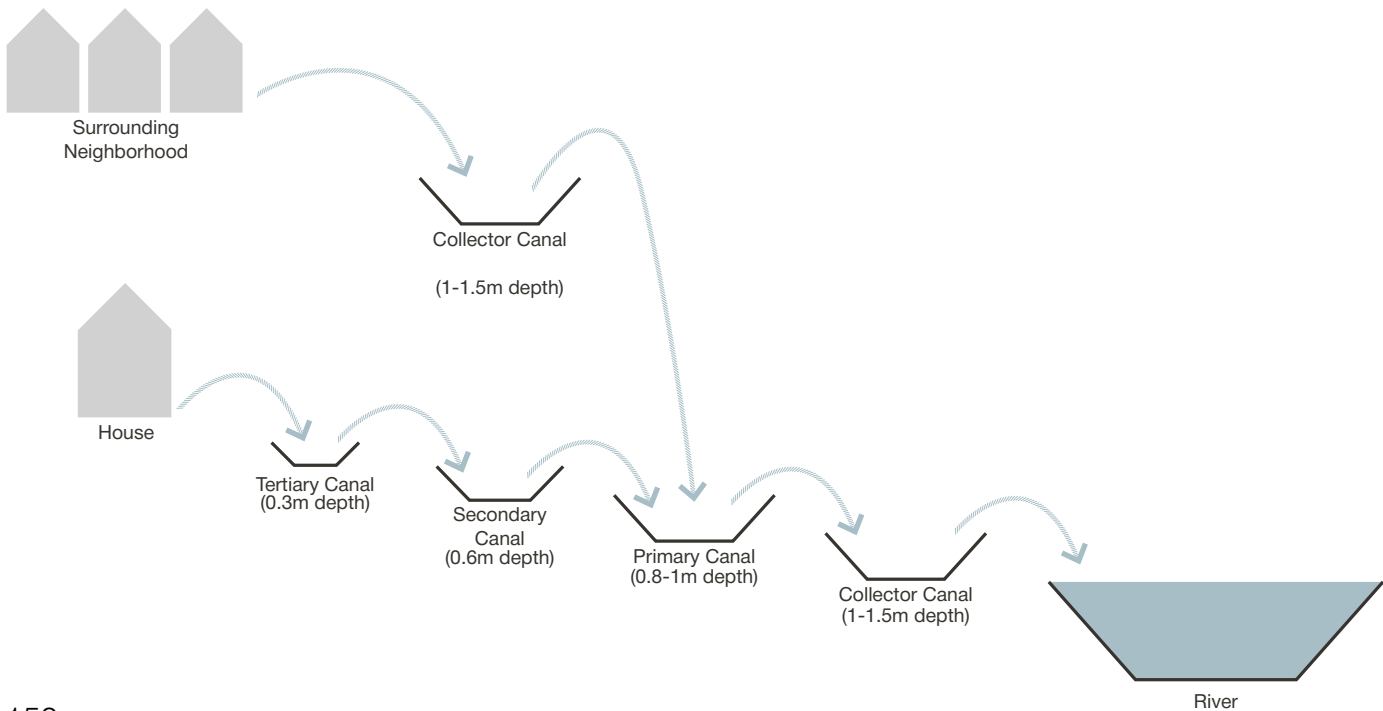
The drainage hierarchy plan establishes the primary organizational ground logic of the technical approach. It introduces a structured system of water conveyance within the informal settlement where none currently exists. The absence of any drainage hierarchy is one of the most critical spatial deficiencies identified in the neighborhood analysis. Without an organized network of channels, stormwater has no directed path of escape and accumulates extensively across road surfaces and low-lying areas. The hierarchy plan directly addresses this challenge by defining clear relationships among drainage levels and organizing the movement of surface water from the settlement’s interior toward the San Juan River in a controlled and legible sequence.

The hierarchy operates across three levels. At the smallest scale, tertiary channels receive rainfall directly from rooftops and immediate ground surfaces at the household level. These tertiary channels feed into secondary canals that run along the neighborhood’s main street, collecting and conveying water from multiple tertiary inputs across the settlement. Secondary canals, in turn, discharge into the primary canal. These primary canals carry the accumulated stormwater toward the river edge. Along the levee, water is collected and held before being released through the flap valve into the San Juan River, preventing backflow during peak river levels while allowing discharge when conditions are suitable.

The hierarchy also addresses surface runoff from adjacent formal areas. The drainage hierarchy plan intercepts this runoff through collective edge canals positioned along the formal-informal boundary, redirecting it into the primary canal network rather than allowing it to accumulate within the settlement interior

It should be noted that the precise dimensions of the proposed canals are conceptual at this stage. Accurate sizing would require detailed hydrological modeling, which is beyond the scope of this design proposal.

Water flow diagram



Drainage hierarchy plan



4.6.1.3 Zoning

The zoning map divides the neighborhood into three elevation-based zones, each characterized by its flood exposure characteristics and assigned a corresponding spatial strategy. Instead of imposing formal planning strategies, the zoning logic emerges directly from the neighborhood's topographic analysis. The logic uses elevation as the primary determinant of what can be built and what program it can accommodate. This approach acknowledges that, in a low-lying basin condition where there is recurring flooding, the ground must determine the patterns of occupation.

Low Zone (3 meters to 7 meters)

Characteristics:

Deepest flooding, longest duration, highest risk

Strategy:

Water storage, minimal permanent structures, permeable ground



Mid Zone (7 meters to 11 meters)

Characteristics:

Regular flooding, moderate risk

Strategy:

Flexible functions



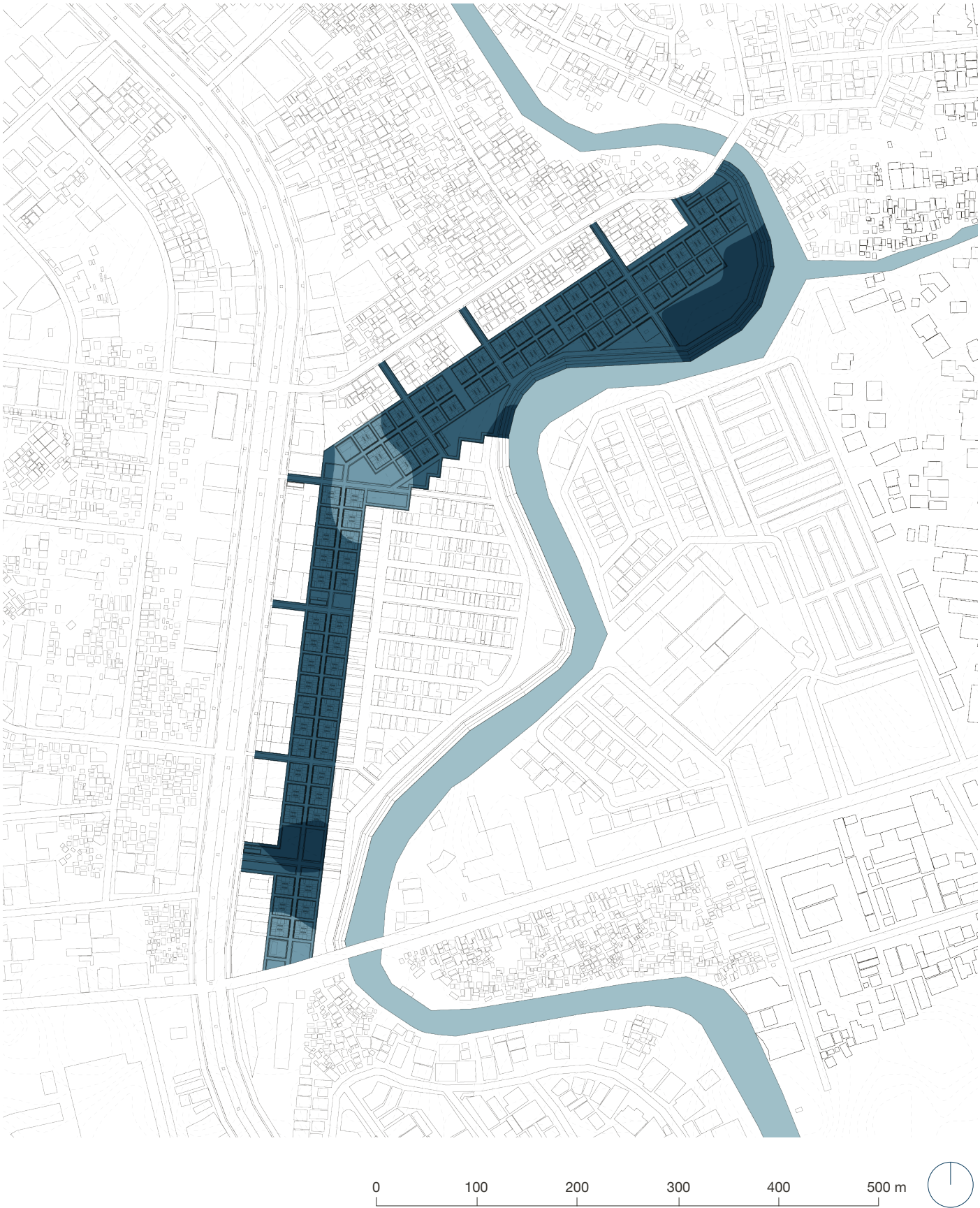
High Zone (11 meters +)

Characteristics:

Regular flooding, lowest risk

Strategy:

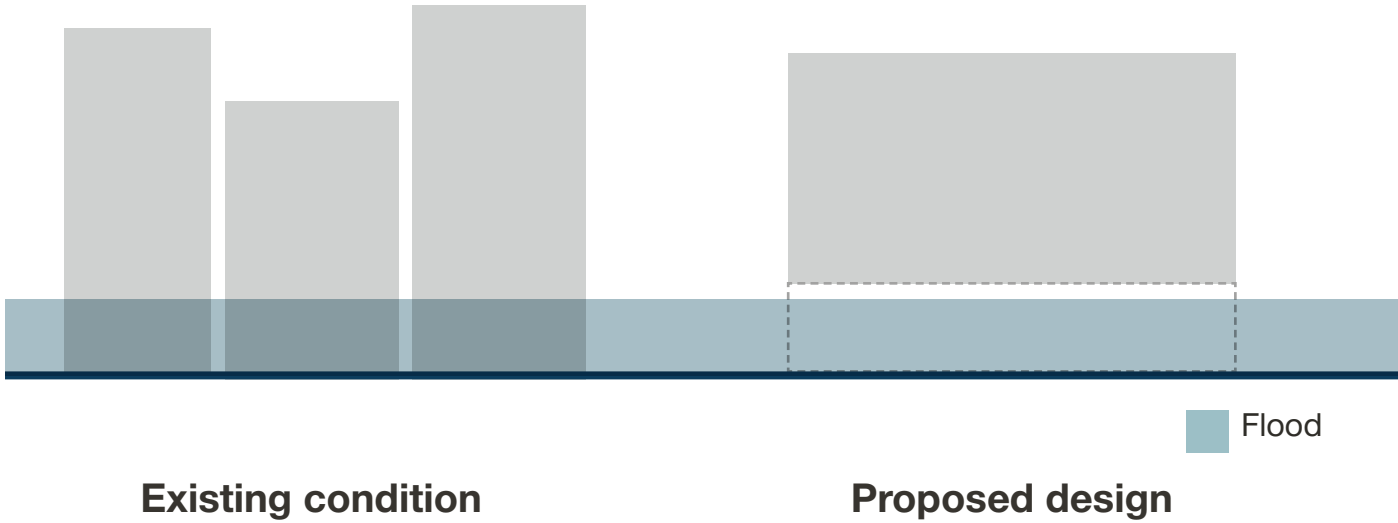
Critical services, community facilities



Zoning map

4.6.1.4 Design improvements

The design proposal does not eliminate flooding within the low-lying basin scale. Flooding is an inevitable consequence of the neighborhood’s topographic condition, compound flood typology, and position within the San Juan River catchment. However, the project transforms flooding from a destructive and unmanaged event into a manageable spatial condition. This is done by reducing its intensity, improving how water moves through the neighborhood, and ensuring that residents can maintain habitability and continuity of daily life even during flood events.

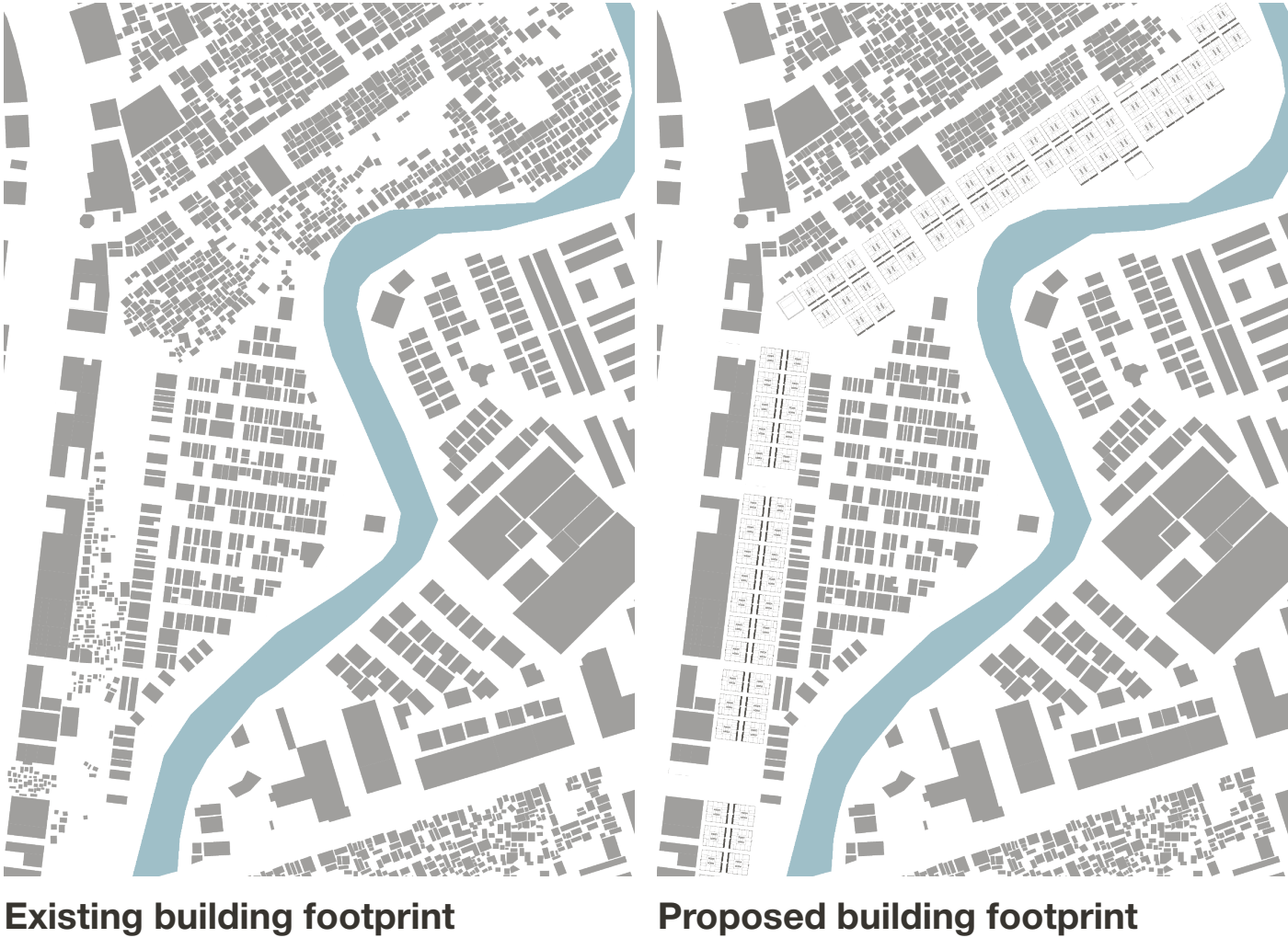


In the settlement’s existing conditions, near-total imperviousness, absent drainage hierarchy, and blocked channels force stormwater to accumulate vertically. In effect, water has nowhere to go and rises in places where it damages structures, displaces residents, and contaminates domestic spaces. The design reconfigures the ground as a permeable, connected, and hierarchically organized system. By opening up the surface, floodwater spreads horizontally across a managed network, reducing peak depth locally, accelerating drainage to the river, and limiting damage to structures and utilities.

The improvements can be understood across three dimensions. Flood depth is locally reduced as water spreads across a larger permeable surface area rather than concentrating in solid-blocked areas. Flood duration decreases as the drainage hierarchy provides organized conveyance toward the San Juan River outlet, thereby accelerating the recession of floodwater after peak events. Flood damage is reduced through the elevation of houses, walkways, and utility infrastructure above the threshold of habitable flood depth.

The total area reconfigured as permeable surface, detention space, and open ground amounts to approximately 56,114 sqm. The storage volume this generates varies across the three elevation zones, being deeper in the low zone and shallower in the medium and high zones. A precise volumetric calculation would require detailed hydrological modeling, which is beyond the scope of this project. Nonetheless, the freed-up area demonstrates the scale and extent of ground reconfiguration.

The 1.2-meter elevation is adjusted to the Quezon City government’s (2022) established threshold of 0.5 meters as the maximum acceptable flood depth before flooding begins to pose risks to life and property. By elevating structures to 1.2 meters, the design ensures that residents remain 0.5 meters above the flood surface, maintaining habitability and continuity of daily life. Ultimately, this elevation is high enough to protect against everyday and moderate flooding and low enough to prohibit illegal habitation.



4.6.2 Humanistic Approach

The humanistic approach addresses the social and community dimensions of flood resilience in Barangay Tatalon. Where the technical approach reorganizes the neighborhood’s physical and infrastructural logic, the humanistic approach works on the social fabric, aimed at strengthening the relationships, spaces, and practices that enable a community to prepare for, respond to, and recover from flooding together.

4.6.2.1 Socio-spatial Resilience Strategy Maps

Drawing from the socio-spatial resilience theory and the work documented in Mission Neighbourhood (2023), the approach is organized around four spatial strategies and the establishment of neighborhood anchors that serve as the social infrastructure of the neighborhood.

