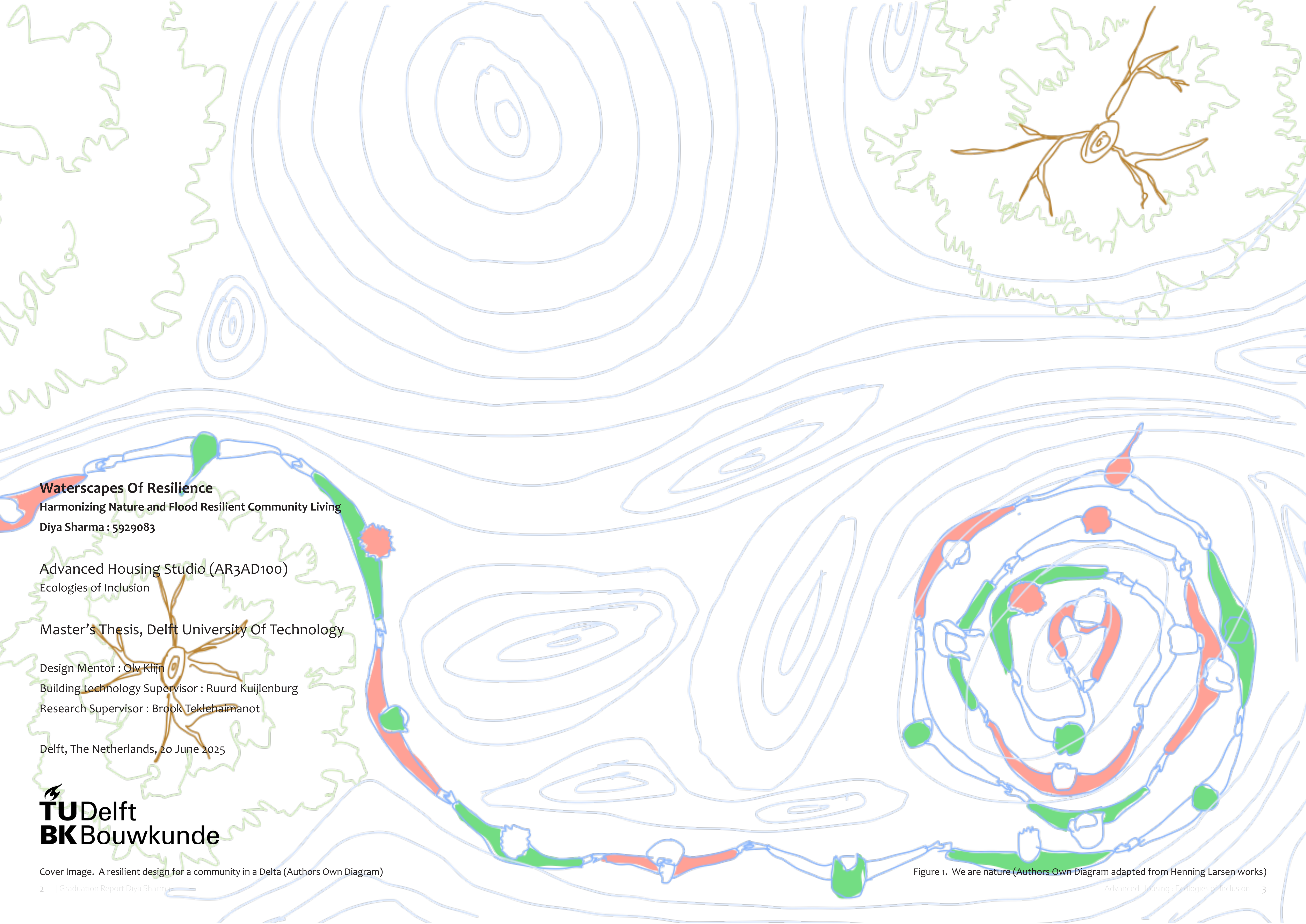
WATERSCAPES OF **RESILIENCE**

Harmonizing Nature and Flood Resilient Community Living

Advanced Housing Graduation Studio

Diya Sharma



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Harmonizing Nature and Flood Resilient Community Living

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Advanced Housing Studio (AR3AD100)

Ecologies of Inclusion

Master's Thesis, Delft University Of Technology

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Building technology Supervisor : Ruurd Kuijlenburg

Research Supervisor : Brook Teklehaimanot

Delft, The Netherlands, 20 June 2025

TU Delft
BK Bouwkunde

Cover Image. A resilient design for a community in a Delta (Authors Own Diagram)

Figure 1. We are nature (Authors Own Diagram adapted from Henning Larsen works)

Preface

In front of you lies Waterscapes of Resilience, the result of a year-long research and design journey within the graduation studio Advanced Housing, under the Ecologies of Inclusion theme. This report marks the conclusion of my MSc Architecture, Urbanism and Building Sciences degree at Delft University of Technology, within the Architecture track. My graduation project was developed from early September 2024 to July 2025.

My passion for architecture has always been rooted in the subtle complexities of residential design. While I have enjoyed exploring various building typologies, designing homes has always felt more intimate and personal—offering a deeper understanding of human behavior and interaction within space.

At the same time, I have been deeply motivated to explore how housing can address pressing global challenges, particularly in terms of affordability, resilience, and scalability. Housing may seem deceptively simple, but it holds within it layers of complexity that I find immensely rewarding to navigate—like solving an intricate puzzle.

When this studio presented the idea of advanced housing in the context of global ecological and climate challenges, it felt like a natural progression in my academic journey. Sustainability has always been a core interest of mine, and a major reason why I chose to pursue my master's at TU Delft. I am grateful that this project allowed me to engage with both personal and global concerns while learning immensely along the way.

I would like to sincerely thank my design mentor, Olv Klijn, for his continuous support, guidance, and belief in my ideas. At the outset, I wasn't entirely confident in the scale or ambition of my chosen topic, but Olv's encouragement helped me find the clarity and motivation to pursue it. His openness to my ideas and constructive feedback played a significant role in shaping the outcome of this project.

I also extend my thanks to my building technology mentor, Ruurd Kuijlenburg, for his clear, honest, and thoughtful feedback throughout the process. I particularly appreciated the time and effort he put in toward the end of the project to help me consolidate my ideas.
A special thank you to my research mentor, Brook Teklehaimanot, for helping me structure and refine the many strands of my research. Your insights helped me gain a clearer understanding of my topic and brought cohesion to my narrative.

Finally, I am deeply grateful to my family and friends for their unwavering support throughout this journey.

I hope you enjoy reading this report as much as I have enjoyed creating it.

Diya Sharma
Delft, The Netherlands, 20 June 2025

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EX-ANTE FRAMEWORK

INTRODUCTION

The landscape around is changing rapidly especially owing to climate change and other environmental conditions. How are we able to live in harmony with nature and respect its biodiversity, or do we continue to create a stark divide between the built environment and the natural world?

“No matter how much one may love the world as a whole, one can live fully in it only by living responsibly in some small part of it. Where we live and who we live there with define the terms of our relationship to the world and to humanity.” (Berry, 1980, p.123). Humanity is steadily drifting away from its fundamental connection with nature. This growing disconnect raises concerns, as many of the solutions we develop inadvertently lead to greater challenges in the future. A deeper understanding of how humans and nature can coexist is essential, with both needing to be respected in their natural states. The research therefore intends to delve into the potential of wetlands to support sustainable living while addressing the critical environmental challenges of water management, biodiversity loss, and urbanization.

Eco-psychologists (cf. Roszak et al., 1995; Roszak, 2001; Fisher, 2002) have echoed Leopold’s statement that feeling a sense of belonging to the broader natural community may be a prerequisite for increasing environmental protection. They argue for fostering ecological behaviour through expanding our sense of self, for ‘if the self is expanded to include the natural world, behaviour leading to destruction of this world will be experienced as self-destruction’ (Roszak, 1995). Wetlands are dynamic ecosystems, vital to global biodiversity, providing essential ecological services such as water filtration, carbon sequestration, and habitats for diverse species. However, they are increasingly threatened by climate change, particularly rising sea levels and increased flood events.

Simultaneously, human interventions in these regions, such as urban expansion and infrastructure development, further disrupt the ecological balance. Given the rising water levels in the Netherlands, it is critical to prepare for future challenges. Embracing flood-resilient housing and allowing the intentional flooding of certain regions can help restore the balance between human habitation and natural ecosystems. Traditional flood defenses frequently involve substantial interventions that can negatively impact wetland ecosystems, underscoring the need for more adaptive, sustainable approaches to housing design.

Additionally, the disintegration of community life is troubling, as more people experience isolated living, far removed from the once vibrant family modules and communal organizations that formed the heart of society. The notion of ‘family’ is evolving and the types of communities are changing.

This research proposes to explore housing designs that incorporate innovative construction techniques and sustainable materials to create adaptable living environments. By integrating flood-responsive architecture with community-centered design, the study aims to develop a framework for housing that aligns with environmental preservation goals while enhancing social cohesion. Through an analysis of existing resilient housing models and an exploration of new design principles, this study seeks to contribute to a broader understanding of how housing in wetland areas can be both resilient and regenerative. It advocates for a shift from rigid flood defenses to flexible, nature-based solutions, fostering sustainable living and stronger, flood-adaptive communities. By rethinking how we dwell in flood-prone regions, this research aspires to bridge the gap between human habitation and natural ecosystems, creating homes that not only withstand the forces of water but thrive alongside them.

The **first chapter** introduces the concept of **de-synchronization** — the growing disconnection between human systems (economy, built environment, and individual behavior) and natural ecosystems. It argues that the Western worldview, rooted in scientific positivism, treats nature either as a resource to exploit or a threat to control, reinforcing a harmful divide. The research frames this imbalance across three levels of disengagement:

Economy vs. Ecology — Economic growth often undermines ecological health by exploiting natural resources, failing to recognize that the economy itself depends on a thriving environment. Built Environment vs. Ecology — Urban planning and rigid infrastructure (like dikes and canals) disrupt natural processes, increasing vulnerability to climate change by suppressing the adaptive capacities of wetlands and floodplains. Individuals vs. Ecology — Modern lifestyles foster a cultural and psychological separation from nature, with urbanization and digital communication further isolating people from ecological realities. The chapter emphasizes the need for re-territorialization — a rethinking of how human and natural systems can co-evolve, allowing controlled flooding and ecological restoration as adaptive responses to climate change.

The first chapter tries to find answers to the questions like How does de-synchronization between human and natural systems contribute to socio-economic and environmental crises? What are the consequences of treating nature as something to be controlled rather than coexisting with it? How can re-territorialization reconnect economy, built environments, and individuals with ecological systems? This chapter justifies why a new design approach is essential — one that doesn't just create resilient housing but also reconnects human systems (communities, economies, and architecture) with the natural environment.

Building on the idea of de-synchronization, the **second chapter** zooms into the **Dutch Delta** — a prime example of how territorialization (controlling water through infrastructure) has led to ecological fragility. The Delta, where natural water systems were controlled through dikes, pumps, and canals. It tries to answer the main question of How has territorialization shaped the Dutch Delta?

Despite advanced flood defenses, the Delta remains vulnerable due to climate change and rigid urban planning. It discusses how rigid water management systems have made urbanized areas more susceptible to climate change answering the question of Why are "protected safe zones" vulnerable to climate change?

This chapter introduces the need for re-territorialization: a shift from controlling water to embracing dynamic, adaptive strategies — like controlled flooding and wetland integration. Crucially, it links back to the research question by underscoring that flood-resilient housing cannot exist in isolation — it must be part of a broader landscape strategy that harmonizes human and natural systems.

While the previous chapters focus on environmental resilience, the **third chapter Need for Community Living**, highlights the social aspect of resilience — the role of community living in fostering adaptability. It traces the shift from historic communal models (like hofjes and canal houses) to modern, isolated living patterns driven by urbanization and high-rise developments.

The chapter emphasizes that resilient housing must go beyond technical solutions — it needs to create spaces for community interaction, resource sharing, and collective adaptation. It delves into concepts of transitional spaces and correlation of public and private realms in community based design. Therefore the key questions that the chapter tries to focus on are, What is community living, and why has it declined in modern housing models? How does community living support flood resilience? What design changes are needed to foster community engagement in housing?

The Living on water chapter serves as a critical turning point in the research, bridging the theoretical concepts of de-synchronization and community living with the practical design strategies explored later in Re-defining dwelling. It challenges the traditional, static notion of "home" by asking what it means to dwell in regions where water levels are constantly shifting. Rather than viewing homes as fixed structures that resist natural forces, this chapter looks at housing as a dynamic relationship between people, water, and community. It raises fundamental questions: How does living on water reshape ideas of home and community? The chapter further explores how water-based living, through floating and amphibious homes, redefines both individual and collective living spaces, emphasizing the importance of shared public spaces and community support systems.

To ground these ideas in reality, the chapter draws on key case studies that illustrate innovative approaches to living on water in Netherlands context. These case studies play a vital role in the research. They test the research's core assumptions: that homes can adapt to rising water without compromising quality of life, that shared spaces strengthen community bonds in times of crisis, and that flood-resilient design must remain affordable and accessible. The case studies collectively show that resilience is layered — not just about withstanding water but about fostering dynamic, interactive environments that align human and natural systems.

Ultimately, this chapter is crucial to the research as it moves the study from problem diagnosis to design solutions. It connects the earlier discussions of de-synchronization — the disconnect between humans and nature — with practical strategies for rethinking housing as part of a larger socio-ecological system.

The chapter Re-defining dwelling brings the environmental and social threads together, proposing flood-resilient housing as a bridge between nature and community. Through the examples of case studies from around the world it presents design strategies like Floating and amphibious houses that adapt to changing water levels, green-blue infrastructure that integrates wetlands and waterways into housing layouts, shared spaces and community modules to strengthen social networks and promote resource sharing during floods. The findings from the case studies show that flood-resilient housing must respond to natural dynamics by allowing controlled flooding and ecosystem regeneration. It should also support community resilience by fostering collective adaptation and reducing isolation while balancing affordability with sustainability, to ensure these solutions are inclusive and accessible.

By redefining dwelling, the research pushes past the idea of homes as static entities and instead proposes flexible, adaptive spaces that respond to both water dynamics and community needs. This chapter solidifies the research's central argument: that flood-resilient housing must support both environmental sustainability and community well-being. It reinforces the idea that future housing solutions must integrate nature-based strategies with collective design principles, laying the foundation for the final design framework.

In doing so, the chapters directly strengthens the research question: ***How can flood-resilient housing be designed to support both environmental sustainability and community well-being in flood-prone regions?***

By merging theory with tangible examples, all the chapters not only advances the study's narrative but also establish a clear path toward innovative, adaptive housing design.

Research Aim

This research aims to explore how flood-resilient housing in wetland and flood-prone regions can be designed to support both environmental sustainability and community well-being. It investigates the potential of architecture and urban design to harmonize with natural water dynamics while fostering social cohesion, collective resilience, and ecological integration.

By analyzing case studies, theoretical frameworks, and spatial strategies in the Dutch Delta and beyond, the research seeks to develop a design approach that responds not only to rising water levels but also to the growing disconnection between people, place, and nature. The goal is to formulate spatial and architectural strategies that enable communities to live with water, rather than resist it, and to redefine dwelling as a symbiotic relationship between human and ecological systems.

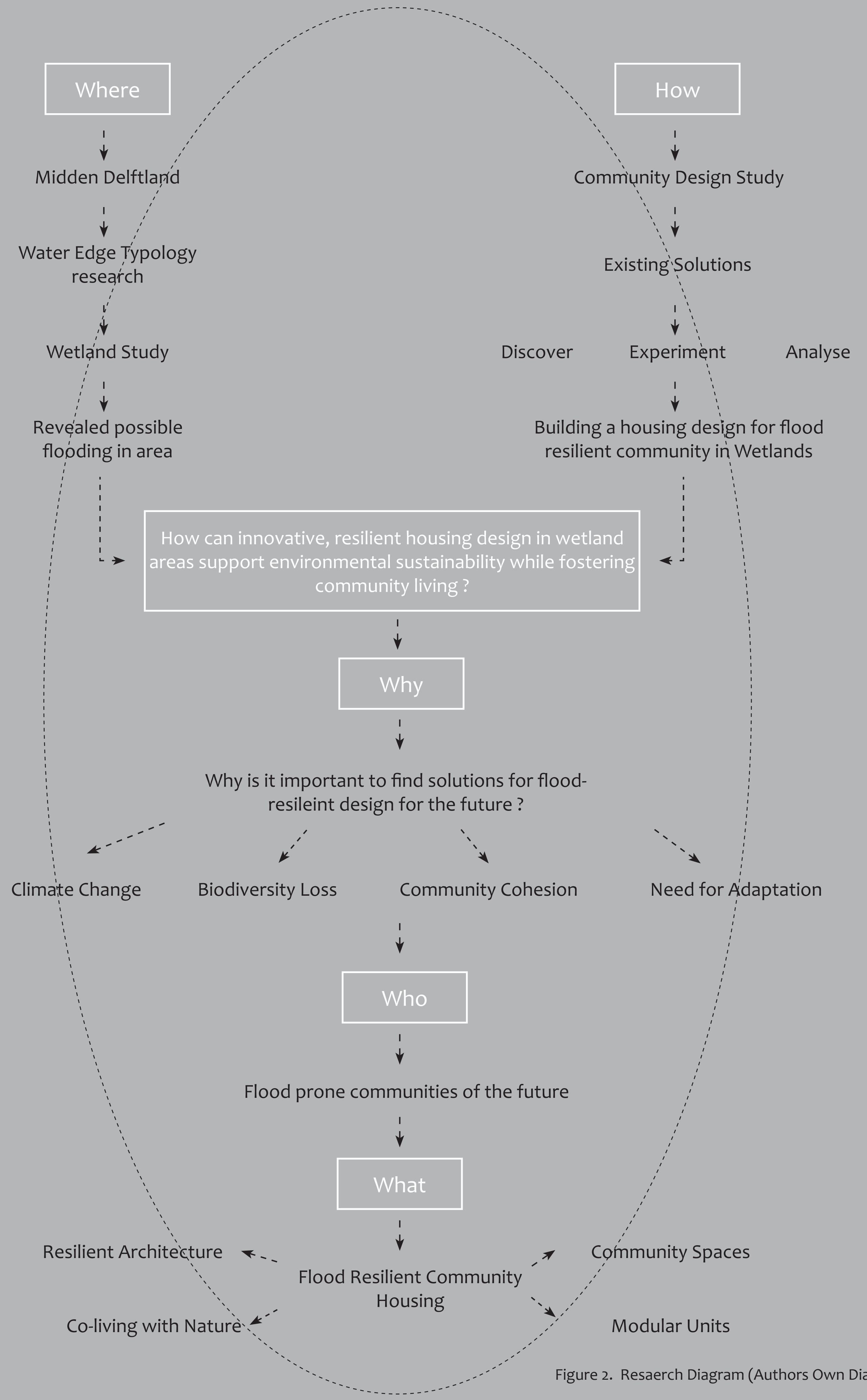


Figure 2. Resaerch Diagram (Authors Own Diagram)

RESEARCH PLAN

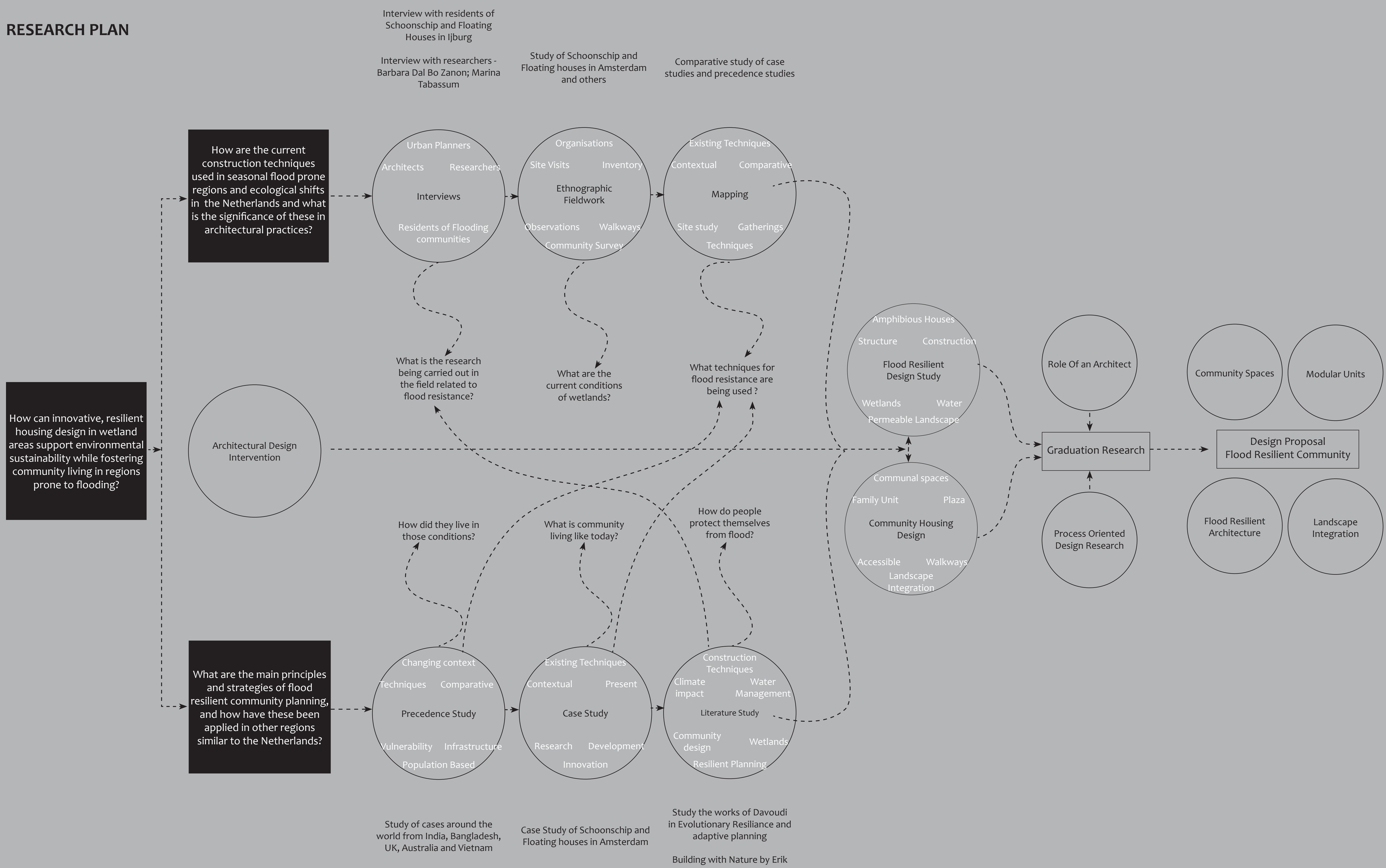


Figure 3. Research Methods Diagram (Authors own Diagram)

Research Methodologies

Literature Review:

Explored theoretical foundations such as de-synchronization, re-territorialization, and adaptive governance, alongside ecological urbanism and resilience theory. Key references include works by Boehnert, Bateson, Davoudi, and Capra, among others.

Historical and Precedent Study:

Investigated Dutch courtyard housing and early social housing to understand principles of collective living. Alongside analysed the failures of post-war Dutch community housing models.

Examined works of Aldo Van Eyck of Herman Hertzberger, Charles Correa, whose ideas on in-between spaces, thresholds, and participatory housing.

Case Study Analysis:

A comparative study of resilient housing projects worldwide—such as amphibious houses in Vietnam and the UK, stilt housing in Assam and Bangladesh, Schoonschip and Ijburg community in Amsterdam—enabled extraction of design principles related to adaptability, modularity, community integration, and circularity.

Findings and Strategic Framework :

The research methodology not only follows a phased approach but is also organized thematically across chapters, where each investigates a critical dimension of the research question: "*How can flood-resilient housing be designed to support both environmental sustainability and community well-being in flood-prone regions?*"

Each chapter posed a focused sub-question, allowing the research to evolve as a multi-scalar and interdisciplinary inquiry. The findings from each chapter led to tangible design strategies, which were later translated into the architectural proposal.

Ethnographic Fieldwork:

Conducted interviews and site visits in IJburg and Schoonschip, Amsterdam, as well as with practitioners and residents.

Semi-structured interviews were conducted with residents, architects (e.g., Marina Tabassum), and researchers (e.g., Barbara Dal Bo Zanon), offering qualitative data on spatial preferences, social cohesion, and ecological awareness.

Mapping and Contextual Research:

Studied Midden-Delfland's topography, water systems, soil composition, and vulnerability using maps and data bases.

Design Iteration & Scenario Thinking:

Used design iteration and "what-if" scenario modeling to test housing typologies under variable flood conditions, using modeling softwares, physical models and sketching.

How to read the Research

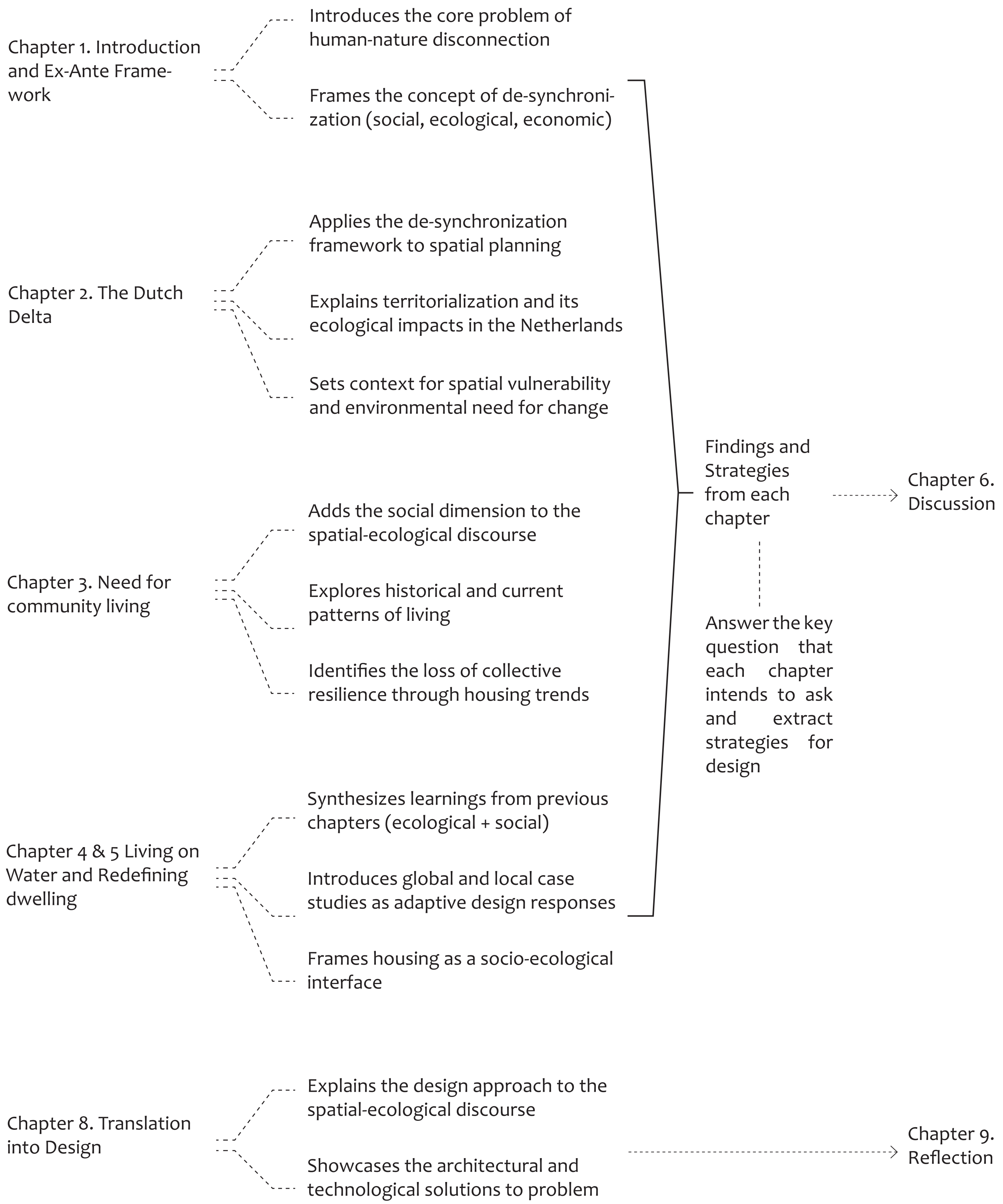
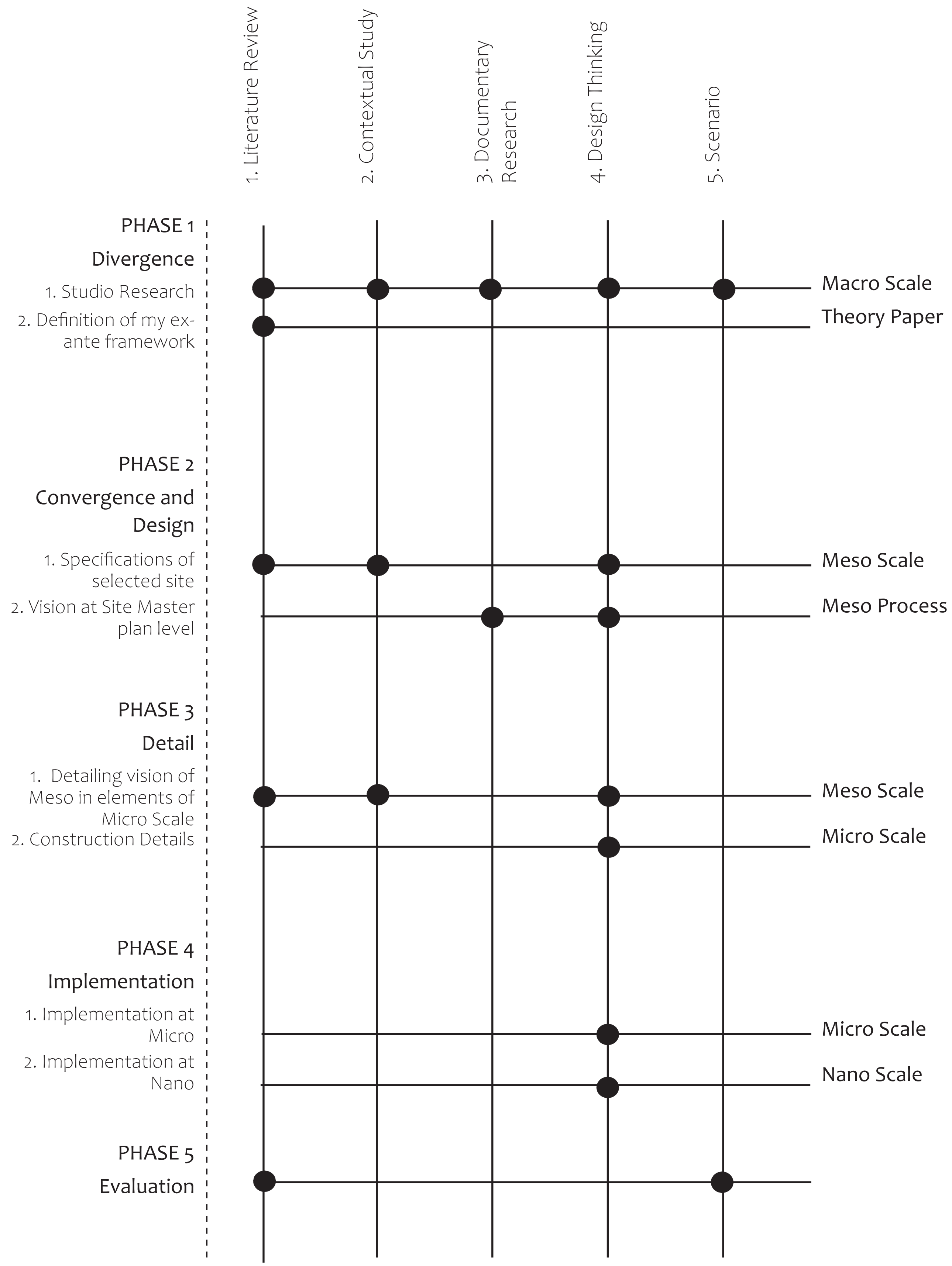


Figure 4. Diagram indicating how to read the research (Authors Own Diagram)



Macro Scale:
Global and National trends study of relevant case studies and theories
Meso Scale:
Focus on the site and development at a master plan level

Micro Scale:
Focus on Individual Units
Nano Scale:
Focus on specific components of individual units of design

Figure 5. Thesis time and method (Authors own Diagram)

De-synchronization

"How is there an imbalance with nature?"

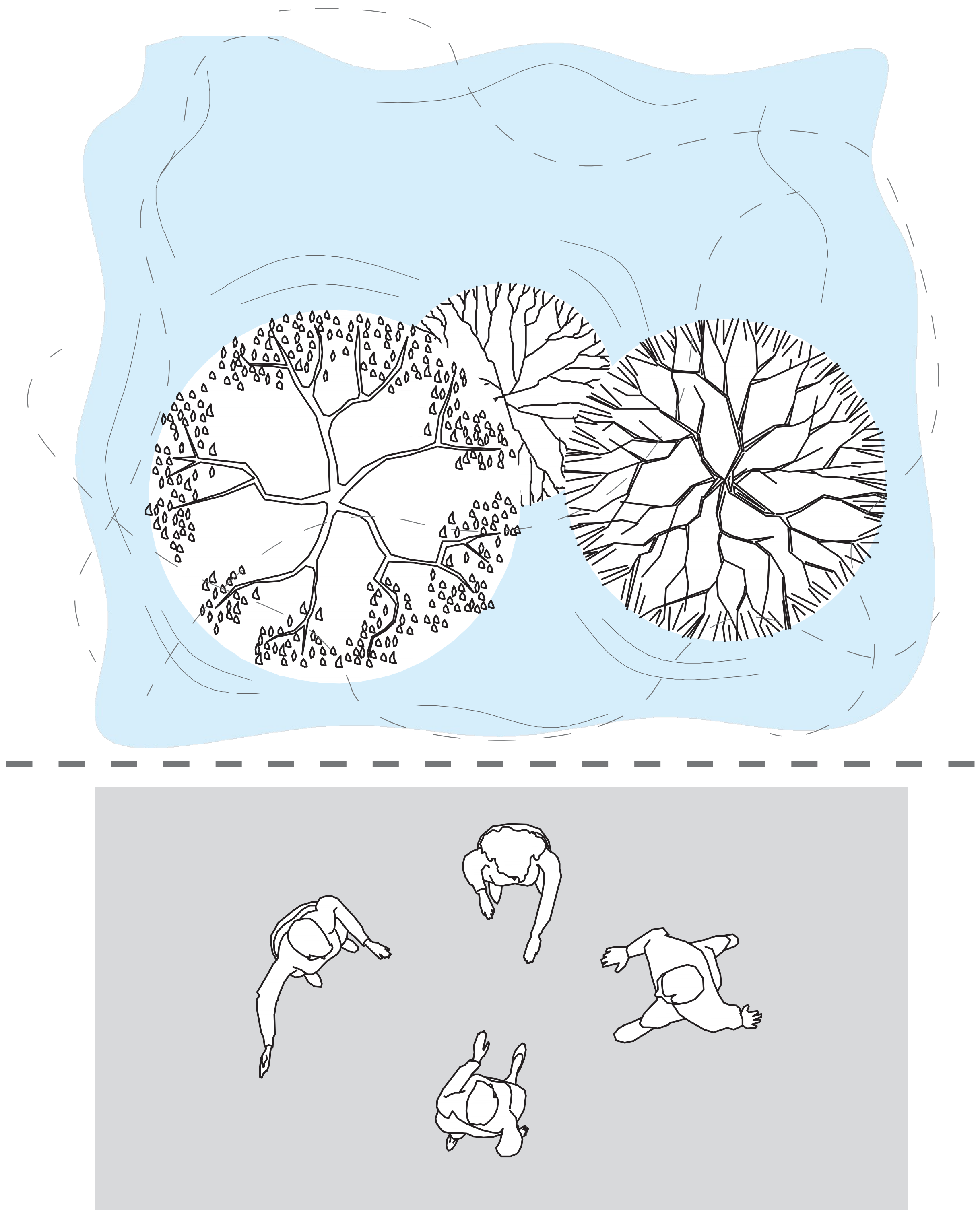


Figure 6. Nature and Human Disconnect (Authors own Diagram)

The Notion of De-synchronization

"The nature/society split was fundamental to a new, modern cosmology in which space was flat, time was linear, and nature was external." (Moore, 2018,p. 5)
The biases rooted in scientific positivism have profoundly shaped the ways in which humans have impacted, controlled, and exploited the natural environment. This perspective has perpetuated a deep disconnect between human and natural systems—both geographically and culturally—reflecting the notion of *de-territorialization*[1] (Deleuze,G., & Guattari,F., 2000).

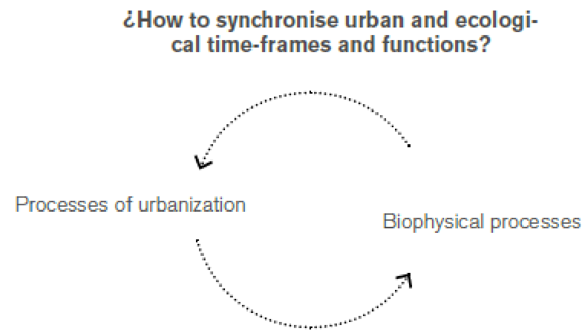
This epistemological framing has reinforced the harmful view of nature as either a resource to exploit or a threat to control. Bateson (1972) described this as an *epistemological error*[2] in Steps to an Ecology of Mind, echoed by later works (Capra & Henderson, 2009; Boehnert, 2018; Moore, 2018). This world-view has driven the disconnection between human systems—economic, spatial, and individual—and the natural environment, leading to a neglect of ecological interdependencies (Capra & Henderson, 2009).

These disconnections can be understood as a form of de-synchronization: a lack of coordination and harmony between human systems and ecological systems. Beyond the notion of coexistence, de-synchronization highlights the absence of integration and interdependence between these spheres, contributing to socio-economic and environmental crises (Boehnert, 2018). This research explores the in-depth problems arising from the disconnection between individuals and ecology, as well as the interrelations among various levels of disengagement. By examining these issues, it establishes the necessity of shifting toward an acceptance of nature and its processes. Specifically, the research advocates for the deliberate flooding of certain areas as a means of integrating water into human environments. This approach requires moving away from controlling nature toward embracing its presence, paving the way for resilient and sustainable cohabitation. This rethinking of our relationship with nature poses critical questions: How can harmonious relationships between humans and ecological systems be reconstructed? What are the implications for governance, spatial planning, and community living? By addressing these questions, the research aims to challenge the anthropocentric world-view and propose strategies to realign human settlements with natural systems, acknowledging water not as a threat but as a vital component of a sustainable future.

Before establishing the need to live with water it is first important to describe three levels of disengagements (economy, built environment and individual) with ecology, while answering to: What are the associated problems coming from these de-synchronizations? And what is the relation between them and current socio-economic-environmental crisis? How do these problems connect to floods?

1] In anthropology, de-territorialization is the separation of social, cultural and political practices from a location.
2] Epistemology error is a term used by Bateson in Steps to an Ecology of Mind, and "posits that the Western premise of radical independence from no-human nature is wrong" (Boehnert, 2018, p.63)

Beyond a matter of co-existence, the notion of de-synchronization and its inherent choreographically sense, expresses the lack of coordination and interdependencies between economy, built environment and individuals and ecology.



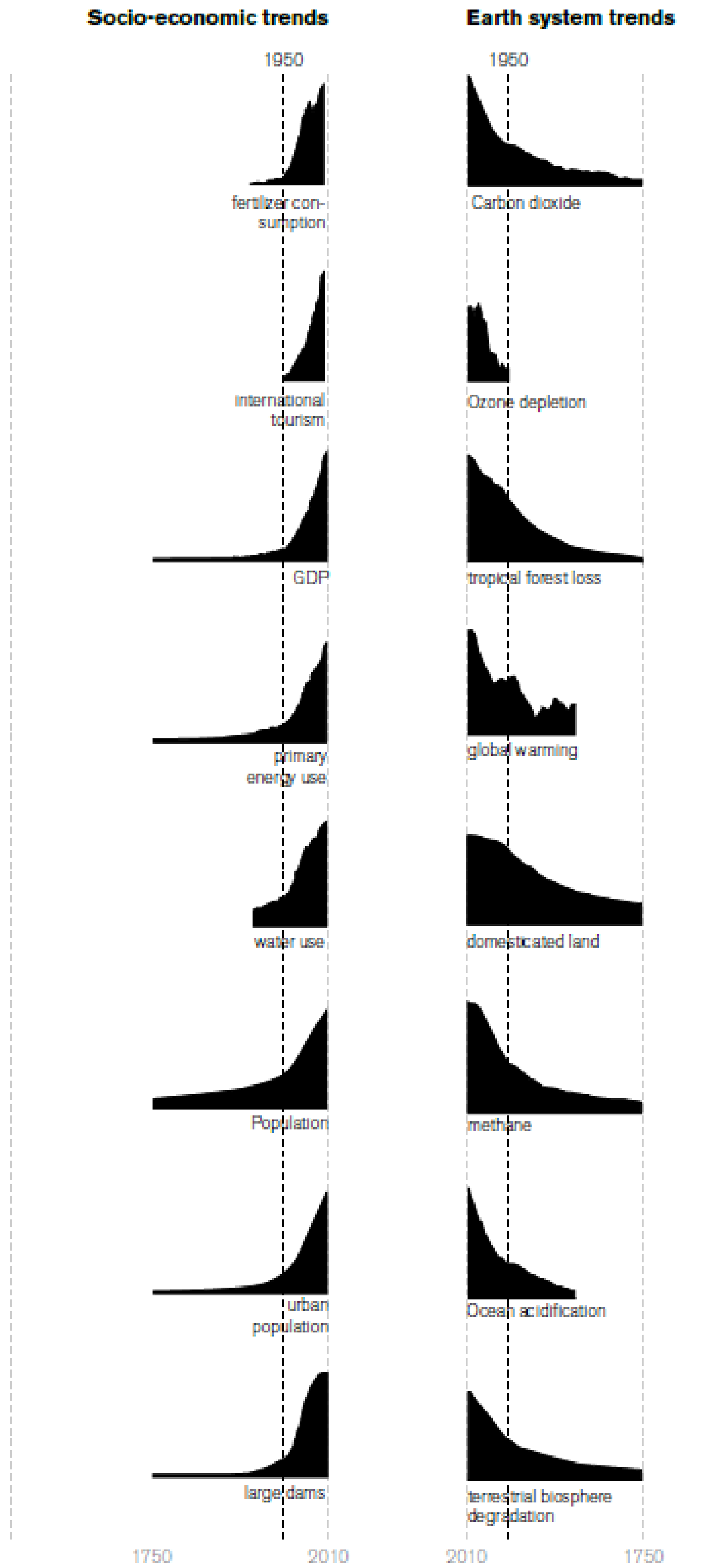


Figure 7. Great Acceleration Socio-economic and Earth System trends from 1750 to 2010 in globally aggregated indicators (Steffen et. al , 2015 a,b)

Degrees of Misalignment and converging socio-economic-environmental crisis

Our modern societies, with their advanced technologies, built environments, and economies, have succeeded in developing sophisticated systems such as precise clocks, vehicles, and flood defense mechanisms designed to fail only once every 1,250 to 10,000 years (Slomp, 2012, p.32). However, they have struggled to comprehend and manage the complexity of interconnected systems (Boehnert, 2012). As Boehnert (2018) points out, this challenge stems from an epistemological limitation: a way of understanding reality shaped by scientific positivism and post-modernism, which view nature primarily as a resource for exploitation.

This worldview is characterized by a deterministic ontology and a reductive, objectivist, and dualist epistemology (Sterling, 2003, in Boehnert, 2018). It creates a division between subject and object, mind and body, humans and nature (Boehnert, 2018, p. 51). Many thinkers, such as Bateson (1972), Capra and Henderson (2009), and Boehnert (2018), have critiqued this dominant perspective, emphasizing that it offers a flawed reflection of reality. Bateson, in Steps to an Ecology of Mind (1972), describes this as an "epistemological error," which Boehnert (2018) uses to highlight the widespread inability to perceive the synergistic relationships within ecological systems.

This misconception is "encoded in the language we use, the objects we create and the cities we build" but also it is "designed into cultural artefacts, language and systems", and it is "reproduced in education, communication, media, policy, law and design". (Boehnert, 2018, p. 64). Ultimately, this worldview underpins socio-economic systems that are in "conflict with the highly complex ecological systems on which we depend." (Boehnert, 2012, p. 3). The result is a distorted relationship with nature—seen both as a resource to exploit and a threat to control—leading to significant misalignment across three critical spheres: natural systems, economic structures, and human communities which are explained in the next segments of this chapter.

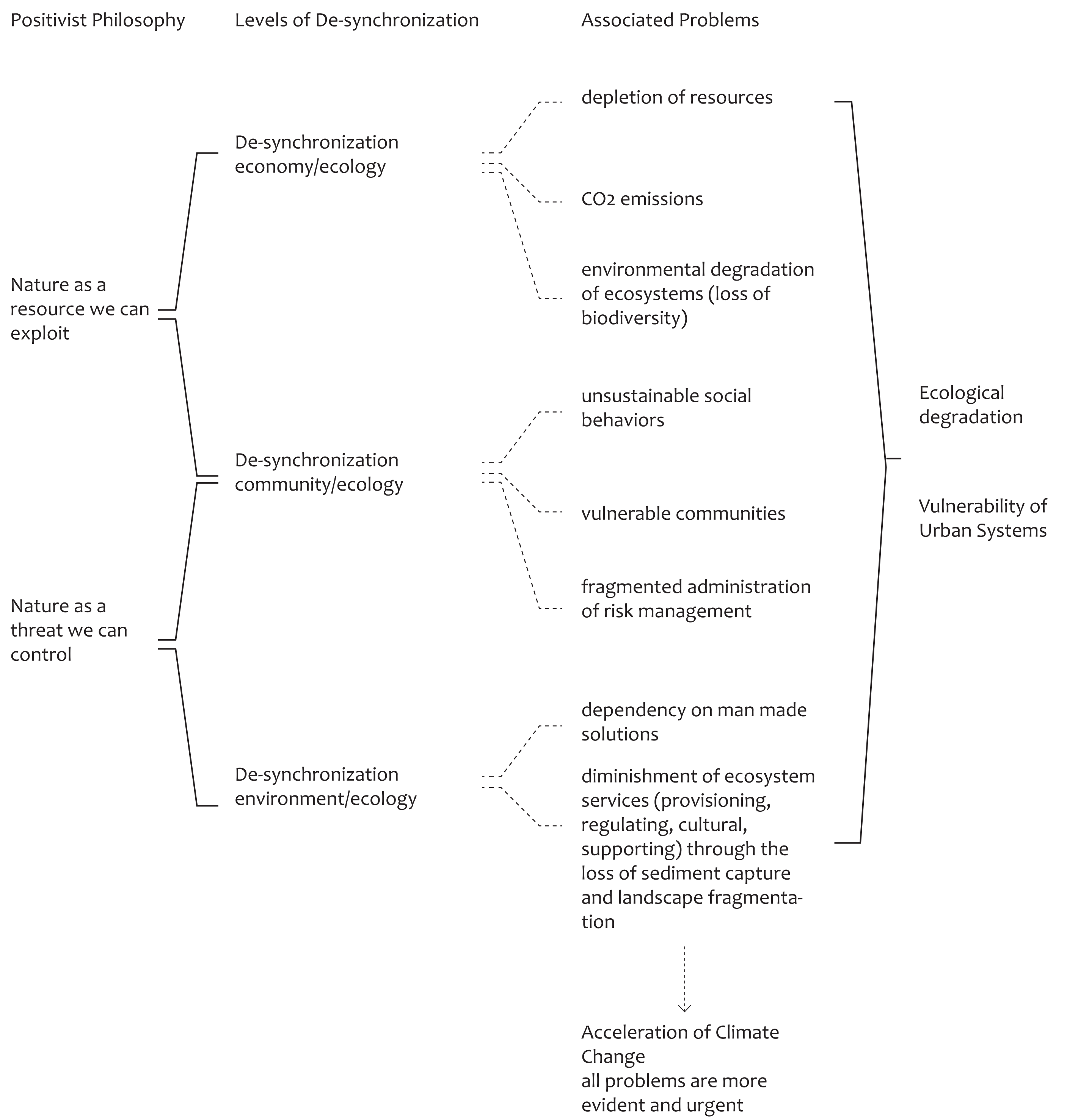


Figure 8. Diagram on the relation between positivist philosophy, levels of de-synchronization and associated problems (adapted from Recubenis, 2022)

De-synchronization of Economy/Environment/Ecology

Economy/Ecology

"Our failure to recognize that economic prosperity depends on ecological wellbeing has developed from a reductive habit of mind that is unable to understand the relationships between complex systems. This has led to a state where we are quickly destroying the possibility of long-term prosperity." (Boehnert, 2012, p. 3)

The disconnection between economy and ecology stems from a fundamental failure to recognize that the economic system is a subsystem of the ecological system. These misunderstanding neglects the dynamic interdependencies between the two and is rooted in the perception of nature as merely a resource for exploitation.

The dysfunction arises from a reductive understanding of the economy, where growth is narrowly viewed in quantitative terms. The relentless pursuit of quantitative economic growth often leads to unsustainable exploitation of natural resources, ultimately undermining long-term prosperity by degrading the very ecological systems on which the economy depends (Boehnert, 2012, p. 3). As Bateson (1972) succinctly observed:

"If an organism or aggregate of organisms sets to work with a focus on its own survival and thinks that is the way to select its adaptive moves, its 'progress' ends up with a destroyed environment. If an organism ends up destroying its environment, it has in fact destroyed itself." (p. 457 in Boehnert, 2018, p. 62)

In contrast, ecological systems demonstrate that growth in organisms, ecosystems, and societies is inherently qualitative, characterized by increasing complexity, sophistication, and maturity (Capra & Henderson, 2009, p.5). Viewing growth through the lens of biology and ecology reframes development as qualitative growth, characterized by balance, adaptability, and interdependence. This perspective bridges economy and ecology, showing how they can be mutually supportive.

Environment / Ecology

The disconnection between the built environment and ecology reflects how cities, with their sealed soils, infrastructure focused on mobility and water management, and flood protection systems such as dykes and sluices, have been developed in opposition to natural processes. This misalignment stems from perceiving nature as a threat to be controlled.

This disconnection is rooted in the act of *territorializing*[4] (Raffestin, 2012), shaped by the biases of scientific positivism and a culture of permanence. Modernist reasoning, with its belief in predictability and control of the future (Albrechts, 2010), has driven the construction of enduring physical structures, designed as if to last forever. This pursuit of permanence has emphasized urbanization as a "grand vision" rather than a "grand adjustment" (Mehrotra, 2019), fostering an obsession with resisting change.

Mehrotra (2019), in his TED Talk The Architectural Wonder of Impermanent Cities, raises critical questions about this paradigm:

"Are we trying to make permanent solutions for temporary problems? Are we locking resources into paradigms that we don't even know will be relevant in a decade? Can we accommodate climate change challenges with softer urban systems? Or will we continue to confront nature with heavy infrastructure, despite its proven inadequacy?"

A striking example of this disconnection can be seen in rivers that have been channelized, leveed, and regulated upstream, leaving little natural floodplain intact. In the Netherlands, such interventions have significantly diminished the ecosystem services provided by urban rivers (Liao, Le & Van Nguyen, 2016).

The loss of ecosystem services, by definition, translates into economic and social losses. Communities and economies must increasingly rely on costly man-made solutions to replace the free services ecosystems once provided. This cultural and economic dependence on artificial systems only deepens the divide, creating vulnerabilities as we continue to challenge nature with rigid, unsustainable infrastructure.

In contrast, addressing this de-synchronization calls for embracing adaptive, resilient, and ecologically integrated approaches in urban and architectural design—prioritizing harmony with natural systems over attempts to dominate or resist them.

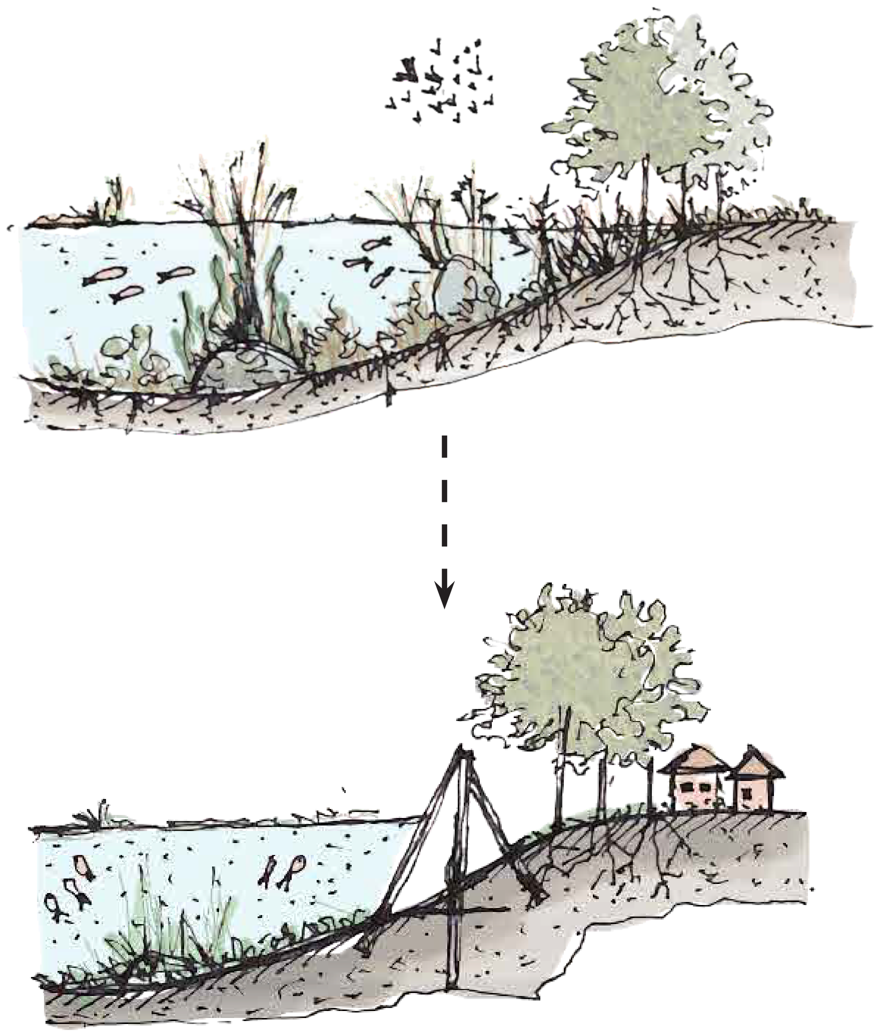


Figure 9. Diagram on the disconnect between Environment/Ecology (Authors own diagram)

De-synchronization of Individuals/Ecology

This type of disconnection operates on the individual level but extends collectively, influencing cultural attitudes and practices that shape territoriality (Raffestin, 2012). At its core is the perception of nature as something to exploit and control, a viewpoint deeply rooted in the biases of scientific positivism. This individual-ecological disconnect has profound implications for governance and planning and underpins other forms of de-synchronization.

The disengagement of individuals from ecological processes aligns with the binary opposition of nature and society described by Moore (2018), Bateson's (1972) concept of epistemological error, and the notion of de-territorialization (Deleuze & Guattari, 2000). While anthropologists traditionally use de-territorialization to describe the weakening of ties between culture and place, in this context, it refers to the separation of human and natural systems on both cultural and geographical levels (LaFleur, 2016).

Key issues stemming from the disconnection between individuals and ecology are outlined below:

Disengagement of Individuals and Communities from Natural Resource Management:

The growing cultural and geographical divide between individuals and the ecosystems they rely on has resulted in a detachment from managing the natural resources they consume. This detachment drives unsustainable behaviours, such as demanding goods that deplete resources, pollute ecosystems, and harm the environment.

As resource extraction and production occur farther from consumption centers, the cultural and perceptual gap widens. This disconnection fosters a lack of awareness about climate change mitigation measures and reinforces behaviours like *NIMBY*[3] ("Not In My Backyard"), reflecting resistance to localized environmental improvements. It also diminishes ecological literacy, perpetuating misunderstandings of natural processes such as flooding in floodplains, which are often seen solely as threats.

Disengagement of Individuals and Communities from Natural Dynamics:

"Reductionism and disciplinary isolation restrict our understanding of a world characterized by surprises and discontinuities." (Levin, 1999 in Armitage et al., 2009, p. 1)

This form of disengagement focuses on controlling or protecting against ecological processes perceived as destabilizing to economies and built environments (see sections 2.1 and 2.2). Natural dynamics are often framed as threats, reinforcing the idea that communities must be shielded rather than engaged as active participants in adapting to climate change (Davoudi et al., 2012).

This perspective distances individuals from the potential benefits of ecological processes, erodes the adaptive capacity of socio-ecological systems, and leaves communities vulnerable. The misconception that stability must be achieved through control further entrenches the disconnect between individuals and nature (Reed & Lister, 2014).

This dual disengagement—individuals from governance and governance from individuals—creates a feedback loop. Neglecting cultural dimensions and clinging to outdated assumptions about ecological stability and scientific certainty exacerbate decision-making challenges (Derek et al., 2008 in Armitage et al., 2009, p. 1).

Re-establishing the connection between individuals and nature requires ecological wisdom (Liao et al., 2016). In the context of the Netherlands, a region prone to flooding, such wisdom is grounded in understanding flood ecology and recognizing the ecosystem services provided by flooding (ibid). Periodic flooding, which has historically shaped the co-evolution of native species, is essential for maintaining the ecological health of floodplain rivers (Ward & Stanford, 1995, as cited in Liao et al., 2016). However, this natural process has largely been suppressed by the built environment designed to shield against it .

[3] NIMBY is an acronym for the phrase "Not In My Back Yard") characterizing opposition of residents to the development of a proposed artifact in their local area.

Figure 10. The de synchronization of economy/ecology/individuals (Authors own diagram)

Implications of Planning and Governance

The present moment represents a phase of reorganization, where socio-economic-ecological systems must be creatively reconfigured to establish harmonious relations. Drawing on the concept of re-territorialization, urban projects should aim to restore the lost connections between the human and natural spheres (Gunderson & Holling, 2012, in Davoudi et al., 2013 ; Deleuze & Guattari, 2000). This section explores planning and governance as tools to determine how, when, and by whom such reorganization and re-synchronization between individuals and ecological systems can be initiated.

The disconnection of individuals from resource management has led to numerous negative consequences, including unsustainable social behaviors, insensitivity toward climate change mitigation, and a misconception of ecological processes as threats. These challenges necessitate a reevaluation of management approaches to foster better engagement and understanding.

From a governance perspective, this re-engagement can be achieved through co-management, defined as "the sharing of power and responsibility between the government and local resource users" (Berkes et al., 1991, in Carlsson & Berkes, 2005). Given the cross-scale nature of environmental issues, as well as the uncertainties and continuous changes inherent in ecological and social systems, co-management is enhanced by incorporating adaptive strategies. Adaptive co-management tailors resource management approaches to specific places and situations, supported by collaboration across various organizations and scales (Armitage et al., 2009). This approach emphasizes trust-building, institutional development, and social learning (Derek et al., 2008).

Recognizing natural dynamics as part of resource management can foster an understanding of dynamic equilibrium—a balance between ongoing processes. This idea aligns with Davoudi's (2012) concept of evolutionary resilience, which emphasizes long-term adaptation to climate change through continuous adjustments. Planning, governance, and design can provide the tools to provoke a mindset shift that restores harmony between individuals and natural systems.

Strategic planning, as revisited by Albrechts (2010), offers a framework for fostering openness to new ideas and promoting awareness of the need for change across sectors, time frames, and spaces. For instance, reducing vulnerability and building agile communities can be achieved by applying principles of flood resilience, such as localized flood-response capacity (Liao et al., 2016). This principle shifts some responsibility for flood risk to property owners while enhancing their adaptive capacity. However, this approach is contentious in the Netherlands, where flood mitigation is widely perceived as the sole responsibility of the government.

This perception has hindered the broader implementation of adaptation measures. Research shows that many Dutch citizens are reluctant to invest in flood preparedness, as they view the government as responsible for flood control. Recent shifts in flood risk governance, however, emphasize the role of residents in flood preparedness and response. While the government retains legal responsibility for mitigation, citizens are increasingly expected to take proactive measures. This shift requires clear communication and education to define the responsibilities of both government authorities and residents (Snel, 2022; Bichard & Kazmiercza, 2012; Terpstra & Gutteling, 2008, in Liao et al., 2016).