Strengthening the neighborhood

The compact neighborhood

Social Infrastructure

Reclaiming streets

Nature in the neighborhood

Social measures

- Community organizations

Community risk mapping

Rainfall gauge and forecasting

Educational program waste management

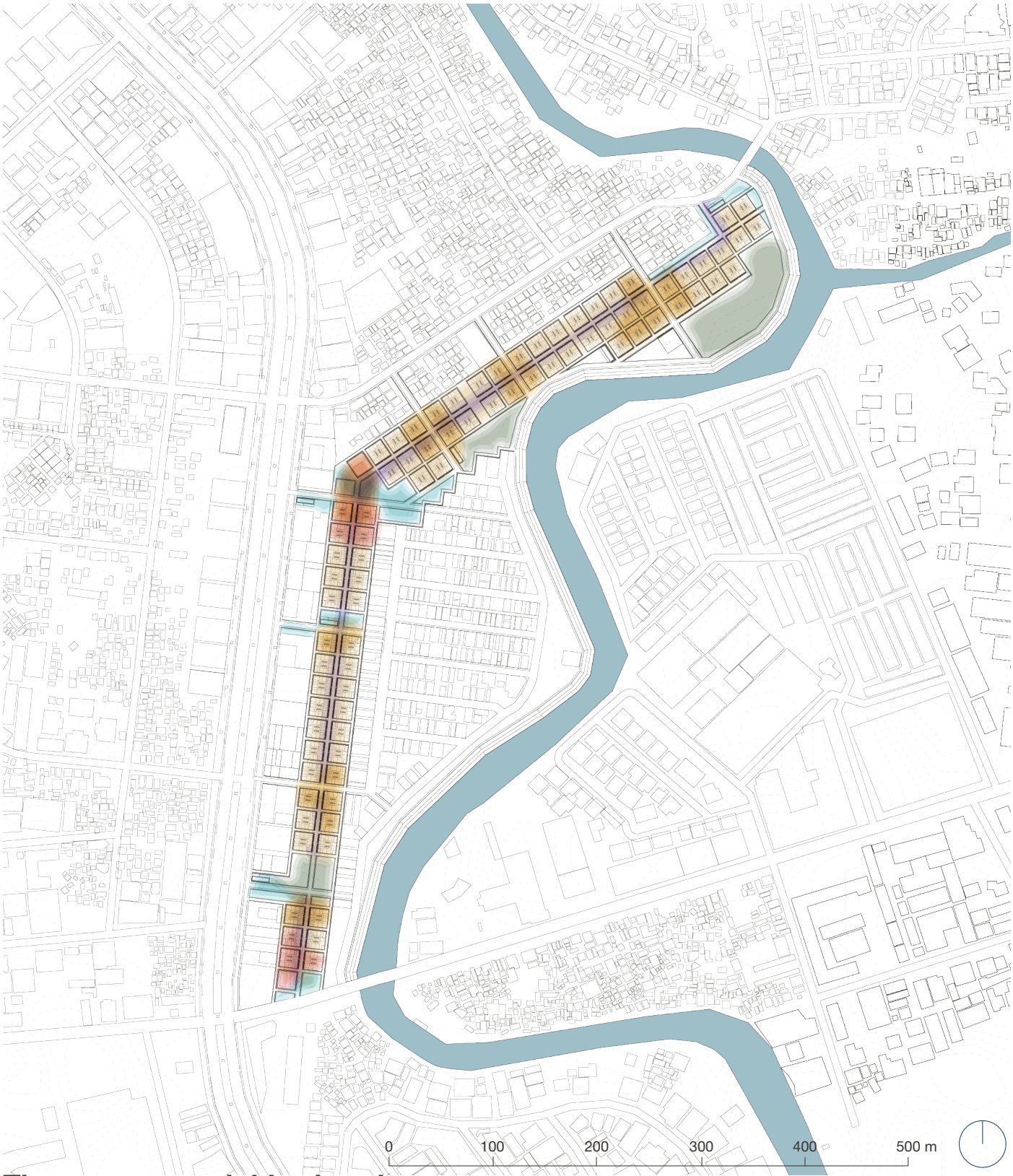
Traditional observation systems
- Community hazard awareness

Temporary business relocation

Flexible informal income activities

Occupational diversification

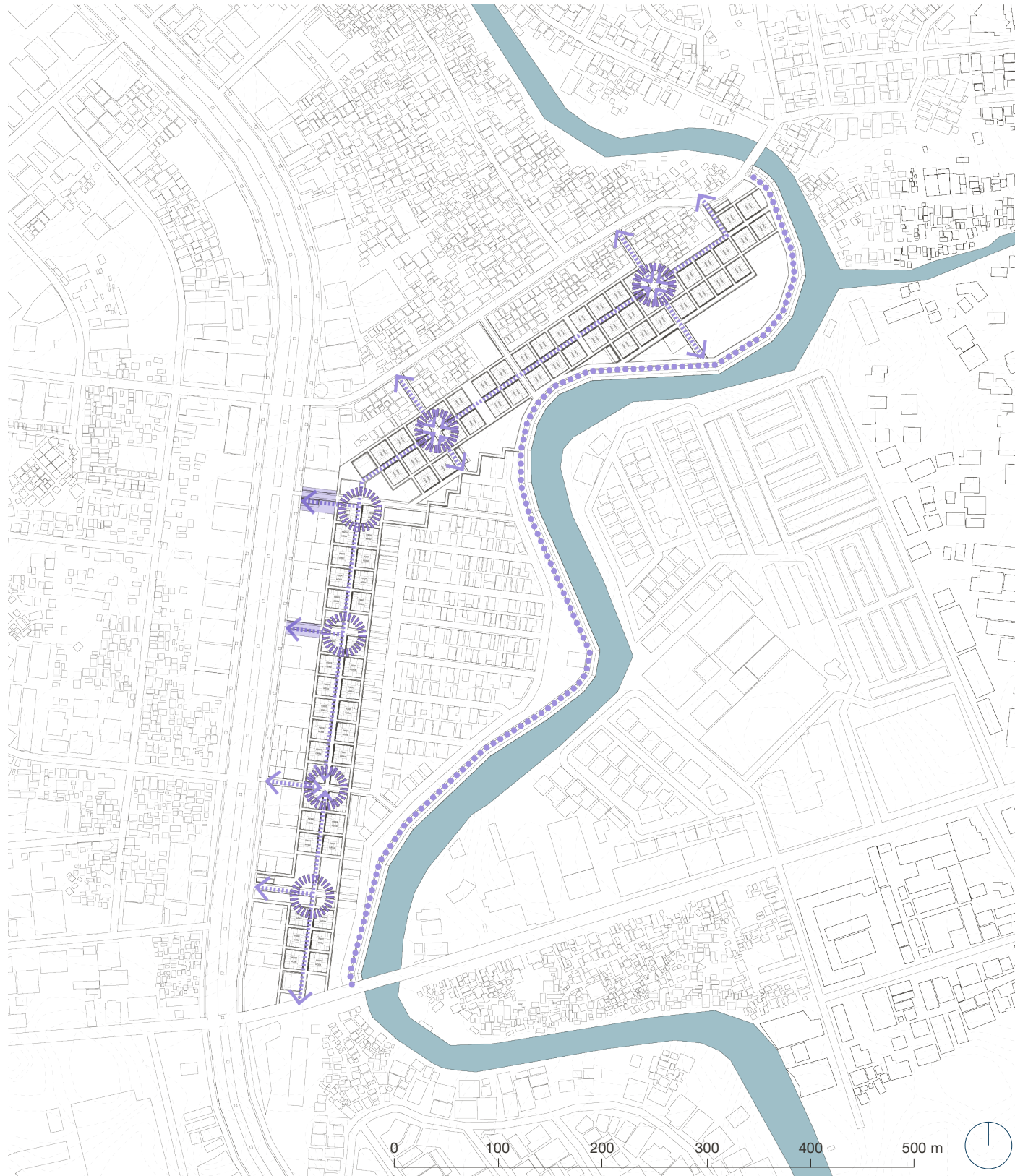
Reconstruction standards



The compact neighborhood

This map proposes a loose zoning organized around the principle of accessibility, which ensures that essential functions are within reach of all residents regardless of their position within the settlement. Six characteristic zones are identified: a low zone green space along the most flood-exposed areas of the settlement, an essential zone accommodating health and service facilities, a potential node zone identifying locations of highest spatial opportunity for community gathering, a commercial zone along the primary spine, a community zone for shared programming and collective activities, and a residential zone occupying the remaining fabric. These zones do not prescribe precise locations for individual functions but establish a spatial logic for their distribution that prioritizes accessibility for the settlement’s vulnerable residents.

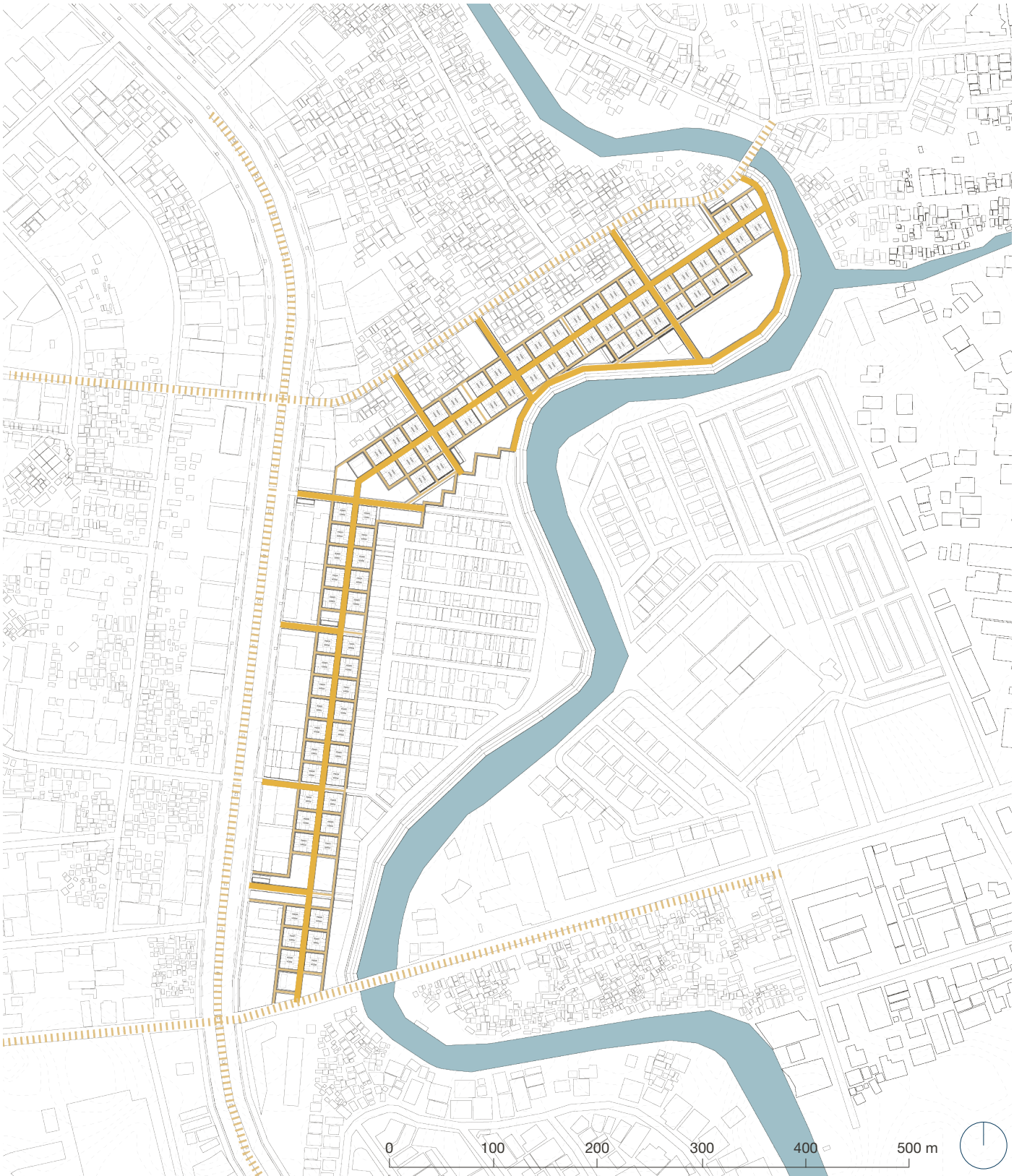
- Low Zone (open green space)
- Essential Zone (health, services)
- Potential Node Zone
- Commercial Zone
- Community Zone
- Residential Zone



Social infrastructure

The social infrastructure map establishes two main strategies that activate community life. Main links and ground-floor activation serve as the primary corridors through which local commerce, informal trade, and everyday economic activity are concentrated. Touchpoints identify the functional everyday community spaces distributed across the settlement. These are accessible and flexible spaces where residents gather, exchange, and maintain social connections. Together with new access points and connections, this strategy aims to strengthen social cohesion

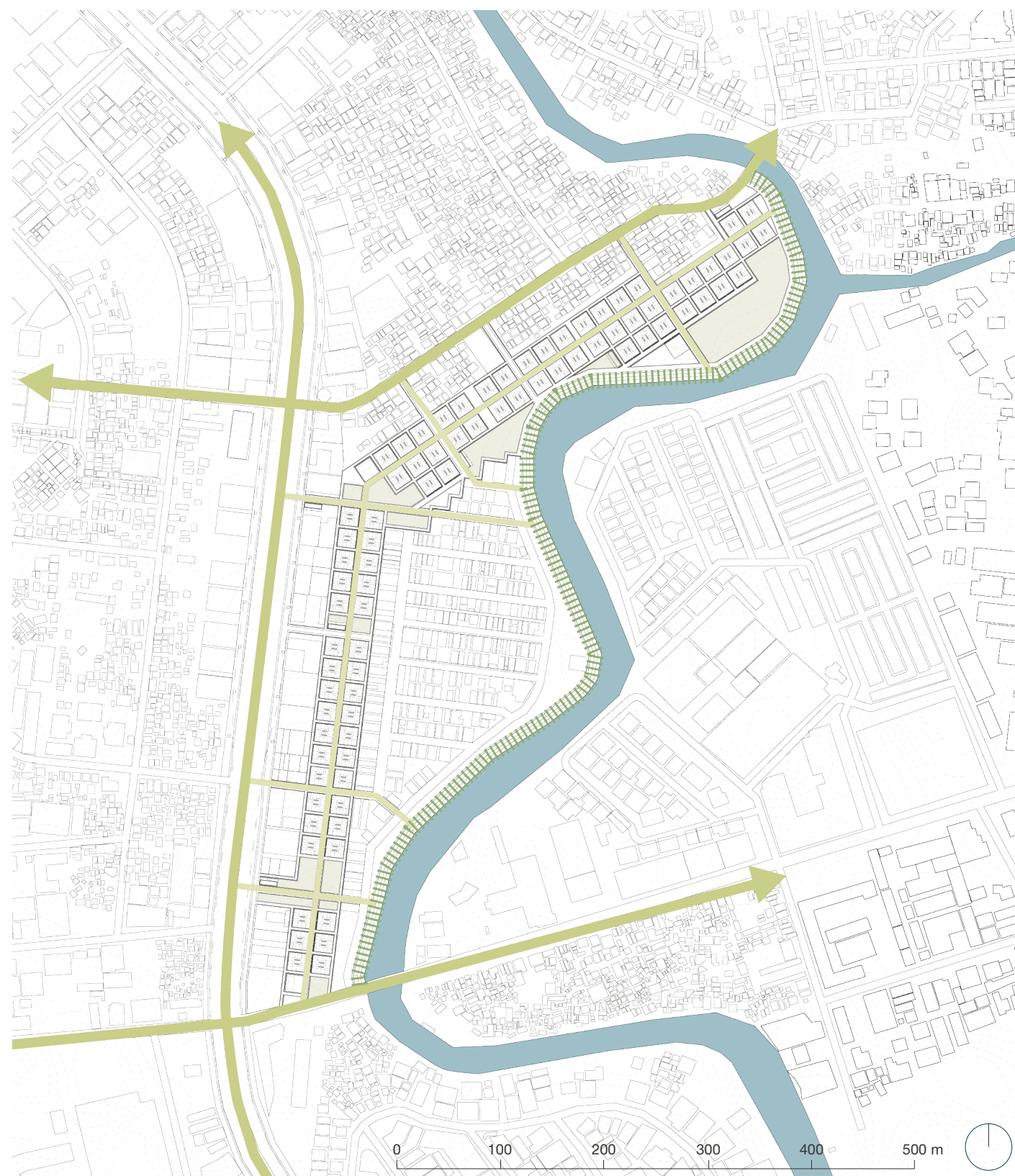
- Main link and ground floor activation 
- Levee as social connector 
- Touchpoints 
- Reclaiming open space 



Reclaiming streets

The reclaiming streets map addresses the quality of movement and public space within the settlement. A new main street and neighborhood spines are designed as a shared civic space that simultaneously serves drainage, pedestrian movement, and social activation. Secondary streets branching from the spine are made legible and safe across the settlement. Along the site boundary, existing streets are upgraded to improve integration between the informal settlement and the surrounding formal area. Better streets lead to more social contact, more economic activity, and stronger community bonds that directly contribute to collective flood

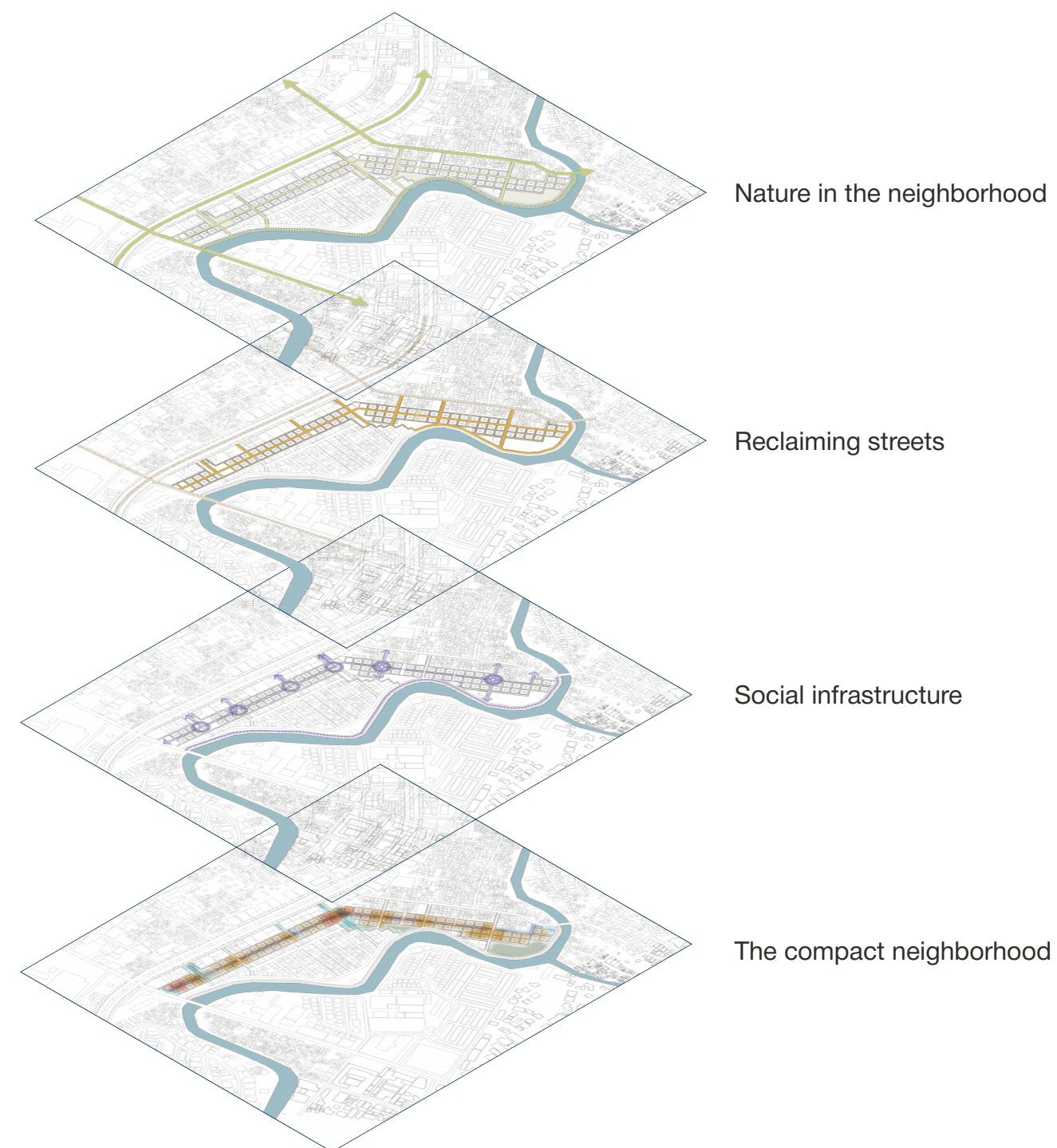
- Main quality street 
- Secondary street 
- Improve existing street 



Nature in the neighborhood

This map shows the settlement's green infrastructure network, starting with the main green corridor and connecting to the secondary green corridor. Secondary green corridors follow the drainage hierarchy established in the technical approach. This serves as both an ecological and a hydraulic strategy. Public green spaces are located at key nodes within the neighborhood, providing open, accessible spaces for the community.

- Main green corridor 
- Secondary green corridor 
- Levee as green public space 
- Public green space 



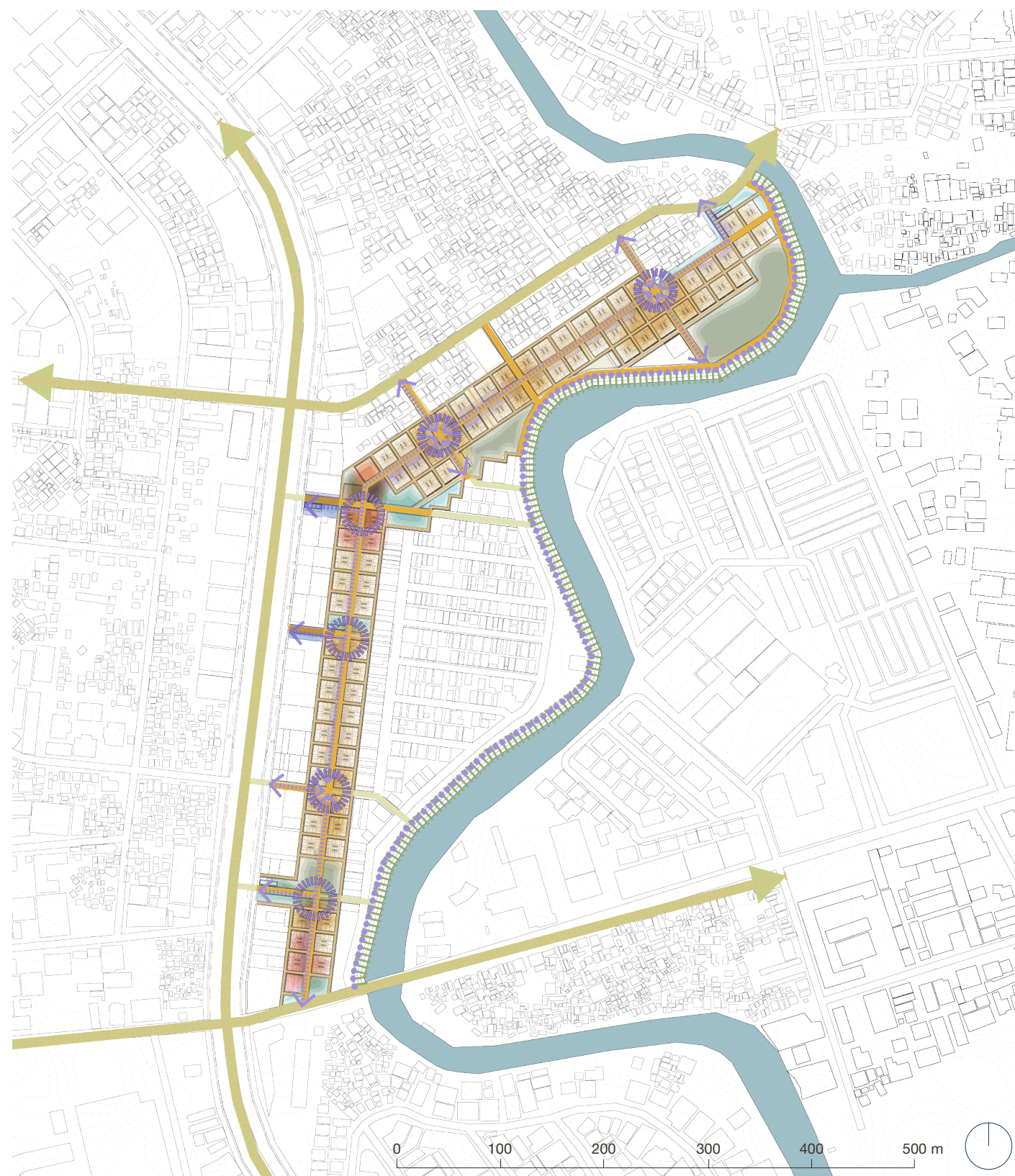
Nature in the neighborhood

Reclaiming streets

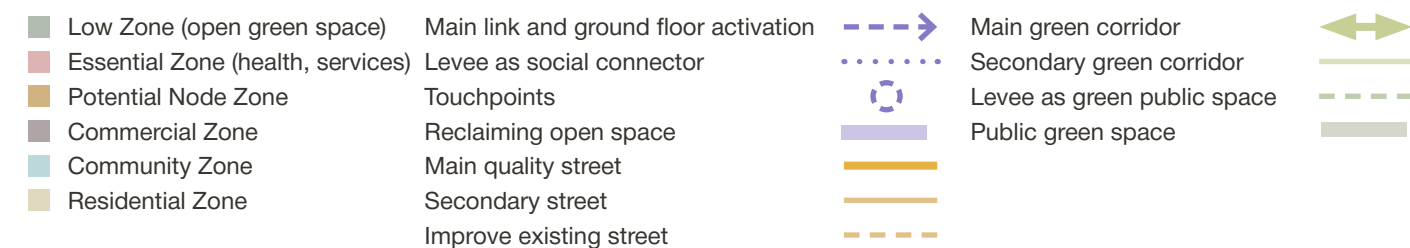
Social infrastructure

The compact neighborhood

Layering of socio-spatial resilience strategies

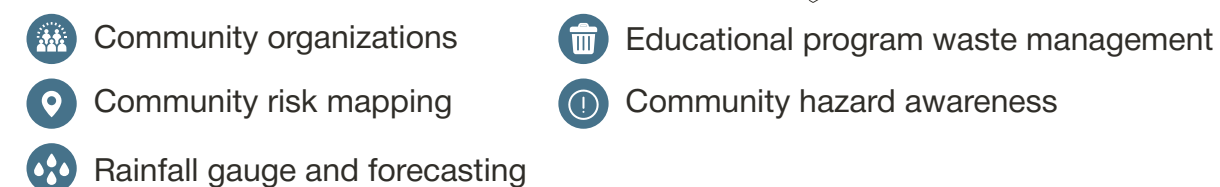
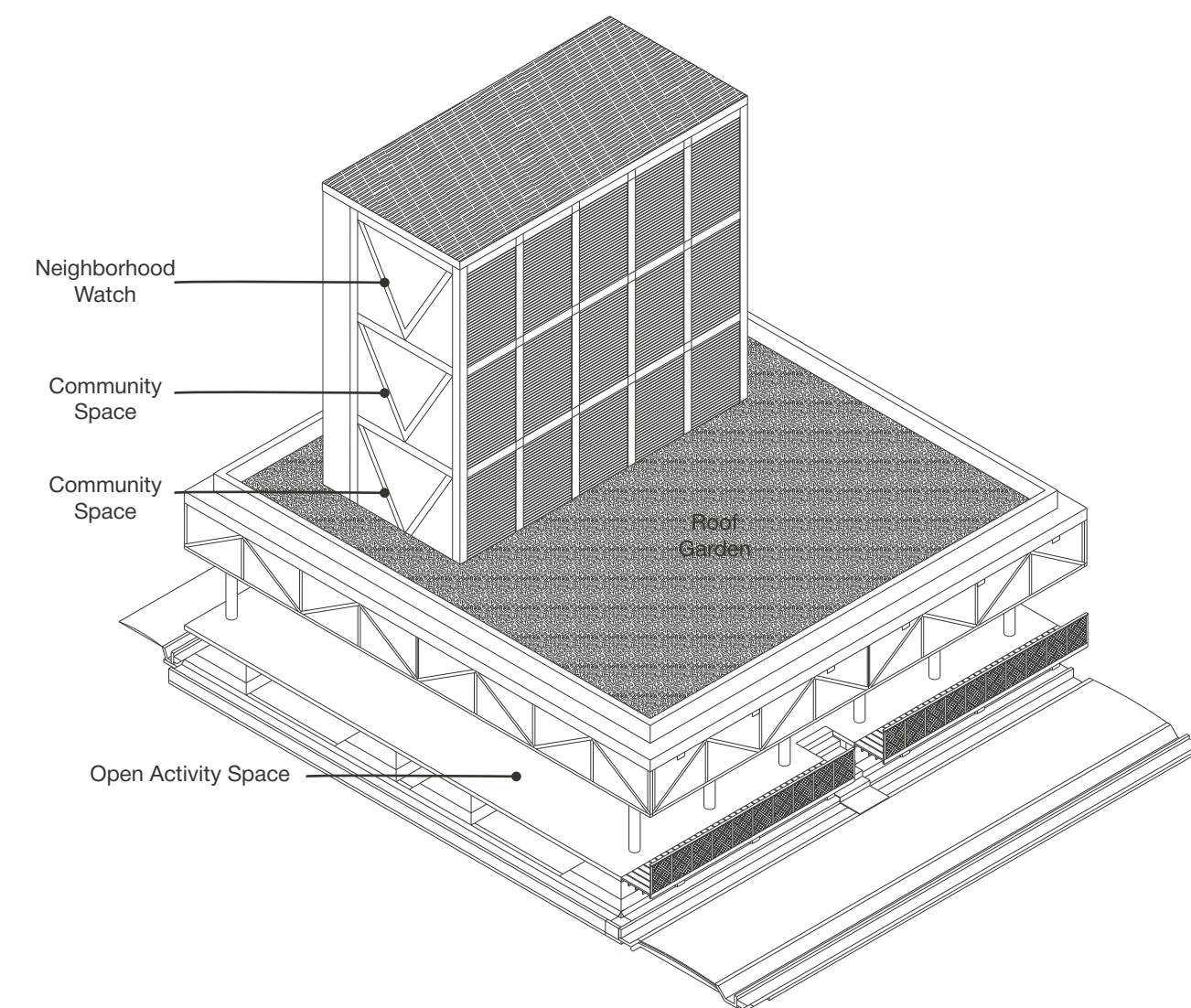


Synthesized socio-spatial resilience strategy map



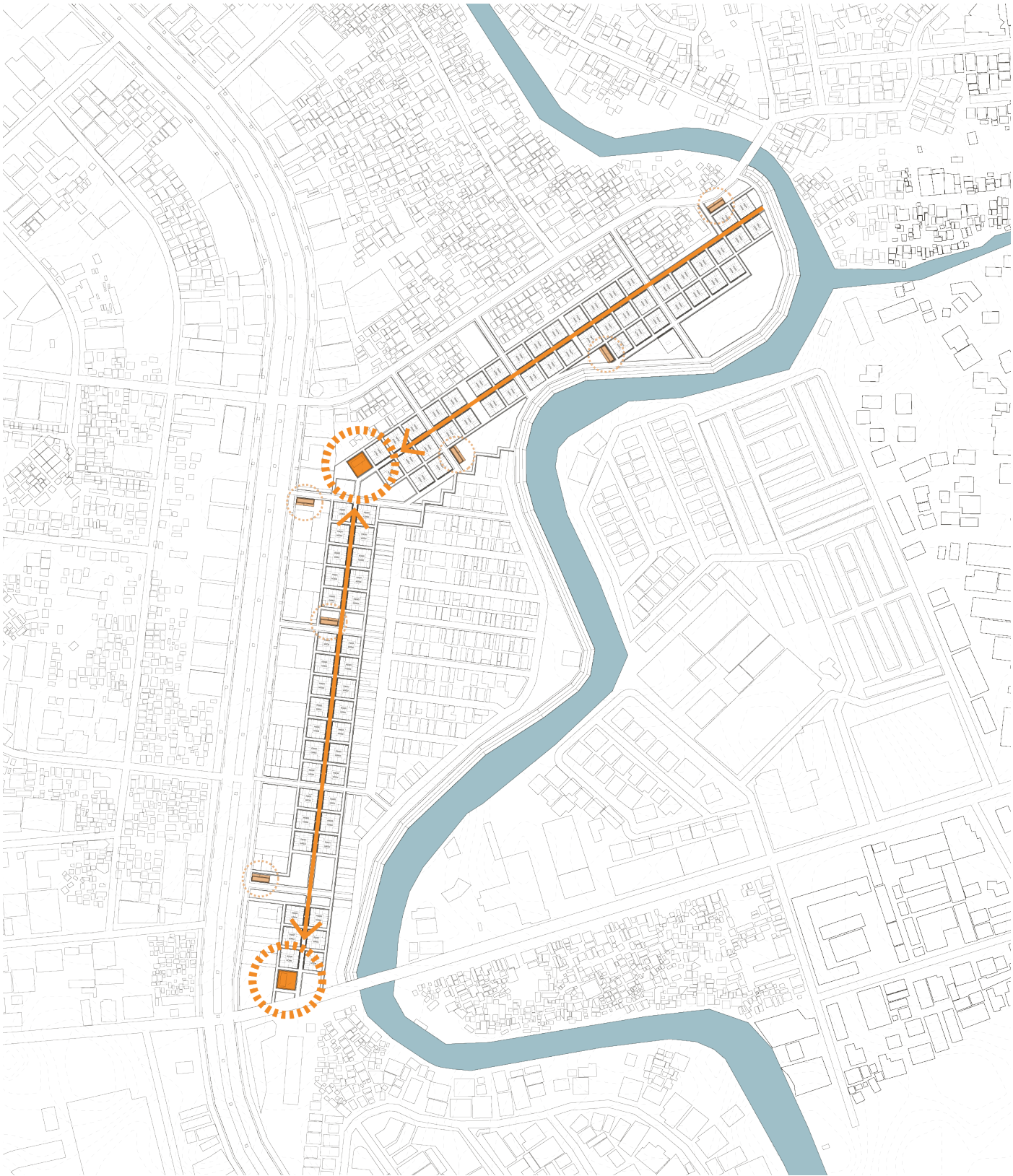
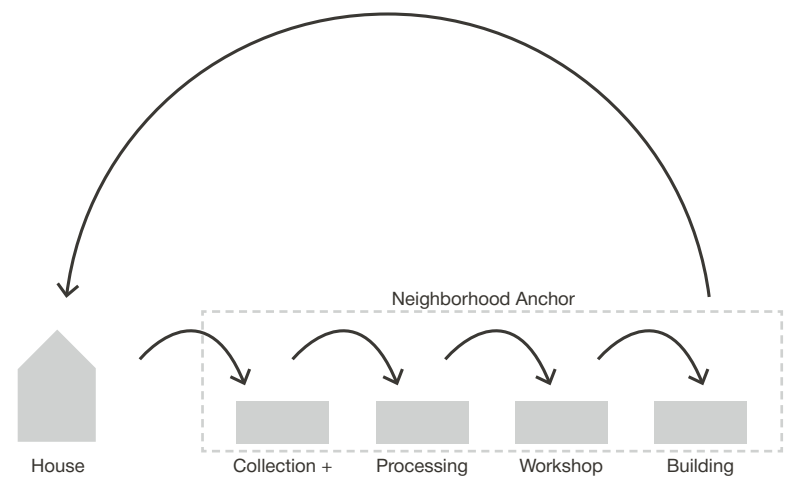
4.6.2.2 Neighborhood anchor

The anchor operates across four interconnected functions. As a community space, it provides a physical venue for the social measures embedded in the design, such as community organizing meetings, participatory planning sessions, hazard awareness programs, and everyday gatherings that build social cohesion. As a disaster announcement and coordination area, it serves as the neighborhood's primary communication and emergency management hub, where early warning information is disseminated, evacuation is coordinated, and post-flood recovery is organized. As a neighborhood watch hub, it provides a permanent, visible presence within the settlement, strengthening the community's capacity for surveillance, safety, and collective accountability. As a circular hub, it generates livelihoods and collective economic activity through the collection, processing, and redistribution of recycled building materials. This creates a local supply chain for the construction materials used in the co-production process while providing income opportunities for residents. The circular hub directly connects the neighborhood's physical transformation to its economic resilience.



Circularity flow

The flow operates in three stages. At the household level, residents bring recyclable and reusable materials to the neighborhood anchor rather than disposing of them onto streets or into drainage channels. At the anchor level, collected materials are sorted, processed, and transformed into usable building components. This processing activity generates direct livelihood for residents employed in the circular hub, creating an economic incentive that reinforces participation in the material collection system. At the neighborhood level, processed components are redistributed to residents for use in constructing and maintaining their own homes within the co-production framework. This completes the cycle from household waste to building material and back to the household.



Neighborhood anchors and community hubs

The neighborhood anchors' location is determined both by centrality and elevation: both anchors are positioned at the highest points within the settlement, ensuring that they remain accessible and functional before, during, and after flooding. This dual location ensures that no resident is more than a short walk from an anchor regardless of their position within the neighborhood

Neighborhood Anchor
Community Hubs
Connections



4.6.3 Integrated Design

Brings the technical and humanistic approaches together into a coherent design proposal, presented through the site plan, site sections, the collective block typology, the benefits to the surrounding neighborhood, and a phasing plan.

4.6.3.1 Site plan

The site plan presents the complete spatial proposal for Barangay Tatalon at the neighborhood scale. It shows how the drainage hierarchy, community anchors, access points, and new spatial spine combine to form a single, integrated design.