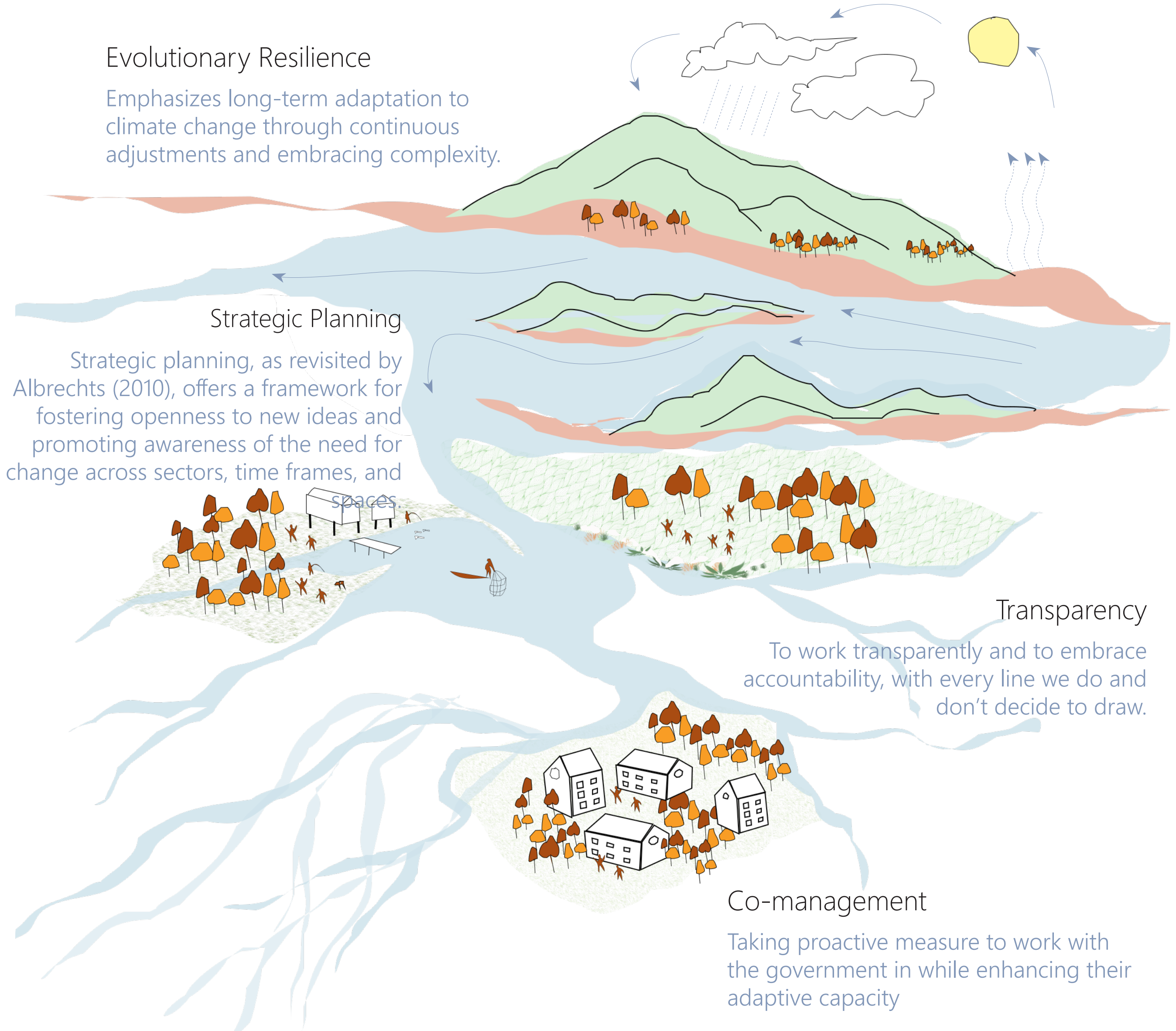


Figure 11. Diagram on the embodying nature's qualities (Authors own diagram adapted from works of Henning Larsen)

“How is there an imbalance with nature?”

- *Nature is treated as a resource or threat, not as a living system to coexist with.*
- *Economic systems prioritize short-term gain, ignoring long-term ecological interdependence.*
- *Urban planning imposes rigid control over natural processes like flooding and sedimentation.*
- *Built environments are disconnected from ecosystems, leading to the loss of natural resilience.*
- *Individuals are culturally and psychologically distanced from nature, weakening ecological awareness.*
- *Scientific positivism reinforces separation, framing humans and nature as opposites.*
- *Flooding is viewed as failure, rather than as a natural and potentially regenerative process.*
- *The built world is designed for permanence, resisting the adaptive, dynamic nature of ecosystems.*
- *De-synchronization across economic, spatial, and personal levels drives the imbalance with nature*

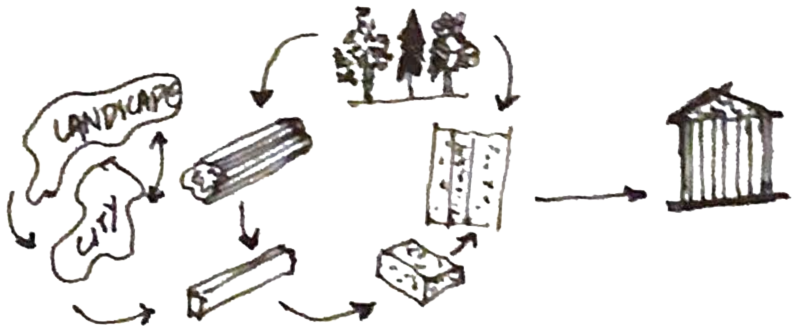
The pre-existing problem field is conceptualized through the lens of territoriality, as defined by Raffestin (2012), where territoriality represents “a spatial strategy to affect, influence, or control resources and people by controlling area” (Sack, 1986, p.1 in Raffestin, 2012, p.126). This framework highlights the disconnection between natural processes—often perceived as threats to human control—and patterns of human occupation in flood-prone regions.

Under this perspective, the problem field is framed as a process of deterritorialization (Deleuze and Guattari, 2015), characterized by the erosion of the ties and experiences (Pyle, 2003) that once connected human and natural spheres. This detachment has led to a loss of symbiosis, where human interventions prioritize resistance to natural phenomena rather than embracing coexistence.

The urban and architectural challenge posed by this thesis is to explore re-territorialization (Deleuze & Guattari, 2000) as a pathway to restoring harmony between human occupation and ecological systems. This involves leveraging culture, technology, and economy to foster a more symbiotic relationship with the environment, especially in the context of wetlands prone to flooding.

Focusing on the case of the Netherlands, particularly the Midden-Delfland area, the thesis addresses the ex-ante positioning by reflecting in the following meta-questions:
How can uncertainty be integrated into housing and urban design strategies to enable adaptive and evolutionary responses to the climate crisis, specifically in flood-prone wetlands?
How can resilient housing design serve as a medium to reconnect cultural and geographical ties between humanity and the natural environment?

Reconnection Between Humans and Nature



Adaptive Co-Management of Natural Resources

Planning for Long-Term Resilience with Strategic planning and vulnerability reduction

Enhancing Community Engagement by supporting social innovation

Integration of Natural Dynamics into Urban Design

Policy and Flood Risk Governance with shift in perception of responsibility

Figure 12. Strategies (Authors own diagram)

02.**DUTCH DELTA**

"Why live with water?"

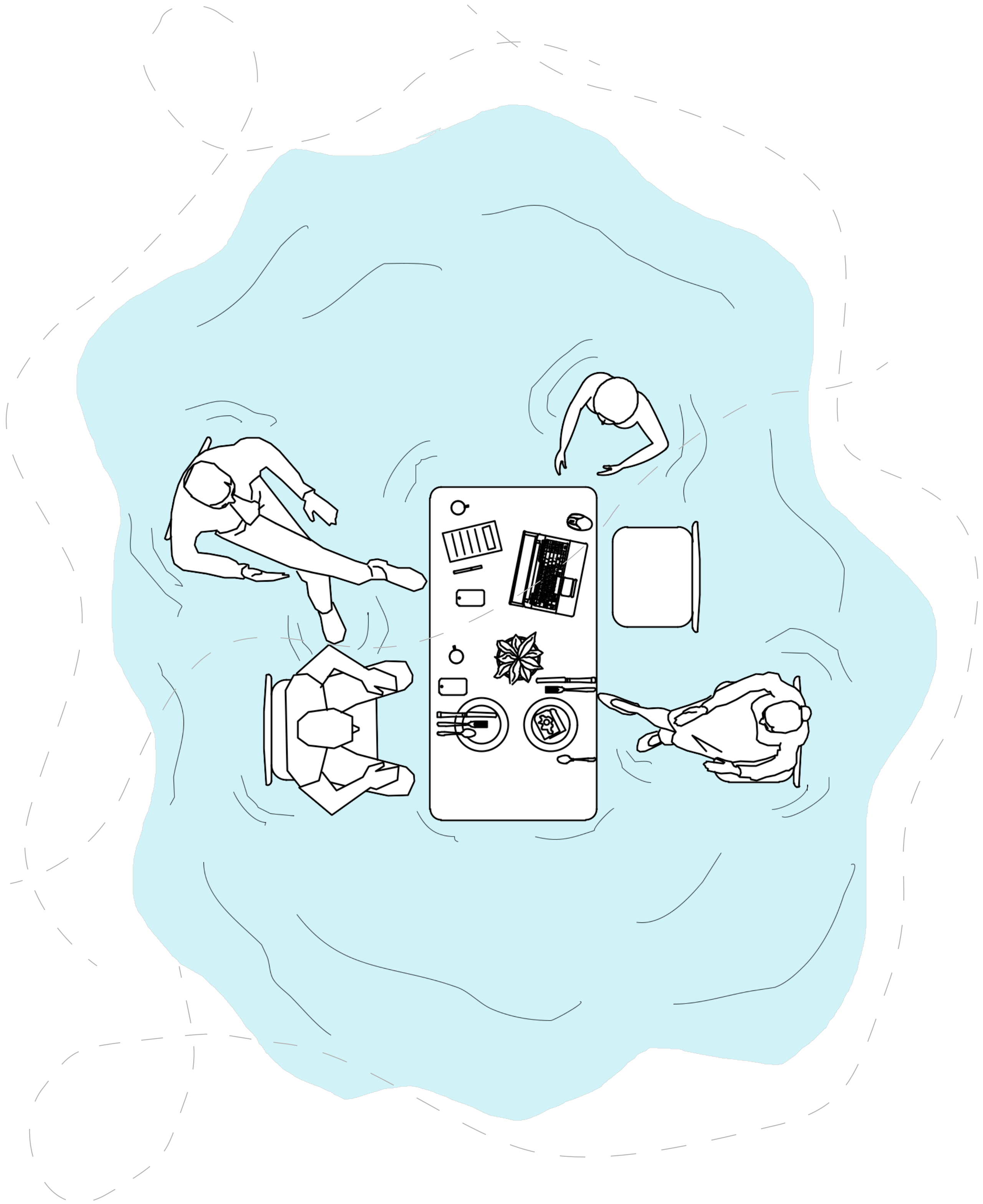


Figure 13. Living with water(Authors own diagram)

Vulnerability of the Dutch Delta

The challenges arising from the defined asynchronization between human occupation and natural processes are particularly evident in highly urbanized deltas. In these regions, natural dynamics, historically perceived as threats, have been suppressed in favor of control and stability (Middelkoop, 2020).

Delta formation is a geological process that has evolved over thousands of years through the interplay between riverine and marine dynamics. These natural forces, combined with wind and the unique topography of low-lying areas, have shaped some of the world's richest ecosystems. These biodiverse habitats rely on sedimentation processes, where marine and riverine sediments interact to form dynamic, adaptive landscapes (Scown & Middelkoop, 2019).

However, with the territorialization of these fertile and resource-rich areas, human interventions have sought to stabilize and control these dynamic environments. This has resulted in extensive soil sealing due to urban sprawl, alongside engineered water management systems such as pumps, dikes, and canals. These interventions prioritize short-term stability but disrupt the delicate balance of natural processes. Consequently, urbanized deltas suffer from severe environmental degradation, loss of ecosystem services such as sediment capture, and fragmentation of critical landscapes (Middelkoop, 2020; Reker, 2006).

Climate change amplifies these existing vulnerabilities. While not the sole cause of disruption, it exacerbates the consequences of human intervention, underscoring the urgent need for adaptive solutions. By altering natural environments to exert control, humanity has diminished ecosystems' innate ability to self-regulate. This dependence on engineered systems leaves urbanized deltas vulnerable, as these infrastructures are often outpaced by evolving climatic and ecological challenges (Scown & Middelkoop, 2019).

The need now is to shift toward re-territorialization strategies that embrace the dynamic interplay of natural and human systems, fostering resilience and co-existence rather than control. In words of Reker (2006):

In a natural delta, the supply of sediment from the land is in a dynamic equilibrium with the sea level and the erosive processes at work along the coast. If anything changes on either side, the delta will find a new equilibrium. Inhabitants of deltas have been adapting their environment for centuries to suit their needs. Measures have been taken to prevent flooding (through the construction of dikes, dams and delta works), to make shipping possible (by canalising and damming rivers and constructing harbors), to enable farming (by de-foresting and draining the land), and to allow the extraction of natural resources (sand, clay, peat). Human intervention has generally led to the disruption or complete obstruction of the natural processes within a delta. Consequently, a delta can lose its natural flexibility and is no longer able to adapt to changing circumstances. (p. 23)

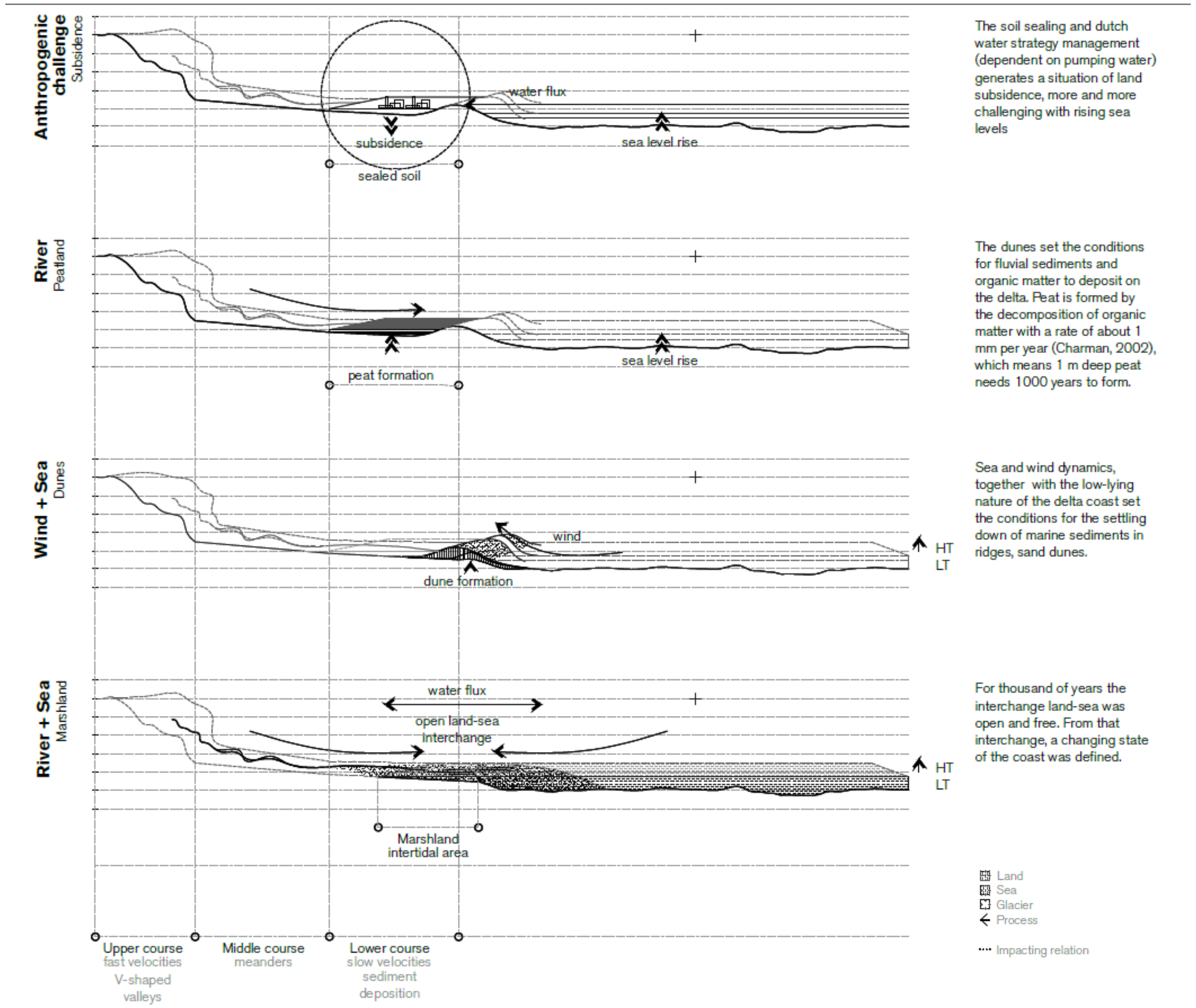


Figure 14. Section on the formation of the Dutch Delta and the anthropogenic challenges today (Recubenis, 2022)

Territorial Production in Deltas

As a country with 29% of its surface below sea level and 26% prone to flooding (Huisman, 1998), the very formation of the Dutch state in the early nineteenth century was shaped by a collective ambition to conquer water. This shared societal drive laid the foundation for the development of a national water management and spatial planning policy (Meyer, 2017). The act of territoriality, as defined by Raffestin (2012), has been central to this process, transforming natural phenomena—such as river floods and tidal surges—into controlled, static landscapes through a process of territorialization.

Water management has been the backbone of territorial production in the Netherlands, enabling the construction of the largest European port and establishing the country as the second-largest net exporter of agricultural products globally (OECD, 2014). This performance comes at a cost: water resources management, flood protection, and other water-related utilities account for approximately 1.26% of the nation's GDP (OECD, 2014). The Dutch model of territorialization has historically positioned economic and urban development as primary drivers of land-use change, which has led to increasing threats to the very ecological systems upon which these activities depend. The 2006 National Spatial Strategy (Nota Ruimte) and the National Water Plan (2009) underscore the integration of water management as a guiding principle for spatial development. These policies explicitly frame water as both a challenge and an opportunity, emphasizing the need for climate adaptation as a central aspect of urban planning. The introduction of tools such as the statutory water test in 2003 ensures that water-related considerations are embedded in every land-use decision, reflecting the interconnectedness of environmental sustainability and territorial development (Stead, 2013).

At the local and regional levels, the groundwater extraction system, managed by the water boards (waterschappen), enables the creation of dry and stable ground for habitation and agriculture. This engineered system, however, induces groundwater seepage and land subsidence, effectively nullifying the natural capacity of wetland soils to function under changing conditions, transforming these dynamic ecosystems into artificially maintained lands. Similarly, at a regional and national level, the canalization of major rivers like the Rhine and the construction of extensive dike systems physically and mentally separate human settlements from the natural water dynamics that have historically shaped the region. These dikes, designed with failure probabilities ranging from 1:10,000 to 1:2,000 years, ensure that the Netherlands is one of the safest deltas in terms of flood protection in the short term. However, the long-term consequences of this territorialization are increasingly evident: the loss of hydrological connectivity between rivers and their floodplains, the depletion of natural sedimentation and erosion processes, and the erosion of the delta ecosystem's ability to adapt to environmental changes (Meyer, 2017).

"The slow but steady natural process of land formation and land rise changed into land erosion and land subsidence; extensive flood plains changed into narrow channels; gradual transition of fresh to brackish to salt water zones changed into sharp separations between fresh and salt water. Rivers lost their room to expand during peak discharges; the consequences of floods became more serious because of land subsidence; ecosystem were destroyed because of the loss of sediment and nutrients. Estuaries and delta, which represent some of the world's richest ecosystems, are threatened seriously with the loss of their richness" (Han Meyer, 2014)

What we usually tend to forget is that this loss of ecosystem richness, as mentioned by Meyer (2014) directly shakes our existence, increasing our vulnerability to a changing and extreme climate.

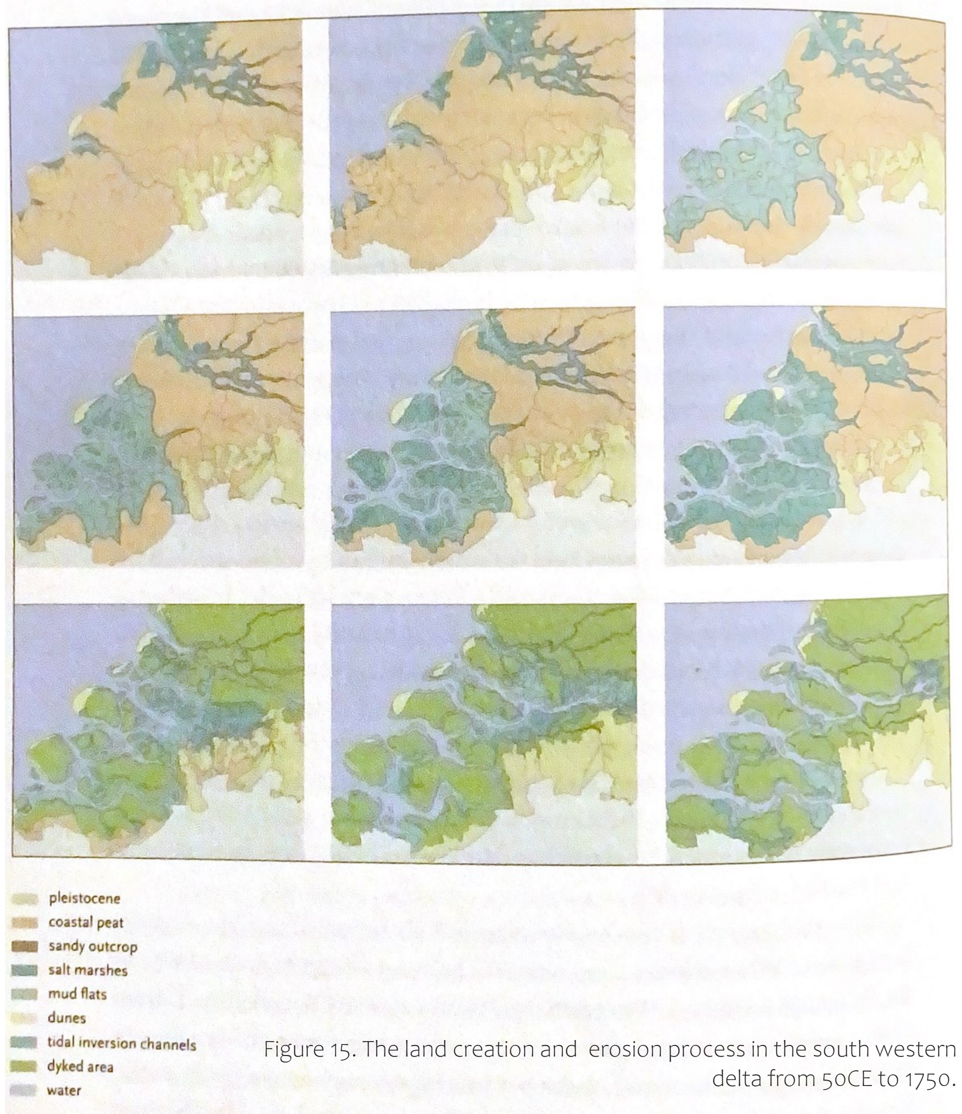


Figure 15. The land creation and erosion process in the south western delta from 50CE to 1750.

Figure 16. Reconstruction drawing of Rotterdam around 1340. Dyke creation resulting in urban settlements forming the beginning of Rotterdam city.

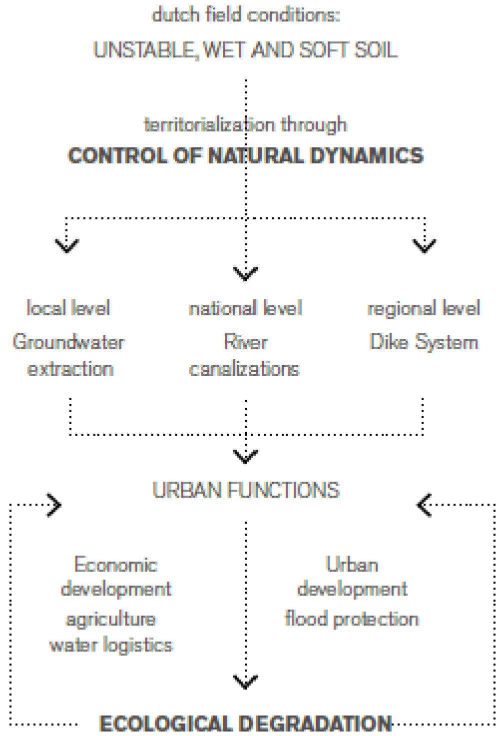


Figure 17. Controlling Natural Soils (Recubenis, 2022)

Vulnerability of Protected Safe Areas

The Dutch have long sought to create secure zones that are separated from the dynamic forces of rivers, seas, and groundwater, largely through extensive infrastructure such as dikes, flood barriers, and water pumps. This territorial model of safety has been based on the assumption of stable water levels and predictable hydrological behavior. However, as climate change leads to increasingly extreme weather patterns, this model is being critically challenged.

Recent climate studies have highlighted the vulnerability of these "protected safe areas" under changing conditions. The Netherlands, with 29% of its territory below sea level and 26% vulnerable to river flooding (Huisman, 1998), has been subject to intense pressure from rising sea levels and altered river discharges. According to Disco and van der Vleuten (2002), the Delta Works represent a triumph of centralized water management but are also emblematic of rigid infrastructure susceptible to systemic failures under extreme conditions. This reliance creates a paradox: while providing safety under "normal" conditions, these areas are increasingly at-risk during compound events, such as simultaneous coastal and riverine flooding. Projections suggest that the Rhine River's discharge could increase dramatically by 2100 due to higher winter precipitation, leading to water flows that exceed the capacity of existing flood defense systems (DeltaCommissaris.nl). This highlights how rigid, "safe" zones designed to physically separate human settlements from water dynamics cannot maintain the same level of protection in the face of increasing hydrological uncertainty.

These vulnerabilities were starkly exposed in the 1990s, when high-water events in the river regions emphasized the inadequacy of the existing control mechanisms. Similarly, floods in Limburg in 2021 demonstrated the risks posed by smaller rivers, further underlining the necessity of evolving flood management strategies. The traditional approach to creating stable, dry, and safe ground for human occupation has, paradoxically, resulted in increased vulnerability as it disconnects human settlements from natural water systems, stripping the land of its capacity to adapt and self-regulate.

The Rhine, Meuse, and Scheldt rivers, which flow through the Dutch Delta, bring additional vulnerabilities. Intensified precipitation in upstream catchments is projected to result in higher river discharges, amplifying flood risks in supposedly safe areas. Disco and van der Vleuten (2002) highlight that canalization and dike construction, while effective in creating navigable waterways, have constrained the natural floodplains, exacerbating flood peaks downstream. Urban expansion into flood-prone areas compounds this risk, as cities such as Rotterdam and Dordrecht encroach on former wetlands, reducing their capacity to act as natural buffers. In the reserach conducted, simulations for the coast showed that at higher sealevels the breaches grow much larger and inflow volumes may double in the inland areas. The area which is flooded increases (Figs.), and so do the water depths (Klijn et al., (2012)).

This rigid model of territoriality has contributed to a growing sense of ecological fragility in urbanized deltas, with water management systems unable to cope with the increasing pace and unpredictability of climate-induced changes. As climate scenarios predict even higher flood risks and more erratic weather patterns, the future of the Netherlands' water management system increasingly lies in the balance between engineered protections and more flexible, adaptive strategies that allow for dynamic, responsive interactions with the landscape.

Figure 18. 1995 High Water in the Waal River
Source: Reprint from Gelderlander by Jan Bouwhuis, Retrieved from https.//gelderlander.nl

Figure 19. 2021 High Water in Limburg
Source: Reprint from Romaine, CC0, via Wikimedia Commons, Retrieved from https.//nltimes.nl

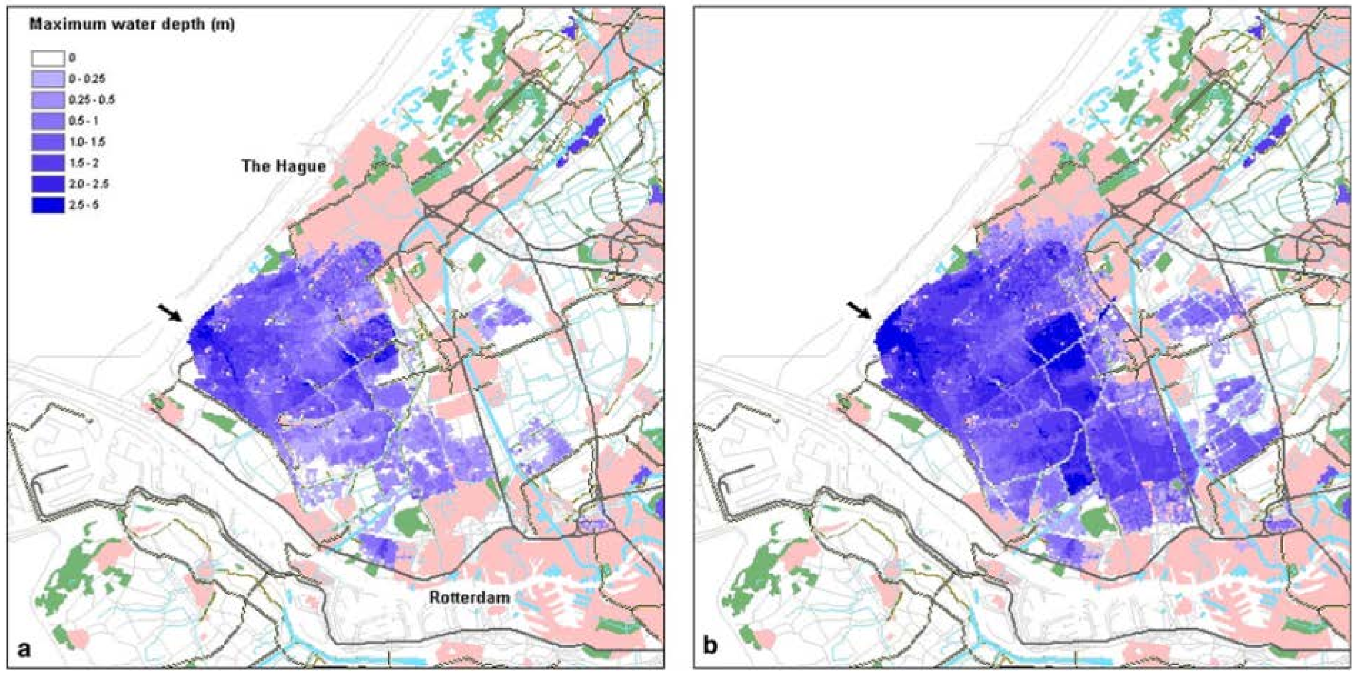


Figure 20. Difference in exposure in terms of flooded area and water depth resulting from a breach at Ter Heijde (indicated with an arrow) during -1:10 000 storm surge level with present sea level (a) and with a sea level that is 1.3 m higher (b) Klijn et al., (2012)

Embracing Uncertainity

The traditional approach to planning operates on the premise that nature can be controlled and its behavior predicted. In the Netherlands, this worldview has historically translated into a regulatory, top-down planning system focused on fixed plans, large-scale infrastructure such as dykes, and long-term strategies aimed at managing groundwater, controlling floods, and mitigating erosion and sedimentation through human intervention.

However, a shift is underway, catalyzed by environmental crises, catastrophic events, and the mounting impacts of climate change. This shift acknowledges that uncertainty and extreme conditions are inevitable and challenges the notion of control over nature. Instead, it embraces the understanding that urban landscapes are complex adaptive systems, as informed by complexity theories (Meyer, 2013). These systems highlight how socio-ecological networks possess an inherent capacity for adaptation, emphasizing the need to work with nature's dynamics rather than against them.

This research addresses this critical gap by questioning the traditional paradigm of controlling nature and advocating for a planning approach that aligns with its changes. This perspective emphasizes adaptation to nature's variability as a means to maintain ecological balance and foster resilience in the face of climate challenges.

PROBLEM STATEMENT

Coming from a traditional approach -rooted within the scientific planning and design of the Delta regions is still based on a control approach to environmental processes and dynamics leading to unsolved vulnerability to climate uncertainty.

Having already shifted the narratives towards an adaptive planning, there is still the need to:

- go beyond the traditional operational and physical separation between protected and protecting areas and beyond the physical separation from the ground that support us, that perpetrates a model based on vulnerability
- to re- consider the role that housing communities can play to trigger a cultural, operative and physical adaptation to changing conditions.

Traditional Approach

Worldview	Regulatory Planning	framework vision strategic actions	Design	Challenges
predict control exploitation	fixed long term vision top-down approach hard infrastructure	- Ground water control (soil drainage systems) -Flood control (dikes, canalization) -Erosion and sedimentation control (canalization, dredging)	maximized for a given extreme condition differentiation of protecting and protected spaces	-Dependency on man-made solutions (hard infrastructure) that cannot cope with uncertainty -Degradation of ecosystems -Vulnerability to extreme natural events for which the system is not designed

Adaptive Approach

Worldview	Regulatory Planning	framework vision strategic actions	Design	Challenges
adaptability uncertainty	adaptive long-term vision space for change in the short-term	space for water dynamics spatial quality creation floodplain habitat restoration	maximized for a given extreme condition (?) diferentiation of protecting and protected spaces (?) open ended (?)	-Implementation - hypothesis creation -Based on the definition of vulnerable areas rather than active ones. Lack of definition of the role of occupation within symbiotic framework with nature

Figure 21. Planning challenge Adapted from (Recubenis, 2022)

DUTCH DELTA ADAPTATION

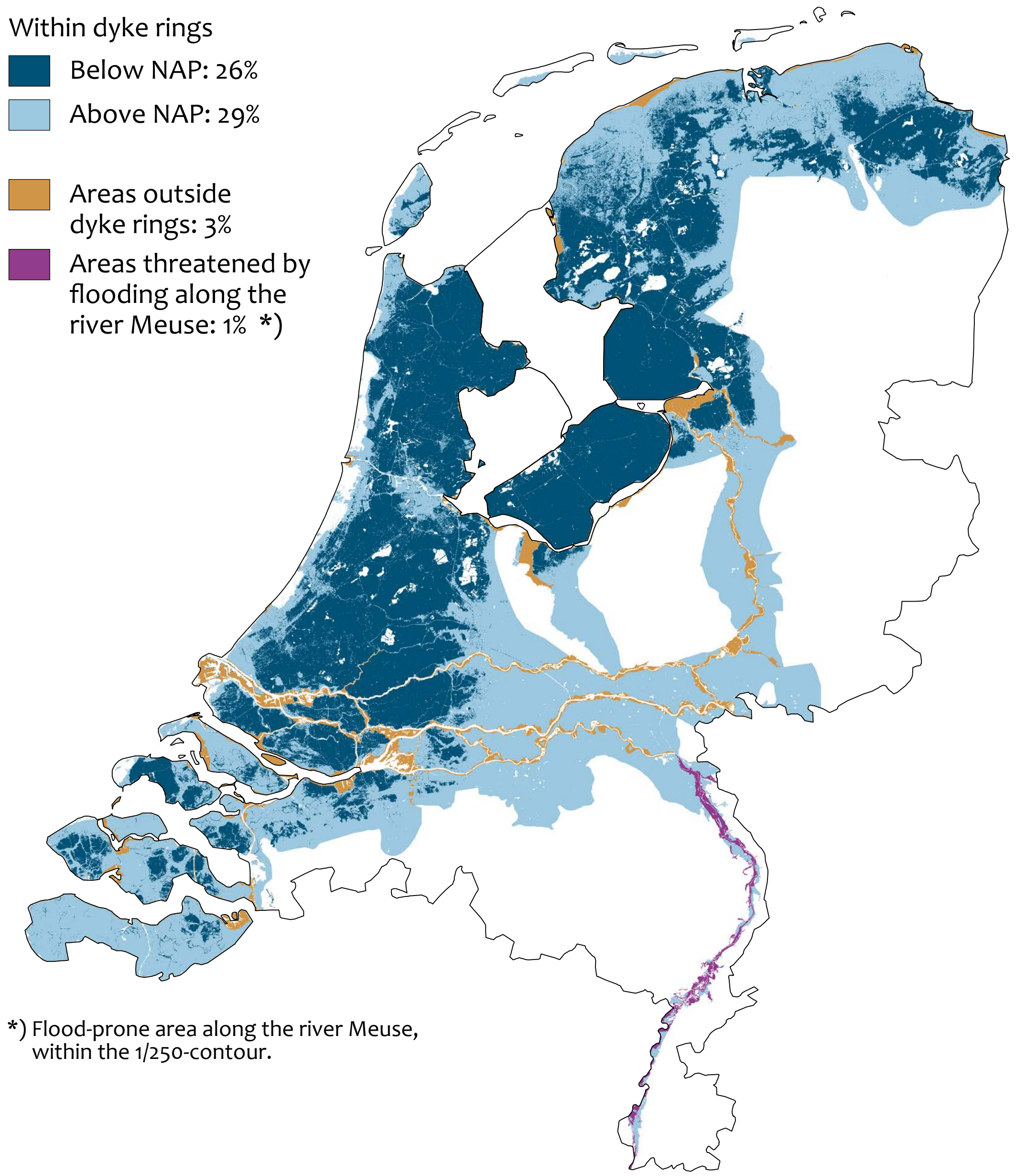


Figure 22. Map indicating the flood prone areas in the Netherlands (PBL Netherlands, n.d.)

In 2021, Delft University of Technology's Delta Urbanism Interdisciplinary Research Program launched the "Redesigning Dutch Deltas" (RDD) initiative, a collaborative design and research effort. This studio aimed to address pressing challenges in the Dutch delta landscape, including sea-level rise, climate adaptation, subsidence, sustainability transitions, housing shortages, and societal boundary conditions. The overarching goal was to envision a resilient and sustainable future for the region (RDD, 2021).

The Dutch delta faces significant environmental and socio-economic challenges. Rapid urbanization, biodiversity loss, and the increasing frequency of extreme weather events exacerbate the urgency of creating adaptive solutions. The RDD design study explored the synergy between spatial design and engineering, focusing on transformative strategies for a resilient Dutch delta that integrates ecological and societal needs.

A major outcome of the study was the proposal to transform Rotterdam into a 'sponge city.' This concept, developed by a team including De Urbanisten, Lost Landscapes, and Royal HaskoningDHV, tackles the anticipated impacts of sea-level rise, such as saltwater intrusion, fragmented ecosystems, sedimentation, subsidence, and the heightened risks of flooding and droughts (RDD, 2021).

To address these challenges, the research proposed two primary strategies. The first focused on enhancing water resilience by creating a large freshwater reservoir and overflow areas within the polder landscape (RDD, 2021). This approach involves a more efficient, shortened dyke system that fosters urban densification while improving water management. The second strategy reimagines the harbor area, moving industrial activities closer to the sea and transforming urban-adjacent zones into ecological buffer areas. These areas would feature softer waterfronts, increased biodiversity, and thriving marine ecosystems (RDD, 2021). Sustainable mobility advancements, such as electric and hydrogen-powered boats, could further integrate these redeveloped harbor areas into the urban landscape (RDD, 2021).

An innovative feature of the water management system is the use of flooded peat soil polders for filtration and storage. This method reduces CO2 emissions by preventing peatland subsidence and oxidation. Wet peatlands act as effective carbon sinks, with the potential to store up to 8 megatons of CO2 annually—more than double Rotterdam's current annual emissions of 3 megatons (RDD, 2021).

Looking toward 2122, the initiative envisions a green-blue infrastructure network connecting cities to surrounding natural systems. Urban densification near infrastructure nodes would create vibrant interfaces between urban and rural areas, while cultural-historical landscapes would be preserved. These strategies aim to redefine urban-rural interactions and foster ecological resilience, positioning the Dutch delta as a global model for climate-adaptive, sustainable urban development (RDD, 2021).

By integrating these approaches, the RDD initiative demonstrates the potential of interdisciplinary collaboration in addressing the Dutch delta's complex challenges. Its vision for Rotterdam as a sponge city offers a forward-looking solution to the pressing issues of climate change, sustainability, and urban resilience.

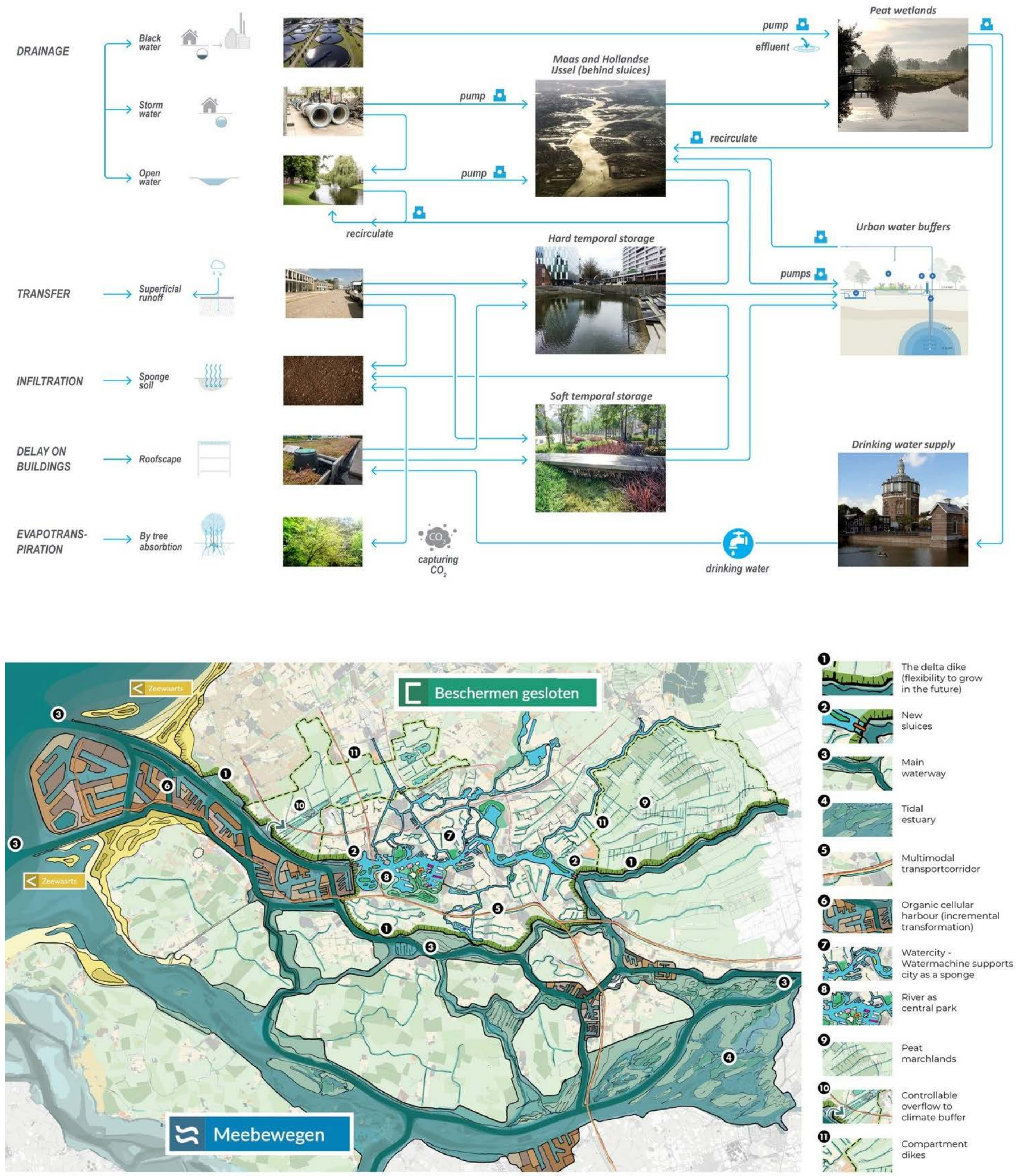


Figure 23. Proposal Rotterdam region water safety and climate adaptation strategy 2100 (RDD, 2021)

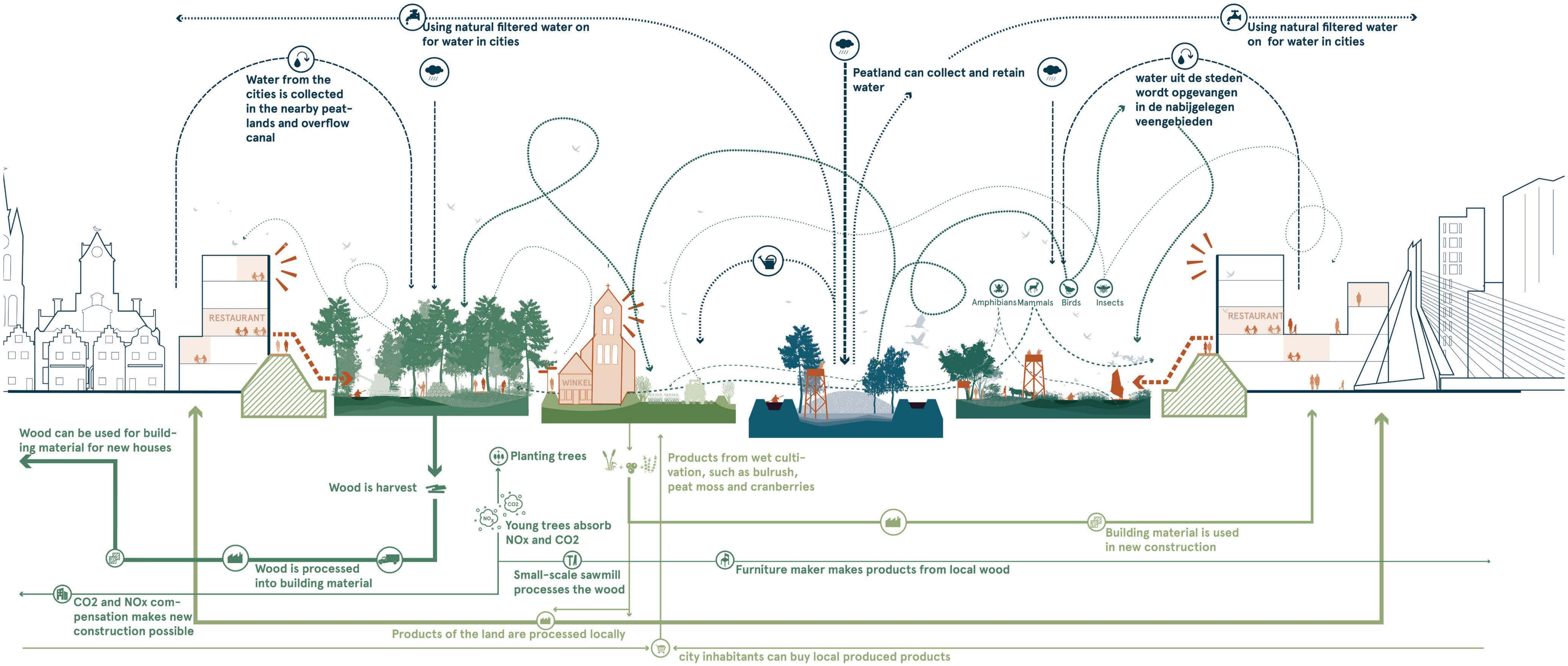


Figure 24. A representation of the flow of services and resources in the new Productive Landscape of Midden-Delfland (RDD, 2021)

Midden Delfland: A case for flood resilient development

Midden-Delfland, a peat meadow landscape located between Rotterdam, Delft, and The Hague, represents one of the Netherlands' most densely populated and industrialized regions. This rural area, characterized by its open green spaces, is under immense pressure from urban expansion, climate change, and environmental degradation. Challenges such as soil subsidence, drought, salinization, and the increasing threat of flooding have placed this low-lying region at the forefront of discussions on climate-adaptive and sustainable development (RDD, 2021).

ZUS (Zones Urbaines Sensibles), an interdisciplinary design office specializing in architecture, urbanism, and landscape design, has taken a leading role in reimagining Midden-Delfland. Collaborating with Flux Landscape Architecture and Sweco Engineering, ZUS has envisioned an innovative strategy for transforming the area into the "National Productive Park Delfland." Their ambition is to redefine the relationship between urbanization and nature by designing flood-resilient, multifunctional landscapes that integrate water management, agriculture, and recreation while preserving cultural and historical elements (RDD, 2021).

Midden-Delfland's unique landscape is deeply influenced by its underlying peat soil, which is declining rapidly due to oxidation and subsidence. This process releases significant greenhouse gases, contributing to global warming. At the same time, the region's intricate water management system, which relies on a network of canals, dikes, pumps, and sluices, is reaching its capacity. The existing system struggles to cope with heavy rainfall and prolonged droughts, making it unsustainable under current and future climatic conditions (RDD, 2021).

The area's vulnerability to flooding is further exacerbated by its topography, with some parts lying as much as six meters below sea level. Historical waterways, visible in the elevation map, highlight the area's dynamic natural systems, but these too are under threat. The salinization of groundwater, driven by saltwater intrusion and agricultural extraction, poses an additional challenge, particularly for greenhouses and other agricultural activities reliant on freshwater (RDD, 2021).

ZUS's vision for Midden-Delfland embraces flooding as an integral part of the landscape's future. Rather than resisting water, the design proposes to adapt and harness it through innovative strategies. The existing boezem (water basin) system, which currently drains excess water to nearby waterways, would be reconfigured to store water during periods of heavy rainfall and release it during droughts. This approach would transform the boezem system into a green-blue infrastructure network that benefits surrounding urban areas.

Adjacent low-lying polders would be redesigned to act as floodable zones, collecting excess water during peak rainfall. These areas would also serve as ecological buffers, supporting biodiversity and natural water filtration processes. By incorporating the region's natural cascading topography into the design, ZUS aims to reduce reliance on mechanical pumping systems and create a more sustainable water management framework (RDD, 2021).

Through its work in Midden-Delfland, ZUS exemplifies a paradigm shift in flood-resilient design. By embracing flooding as a natural process and integrating it into the region's landscape, their proposal addresses immediate challenges such as climate change, urbanization, and biodiversity loss.

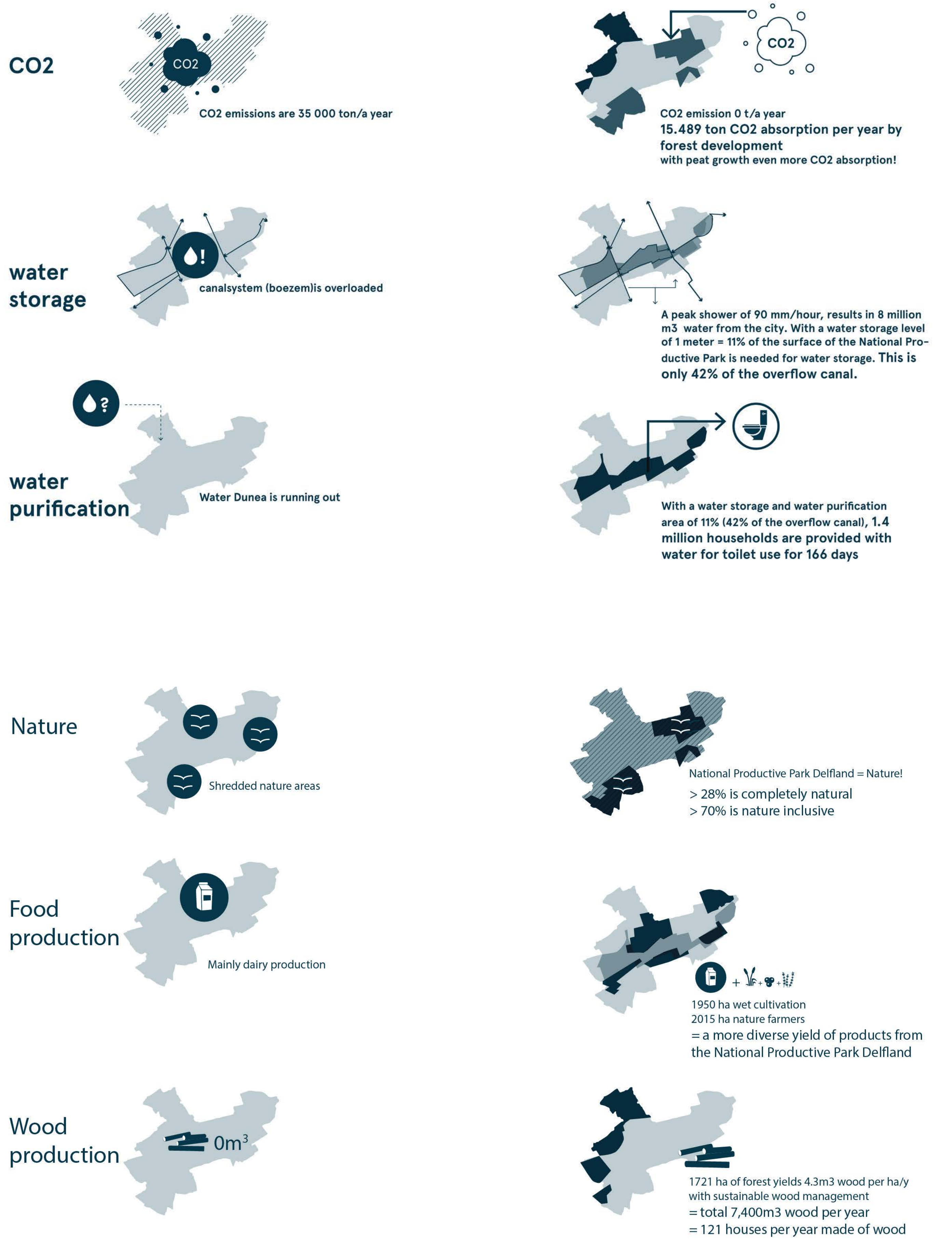


Figure 25 . The polderlandscape could be transformed into a productive landscape: wetland ecosystem, bio-based materials and recreation (RDD, 2021)

National Productive Park Midden Delfland

The National Productive Park Delfland is an ambitious vision that transforms Midden-Delfland into a multifunctional, climate-resilient landscape. Designed by ZUS in collaboration with Flux Landscape Architecture and Sweco Engineering, the park addresses the pressing challenges of flooding, drought, and biodiversity loss while integrating sustainable land use, water management, and recreation. This innovative concept aims to balance the ecological, agricultural, and urban needs of the region, creating a cohesive system that embraces natural processes rather than resisting them (RDD, 2021).

Central to the park's design are wetlands, which serve as both ecological sanctuaries and functional infrastructure. Strategically placed in low-lying areas, these wetlands act as natural sponges, absorbing excess water during heavy rainfall and releasing it during dry periods. This system reduces the risk of flash flooding in urban areas and provides a reliable water supply for agriculture and cities. In addition, the wetlands purify water through natural filtration processes, enhancing the quality of water stored and redistributed. Flooded peatlands, in particular, play a critical role in this system, preventing subsidence and reducing CO2 emissions caused by peat oxidation. These areas become vital carbon sinks while supporting biodiversity (RDD, 2021).

The park reimagines flood management, shifting from traditional resistance-based methods to an adaptive approach that embraces flooding. Existing boezem canals, which currently drain excess water to larger waterways, are redesigned to double as reservoirs and green-blue infrastructure. At designated points, canal dikes are deliberately lowered to allow controlled overflow into surrounding polders during peak rainfall. These polders, reconfigured as floodable zones, collect excess water and serve as ecological buffers, supporting biodiversity and providing space for water storage. By integrating natural processes into the water management framework, the park reduces reliance on energy-intensive pumps and sluices, creating a sustainable system that works with the landscape's natural dynamics (RDD, 2021).

The design of the National Productive Park Delfland is deeply rooted in the region's topography and soil morphology. Land use is organized into zones tailored to specific soil conditions. Peatlands are designated for wetland agriculture and carbon storage, maintaining high water levels to prevent subsidence and emissions. Clay-rich areas are used for wood production and fruit-picking forests, creating economic opportunities while acting as flood buffers. These natural land uses are complemented by strategically planned urban expansion at the park's edges. New developments are concentrated near infrastructure nodes, forming a dynamic interface between urban areas and the natural landscape (RDD, 2021).

In addition to addressing water management and land use, the park acts as a "green lung" for nearby cities like Rotterdam, Delft, and The Hague. Its wetlands and green infrastructure alleviate urban heat islands, improve air quality, and provide recreational spaces for residents. The integration of these green and blue networks enhances biodiversity and fosters a stronger connection between urban populations and the natural environment. Innovative agricultural practices within the park also promote sustainable food production, ensuring the coexistence of ecological resilience and economic viability (RDD, 2021).

The National Productive Park Delfland represents a forward-looking model for climate-resilient development. By leveraging natural processes and multifunctional land use, the park addresses critical challenges such as flooding, drought, and urbanization while preserving the unique ecological and cultural identity of Midden-Delfland. This vision demonstrates how rural and urban landscapes can coexist harmoniously, providing a sustainable framework for future generations. As a global precedent for adaptive design in flood-prone areas, the park exemplifies how embracing the dynamic relationship between water and land can lead to innovative and lasting solutions.