- Legend
- 1

Neighborhood Anchor
- 2

Community hubs
- 3

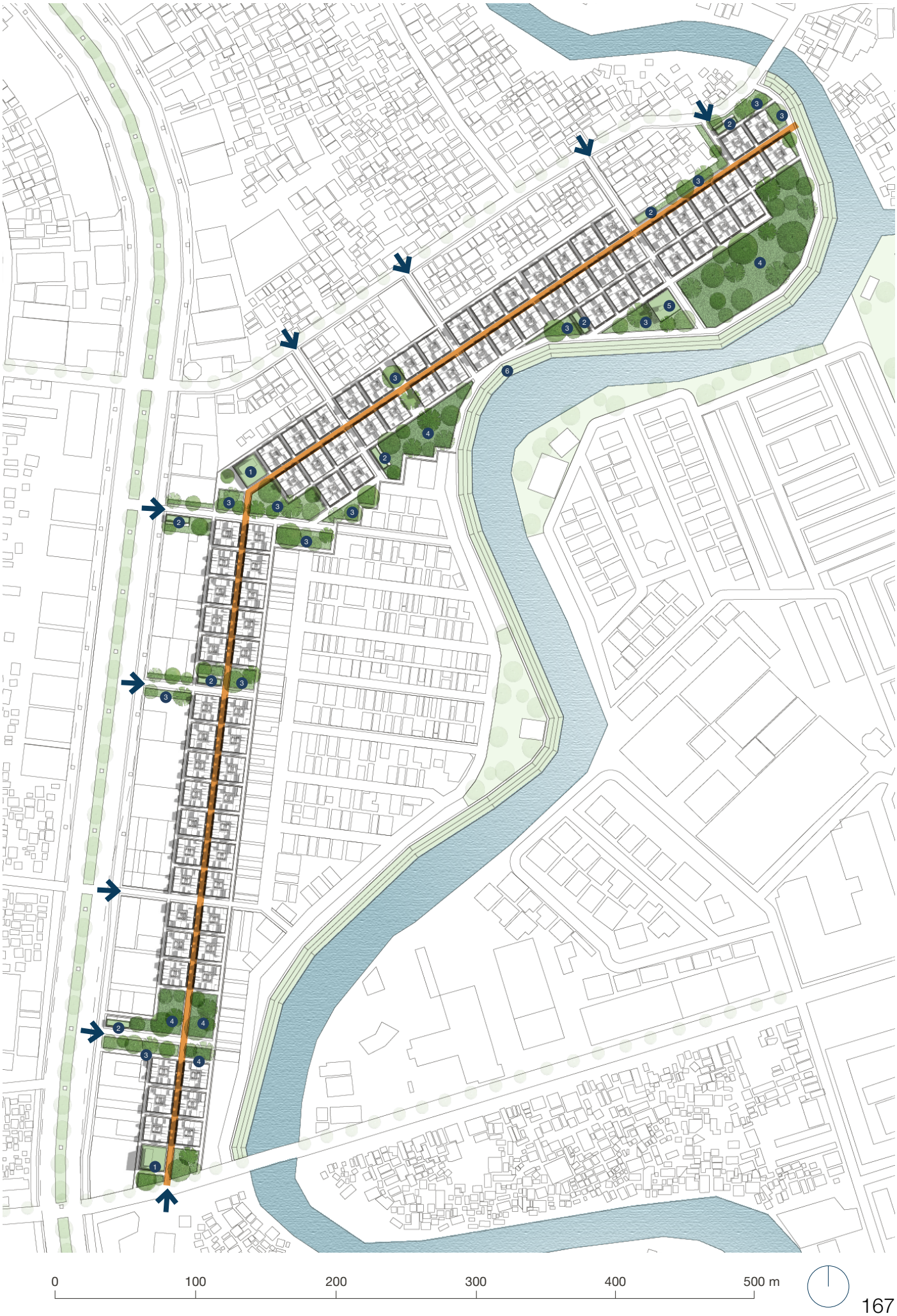
Multifunctional public spaces
- 4

Rain gardens
- 5

Pumping station
- 6

Levee with flap valve
- Main spine
- ➔

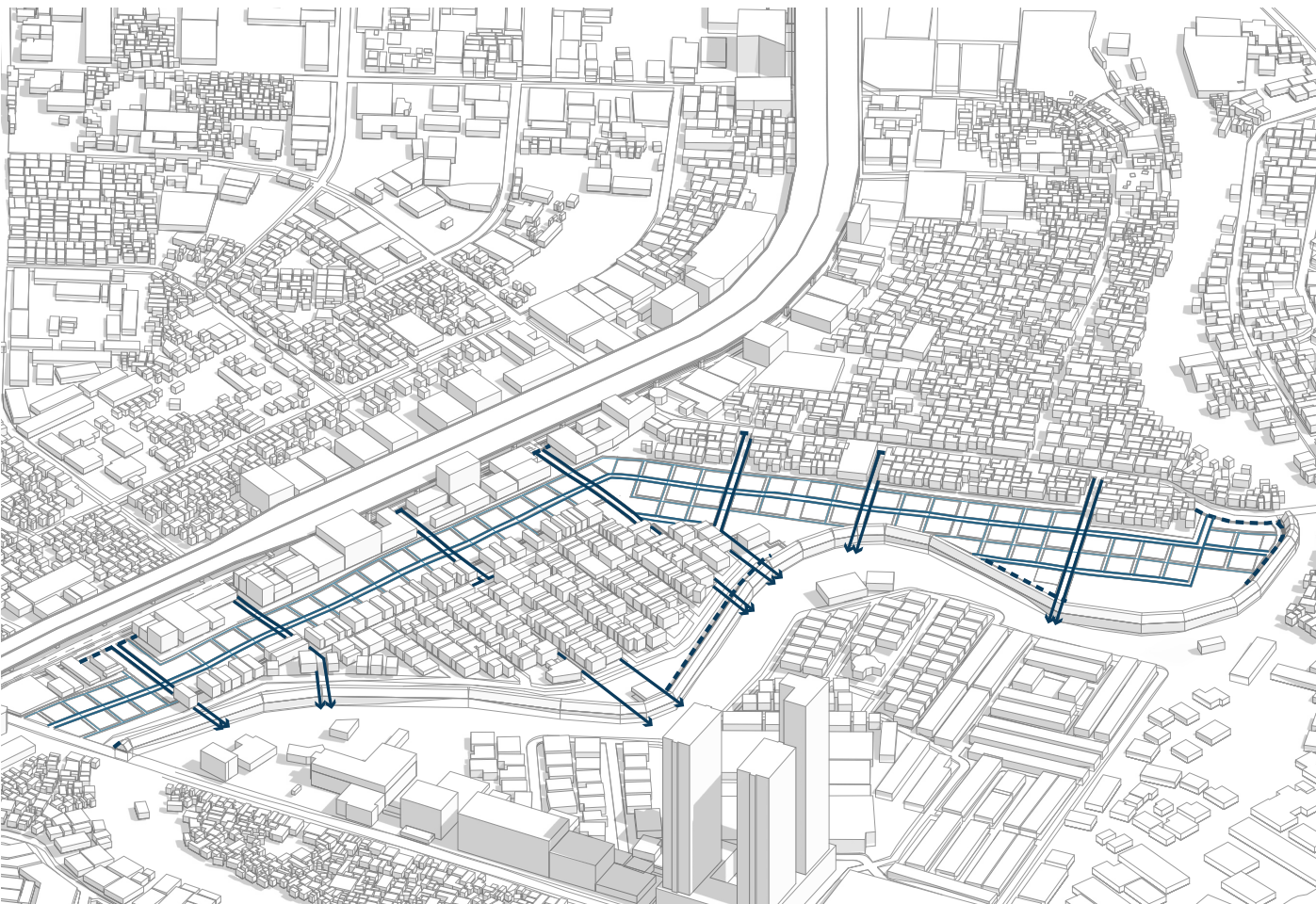
Access points



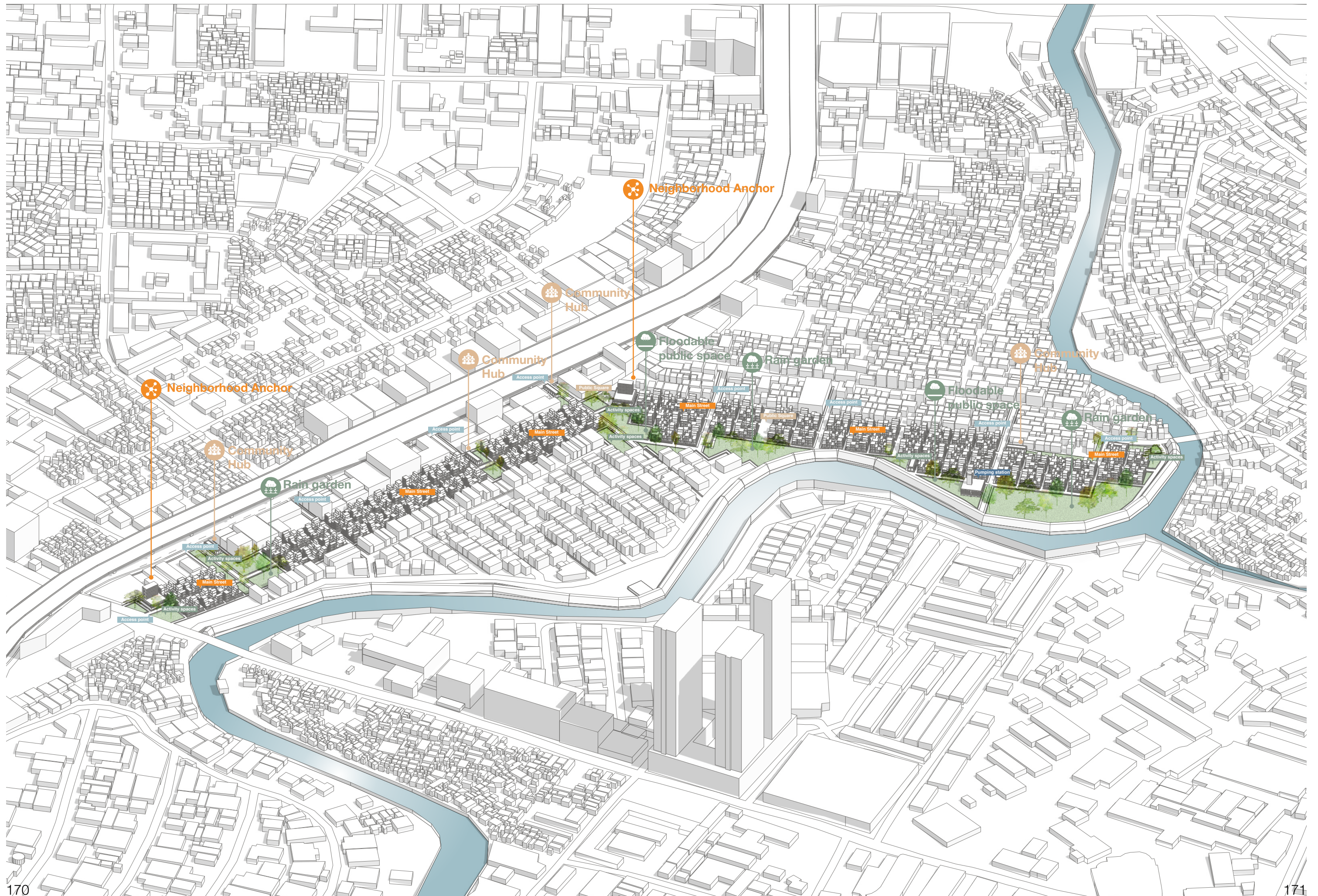
New floodable public green spaces



Renewed ground drainage logic

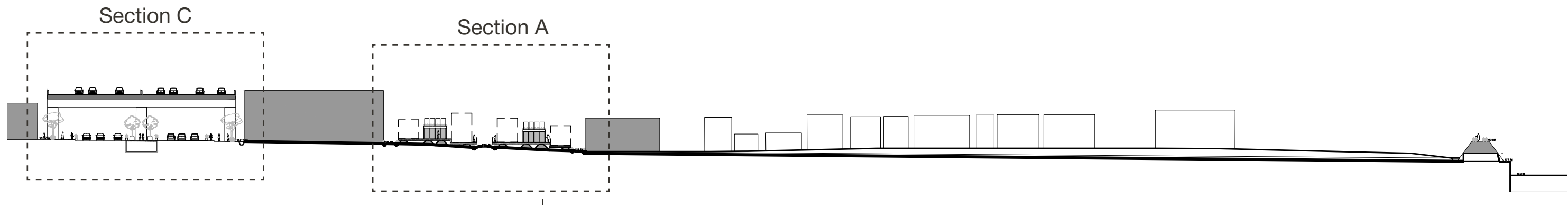


- Collector Canal
- Primary Canal
- Secondary Canal
- Tertiary Canal

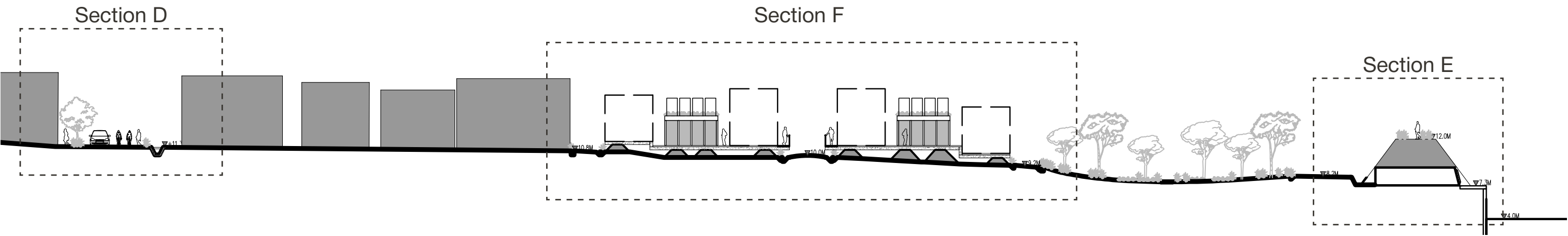
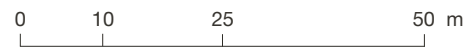


4.6.3.2 Spatial section

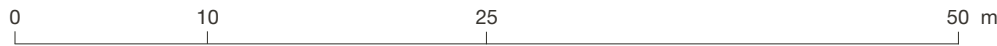
The site sections cut through the neighborhood at key locations to reveal how the layered basin concept operates across different cross-sectional conditions.



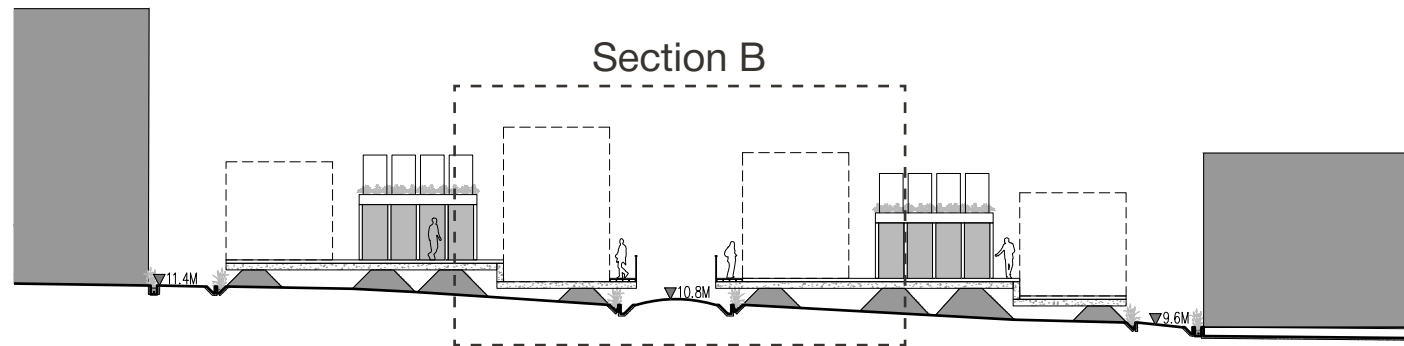
Site Section AA



Site Section BB

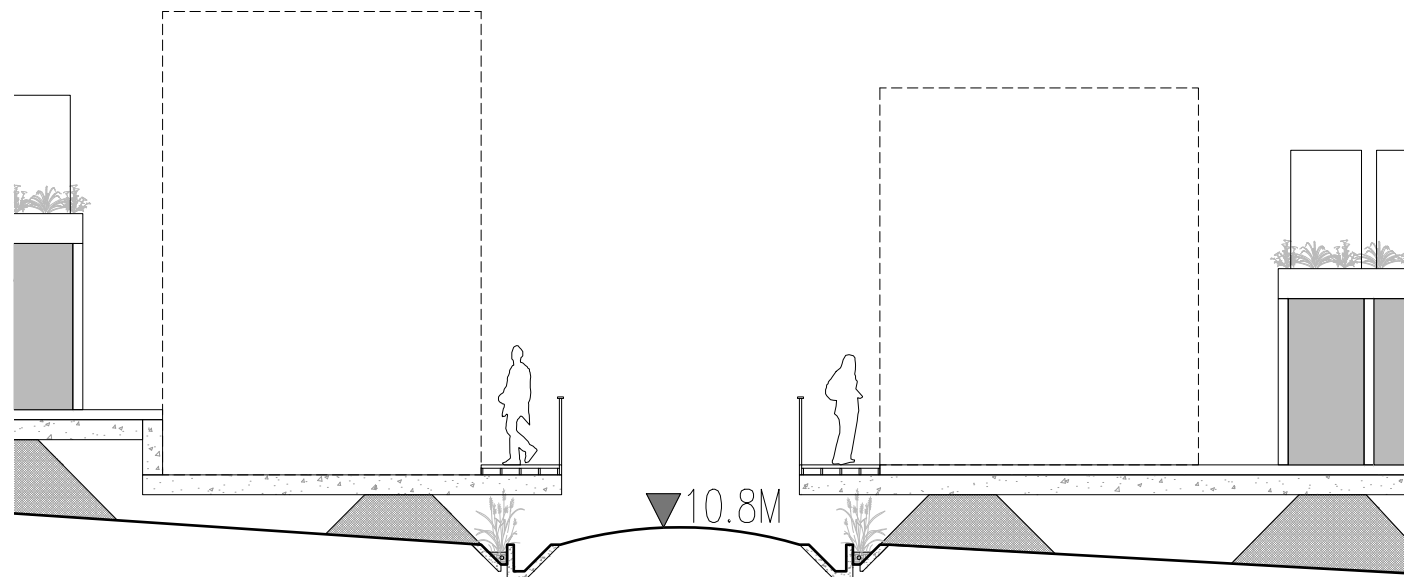


All elevations are measured above sea level



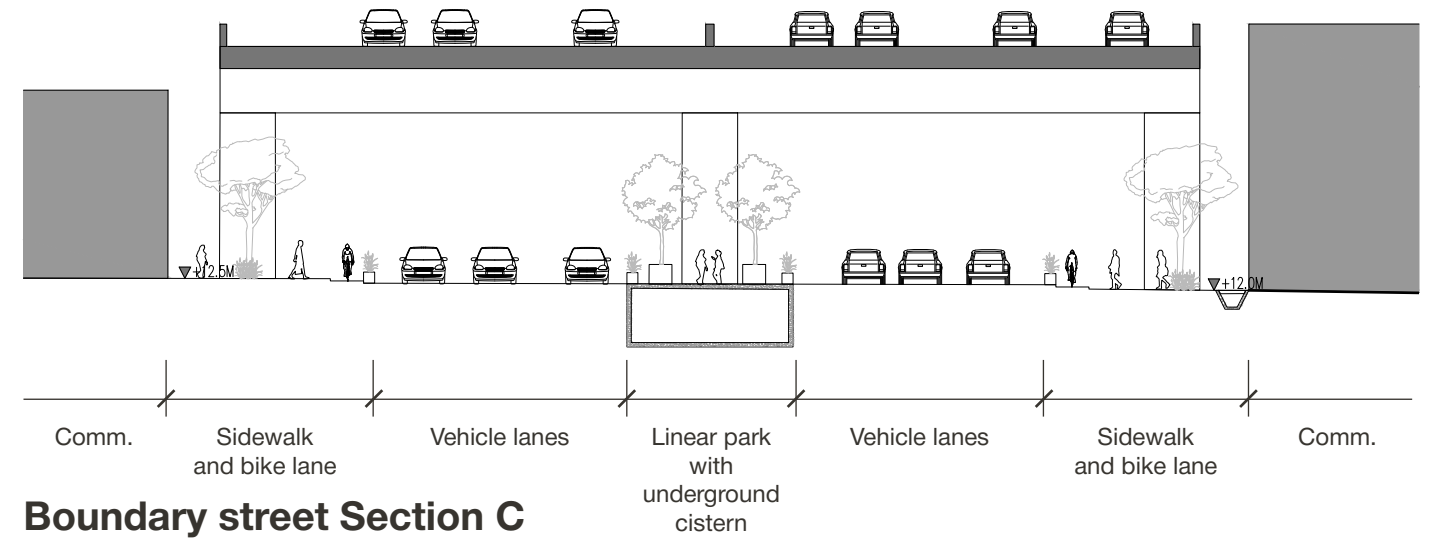
Neighborhood Section A

0 5 10 m



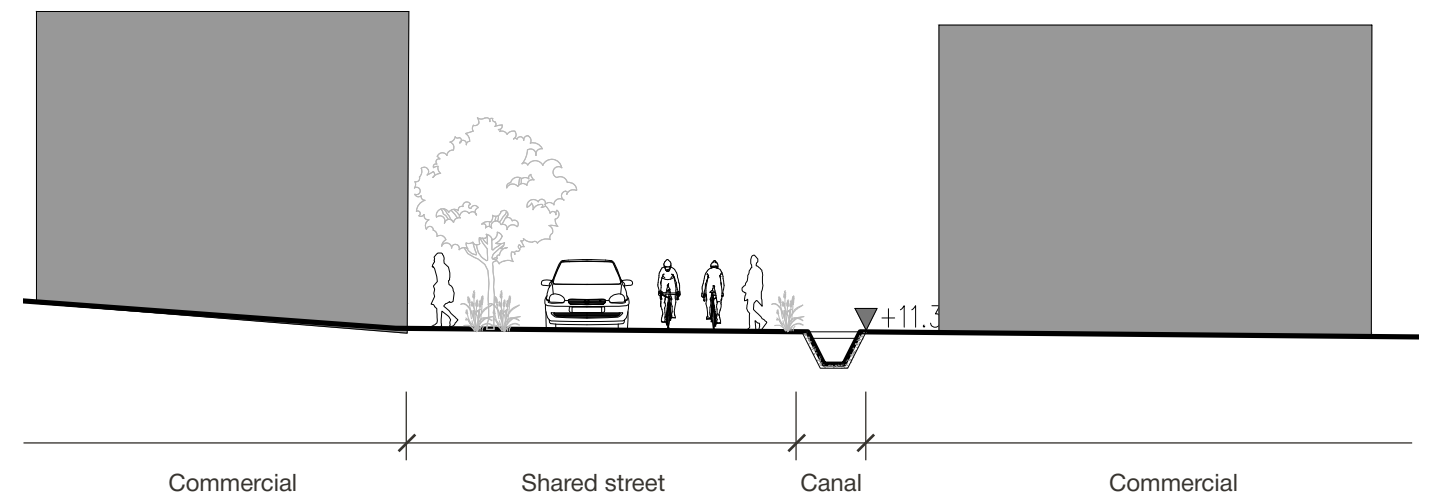
Main Street Section B

0 5 10 m



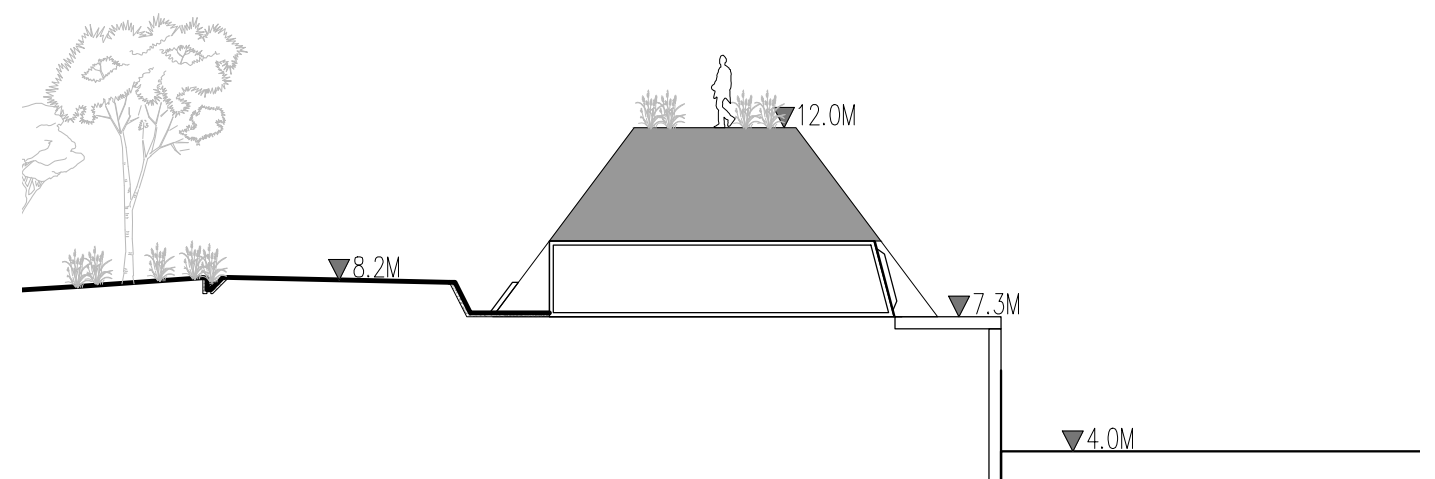
Boundary street Section C

0 5 10 m



Boundary street Section D

0 5 10 m

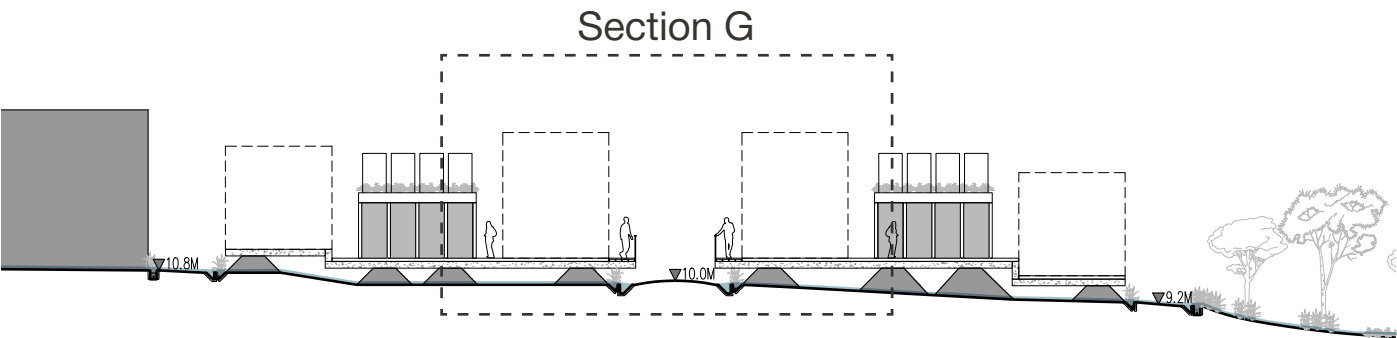


Levee Section E

0 5 10 m

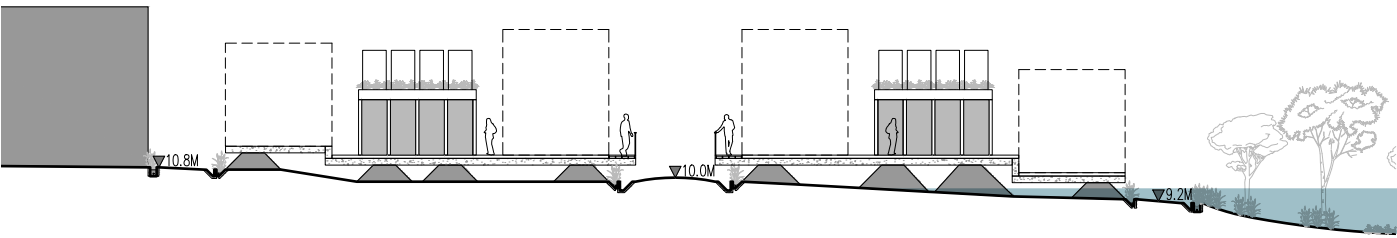
All elevations are measured above sea level

Main Street Section F



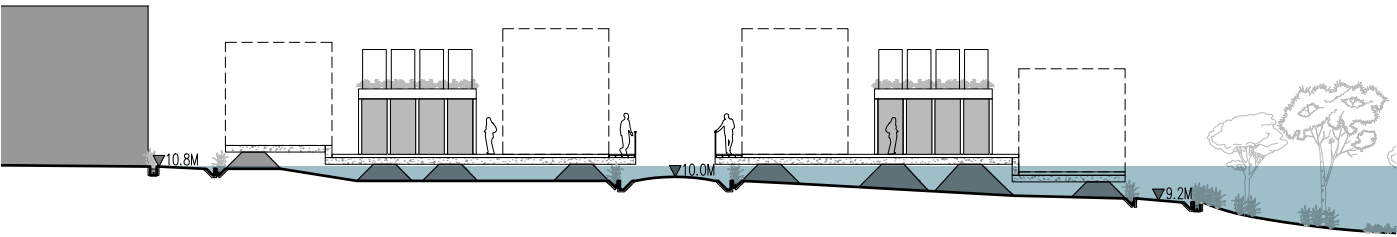
Intermediate scenario

This scenario represents pre and post flood condition. Water is retained in drainage channels, bioswales, and rain gardens.



Flood scenario

This scenario shows the first phase of flood response wherein rain gardens fill first, absorbing and detaining stormwater before it reaches the primary canals.

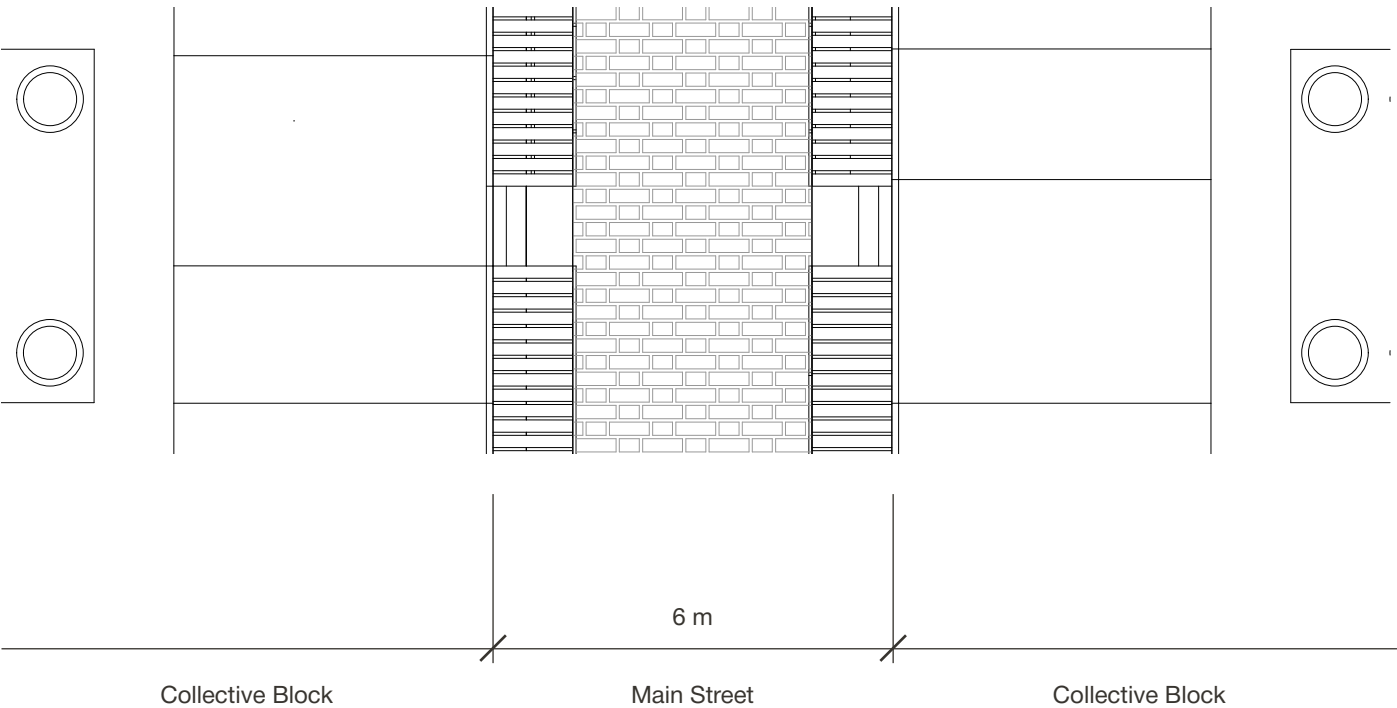
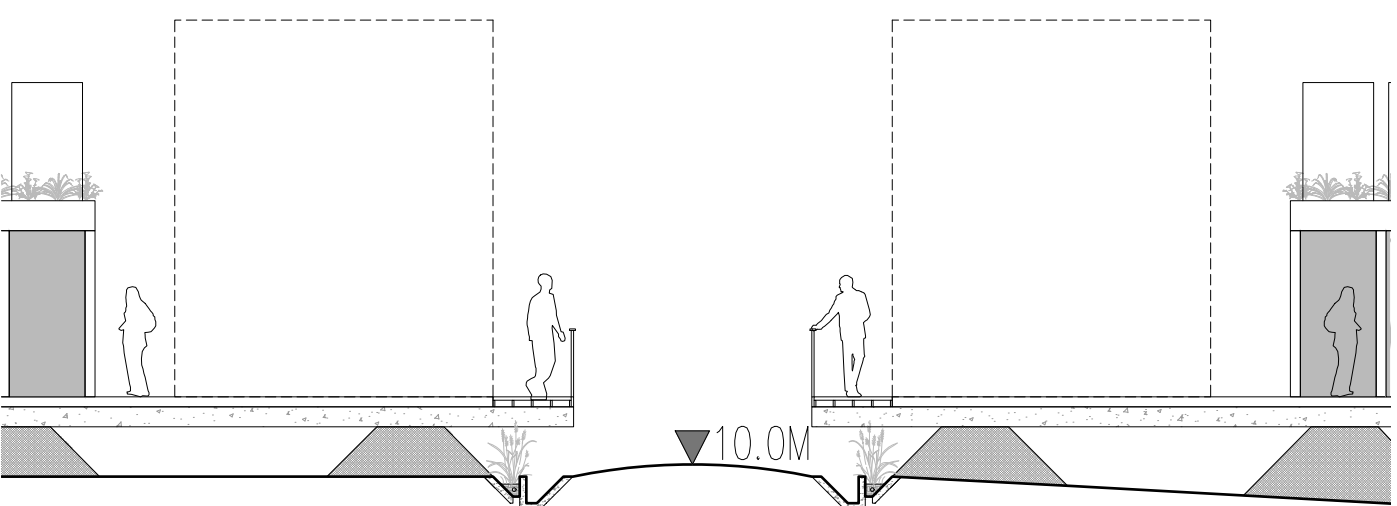


Extreme flood scenario

This scenario shows the design under maximum stress, wherein water reaches the main street. Elevated ground floors, elevated walkways, and collective block's upper levels remain above water.



Main Street Section G

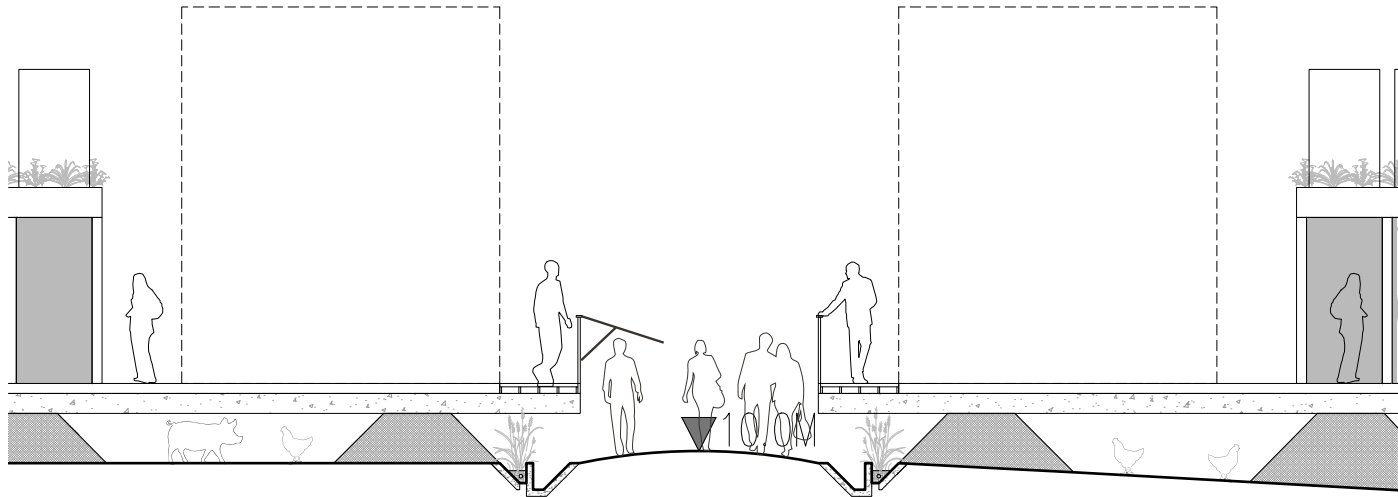


By having a 6 meter wide main street, adequate space is allocated for a pedestrian network, emergency vehicles, and critical services.

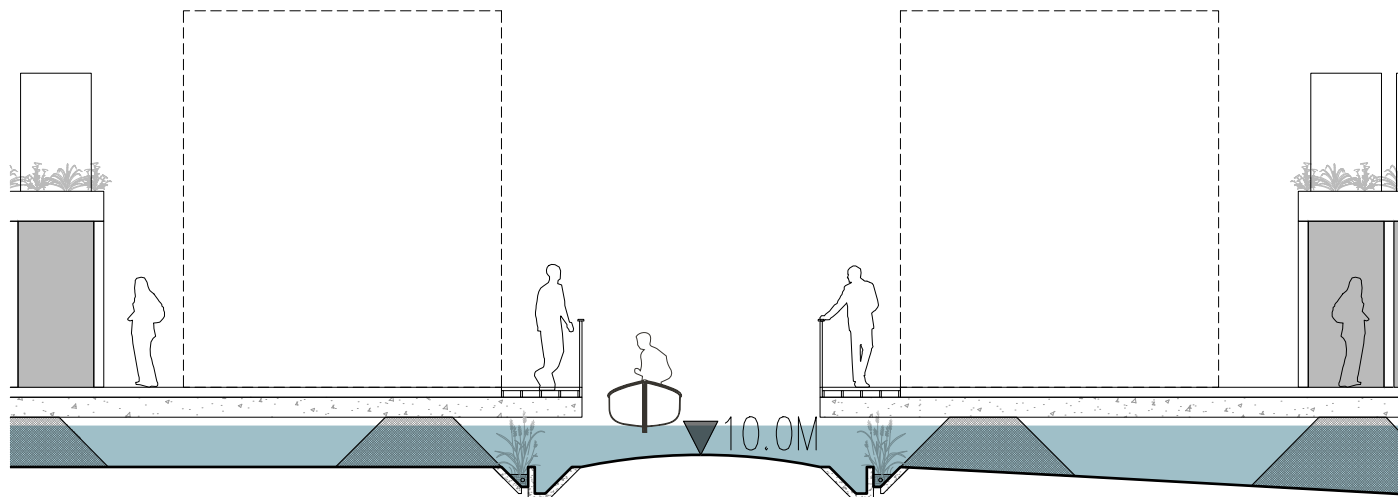


All elevations are measured above sea level

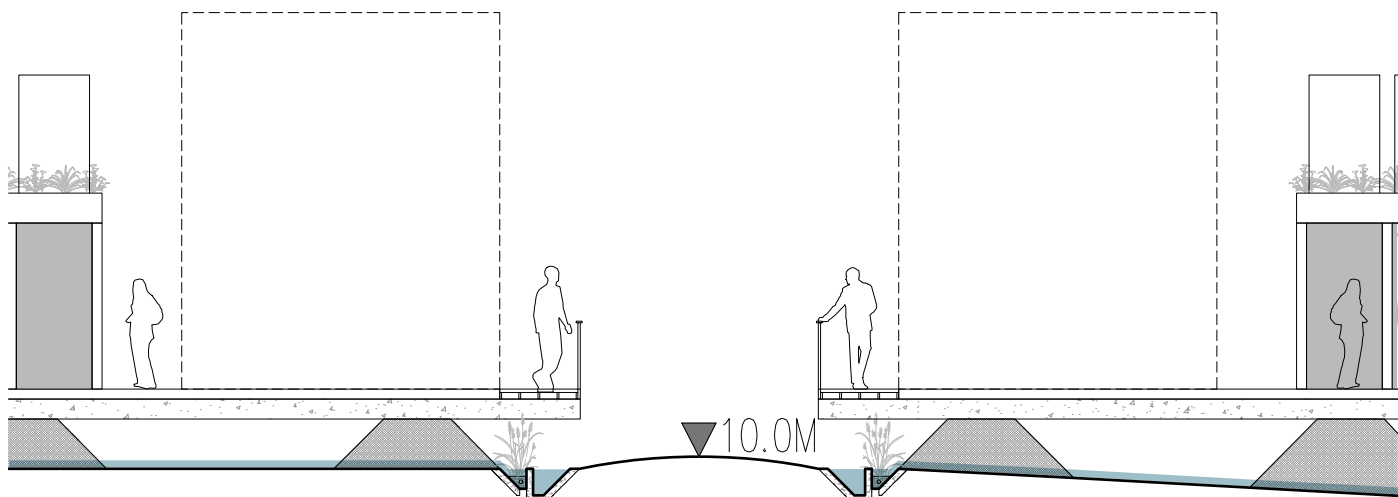
Main Street Section G



Dry scenario



Flood scenario

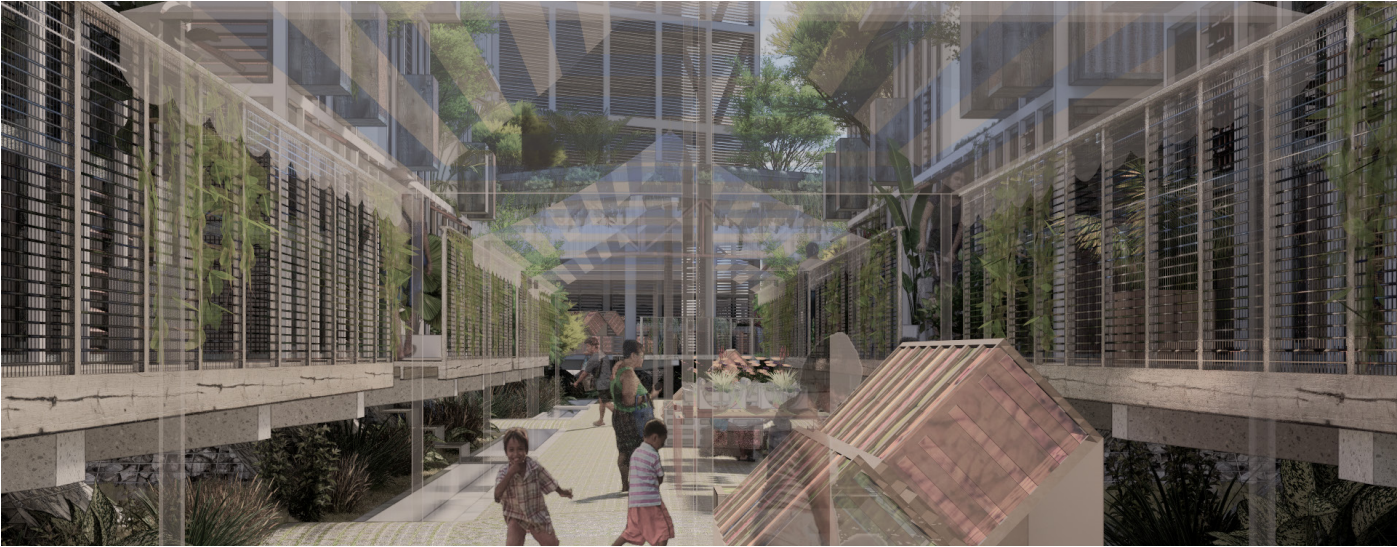


Post flood scenario



All elevations are measured above sea level

Scenarios

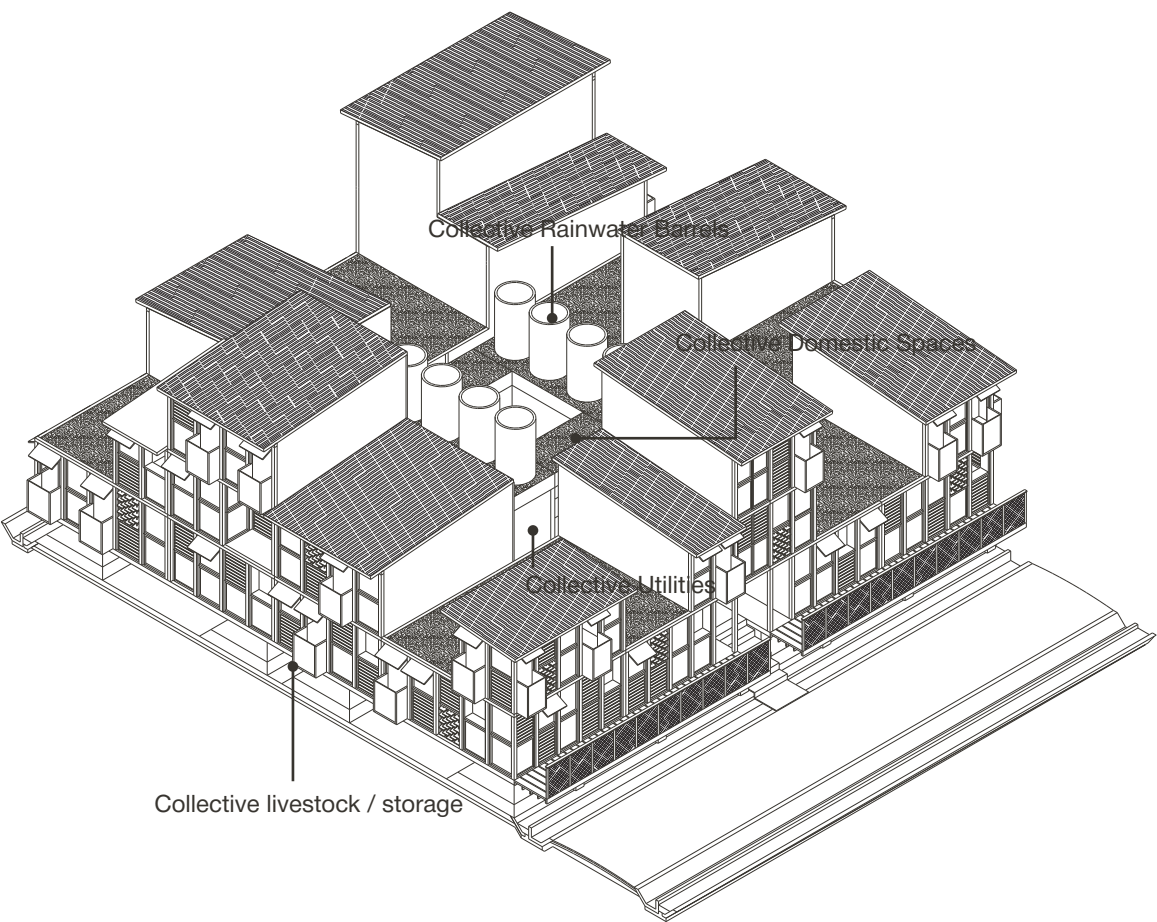


4.6.3.3 The collective block

The collective block is the primary building typology of the integrated design. This embodies the co-production gradient at the architectural scale and translates the what-if scenario into built form. It is used as a design principle for the entire settlement.