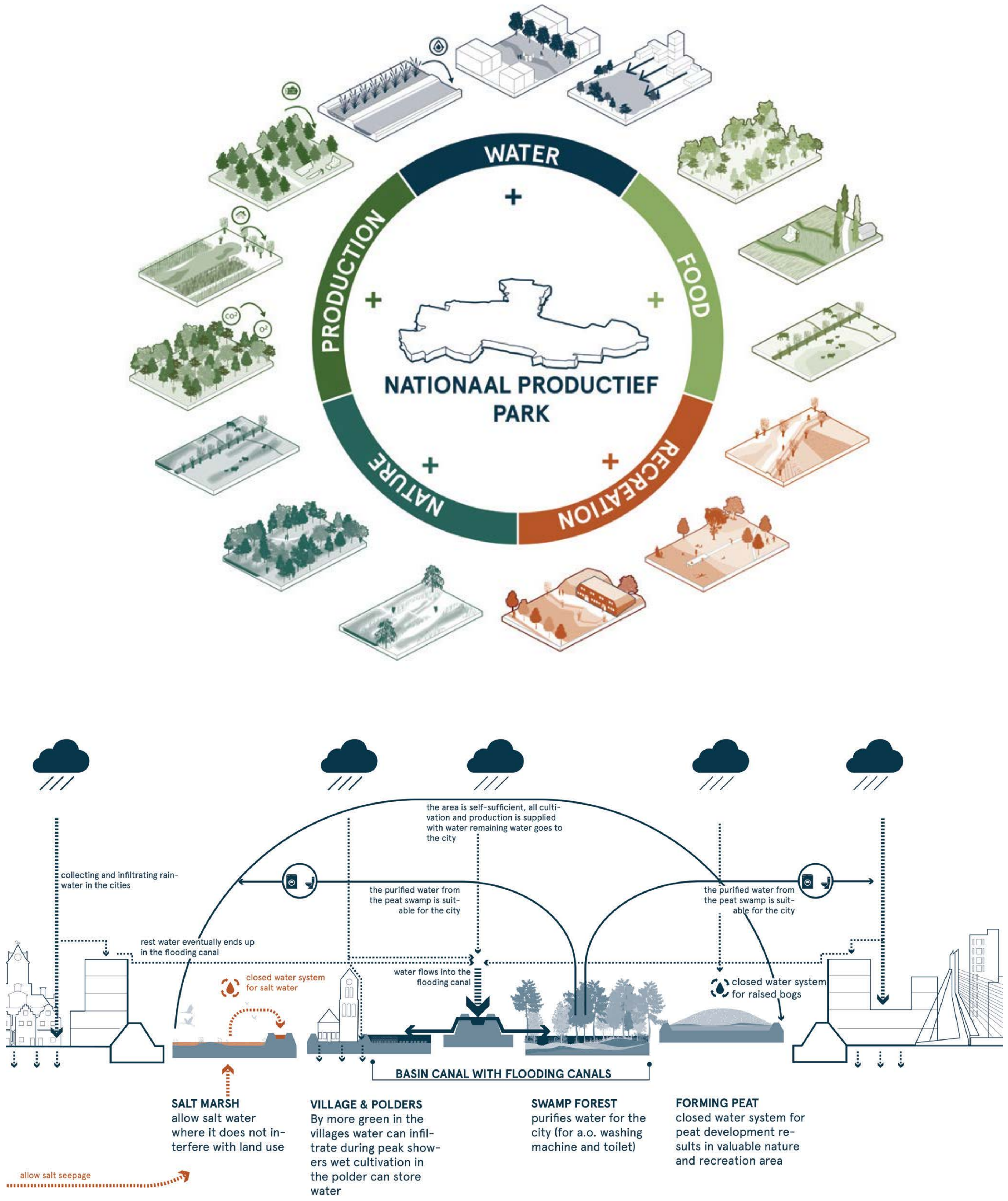


Figure 26. Midden Delfland as a National Productive Park and design of A self-sufficient water system with more space for the basin canals in the form of a flood canals. (RDD, 2021)

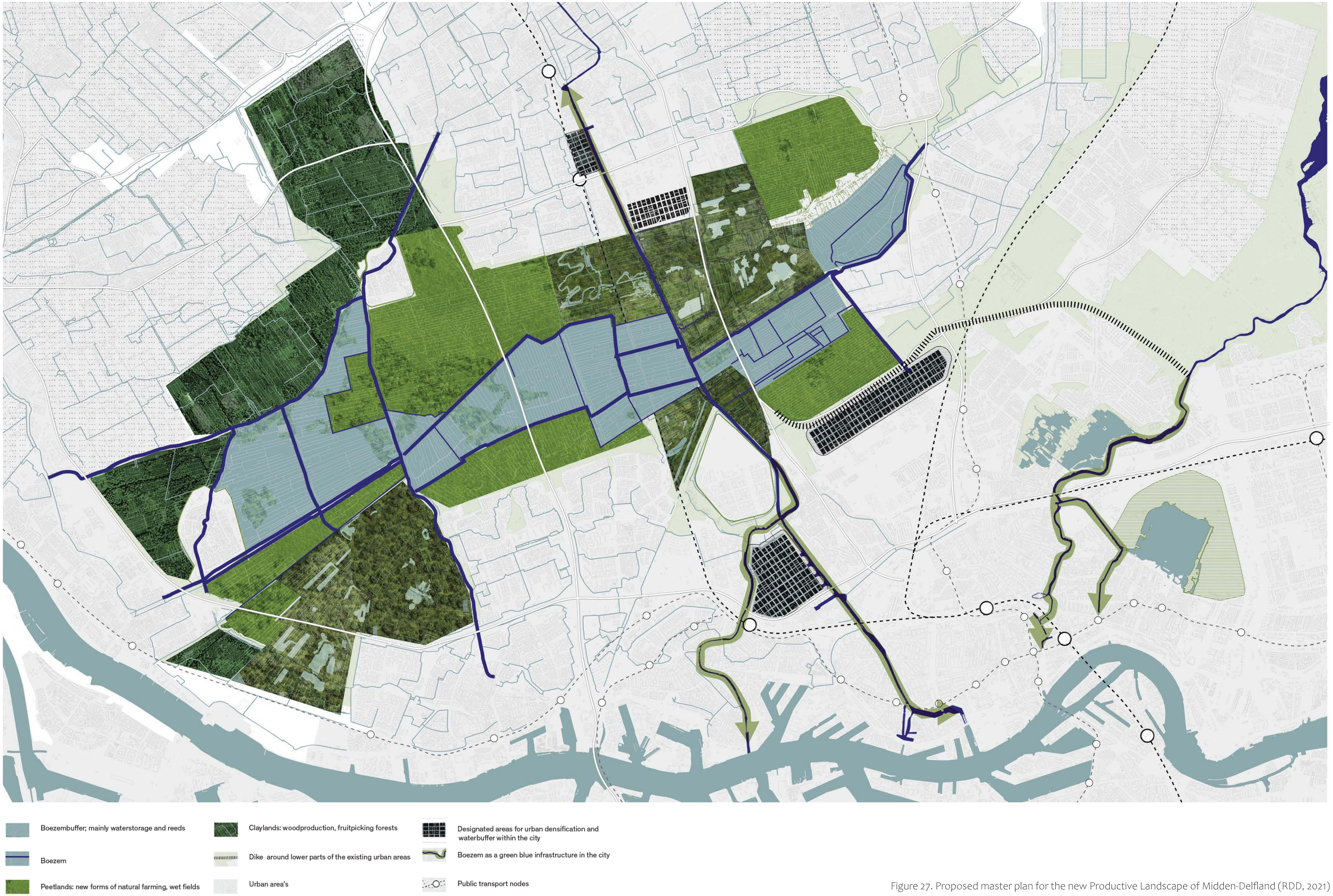


Figure 27. Proposed master plan for the new Productive Landscape of Midden-Delfland (RDD, 2021)

WETLAND ECOSYSTEM

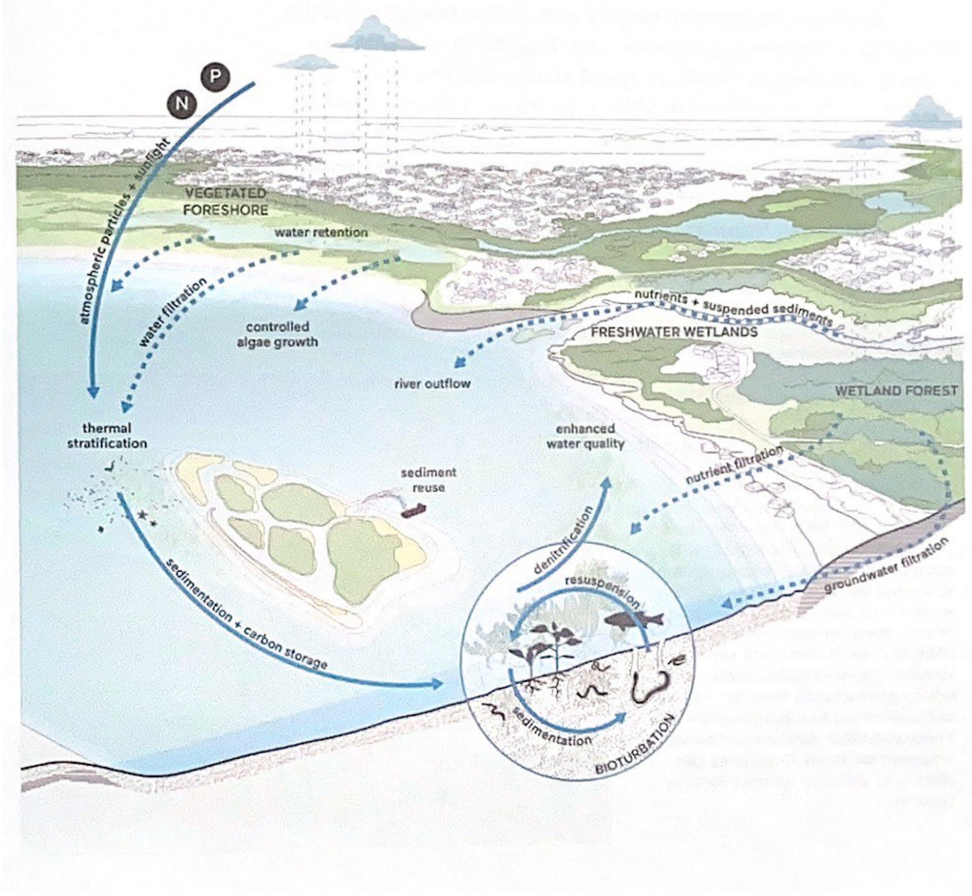
Wetland ecosystems play a crucial role in adapting to flooding and supporting resilience in the face of climate change. These natural systems, such as lowland lakes and freshwater wetlands, are integral to managing regional water systems and providing essential services to adjacent delta and coastal communities. Wetlands act as natural floodplains that absorb heavy rains and reduce the risk of inland flooding, making them indispensable in mitigating the impacts of extreme weather events. By storing excess water during storms and slowly releasing it, they moderate water flow and protect surrounding areas from severe flooding.

Lowland lakes and wetlands also serve as vital ecosystems that support biodiversity and regulate water quality. These freshwater environments, formed naturally or through engineered interventions like dams and floodgates, maintain water balance and nutrient cycles. However, many wetlands have been isolated from their natural lake systems due to flood control structures and land use changes, leading to significant degradation. Poor water quality, disrupted nutrient dynamics, reduced biodiversity, and increased turbidity are common consequences of this isolation. Restoration efforts aim to reconnect these wetlands to their natural systems, renewing sediment profiles, introducing native plant species, and enhancing the ecological integrity of these areas (Erik,2020).

In delta regions and urban landscapes, wetlands and lowland lakes provide valuable services beyond flood management. They offer recreation opportunities, drinking water resources, and serve as buffers against climate extremes like droughts and heatwaves. Wetlands' ability to filter pollutants and trap sediments contributes to water purification, while their vegetation stabilizes soil and prevents erosion. These ecosystems not only mitigate immediate risks but also enhance long-term resilience by supporting the health of water systems and nearby communities (Erik,2020).

In the book "Building with Nature" Erik (2020) approaches embrace the dynamic nature of wetland ecosystems, emphasizing adaptive management to align human activities with natural processes. These solutions leverage the hydrodynamic and morphological characteristics of wetlands to balance ecological integrity with human use. Adaptive management involves setting clear goals, monitoring ecosystem responses, and making incremental changes based on observed outcomes. This approach recognizes that natural systems are inherently unpredictable and requires robust collaboration among stakeholders. By engaging local communities, policymakers, and environmental organizations, restoration and enhancement projects can gain the necessary support to succeed (Erik,2020).

Ultimately, wetlands are more than just ecosystems—they are critical infrastructure in a changing climate. Their ability to buffer floods, support biodiversity, and provide water management services makes them an essential component of sustainable development. By prioritizing wetland preservation and restoration, societies can build resilience against climate extremes, protect vital ecosystems, and ensure the well-being of future generations.



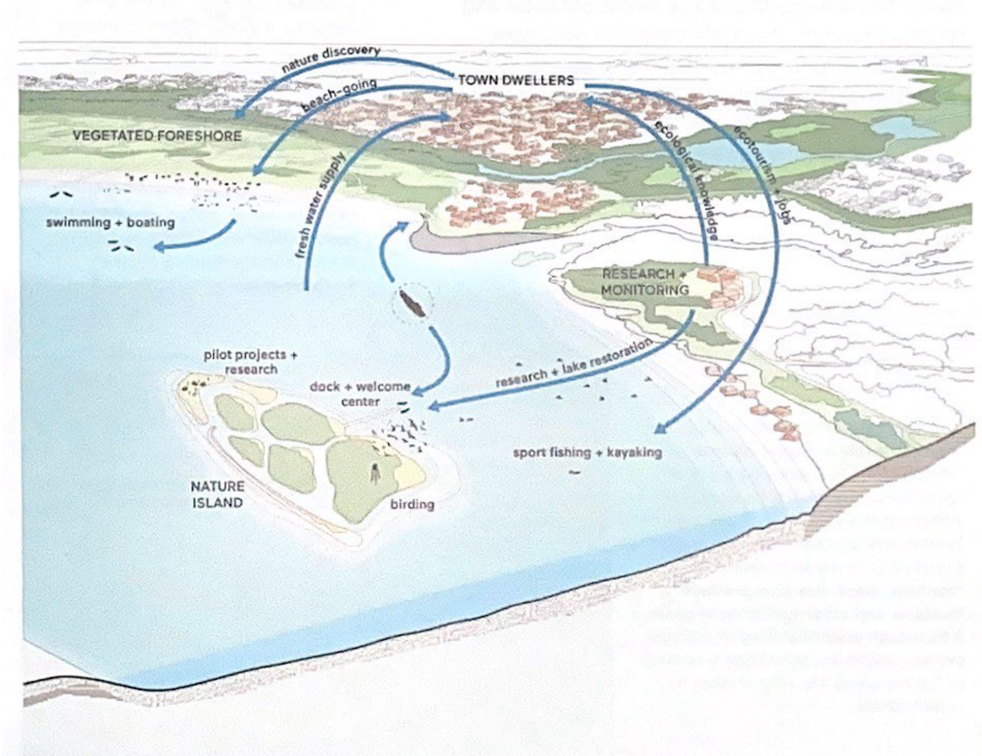


Figure 28. Wetland Ecosystem and benefits of living with water(Erik,2020)

"Why live with water ?"

- *Deltas are dynamic ecosystems; controlling water disrupts their balance.*
- *Rigid flood defenses fail against climate change, making cities more vulnerable.*
- *Wetlands, floodplains, and controlled flooding reduce risks and restore ecosystems.*
- *Green-blue infrastructure improves urban resilience, biodiversity, and climate adaptation.*
- *Working with water creates adaptable, future-proof cities and landscapes.*

The Dutch Delta has long been shaped by efforts to control nature, transforming dynamic floodplains and waterways into static landscapes through extensive engineering interventions such as dikes, pumps, and canals. While these measures have historically ensured safety and enabled economic growth, they have also disrupted the delicate balance of natural ecosystems. The suppression of natural dynamics—such as sedimentation, nutrient cycling, and hydrological connectivity—has led to environmental degradation, loss of biodiversity, and an increased vulnerability to climate-induced uncertainties. The Dutch model of territorialization has prioritized short-term stability over long-term resilience, leaving urbanized areas increasingly dependent on rigid systems that are ill-equipped to adapt to accelerating climate change.

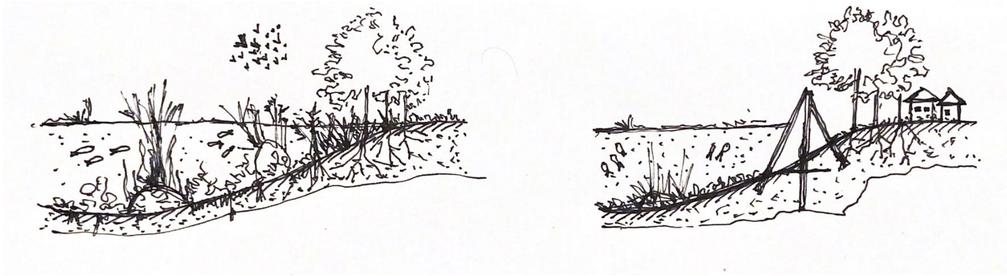
A paradigm shift is urgently needed. Instead of transforming the delta to fight against floods, the focus must shift toward embracing natural processes and restoring ecosystem balance. Wetlands, lowland lakes, and floodplains, which have been historically isolated and degraded, should be reintegrated into the landscape as dynamic systems that can adapt to changing conditions. These areas serve as natural buffers, absorbing excess water during floods and gradually releasing it during droughts. Reconnecting these systems would enhance their capacity to self-regulate while reducing dependency on energy-intensive infrastructure.

ZUS's proposal for Midden-Delfland embodies this adaptive approach. The vision for the National Productive Park Delfland centers on re-territorializing the landscape by embracing controlled flooding and restoring wetland ecosystems. By allowing periodic inundation, the project reestablishes natural sedimentation processes and nutrient cycles critical for ecosystem health. This strategy not only mitigates flood risks but also enhances biodiversity and improves water quality. Wetlands and floodplains are envisioned as multifunctional spaces, providing ecological services such as carbon sequestration, water filtration, and habitats for diverse species while also offering recreational opportunities for nearby urban populations.

Urban development in this framework shifts toward harmonizing with natural systems rather than opposing them. Cities bordering the delta can adopt green-blue infrastructure designs that integrate natural waterways, wetlands, and open spaces into the urban fabric. Densification strategies at urban edges reduce sprawl and preserve critical ecological zones, while incorporating nature-based solutions into city planning can help manage stormwater, moderate urban heat islands, and support biodiversity. By aligning urban expansion with the natural dynamics of the delta, cities can foster coexistence with their surrounding ecosystems.

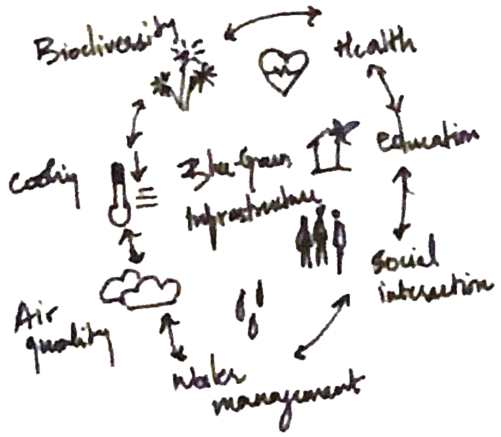
In conclusion, the future of the Dutch Delta lies in moving away from the traditional model of controlling nature and toward a vision of coexistence and adaptation. Embracing the dynamic interplay of water and land allows for the restoration of ecosystem balance, which is essential for resilience in the face of climate change. By integrating wetlands, floodplains, and urban areas into a cohesive system, the Dutch Delta can transition from a state of environmental degradation to one of ecological and societal harmony.

The National Productive Park Delfland , in some ways demonstrates how adaptive strategies can redefine the relationship between urban areas and natural systems. By prioritizing ecosystem restoration, controlled flooding, and nature-based solutions, this model offers a blueprint for resilient development in delta regions worldwide. Urban growth need not come at the expense of nature; instead, cities can evolve in ways that produce harmony with their environments, ensuring a sustainable future for both human and ecological communities. The path forward requires rethinking long-held assumptions about controlling nature and embracing the dynamic, adaptive processes that define life in delta landscapes.

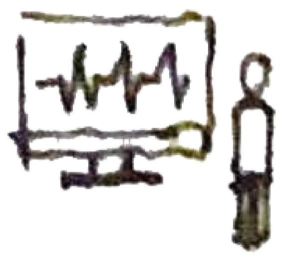


Re-Territorialization Through Nature-Based Solutions

Embracing Uncertainty in Planning

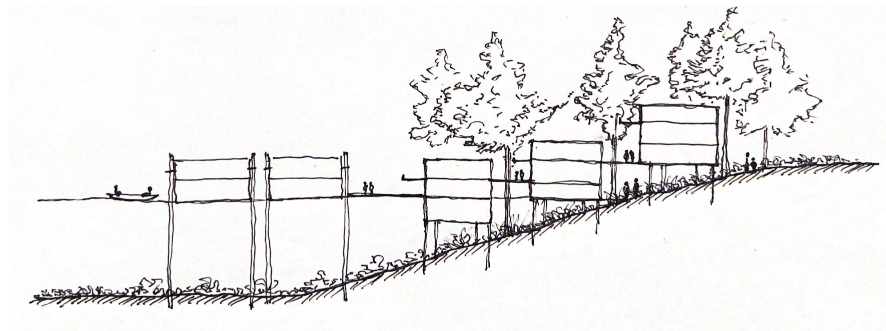


Green-Blue Infrastructure for Urban Areas



Implement monitoring systems

Sponge City Concept



Flood-resilient multifunctional landscapes

Figure 29. Strategies (Authors own diagram)

03.COMMUNITY LIVING TRANSITION

"What is the need for community living ?"

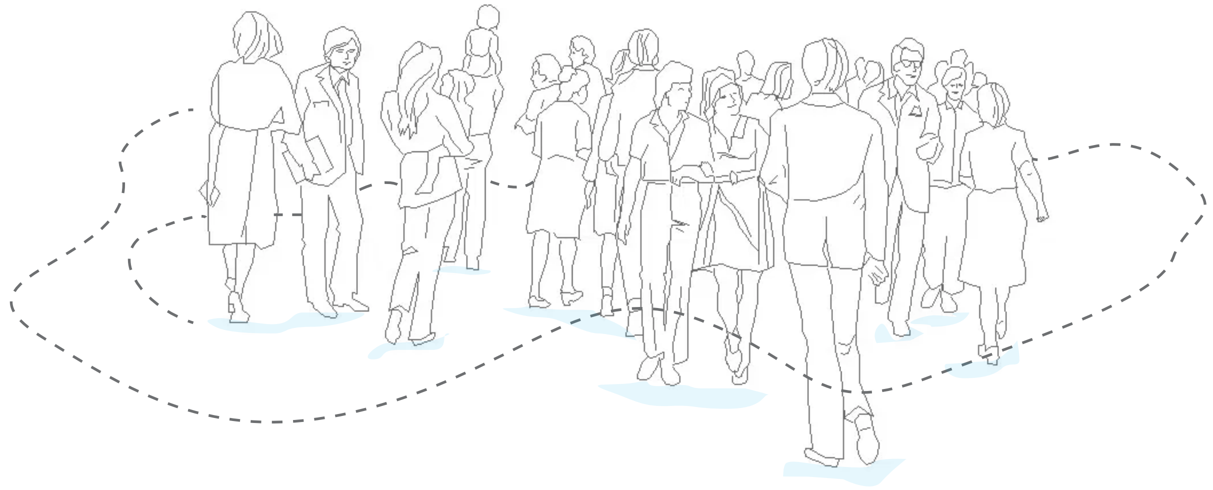


Figure 30. Community Living (Authors own diagram)

HISTORY AND CONTEXT OF COMMUNITY LIVING IN NETHERLANDS

The Netherlands' history of community living is intricately tied to its unique geography, culture, and historical development. To understand how future housing can support resilience, it is essential to examine how communities in the Netherlands have historically lived, cooperated, and coexisted. In the medieval period, hofjes emerged as an innovative housing solution to support vulnerable groups. These courtyard-style complexes, funded by affluent benefactors, provided housing for the elderly and poor. With their shared courtyards and intimate designs, hofjes balanced the need for privacy with communal living, offering a dignified space for interaction and mutual care (Wilms (n.d.)). Similarly, rural areas in provinces like Friesland and Drenthe relied on communal farming practices. These cooperative efforts enabled families to share resources such as land and livestock, highlighting the interdependence necessary to thrive in challenging environments (Wilms (n.d.)).

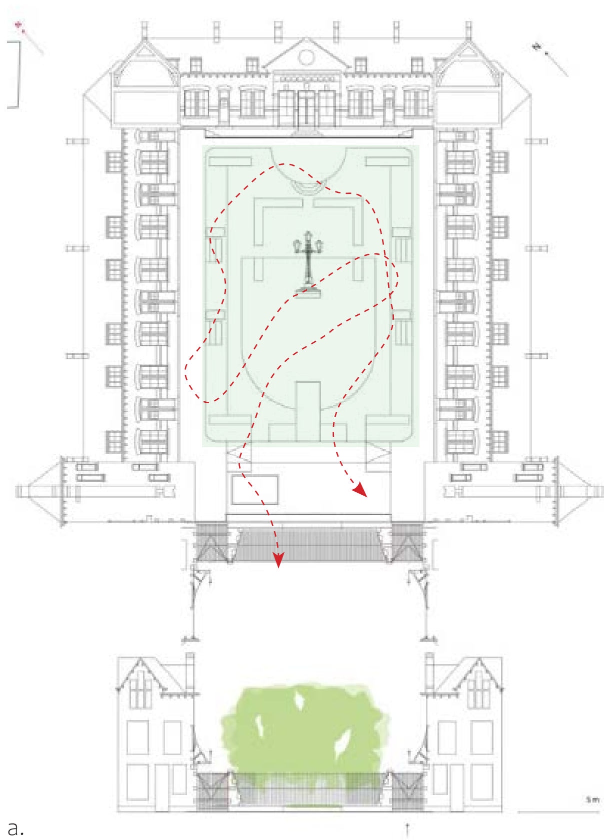
Urban planning played a pivotal role in shaping community interactions. Compact cities with narrow streets, public squares, and marketplaces facilitated daily social exchanges. Public spaces, such as parks and communal gardens, became the heart of neighborhoods, hosting festivals and fostering a sense of shared identity (Clarke, 2021). Notably, water management projects, including the construction of dikes, canals, and polders, underscored the collaborative spirit of Dutch communities. These efforts not only safeguarded the land from flooding but also cultivated solidarity and collective resilience.

The transition from collective living to individualism began during the Industrial Revolution. Subsequently, the emergence of the more 'modern' perimeter block or street-side house became one of the most widely adopted planning strategies in 19th and 20th century European residential architecture. At first glance, these layouts may resemble the traditional hof typology—with dwellings arranged around an inner courtyard—but their spatial organization differs significantly. In fact, they can almost be seen as a reversal of the hof model. The European perimeter block is fundamentally based on principles of inclusion and exclusion: the exterior, facing the street, becomes the 'public' side with house entrances, while the interior courtyard transforms into a 'private' zone with backyards. These private outdoor spaces are often fenced off, accessible only through individual homes, and rarely intended for collective use. One typically enters directly from the street into a private living space, which minimizes opportunities for social interaction and excludes a communal domain for either residents or passersby.

Post-World War II housing policies reinforced this tendency, prioritizing functional, self-contained living spaces in response to housing shortages. The rise of apartment complexes and suburban homes reflected a broader shift toward individuality and self-sufficiency, steering away from traditional communal designs such as hofjes. By the late 20th century, increasing wealth, educational attainment, and technological progress further entrenched a culture of individualism. The nuclear family became the dominant household unit, and digital communication began to replace physical communal spaces as the primary medium for social interaction (Wilms Floet, n.d.).

The erosion of communal living is particularly evident in modern urban life. Many neighborhoods have grown increasingly fragmented, with public spaces rarely serving as vibrant social hubs. Urban development has often prioritized economic efficiency and spatial optimization over social cohesion, neglecting the critical role that shared spaces play in fostering community bonds.

In this context, historical forms of community living are not merely architectural typologies but embodiments of social resilience. They illustrate how spatial and social arrangements can be consciously designed to promote mutual care, shared resources, and adaptive lifestyles—qualities that are becoming increasingly essential in today's complex urban environments.


a.


b.

Figure 31. a. Dutch Hofjes (Wilms (n.d.)), b. Dutch Hofjes Housing Amsterdam (Nadeau, 2023)

Figure 32. Dutch Houses with private back courtyards (Alamy)

URBANIZATION AND HOUSING TRENDS

Over time, these traditional models of community have been eroded by urbanization and socio-economic shifts. The housing landscape in the Netherlands reflects complex interactions between urbanization, land use, housing policies, and societal preferences. The rapid urban growth in major cities such as Amsterdam, Rotterdam, and Utrecht has heightened housing demand, leading to a reliance on high-rise developments. High-rise developments, increasingly favored in Dutch cities due to land scarcity, often prioritize efficiency over community engagement. While these buildings provide necessary housing, they can foster isolation. Research indicates that shared spaces like courtyards and communal areas are crucial for fostering social interaction. Without them, high-rise residents may experience limited community bonding (Van Doorn et al., 2019) .

Between 1980 and 2000, residential land use grew by 14% (Koomen, 2004), and this trend is expected to continue due to a gradually increasing population and rising prosperity. The latter has led to a demand for larger and second homes, which has contributed to the spread of suburban sprawl. Many people now prefer a rural living environment, though for many, a few green spaces in suburban areas are enough to meet their needs. While past rural spatial policies have limited extensive urbanization of designated green areas, recent initiatives have allowed for the small-scale conversion of farmland into new estates (Koomen, 2004). As prosperity increases and the population ages, the demand for recreational spaces also rises. However, this urban expansion and focus on individualistic, suburban lifestyles have eroded the sense of community living. Rural areas, once spaces for shared experiences and communal engagement, are now more frequently visited by individuals seeking leisure, thrills, or tranquility, often leading to fragmentation in the social fabric and a decline in opportunities for collective living (Koomen, 2004).

Land scarcity significantly contributes to the housing shortage in Dutch cities. In urban centres, available land for new developments constitutes less than 10% of the total area due to zoning restrictions and preservation efforts for green belts . This limit has driven the need for vertical expansion through high-rise construction, increasing housing capacity but compromising traditional neighbourhood layouts. The Urban Land Institute highlights, "The lack of suitable land for urban development escalates land values, pushing housing costs beyond affordability" (Gaglione et al., 2018) .

The growing preference for single-room homes reflects broader societal changes, including the rise of flexible labour markets and smaller households. Factors such as tighter mortgage regulations and high property costs make owning larger homes unattainable for many young professionals and single individuals. Furthermore, the appeal of mobility and independence leads many to opt for compact living arrangements.
Housing policies have played a pivotal role in shaping the Dutch housing market, particularly through the regulation of rental and owner-occupied sectors. Social rental housing, which comprises approximately 30% of the national housing stock, provides affordable options for low-income residents. However, middle-income earners face a gap in access to both social rentals and affordable private rentals, intensifying their reliance on isolated housing solutions .

The Dutch government's tightening of mortgage regulations post-2008 has also contributed to a shift towards renting. Homebuyers must now provide larger down payments, limiting access to ownership. This policy disproportionately affects younger households and further drives the demand for single-room and rental housing.
The current housing reveals a need for more inclusive and community-oriented development strategies. Policies should prioritize integrating communal spaces within high-density housing and revisiting land-use frameworks to allow more diverse housing typologies. As Van Doorn et al. (2019) emphasize, "A balanced approach between affordability, inclusivity, and spatial quality is essential to sustaining vibrant urban communities" .

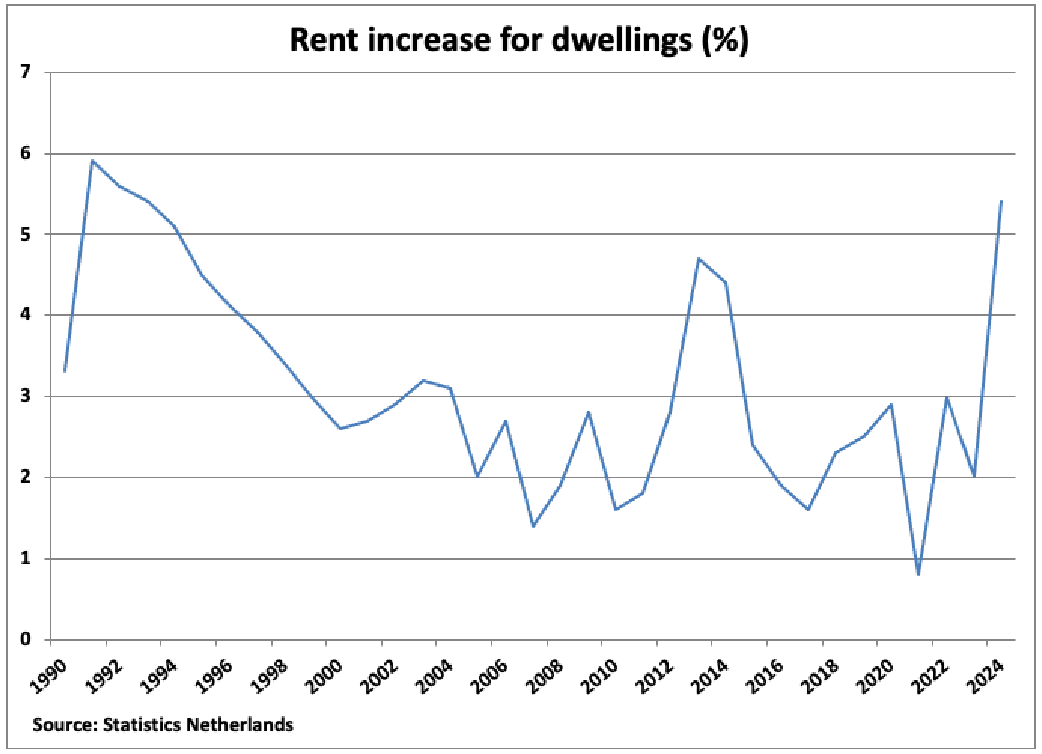


Figure 33. Rents Rising Strongly in the Netherlands (Global Property Guide, 2024)

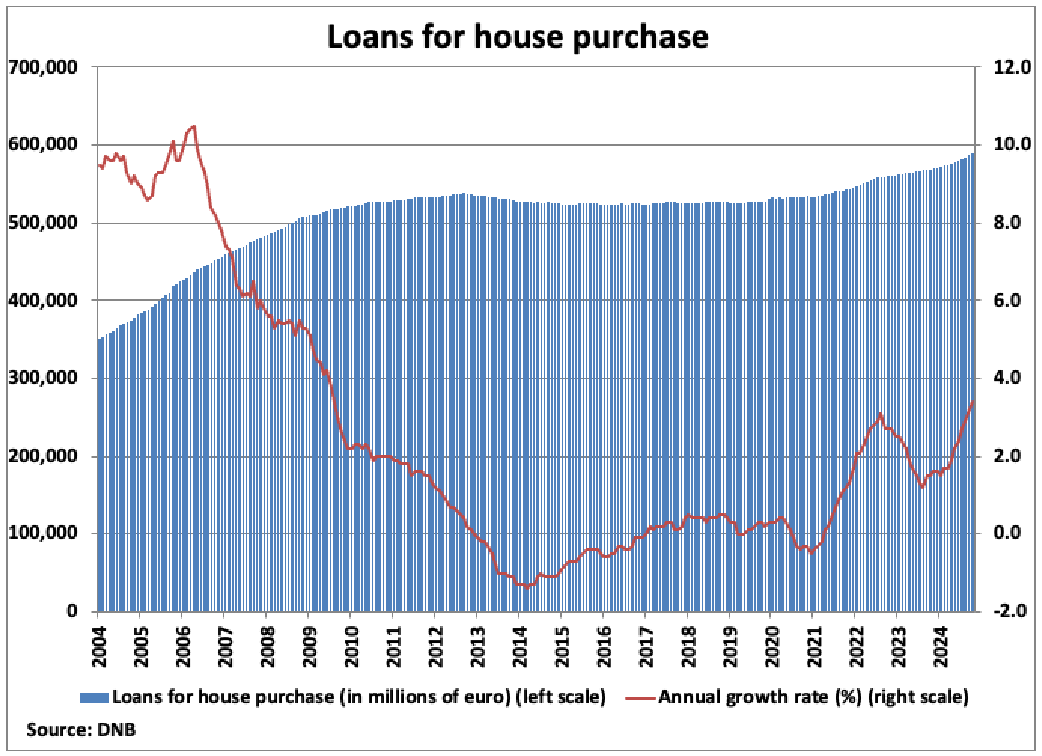


Figure 34. Value of housing loans increasing, but size of mortgage market continues to shrink (Global Property Guide, 2024)

Poor Community Housing Design in the Netherlands

Urban environments often present a paradox when it comes to community living: while cities like Amsterdam and Rotterdam face significant overcrowding, they simultaneously suffer from a lack of functional communal spaces. Overcrowding stems from the increasing demand for housing, driven by population growth, urban migration, and limited land availability. This surge in population density often results in smaller living units, reduced privacy, and heightened competition for public amenities. However, the design of urban housing has not always adapted to support communal interaction. In many newly developed high-rise complexes, there is an absence of shared spaces such as courtyards, communal gardens, and gathering areas — elements historically present in older housing typologies like hofjes (Wilms (n.d.)). The tension between high-density living and a scarcity of inclusive public spaces undermines the potential for fostering community engagement and collective adaptation to climate risks.

Gentrification further complicates the dynamics of community living in urban settings. In both Amsterdam and Rotterdam, rising property values and upscale developments have displaced long-standing residents, fragmenting established community networks. While gentrification often brings infrastructural improvements, it simultaneously erodes the social fabric by altering the demographic and economic composition of neighborhoods. For example, Rotterdam's Katendrecht district has seen a wave of revitalization projects aimed at transforming the area into an attractive, high-end waterfront community. Although these changes have boosted local businesses and improved public spaces, they have also marginalized lower-income residents who previously relied on tightly-knit social networks for support (Nientied, P. (2016)).

Several community housing projects in the Netherlands serve as cautionary tales about the risks of poor design and planning. One notable example is the Bijlmermeer housing project in Amsterdam, constructed in the 1960s as a modernist utopia promoting collective living. The design featured massive concrete high-rises separated by green spaces and skywalks, with minimal ground-level communal areas. However, the project failed to foster a sense of community due to its isolated, fortress-like architecture, lack of mixed-use spaces, and poor maintenance (Van Der Veer & Kornatowski, 2023). Residents found the design disconnected from their social needs, leading to high vacancy rates and increasing crime levels. The Bijlmermeer's downfall underscores the importance of integrating communal spaces within residential areas, ensuring accessibility, safety, and opportunities for spontaneous social interaction.

Another example is the urban renewal of Rotterdam's Tweebosbuurt neighborhood. Initially intended to rejuvenate the area, the project ultimately displaced many long-term residents without adequately considering their role in the local community. The abrupt removal of familiar social networks resulted in protests and highlighted the emotional and social costs of neglecting community bonds during urban redevelopment(VanDerVeer&Kornatowski,2023).

Lessons learned from these cases emphasize the need to prioritize bottom-up design approaches by involving residents in planning communal spaces, ensuring they meet actual social and environmental needs. Integrating multi-functional public spaces into housing projects promotes interaction, resource sharing, and collective flood preparedness. Balancing urban renewal and affordability is crucial to avoid displacing vulnerable communities and weakening their adaptive capacities.

Figure 35. Katendrecht district in 1920 vs today (Shipyard, 2019; Kooyman, 2025)

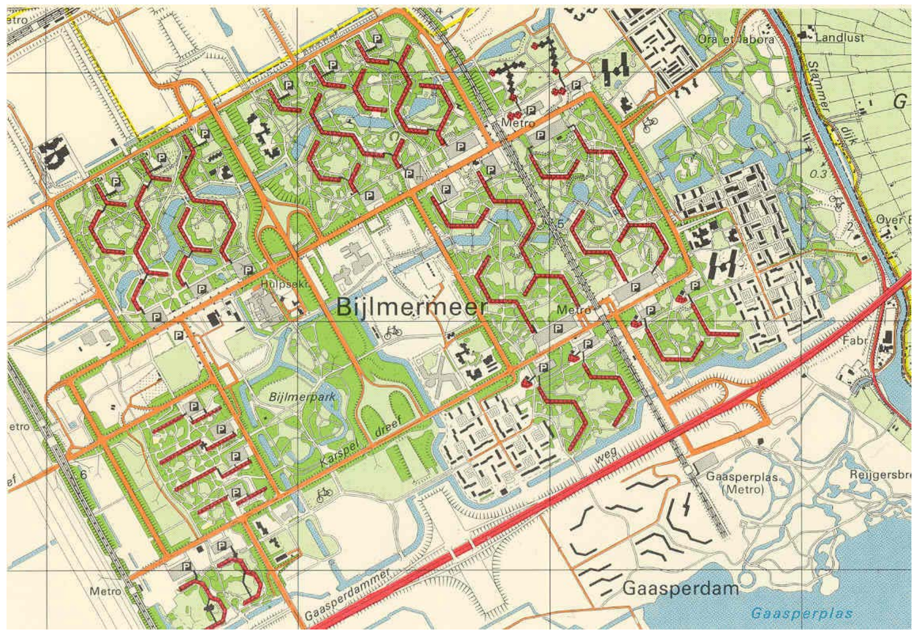


Figure 36. Original master plan for the Bijlmemeer (Mingle , 2019)

Figure 37. Honeycomb structure of Bijlmemeer towers(Mingle , 2019)

THE TRANSITIONAL SPACE

In the early 20th century, the Congrès Internationaux d'Architecture Moderne (CIAM) was formed as a progressive platform to promote the principles of modernist architecture. CIAM advocated for rational planning, functional zoning, and the use of standardized forms to respond to the challenges of industrialization and urbanization. While its early ideals were rooted in social reform, over time CIAM's doctrine evolved into a rigid, technocratic functionalism that often overlooked the human scale and everyday lived experience (Vink, 2021).

This growing dissatisfaction led to internal critique. Among the dissenters were a group of younger European architects—including Dutch architects Aldo Van Eyck and Jaap Bakema—who eventually formed Team 10 in the 1950s. Herman Hertzberger, representing the younger generation, was deeply influenced by their ideas and later joined the editorial board (Vink, 2021).

Both Van Eyck and Hertzberger developed the concept of the in-between space as a spatial and philosophical response to the shortcomings of modernism. Van Eyck, trained as an artist and inspired by anthropology and structuralist thought, proposed the idea of "twin phenomena"—polarities that find their meaning in relation to one another, such as inside-outside, individual-collective, house-city. The reconciliation of these opposites gives rise to the in-between space, an ambiguous yet meaningful realm where architecture supports coexistence and participation (Vink, 2021).

This can be clearly seen in his design for the Amsterdam Orphanage, where a cluster of interlocking residential and communal pavilions is connected by an interior "street"—a semi-public zone that softens the boundary between institutional and domestic, private and shared. Corridors act as interior streets, connecting the pavilions and other service areas. This street, an intermediary place, enables children to move and behave freely, fostering interaction across departments. It also reduces the emotional stress associated with transitions like leaving or returning home. Van Eyck used such intermediary spaces to reconcile oppositions—inside-outside, house-city, individual-collective—making the building a cohesive, fluid whole (Vink, 2021).

Similarly, Hertzberger embraced the in-between space, but he called it the "threshold"—a transitional, overlapping zone between public and private. Influenced directly by Van Eyck and Team 10, he saw architecture as a framework that must be completed by the user, emphasizing spatial experience over formal expression (Vink, 2021).

In the Centraal Beheer Office in Apeldoorn (1972), Hertzberger rejected the open-plan monotony of modern office design. Instead, he structured the building as a city of interlocking modules. Comprising 60 spatial units measuring 9 x 9 metres, the building could house 1,000 workers. These modules are configured both horizontally and vertically, allowing users to personalize their environment. Hertzberger emphasized that users should become inhabitants—a key to his idea of "homecoming." The spatial organisation includes streets, bridges, and intersections, all layered to create a porous, accessible building without a single main entrance. Workers can view and engage with other units across open voids, facilitating social interaction and a sense of belonging within a larger collective (Fracalossi, 2024).

Both architects used the metaphor of the city as a house and the house as a city to blur the boundaries between scales and between polarities. They viewed architecture not as a finished object, but as a living, social structure capable of adaptation, encounter, and meaning-making. Thus, the in-between space—whether understood as threshold, transition, or twin phenomenon—remains a fundamental design tool in the humanist architecture of the Netherlands. It stands not as a leftover space, but as a rich territory of possibility, capable of reconciling opposites, evoking identity, and nurturing community.

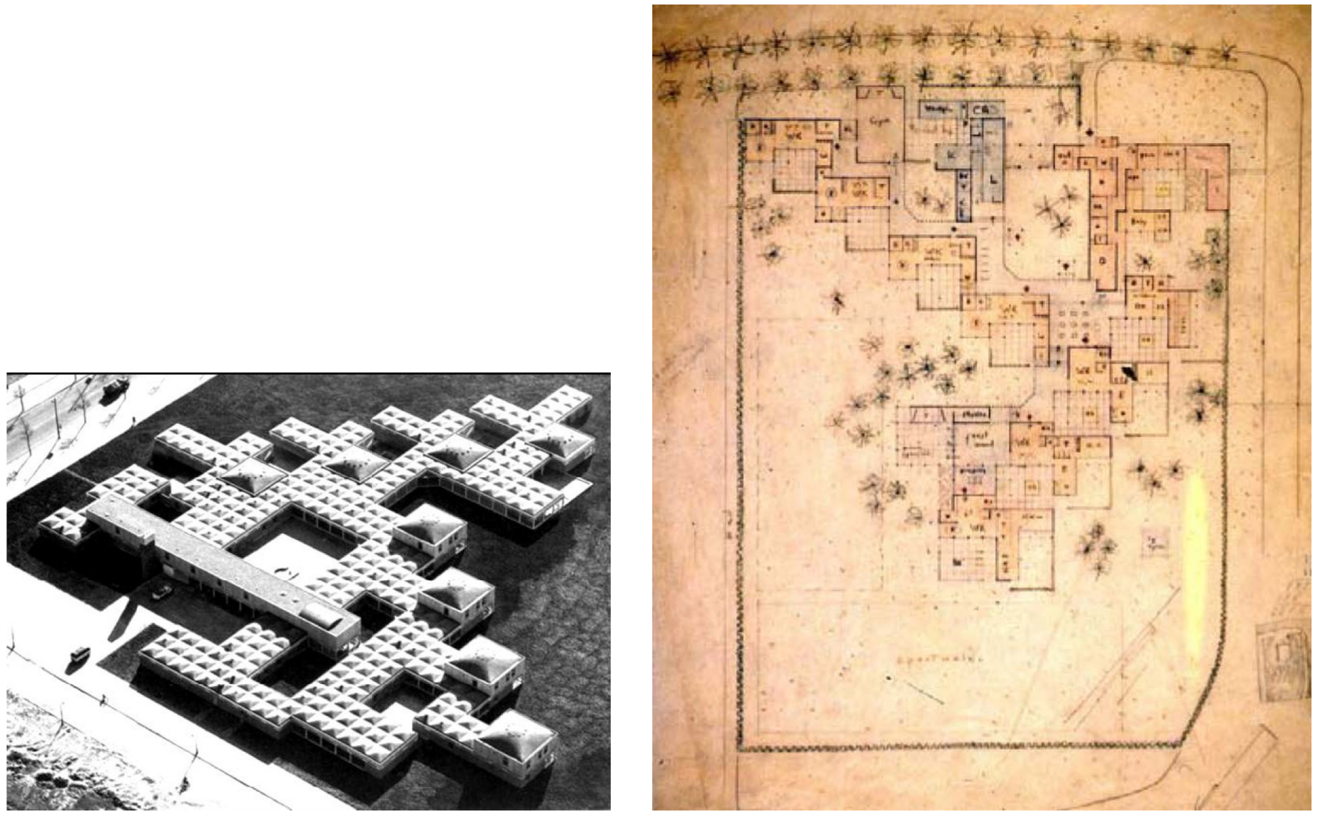


Figure 38. The in between spaces defined by Aldo Van Eyck in his design of The Orphanage (Fracalossi, 2024)

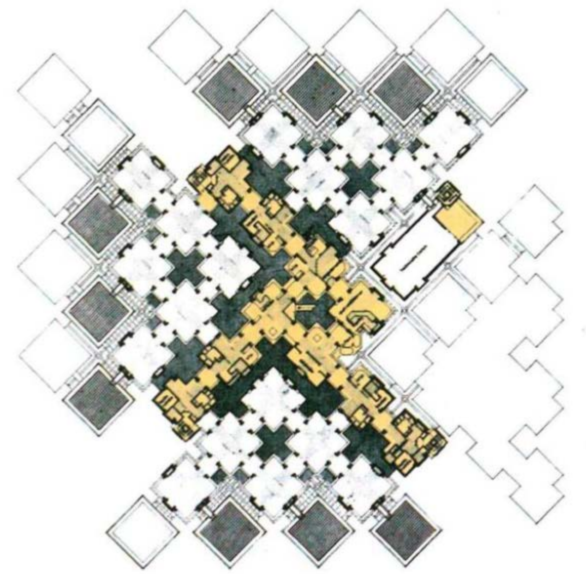


Figure 39. Threshold spaces in Central Beheer Office by Hertzberger (HIC Arquitectura. 2022)

BELAPUR HOUSING , CHARLES CORREA

In his seminal publication The New Landscape (1985), Correa introduced the idea of "space as a virtue," arguing that urban living extends beyond the four walls of a home. He described a hierarchy of spaces — from private interiors to semi-private thresholds, neighborhood gathering areas, and finally, the broader urban realm — which is a foundational structure in human settlements across cultures and time. Notably, the transition from private to public space is often marked by a shift from enclosed to open-to-sky environments. Correa paid special attention to the in-between spaces — verandahs, terraces, courtyards, and even the shade of a tree — believing these could flexibly serve both intimate and communal functions, depending on how layers of privacy are designed.

Belapur Housing (1983), completed on 5.5 hectares of land to accommodate 500 people per hectare (20 sqm per person), demonstrates these principles through its low-rise, high-density layout. Rather than employing the typical row-house format, Correa arranged individual housing units into clusters of seven around intimate courtyards. These clusters scale up to form larger communal courtyards, eventually connecting to public amenities like parks and schools — establishing a multi-scalar network of shared spaces. Each unit includes a private open space, which can be expanded incrementally as the family's needs and income grow, allowing for personalization and adaptability.

Correa's core design philosophy emphasized principles such as **incrementality, participation, pluralism, income generation, equity, open-to-sky space, and disaggregation** — all seen as essential for the success of mass housing in rapidly urbanizing regions. These ideas are still relevant today and offer valuable insights into affordable housing solutions globally. The simplicity of construction allows residents to participate in the building process, fostering a deeper connection to their homes and surroundings.

At the heart of Belapur's success is its thoughtful spatial hierarchy — organizing private, semi-private, and public spaces in a fluid continuum. Private homes form the core, designed as sanctuaries that are not isolated but arranged in close-knit neighborhoods. Semi-private areas, such as shared courtyards, hallways, and terraces, encourage spontaneous interactions and build social bonds. Public spaces, including large courtyards and community areas, serve as vibrant centers for social life, celebrations, and collective activity.

Being a low-rise development, residents can easily be involved in the decision making and construction process with the possibility of a high degree of personalization of spaces. Thus we see the fundamental role that the 'transitional' spaces play in residential architecture, giving rise to a sense community that can traverse the concrete nature of the built form. The ability to define one's own thresholds and degrees of privacy is also a small yet powerful way to create a healthy relationship with one's immediate surroundings and neighbourhood. The absence of the transient space in the most modern row housing typology points to one of the key planning flaws that led to failure of the living environment in such buildings.

As this research explores water-adaptive housing projects such as Schoonschip and IJburg, Belapur serves not as a direct response to flooding but as a crucial reference for designing social infrastructure. It reminds us that resilience is not just about protecting against environmental threats, but about building strong, adaptive communities — where spatial design becomes a catalyst for both personal well-being and collective strength.

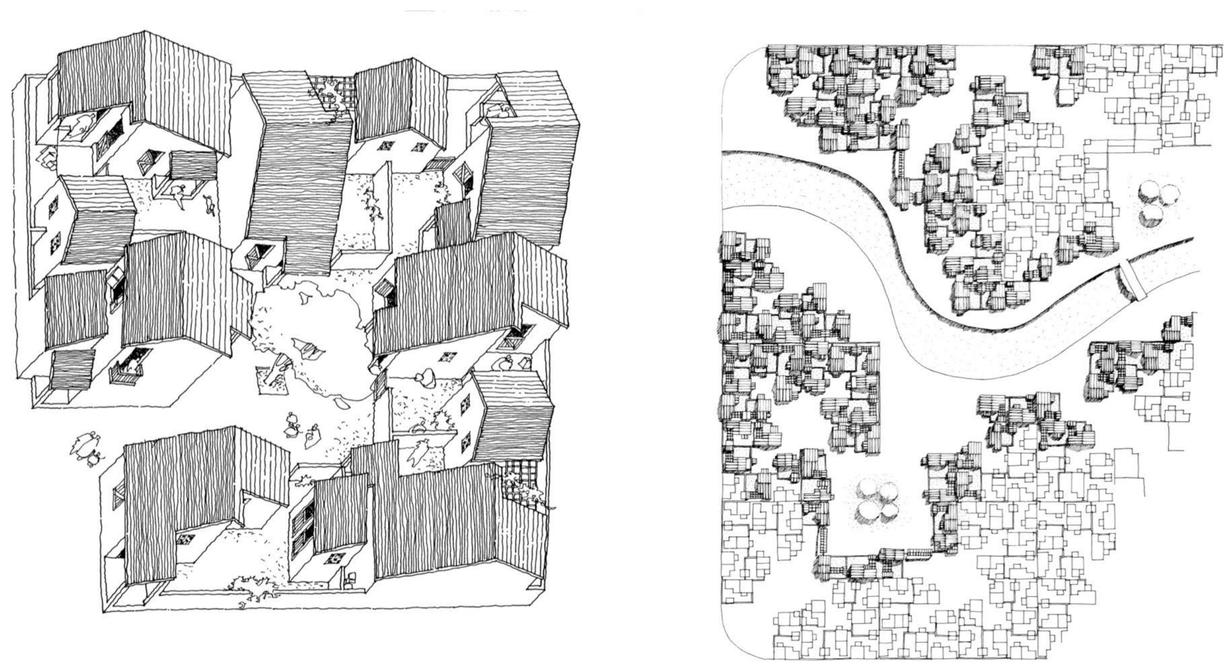


Figure 40. Charles Correa Belapur Housing (Architecture, 2023)

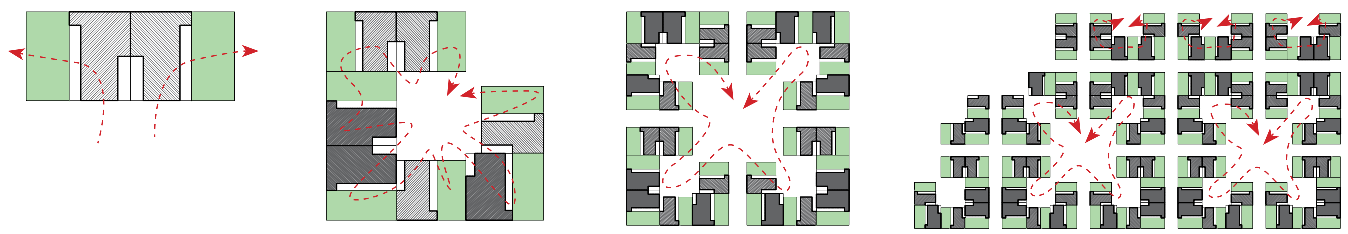


Figure 41. Spatial Hierarchy Concept in Charles Correa Belapur Housing (Authors Own diagram)

"What is the need for community living ?"

- *Community living fosters social cohesion, reduces isolation, and enhances resilience.*
- *Hofjes and communal farms historically balanced privacy and shared spaces.*
- *Traditional canal houses integrated communal courtyards for social interaction.*
- *Urbanization has led to high-rise developments, prioritizing efficiency over community.*
- *Increased isolation weakens social bonds in modern housing.*
- *Overcrowded cities lack communal spaces, limiting social connection.*
- *Gentrification displaces communities, reducing resilience.*
- *Community-oriented housing strengthens social bonds and reduces isolation.*
- *Shared spaces support climate adaptation in flood-prone areas.*
- *Co-housing and cooperative models promote affordability and sustainability.*

The history of community living in the Netherlands reveals a strong tradition of shared spaces and collective resilience, particularly through housing models such as hofjes and cooperative farming settlements. These early housing typologies successfully balanced private and communal needs, fostering social bonds while ensuring individual privacy. In urban centers, historical housing forms, such as canal houses and mixed-use developments, encouraged neighborly interactions through shared courtyards and multifunctional layouts. However, modern developments have largely moved away from these principles, prioritizing efficiency and individualism over communal living.

Urbanization and shifting housing trends have significantly altered the Dutch residential landscape. The rise of high-density, high-rise developments in major cities such as Amsterdam and Rotterdam has responded to growing housing demand but often comes at the cost of community engagement. The prioritization of space efficiency over social connectivity has led to an increase in isolation among residents. Additionally, the trend towards suburban expansion and single-family housing has further fragmented communities, reducing opportunities for collective interaction. As housing policies have tightened, especially following the 2008 financial crisis, affordability has become a major concern, particularly for middle-income groups who are left with limited access to both social and private rental housing.

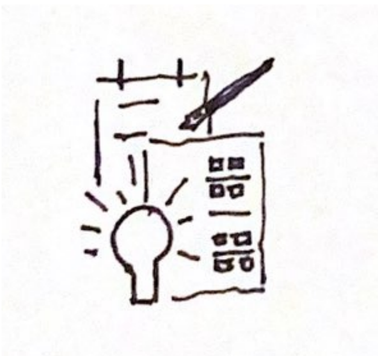
A key challenge in contemporary urban settings is the paradox of overcrowding and a simultaneous lack of communal spaces. While cities continue to densify, public and semi-private areas that facilitate community interaction are becoming increasingly scarce. Gentrification has further disrupted social networks, displacing long-established communities and eroding local support structures. The case of Rotterdam's Katendrecht district highlights how urban renewal projects, despite improving infrastructure, have unintentionally marginalized lower-income residents, weakening community resilience.

Similarly, past housing experiments such as the Bijlmermeer development in Amsterdam demonstrate the consequences of poorly designed communal spaces, where the absence of social integration led to high vacancy rates and increased crime.

Despite these challenges, the works of Aldo Van Eyck, Herman Hertzberger, Charles Correa, and other key projects demonstrate that transience is central to their success. This quality is expressed not only through tangible 'in-between' spaces but also as a conceptual framework for growth and adaptability. When homes are designed to embrace change, foster communal interaction, and allow individuals the freedom to define their own boundaries, they contribute to the formation of a thriving society. For a residential neighbourhood to truly function, there must be a meaningful synergy between its different spheres—private and public, enclosed and open, immediate and long-term. Neglecting one aspect in favour of another disrupts the delicate balance between architecture, nature, and social cohesion. It is this balance that sustains a neighbourhood over time, nurtures bonds among its residents, and allows multiple generations to find belonging and continuity in their homes.

Integrating Communal Spaces in Housing Design

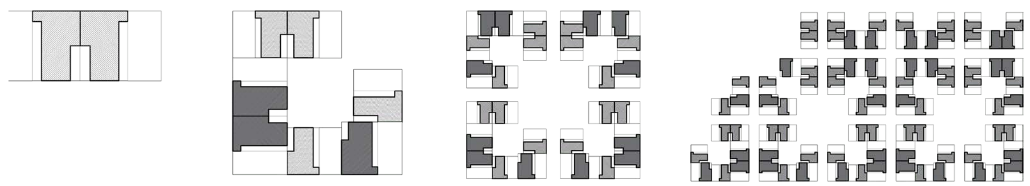
Preventing Social Fragmentation in Urban Redevelopment



Policy and Planning Adjustments

Affordability to prevent displacement

Reduce isolation with social bonds and community orientation



Adapt spatial hierarchy concepts to balance privacy and interaction.

Figure 42. Strategies (Authors own diagram)

05. LIVING ON WATER

"How to realize affordable housing types without losing essential qualities on water?"

Figure 43. Floatig Houses in Amsterdam(Waterwoningen ,2015)

EVOLUTION OF BUILDING ON WATER

The Netherlands' history is deeply intertwined with water. In the Middle Ages, the Dutch began reclaiming land from water through extensive drainage of peat bogs and the construction of *terpen* (man-made mounds) to safeguard settlements from floods. By the 12th and 13th centuries, villages coordinated the building of dikes, which later linked to form continuous barriers along rivers and coastlines. This era marked the rise of water boards ("waterschappen"), local institutions responsible for managing water systems and mitigating flood risks. However, land subsidence caused by peat oxidation after drainage rendered many reclaimed areas vulnerable to flooding, prompting the Dutch to develop more advanced water control technologies. These early practices established the foundational principles of Dutch water management: collaboration, innovation, and adaptation.(Disco & Van 2002).

During the 16th and 17th centuries, the Dutch Republic undertook large-scale land reclamation projects, such as the *Beemster Polder*, using windmill-powered drainage systems. Cities expanded their canal networks for navigation, trade, and urban development, creating a symbiotic relationship between urbanization and water management. Simultaneously, military strategies incorporated water through the use of "water lines"—intentional inundations to defend against invaders. The advent of the *Rijkswaterstaat* (State Water Service) in 1798 marked a shift toward centralized water management. Large-scale projects such as the *Zuiderzee Works and the Delta Works* in the 20th century epitomized the Netherlands' engineering prowess. The Delta Works, initiated after the catastrophic North Sea Flood of 1953, included massive dams, sluices, and barriers to protect against storm surges while balancing ecological concerns (Disco & Van 2002).

The post-war period also saw a growing emphasis on multifunctional water systems, integrating flood control, navigation, freshwater supply, and urban development. Key projects during this era include the closing of the *Zuiderzee* in 1932 and the *Delta Works* from 1958 to 1997, which showcased a shift from conquering water to living with it. By the 1970s, increasing awareness of environmental degradation and societal pushback against technocratic approaches led to a paradigm shift that resulted in Integrated water management and participatory planning (Disco & Van 2002).

The development of Amsterdam by its canals also introduced house boat living in the Netherlands that historically began during the Dutch golden age of sea trade in 17th – 19th Century. Houseboat living originated as a practical solution to housing shortages and later evolving into a lifestyle choice. Living afloat has made the Dutch society gain confidence in 'back to water' along with Dutch Government policy in the Netherlands in general people have positive attitudes toward living on water; a new typology of water-based dwellings such as floating house or neighborhood remain a new entity in current spatial planning; it still exposes to difficulties in the future development due to the present laws and regulations that do not fit into this new typology of water dwellings (Nillesen & Singelenberg, 2011). The boat houses (a ship that converted into residence) are regards as a movable property not as a real estate (land housing), where rules and regulations are applied differently for both categories; including here the issues on property tax, legality of mooring sites, mortgage financing and so forth (Nillesen & Singelenberg, 2011; Kloos & Korte, 2007; Gabor & Blaustein, 1979).

Overall, the global effects of climate changes and the proof that stand alone technology approach by construction dikes and dams are not enough to tackle the floods and avoid the Netherlands from sinking. Spatial planning that was initially separated from water management, since late 1990s has been integrated with and accommodated within the national spatial policy. "Room for the rivers (2005)" and "Working together with water (2008)" are the new campaign in current Dutch urban development. While providing enough water storage, the water space also offers new land use for urban functions(Nillesen & Singelenberg, 2011). This transformation enables new possibilities for urban expansion and ecological restoration.

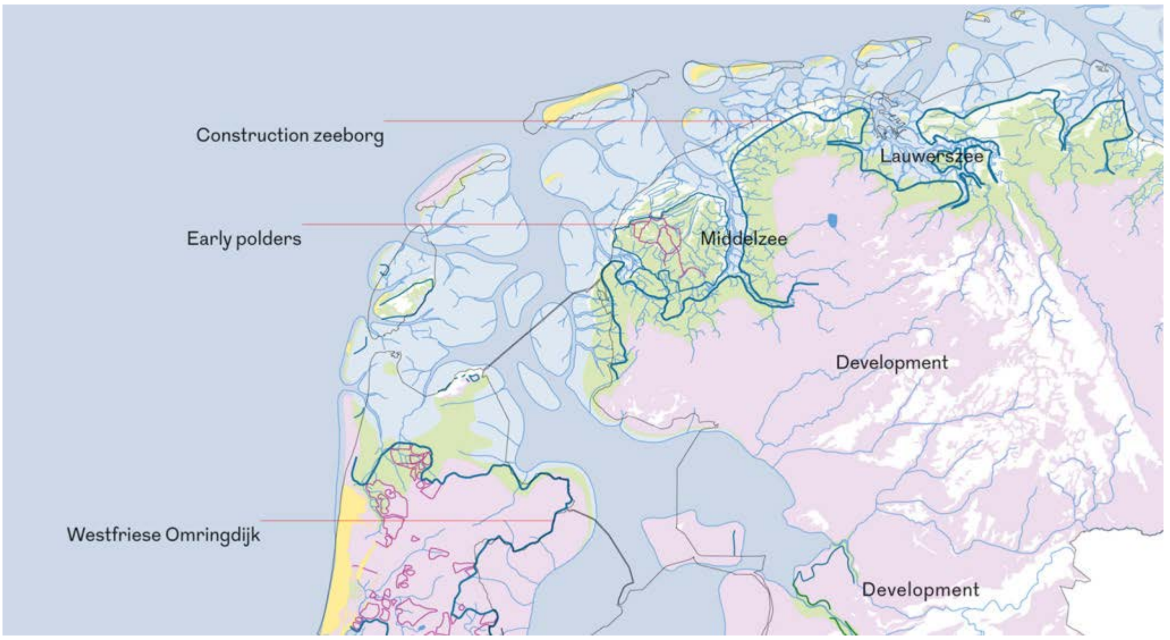


Figure 44. Map of the dikes period 700 – 1200 (northern Netherlands) (History, n.d.)

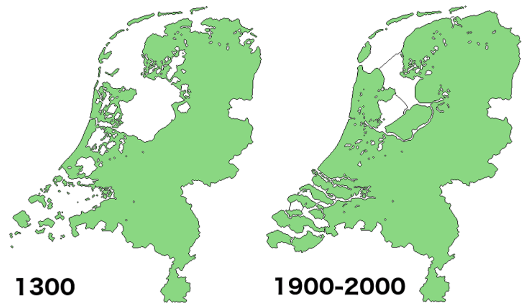


Figure 45. Land reclamation map of Netherlands (2023)

Figure 46. Closing of Zuiderzee project in 1932 with a dam Afsluitdijk at IJsselmeer (Nillesen & Singelenberg, 2011).

(a) 1650 (b) 1903 (c) 2012

Figure 47. Amsterdam boat houses and evolution(Nillesen & Singelenberg, 2011).

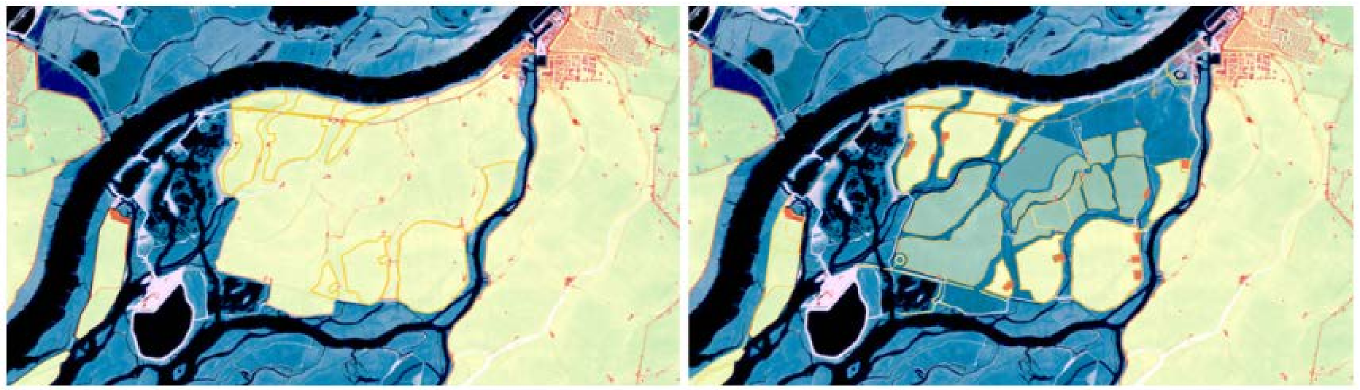


Figure 48. Spatial adaptation in the Noordward area Room for the rivers project (Rossano,2014)

THE FLOATING HOUSES, IJBURG

A Housing Project Designed for Climate Adaptation and Community Living

Time Frame : 2011 Executed

Location : Ijburg, Amsterdam

Size: 10,652 square meters

No: Of Homes: 75 homes with 1800 sqft Water plot of (6X10m or 7X15m)

Clients: Ontwikkelingscombinatie Waterbuurt West

Architects and Collaborators: Architectenbureau Marlies Rohmer

**Old Interview about the development of the project with Marlies Rohmer (and building technologist) by Architizer (Waterwoningen ,2015)*

The Waterwoningen project is part of Amsterdam's IJburg district, a pioneering urban initiative to develop sustainable, flood-resilient housing. The site , Steigereiland is located in the IJmeer between Zeeburgereiland and Haveneiland. It is the first in a series of islands that form the new urban district of IJburg. The "water neighbourhood", Waterbuurt West, lies along IJburglaan, the main access road to IJburg which passes over the Enneus Heerma Bridge. On Steigereiland, water, quays and jetties form the framework of public space. The island's inner basin contains two neighborhoods with floating homes and dyke houses. Waterbuurt West is a compact urban development with a density of 100 homes per hectare. The floating houses are accessed by jetties. The subsoil of Steigereiland is relatively unstable compared to that of the other islands, so the recently drained land takes longer to consolidate. This is one reason why floating homes were made an important component of the program of construction in the Memorandum of Starting Points (1996). The plan for the island moreover stipulated a 100 meter wide zone to accommodate the high voltage electricity transmission line. This resulted in a large internal basin in the middle of the island.

"We decided to arrange the floating homes along the jetties in an informal, loosely-structured way, within the strict geometrical organization of the triangular site which results from the line of electricity pylons cutting diagonally across the basin. Simply by varying the separation distance between the units and the alignment of their roof terraces, we achieved a lively pattern of continually changing clusters."- Rohmer (Waterwoningen ,2015)

There is plenty of room for small boats between floating homes and these will contribute to the informality of the layout: a pleasantly untidy character, the typical atmosphere of living on the water, with movement, individualism and a boat moored at the door.

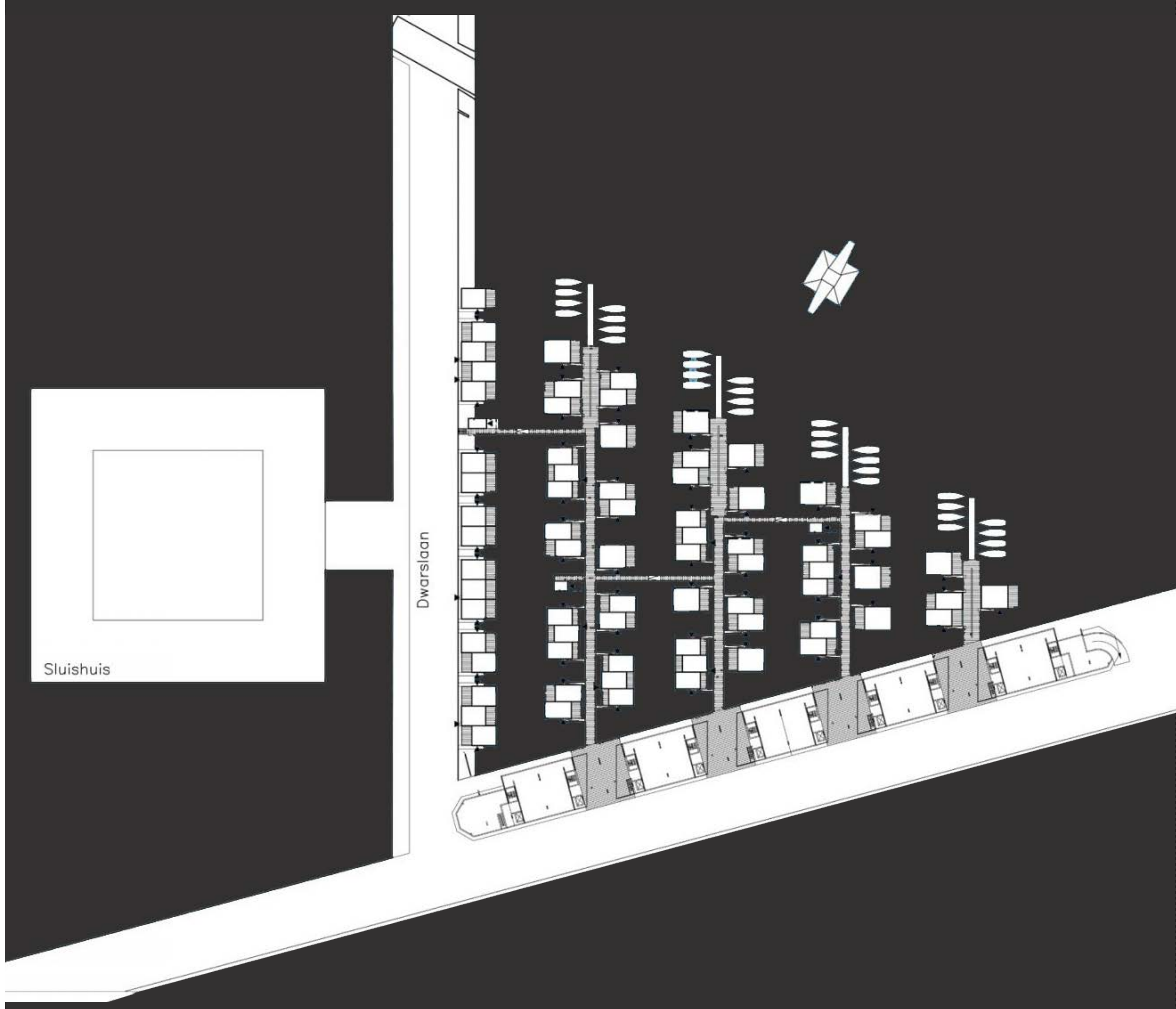


Figure 49. Adaptation of floating houses in Ijburg (Authors own diagram)

What do the residents think of the place?

The residents of the floating houses in IJburg have a range of reasons for choosing this unique lifestyle. Some were drawn to the tranquil water views and the sense of nature, while others moved in simply because a house was available, without specifically seeking a home on the water. Despite these varied motivations, both residents agreed that living on the water offers a unique experience that blends the feeling of being close to nature with the convenience of city living.

One of the most appreciated aspects of the floating home design is the connection to the outdoors. The panoramic water views, peaceful atmosphere, and opportunities to spend time outside — whether on roof terraces or by swimming directly from their homes — create a sense of escape, almost like living in a holiday home. However, this lifestyle does come with its challenges. The homes can wobble in strong winds, sometimes causing unsettling creaks and rattling doors. Maintenance is also more complex than in a typical house, requiring water pumps instead of normal plumbing and frequent cleaning due to increased spiders and insects.

Interestingly, both residents emphasized the strong sense of community. They described having much more interaction with neighbors than they did while living in apartments, comparing the floating neighborhood to a small village. There's a shared sense of support, with residents helping each other out — whether by locating a lost surfboard floating past or borrowing tools through a neighborhood chat group. The slight physical separation between houses seems to strike a balance, fostering connection without the tensions that can arise from overly close living quarters.

Living on the water has also influenced their awareness of climate change. One resident mentioned noticing the fluctuating water levels and experiencing more frequent and severe storms, highlighting how these changes have made climate issues feel more immediate. Another resident, while acknowledging these shifts, remained somewhat skeptical about the impact of individual actions compared to larger global contributors. When asked about improvements, the residents suggested that the government could support water-based living by creating more spaces for floating homes in Amsterdam and simplifying complex regulations, such as leasehold rules. The cost of living on the water is high, with one resident mentioning an annual leasehold fee of €4,000, but both agreed that the lifestyle — combining nature, community, and a unique sense of freedom — makes it worthwhile.

Ultimately, both residents expressed greater happiness since moving to the floating houses. They enjoy the quieter, more nature-focused environment compared to their previous city apartments. The sense of coming home to a peaceful, water-bound neighborhood — where children swim in the summer and neighbors look out for each other — creates a feeling of relief and belonging. It's not just about living on the water; it's about building a lifestyle that balances community, nature, and a certain freedom that traditional housing often lacks.

1. Why did you decide to live on the water?

"No neighbor, and for partner water view. Was the best option in Amsterdam."

"This was simply for sale, special neighborhood, was not looking for a house on the water."

2. What do you think is the nicest part of the design of your floating home?

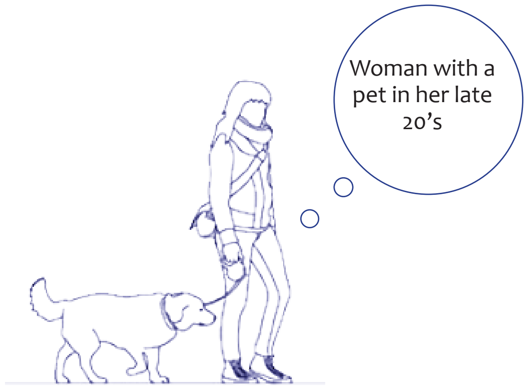
"View, silence, feels like I am in nature, not in the city"

"Roof terrace, feels like a holiday home. Jump into the water from the roof terrace. Bedroom downstairs in concrete box, below the water line, stays nice and cool in the summer"

3. What would you have liked to see it differently about the house?

"House wobbles in wind, doors rattle. Sometimes a bit scary because of storm. A few times a year, depends on the direction, mainly from the south (towards open water, on the other side there is construction that blocks the wind more)."

"Maintenance, not normal pipes, really a pump. Many more flies and mosquitoes and therefore spiders. Outside quickly gets dirty, due to spider droppings."



4. How has living on the water affected your interaction with neighbors? Is this different from living on land?

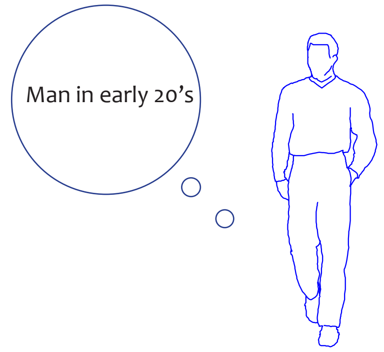
"More contact with neighbours than in an apartment. Waterbuurtapp. A neighbor asks in the group app if someone has seen their surfboard, she sees surfboard floating by in the water."

"Much more contact with neighbors, previously an apartment in Amsterdam. Even became good friends with neighbors, houses are separate from each other. Sharing, neighborhood chat, does anyone have a pressure washer? It's like a small village. Especially because they are detached houses, so less neighborhood quarrels. On land it would probably have the same effect. Small distance, but a bit of distance."

5. What advice would you give to other people who are considering living in a floating house?

"Enjoy it. Doing different things to be able to live on water, takes time and a bit of money. Different from a country house. Maintenance. Water pump."

"Would recommend it, the benefits outweigh the maintenance and thinking, it's worth it. It also increases in value. Unique houses. All owner-occupied houses, sometimes rented out. You can see that people with kids are sometimes afraid."



6. Do you feel a stronger connection to your surroundings, and do you spend more time outdoors?

"More outside, more space to sit outside. But garden would also be nice, so that dog can pee."

"More outside, walk a lot more. Born in the city center, afraid to miss the hustle and bustle, but love the peace now."

7. Do you have ideas about how the government can make living on the water more attractive?

"People are more interested in living on the water, but not many places in Amsterdam. More space needed."

"Pay leasehold, strange regulations. You can buy it off in perpetuity, but it is actually 50 years. He pays 4000 euro leasehold per year. Part work, part living, rule. Hustle to find out. And make it cheaper, you buy a house but not the land."

8. Do you feel happier since you live on the water? What do you think is the reason for this?

"Yes, compared to the previous situation. Quieter than the previous apartment in De Pijp, was quite busy. Feel the wind in my face. Feels like coming home when I cross the bicycle bridge, a kind of relief. In the summer, children in the water everywhere, a real holiday neighborhood."

"Yes, definitely, water is more connected to nature, but also contact with neighbors, brother lives next to the jetty, but also the space. Is a lot of money, but per m2 than in the city."

Technical Challenges

The construction of floating houses presents several technical challenges that are unique to the interaction between water-based and land-based systems. One of the major hurdles is the transportation and assembly process. These homes are built in a dry dock, where they are assembled in sections, such as the concrete flotation tank, which forms the foundation. Once the structure is completed, it is transported by water, requiring careful consideration of factors like lock widths and bridge heights. These dimensions can limit the size and mobility of the homes (Waterwoningen ,2015).

Another significant technical challenge involves stability and flotation technology. Two main flotation methods are used: the Dutch method, which relies on a concrete tank that remains afloat through the upward force of water, and the Canadian method, which uses a foam-filled concrete platform. Both systems have their advantages, but maintaining the stability of floating homes remains a primary concern. The stability of the structure is highly dependent on the design of the flotation body and the mass distribution within the house. Wider flotation bodies and lower centers of gravity generally improve stability, but larger flotation bodies can present challenges during transportation, as they must fit through locks and bridges. Furthermore, the floating homes must be able to endure vertical movements due to waves and swell, and careful design is needed to ensure they are not vulnerable to tilting or capsizing under extreme weather conditions or during regular use (Waterwoningen ,2015).

The integration of services presents another key challenge. Unlike conventional buildings, floating homes have unique requirements when it comes to utilities such as water, gas, electricity, and sewage systems. These utilities must be adaptable to the dynamic nature of floating structures, with flexible pipes and cables designed to accommodate movement. Additionally, utility companies, unfamiliar with providing services to floating homes, had to negotiate new systems for connecting services from the shore to the homes. These negotiations involved the creation of mains connections, which include concrete conduits under the jetties, with meter cupboards placed on the jetty itself. Fire safety is another area where technical difficulties arise. The floating homes require additional escape routes, including fire screens along the jetty, and the integration of fire extinguishing systems that must be carefully designed to handle the unique risk factors of floating dwellings (Waterwoningen ,2015).

Environmental considerations also played a major role in the design and construction process. The materials chosen for the construction must not only be durable but also non-toxic to ensure that no harmful substances leach into the water. For example, any steel used must be either stainless or galvanized to prevent pollution. The design also needed to address water quality concerns, with strategies for keeping the waterway clean, including the installation of electric propellers under the jetties to maintain circulation and prevent stagnation. Moreover, the floating homes needed to comply with regulations imposed by local authorities, such as ensuring that rainwater runoff from the homes did not negatively impact the surrounding water (Waterwoningen ,2015).

Finally, the logistical and regulatory challenges posed by the integration of floating homes into urban spaces like Amsterdam's IJburg are considerable. The homes are subject to the same fire safety, accessibility, and emergency response requirements as land-based structures, but with the added complication of being on water. This includes designing emergency escape routes and fire-fighting systems that are compatible with the floating nature of the homes. Similarly, environmental protection measures, such as maintaining water quality and avoiding pollution, required new approaches to managing utilities and waste disposal systems. The development also had to ensure that the jetties were accessible and safe for pedestrians, incorporating various systems for waste management, bicycle storage, and maintenance of the floating structures (Waterwoningen ,2015).

The fairly shallow surface water of the Netherlands is particularly suitable for flotation bodies with a limited draught. "It is moreover important to leave sufficient room under the floating structure to help protect water quality." A water depth of 150 cm is generally sufficient for floating platforms made of concrete and polystyrene foam; the draught of this kind of platform varies from 90 to 120 cm according to the volume and the weight of the superstructure.

Concrete shells generally have a draught ranging from 70 to 150 cm, but it can easily be more than that when a heavier floor is present. The draught of a floating structure can be reduced by keeping the weight low. "The superstructure of floating dwellings in the Netherlands is usually built around a wooden skeleton for this reason and is limited to three storeys in height." It is awkward to deal with taller structures because they are unstable (Waterwoningen ,2015).

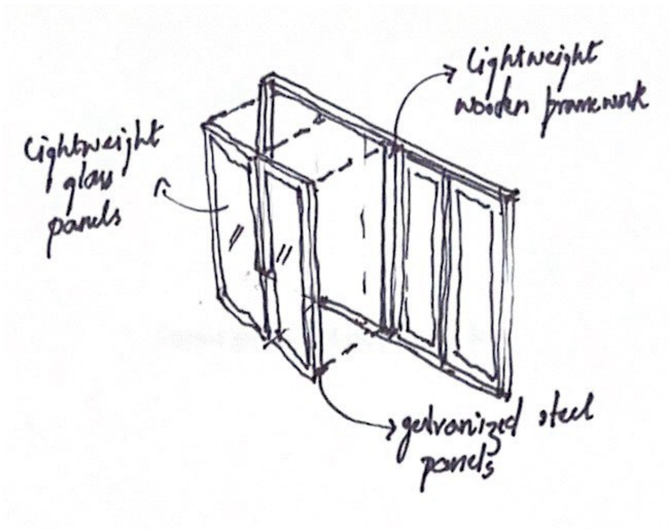


Figure 50.Use of lightweight non toxic materials for construction(Authors Own Diagram)

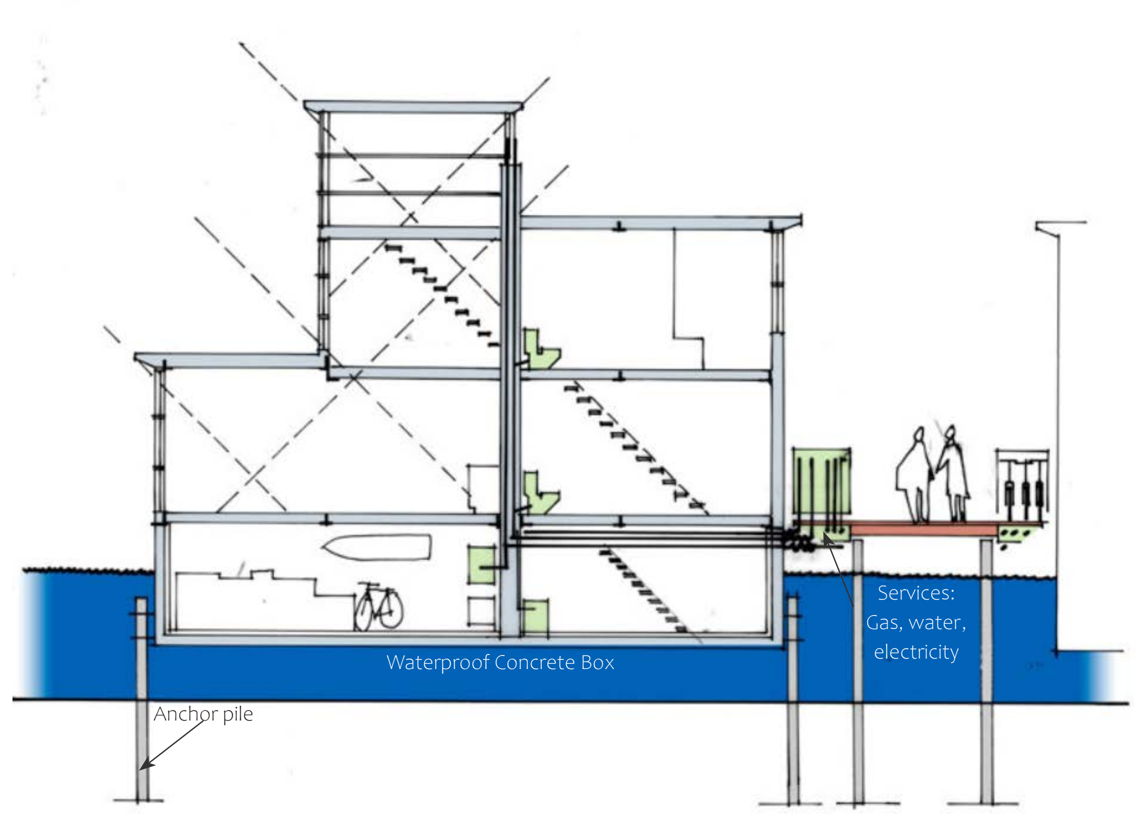


Figure 51. Concrete caissons support the house and are fixed to piles that allow some movement of the shell (Rubin. S,2021)

Figure 52. Identical Floating Units with their decks and lightweight materials in the Urban Setting (Authors own Image)

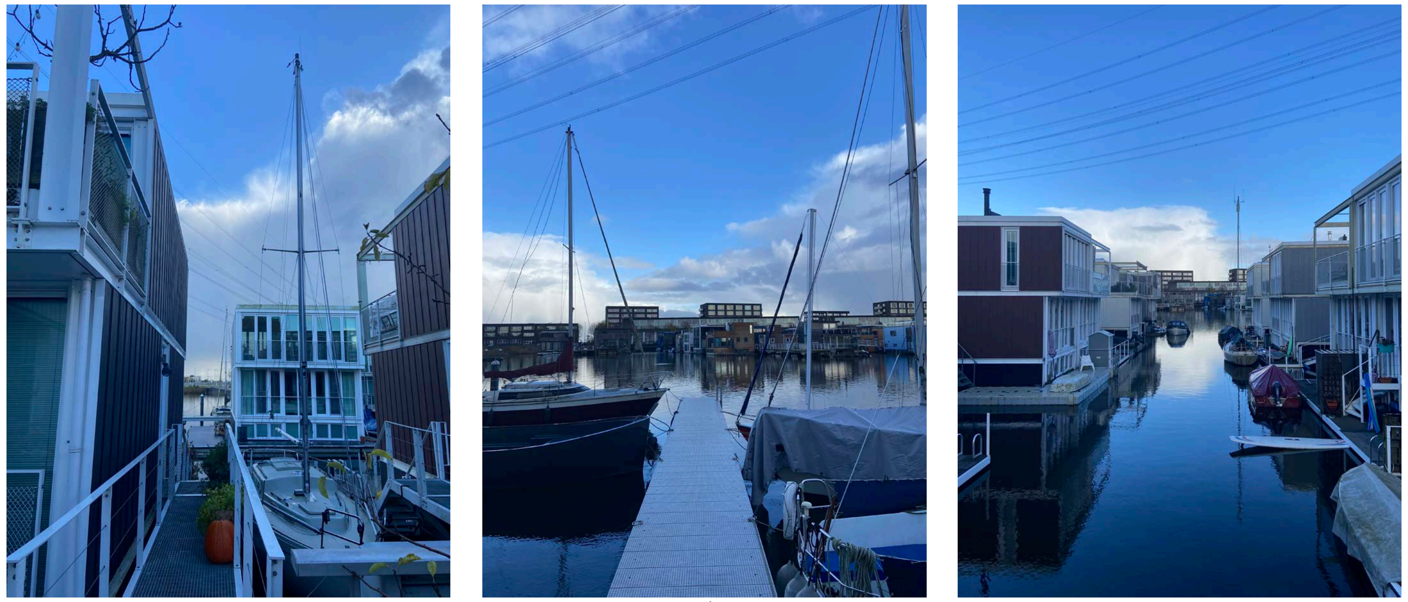


Figure 53. Boats pared at the end of jetties and closer to the units (Authors own images)

Figure 54. Jetties connecting the walkways across different units also used for cycles (Authors own images)

Figure 55. Prefabricated units being transported through the canals and placed on site (Waterwoningen ,2015)

Figure 56. Frozen lake being used as a recreational activity zone (Waterwoningen ,2015)

Dwelling Arrangements

The project on Steigereiland in IJburg presents an innovative approach to urban living, focusing on floating homes and their integration within the water-based environment. The floating houses, arranged along jetties in a loose and informal manner, contrast with the island's geometric structure, defined by electricity pylons cutting diagonally across the basin. This arrangement creates clusters of homes, each with varying distances between units and different orientations of roof terraces. The resulting layout promotes a lively, dynamic atmosphere, where residents can experience a close connection with the water. This informal design allows small boats to moor between homes, further enhancing the sense of individualism and casual living.

Each floating house is built on a concrete tank submerged in water, which also serves as a basement that can be used for living space or storage. The lightweight, wood-framed superstructure is clad in glass and synthetic panels, offering flexibility for the interior and exterior design. Occupants can customize their homes by selecting the side that offers better views or privacy. The houses can also be extended through a per-designed package, which includes elements such as sun rooms, verandas, and floating terraces. This adaptability ensures that each home reflects the needs and preferences of its occupants, while maintaining the integrity of the overall design (Waterwoningen ,2015).

The floating homes are supported by a boardwalk that slopes towards the water, creating an uninterrupted connection between the home and its aquatic surroundings. This feature allows residents to walk around the house, much like being on a boat, fostering an intimate relationship with the water. The houses are available in various configurations, including standalone versions, semi-detached units, and multi-unit combinations, offering a range of options for both private and rental markets. The design is practical yet comfortable, with a focus on providing sustainable and flexible living spaces that can adapt over time (Waterwoningen ,2015).

Despite their innovation, these floating homes are *"hard to avoid comparing to traditional houseboats."* However, the key distinction lies in their permanence and full integration with the urban infrastructure. As Ton van Namen, the developer of the Water Neighbourhood in IJburg, points out, *"the floating house has three floors and lacks the long, narrow shape of a houseboat."* The floating houses "meet all the requirements of the Building Decree" and are designed to *"last just as long as land-based houses,"* making them a valuable asset in the urban landscape (Waterwoningen ,2015).

Rohmer adds that while living on water may be an appealing idea for many, some potential residents may be deterred by practical concerns, such as *"you can't park your car at the front door and you may have to haul your shopping bags along a lengthy jetty."* The overall urban design of the floating homes incorporates a 100-home-per-hectare density, balancing compact urban development with the unique challenges of living on the water. The houses are part of a larger urban plan that includes essential services such as parking and public spaces. This results in a more stable, value-retaining property that contributes to the overall urban landscape.

Rohmer explains that the floating buildings are *"easy to move,"* and neighborhoods can be *"easily expanded or reduced in size"* if needed. She exclaims that *"the occupant can choose freely which side will have more privacy or a better view,"* allowing for a high degree of customization(Waterwoningen, 2015).

The innovative building system with prefabrication and quick assembly of water-based neighborhoods offers the potential for future reconfiguration or expansion. The floating homes are securely anchored to the bed of the basin, ensuring stability and permanence despite their mobility. This feature highlights the unique potential of floating urbanism, where homes can be adapted, moved, or reoriented to suit changing needs and conditions.

Figure 57. Arrangement of the units along the jetties with boats allowed to moor between (Waterwoningen ,2015)

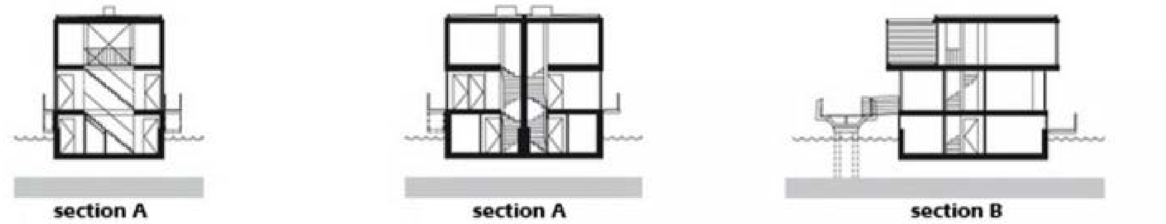


Figure 58. Units are easy to move and adaptable (Waterwoningen ,2015)

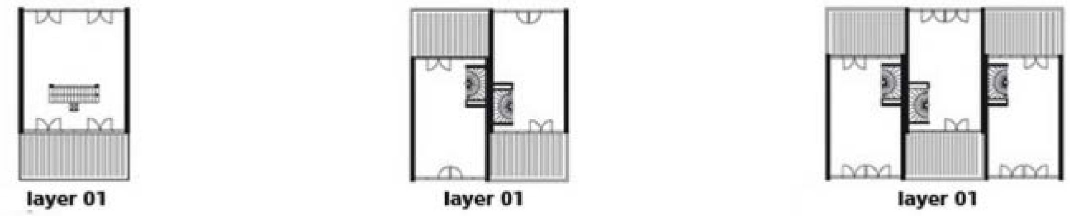


Figure 59. The units can be expanded wit additional living space or verandas(Waterwoningen ,2015)

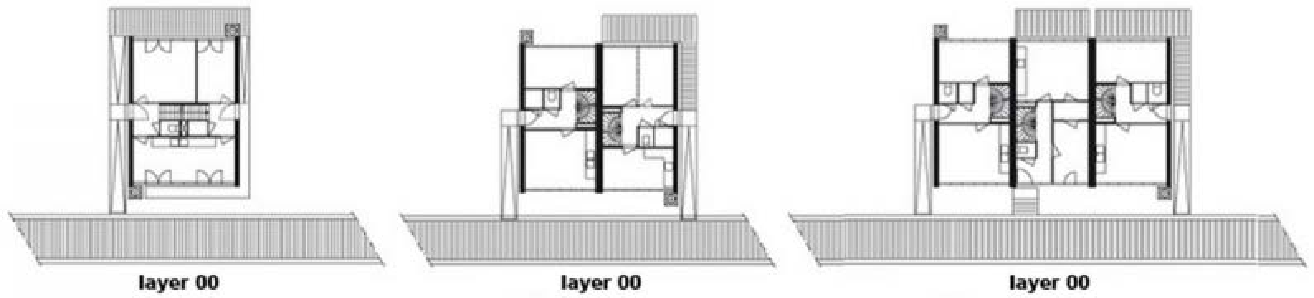


Figure 60. Boardwalk around the house,creating connection with water. (Waterwoningen ,2015)

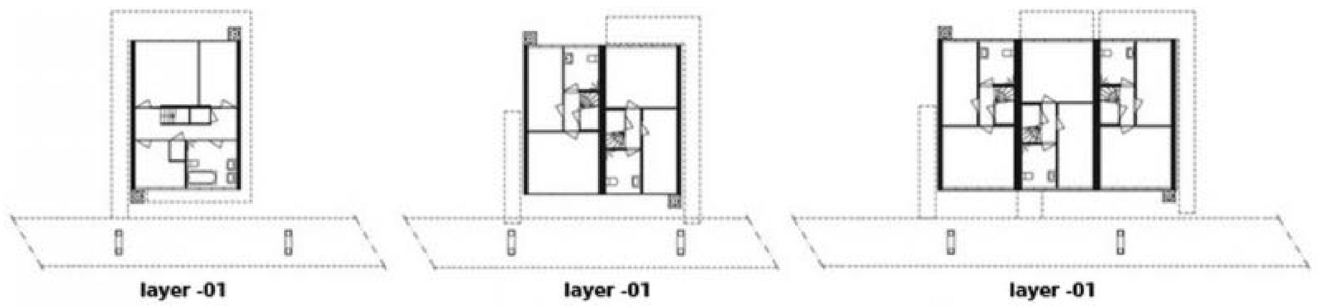


Figure 61. Concrete tank serves as basement that can be reused as storage / bedroom (Waterwoningen ,2015)

SCHOONSCHIP, AMSTERDAM

Sustainable Floating Community Addressing Urban Housing and Climate Challenges

Time Frame : 2008-2022

Location : Amsterdam , Netherlands

Size: 10,652 square meters

No: Of Homes: 75 homes with 1800 sqft
Water plot of (6X10m or 7X15m)

Clients: Ontwikkelingscombinatie Waterbuurt West

Architects and Collaborators: Marjan de Blok, Thomas Sykora / Space & Matter, various architects

The Schoonschip project, located on the Johan van Hasseltkanaal in the northern part of Amsterdam, exemplifies innovative and sustainable urban living. This site was carefully selected for its proximity to the city center, accessibility to public transport, and its potential to repurpose underutilized water spaces. Formerly an industrial zone, the area has been transformed as part of Amsterdam's broader urban redevelopment initiatives, evolving into a vibrant hub for forward-thinking, eco-conscious housing solutions.

Initiated in 2008 by a group of residents led by Marjan de Blok, the project was developed in collaboration with the architecture firm Space&Matter and sustainability consultancy Metabolic. Completed in 2021, Schoonschip comprises 46 floating houses accommodating approximately 180 residents. The project's primary aim was to create Europe's most sustainable floating community, addressing urban housing challenges while enhancing climate resilience (M. Sorkhabi, n.d.,2023).

To make the project more affordable, the committee increased density, that effectively reduced costs, ensuring greater accessibility. The philosophy underpinning the project emphasizes that "investing before flooding costs less than cleaning up after water." Sustainability measures also played a pivotal role in reducing long-term costs, ensuring the community could be self-sufficient and resilient (M. Sorkhabi, n.d.,2023).

Situated on the Johan van Hasseltkade Kanaal-West, Schoonschip illustrates the Netherlands' innovative approach to managing climate change impacts such as flooding. Instead of constraining water, the project embraces the concept of "giving space to water." By building on water, Schoonschip not only provides a sustainable response to the housing crisis but also addresses environmental concerns like rising sea levels and increased flood risks (M. Sorkhabi, n.d.,2023).

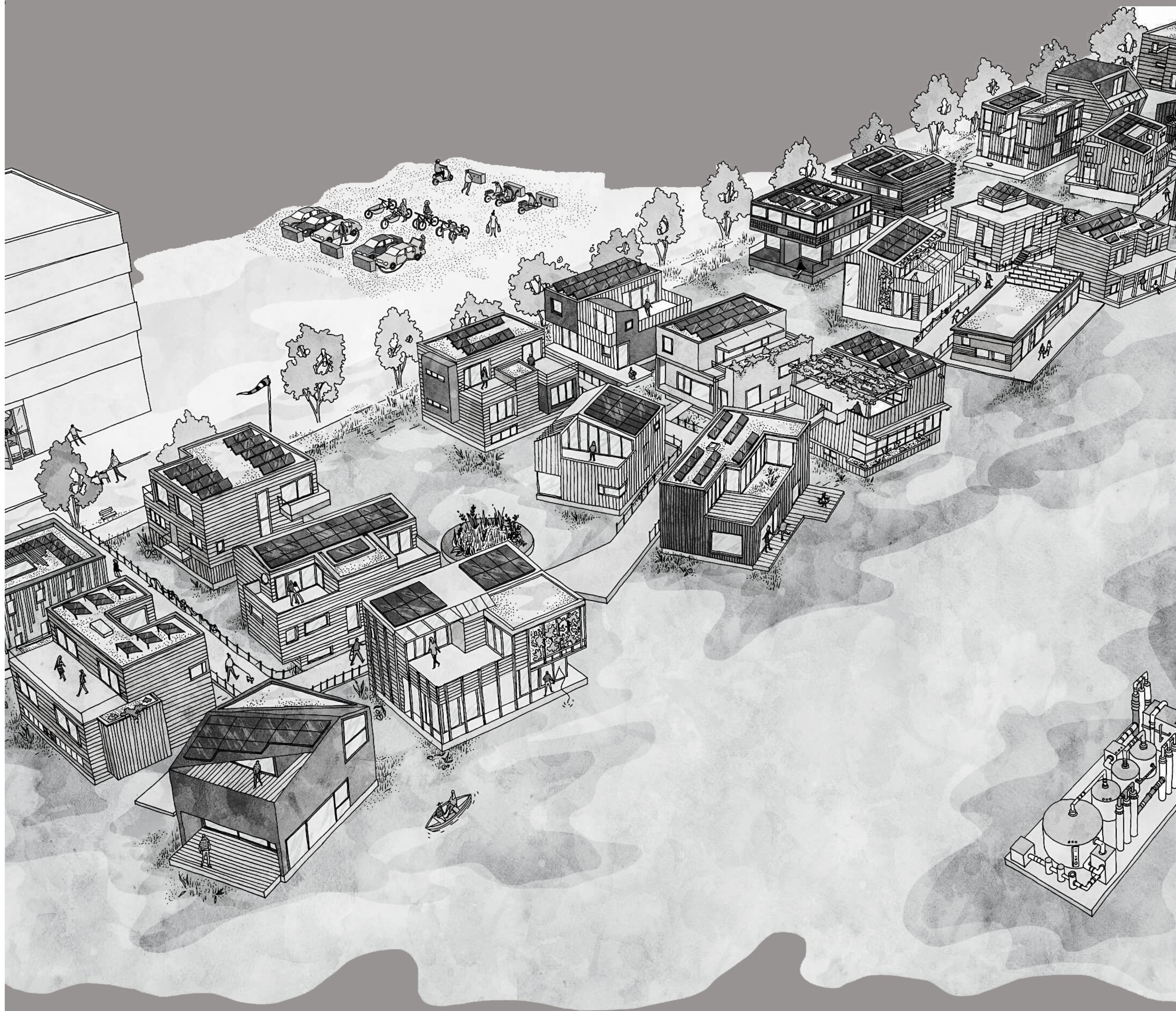


Figure 62. Adaptation of Schoonschip diagram (Schoonschip , n.d.)

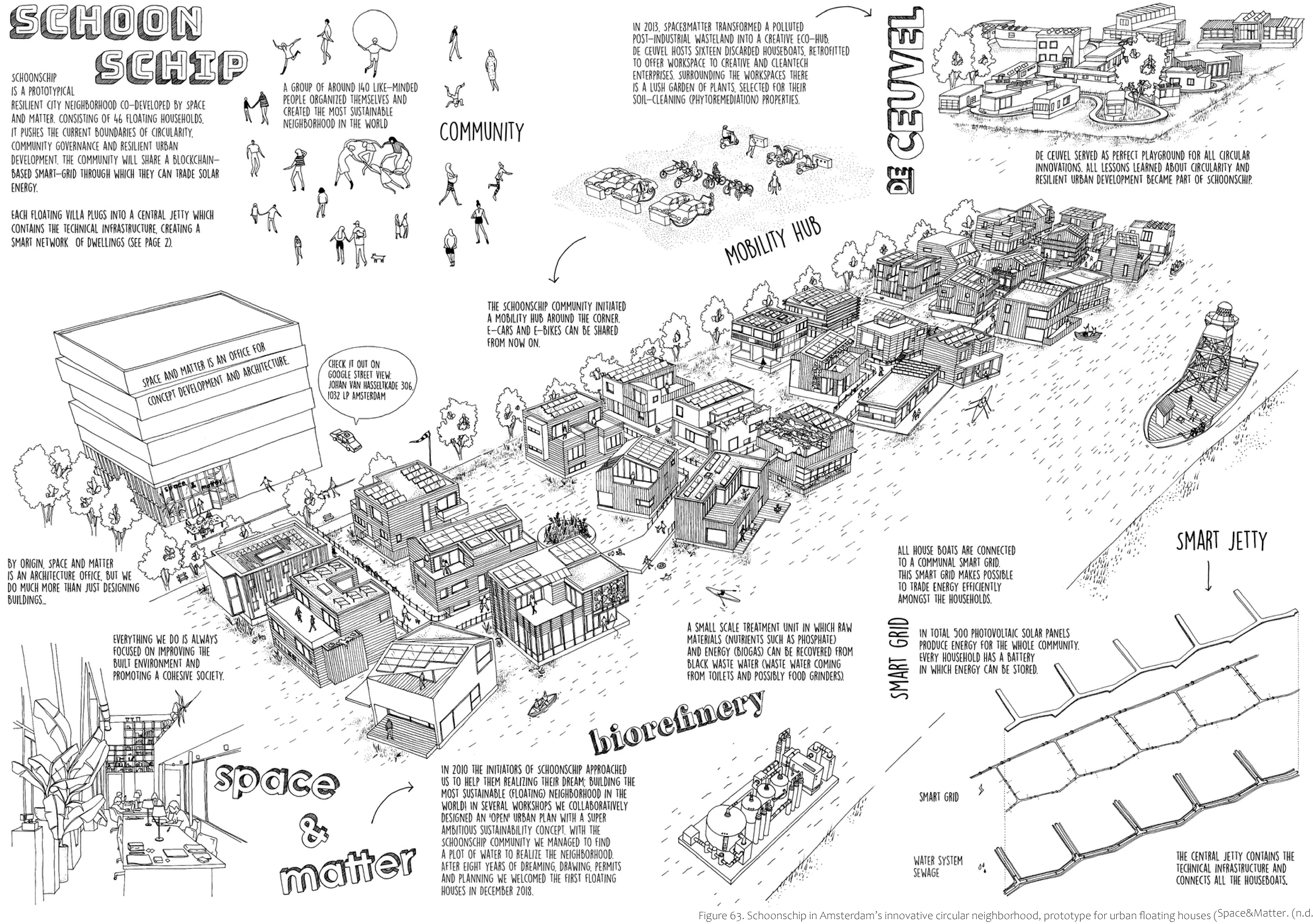


Figure 63. Schoonschip in Amsterdam's innovative circular neighborhood, prototype for urban floating houses (Space&Matter. (n.d.)

What do the residents think of the place ?

The residents of Schoonschip in Amsterdam have various reasons for choosing to live on the water, ranging from climate change concerns and a desire for a shared, sustainable community to a long-standing dream of living close to nature. While some were drawn to the unique project as it came their way, others saw it as an opportunity to be more involved with their neighbors and the environment.

When asked about the design of their floating homes, the residents highlighted their deep appreciation for the strong connection to nature. They praised the abundance of natural light, panoramic views of the water, and thoughtful integration of indoor and outdoor spaces. The feeling of openness and proximity to wildlife, combined with innovative architectural elements, creates a sense of freedom and tranquility.

However, the design does come with its challenges. Residents mentioned issues related to construction details, such as the difficulty of adding solar panels after construction or minor structural quirks like uneven floors and shifting doors due to weight distribution. There were also comments about insulation, maintenance, and the need to balance innovative design with practical functionality.

Despite these challenges, all three residents would recommend floating homes to others, with some practical advice: be prepared for more maintenance, such as painting every five years, and carefully consider weight distribution to prevent the house from tilting. They emphasized the importance of truly wanting to embrace this lifestyle, as it involves more than just living on the water — it requires an active role in caring for both the home and its environment.

One of the most striking aspects of life at Schoonschip is the strong sense of community. The residents described their neighborhood as a "village," where neighbors are close friends, and cooperation is a natural part of daily life. From maintaining shared spaces to organizing community activities, there is a collective spirit of helping one another. This social bond is seen as even more valuable than the unique experience of living on the water.

Living on the water has also heightened their connection to nature. Residents spoke about swimming in the summer, observing wildlife up close, and feeling more attuned to the changing weather. The need for constant maintenance, like removing algae or reinforcing docks, also fosters a hands-on relationship with their surroundings.

Regarding climate resilience, the residents expressed a growing awareness of environmental sustainability. They take pride in their off-grid systems, energy-efficient designs, and shared energy networks. This lifestyle has reinforced their commitment to eco-friendly practices, from reducing clothing consumption to promoting local biodiversity through floating gardens.

When asked how the government could support floating communities, residents suggested creating more space for water-based living while ensuring it doesn't come at the expense of natural habitats. They advocated for fewer restrictions, allowing residents to design their own homes and showcase individual creativity, rather than enforcing uniformity.

Ultimately, all three residents reported feeling happier since moving to Schoonschip. While the water and nature play a role, they emphasized that the sense of community is the greatest source of their contentment. They enjoy the camaraderie, the spontaneous interactions, and the shared sense of responsibility — fostering a lifestyle that is both environmentally and socially enriching.

1. Why did you decide to live on the water?

"Climate change, Amsterdam water city, idea of a shared neighborhood attractive"

"Something that seemed nice to me, project came my way"

"Always wanted to live on the water, studio around the corner. Location, but also community, doing more together, taking care of each other, sustainable appealed to us, being more involved"

2. What do you think is the nicest part of the design of your floating home?

"Bringing nature outside into the house, different from an apartment, animals"

"Lots of light, small rooms on 3 floors, but everything is connected"

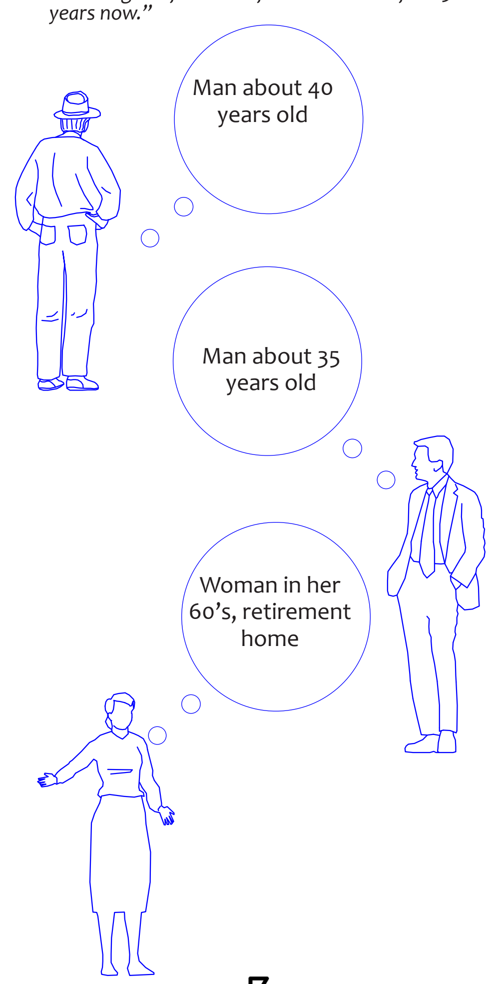
"The view in all directions of the water, large living space, bought from an architect who had designed for himself. Has lived here for 1.5 years now."

3. What would you have liked to see it differently about the house?

"A lot of premature equipment, not yet fully developed, still in the development phase"

"Actually no disadvantages, some construction details perhaps, just that pole 5cm to the left etc, place solar panels on it later (instead of during the construction phase) problem, nothing is standard here, everything is difficult"

"Daylight now reaches the lower floor, (concrete box). Initially, a trampoline net was used as a walking surface, reflecting the home's connection to the shipping industry and budget constraints. "



4. How has living on the water affected your interaction with neighbors? Is this different from living on land?

"Yes, neighbours are good friends, a real village, who wants to eat with us? community driven, built together, but also comes from water, your freedom ends with my freedom, negotiating with neighbours, not doing and letting what I want"

"Yes, but also because we developed it together, was a vague dream. Taking 5 years to find a place. Different for people who came later perhaps. Because of water, things often go wrong. Leaks, flooding. Broken non-return valve, water came in, house started to sink. Solved with submersible pump."

"Yes, maintain the VVE jetty together, common area further on in the neighbourhood in concrete container, house above that. A semi-detached house would have been fine too, you really have to like each other, share a lot."

5. What advice would you give to other people who are considering living in a floating house?

"You really have to want it, living here has many advantages, pay close attention to children (for safety on the water, so they don't drown), more maintenance, paint every 5 years"

"I would recommend it, make sure you have a number of places where you can add weight, because you don't know the weight distribution in advance, it also changes sometimes. Green roof with a lot of rain much heavier, without rain much less heavy. Floor is always a bit crooked. Sliding doors move/slide in a northwesterly wind."

"Yes, so much more connection with nature, suddenly cormorant with fish in front of the window in between while cooking, fish in its beak, swans. Also do their best with floating gardens, facilitate brooding birds. Agreement with the municipality to maintain the quay, make it pleasant for hedgehogs and animals. More happens here. Also like water sports, kayaking, jump into the water daily (they until October), share a small boat with 10 families"

6. Do you feel a stronger connection to your surroundings, and do you spend more time outdoors?

"Yes, in the water in the morning, lots of children swimming in the summer"

"Yes, more outside. You experience the transitional weather much more. Wind, rain, sun. Nature is closer. More attention for urban nature. Floating jetty came loose during a storm. But not scary at home during storm."

"Yes, we do not plan to leave this place. With the decline of retirement homes, people increasingly have to care for each other. I am thinking of my mother, who lives in Rotterdam, move in here. I often spends time on the roof terrace, especially in the summer, watching boats pass by."

7. Do you have ideas about how the government can make living on the water more attractive?

"Free up space on the water, repeat a district further away, it is not much more expensive, but it does invest time, we live in an individualized society"

"Yes, they should do it, but it should not be at the expense of nature on the water, land already built up, cultivated"

"They should do it, more freedom. Everyone has been able to design their own house, it had to be energy neutral, solar panels, sedum roof, list of building materials. Local sourcing or better to get from Scandinavia? If you let 1 architect design everything, you get a district like in Nijmegen, uniformity. Show your own initiative here. It is also funny, sometimes also a Pippi Longstocking house."

8. Do you feel happier since you live on the water? What do you think is the reason for this?

"I believe so, not dependent on the environment, but sharing with each other really gives happiness in life"

"Yes, house fantastic, happy with my own home. Biggest plus is community, even more than water"

"Yes! Happy with the view, wave to everyone, know everyone, kids from school immediately jump into the water. Fits together. Marketplace for our neighborhood. The community values taking initiative, being open to others, and working together, which fosters a welcoming environment for new neighbors."

Sustainability Framework

The Schoonschip community embodies innovative ecological and social sustainability practices, offering a model for future urban development. One of its standout features is energy efficiency. Each house is equipped with solar panels that generate renewable energy, making the community self-sufficient in energy production. The homes are connected through a smart grid, allowing residents to share surplus energy efficiently, minimizing waste. In addition, the buildings meet high energy performance standards, incorporating features such as excellent insulation, heat recovery systems, and energy-efficient appliances (Greenprint. (n.d.)).

Water sustainability is another core aspect of the project. Schoonschip employs a circular water management system, where water is reused and treated for various applications. Wastewater is processed to recover nutrients and generate biogas, further supporting the community's sustainable ethos. Some homes feature composting toilets, reducing reliance on traditional wastewater systems, while green roofs are common, helping to manage stormwater and providing natural insulation. These solutions create a closed-loop water system that conserves resources and reduces environmental impact.

The construction and design of the homes reflect a commitment to sustainability. The houses are built using eco-friendly, locally sourced materials such as FSC-certified wood and recycled components. Many of the units were prefabricated off-site, minimizing construction waste and on-site disruption. Low-carbon construction techniques were prioritized to ensure the project's long-term environmental benefits. Additionally, the homes are designed to integrate harmoniously with the environment, using floating foundations that have minimal impact on aquatic ecosystems. Floating gardens and surrounding vegetation enhance biodiversity, creating habitats for fish, birds, and insects, and promoting natural water filtration (Greenprint. (n.d.)).

Social sustainability is at the heart of the Schoonschip project. The community is designed to foster interaction and collaboration among residents. Shared resources, such as communal laundry facilities and gardens, reduce individual consumption and encourage cooperation. Beyond being a residential area, Schoonschip is an educational initiative, demonstrating how sustainable living can be achieved in urban settings.

The community also follows a zero-waste approach, emphasizing recycling, composting, and nutrient recovery. Organic waste is processed to produce biogas, which serves as a renewable energy source for the community. By embracing a circular economy, Schoonschip reduces waste and maximizes resource use.

Technological innovation enhances sustainability at Schoonschip. Each house is equipped with smart home technologies, allowing residents to monitor and optimize energy usage. These systems control lighting, heating, and ventilation, ensuring efficient resource use. The integration of digital technologies makes sustainable living not just possible but convenient (Greenprint. (n.d.)).

Finally, Schoonschip demonstrates resilience to climate change through its adaptive design. The floating homes are inherently flood-proof, addressing the challenges posed by rising water levels. The community's energy independence ensures stability even during grid outages, making it a robust solution for a changing climate (Greenprint. (n.d.)).

Therefore, Schoonschip indicates how innovative design, advanced technology, and community collaboration can create a truly sustainable and resilient urban living environment. It serves as an inspiration for future developments, especially in regions grappling with climate change and resource scarcity.