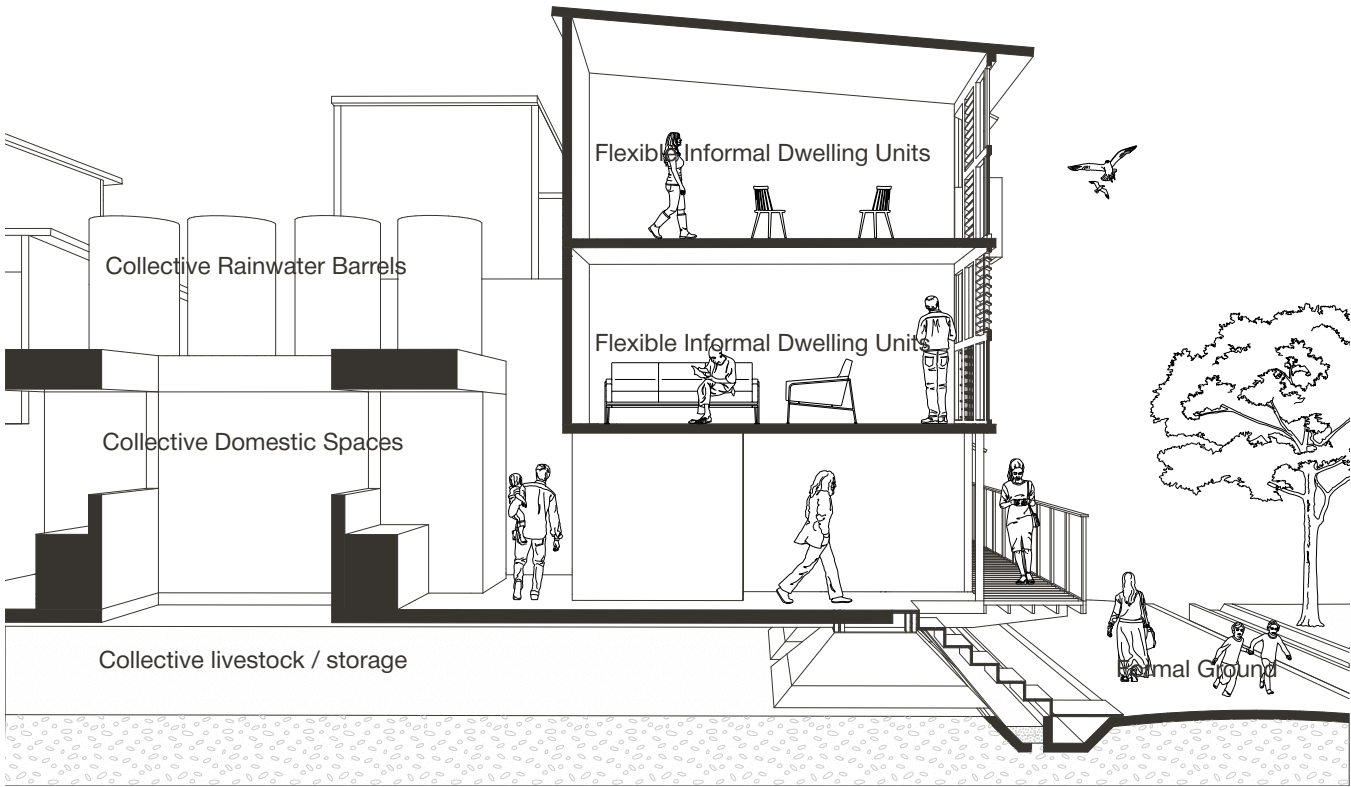
Collective as strategy

The collective block is organized around the principle that shared accountability produces stronger and more durable resilience than individual household adaptation alone. In Barangay Tatalon, the recurring condition of residents sharing utilities, borrowing facilities from neighbors, and collectively managing flood response during emergencies reveals an existing social logic of interdependence that the design formalizes and strengthens instead of replacing. By embedding communal facilities within the block’s core, the collective block creates a built-in accountability between neighbors that reinforces both daily community life and collective flood response



The core

The core of the collective block is part of the negotiated layer. It is structurally permanent and designed to remain functional during and after flood events. It houses the block’s shared domestic space, including communal bathrooms, a kitchen, and laundry facilities, addressing the sanitation challenge identified in the fieldwork, where many residents lack access to basic services and rely on neighbors’ facilities informally. By elevating and centralizing these shared facilities within a permanent structure, the collective block resolves a daily problem and provides an elevated refuge accessible to all residents during flood events.



Architectural material selection

Ground layer (formal)

The ground level uses recycled concrete aggregate sourced from demolition material and gabion from locally available waste material. Recycled concrete aggregate reduces construction costs and embodied carbon while putting to productive use the demolition debris that the neighborhood’s incremental transformation will inevitably generate. Gabions provide drainage integration, allowing water to pass through rather than accumulate against solid materials.



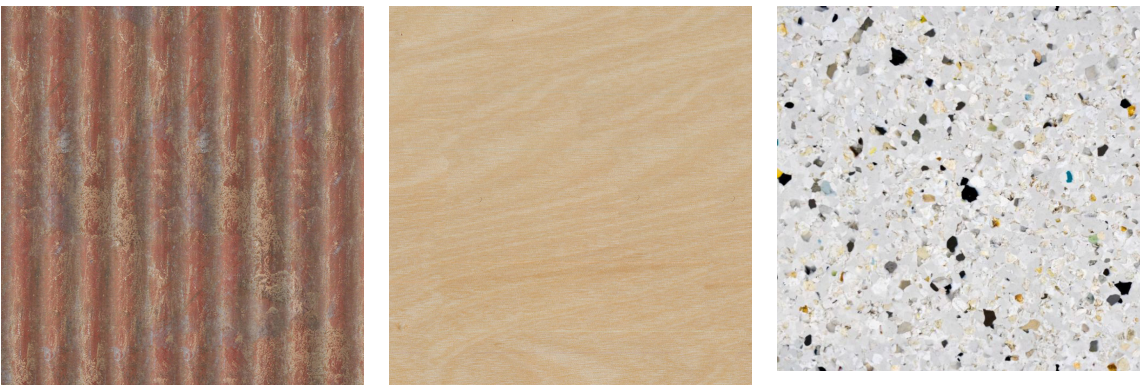
Negotiated layer

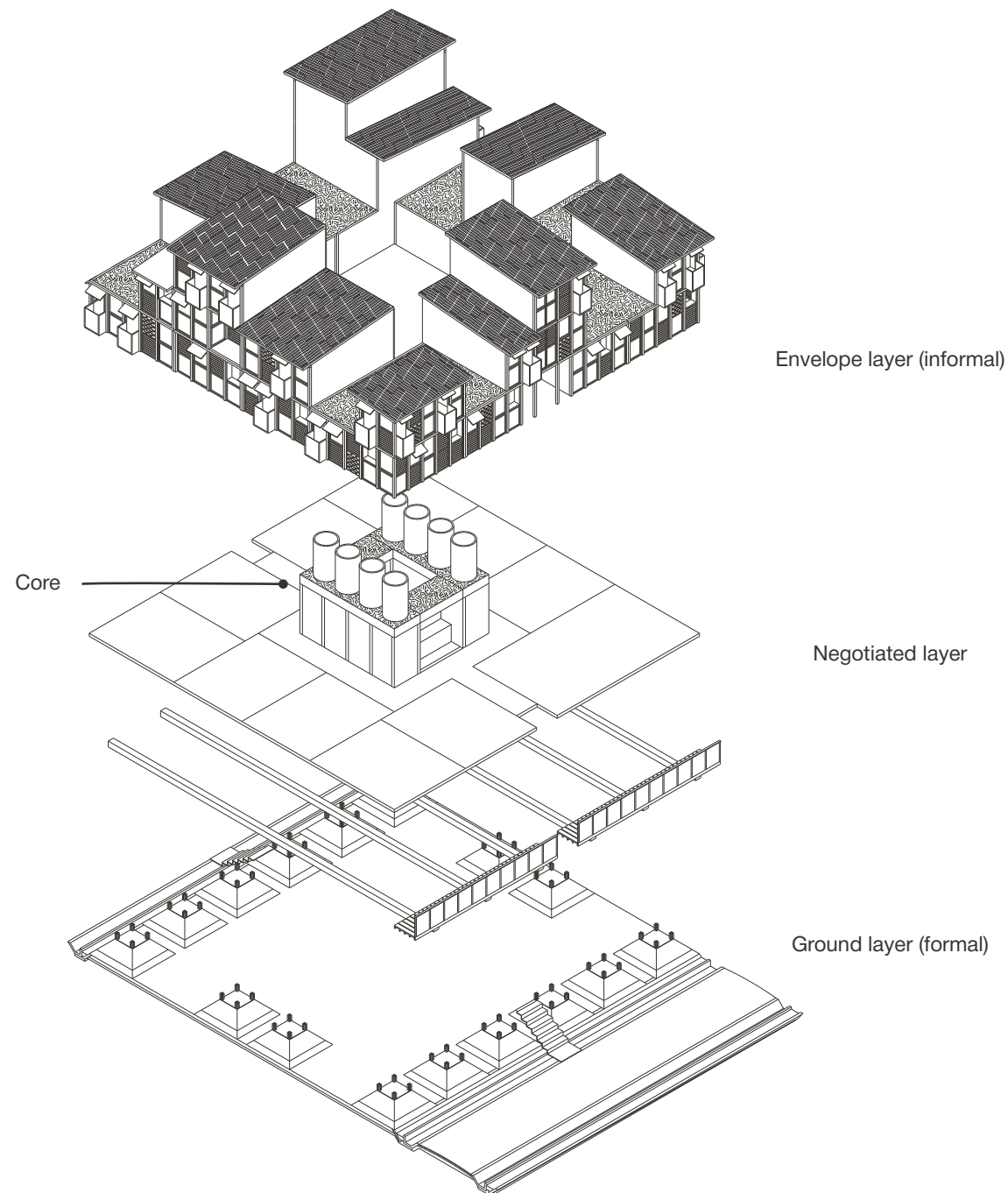
The negotiated layer uses recycled plastic aggregate concrete for the primary structural frame. This material combines structural performance with locally available plastic waste. The floor system of reclaimed wood planks, compressed wood boards, or compressed earth blocks introduces warmth and workability into the intermediate layer, materials that local builders can work with without specialist equipment.



Envelope layer (informal)

The informal envelope uses the existing material language of the settlement. Corrugated metal sheets, reclaimed plywood, and recycled plastic boards are retained deliberately. Using familiar materials reduces construction cost, supports local supply chains, and ensures that the community can maintain, repair, and extend their units independently without relying on external contractors or specialist knowledge.

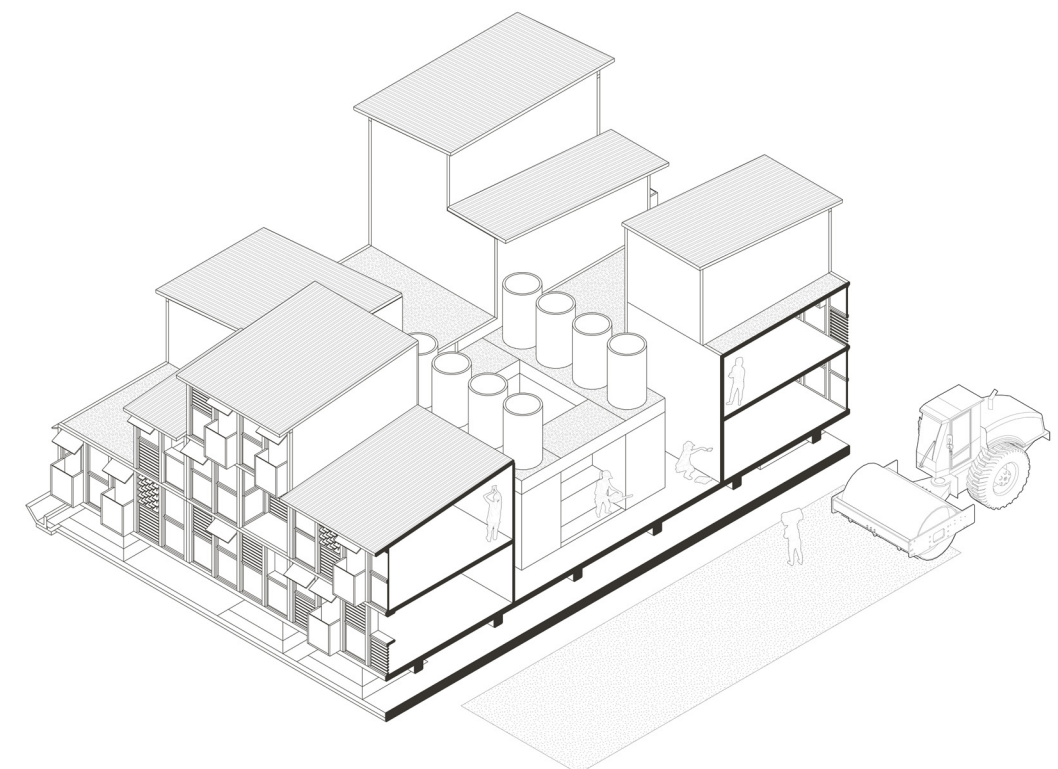




Design Guidelines

The collective block contains a set of design principles that enable it to grow, adapt, and replicate throughout the settlement without requiring a professional for each iteration. The following guidelines define the non-negotiable spatial rules that maintain the block's structural integrity and co-production logic while leaving maximum freedom for community adaptation above:

1. The ground-level structural frame and drainage connections must be constructed by government authorities and professionally engineered. This foundational layer is non-negotiable and may not be altered by residents.
2. The collective domestic space, which includes the shared bathroom, kitchen, and laundry, must remain accessible to all block residents and may not be privatized or enclosed by individual households.
3. The structural frame of the negotiated layer establishes the maximum allowable footprint and height for household units above. Residents may construct within this frame, but any extension beyond it requires a structural assessment.
4. Materials used in the informal envelope must be lightweight. Materials such as masonry or concrete construction above the negotiated layer must be reviewed.
5. Ground surfaces immediately surrounding the block must connect to the neighborhood drainage spine. Obstructing the flow of water toward the primary canal is prohibited.
6. Utilities must be installed at the ground level before any upper-level construction begins. Utility connections branch upward from this point and cannot be embedded in ground surfaces.



4.6.3.4 Benefits to the surrounding neighborhood

The impact of the design proposal is not limited to the informal settlement. Changes within the informal settlement directly influence the surrounding formal urban fabric, and vice versa. The interventions proposed within Barangay Tatalon, therefore, produce spatial, hydraulic, and social benefits that extend beyond the settlement’s boundaries. This challenges the perception that investing in informal communities is an act of charity rather than a structural necessity for the neighborhood.

The first benefit is hydraulic. By introducing a drainage hierarchy within the informal settlement, the design reduces the volume and velocity of floodwaters that build up in the neighborhood. Stormwater is absorbed and slowed using strategies and measures such as green corridors, bioswales, and permeable surfaces. Therefore, the formal neighborhood becomes drier as a direct result of investment in the informal one.

The second benefit is spatial and social. The selective renegotiation of the formal-informal boundary by opening fences, creating new access points, and establishing shared green infrastructure along the edges produces a more connected and permeable neighborhood fabric that serves both informal and formal residents. New green corridors and floodable public spaces are not designed exclusively for informal settlers but positioned as shared community spaces accessible to the wider neighborhood. The collective block’s ground-level program and the primary spine both generate activity and connectivity that extends outward from the settlement into the surrounding neighborhood. In effect, transforming a previously closed and isolated spatial condition into one that contributes to the public life of the surrounding neighborhood.



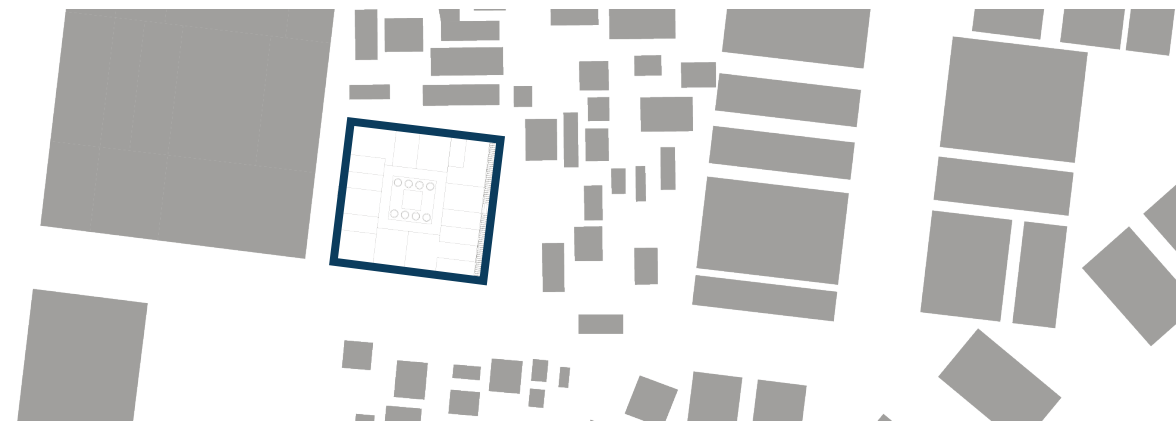
Benefits map

- Primary spine/Main street →
- Green corridors →
- Surface water movement ····→

4.6.3.5 Phasing plan

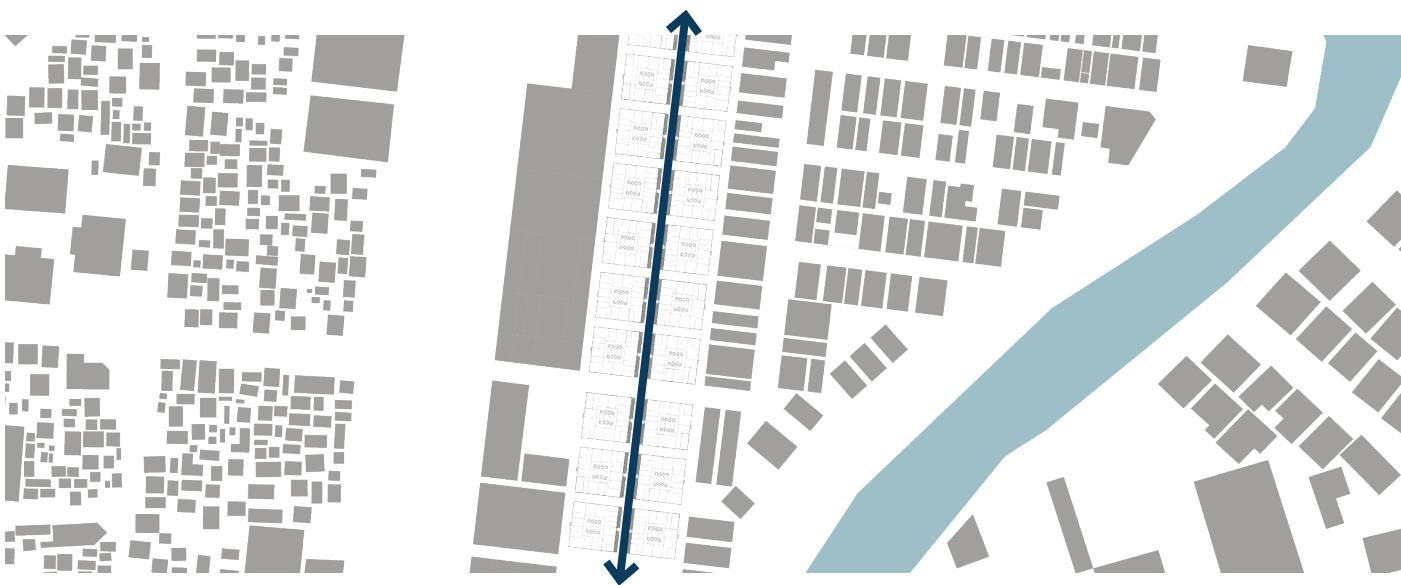
Phase 1- the pilot block

A pilot block is first established to grow incrementally rather than through complete redevelopment. The co-production model is tested here first wherein the government builds the ground level while community builds above. The drainage immediately surrounding the block is also addressed as part of this phase since the block cannot function without its immediate drainage connection. Priority 1 measures are established in this phase.



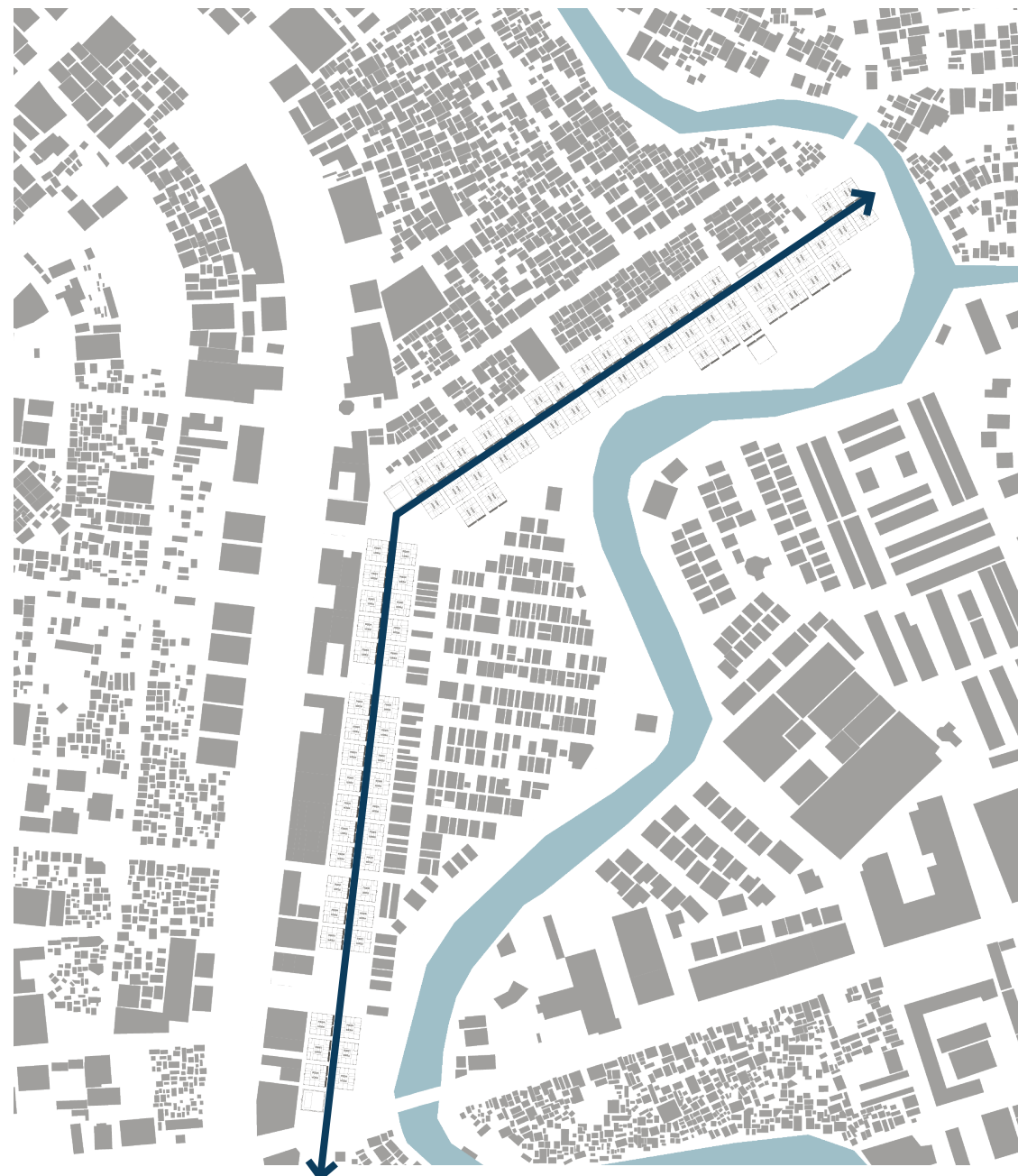
Phase 2- the spine

The neighborhood grows using the street as a tool for urban transformation (UN-Habitat, 2018). A main street is constructed and acts as spine that aims to connect the neighborhood. As the spine grows, more blocks are added along it. The collective block typology replicates along the spine using the same co-production principle. Priority 2 measures and formal-informal boundary negotiation are established in this phase.



Phase 3- the neighborhood

In this final phase, the drainage hierarchy is complete, the spine connects the entire settlement, collective blocks are distributed across the neighborhood, green corridors thread through the fabric, and the formal-informal boundary has been selectively opened. This is also where the connection to the surrounding formal neighborhood becomes visible where the benefits extend beyond the settlement edges



4.6.3.6 Perspectives

The set of perspectives presents three scenarios: dry, flood, and post-flood.

The dry scenario establishes the neighborhood as a functional and inhabited everyday environment where streets are active and collective spaces are in use.

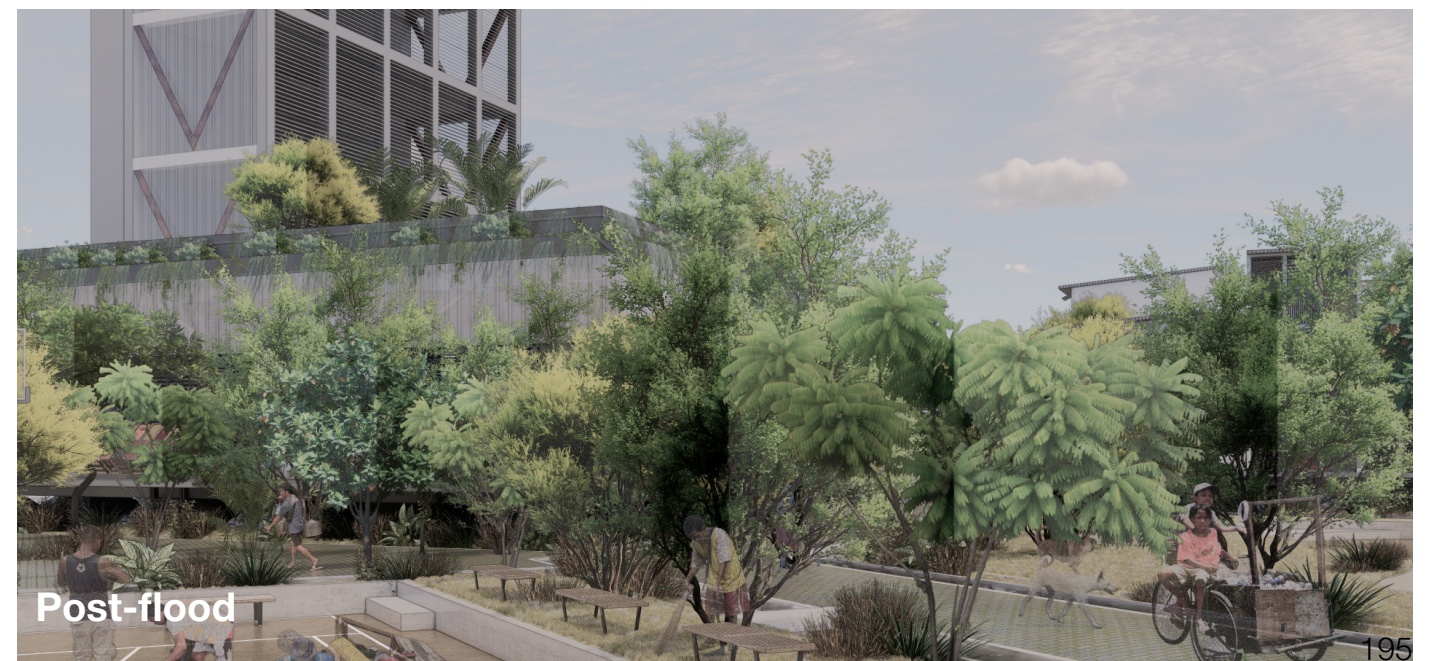
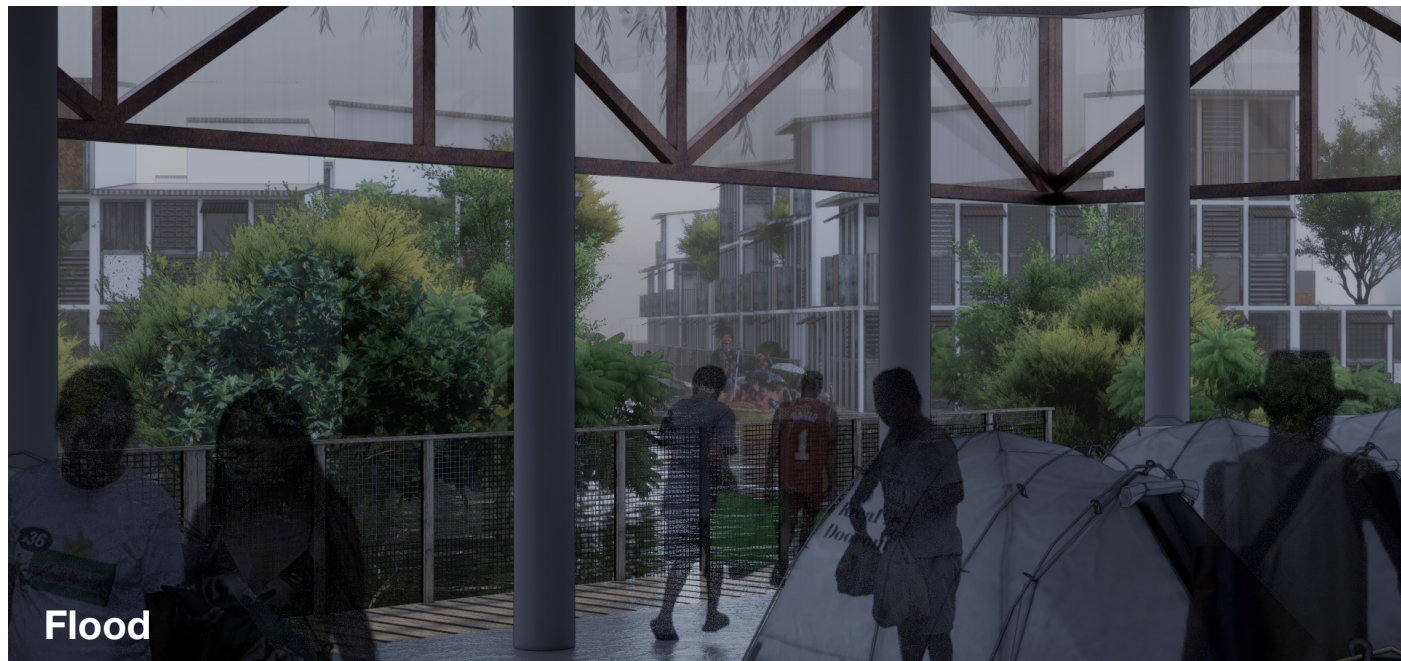
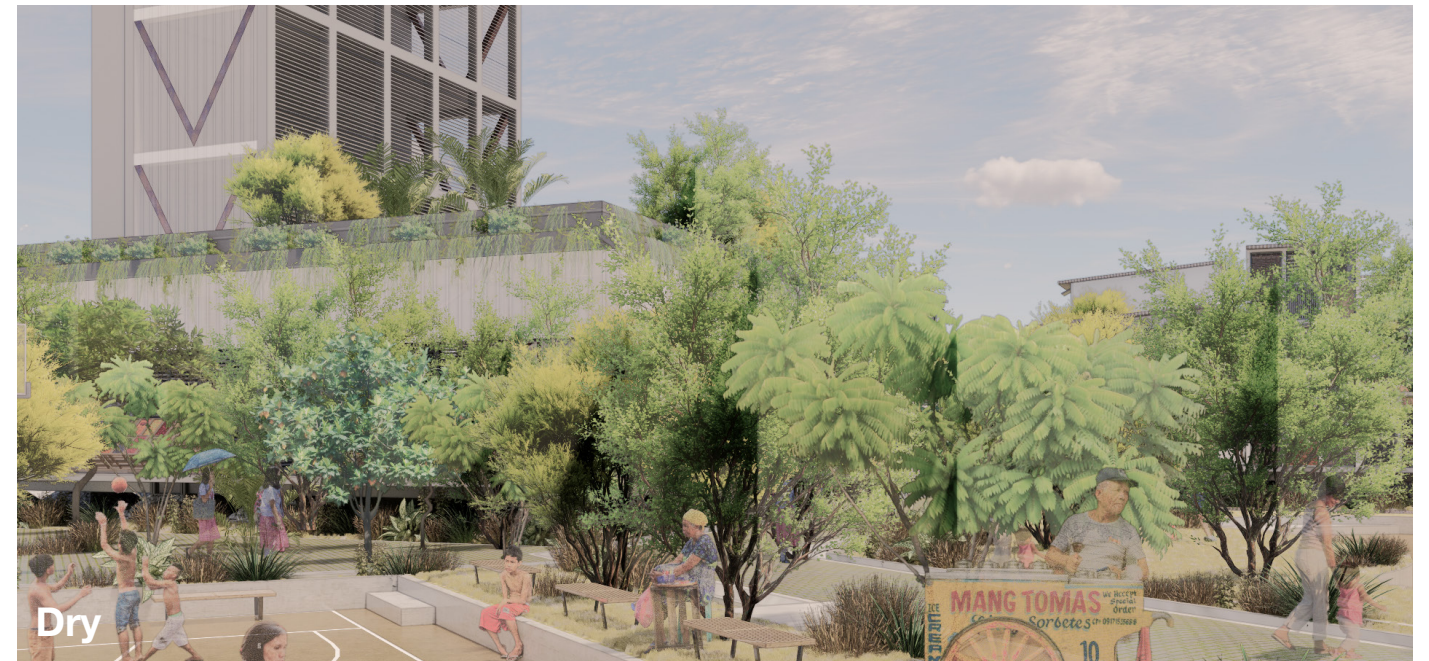
The flood scenario shows the neighborhood inundated, with elevated walkways and ground floors remaining above water. Rain gardens and floodable public spaces are submerged and function as intended detention spaces.

The post-flood scenario shows the neighborhood as the water recedes. Drainage channels carry the last of the stormwater toward the San Juan River outlet, green spaces emerge, and the community returns to normal life. Streets are cleared; collective spaces are reactivated. The post-flood condition demonstrates that the design not only protects residents during flooding but also enables rapid recovery afterward.

Together, the three scenarios demonstrate how the design performs under flooding conditions.









05

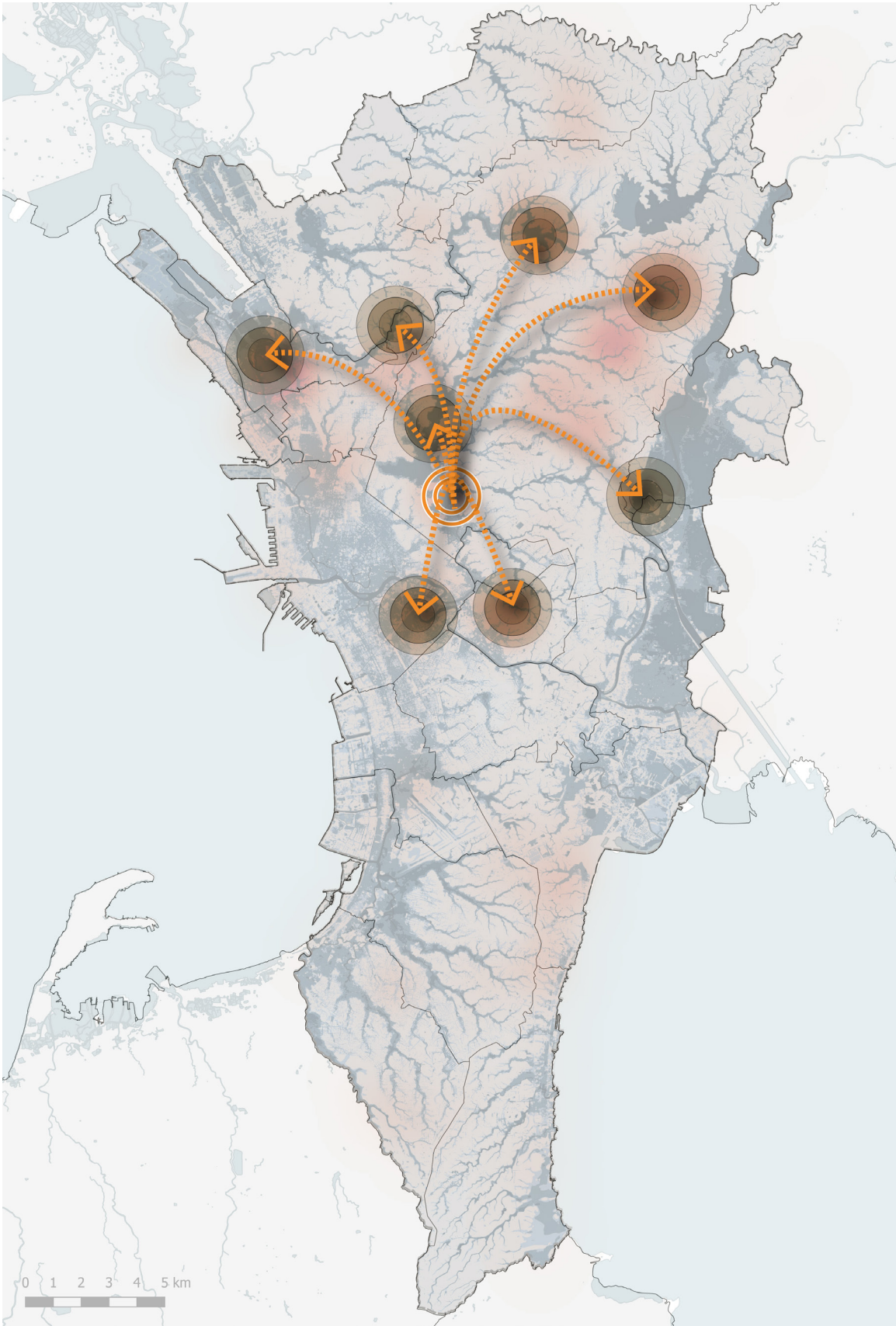
Replicability

The design proposal for Barangay Tatalon is not a one-time intervention. It is a spatially grounded design for flood resilience in dense low-income neighborhoods across Metro Manila. Replicability here does not mean directly duplicating every design decision. Each neighborhood presents unique contextual factors that require adaptation. Replicability in this chapter refers to the transferability of the condition-based approach developed through this project. This approach serves as a framework for identifying when and where the layered basin concept, co-production model, and selected measures are relevant and applicable.

The basis for replicability lies in the recurring pattern of flood hazard and informal settlement present in many areas of Metro Manila. The approach developed in this project is most relevant where these two conditions intersect. The vision map highlights this overlap across Metro Manila and proposes three example sites where the spatial, environmental, and governance conditions closely resemble those of Barangay Tatalon.

5.1 Vision Map

The vision map situates Barangay Tatalon within the broader metropolitan pattern of flood vulnerability and informal settlement. This reveals the conditions address by this project is prevalent. Across Metro Manila, the overlap between flood hazard zones and dense informal settlement produces a recurring spatial condition of low-lying neighborhoods enclosed by formal urban fabric, lacking drainage infrastructure, and deprioritized by government flood control efforts.



Vision Map

5.1.1 Candidates for replication

Three sites are identified as candidates for replication. These were selected through the recognition of it spatial, environmental, and governance conditions.