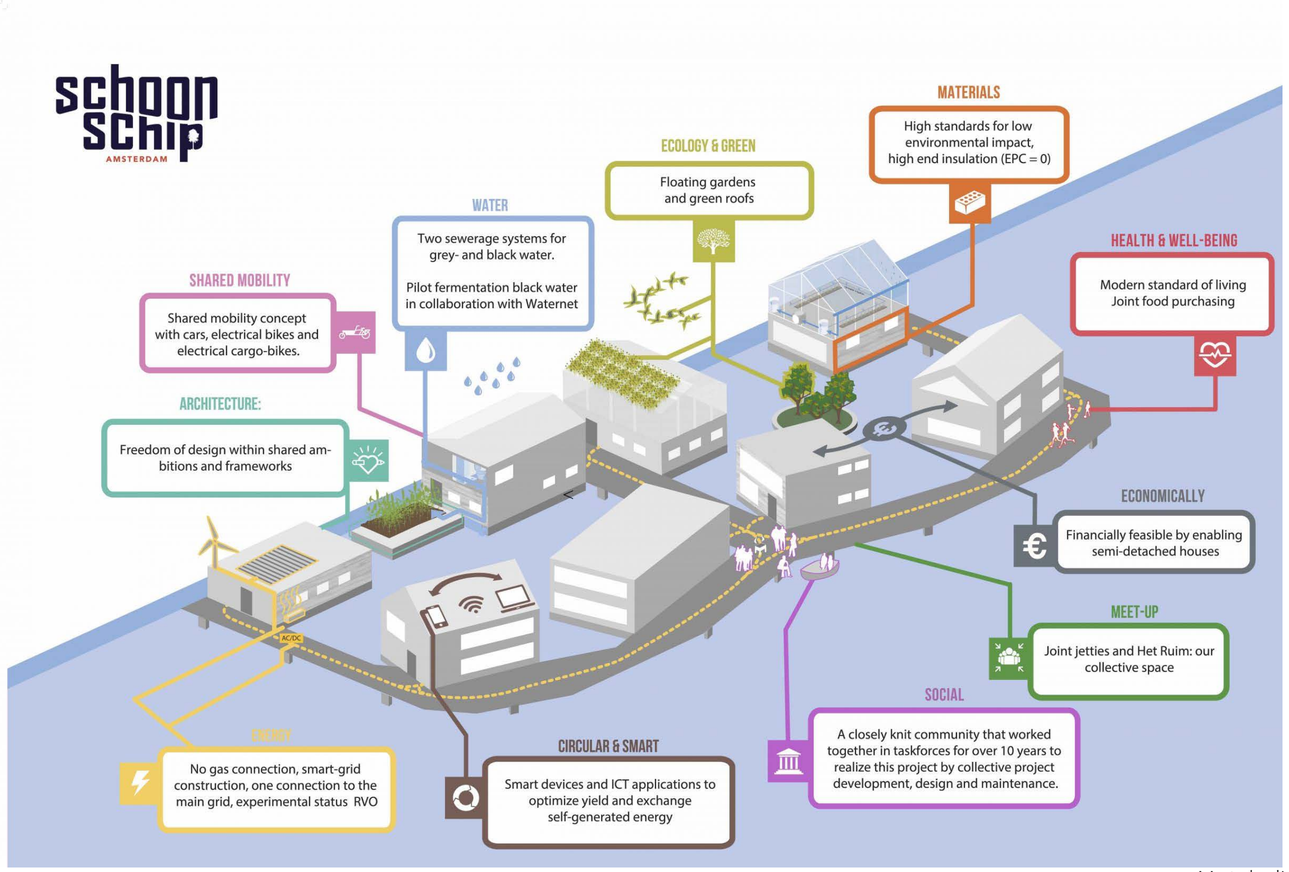


Figure 64. Schoonschip's innovative local solutions and sustainable practices (Metabolic 2015)

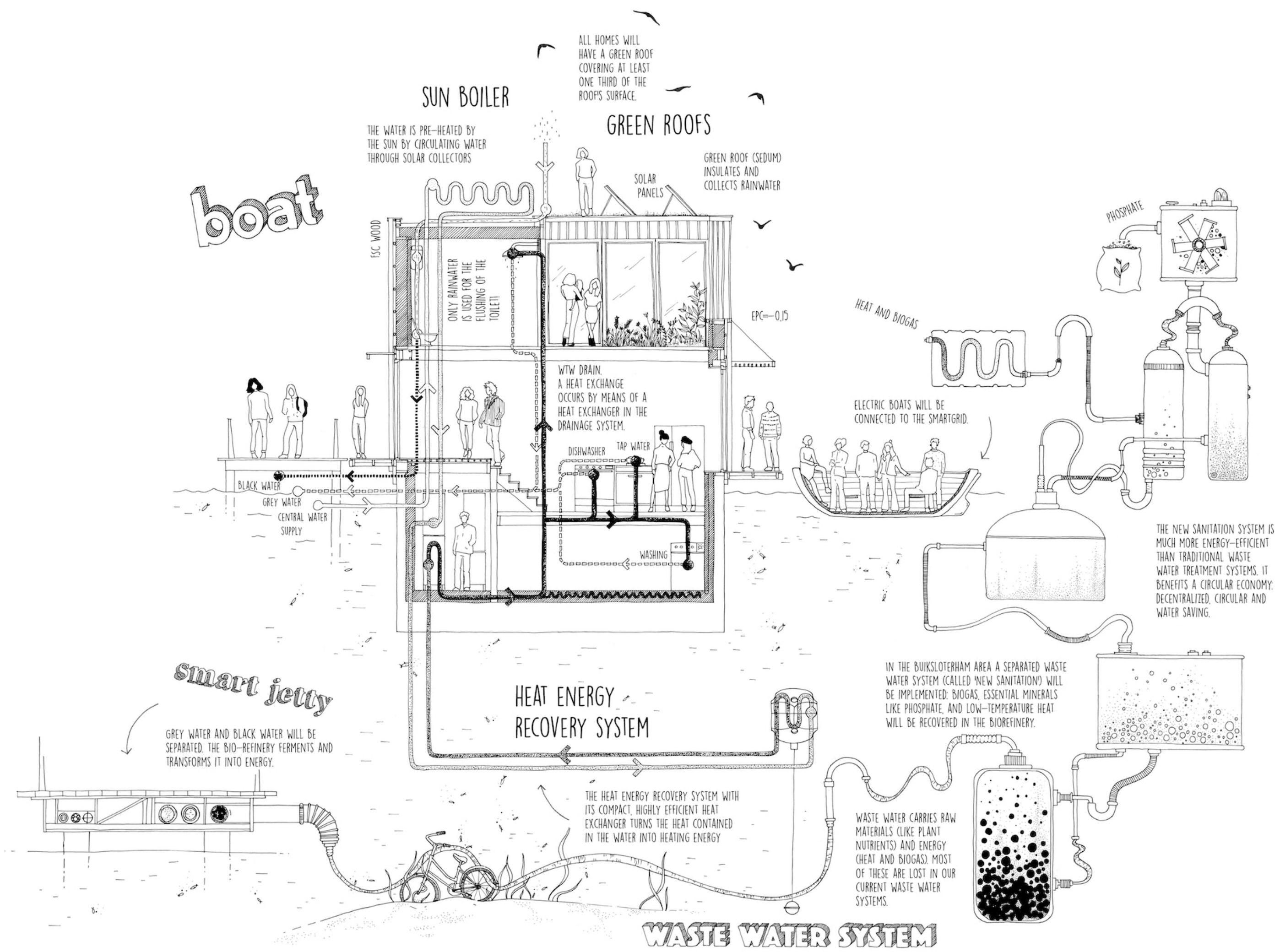


Figure 65. Schoonschip's innovative local solutions and sustainable practices (Space&Matter. (n.d.)

Spatial Configuration

The neighborhood is designed as a linear floating community, consisting of 30 houses organized along the canal. This layout ensures optimal use of the water space, providing each home with direct access to the canal while maximizing exposure to sunlight and scenic views. The linear arrangement also supports passive solar design, reducing energy needs by taking advantage of natural light and heat.

In terms of spatial organization, the project balances public and private areas effectively. While each house features private decks or terraces extending onto the water, these are complemented by shared spaces, such as floating gardens, communal jetties, and a community dock. These shared areas promote social interaction while fostering a sense of community among residents. The floating jetties not only provide access to the homes but also function as pedestrian-friendly walkways, further encouraging informal social connections and car-free living (Greenprint. (n.d.).

The integration of the community with its aquatic environment is a defining feature. Each house is built on a floating foundation anchored to the canal bed, allowing it to adapt to fluctuating water levels, which is essential in the context of climate change and rising sea levels. Surrounding the homes are floating gardens and green zones, which enhance biodiversity by creating habitats for aquatic life, birds, and insects. These natural buffers also contribute to water purification and flood management, making the project a sustainable addition to the urban ecosystem (Greenprint. (n.d.).

The dwellings themselves exhibit a high degree of customization and adaptability. While each home is uniquely designed to meet the needs of its residents, all adhere to the collective principles of sustainability. The houses are compact and vertical, often spanning two to three stories, with open-plan interiors that maximize functionality within a small footprint. Living areas are typically located on upper levels to take advantage of natural light and views, while bedrooms and utility spaces occupy lower levels. Large windows and skylights enhance natural lighting, creating a sense of spaciousness within the compact homes (Greenprint. (n.d.).

Outdoor spaces are an integral part of the dwelling design. Private terraces extend the indoor living areas onto the water, allowing residents to engage with their surroundings. These terraces are often used for gardening, relaxation, or as a social space, fostering a strong connection between the inhabitants and the aquatic environment. Sustainable materials, such as FSC-certified wood and recycled components, were used extensively in construction, ensuring low environmental impact. The modular design of the homes also allows for future adaptability, enabling them to evolve alongside changing resident needs or advancements in technology (Greenprint. (n.d.).

The spatial planning emphasizes community living while maintaining environmental harmony. Shared amenities, such as laundry facilities and communal green spaces, reduce resource consumption and encourage collaboration among residents. Furthermore, the participatory design process involved future residents in planning and decision-making, ensuring that the community reflected their shared values and aspirations. This collaborative approach not only strengthened the social fabric but also led to a design that balances individual privacy with collective well-being. Schoonschip demonstrates resilience and adaptability in its design. The floating homes are inherently flood-proof and prepared for rising water levels, making the community a model for climate-adaptive housing.

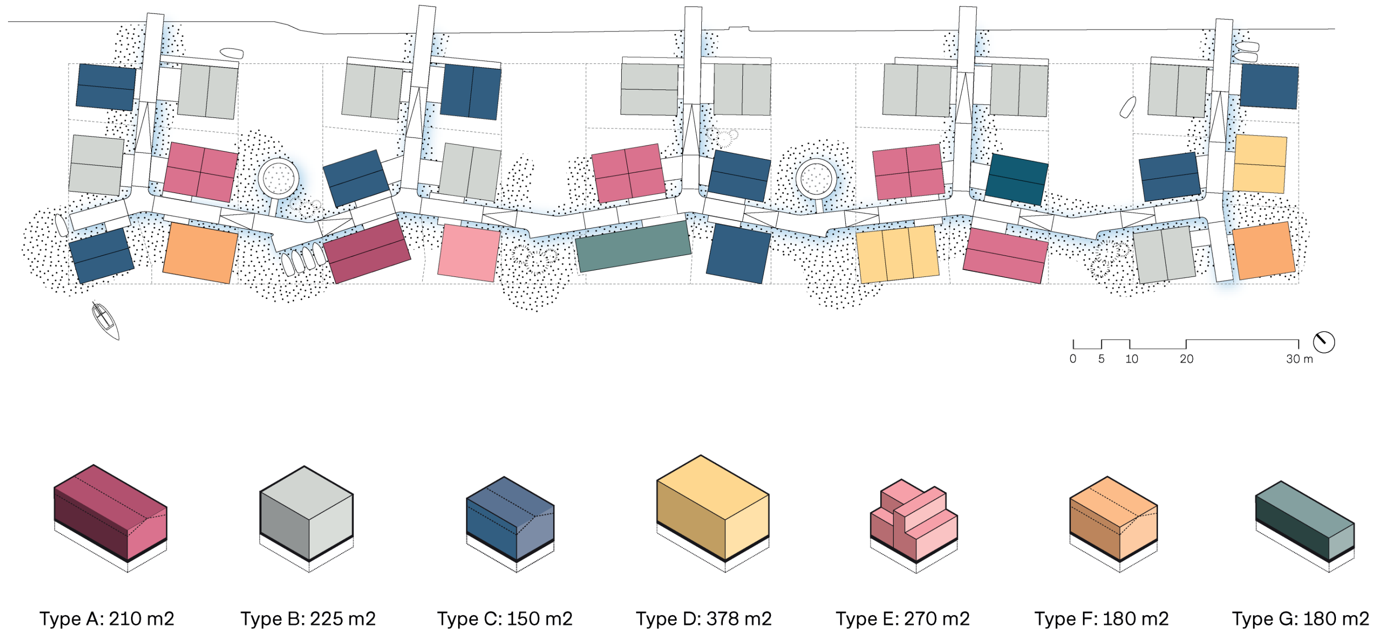


Figure 66. Schoonschip's different hosing typologies with their positions and sizes (Space&Matter. (n.d.)

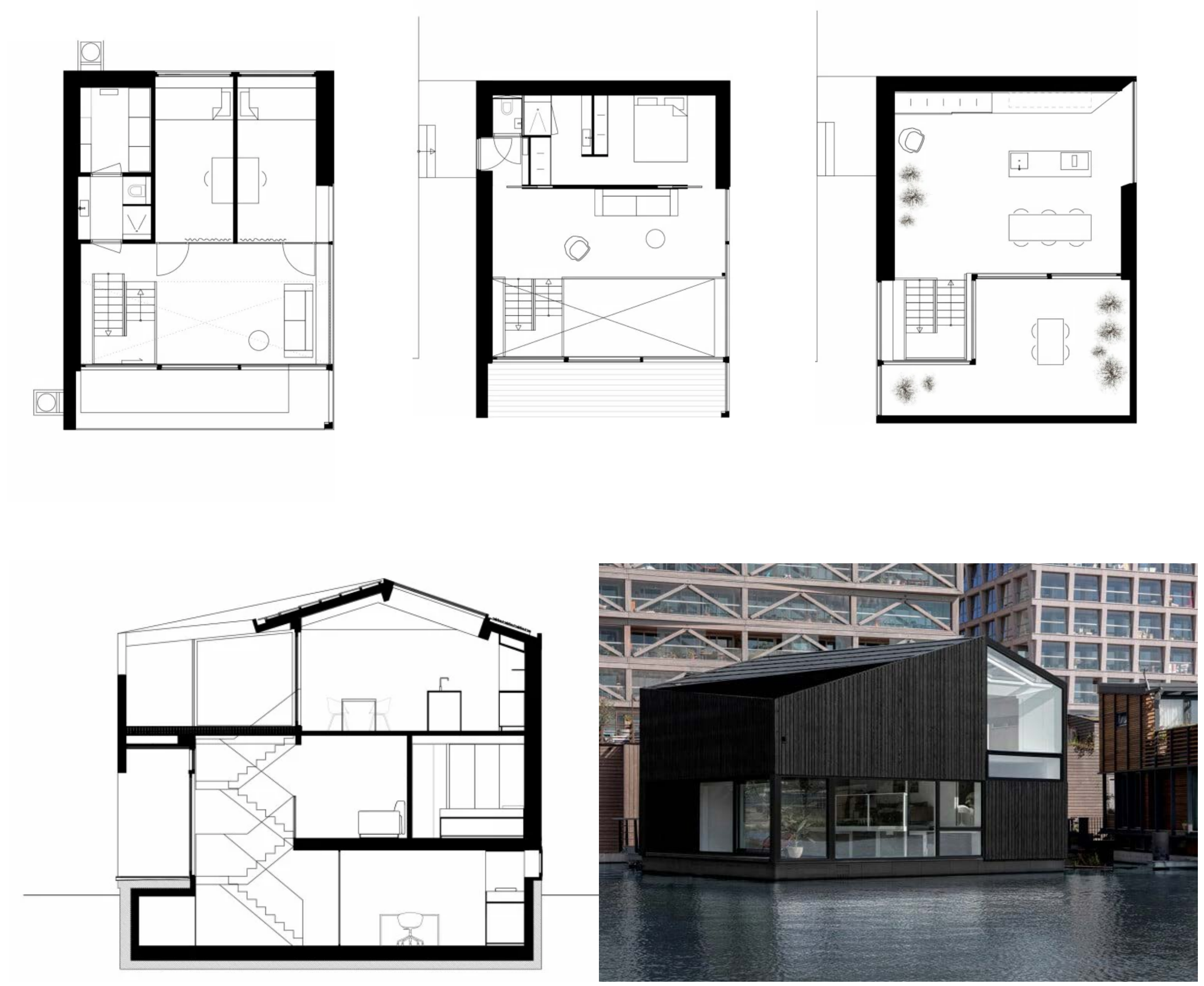


Figure 67. Design of one of the homes in Schoonschip by i29 with open and closed terraces(Baunetz. (n.d.)

CASE STUDY COMPARISON

PHASE 1	SCHOONSCHIP, AMSTERDAM	IJBURG WATERBUURT, AMSTERDAM
Scale	45 Households, 30 water plots	100+ floating homes
Development Model	Bottom-up community-led initiative	Top down, municipality-driven urban expansion
Core Vision	Experimental energy-positive self-organized community	Mainstream urban extension , exploring living on water at scale
Flood Resilience Strategy	Floating platforms, adaptive anchoring, decentralized infrastructure	Amphibious and floating units with secure mooring
Community Design	Strong emphasis on co-living, shared systems, communal decision-making	Individual housing plots, less focus on collective governance
Infrastructure	Circular systems: greywater reuse, solar panels, bio-waste management	Standard Utilities: with integration of water-level responsiveness
Affordability focus	Mixed- cost-intensive due to custom designs and systems innovation	More standardized and scalable designed for middle-income residents
Architectural Diversity	High: each floating house is uniquely designed	Moderate: design coherence maintained with some variation
Social Resilience	Very high: collective energy/ grid, water management, shared ownership	Moderate: residents share proximity, but limited formal collectively
Limitations	High cost, niche scalability, complex coordination	Risk of limited social cohesion, reliant on city utilities

Figure 68. Case study comparison (Authors own diagram)

"How to realize affordable housing types without losing essential qualities on water?"

- *Modular construction techniques allow scalability and cost control without compromising quality.*
- *Amphibious and floating housing models adapt to water levels while remaining simple in form and accessible in cost.*
- *Shared infrastructure (energy, water, waste) reduces individual costs and supports collective living.*
- *Compact design strategies preserve essential spatial qualities while keeping footprints and budgets small.*
- *Local materials and prefabrication lower construction costs and environmental impact.*
- *Case studies like Schoonschip and IJburg demonstrate how high-quality design can coexist with affordability through community-driven processes.*
- *Designing for flexibility and incremental growth allows homes to evolve with user needs and budgets over time.*
- *Emphasis on shared public spaces ensures spatial richness even in lower-cost units.*
- *Nature-based solutions (wetlands, retention basins) are integrated into housing layouts to manage water affordably and sustainably.*
- *Affordability is achieved through co-living models, community participation, and low-maintenance, resilient design.*

The chapter re-defining dwelling aims to learn from the present to provide a window into the future. By looking at current developments with water, a deeper understanding of ambitions and consequences during periods of crisis is developed. Therefore, a selection of case studies have been analyzed to understand how realized and proven examples can inspire new ways of dwelling in the decades to come, dealing with transformation, affordability, urban planning, social inclusion and spatial configurations for decent living qualities.

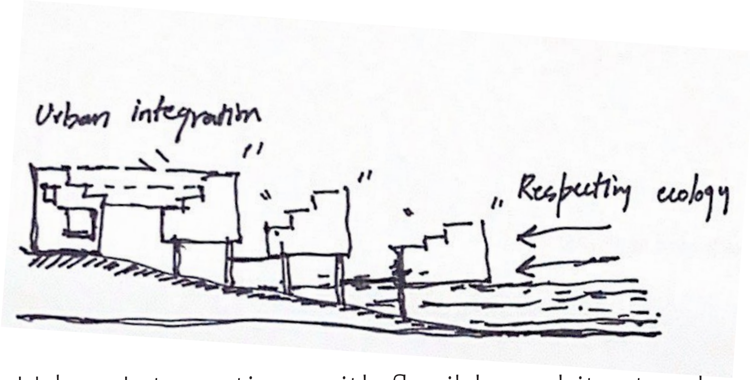
Both IJburg and Schoonschip employ materials specifically chosen for resilience in aquatic environments. The floating structures are primarily built on buoyant foundations, such as concrete pontoons, which ensure stability and durability. IJburg's floating houses utilize lightweight, water-resistant materials like cross-laminated timber (CLT) and sustainably sourced wood for superstructures, reducing the overall environmental footprint. Similarly, Schoonschip incorporates recycled and eco-friendly materials, aligning with circular economy principles.

Spatial planning in these projects reflects a keen understanding of the need for adaptability and functional living in limited space. The dwellings in both IJburg and Schoonschip emphasize vertical spatial organization, with multilevel layouts optimizing the use of the limited footprint. Open-plan designs with large windows and decks connect the residents with the surrounding water, fostering a sense of harmony with the environment. In Schoonschip, modular layouts allow for customization and potential expansion, providing a flexible solution for changing family needs or community requirements. These strategies highlight the importance of designing adaptable and compact living spaces in flood-resilient housing.

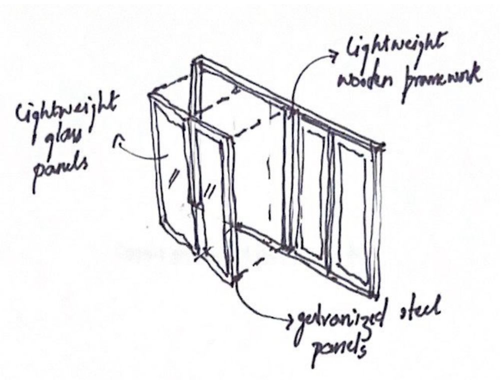
The urban planning strategies in IJburg and Schoonschip illustrate how floating housing developments can integrate into urban frameworks while retaining ecological sensitivity. IJburg features a grid-like layout with floating homes connected by piers and pedestrian pathways, enabling a sense of urban continuity. Schoonschip adopts a more organic arrangement, with homes clustered around shared spaces, fostering a village-like atmosphere. Both projects emphasize integration with renewable energy infrastructure—Schoonschip is entirely energy self-sufficient, utilizing solar panels, heat pumps, and smart energy-sharing systems among residents.

A key finding from the projects is the transformative power of community-driven living. Schoonschip, in particular, exemplifies the strength of collective action, with residents collaborating in the planning, financing, and management of the project. This participatory approach has cultivated a strong sense of ownership and shared responsibility among residents, promoting sustainable practices and mutual support. Residents in both projects have adapted to unique lifestyles that align with the principles of water-based living. Daily life includes increased interaction with water, from transportation by boats to recreational activities like swimming and fishing. These interactions enhance residents' connection to nature and awareness of environmental issues. However, challenges such as maintenance demands, dependency on advanced technologies, and potential social disparities must be critically addressed.

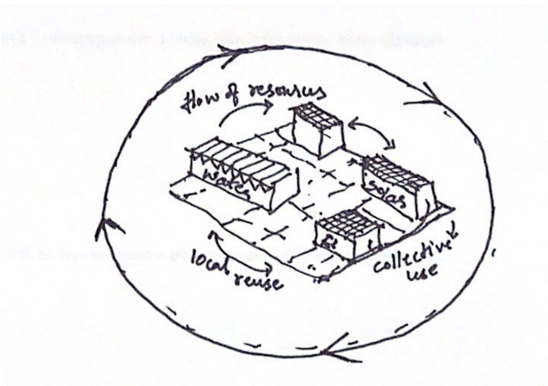
While these case studies illustrate innovative strategies for flood-resilient housing, they also reveal challenges and limitations. The reliance on high-tech solutions and specialized materials may pose accessibility issues for low-income communities or regions with limited resources. Furthermore, long-term ecological impacts, such as potential disturbances to aquatic ecosystems, require ongoing assessment. These insights suggest that future designs must prioritize scalability, affordability, and environmental monitoring to ensure broad applicability and sustainability. In conclusion, these projects offer a blueprint for addressing the dual challenges of environmental sustainability and community well-being in flood-prone regions.



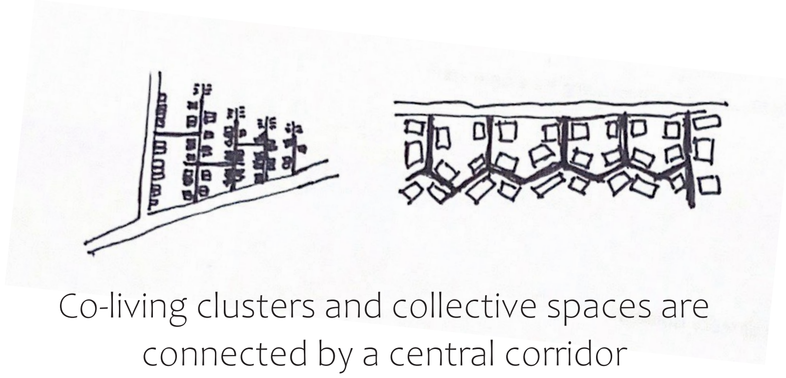
Urban Integration: with flexible architectural approach that respects natural landscape to blend with water environment



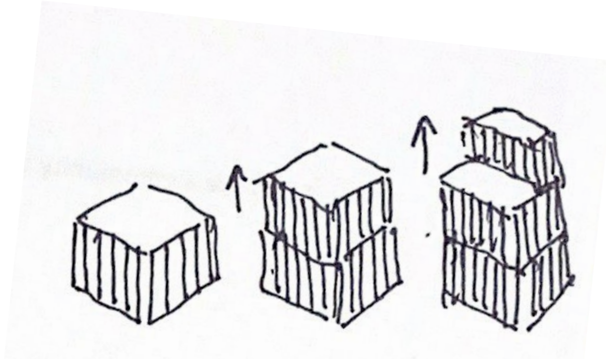
Lightweight materials with simpler installation and optimal structural flexibility



Sustainability at the core with water management, energy efficiency and resource optimization



Co-living clusters and collective spaces are connected by a central corridor



Scalability and accessibility of resources using standardized, cost effective techniques

Community participation with policy and collaboration framework of residents

Figure 69. Strategies (Authors own diagram)

05.RE-DEFINING DWELLING

"What are the main principles and strategies of flood resilient community planning ?"

Figure 72. Below Sea level farming communities, Kuttanad Kerala, India(KuttaNad Systems ,n.d.)

COMMUNITY RESILIENCE

Community resilience is the ability of a community to resist, absorb, accommodate, and recover from the effects of a hazard in a timely and efficient manner (Chowdhooree & Islam, 2018). By contrast, community vulnerability exists where the community is susceptible to the adverse effects of a hazard (United Nations International Strategy for Disaster Reduction, 2009). Geis (2000) proposes that a resilient community is "the safest possible community that we have the knowledge to design and build in a natural hazard context" (152) through minimising its vulnerabilities.

Schelfaut et al. (2011) argue that enhanced resilience hinges on community perceptions of risk and resilience. Individual lived experiences provide contexts for generating perceptions of change in and of the environment (Casey, 2009). Interactions of potential mitigation measures provide a context to perceive community resilience. As in the case of the agricultural community of Kuttanad Kerala,which has long embraced a way of life deeply connected to water (Fig.72). Located in a low-lying polder landscape, the community adapted to seasonal flooding through traditional farming techniques and an intimate understanding of water management. Their settlements, often organized along dikes and canals, reflect a deep-rooted coexistence with the natural rhythms of the land (Kuttanad Systems, n.d.). This way of living demonstrates that adapting to nature—rather than resisting it—is both possible and sustainable. The resilience and harmony found in this community offer a powerful reference for this research, reinforcing the idea that living with water can foster environmental balance, cultural continuity, and a more adaptive built environment.

Rising sea levels, extreme weather events, and changing precipitation patterns necessitate innovative architectural responses. Structural mitigation measures, like any change in the built environment, denote development and ideally, development intends to make a change: not just any change, but a definite improvement, a change for the better (Slim, 1995). Cannon and Muller-Mahn (2010) link development and adaptation, migrating earlier theories into the sphere of disaster management. Adaptation, or the process of enhancing resilience, is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, helping to lessen adverse impacts of climatic stimuli (United Nations International Strategy for Disaster Reduction, 2009).

Cannon and Muller-Mahn (2010) classify adaptation as either responsive or anticipatory. Responsive adaptation is spontaneous and generally addresses everyday challenges, while anticipatory adaptation tackles higher risk scenarios involving greater uncertainty (Cannon & Muller-Mahn, 2010). Structural mitigation measures are classified as anticipatory, and although recommendations for such measures are grounded in external experts or funders' understanding of risk, they do not eradicate uncertainty. The success of adaptation measures is never guaranteed. Such measures can be seen as adaptive answers to problems especially as there are inherent uncertainties in innovations (Cannon & Muller-Mahn, 2010). This is potentially troubling for communities, as they may expect technology to be more reliable than traditional methods in reducing vulnerabilities.

Global examples of flood-resilient architecture provide valuable insights for designing solutions that respect ecological systems while safeguarding human life and livelihoods (Thieken et al., 2014; Chowdhooree et al., 2018; Lopez-Marrero & Tschakert, 2011). This perspective advocates for reimagining of architecture as a tool for fostering harmony between humanity and nature. To investigate how flood resilient architecture could be developed into ecologically sustainable and resilient neighborhoods, a selection of case studies are developed. Through analyzing the strategies, methods and outcomes of developments around the world, a better understanding is established of the strategies that can be applied when designing urban wetlands into resilient communities.

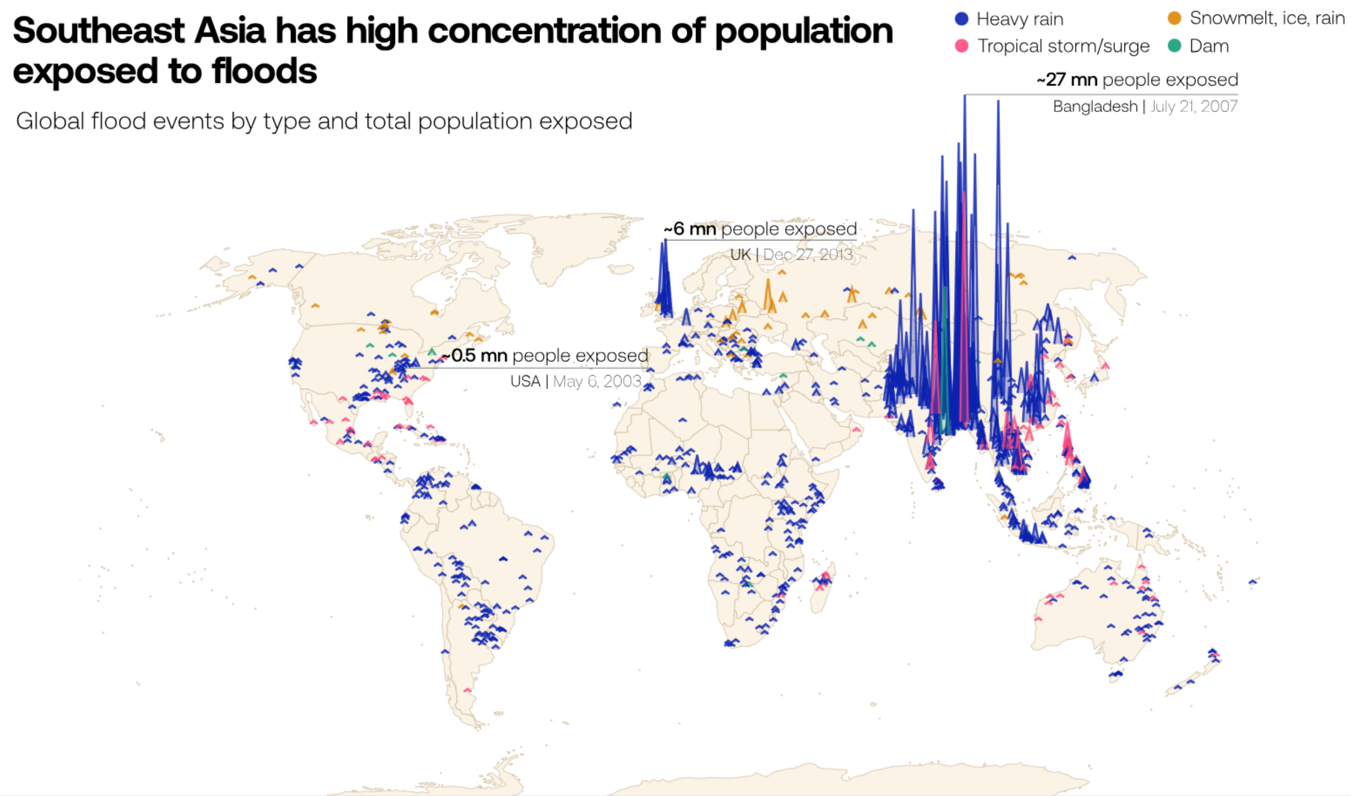


Figure 71. Global events by type and total populations exposed (Global Flood Dataabase, n.d.)

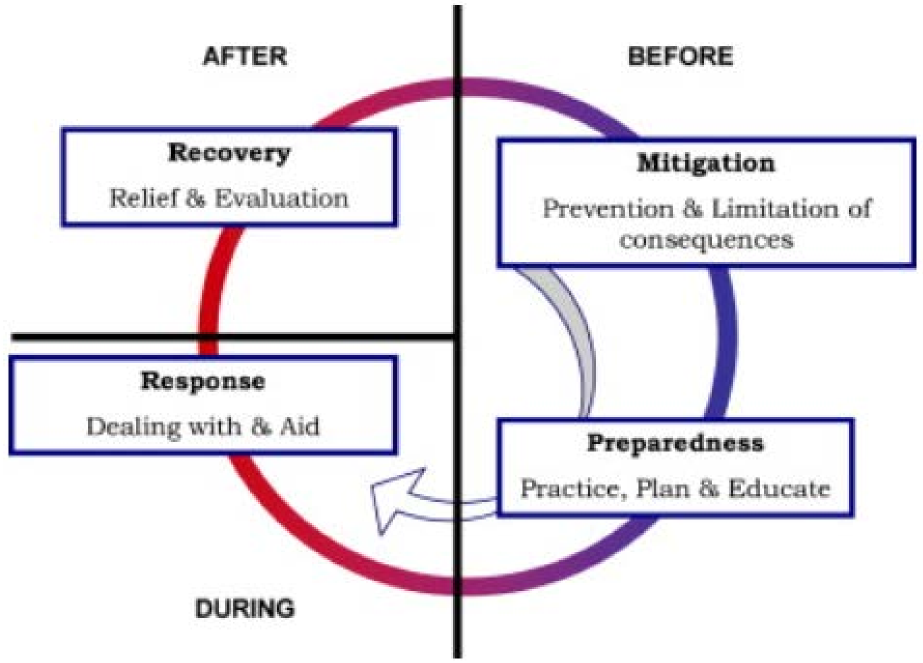


Figure 72. Resilient communities have an improved capacity in each of the phases of flood management cycle (Schelfaut et al. ,2011)

THE HANGING VILLAGE, KALABOGI

Kalabogi Village, located near the Sundarbans in Bangladesh, is a striking example of human resilience against climate change. The village has faced escalating challenges, including land erosion, salinity intrusion, and devastating cyclones like Aila in 2009. These disasters have reshaped the community's living environment and forced residents to adopt innovative solutions, such as building elevated homes known as "hanging houses" (Report,2022).

In response to frequent flooding and rising sea levels, the houses in Kalabogi are constructed on bamboo stilts, lifting them above ground level. This stilt-based architecture is both practical and economical, relying on locally available materials like bamboo and timber. The lightweight structure enables quick assembly and repair, making it an accessible solution for low-income families.

The elevated design protects the homes from tidal surges and minimizes the risk of property loss during heavy rains or cyclones. Open spaces beneath the houses allow water to flow freely, reducing pressure on the structures during floods. However, the reliance on bamboo, while cost-effective, limits durability, as the material is vulnerable to rot and pests (Report,2022).

Despite its ingenuity, Kalabogi's architecture reflects the ongoing struggle to balance immediate needs with long-term resilience. The village faces severe salinity issues, which affect both drinking water and agricultural productivity. These challenges exacerbate poverty and health risks, particularly for women, who experience higher rates of complications during pregnancy due to saline water exposure (Report,2022).

To enhance the architectural response, integrating modern materials like treated bamboo or steel could improve the durability of stilted homes without compromising affordability. Additionally, incorporating rainwater harvesting systems and water desalination technologies would address the critical issue of clean water access, aligning with environmental sustainability and community well-being.

Kalabogi Village serves as a critical precedent in this research as its stilted architecture demonstrates how traditional, low-cost solutions can adapt to the realities of climate change. However, it also highlights the need for interventions that combine local knowledge with innovative technologies to ensure sustainability and improved living conditions.

Figure 73. The 'Hanging Village' of Kalabogi, near Sundarbans demonstrates critical need for adaptive solutions (Report, 2022)

Figure 74. The 'Hanging Village' of Kalabogi (Report, 2022)

STILT HOUSES, ASSAM INDIA

In the flood-prone regions of Assam, India, traditional stilt houses, known locally as Chang Ghars, provide an exemplary model of indigenous, flood-resilient architecture. These houses, primarily used by the Mising community, are elevated on bamboo or wooden stilts, allowing floodwaters to pass beneath without damaging the main structure. The stilts are strategically placed and can be adapted in height based on the highest recorded flood levels, making them highly resilient to annual flooding in the Brahmaputra River basin.

Chang Ghars are constructed with locally available materials like bamboo, cane, and thatch, ensuring affordability and accessibility. Bamboo stilts are sometimes waterproofed or reinforced with rubberized coatings for durability against water and rot. The structures employ indigenous joinery techniques, using natural binding materials like rattan, to enhance flexibility and withstand lateral forces during floods and earthquakes. Some modern adaptations include using concrete stilts for additional stability (Krishna, 2023).

These houses feature open basements where livestock can be sheltered and essentials stored during floods. This area also doubles as a workspace for weaving or other activities during the dry season. The houses often have semi-open verandahs for social interaction and traditional practices like basket weaving. Access to the house is via a raised ladder, called Jokhola, which holds cultural significance in community ceremonies (Krishna, 2023).

In response to increasingly severe flooding, community-driven innovations have introduced flexible designs allowing homeowners to adjust floor heights. These new Chang Ghars, designed collaboratively by local artisans and organizations like SEEDS, include reinforced bamboo stilts and cross-bracing to improve stability and longevity (Krishna, 2023).

The Chang Ghars demonstrate how traditional knowledge can effectively address modern challenges. By integrating locally sourced materials and community participation, these structures balance sustainability, resilience, and cultural relevance. Their ability to withstand recurring floods highlights their potential as a blueprint for adaptive housing in other flood-prone regions, aligning with the research focus on combining environmental sustainability with community well-being

Figure 75. Chang Ghar from Assam India, standing on wooden stilts being accessed by a ladder. (Krishna, 2023)

Figure 76. Chang Ghar during floods (Krishna, 2023)

AMPHIBIOUS HOUSES, MEKONG DELTA, VIETNAM

The Mekong Delta in Vietnam, home to 17 million people, is one of the world's most vulnerable regions to climate change. Seasonal flooding, exacerbated by rising sea levels and unpredictable weather patterns, poses a significant challenge to local communities, many of whom depend on agriculture and aquaculture for their livelihoods. Traditional stilt housing, a vernacular response to flooding, is increasingly inadequate as floods become more severe and frequent (Vietnam n.d.).

Design and Construction Techniques
Amphibious housing in the Mekong Delta represents a hybrid approach that adapts to the dynamic flooding conditions rather than resisting them. These homes are built with buoyant foundations that allow the structures to float during floods and rest on the ground when the waters recede. Key elements of this system include Buoyancy Blocks that provide the flotation needed to lift the house during floods. Vertical Guidance Posts are anchored firmly into the ground, these posts guide the house's vertical movement and prevent lateral displacement during floods. Structural Frames are integrate the buoyant foundations with the existing house, ensuring stability and resilience. This technology is designed to be cost-effective and relies on locally available materials, making it accessible to low-income communities. Local carpenters are trained to implement these retrofits, fostering a community-driven, bottom-up approach to climate adaptation. (Vietnam n.d.).

Implementation and Community Impact
In projects spearheaded by the Buoyant Foundation Project and local collaborators, houses in the An Giang and Long An provinces have been retrofitted with amphibious foundations. These prototypes have demonstrated their effectiveness during seasonal monsoons, keeping homes and belongings safe while minimizing displacement. Residents have reported high satisfaction with the design, which preserves their connection to their land and livelihood (Vietnam n.d.).

The Mekong Delta's amphibious housing highlights how passive adaptation techniques can mitigate the impact of floods, reduce reconstruction costs, and foster long-term community resilience. The use of floating foundations addresses immediate needs while allowing for scalability, making it a replicable solution for similar environments globally.

This case underscores the importance of designing for environmental sustainability and community well-being, harmonizing with natural cycles rather than imposing rigid interventions. As a precedent, it demonstrates how innovative housing solutions can provide stability and continuity for vulnerable populations while adapting to evolving climate conditions

Figure 77. Stilt homes in Vietnam Mekong Delta converted to Amphibious homes with local materials (Vietnam n.d.)

Figure 78. Retrofitted Amphibious homes during floods in the Mekong Delta (Vietnam n.d.)

AMPHIBIOUS HOUSE ON RIVER THAMES, UK

The Amphibious House in England, designed by Baca Architects, represents a groundbreaking solution for flood-resilient living in the UK. Located in Buckinghamshire along the River Thames, this home integrates advanced engineering with environmental considerations to adapt to its flood-prone site. The house is designed as a floating structure within a wet dock. The base consists of a concrete hull, providing buoyancy and stability, while a lightweight timber-framed superstructure houses the living spaces. This innovative construction allows the house to rise with floodwaters, tethered securely to four vertical guideposts known as “dolphins.” These posts ensure the house remains level during floods, even as it floats (Baca Architects, 2015).

The home is engineered to handle water levels rising up to 2.5 meters, exceeding predictions for the area. When not flooded, the house rests on the ground like a conventional building. The wet dock doubles as a protective barrier, preventing damage from debris during floods (Baca Architects, 2015).

The system consists of two foundations, one static foundation in the ground and one dynamic floating foundation of the house. The floating foundation can be seen as a concrete box, of which the space is used as living space. This also lowers the center of gravity, because the rest of the building is made of timber, which is more lightweight than concrete. The depth of the building in floating condition is 2,3 meters. Above this height there are situated windows, to get light into the basement. For fixation, four mooring posts are integrated into the building’s design (Baca Architects, 2015).

In addition to its amphibious capabilities, the house incorporates sustainable technologies like High-performance insulation and double glazing reduce energy consumption. A heat recovery ventilation system and external blinds enhance climate control. Solar panels contribute to renewable energy use. A landscaped garden functions as a flood warning system, with terraced levels indicating rising water(Baca Architects, 2015).

This project demonstrates how amphibious architecture can address flood resilience without sacrificing environmental and community integration. It aligns with the research focus on sustainable housing in flood-prone regions by combining adaptive construction methods with low-energy design. The house exemplifies how innovative engineering can coexist with natural water systems to mitigate flood risks.

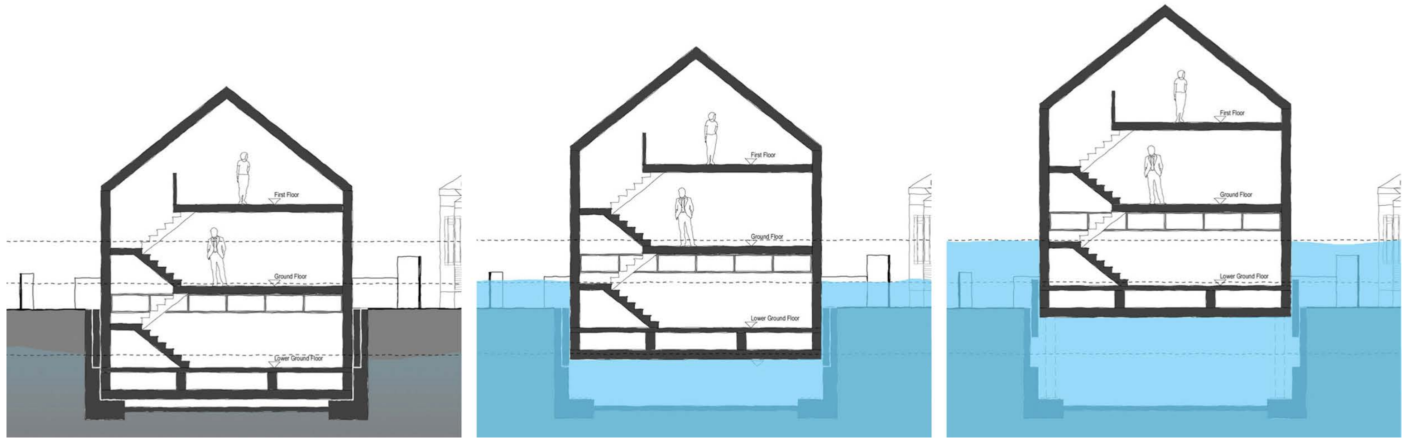


Figure 79. Rising of the house during a flooding event (Baca Architects, 2015)

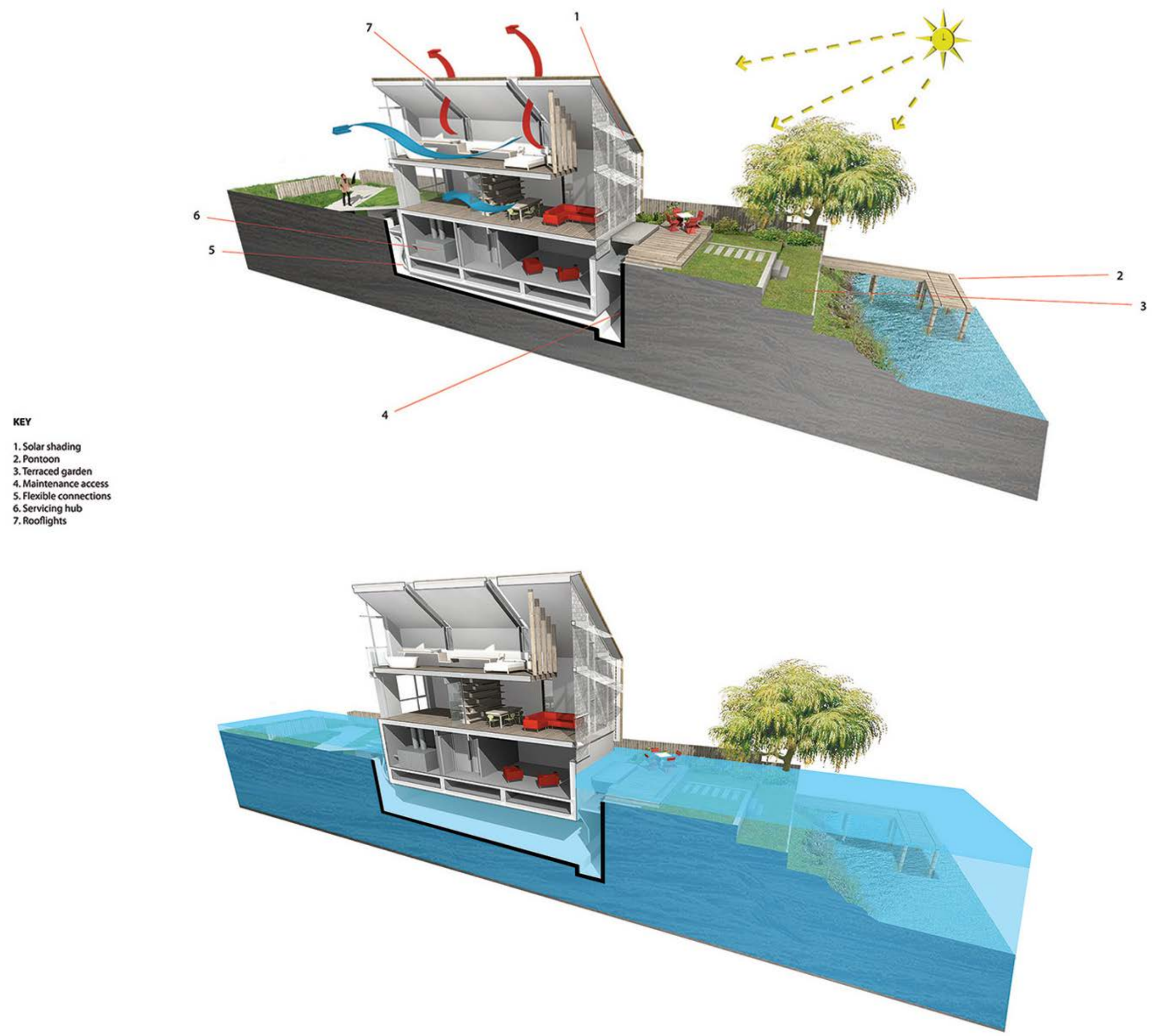


Figure 80. Key elements of the house that make it climate adaptive and flood resilient along with sustainable features (Baca Architects, 2015)

PONTOON CONSTRUCTION , AUSTRALIA

The pontoon construction in Brisbane, Australia, designed by James Davidson Architects, exemplifies flood-resilient architecture tailored for flood-prone regions. Brisbane, located in Queensland, experiences subtropical weather conditions with heavy seasonal rainfall. The Brisbane River and its tributaries make the area highly susceptible to riverine flooding. Extreme weather events, such as cyclones and intense rainfall, often lead to flash floods and prolonged inundation of urban and suburban areas. These challenges prompted innovative architectural interventions like the pontoon construction, which prioritizes adaptability and sustainability in flood-prone environments (JDA,n.d.).

The design features of the pontoon construction focus on mitigating the risks of flooding while maintaining functionality. The most notable element is the use of floating structures. These buildings are designed to rest on floating platforms tethered to vertical pylons, enabling them to rise and fall with changing water levels. This ensures stability and usability even during severe floods. Lightweight materials, such as hollow-core concrete and timber, are incorporated into the design to enhance buoyancy and structural efficiency. Additionally, the modular nature of the design allows flexibility, making it adaptable for various housing needs and ensuring scalability for future applications. Green spaces, including green roofs and vertical gardens, are seamlessly integrated into the design, improving thermal performance, enhancing biodiversity, and fostering a stronger connection between the residents and their natural environment (JDA,n.d.).

The construction techniques employed in this project demonstrate innovation and resilience. Floating foundations are made using reinforced concrete pontoons with foam cores, which provide durability and buoyancy while minimizing maintenance. Resilient anchorage systems, using steel guideposts, allow vertical movement of the structures in response to water-level changes, ensuring they remain secured in place without drifting. Prefabrication plays a crucial role, as the modular units are constructed off-site to reduce environmental impact and accelerate the building process. The materials used, such as treated timber, corrosion-resistant steel, and waterproof finishes, are carefully selected to withstand prolonged water exposure and the harsh conditions of flooding events(JDA,n.d.).

The pontoon construction by James Davidson Architects not only addresses the immediate challenges posed by flooding but also serves as a sustainable model for community-centric architectural design. By embracing the natural conditions of flood-prone areas rather than resisting them, the project minimizes economic losses, enhances community resilience, and promotes a harmonious coexistence between humans and their environment.

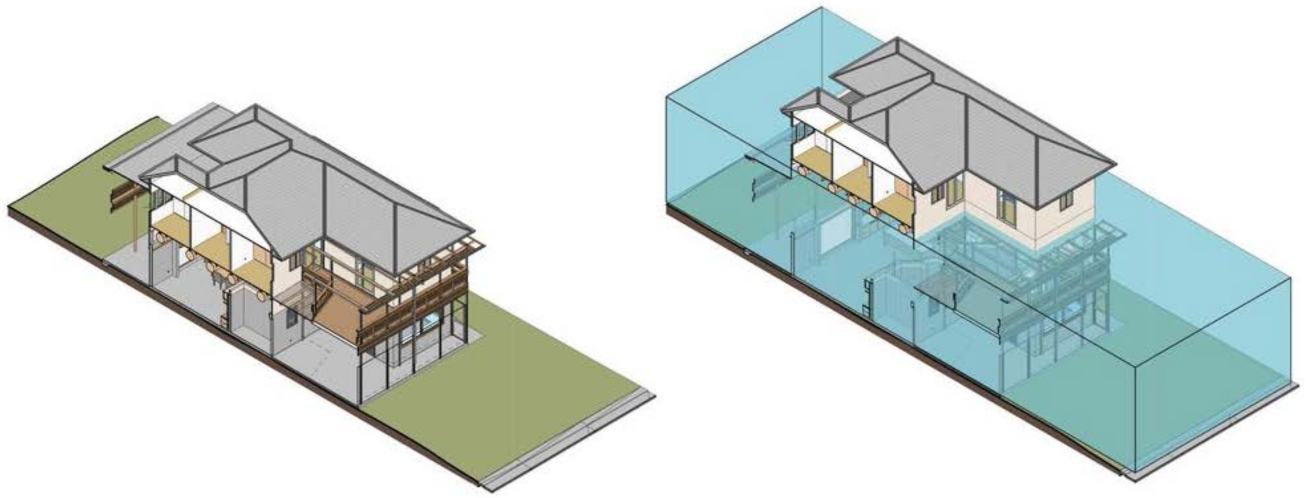


Figure 81. Cross Section showing how the Queenslander house floats using the pontoons (JDA, 2011)

Figure 82. Illustration Showing how the Pontoon device lifts the first floor above (JDA, 2011)

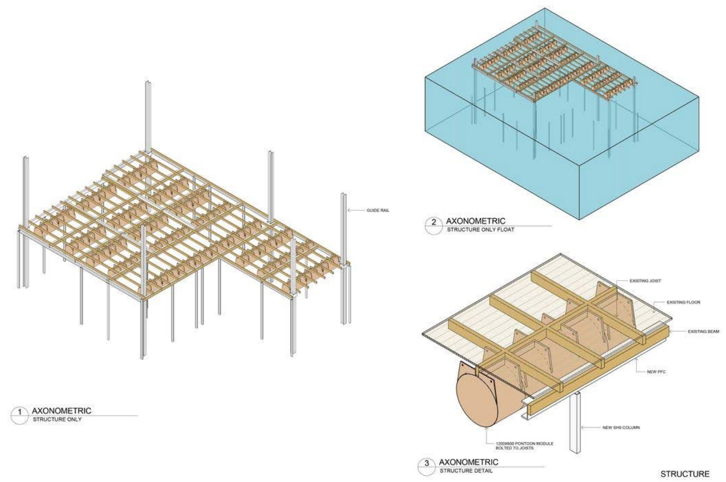


Figure 83. Diagram showcasing the Pontoon devices and their placement (JDA, 2011)

What do the experts think on the idea of living with water?

As the Netherlands grapples with the growing impact of climate change, experts from both local and global contexts are calling for a fundamental shift in how we conceive of living with water. Through conversations with professionals deeply involved in water-resilient design, a clearer picture emerges of both the opportunities and complexities that come with this approach.

In a meeting with Researcher Isabel Recubenis Sanchis (2024), the physical realities of the Dutch landscape were laid bare. The flat terrain, combined with the naturally shifting deltas and rivers, creates an environment where water is constantly on the move, eroding land and carving new paths. Over time, human efforts to dry and control this land—particularly in peat-rich areas—have led to land subsidence, making the region even more vulnerable to flooding. Isabel explained that the long-standing tradition of resisting water is no longer viable. Instead, a shift is underway, encouraging architects and planners to explore strategies that embrace water. This includes designing floating structures and using materials resilient to intermittent submersion—especially in ground-floor zones—as practical responses to a changing climate.

When speaking with renowned Bangladeshi architect Marina Tabassum (2024), she emphasized that in her context, living with water is not a novel idea but a deeply rooted necessity. Bangladesh's geography demands it. However, she was quick to point out that applying similar strategies in the Netherlands requires a nuanced understanding of the local conditions. According to her, this means identifying the types of water bodies at play, the stakeholders involved, the nature of the communities intended to inhabit such developments, available material resources, and the long-term trajectory of the built environment. She underscored that while low-cost, adaptive housing has been effective in Bangladesh, the solutions in the Netherlands will need to respond to different socio-economic, environmental, and infrastructural frameworks. Her insights reinforce the importance of site-specific adaptation and the need for design to be rooted in ecological, cultural, and material realities.

From a research and innovation standpoint, Barbara Dal Bo Zanon (2024), currently working on the Floating Future project in the Netherlands, highlighted one of the most pressing challenges of water-based living: scalability. While individual or small-scale floating homes have been successfully implemented, scaling these concepts to meet broader urban housing demands remains difficult. The unique relationship between water and the built environment introduces a level of complexity that makes replication slow and costly. According to Barbara, this hinders the ability of such housing models to respond to issues of urban growth, which are central to preparing for future climate-related pressures. Her work seeks to bridge the gap between innovation and practicality, exploring how floating architecture can be integrated more effectively into urban systems.

Together, these interviews present a layered understanding of what it means to design for life with water. While the Dutch context demands new approaches to environmental adaptation, the experience of regions like Bangladesh offers valuable lessons in resilience. However, as both Marina and Barbara point out, local context—whether in terms of materials, community, or infrastructure—is everything. What emerges is not a one-size-fits-all model, but rather a call for place-based innovation, cross-cultural learning, and scalable solutions that can shape a more adaptive and sustainable future.

Isabel Recubenis Sanchis

Researcher and designer at Delta Urbanism Interdisciplinary Group(TU Delft)

"Historically, the Netherlands has focused on controlling and resisting water. However, this approach is now pushing the country toward other extreme climate-related risks. As a result, there is a growing shift in perspective, with new projects advocating for living with water rather than fighting it. Architects are now being asked to design for coexistence with water. Based on her research, she suggested approaches such as designing buildings that float or using materials that can withstand periodic submersion—particularly focusing on adapting the ground floor to respond to changing water levels."

Marina Tabassum

Principal Architect of Marina Tabassum Arcitects
Agha Khan Award, Architecture, Bangladesh

"Living with water has been a way of life in Bangladesh for many years. There, it is not a choice but a necessity—an adaptation to the realities of their environment. To implement a similar approach in the Netherlands, it is crucial first to understand the specific types of water bodies involved, the stakeholders at play, the envisioned community that will inhabit the space, the potential sources of materials, and how the development might evolve over time. In Bangladesh, because the focus was on low-cost housing, the materials and structural solutions were very different from what would be appropriate or feasible in the Dutch context."

Isabel Recubenis Sanchis

Architect, Project Leader (Blue21), PhD Student "Floating Future' project (TU Delft)

"Scalability has been a major challenge we have been addressing in recent years when it comes to designing homes with water. One of the key issues is that homes situated in or surrounded by water cannot respond to urban challenges as swiftly due to the complex interactions between the built form and the aquatic environment. This makes such housing types extremely difficult to replicate at scale, limiting their ability to address urban growth—a critical factor in preparing for future crises."

"What are the main principles and strategies of flood resilient community planning ?"

- *Allow for controlled flooding by integrating water into the design through amphibious, stilted, and floating housing typologies.*
- *Design with modular and flexible structures that can adapt to changing water levels and community needs.*
- *Include shared spaces and community modules to strengthen social ties and promote collective response during climate events.*
- *Use green-blue infrastructure (e.g., wetlands, canals, retention zones) to manage water naturally within the urban fabric.*
- *Embrace mixed-use layouts that combine housing with ecological zones and communal functions for long-term resilience.*
- *Promote decentralized systems for water, energy, and waste, increasing autonomy and reducing vulnerability.*
- *Design incrementally and affordably, allowing for growth over time while remaining accessible to diverse populations.*
- *Encourage co-governance and community participation in design and maintenance to increase engagement and resilience.*
- *Anchor planning in ecological cycles, respecting natural hydrological flows and restoring native ecosystems.*
- *Balance sustainability with social equity, ensuring flood-resilient housing is inclusive, not exclusive.*

Flood-resilient housing strategies around the globe reflect diverse approaches tailored to the unique geographical, cultural, and socioeconomic contexts of different regions. These examples showcase how various regions address flooding challenges while accommodating the needs and lifestyles of their communities, offering valuable insights for applications in the Netherlands.

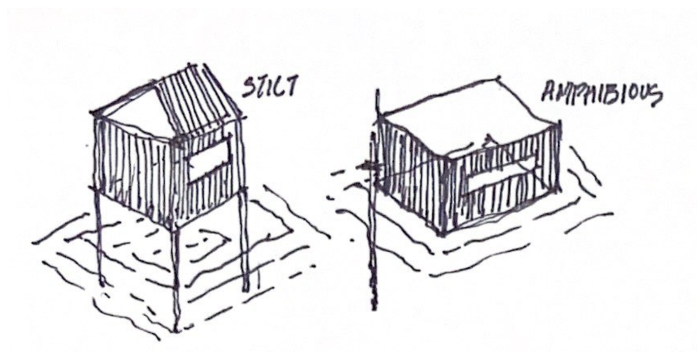
The Pontoon Construction in Brisbane, Australia, demonstrates the potential of floating structures as a flood-resilient solution. These houses rest on platforms tethered to pylons, allowing them to rise and fall with changing water levels. Lightweight and water-resistant materials, such as hollow-core concrete and timber, enhance buoyancy and durability. Modular layouts and the integration of green spaces support both sustainability and community living. This project highlights the importance of balancing adaptability, functionality, and ecological design in urban flood-prone areas.

The Amphibious House by Baca Architects in the UK presents an innovative approach to flood-resilient architecture. Resting on a buoyant concrete base, the house rises with floodwaters while remaining anchored to vertical guideposts. The use of sustainable materials, solar panels, and rainwater harvesting enhances environmental resilience. Advanced warning systems and thorough site analysis further ensure preparedness for extreme weather. This case study demonstrates how modern technologies can integrate seamlessly with adaptive design to protect homes from flooding without disrupting the landscape.

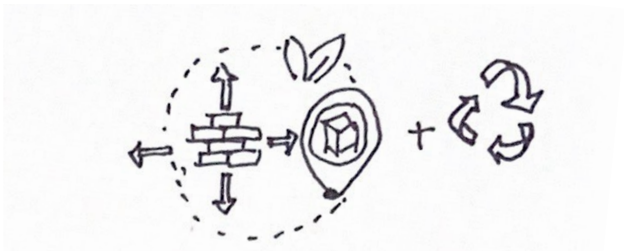
In the Hanging Villages of Kalabogi, Bangladesh, houses are built on elevated platforms using bamboo and other local materials to withstand tidal flooding and heavy rainfall. These structures, rooted in indigenous knowledge, are cost-effective and sustainable. They are also designed to be flexible, with the ability to be dismantled and modified as water levels change. This approach highlights the importance of leveraging traditional construction techniques and local materials to create resilient, adaptable housing for flood-prone communities.
The Stilt Houses in Assam, India, are another example of how traditional construction methods address recurring flooding. Elevated on wooden or bamboo stilts, these houses keep living spaces above water levels during monsoons. The use of low-cost, locally available materials like bamboo and thatch makes these structures economical and easy to repair. This simple yet effective solution ensures that communities can coexist with their natural environment while maintaining their social and cultural cohesion.

The Amphibious Houses of Vietnam, located in the flood-prone Mekong Delta, offer valuable insights into how mobility can be integrated into flood-resilient design. These floating homes are tethered to anchors, allowing them to rise with water levels. Lightweight materials, such as bamboo and recycled components, enhance affordability and functionality. Many of these houses are designed to be mobile, enabling relocation during extreme flooding. This approach underscores the significance of flexibility and cost-effectiveness in designing resilient housing for vulnerable regions.

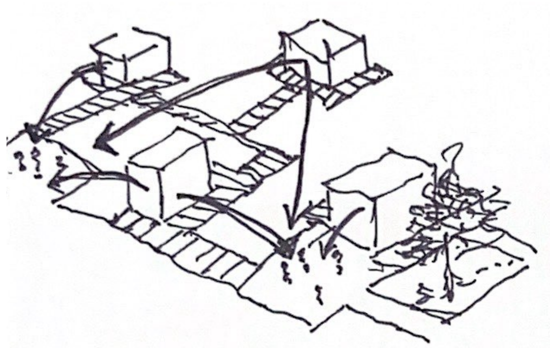
In the context of the Netherlands, these global examples provide a wealth of inspiration. Floating and amphibious solutions, as seen in Australia and Vietnam, and the elevated designs, like the stilt houses of Assam and the hanging villages Bangladesh, offer effective solutions for coastal and wetland areas. Indigenous techniques and sustainable materials from Assam and Vietnam highlight the value of using locally sourced resources to reduce costs and enhance environmental sustainability. Additionally, these community based designs highlight the means to focus on communal spaces in flooding context. These case studies reinforce the necessity of rethinking our relationship with water, promoting designs that embrace nature's challenges rather than resisting them.



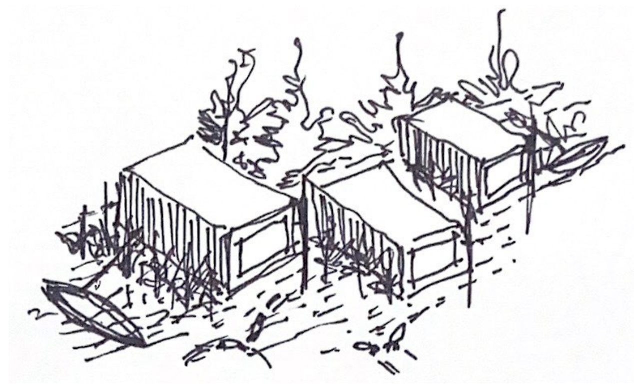
Resilience and Adaptability in design with stilt houses for fixed water levels and amphibious to adapt to changing water levels



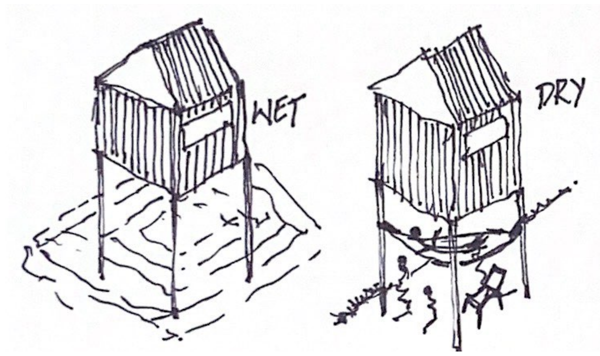
Use of locally available materials, renewable materials to reduce environmental impact



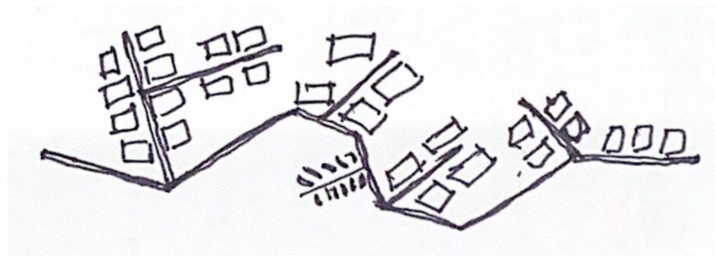
Facilitate Community led design through participatory design using shared platforms, piers, or communal areas



Embrace local ecosystems by incorporating wetlands or water buffers



Innovation in design by respecting flood dynamics and working on natures cycle



Cluster planning to promote interdependence and social support.

Figure 84. Strategies (Authors own diagram)

DISCUSSION

The research began with a critical question: How can flood-resilient housing be designed to support both environmental sustainability and community well-being in flood-prone regions? The findings presented throughout this report suggest that such housing cannot exist in isolation — spatially, socially, or ecologically. Instead, it must emerge from a deep understanding of the interdependencies between natural systems, human communities, and the built environment. This discussion chapter synthesizes the key insights, with specific emphasis on the interplay between theory and practice — particularly through the analysis of global case studies and the Dutch Delta.

Bridging De-Synchronization Through Design

Chapter 1 introduced the concept of de-synchronization — a growing disconnection between economic, environmental, and individual systems. The case studies explored in this research directly address these disconnections. For instance, the Schoonschip Amsterdam project exemplifies how community-led development can re-align economic behavior with ecological awareness through energy-neutral design and collective governance models . Similarly, the Floating Houses in IJburg not only adapt to water level changes but integrate community organization, shared utilities, and awareness of seasonal water dynamics, thus addressing individual disengagement from ecological processes.

These examples operationalize the theoretical framework of re-territorialization (Deleuze & Guattari, 2000), demonstrating how the built environment can be reimagined to re-integrate with natural cycles. Where traditional urban infrastructure seeks to control nature, these housing models adapt to it — promoting coexistence rather than resistance, a key theme also emphasized in Chapter 2 on the Dutch Delta.

The Dutch Delta: From Control to Coexistence

As outlined in Chapter 2, the Dutch Delta's historical reliance on hard infrastructure — dikes, sluices, and polders — has paradoxically increased vulnerability by suppressing natural water dynamics. The case of Midden-Delfland, through the National Productive Park vision by ZUS and collaborators, offers a compelling alternative. By reimagining low-lying polders as floodable zones, incorporating wetlands as ecological buffers, and redesigning boezem systems to store and release water dynamically, the proposal echoes the principles derived from the global precedent.

In this way, the Delta becomes a testing ground for transitioning from a deterministic, control-based model to an adaptive, regenerative landscape. The Mekong Delta's amphibious houses and Assam's stilt homes, while rooted in vernacular knowledge, offer critical inspiration here — proving that living with water has long been viable and sustainable when aligned with local context and natural systems.

Community Living as Infrastructure

Chapter 3 foregrounds the social component of resilience, arguing that technical solutions are insufficient without strong social ties. The evolution of Dutch housing—from communal hofjes to isolated high-rises—reflects a broader societal shift from collective resilience to individualism. While traditional models emphasized shared courtyards and mutual care, modern developments often prioritize efficiency and privacy, resulting in fragmented communities and reduced social interaction. Urbanization, land scarcity, and policy changes have intensified this trend, leading to the erosion of communal spaces crucial for fostering social cohesion and adaptive capacity.

In contrast, architectural approaches by Van Eyck, Hertzberger, and Correa highlight the enduring value of transitional and in-between spaces in building strong communities. Their work demonstrates how spatial design can balance public and private realms, encouraging participation, belonging, and flexibility. As climate resilience becomes a pressing concern, these principles offer valuable insights for rethinking housing not just as shelter, but as a framework for collective well-being and environmental adaptability. Likewise, the Kalabogi Hanging Village in the Sundarbans is an example that highlights how even precarious dwellings can demonstrate collective adaptation, shared resource management, and cultural resilience.

These case studies validate the assertion that community is not just a social concept but a form of infrastructure. It is a system of mutual support that, when spatially embedded in housing design, enhances both preparedness and adaptability. This connects directly to the findings from Chapter 4 on redefining dwelling, where housing is conceptualized not as a static shelter but as a living, adaptive interface between people and place.

Redefining Dwelling: A Synthesis of Strategies

Chapter 4 brought together architectural innovations from around the world to propose a redefinition of dwelling — one that is modular, communal, and ecologically responsive. The discussion of Schoonschip, floating housing in IJburg, and amphibious homes in the UK and Vietnam revealed several consistent strategies: elevation, buoyancy, modularity, and the integration of blue-green infrastructure.

These design elements are not just technical solutions but spatial responses to the deeper systemic issues identified earlier in the thesis. They tackle ecological disconnection (through permeability and water integration), economic constraints (via modular, low-impact construction), and social fragmentation (through shared courtyards, communal zones, and co-governance models). The projects thus materialize the reconnection across the three spheres of de-synchronization: economy, environment, and individuals.

Design Implications for Future Resilience
Taken together, these insights suggest several implications for future design practice:

Flood-resilient housing must embrace water, not resist it. This means planning for controlled flooding, integrating retention basins and wetlands into urban form, and accepting change as an inevitable part of the design life cycle.

Community must be designed as infrastructure. Shared spaces, cooperative ownership, and collective resource management increase the social capital needed to respond to flood risks — a lesson learned from both historic Dutch hofjes and contemporary co-housing models.

Flexibility and modularity are essential. Housing must be adaptable — physically, socially, and institutionally — to respond to uncertainties in climate, economy, and demographics. The sponge city model of Rotterdam and the adaptable housing layouts of IJburg exemplify this approach.

Co-management and participatory governance are key. Resilience is not just technical but institutional. Flood-resilient communities require active roles for residents in planning and decision-making, as shown in Amsterdam's Schoonschip initiative.

Further in the discussion light is shed upon the two meta questions that were addressed in the research.

Meta-Question 1: How can uncertainty be integrated into housing and urban design strategies to enable adaptive and evolutionary responses to the climate crisis, specifically in flood-prone wetlands?

Uncertainty is no longer an anomaly in environmental planning—it is the new norm. From climate variability to sea-level rise, the rigid, deterministic models that once shaped Dutch water management are no longer adequate. This research advocates for a process-oriented design approach that accommodates rather than resists change—a perspective emphasized in the Redesigning Dutch Deltas initiative and the National Productive Park Midden-Delfland proposal.

Case studies such as the Floating Houses in IJburg and amphibious housing in the Mekong Delta exemplify adaptive responses where homes adjust to fluctuating water levels, transforming risk into a manageable variable. These models show how design can move beyond failure thresholds (e.g., dikes built to 1-in-10,000-year flood levels) to systems that perform through flexibility. In both examples, housing adapts dynamically rather than relying on engineered permanence.

This adaptation is not only architectural but ecological—wetlands in Midden-Delfland are re-envisioned as active components of water management, absorbing, filtering, and releasing water as conditions shift. This integration of green-blue infrastructure builds ecological intelligence into the very fabric of urban design, showcasing how uncertainty can become a design input rather than an obstacle.

Meta-Question 2: How can resilient housing design serve as a medium to reconnect cultural and geographical ties between humanity and the natural environment?

At the heart of this question lies the problem of disconnection, discussed in Chapter 1 as a form of de-synchronization. The built environment has historically severed ties between people and nature—through sealed surfaces, rigid zoning, and separation from water systems. This research suggests that housing can become the bridge that reestablishes these lost ties.

Designs such as Schoonschip Amsterdam reveal how architecture can restore local ecological cycles (e.g., water reuse, solar energy) while nurturing new forms of urban community. Similarly, the Belapur Housing model in India leverages spatial typologies that honor communal traditions and localized knowledge, embedding culture into everyday dwelling.

Furthermore, the report's analysis of historical Dutch settlements—from hofjes to canal houses—illustrates how past models of cohabitation were deeply embedded in collective resource management and place-based identity. This cultural embeddedness has been lost in modern, hyper-individualized housing typologies. Through the lens of re-territorialization, the thesis reframes resilient housing not merely as a protective shell, but as a medium of cultural continuity and ecological interdependence.

Reconnection is also spatial: the proposed shift toward floodable zones, shared water landscapes, and wetland restoration in Midden-Delfland reintroduces water as an active agent in daily life. Housing, situated within this dynamic landscape, fosters awareness, stewardship, and belonging—precisely what is needed to reverse ecological detachment.

The discussion reinforces this thesis's central argument: Flood-resilient housing must harmonize natural dynamics with human needs. This means rethinking planning, policy, and design through the dual lenses of adaptation and connection. Housing is no longer just a barrier between people and water — it can become the mediator that enables life with water, rather than in opposition to it.

CONCLUSION

This research set out to explore how flood-resilient housing can be designed to support both environmental sustainability and community well-being in wetland and flood-prone regions. The example of community life in Kuttanad, India, gave this research a direction of coexisting with nature as a means of life. Through a critical examination of the Dutch Delta, comparative global case studies, and theoretical frameworks around de-synchronization and re-territorialization, the study has uncovered a path forward — one that calls for a fundamental shift in how we design, dwell, and relate to our landscapes.

The findings confirm that traditional flood management strategies, based on rigid control and separation from natural systems, are no longer sufficient in the context of increasing climate unpredictability. Instead, adaptive, nature-based strategies — such as integrating wetlands, allowing controlled flooding, and designing with ecological dynamics — offer more resilient and regenerative alternatives. Simultaneously, the social dimensions of resilience cannot be ignored. As highlighted in both historical Dutch precedents and international case studies, community-based living models are essential for fostering collective adaptation, emotional well-being, and long-term sustainability.

Rather than treating housing as static and defensive, this thesis proposes a redefinition of dwelling — one that is fluid, communal, and symbiotic with nature. Resilient housing in flood-prone areas must operate at the intersection of architecture, ecology, and society, and be designed not to resist nature but to live with it.

While the Dutch context offers both the urgency and opportunity to implement these ideas, the underlying principles are globally relevant. The insights from Midden-Delfland, Schoonschip, IJburg, and international references like Belapur and Kalabogi suggest that resilience is not a universal formula, but a contextual, evolving process — one rooted in both place and people.

Ultimately, this research advocates for a future where housing is not only flood-resistant but also environmentally embedded and socially restorative. By bridging the gap between human and natural systems, we can begin to reimagine our relationship with water not as a threat, but as a guide — shaping landscapes that are not only resilient, but deeply alive.

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08.TRANSLATION INTO DESIGN

Figure 85. Resilient Housing (Authors own diagram)

SITE AND DESIGN APPROACH

This design aims to tackle the challenges of climate change and promote community sustainability in similar environments, focusing on resilience, modularity, self reliance, and community architecture by answering the research question: How can innovative, resilient housing design in wetland areas support environmental sustainability while fostering community living ?

Community Architecture

Design for people

Central to this vision is the cultivation of a communal way of living to promote sense of belonging and mutual support. Incorporating natural elements, shared spaces and designing for accessibility is important to promote sense of community.

Resilient Housing

Design with Nature

Resilient housing is at the center of this design, incorporating innovative amphibious and floating architecture. Each dwelling is carefully designed to adapt to the changing water levels, providing shelter amidst nature's unpredictability.

Self-Reliant Living

Sustainability

The design is powered to promote sustainability through renewable energy generation and innovative water management systems. These elements integrate into daily life, entrusting residents to minimise environmental impact and widens resilience against external challenges.

Modular Units

Adaptability and Flexibility

Modular units is another aspect of this approach. By using modular construction techniques, we ensure flexibility and scalability in building homes. Residents can customize and expand their living spaces over time, fostering a sense of ownership and empowerment within the community.

Midden Delfland Proposal

Tanthof, developed between the 1970s and 1990s as an extension of Delft, was notable for its distinctive approach to urban development. Unlike many polder neighborhoods, Tanthof preserved the inherent watery nature of the landscape rather than covering it with sand. The historic farm axis, Abtswoude, ran centrally through the area and served as a significant spatial and cultural element, physically dividing Tanthof East and West. The original urban design emphasized small-scale buildings and a human dimension, oriented towards young families.

However, demographic trends indicated a shift away from the initial family-centric population: single-person households constituted approximately 39% of Tanthof West and 45% of Tanthof East, while families with children ranked third among household types. Additionally, the connection between the residential zones and the surrounding polder landscape had diminished over time (Tanthofkadebuurt, gemeente Delft).

Tanthof's site was predominantly situated on stable clay soils, in contrast to nearby peatlands, which were more challenging to build upon. The elevation at Tanthof was approximately -1.8 meters NAP, higher than the adjacent meadows, which ranged between -2.8 and -3.5 meters NAP, reducing flood risk and facilitating construction feasibility. Real estate analysis indicated an average property value of approximately €316,000. More specifically, inner zones away from natural borders exhibited property prices around €3,800 per m², rendering housing development in these areas economically viable. Conversely, properties adjacent to natural landscapes commanded premium prices near €4,800 per m² (Tanthofkadebuurt, gemeente Delft).

The neighborhood's existing infrastructure prioritized slow traffic, with well-designed dead-end streets and woonerfs that promoted pedestrian and cyclist safety. However, the dike axis remained a barrier, characterized by car-oriented traffic and limited connectivity between East and West. Additionally, the architectural relationship between the built environment and the bordering landscape indicated weakness, as many dwellings turned away from green spaces, isolating residents from natural elements.

The studio group's focus area functioned as an informal park with sports fields and recreational benches, yet it lacked formal designation and integration with Tanthof's slow traffic network. This area presented significant potential to become a vital transitional zone bridging the two neighborhoods.

Vision

The group's overarching vision was to develop a natural, biodiverse, and multifunctional transitional park that integrated innovative housing typologies both inside and outside a flexible water barrier. Rather than adopting a rigid dike with built structures atop, as proposed in the Redesigning Deltas plan, the team advocated for a soft, adaptive border that mediated between urban development and the dynamic deltaic landscape. This border was intended to enhance flood resilience by incorporating wetland ecosystems while maintaining meaningful connections between the city and its natural surroundings.

The proposal addressed two principal challenges: (1) redesigning the dyke to accommodate future flood scenarios, and (2) overcoming the physical and social division between Tanthof East and West caused by the underutilized central zone along the Abtswoude axis. By establishing a continuous, accessible recreational corridor, the plan aimed to reinforce slow traffic links, promote biodiversity, and create new housing opportunities tailored to current demographic realities.

This strategy aligned with and anticipated the goals of the broader Redesigning Deltas initiative, serving as a phased implementation that supported resilient urban growth, ecological enhancement, and community well-being over the coming decades. Ultimately, the intervention sought to dissolve existing spatial fragmentation through integrated functions at the local scale, fostering a cohesive and adaptive neighborhood in harmony with its landscape context.

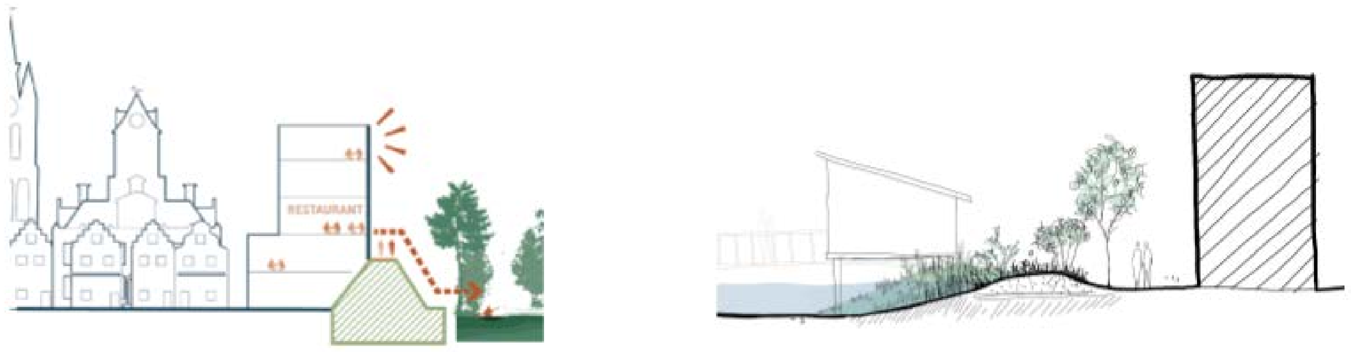


Figure 86. Dike as a border and connection(Studio diagram)

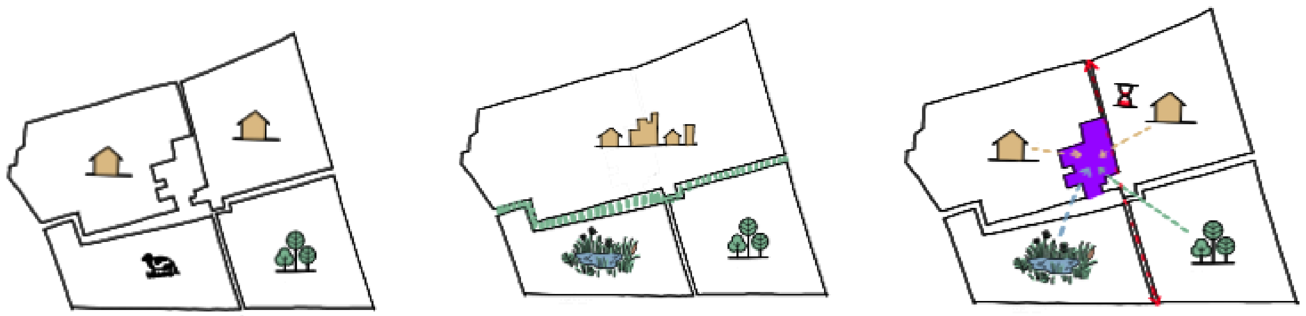


Figure 87. Dissolving the patchwork (Studio diagram)

Studio Masterplan

The proposed design for the Tanthof site was developed through an integrated approach that addressed environmental, social, and urban challenges to create a resilient and adaptive landscape. Based on projections from the Redesigning Deltas study, the polder area was expected to transform into a wetfield by 2122, with higher and less regulated water levels. While the original study suggested a straightforward west-to-east alignment for the dike, the design team chose to reroute it inward to allow for a more gradual and natural transition between the urban area and the landscape. This curved alignment took advantage of the relatively higher elevation of this part of the land, improving flood protection while preserving existing buildings of social or cultural significance. Concurrent with or following the dike construction, new residential blocks were planned within the dike's protection. These buildings addressed contemporary housing demands and provided financial support for the landscape's redevelopment. A multifunctional park was incorporated, featuring pedestrian and cyclist access and seasonal functions that corresponded with the area's anticipated identity as a wetfield. This park acted as a green buffer, enhancing connectivity and promoting interaction with the natural environment. Ultimately, the design not only protected the area from flooding but also embraced a new relationship with water, envisioning a living environment where water was integrated into daily life. Adaptive water management strategies were incorporated to increase resilience and enrich urban quality, reflecting a shift from resisting to harmonizing with the dynamic deltaic landscape.

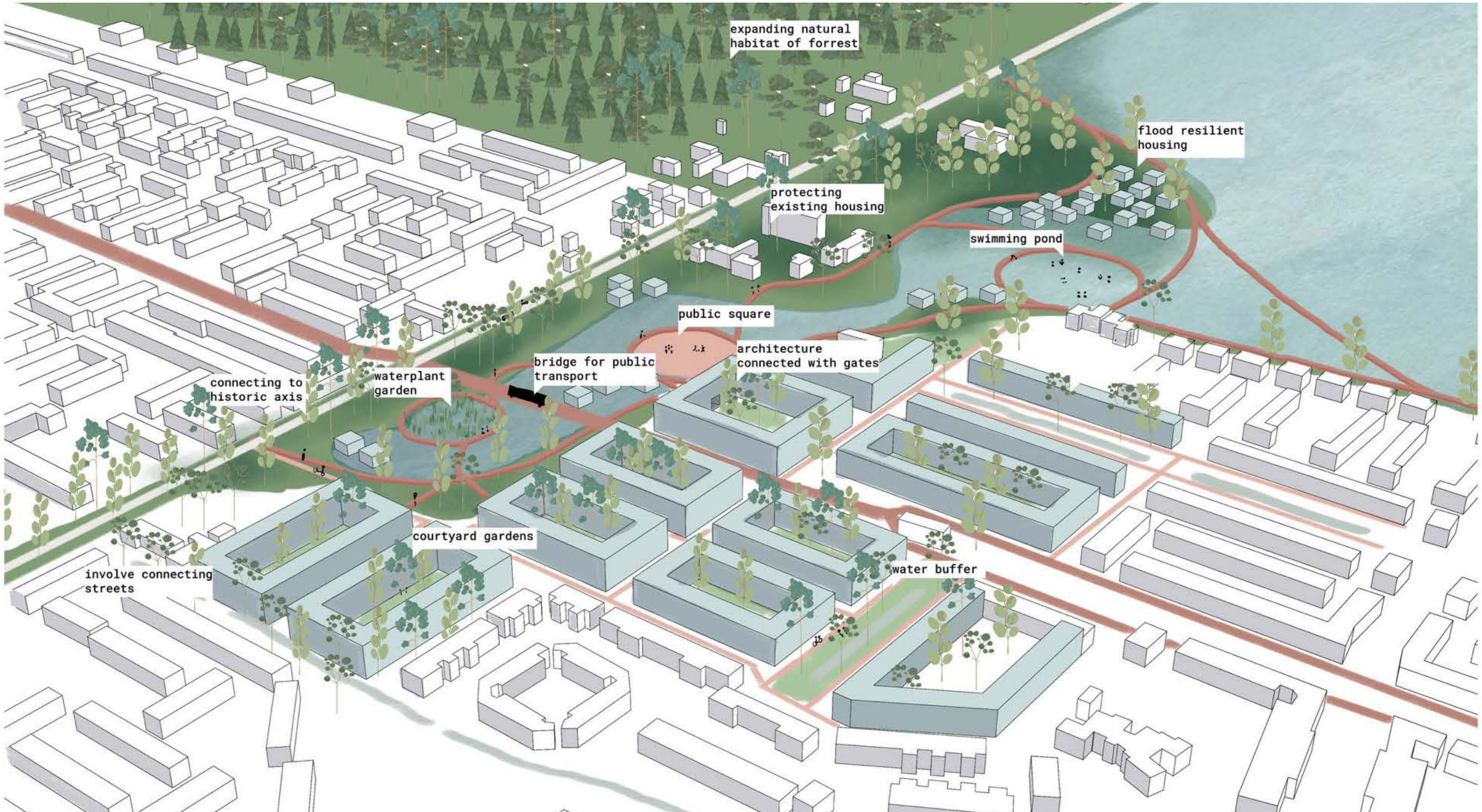


Figure 88. Birds Eye View of the proposal(Studio diagram)

Figure 89. Chosen site in Studio Masterplan(Authors own diagram)

Site of Design proposal

The site for this research, is positioned at the edge of the water, making it highly susceptible to fluctuating water levels. It is primarily accessed via Abtswoude, the main road that serves as a crucial connection between the site and the center of Tanthof. A network of tertiary roads branches off from this axis, integrating the site into the predominantly low-rise residential fabric of the area.
In terms of urban context, the site is bordered by key social and infrastructural elements. To the north, a six-story elderly care hospital introduces a vertical contrast to the otherwise two-story residential surroundings. In adjacent, a school and kindergarten establish an educational and communal presence, reinforcing the site's role within a broader social framework. Additionally, a carpenter's house, identified as a resource outlet, presents opportunities for locally sourced materials and community-driven craftsmanship.

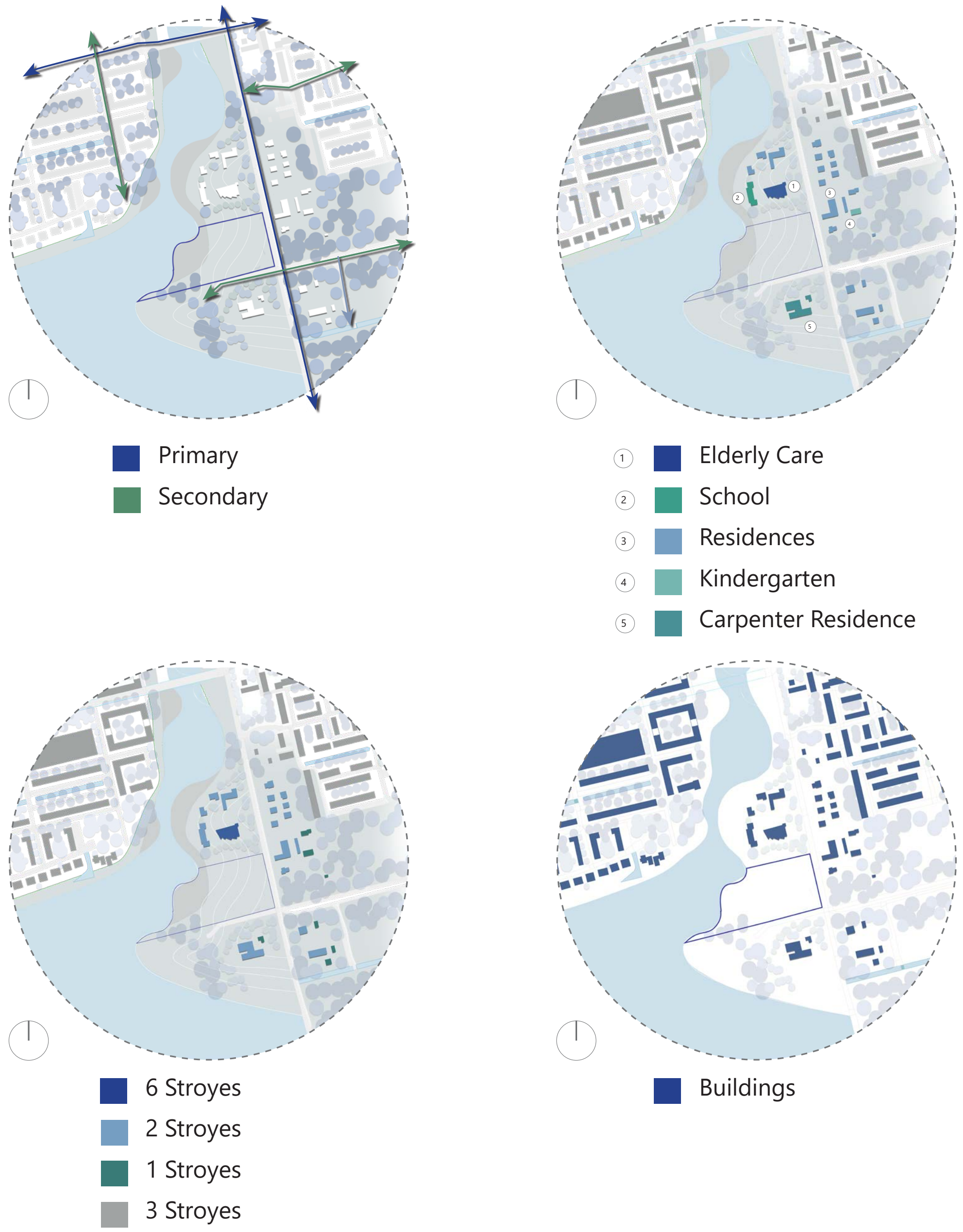


Figure 90. Contextual analysis (Authors own diagram)

Figure 91. Images of Elderly Care and residences near site (Authors own pictures)

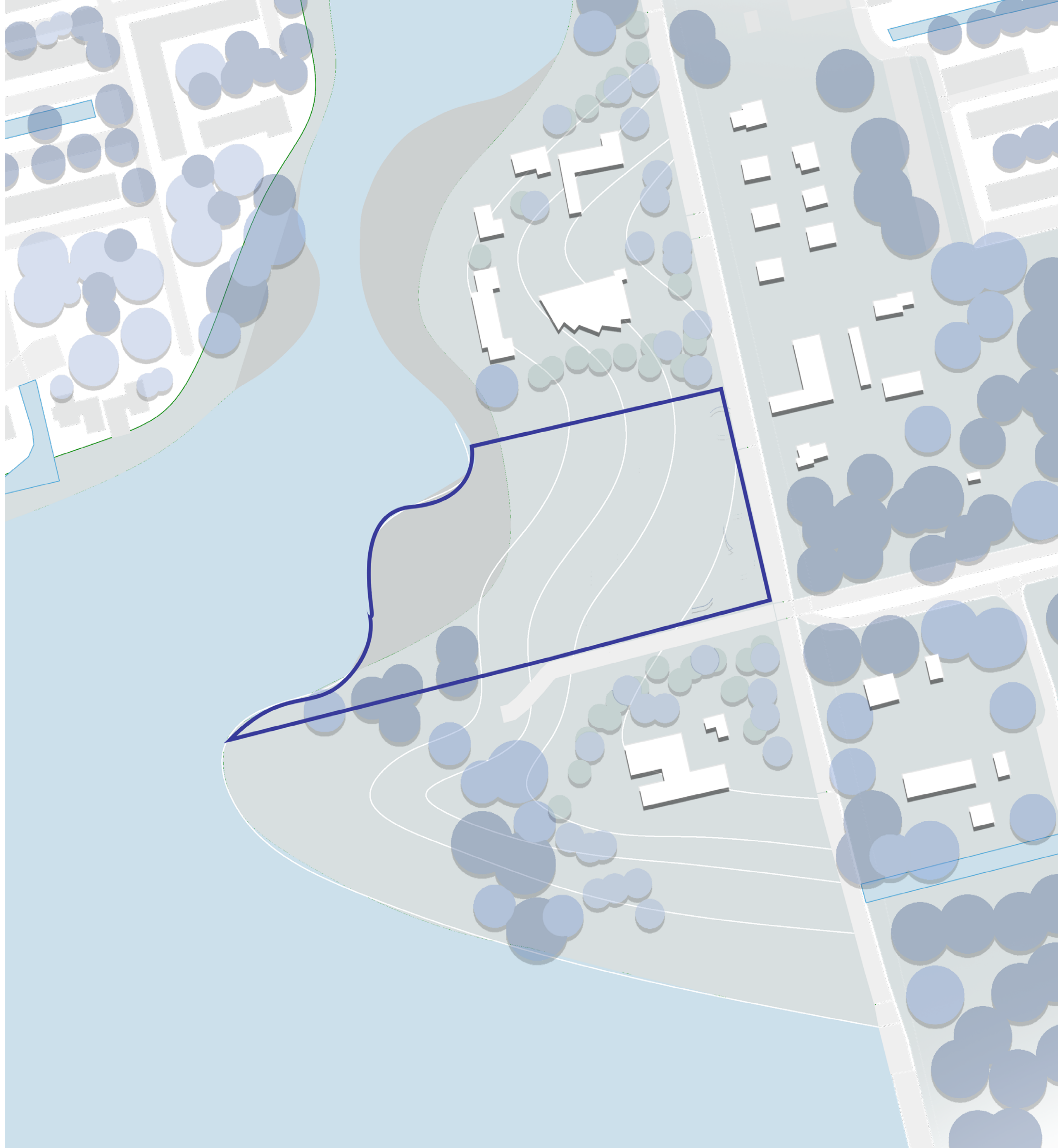


Figure 92. Site of Design proposal (Authors own diagram)

According to climate research projections, coastal flooding levels are expected to rise between 0.2 and 2.8 meters over the next century. In response to this, the design takes a future-forward approach, accommodating the upper threshold of 2.8 meters (Mulhern, 2020). This allows the proposal to engage with extreme climate scenarios, thereby positioning the project as a speculative yet pragmatic exploration of flood-resilient housing strategies under severe sea-level rise conditions.

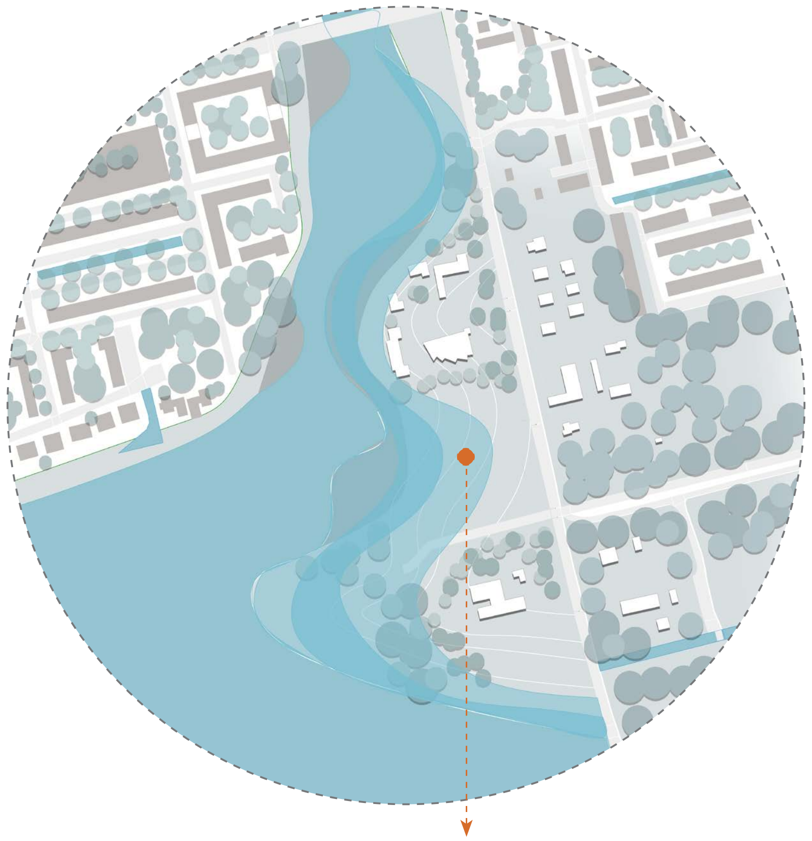


Figure 93. Maximum water level rise on site (Author's own diagram)

Hydrological data from a lower Rhine at lobinthin the Netherlands reveals annual water level fluctuations, with the lowest levels occurring during the summer months and peak levels observed in December and January (Geest et al., 2005). This data has been instrumental in informing the design research, serving as a basis for anticipating seasonal variations in water levels for the proposed site. The identified maximum winter water levels are used to define the critical flooding periods within this study, guiding the spatial organization, housing typologies, and landscape strategies to ensure year-round resilience.

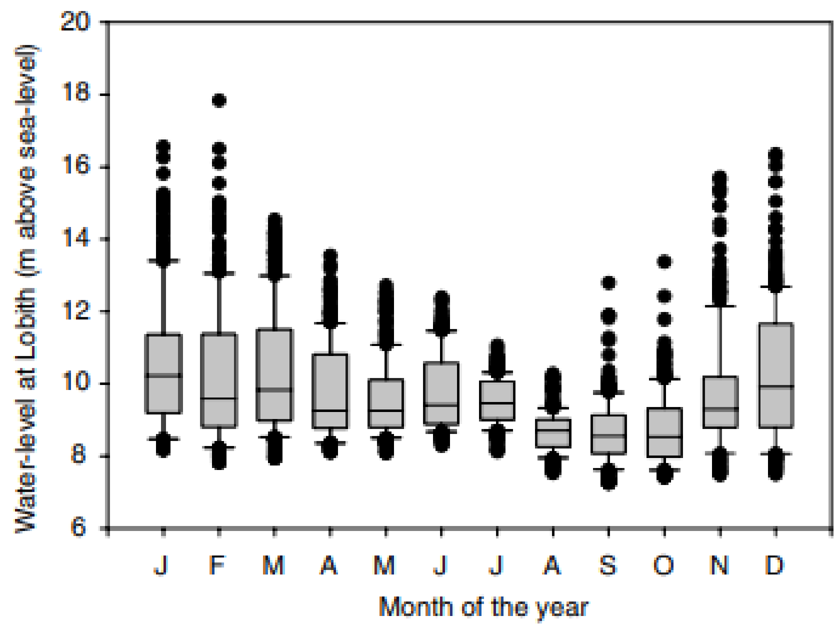


Figure 94. Water level of lower Rhine at Lobinth(Geest et al., 2005)

Program of Requirements

Resilience

- Ability to adapt to extreme natural conditions
- Implementation of robust infrastructure and architectural designs to withstand floods and other environmental challenges.

Flexibility

- Easily expandable for residents
- Modular design approach allowing for incremental development and scalability

Housing

- Variability in housing types to accommodate diverse socioeconomic backgrounds

Community space

- Designated areas for social gatherings, cultural activities and events
- Promote social cohesion and inclusivity within the community

Waste management system

- Implement eco-friendly waste management solutions, including recycling and composting, to minimize environmental impact.

Water supply and sanitation

- Ensure access to clean water and sanitation facilities, possibly through rainwater harvesting

Recreational spaces

- Include spaces for recreational activities, like community gardens, playgrounds, elevated walkways

Parking Area

- Car Park and Visitor parking

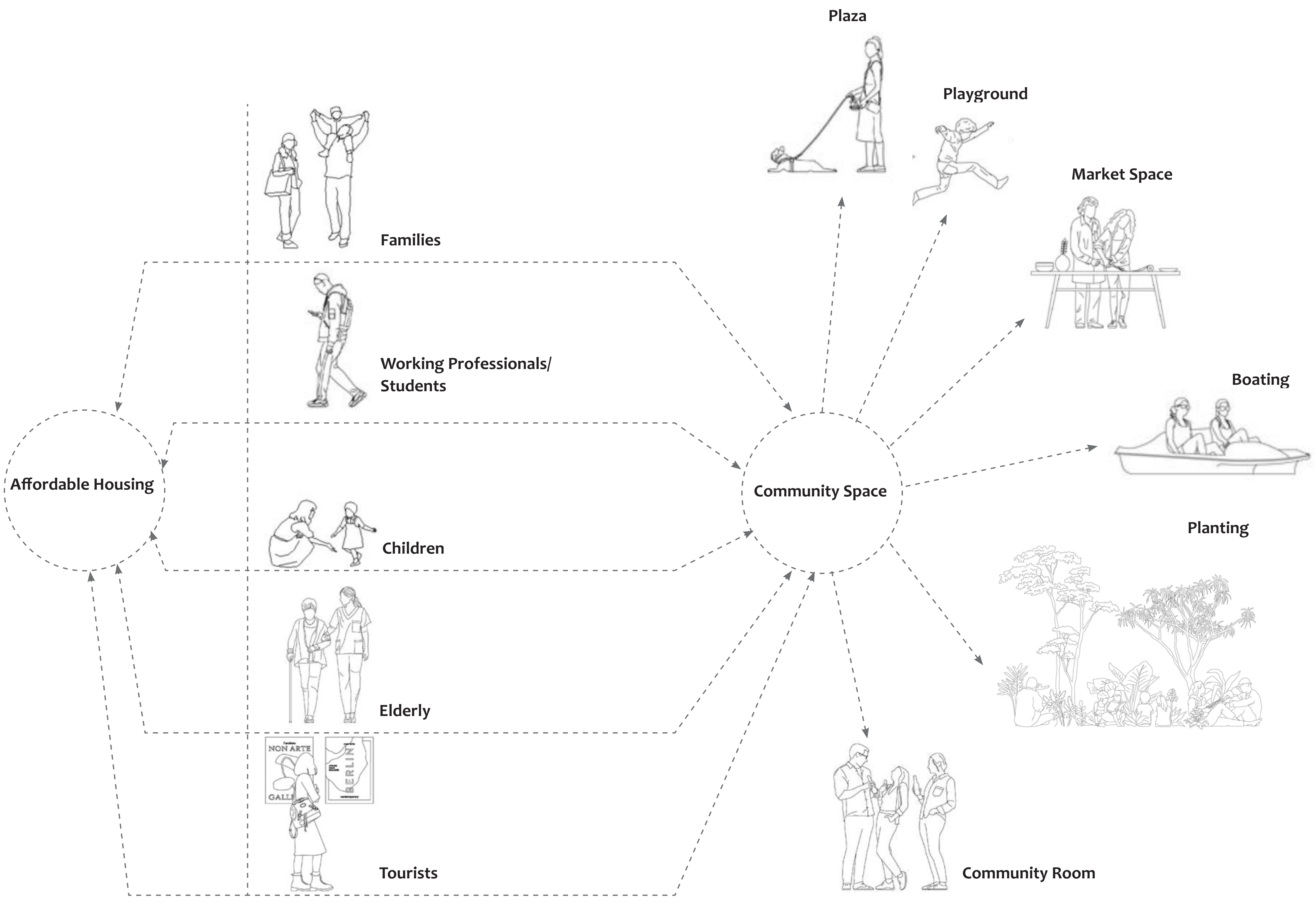


Figure 95. Program and Users (Authors own diagram)

ARCHITECTURE

The design proposal, Waterscapes of Resilience, serves as a critical instrument through which the research question is explored and articulated. Grounded in a rigorous comparative analysis and a comprehensive contextual study, the design translates research findings into spatial strategies that directly respond to the question: "How can flood-resilient housing be designed to support both environmental sustainability and community well-being in flood-prone regions?"

While design outcomes could take multiple directions based on varied interpretations of the contextual data, this iteration represents one synthesized response—acknowledging that further design experimentation and iterative exploration would enrich and deepen the discourse.

Given the scale of the selected site and the constraints of the design timeframe, the project strategically concentrates on the key components that offer the most meaningful contribution to the research—namely, the modular housing typologies and community-based cluster formations. Elements such as public amenities and amphibious housing technologies are intentionally addressed at a foundational level, as their detailed development would offer only marginal gains in relation to the core objectives. The focus, therefore, remains on designing spatial frameworks that can embody resilience, promote ecological integration, and foster a socially cohesive living environment.

Figure 96. Design impressions from the designed lake (Authors own diagram)

Zoning

In pursuing sustainable housing, a comprehensive approach has been adopted to address the challenges and opportunities of the site's dynamic landscape. Integrating innovative design principles with understanding local environmental factors and community aspirations stands central.

The division of the site based on the site study and research is in the three zones respectively with dry, potential wet zones and amphibious houses on water. The site also has zoning responding to the urban context with a quitter zone towards the elderly care and public zone on the southern zone consisting of communal spaces and public access to the water edge for activities like fishing and boating.

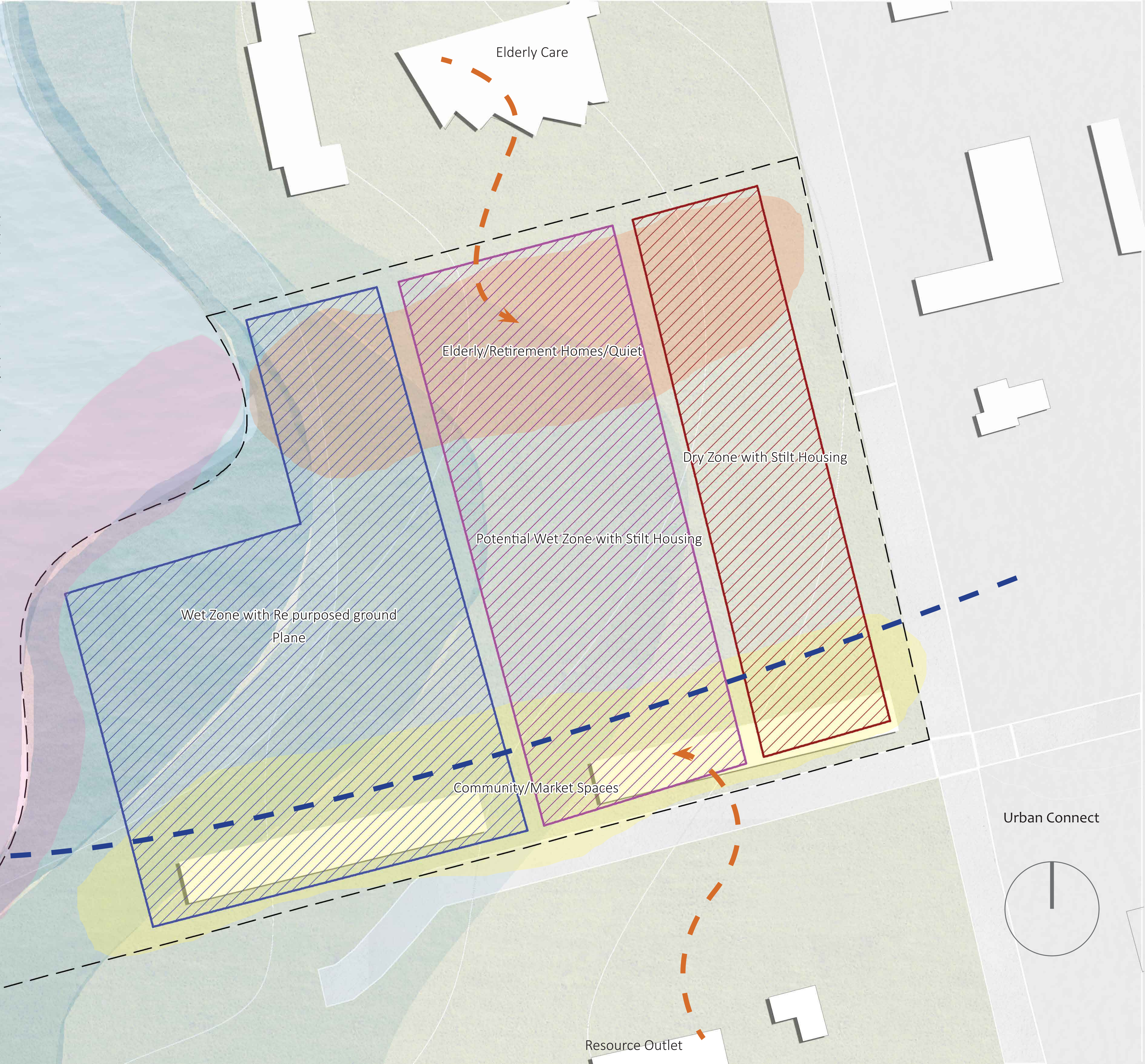


Figure 97. Zoning Diagram (Authors own diagram)

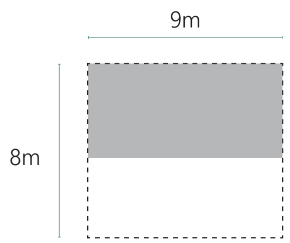
Dwelling Module

These drawings represent the standard modular typologies, with Module A conceived as a compact unit that explores themes of spatial transition. The module is organized around a central courtyard, which serves as a threshold between a private domestic zone and a more parochial semi-public zone, gradually transitioning toward the adjacent main street.

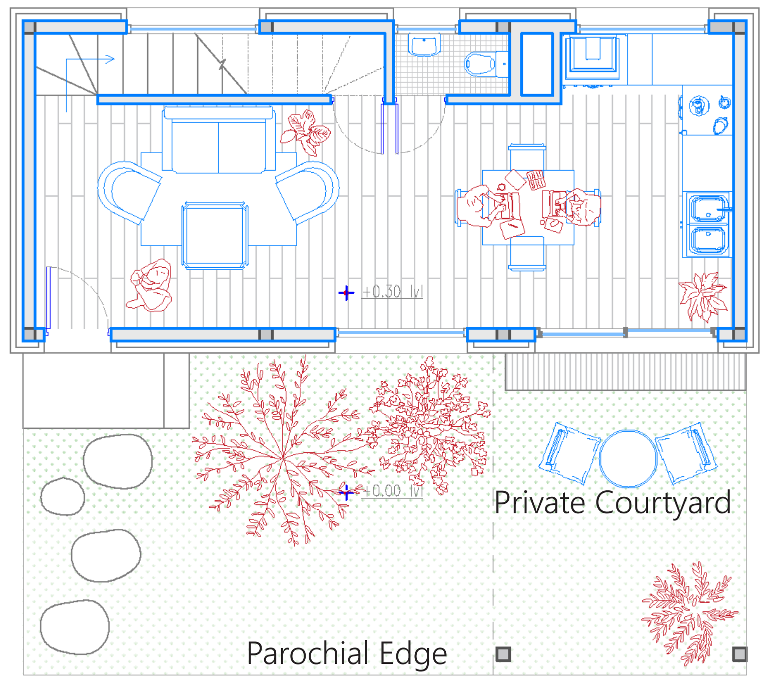
The ground level is deliberately the most active plane, accommodating communal and high-activity functions such as the living room and kitchen. In contrast, the upper level houses the private quarters, including bedrooms and quieter retreat spaces, as well as outdoor terraces, reinforcing a vertical stratification of public to private uses.

Each module is designed to be highly efficient and compact, minimizing circulation space in order to address the pressing theme of affordability. The spatial configuration aims to deliver a quality living environment within a reduced footprint, balancing economic constraints with architectural integrity.

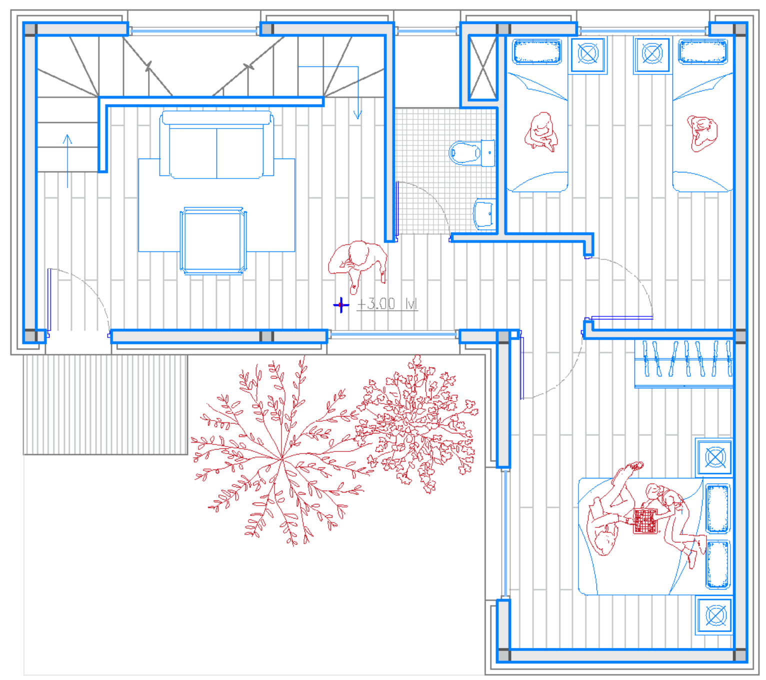
Liv/Din + 2 Bedrooms



Built 37sqm + 50sqm | Unbuilt 40sqm



Ground Floor



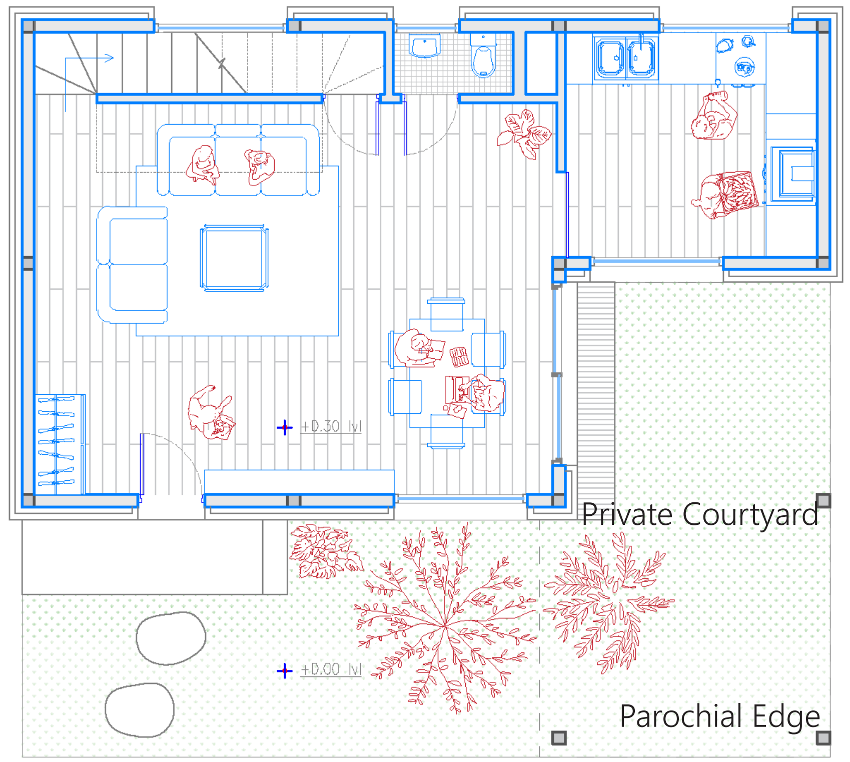
First Floor

Figure 98. Plans of Module A (Authors own diagram)

While Module A was designed for a family of four, emphasizing compactness and efficient use of space, Module B is tailored for a larger family unit, offering more generous spatial volumes and enhanced privacy gradients. The layout is organized around a more secluded private courtyard, reinforcing a sense of enclosure and intimacy within the domestic realm.

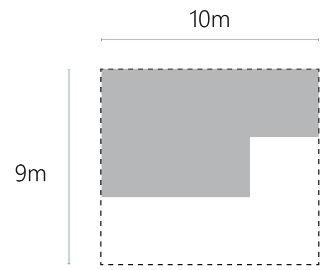
A key spatial feature of this module is the incorporation of a double-height volume, which visually and physically connects the lower and upper living areas, creating a dynamic spatial dialogue and a greater sense of openness. This vertical connection not only enhances natural light penetration but also fosters a stronger sense of familial cohesion across floors.

Compared to Module A, Module B offers more breathable interiors, with increased spatial buffers and articulated nooks that support both collective living and moments of retreat, responding to the nuanced needs of extended family living.

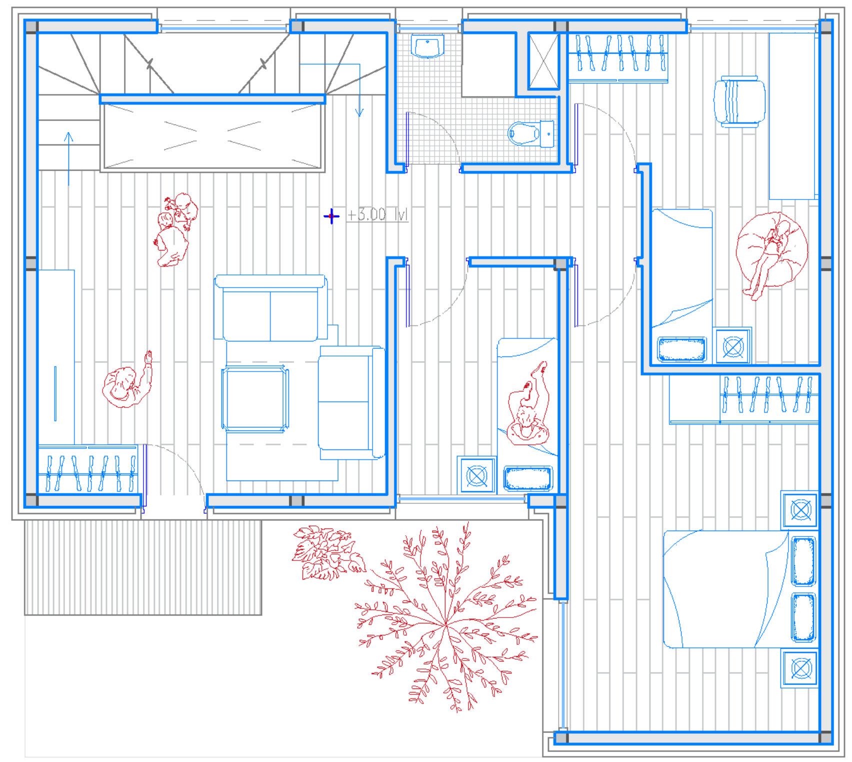


Ground Floor

Liv/Din + 3 Bedrooms



Built 52sqm + 70sqm | Unbuilt 36sqm



First Floor

Figure 99. Plans of Module B (Authors own diagram)

Site-Translation

The Masterplan is structured to facilitate community-oriented living, integrating a smooth transition between individual and collective spaces. The northern zones prioritize smaller, quieter clusters with local communal spaces, while the southern edge provides direct public access to the waterfront, reinforcing the relationship between built form and natural context.

The design follows a network of nested clusters that are systematically design to incorporate specific amount of units. Each unit is designed to have its own courtyard that opens towards the streets, giving an open facade to the cluster. The central garden in every cluster reinforce the senseof community.

Figure 100. Master plan Summer (Authors own diagram)

The dwelling modules are conceived as responsive architectural systems, carefully attuned to the site's topography and fluctuating water levels across its varied zones. Rather than applying a uniform solution, the design employs a diversified typological approach, where each housing typology is strategically situated to address the specific hydrological and spatial conditions of its context.

Figure 101. Master plan Winter (Authors own diagram)

The dwelling typologies are designed in direct response to the site's topography, accommodating the natural gradients and hydrological behavior of the landscape. Each clustered unit is organized around communal gathering spaces, which not only function as zones of shared activity but also act as social anchors—spaces that psychologically reinforce a sense of community cohesion and collective identity.

The distinct zoning strategy integrates housing and landscape as interdependent systems, allowing the architectural fabric to adapt fluidly to the site's natural rhythms, including seasonal water level fluctuations. In doing so, the built environment emerges as a seamless extension of the waterscape, offering a sensitive and adaptive response to flood dynamics while nurturing a resilient, contextually grounded mode of living.

Figure 102. Site topography integration (Authors own diagram)

Spatial-Translation

Each cluster is carefully structured to facilitate a spatial transition from private to semi-private, and ultimately to public realms, creating a layered flow of activities within. This gradation not only supports diverse patterns of use but also reinforces a sense of territorial hierarchy and spatial intimacy.

When translated onto the site, these clusters are strategically positioned to interface with public zones, gradually opening up into larger communal plazas. This spatial arrangement fosters a rhythmic balance between built and open space, enabling moments of social interaction, collective use, and ecological integration at multiple scales. The result is a dynamic, socially responsive urban fabric rooted in both community needs and landscape logic.