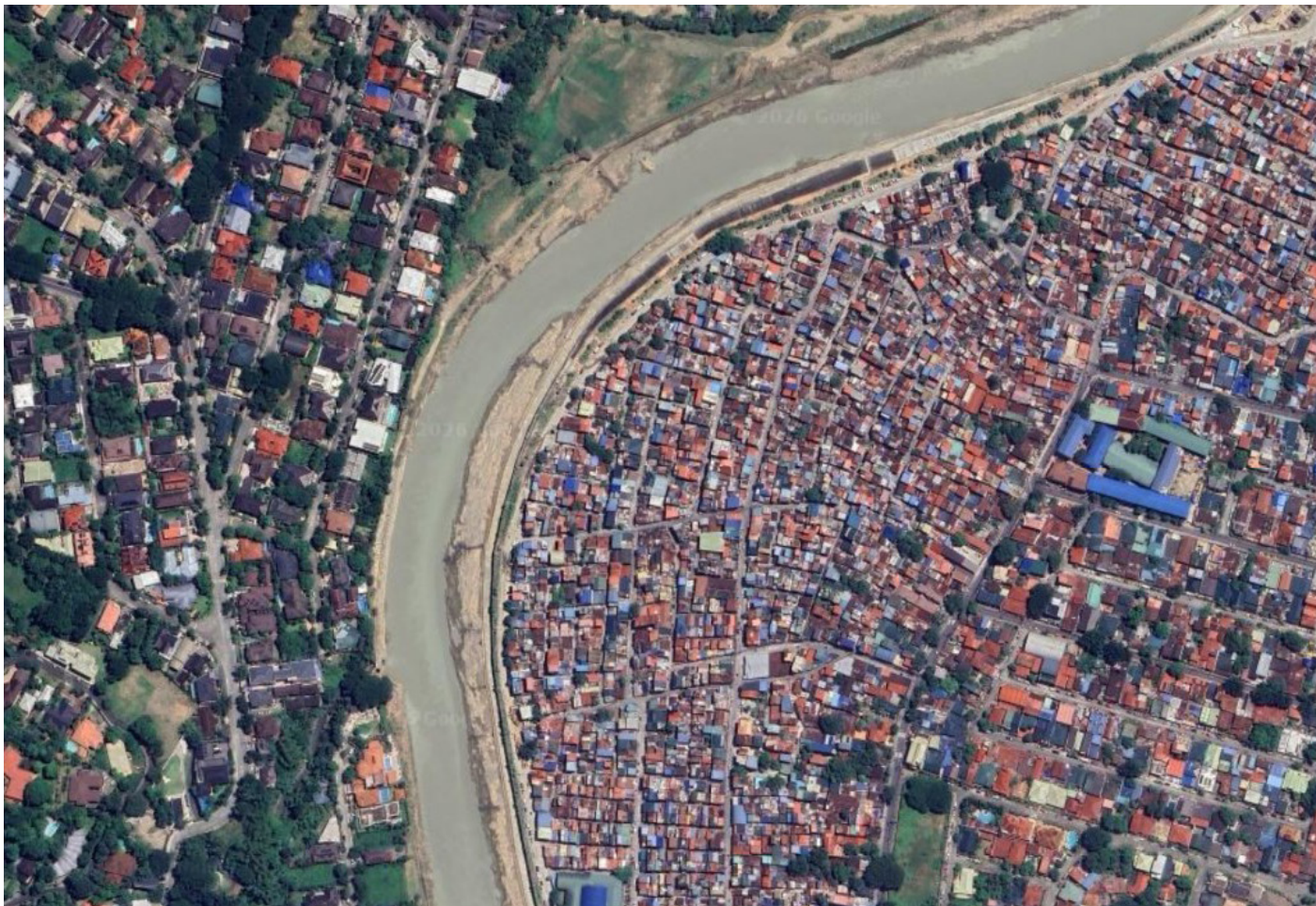
1. Barangay Damayang Lagi, Quezon City

Located adjacent to Barangay Tatalon along the San Juan River, this neighborhood shares most of the spatial and environmental conditions of Barangay Tatalon. It sits on the same Novaliches clay loam soil, experiences the same compound pluvial and fluvial flooding, and contains a concentration of dense informal settlements in a low-lying topography. The form-informal divide is present and legible. Drainage infrastructure is absent within the settlement’s interior, and government flood control effort have produced similar unintended consequences. Being in the same proximity as Barangay Tatalon, Damayang Lagi represents the most immediate candidate for replication.



2. Barangay Tumana, Marikina City

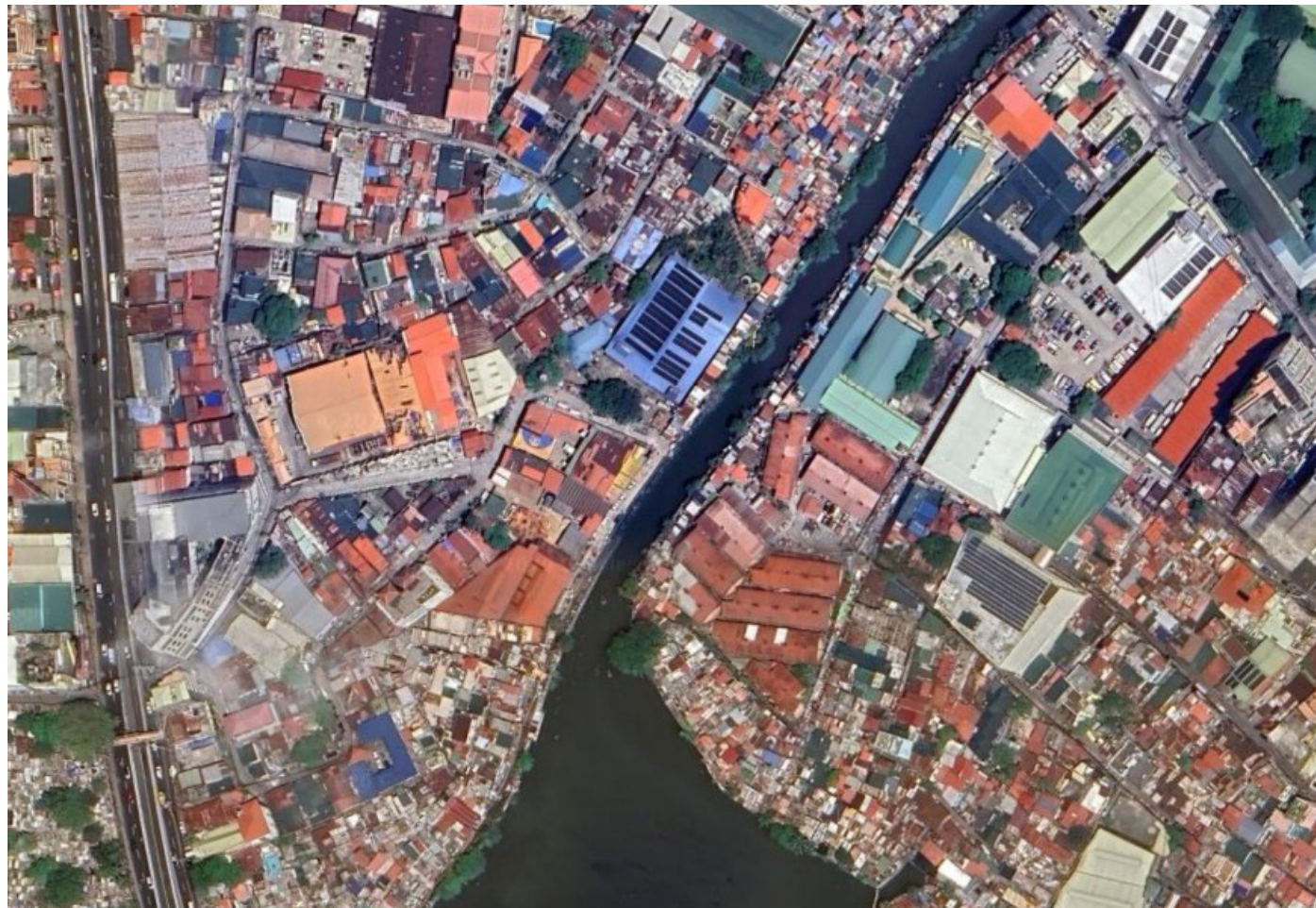
This neighborhood sits at the lower end of the Marikina River corridor where it meets the Pasig River system. This neighborhood experiences compound pluvial and fluvial flooding. The neighborhood contains densely built informal settlements organized at a low-lying area; this reflects the same spatial quality of Tatalon. The formal-informal divide is present along its edges; drainage hierarchy is also absent within the settlement. And government invest along the Marikina River is present but is focused large-scale grey infrastructure that does not address the neighborhood scale drainage problem within these vulnerable communities.



5.2 Condition-based framework

3. Estero Tripa de Gallina, Pasay City

The neighborhoods along Estero Tripa de Gallina represent a different urban context but share the core spatial and environmental conditions of Tatalon. The channel along these neighborhoods produces compound flooding. The dense informal settlement is along the waterway separated from the commercial and residential fabric. Drainage infrastructure is inadequate, ground surface is entirely impervious, and government flood efforts have prioritized the channel rather than addressing the informal settlement's drainage conditions.



The condition-based framework identifies the spatial, environmental, and governance conditions under which the approach developed in the project is transferable to other similar neighborhood contexts. It is not a checklist of data points but a qualitative description of the neighborhood types this project addresses. These are drawn directly from the analysis of Barangay Tatalon. A neighborhood that recognizes itself in these conditions is a candidate for replication.

1. Environmental Conditions

- **Compound flooding**- the neighborhood experiences both pluvial flooding from intense rainfall and fluvial flooding from backflow from an adjacent river or waterway simultaneously which produces flood conditions more severe than either can cause alone.
- **Low-lying enclosed topography**- the settlement occupies a basin-like configuration where water accumulates from multiple directions with limited natural escape, regardless of rainfall intensity.
- **Low-permeability soil**- infiltration-based flood strategies are limited, making surface detention and conveyance the primary approach to stormwater management.
- **Proximity to a river or waterway**- the settlement's primary natural drainage outlet is a river or channel that doubles as a source of fluvial backflow during peak events.

2. Spatial Conditions

- **Dense informal settlement**- the neighborhood is characterized by a high concentration of informal structures with minimal setbacks, narrow pathways, and an almost continuous built mass.
- **Absent drainage hierarchy**- there is no organized system of primary, secondary, or tertiary drainage channels within the settlement interior. Road surfaces serve as the primary conveyance mechanism.
- **Near-total imperviousness**- concrete surfaces dominate throughout the settlement, eliminating absorption and accelerating surface runoff.
- **Formal-informal divide**- the settlement is bounded by formal urban fabric such as gated communities, commercial strips, major road infrastructure. This generates runoff which is then discharged into the informal settlement without contributing to its drainage capacity.
- **Barriers restricting access**- the settlement is enclosed by physical barriers such as walls and infrastructure. This restricts movement, blocks drainage paths, and limits the integration of the informal settlement with the surrounding neighborhood.

2. Governance Conditions

- **Government flood infrastructure is present but misaligned-** investment in flood control exists but takes the form of top-down grey infrastructure such as sheet piles, pumping stations, river dredging. These infrastructure addresses symptoms rather than the neighborhood-scale spatial causes of flooding, and in some cases produces unintended consequences that worsen inundation
- **No community participation in flood planning-** residents have not been involved in the design or decision-making of flood control measures, and have developed passive rather than active adaptive practices in response to the recurring reality of flooding
- **Willingness to invest exists but is misdirected-** the government demonstrates a financial commitment to flood management in the area. This provides an opportunity for a co-production model that redirects that investment toward integrated neighborhood-scale infrastructure rather than large-scale grey solutions

5.3 Decision matrix

The decision matrix operationalizes the condition-based framework into a practical assessment tool for planners, designers, and local governments evaluating whether the neighborhood design approach is applicable to a new site. It is observation-based rather than data-driven. All conditions can be assessed through site visit, aerial analysis, and spatial mapping.

For each condition, the assessor assigns one of three responses: Yes- the condition is clearly present; Partial- the condition is present but not fully developed; No- the condition is absent.

Condition	Yes	Partial	No
Compound pluvial and fluvial flooding (E)			
Low-lying enclosed topography (E)			
Low-permeability soil (E)			
Proximity to river or waterway as flood source (E)			
Dense informal settlement (S)			
Absent or inadequate drainage hierarchy (S)			
Near-total imperviousness (S)			
Formal-informal divide worsening flood (S)			
Physical barriers restricting access and drainage (S)			
Government flood infrastructure present but misaligned (G)			
No community participation in flood planning (G)			
Government willingness to invest in flood infrastructure (G)			

Table 5.1 Decision matrix table

Note. Made by Author

Reading the matrix

1. A site that scores Yes on all or most environmental and spatial conditions, combined with Yes on government investment willingness and misaligned infrastructure, is a direct replication candidate. The full design approach model apply.
2. A site that scores Yes on environmental and spatial conditions but No on government investment willingness is a partial replication candidate. The spatial measures and drainage hierarchy approach remain relevant but the co-production model needs to be renegotiated through community-led or NGO-supported pathways.
3. A site that scores *Partial* across multiple conditions is an adaptation candidate. The approach provides a relevant framework but requires significant modification to fit the specific spatial, environmental, and governance context of the site.
4. A site that scores *No* on the compound flooding condition or the low-lying topography condition is outside the scope of this framework. The spatial logic of the layered basin concept depends fundamentally on these two conditions being present.

Note: Measures applicable to each replication context can be identified through the evaluation criteria presented in chapter 4, cross-referenced against the site’s specific spatial and governance conditions.



06

Discussion and Conclusion

6.1 Conclusion

The project aimed to answer a central research question: how can understanding flood risk factors in dense low-income neighborhoods in Metro Manila guide the development of flood resilience strategies and measures that are effective and replicable? Through analysis, evaluation, and design, it was determined that in these contexts, flood resilience is not a technical problem with a technical solution. It has spatial, social, and political implications that need to be answered.

The first sub-research question asked what spatial, social, and environmental factors influence flood risk in low-income neighborhoods in Metro Manila. The analysis of Barangay Tatalon revealed that flood vulnerability results from overlapping conditions. These factors include the low-lying basin topography which physically influences the settlement to water accumulation, a clay soil that reduces infiltration-based solutions, a compound flood typology that combines pluvial and fluvial flooding simultaneously, an almost entirely impervious ground surface, an absent drainage hierarchy, a formal-informal divide that concentrates the hydraulic burden on the most vulnerable residents, and a governance context in which flood control investment exists but consistently fails to address the neighborhood-scale spatial causes of flooding. These factors are systemic and decades in the making. Flood vulnerability is a condition produced by the same forces of urbanization, inequality, and institutional neglect that gave rise to informal settlement itself.

The second sub-research question asked what general strategies can effectively enhance flood resilience in flood-prone low-income communities. The catalogue of practices and the multi-criteria evaluation revealed that the most effective strategies are not the largest or most expensive ones, such as pumping stations, secondary dikes, and amphibious housing. The strongest-performing strategies were those that worked with the settlement's context and spatial conditions. These measures included sloped surfaces and gravity channels, elevated ground floors, community organizing, participatory risk mapping, bioretention, and drainage system improvements. These findings challenge the idea that mitigating flooding in informal settlements requires massive infrastructural intervention. The results show that low-cost, community-compatible strategies are effective. The only problem is that they aren't happening yet.

The third sub-research question asked under what conditions these measures could be replicated. The replicability framework established that most of the conditions for transferability are spatial and environmental. These include compound flooding, low-lying enclosed topography, low-infiltration soil, absent drainage hierarchy, and the formal-informal divide. When combined with the governance context of misaligned investments, they constitute the most critical condition for transferability. Where these conditions are evident, the approach developed in this project is relevant. The vision map identified three sites in Metro Manila where this convergence is present, demonstrating that the conditions in Barangay Tatalon are a recurring pattern in Metro Manila.

The first design question asked what types of spatial strategies can enhance flood resilience within a dense neighborhood context. The technical approach demonstrated that the primary spatial strategy is organizational rather than infrastructural. This is done by establishing a drainage hierarchy where none exists, reconfiguring the ground into a permeable, connected system, and introducing a primary spine that simultaneously organizes water, movement, and community life. In a context where space is scarce and resources are limited; the most powerful design move is not to add new infrastructure but to reorganize what is already there.

The second design question asked what forms of neighborhood-scale physical interventions can translate flood resilience strategies under conditions of high density and limited space. Both the collective block and the phasing strategy answer this question. These two strategies demonstrate that incremental, co-produced, and grounded interventions can embed flood resilience measures within an existing dense urban fabric without requiring large-scale demolition or relocation. The pilot block approach shows that transformation does not need to happen all at once. It can begin with one block, one spine, one drainage connection, and then grow outward from there.

The third design question asked what spatial relationships and configurations allow flood resilience interventions to co-exist with the daily use of space. The integrated design, with the site plan, site sections, and perspectives across dry, flood, and post-flood conditions, demonstrates that coexistence is possible when flood resilience is treated as the organizing logic of the neighborhood. The primary spine is both a secondary drainage channel and the neighborhood's main social axis. The collective block is simultaneously a flood-proof structure and a shared domestic infrastructure. Therefore, in this project, co-existence isn't seen as a compromise but as a result of designing with the same priority in mind.

6.2 Implications

The primary implication of this project is a reframing of what flood resilience means in the context of dense informal settlements. Flood resilience is not the elimination of flooding. Looking back at the neighborhood context, a low-lying basin settlement with compound flooding, low-infiltration soil, and a river on its edge, flooding will always happen. Therefore, flood resilience makes flooding manageable and, in effect, creates conditions for residents to adapt, respond, and recover from flooding without being displaced or marginalized.

This reframing has implications for urbanism beyond Metro Manila. Informal settlements facing compound flood risk exist across the developing countries. These risks happen in contexts where the communities have been left to manage flood risk on their own for decades, and where the formal sector's response has consistently failed to address the neighborhood-scale spatial causes of vulnerability. The layered basin concept, the co-production gradient, and the condition-based replicability framework developed in this project offer a transferable model that can be adapted to similar contexts where density, informality, compound flooding, and governance misalignment persist.

The project also has implications for how the relationship between formal and informal urban fabric is understood in flood risk management. The analysis clearly demonstrated that flooding in Barangay Tatalon is not solely caused by the informal settlement but is significantly exacerbated by the hydraulic effects of the surrounding formal areas. Therefore, addressing flood risk in informal settlements requires engaging the formal sector. They should not act as a sponsor but as a co-responsible party. The co-production model proposed in this project begins with this principle, and its replicability depends on identifying where the formal sector's interests and the informal community's needs could converge.

Finally, this project contributes to a growing body of urbanism knowledge that argues for the neighborhood scale as the critical unit of flood resilience intervention. Resilience is built at the scale where social networks, spatial organization, and physical infrastructure can be integrated into a coherent whole, not just at the individual household level or the city-wide infrastructure system. The neighborhood is where that integration becomes possible, and where design can make the most meaningful difference

6.3 Reflection

The graduation project process was more challenging than anticipated. The project began with a straightforward problem: flooding in informal settlements. But this was progressively revealed to be much more layered and complex. The environmental dimensions alone have established that there is no simple solution. The social and political conditions, such as systemic marginalization, governance failures, and the long-standing neglect of these settlements, have added complexity to the current situation.

One of the most significant methods used was the multi-criteria evaluation. The process of evaluating strategies against the site's specific conditions has informed the design decisions. There were realizations that the most interesting strategies, such as amphibious housing, were not always the best choice for this context. Therefore, the evaluation made the selected measures more defensible and honest.

The site visit to Barangay Tatalon was the most significant moment of the research process. There is a different understanding of the site once you walk through it. The moments when observations such as narrow streets, flood lines marked on walls, and residents who have just completely accepted that flooding is a permanent part of their lives. The site visit reinforced my motivation not to save these communities from flooding, but to give them the capacity and conditions to save themselves.

An honest limitation of the project is the absence of community participation in the design process. Co-production is the central idea of the what-if scenario, yet the design was produced without the direct involvement of the residents. This is a contradiction that wouldn't have been resolved within the time constraints of the graduation project. What the design offers instead is a set of principles where co-production could occur if the project were to move forward in the future.

The second limitation is the limited amount of accessible data in Metro Manila. Having studied in the Netherlands, it is hard not to compare how stark the contrast is. Data in the Netherlands is comprehensive and publicly accessible to researchers and students. In the Philippines, data for informal settlements is difficult to access and often nonexistent. The absence of this data has direct consequences on the way the design was approached. A more complete version of this project would require sustained research in Metro Manila, where direct community engagement and access to data are available and fit within the timeline.

The research by design approach generated new analytical questions and created a feedback loop between research and design. The most valuable finding of the process was during the gathering of strategies and measures for the catalogue. Flood resilience strategies that are low-cost, spatially feasible, and compatible with the community exist, and the reason that they are not already being implemented is not a technical challenge but a political one. This demonstrates the lack of institutional and political will. The project positions itself between the existing conditions and the possible future conditions that can happen. This project does not claim to solve flooding in Metro Manila. It claims that with the right measures, a co-production framework, and proper alignment of interests, valuable transformation can occur.



07

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