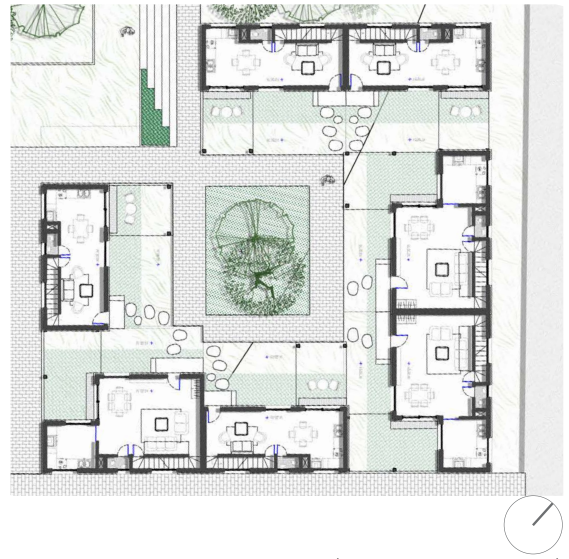


Figure 103.Cluster Arrangement (Authors own diagram)

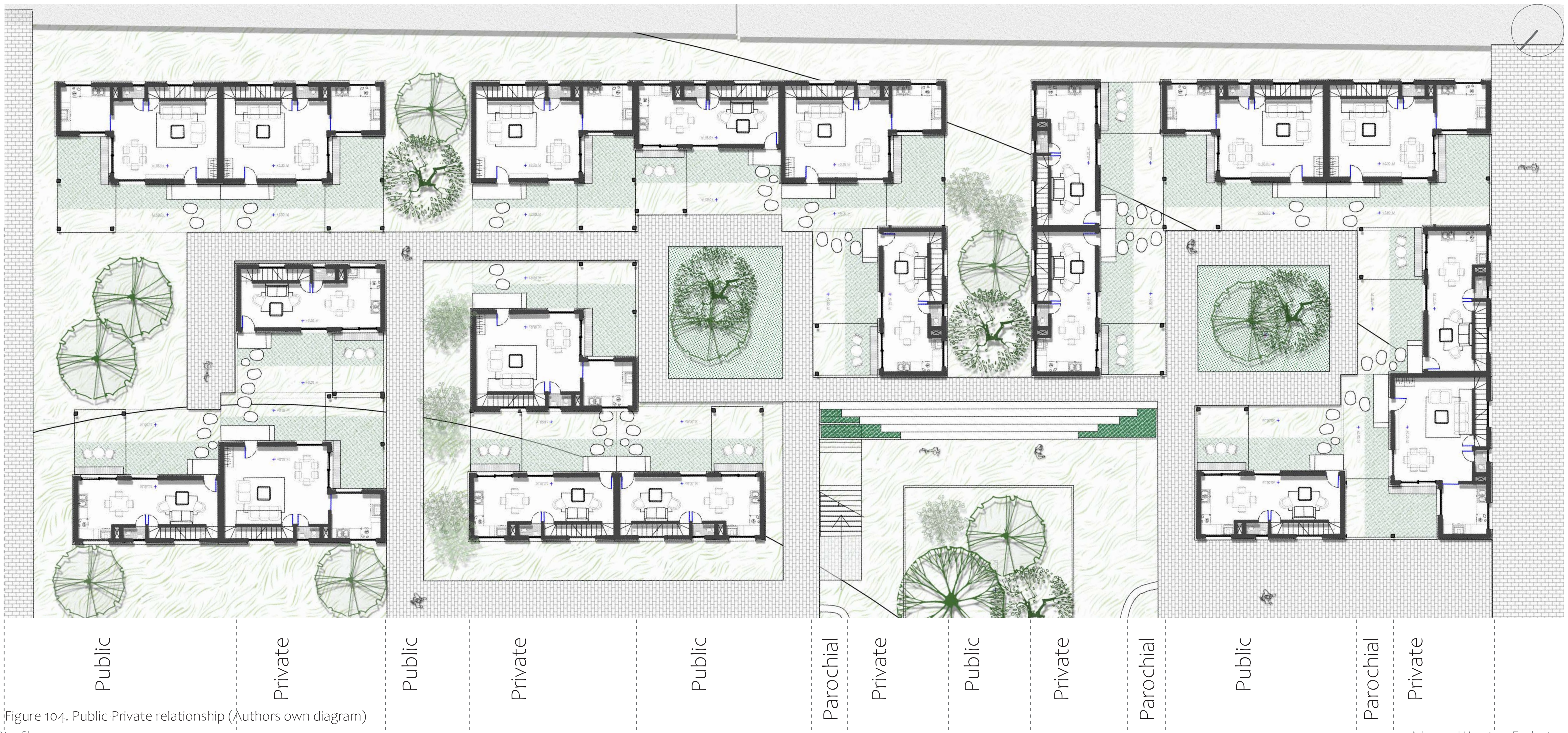


Figure 104. Public-Private relationship (Authors own diagram)

The spatial translation extends vertically through a network of elevated walkways and bridges, connecting upper-level circulation paths across clusters. These connections not only allow for continuity of movement during times of flooding but also create multi-scalar volumetric relationships, offering a dynamic interplay of enclosed, semi-open, and open spaces.

Bridges span over narrow alleys and frame views into shared courtyards, generating a rich spatial layering that enhances visual and physical connectivity within the clusters. This vertical and horizontal porosity fosters an engaging, immersive environment where the built form and landscape remain interwoven.

Such spatial dynamics cultivate both intimacy and interaction, allowing residents to remain physically close to nature while sustaining a strong sense of community resilience—especially crucial during flood events, when collective support and shared space become vital.

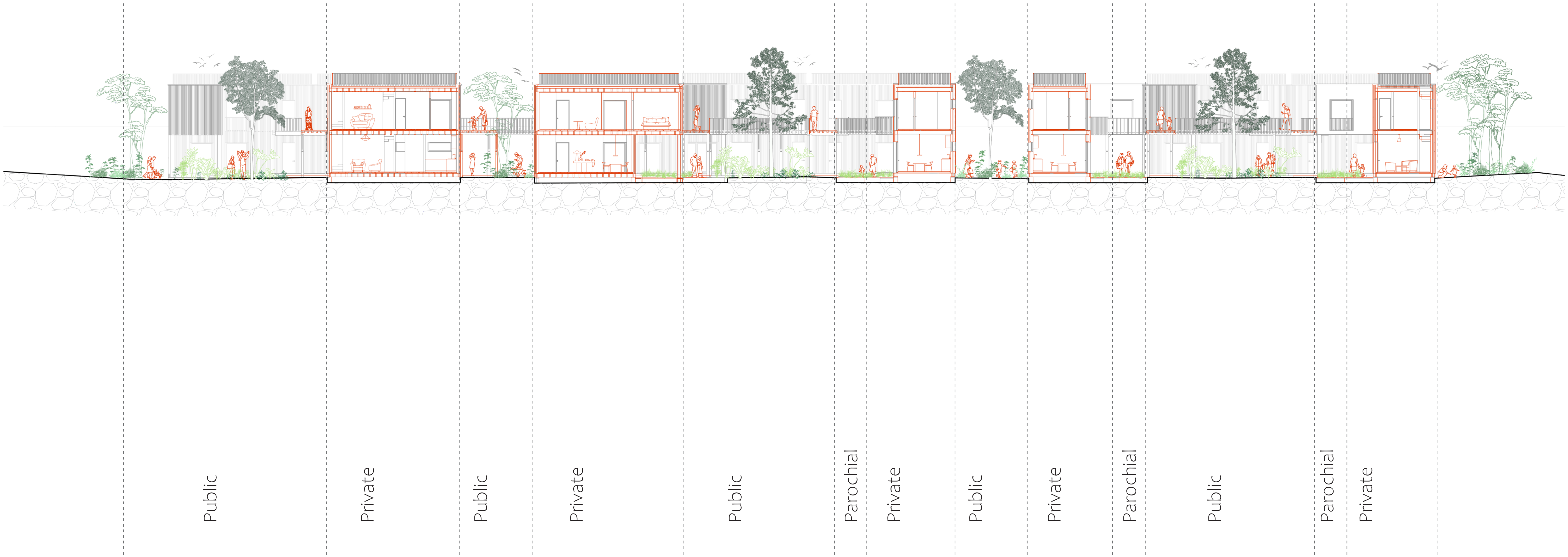


Figure 105. Public-Private relationship (Authors own diagram)

Dwelling Typologies

The four housing typologies are defined by their adaptive response to the surrounding hydrological landscape:

Dry Houses (Typology 1): These are elevated or strategically placed dwellings that remain unaffected by seasonal water fluctuations, maintaining a consistently dry footprint throughout the year.

Stilt Houses (Typology 2): Raised above the ground on stilts or pilotis, these structures accommodate periodic water ingress by allowing water to flow beneath them, preserving habitation spaces above the flood line.

Floodable Houses (Typology 3): Designed to tolerate controlled inundation, these dwellings are intentionally situated in flood-prone zones and are resilient to seasonal or temporary flooding, particularly during the wetter months.

Amphibious Houses (Typology 4): Engineered to float or vertically shift with rising and falling water levels, these homes rest on the ground during dry periods and buoyantly adapt when water levels rise, enabling continuous habitation without damage.

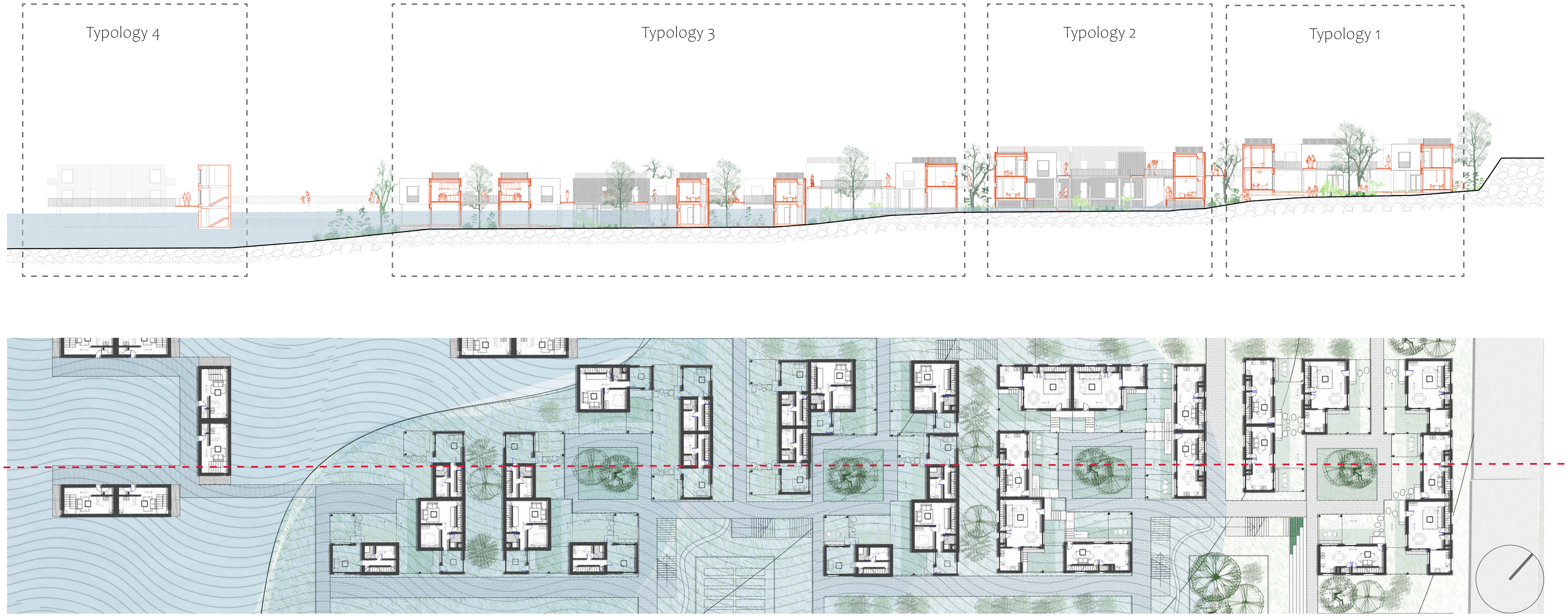


Figure 106. Dwelling typologies wit respect to site (Authors own diagram)

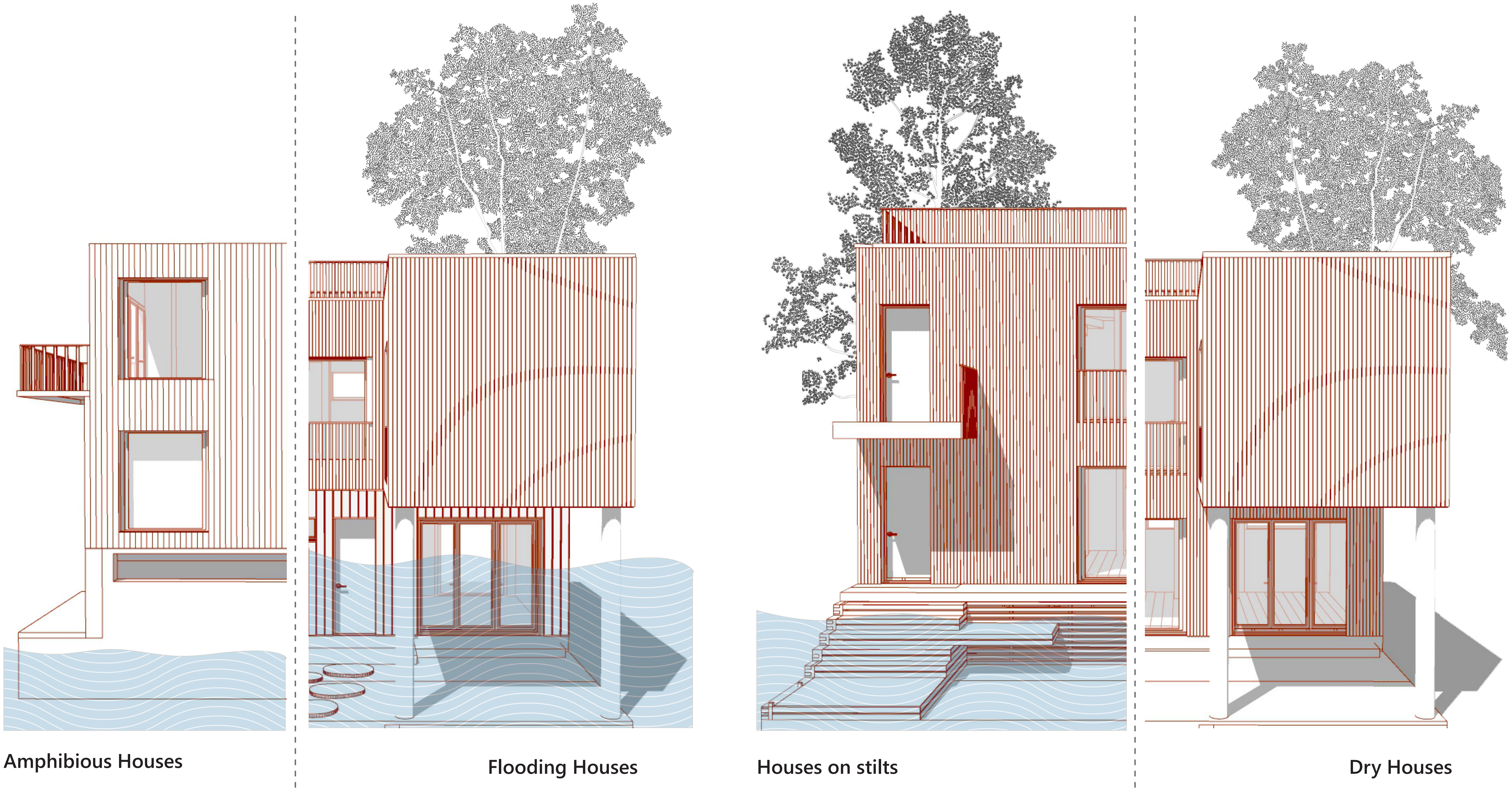


Figure 107. Dwelling typologies (Authors own diagram)

Dry Houses

Figure 108. Key Plan (Authors own diagram)

Figure 110. Key Section (Authors own diagram)

These units maintain a continuous connection with the ground plane throughout the year, enabling greater potential for the integration of expansive communal and shared outdoor spaces. The architectural configuration ensures that both the lower and upper levels function as active transitional zones, fostering fluid movement and interaction between interior and exterior environments regardless of seasonal conditions.

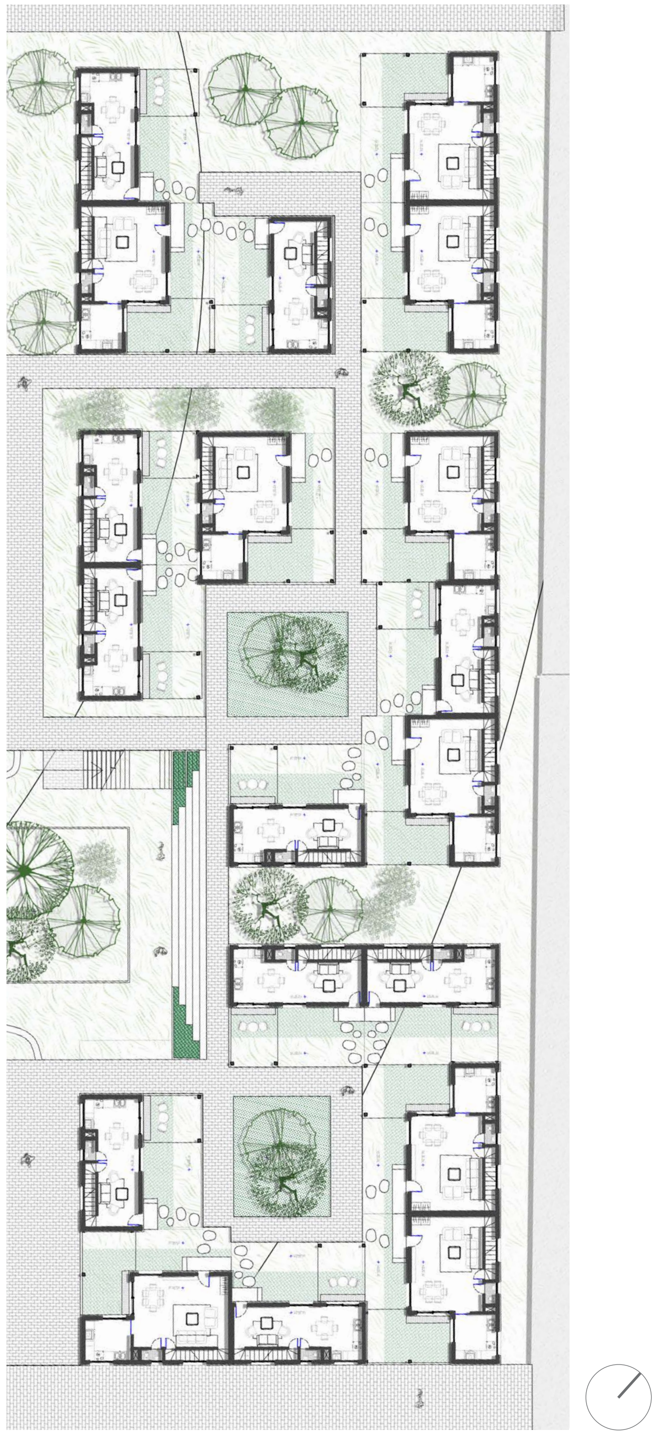


Figure 109. Dry Houses in Summer/Winter (Authors own diagram)

Figure 111. Dry Houses in Summer/Winter (Authors own diagram)

Figure 112. Dry Units in Summer (Authors own diagram)

Houses on Stilts

Figure 113. Key Plan (Authors own diagram)

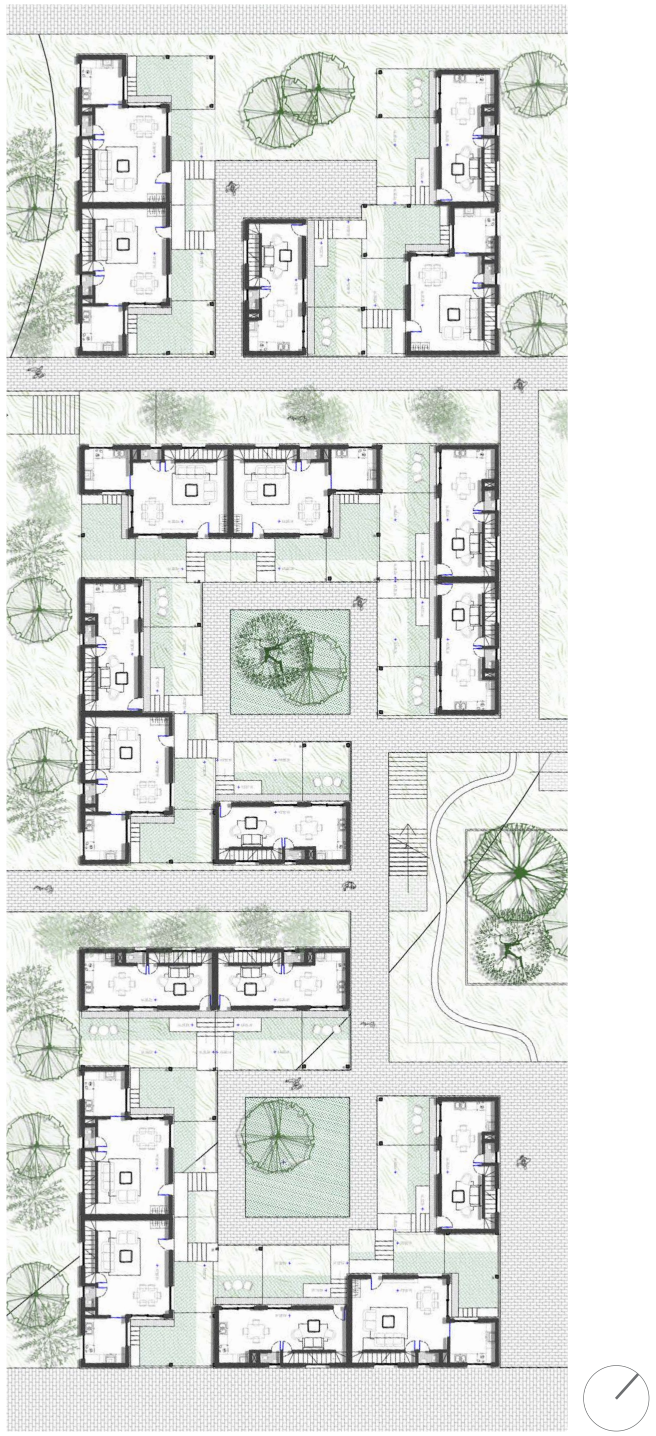


Figure 114. Stilt Houses Summer (Authors own diagram)

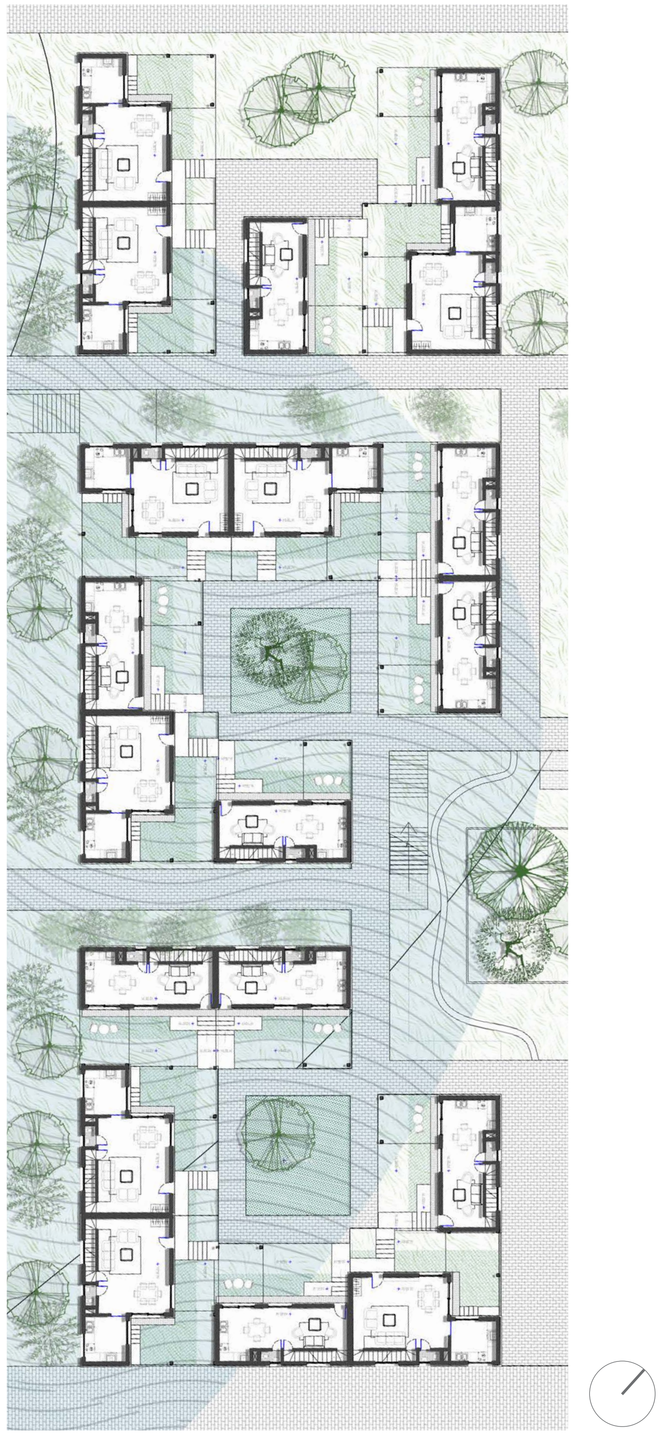


Figure 115. Stilt Houses Winter (Authors own diagram)

Figure 116. Key Section (Authors own diagram)

Stilt Houses are elevated structures designed to accommodate occasional extreme flooding events. Raised sufficiently above the ground, they allow water to flow freely beneath the built form without disrupting the primary living spaces. Functionally, they operate similarly to Dry Houses under normal conditions; however, during periods of seasonal inundation—typically in winter—the ground plane may become temporarily inactive. The dwellings are supported by galvanized steel columns, providing structural resilience, and are visually grounded with timber cladding or plank enclosures that allow water permeability while maintaining a cohesive architectural expression.

Figure 117. Stilt Houses Summer (Authors own diagram)

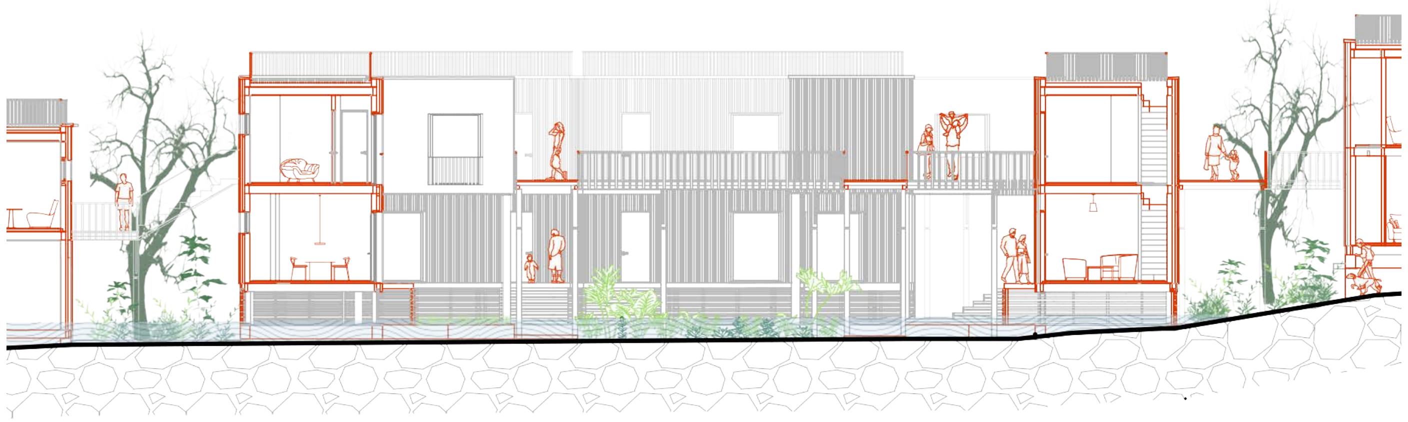


Figure 118. Stilt Houses Winter (Authors own diagram)

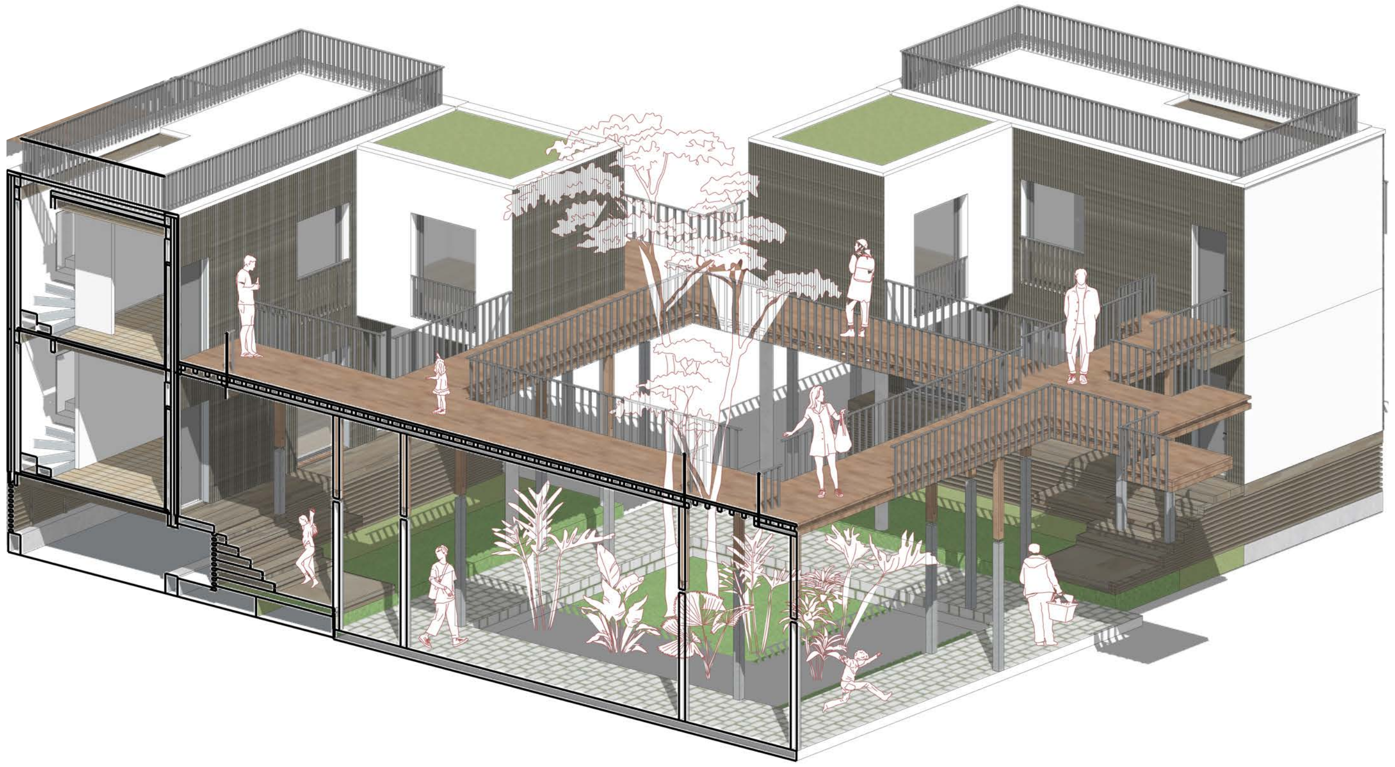


Figure 119. Stilt Houses Summer (Authors own diagram)

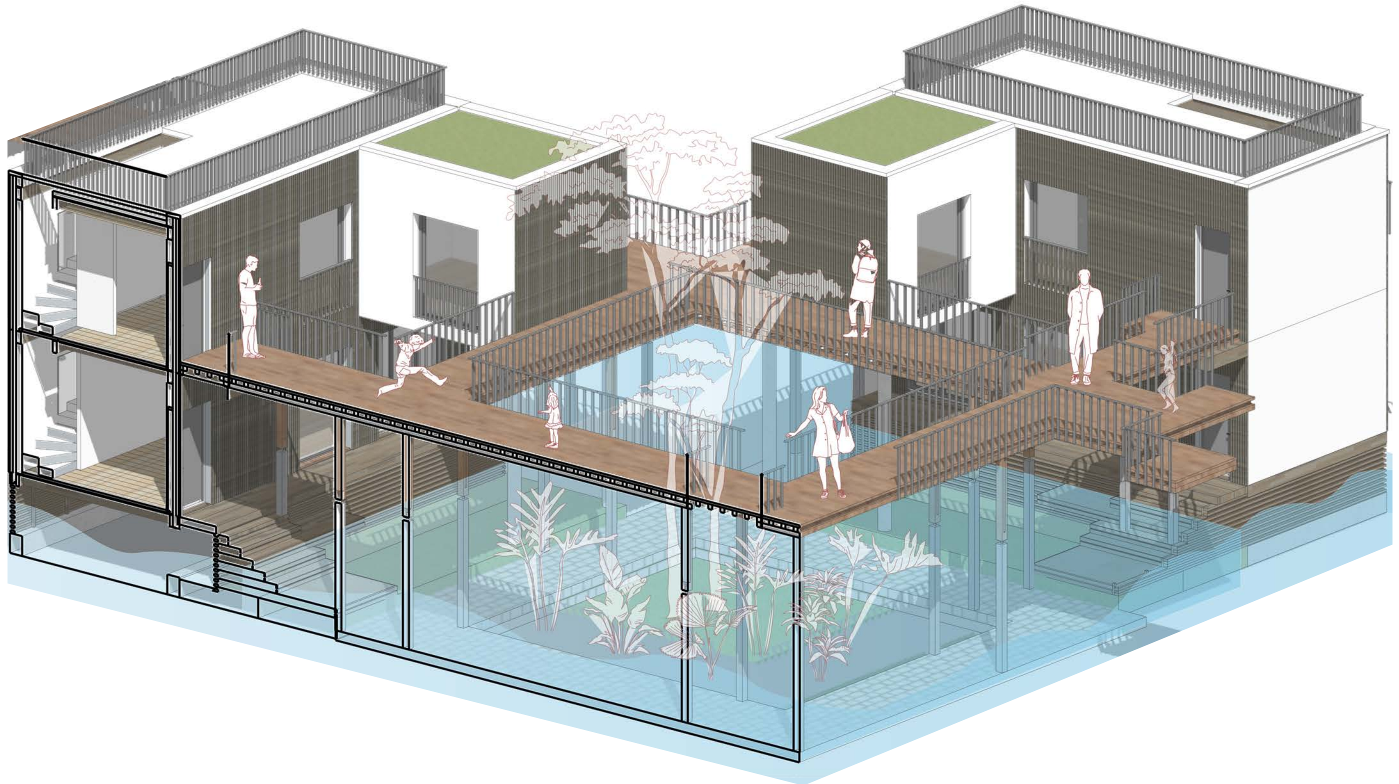


Figure 120. Stilt Houses Winter (Authors own diagram)

Figure 121. Stilt Houses in Winter from Ground View(Authors own diagram)

Figure 122. Stilt Houses Walkway view (Authors own diagram)

Flooding Houses

Figure 123. Key Plan (Authors own diagram)

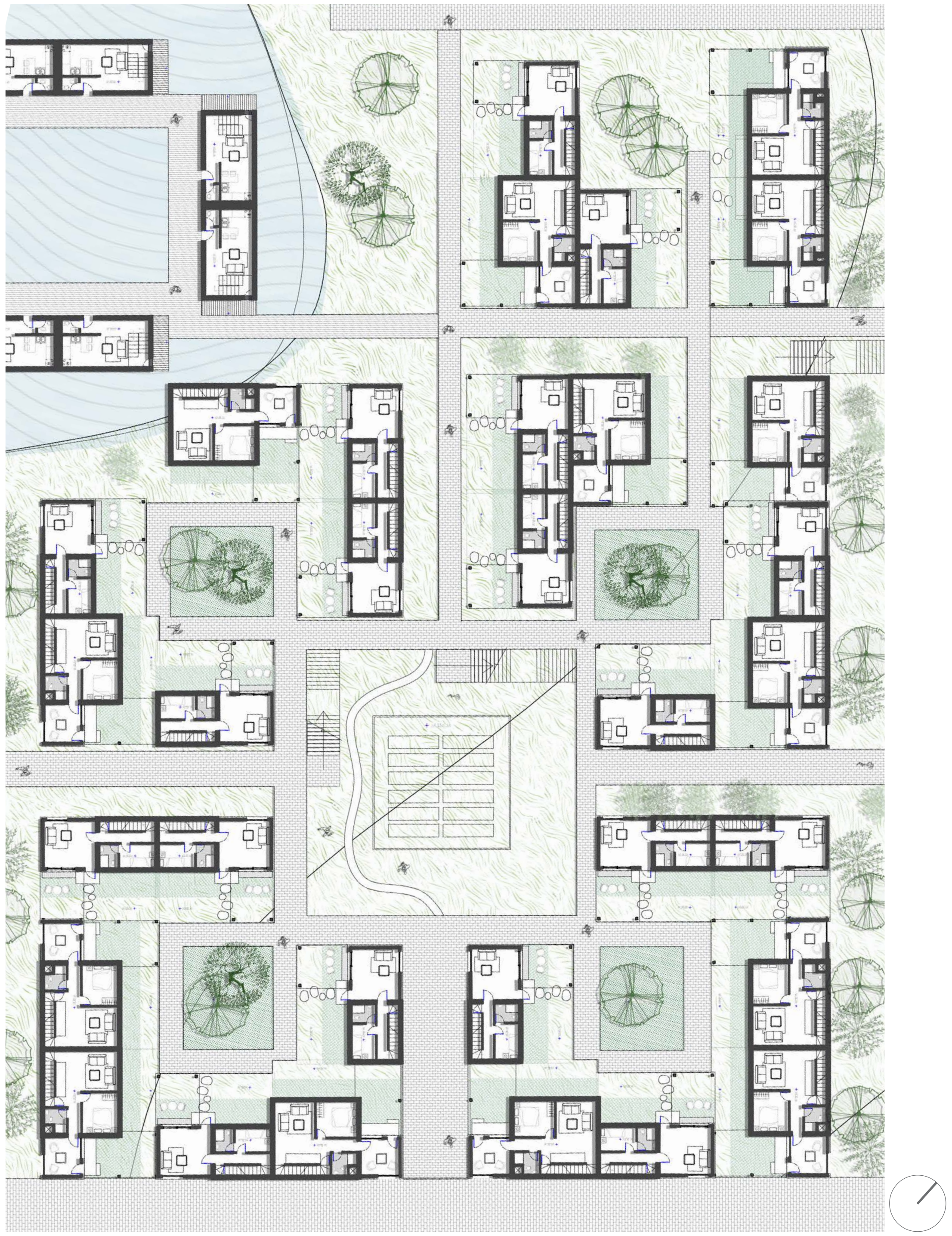


Figure 124. Flooding Houses Summer (Authors own diagram)

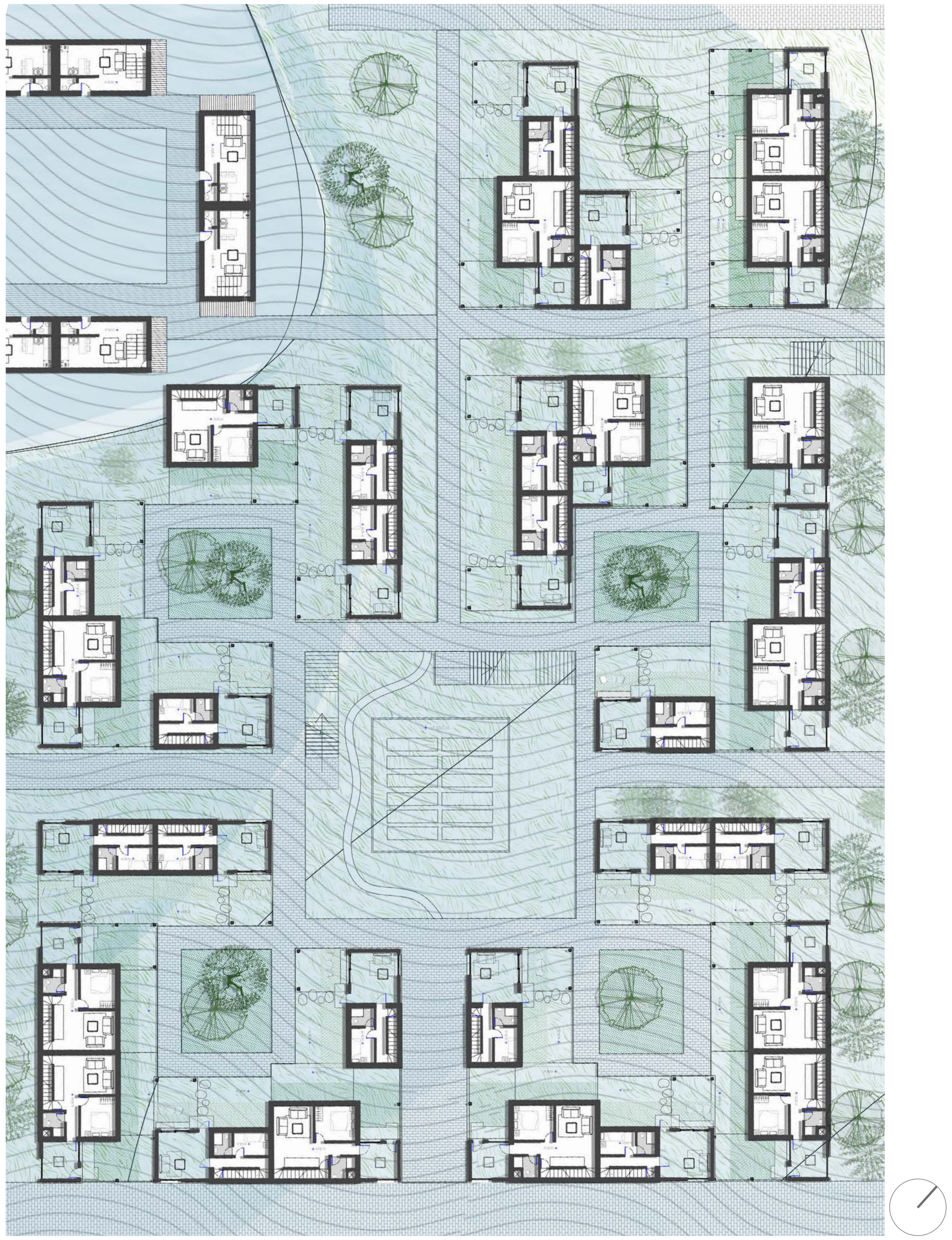


Figure 125. Flooding Houses Summer (Authors own diagram)

Figure 126. Key Section (Authors own diagram)

The housing typologies that experience the highest degree of flooding incorporate a dual-ground floor strategy, consisting of two distinct structural elements. One segment is constructed with thick, fully waterproof reinforced concrete walls, engineered to resist hydrostatic pressure and ensure durability during flood events. The second segment is an optional, user-defined extension that is deliberately non-waterproof and designed to allow water ingress during flooding. This adaptable space can be customized or omitted entirely based on individual user preferences prior to construction, offering flexibility in use and engagement with the dynamic water landscape.

Figure 127. Flooding Houses Summer (Authors own diagram)

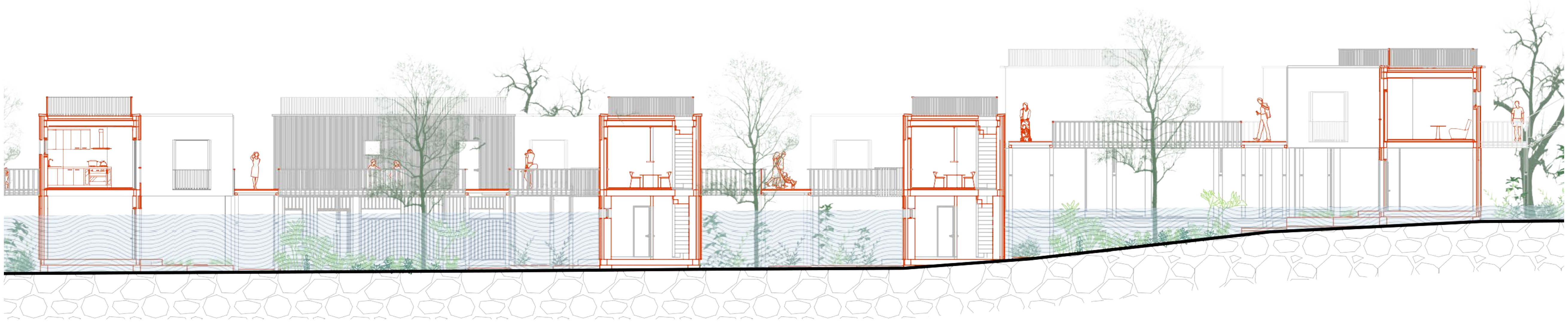


Figure 128. Flooding Houses Summer (Authors own diagram)

Figure 129. Flooding Houses Ground View (Authors own diagram)

Figure 130. Flooding Houses Walkway View (Authors own diagram)

Amphibious Houses

Figure 131. Key Plan (Authors own diagram)

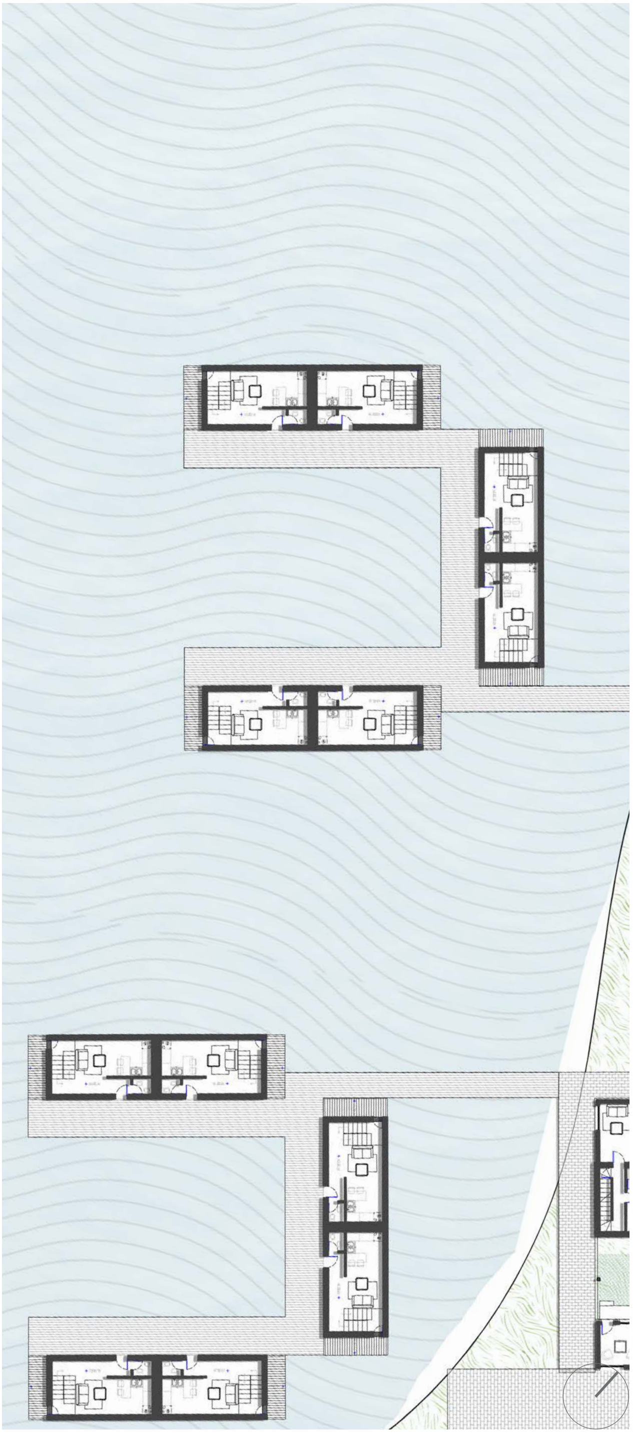


Figure 132. Amphibious Houses Summer (Authors own diagram)

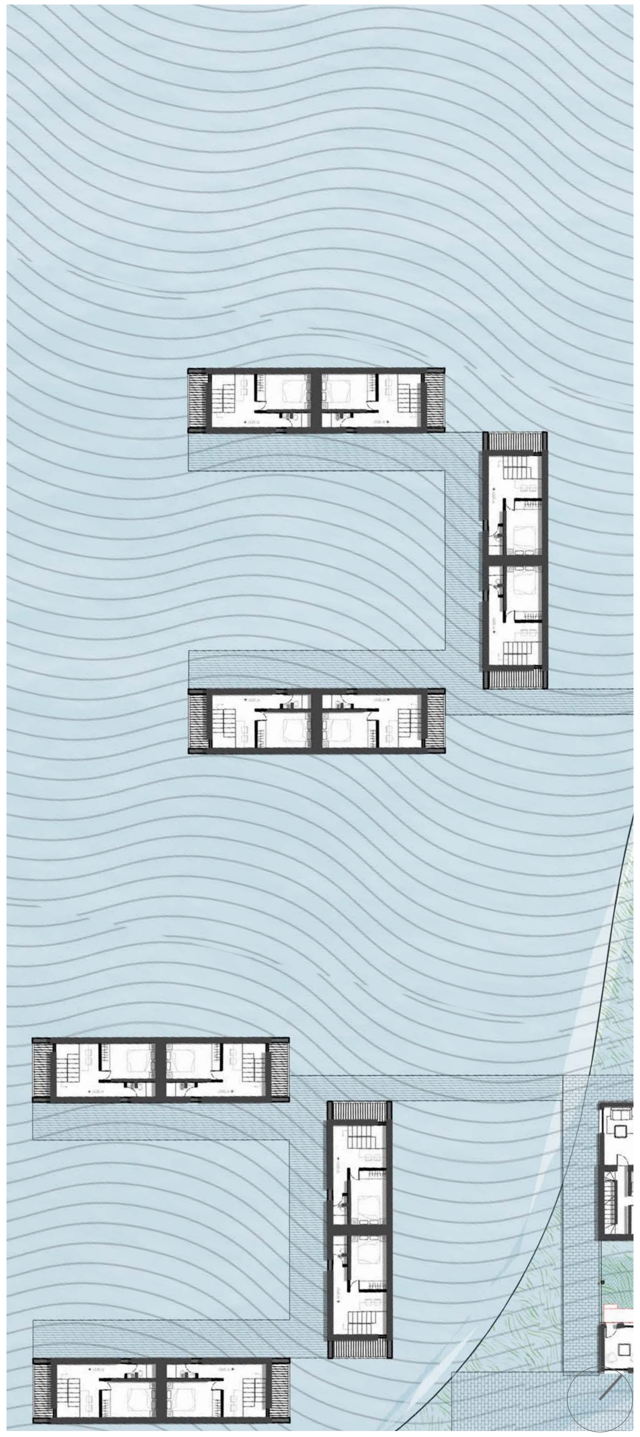


Figure 133. Amphibious Houses Winter (Authors own diagram)

Figure 144. Key Section (Authors own diagram)

Amphibious Houses are designed to respond dynamically to fluctuating water levels, rising with floodwaters and descending as water recedes. These dwellings are anchored by vertical mooring poles, which guide their vertical movement and prevent lateral drift. A buoyant concrete base provides stability and ensures the structure remains level as it floats. During periods of high water, elevated deck connections maintain access and circulation, enabling uninterrupted entry and movement between the dwelling and surrounding infrastructure. This system allows the house to adapt fluidly to changing hydrological conditions while ensuring safety, accessibility, and structural integrity.

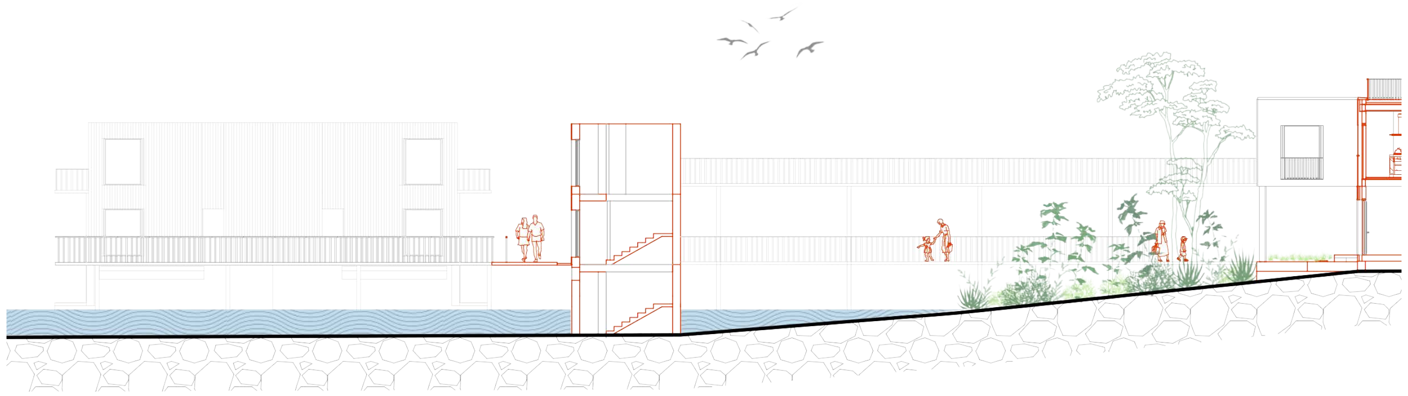


Figure 155. Amphibious Houses Summer (Authors own diagram)

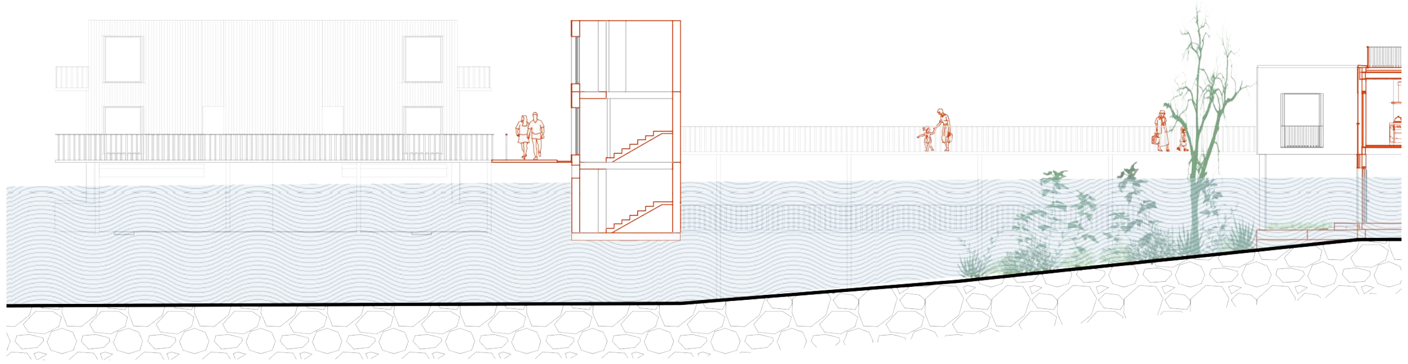


Figure 156. Amphibious Houses Winter (Authors own diagram)

Figure 157. Amphibious Houses in the lake (Authors own diagram)

While Dry Houses and Stilt Houses maintain similar spatial configurations—given that stilt houses are essentially vertically elevated versions of dry dwellings—the Floodable Houses diverge in layout due to the seasonal inactivation of the ground plane. In floodable typologies, the lower level becomes unusable during high-water periods, prompting a functional reorganization: primary activity zones such as the kitchen, living, and dining areas are relocated to the upper level with a dedicated external entrance, while private spaces like bedrooms are positioned on the lower level, designed to withstand temporary disuse or water exposure.

In contrast, Amphibious Houses are more compact in form, designed to float or adjust vertically with fluctuating water levels. Their layout is vertically layered to accommodate buoyancy systems and hydrological constraints. Bedrooms are typically placed at the basementor lowest level, followed by an intermediate living and kitchen space, and capped with a master bedroom and terrace on the top floor—offering both privacy and elevated outdoor space. This stratification supports both spatial efficiency and adaptability to changing water conditions.

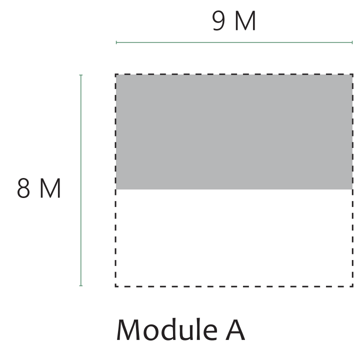
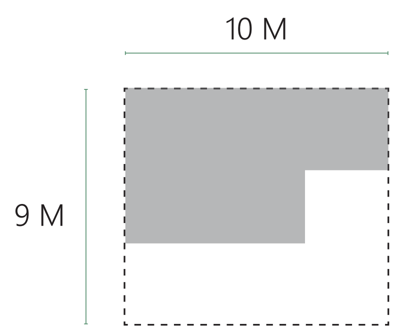


Figure 158. Dwelling typologies Module A (Authors own diagram)

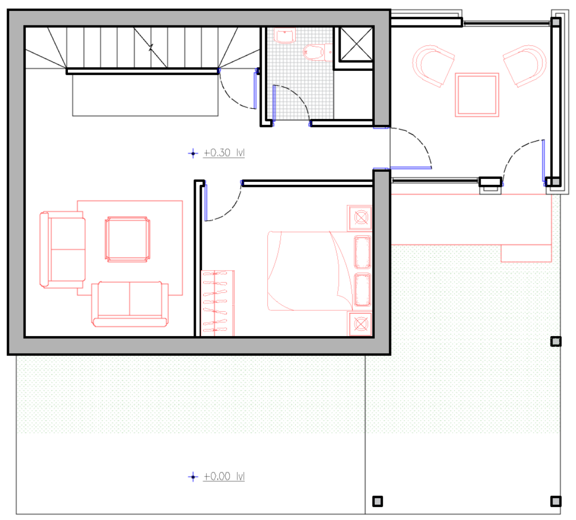


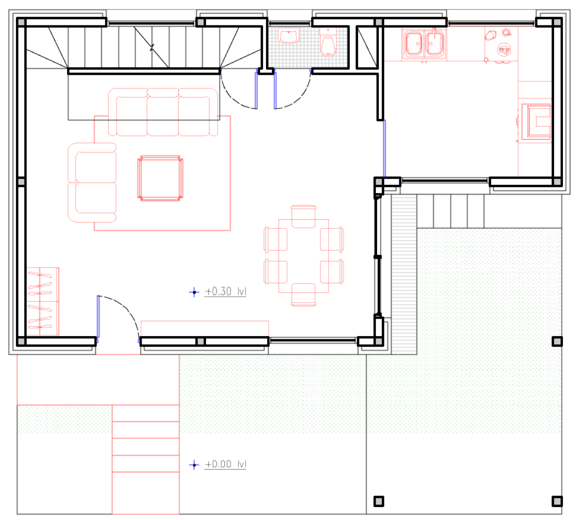
Module B

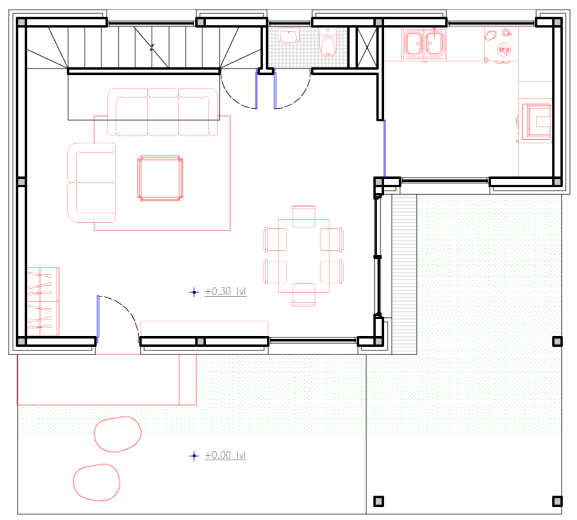
Flooding Houses

Houses on Stilts

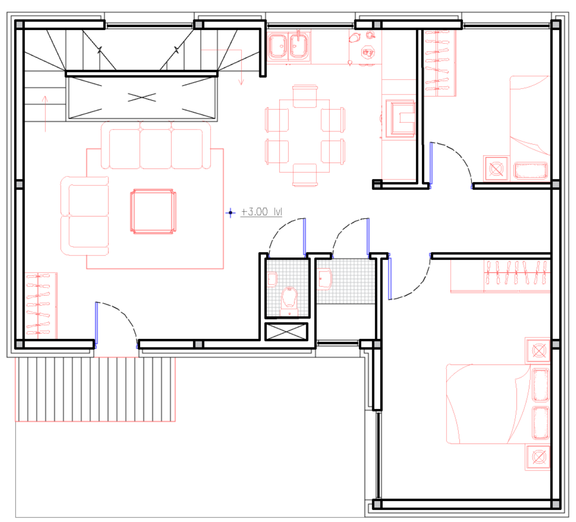
Dry Houses

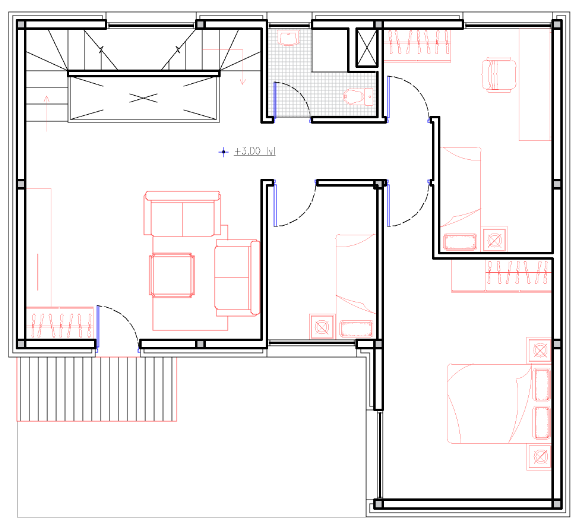


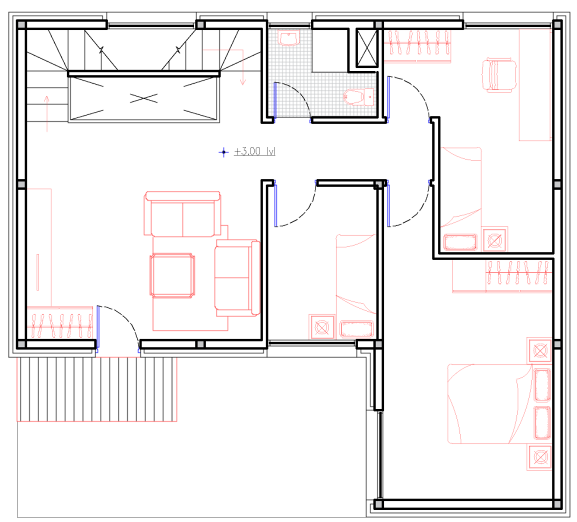




Ground Floor







First Floor

Figure 159. Dwelling typologies Module B (Authors own diagram)

Circulation and multi-level framework

The design, informed by the site's natural topography, results in subtle level variations that generate a rich diversity of spatial experiences. These elevation changes are leveraged to create multiple thresholds and programmatic zones within the housing system. Strategically integrated voids and buffer spaces function as light wells and ventilation corridors, enhancing passive environmental performance and spatial permeability. Additionally, the design incorporates elevated circulation pathways, carefully interconnected to ensure continuity and accessibility. These elevated routes not only facilitate daily movement but also serve as designated escape routes, strengthening the overall resilience of the settlement in response to flood events.

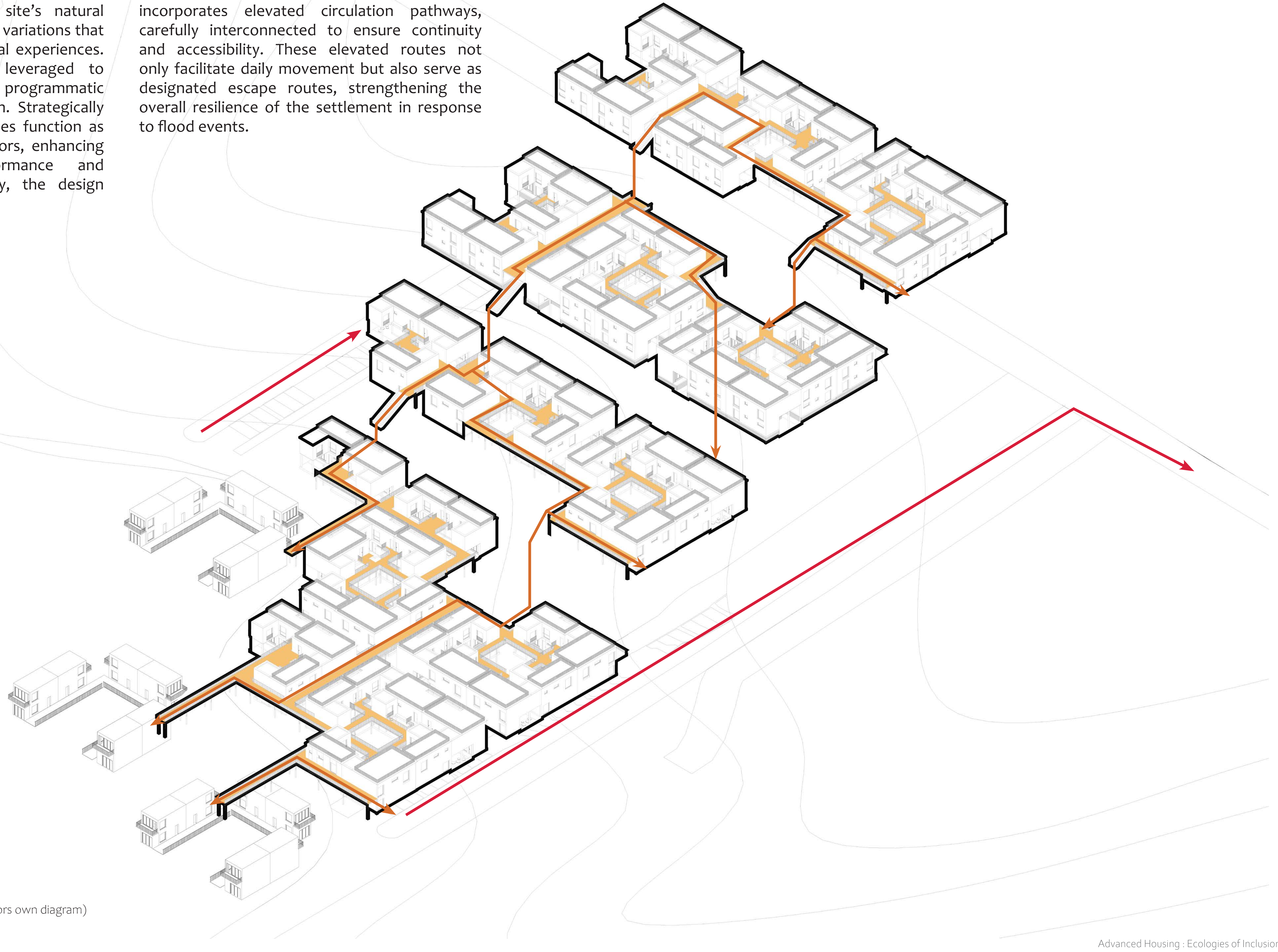
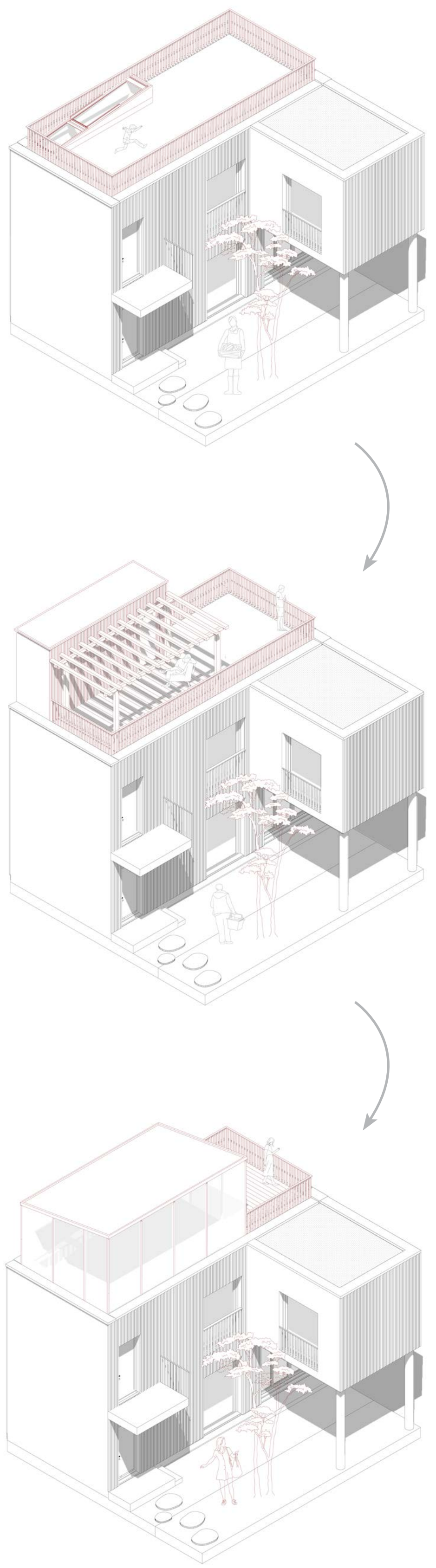


Figure 160. Circulation and levels (Authors own diagram)

Figure 161. Side Elevation of the houses (Authors own diagram)

Possible growth in Units



Phase 1

Phase 2

Phase 3

Figure 162. Possible phases of growth in Units (Authors own diagram)

The design concept is rooted in the principles of incrementality and growth, allowing for long-term adaptability from the outset. Each housing unit is conceived with access to a private roof terrace, which can be customized by residents within defined spatial and structural parameters. Initially delivered as simple, functional core units, these homes are intentionally modest—designed to empower residents to personalize and transform them over time. Through thoughtful spatial planning, the rooftop platform becomes a site for potential expansion or enhancement. Residents may choose to incorporate elements such as a pergola, a roof garden, a seating area, or even construct an additional room or studio above the original terrace slab, provided it aligns with the structural and zoning constraints.

While the notion of incrementality is not commonly embedded in Dutch housing models, this approach fosters resident agency and creative autonomy. By allowing small-scale, user-driven modifications within the bounds of their plot, the design promotes a balance between standardization and personalization, enabling homes to evolve organically in response to changing needs and aspirations.

Figure 163. Landscape blends with the built (Authors own diagram)

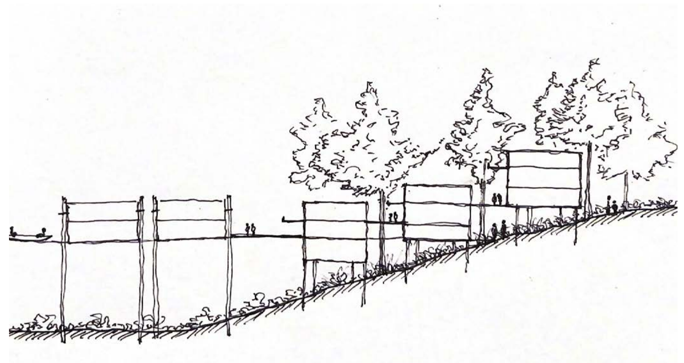
Figure 164. Central communal spaces (Authors own diagram)

BUILDING TECHNOLOGY

Landscape Integration

Sustainability

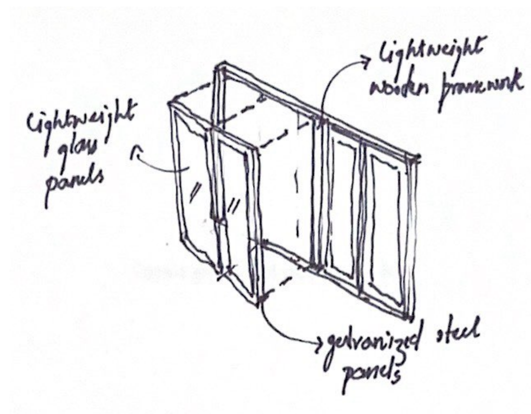
Landscape integration has been central to the design from the outset. By utilizing the site's existing water features, each unit is designed to be self-reliant in terms of water and sanitation management. This approach not only conserves energy and promotes environmental awareness but also reduces long-term energy use and associated costs.



Lightweight&Affordable

Lower Carbon Footprint

To address the themes of affordability and environmental awareness, it was essential to use lightweight, cost-effective materials. This led to designing compact units that occupy less square meterage and utilize low-cost, low-carbon materials, thereby minimizing environmental impact while maintaining economic feasibility.



Scalable Structure

Design for people

The concept of modular, scalable units allowed for certain components to be expanded in the future, offering flexibility for growth and emphasizing simple, adaptable expansion methods.

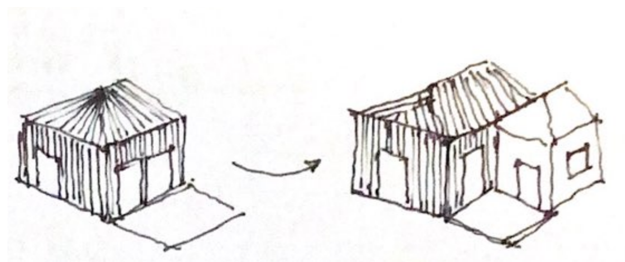


Figure 165. Building Technology Goals (Authors own diagram)

Facade Concept

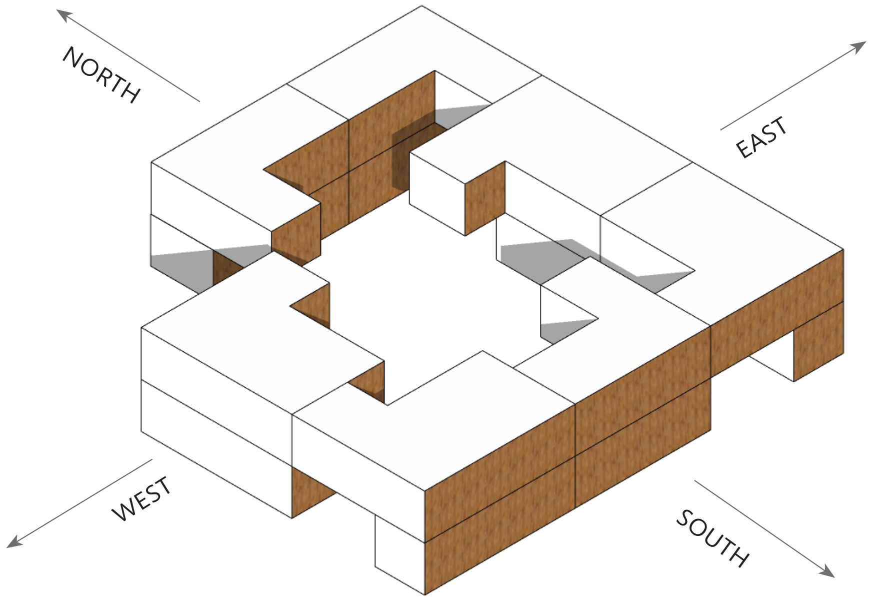


Figure 166. Facades reacting to orientation (Authors own diagram)

The housing units are designed with an emphasis on passive design strategies, particularly in response to solar orientation. Facades facing the south and north, which are exposed to more intense sunlight, are clad in durable Accoya wood. This cladding system includes an air cavity behind the timber, enhancing thermal performance by allowing ventilation that helps to cool the façade in summer and retain warmth in winter. In contrast, the east- and west-facing facades, which receive less direct solar radiation, are finished with a cost-effective plaster, reducing material expenses while remaining functionally sufficient.

This deliberate variation in material treatment not only improves the building's thermal comfort and energy efficiency, but also introduces an alternating material rhythm, contributing to the visual identity and architectural coherence of the housing cluster.

Ventilation

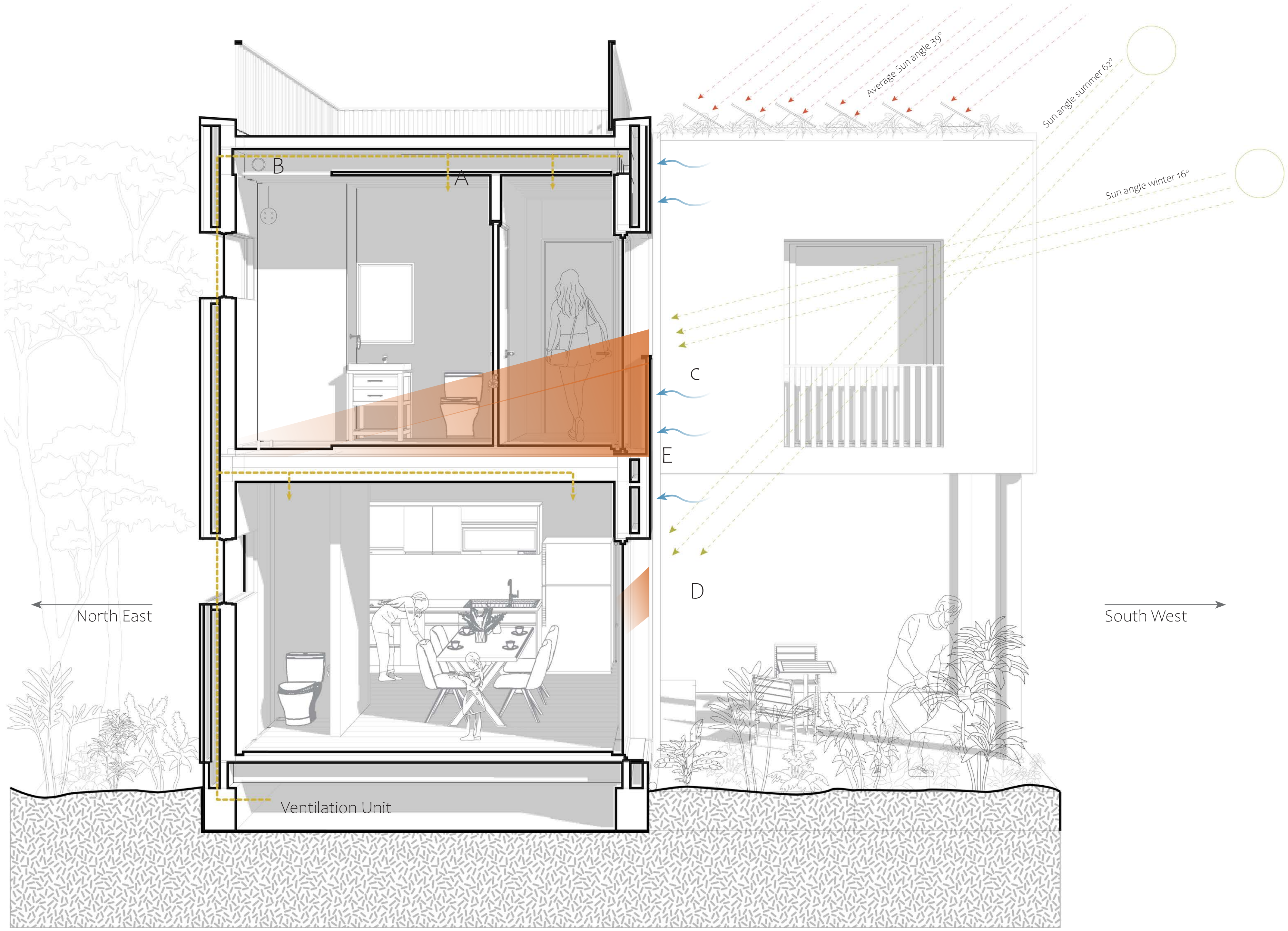


Figure 167. Ventilation of each unit (Authors own diagram)

Ventilation

A. The building is ventilated with ventilation type D, and is heated and cooled via ventilation through an AHU (LBK). The air supply takes place in the circulation areas.

B. The used air is removed in the toilets. The supply is visible, the discharge is behind a suspended ceiling.

C. Lower Winter Sun lights almost the entire part of the house

D. Harsher summer sun is blocked by indoor screens

E. Wood facade helps keep the building cool on North and South from direct sunlight

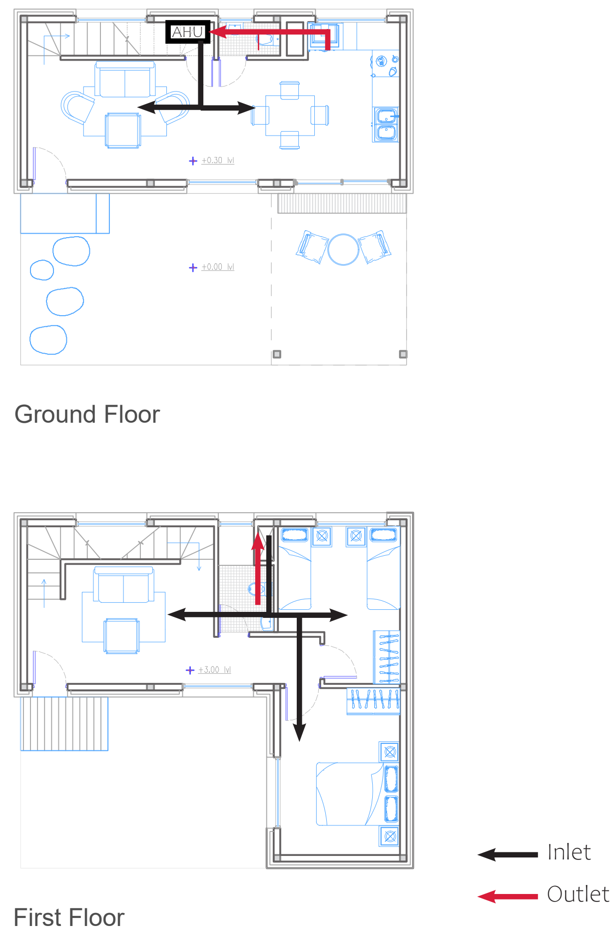


Figure 168. Ventilation system of unit (Authors own diagram)

Water Management

Each housing unit is equipped with an integrated water filtration and on-site sewage management system, promoting self-sufficiency and environmental sustainability. Rainwater harvesting is incorporated into the design, with collected water directed through helophyte (constructed wetland) filters for natural purification. This filtered water is then utilized for toilet flushing, while an additional filtration layer is applied to supply potable water for drinking and washing.

Greywater from taps and showers is channeled through a grease separator and septic tank, before being reintroduced into the helophyte system for further ecological treatment. This closed-loop system not only minimizes reliance on external infrastructure but also enhances the project's resilience, circularity, and environmental performance, aligning with principles of regenerative design.

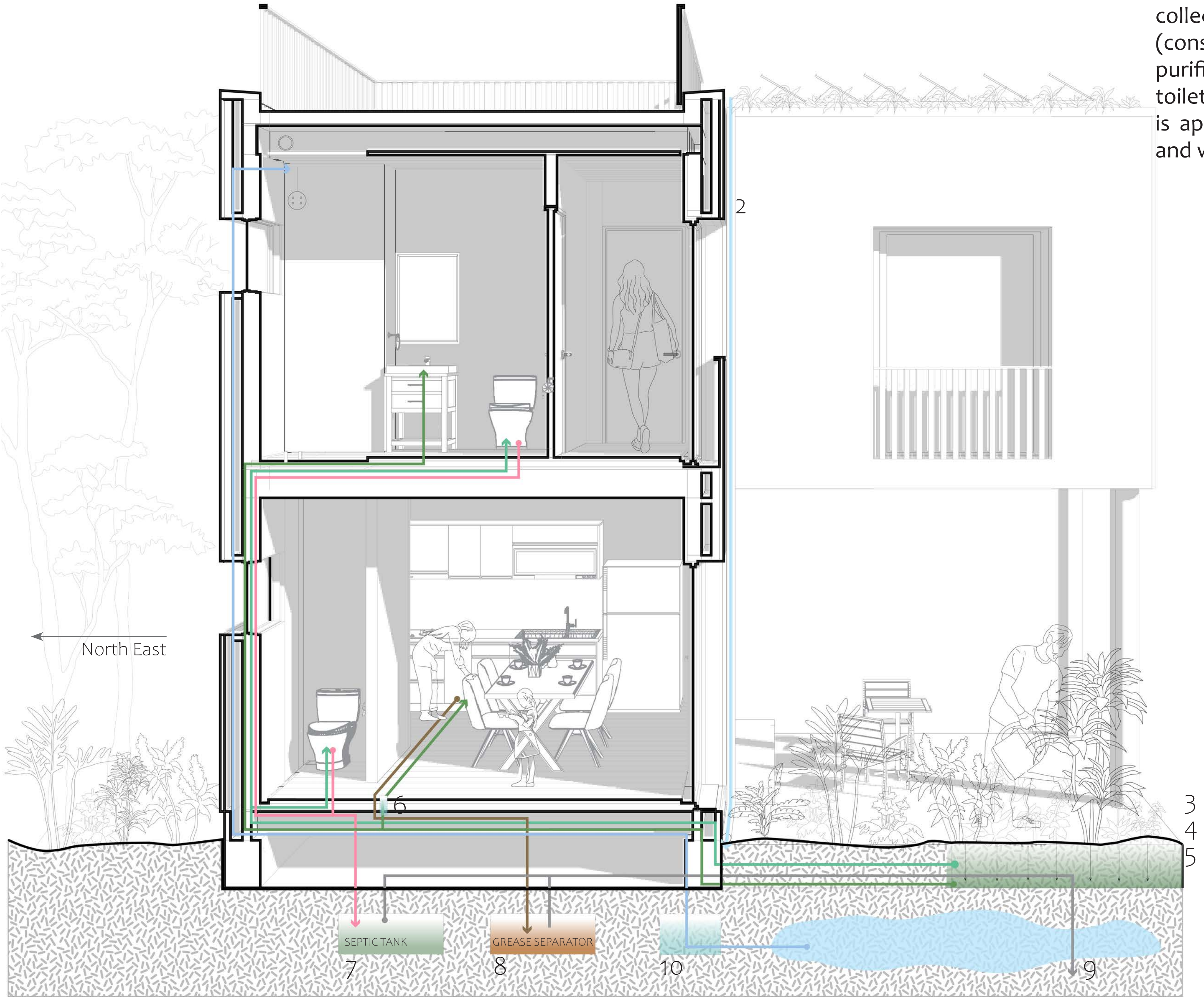


Figure 169. Water Management system of each unit (Authors own diagram)

1. Rainwater collection on the roof, 95200 L per month

2. Rainwater is used for irrigation of the saline agriculture in the courtyard and greenroof , surplus rainwater poured into the lake

3. Marsh plants in helophyte filter (bulrush, rush, sedge and arrowweed)

4. Pressure pipe in gravel bed

5. Drainage pipe with venting, after which the water is used for the toilets and outdoor taps (not drinking water)

6. Filtered water is purified with membrane filtration using osmosis, making the water drinkable

7. Drain tap and shower water into grease separator

8. Drain toilets in septic tank

9. Gray water again through helophyte filter installed with local plants into central courtyard system

10.Heat supply via a heat-cold storage (WKO),connected to a ground source heat pump. In summer, excess heat is stored in the ground so that it can be used in winter.

The helophyte filtration systems integrated within each individual unit are further connected to a centralized ecological treatment system located in the shared courtyard of every housing cluster. Each courtyard incorporates its own communal helophyte filter, serving as a secondary layer of purification.

Greywater from each unit first undergoes initial treatment on-site, then flows into a central separator within the courtyard for additional filtration. These courtyard systems are interconnected, forming a continuous ecological network that processes and purifies the water as it moves sequentially through multiple clusters. Ultimately, the treated water is discharged into the adjacent lake or water body, ensuring that only clean, filtered water is reintroduced into the natural system. This layered water management strategy not only enhances environmental resilience but also transforms the courtyards into productive, living infrastructure that supports ecological health and community well-being.

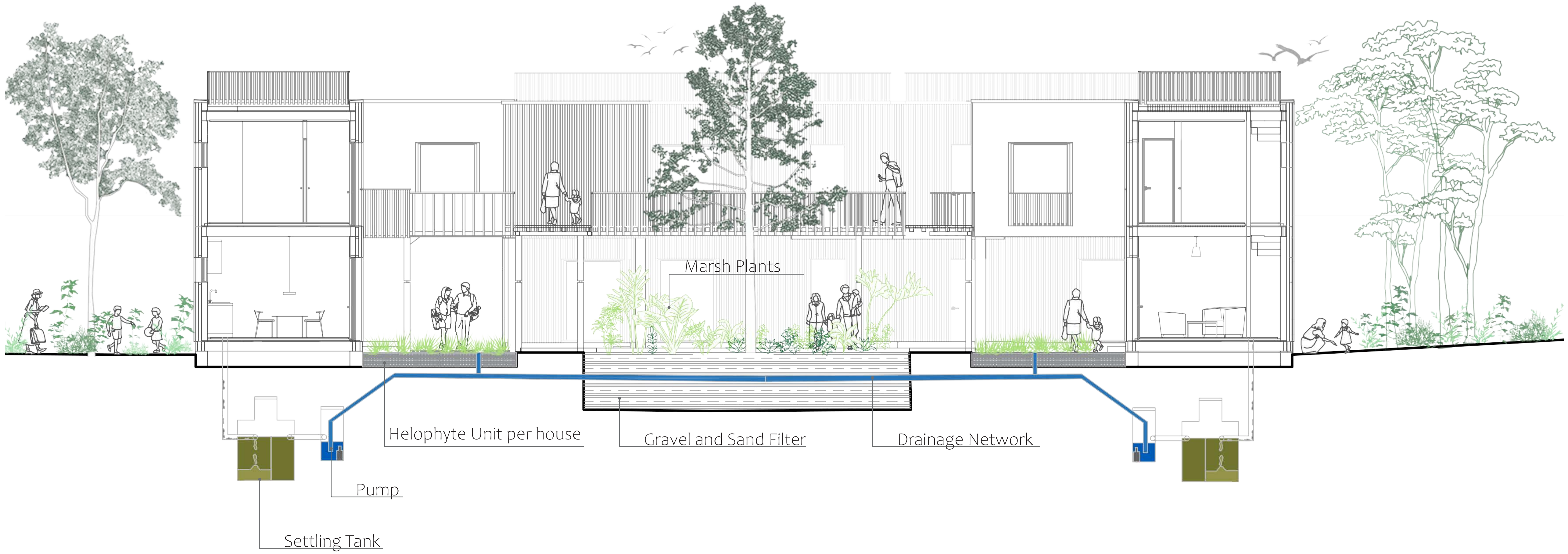


Figure 170. Helophyte system of every cluster (Authors own diagram)

During the winter season, when flooding occurs, the water management system transitions from the initial ground-based helophyte filters to a floating helophyte filtration system. This adaptive mechanism ensures that treated water is efficiently purified and discharged directly into the surrounding water bodies, even when the ground systems are submerged.

In contrast, the Dry Houses, which remain unaffected by seasonal flooding, continue to operate using their primary fixed helophyte filters, consistently directing filtered water into the river throughout the year. This dual filtration strategy—combining both static and floating systems—ensures uninterrupted sanitation, effective greywater management, and sustained environmental protection across varying hydrological conditions.

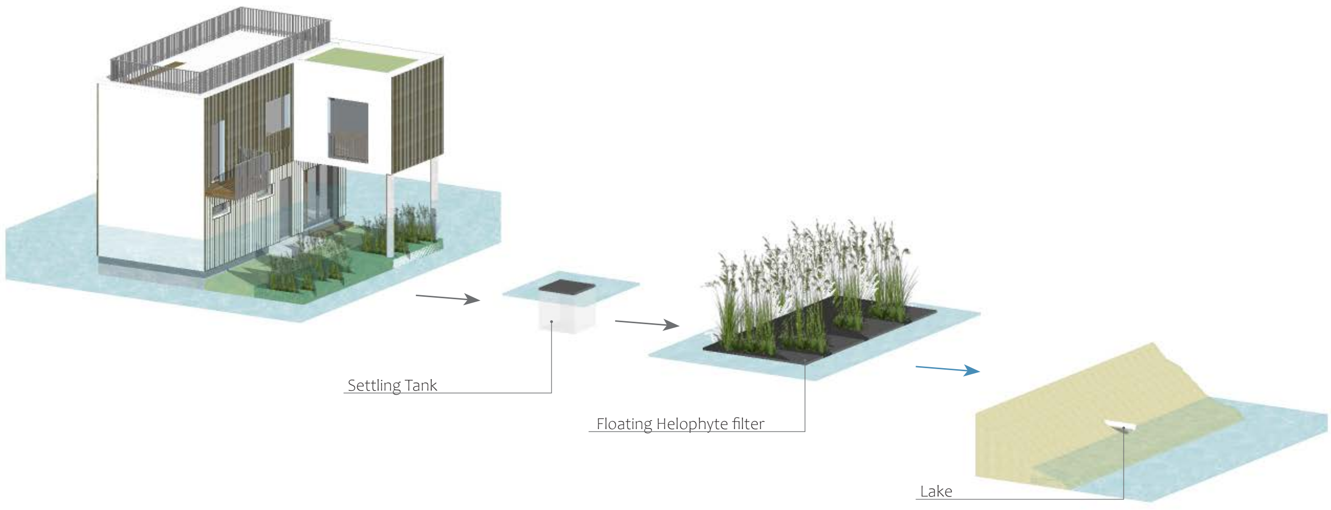


Figure 171. Water Management Winter Situation (Authors own diagram)

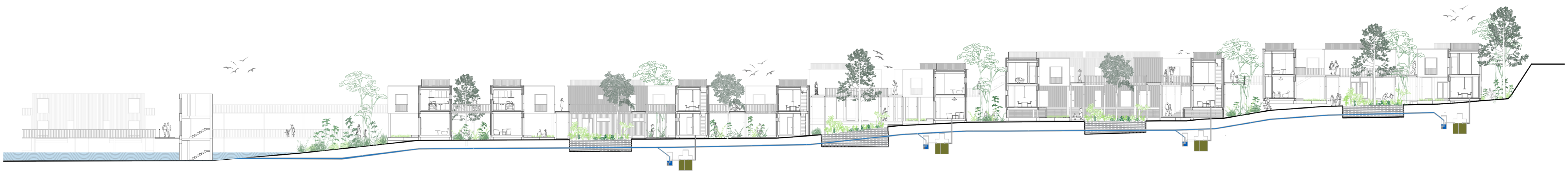


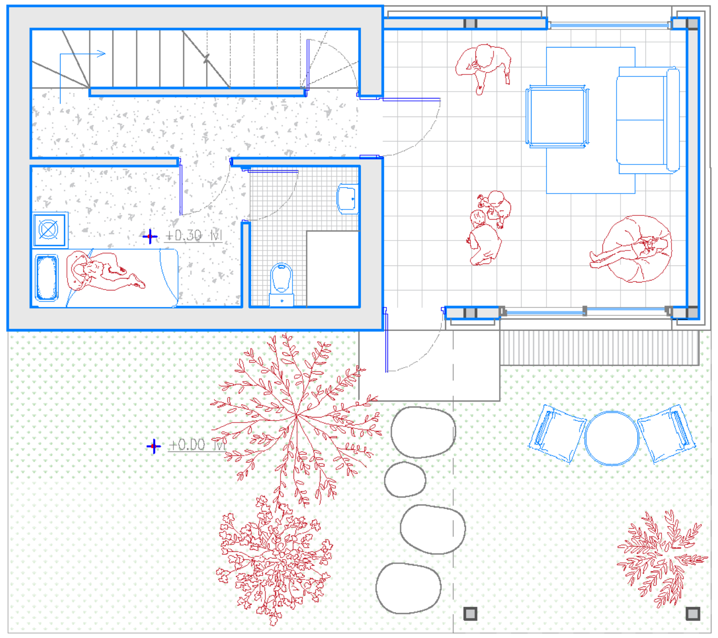
Figure 172. Helophyte system through site (Authors own diagram)

Figure 173. Floating Garden held by poles in filtering dirty flood water (Authors own diagram)

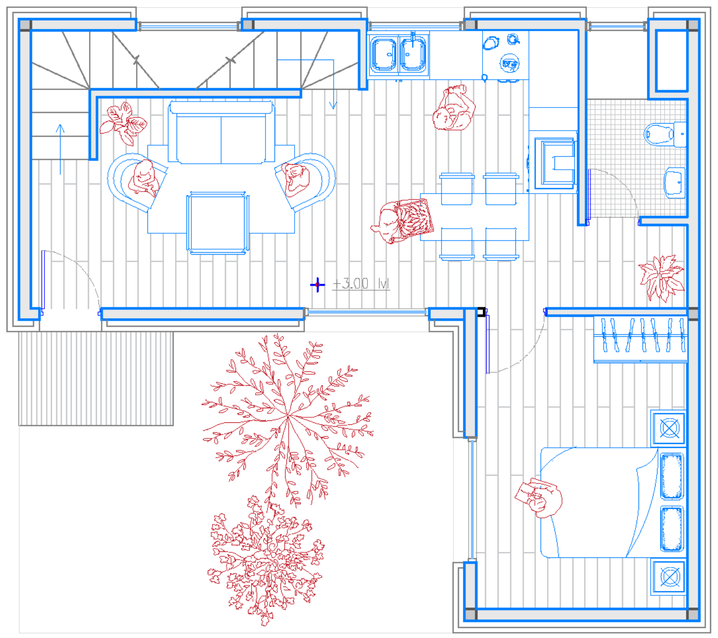
Dry and Flooding Houses

Given the scope and time constraints of this project, the study focused on detailing the building and structural systems of the various housing typologies to understand the constructional variations across unit types.

The Floodable Houses incorporate a robust waterproof base, as previously described, to withstand seasonal inundation. These units are designed with a reinforced concrete plinth or ground floor structure, providing resilience against hydrostatic pressure. Above this, a superstructure of Robinia wood—a durable, water-resistant hardwood—is employed. The exterior is clad in a hydroskin membrane, a water-tolerant façade material that enhances protection and supports the unit's performance in wet conditions.



Flooding House Ground Floor

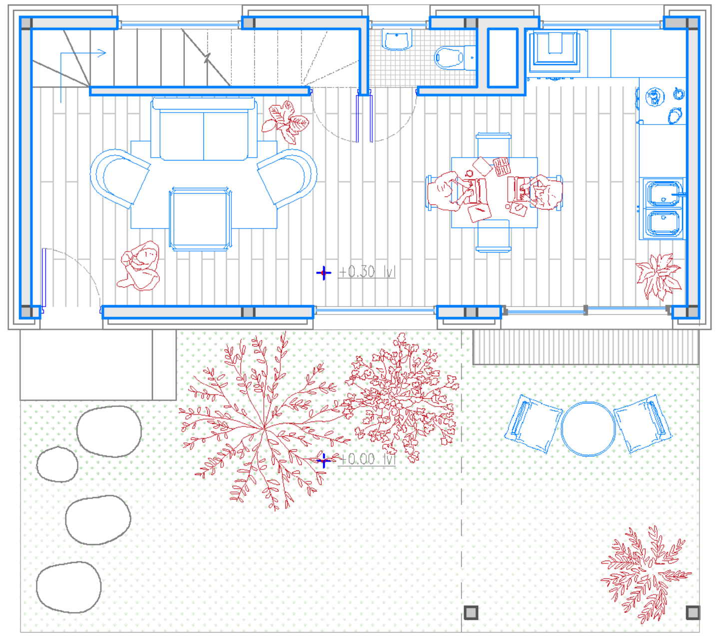


Flooded House First Floor

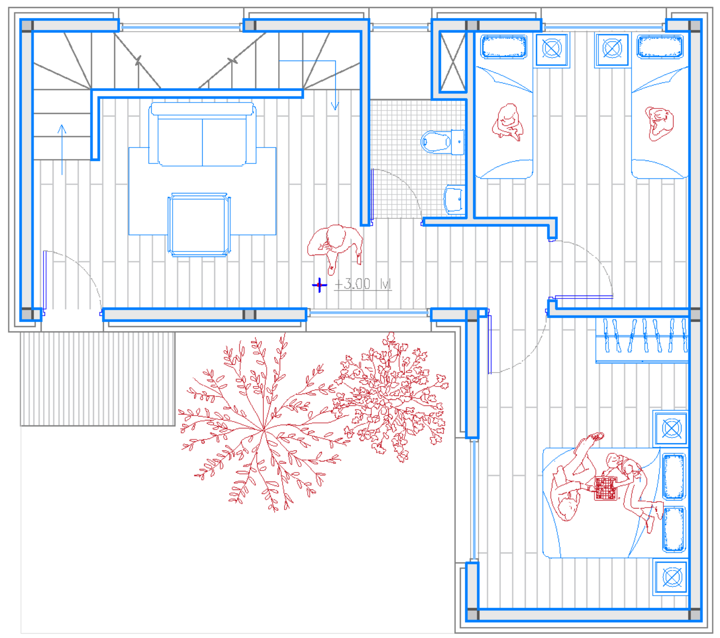
Figure 174. Buildup of Dry Houses (Authors own diagram)

In contrast, the Dry Houses are constructed using a lightweight timber frame system, primarily composed of pine wood, with external cladding comprising a combination of Accoya wood and plaster, depending on the façade orientation and exposure. This approach ensures a balance between durability, thermal performance, and cost-efficiency.

This comparative structural approach highlights how material choices and construction systems are tailored to respond to each unit's hydrological exposure and functional needs.



Dry House Ground Floor



Dry House First Floor

Figure 175. Buildup of Flooding Houses (Authors own diagram)

Flooding Houses

Dry Houses

Figure 176. Difference in Wall section and Elevation of Dry and Flooding Houses (Authors own diagram)

From a structural standpoint, the Flooding Houses adopt a post-and-beam timber frame system paired with a reused concrete base. This concrete plinth plays a critical role in ensuring the watertightness and structural stability of the building during prolonged exposure to water. In contrast, the Dry Houses utilize a more conventional shallow foundation system, appropriate for stable, non-flood-prone ground conditions.

Materiality further distinguishes the two typologies. A key innovation in the Flooding Houses is the use of Hydro-Skin—a lightweight, multilayer textile cladding originally developed by the University of Stuttgart. This fully recyclable and breathable membrane functions as a dynamic façade system: it absorbs moisture during periods of flooding and releases it in drier conditions. This adaptive behavior not only protects the timber structure but also plays an active role in sustainable water regulation, aligning with the project's broader environmental goals.

Figure 177. Structural framing of Dry and Flooding Houses (hydro-Skin (n.d.))

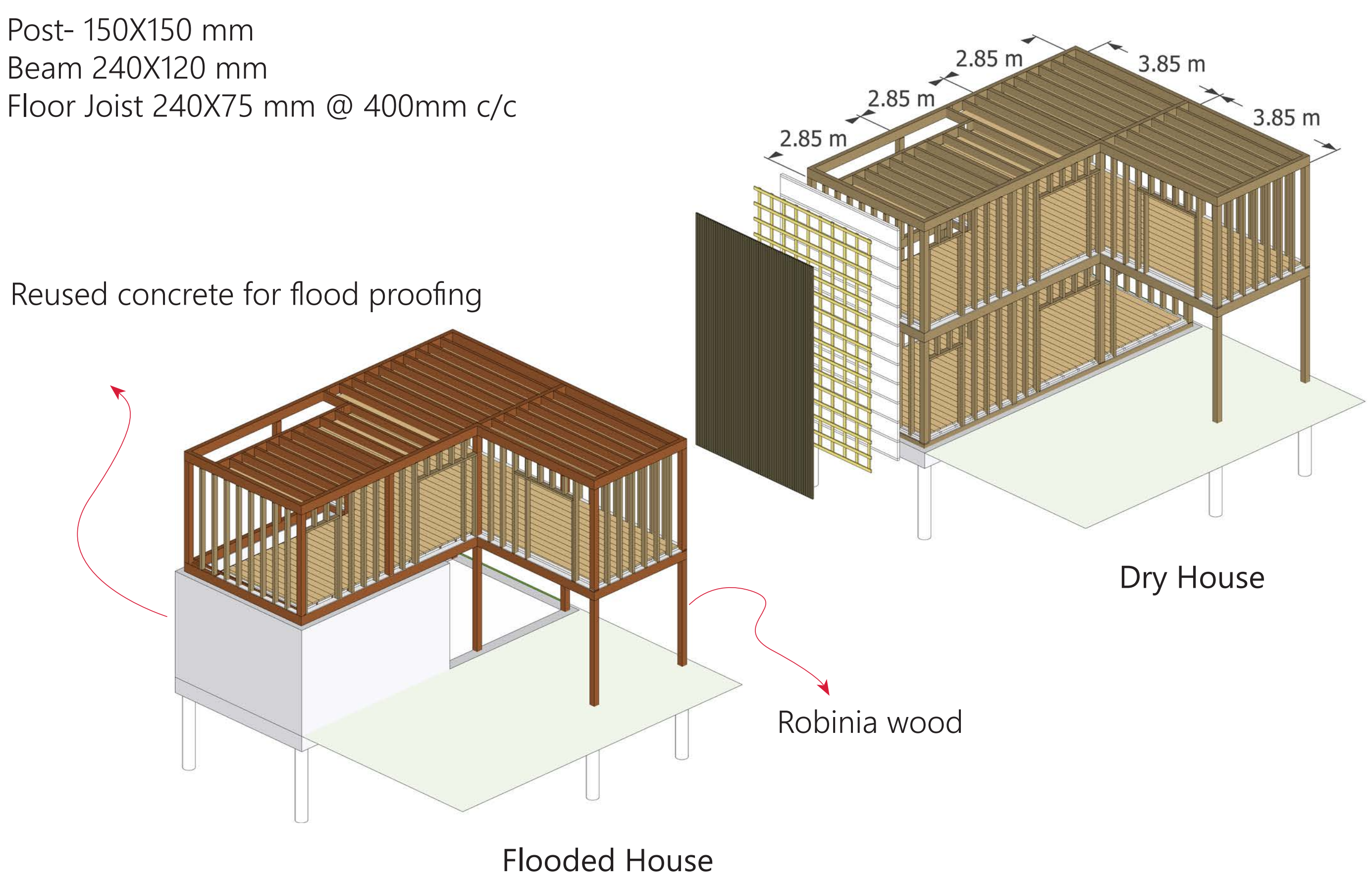


Figure 178. Structural framing of Dry and Flooding Houses (Authors own diagram)

The construction details of the Flooding House typology were studied in depth to examine both materiality and structural strategy. The primary aim was to explore how lightweight and sustainable materials could be prioritized while effectively addressing the challenges posed by fluctuating water levels. Special attention was given to designing with materials that are resilient to moisture, adaptable to changing environmental conditions, and environmentally responsible in terms of resource use and lifecycle impact. This detailing process aimed to strike a balance between performance, durability, and sustainability, supporting a construction approach that is both ecologically responsive and technically robust in flood-prone environments.

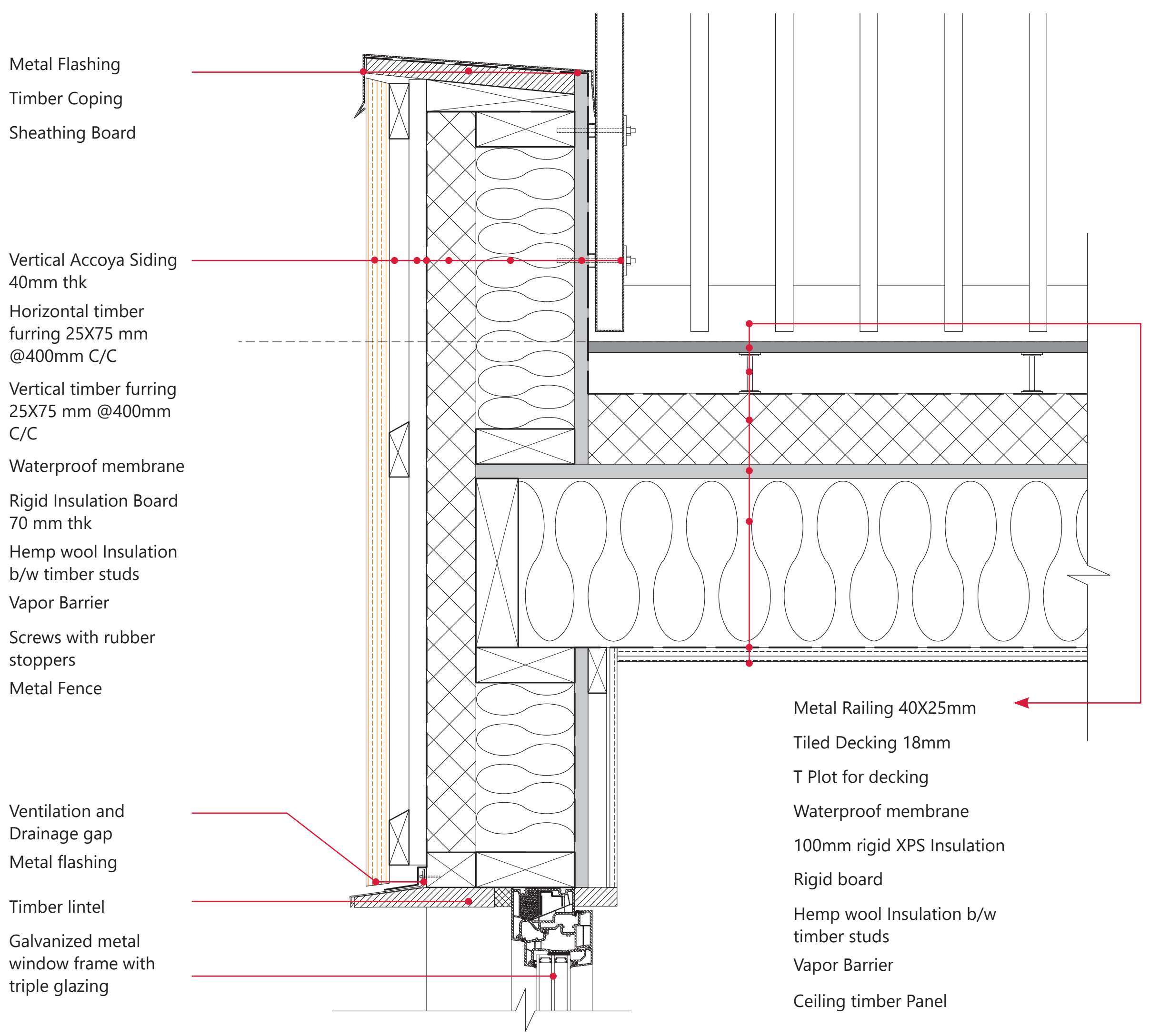
Figure 179. Details of Flooding Houses that were focused on (Authors own diagram)

Detail A illustrates the terrace assembly, emphasizing the design intent of accessibility and future adaptability. The terrace features modular decking and removable railing components, allowing for potential expansion or personalization by residents as part of the project's incremental growth strategy.

The detail also reveals the façade cladding system, which uses durable Accoya wood mounted with an air cavity behind it to enhance thermal performance and ventilation. Additionally, the drawing includes the terrace parapet detail, highlighting the integration between the cladding, railing, and waterproofing layers, ensuring both functionality and weather protection at the roof level.

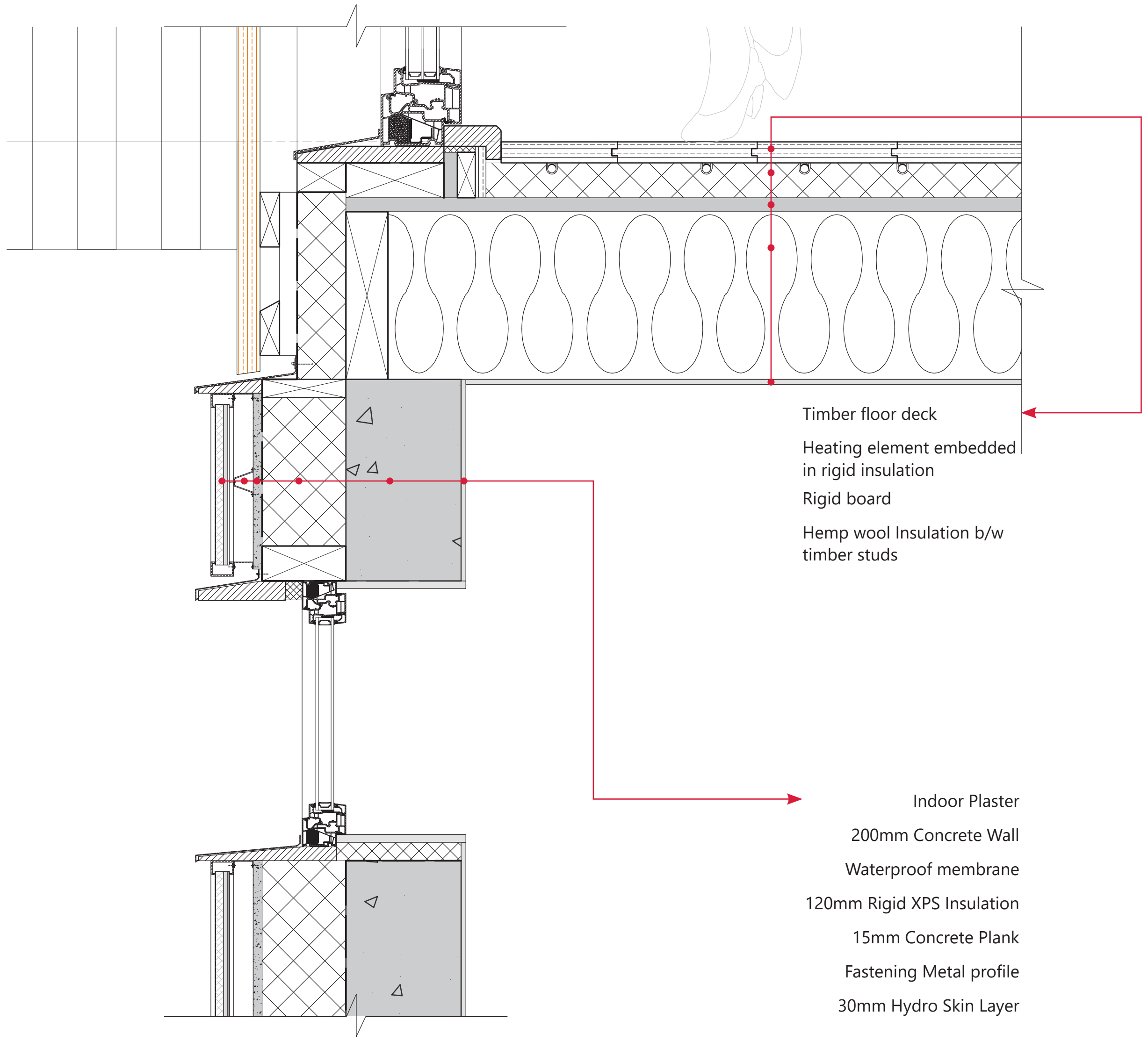
Detail B presents the junction between two façade systems—the timber cladding and the Hydro-Skin membrane—highlighting how these materials interface within the building envelope. The detail explores the integration of the breathable Hydro-Skin cladding, which remains in the conceptual phase by its developers, and is here interpreted based on available reference imagery and performance data.

This speculative construction detail proposes a method for mounting the lightweight, multilayer textile system alongside the Accoya wood cladding, ensuring continuity of insulation, ventilation, and moisture control. The detail aims to reflect how these two materials might coexist in a functional and visually cohesive manner, while supporting the project's broader goals of sustainability, flood adaptability, and innovative envelope design.



DETAIL A

Figure 180. Terrace Detail (Authors own diagram)



DETAIL B

Figure 181. Cladding Detail (Authors own diagram)

The foundation detail illustrates the use of continuous insulation along the entire base of the structure to enhance thermal performance and minimize heat loss. It also shows the integration of a geotextile membrane and a drainage layer, which work together to manage excess water during the flooding season by facilitating efficient subsurface drainage. This assembly supports the structural integrity of the foundation while contributing to the building's resilience against fluctuating groundwater levels.

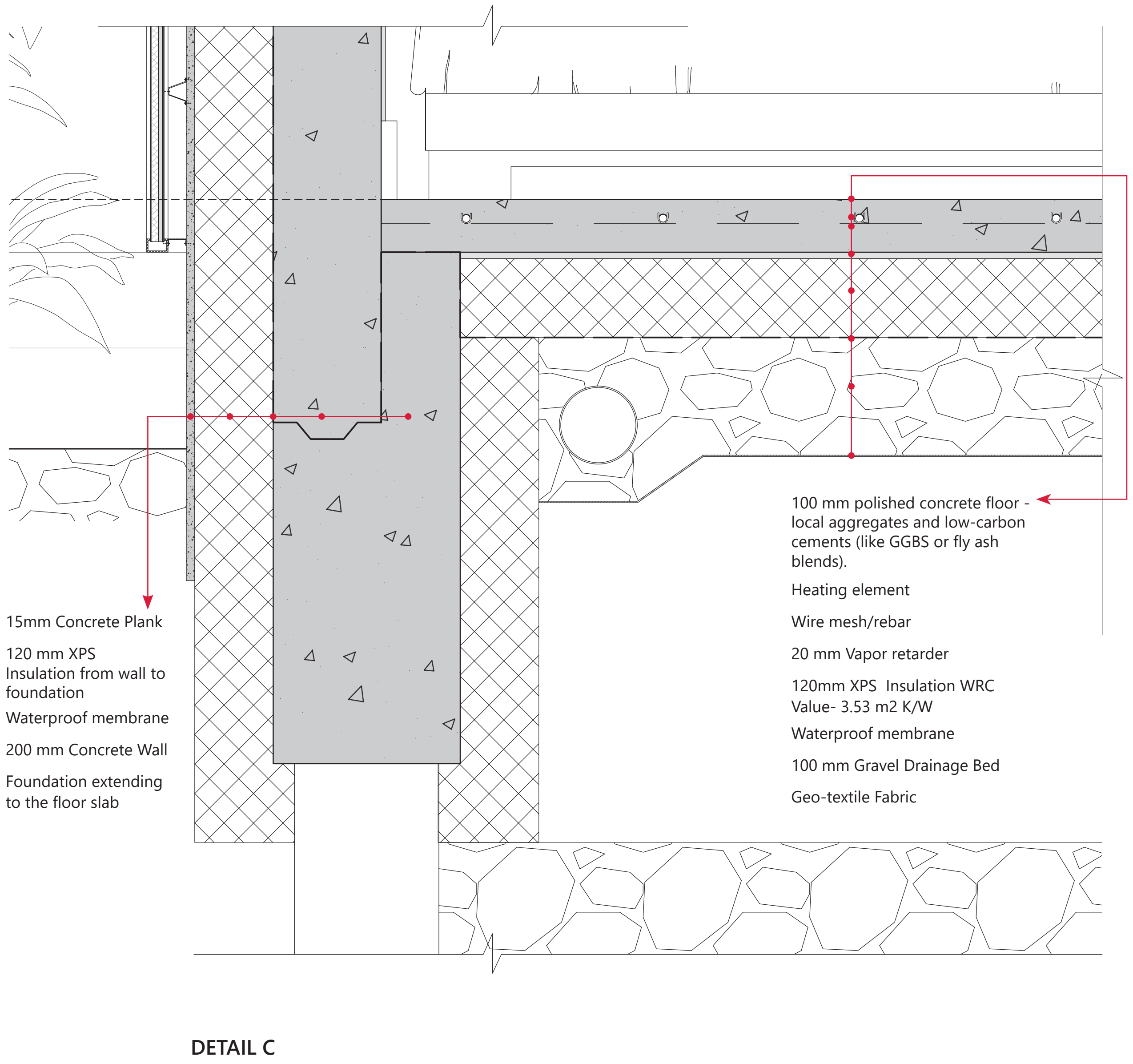


Figure 182. Foundation Detail (Authors own diagram)

The plan detail represents one of the possible interpretations of how the dual ground floor zones in the Flooding House typology may function. The first section illustrates the thick, reinforced concrete wall, designed to be completely waterproof and capable of withstanding hydrostatic pressure during seasonal flooding..

In contrast, the adjacent zone proposes a more sustainable and adaptable alternative—a floodable space constructed using a Robinia wood frame, integrated with air cavities to facilitate natural drying, and insulated with foamed glass, a water-resistant and reusable insulation material. The external cladding in this zone is designed to be removable, allowing panels to be taken off and dried after flooding events, then reinstalled for continued use. This approach not only enhances material circularity but also supports a resilient and low-maintenance flood response strategy, offering flexibility to residents based on their preferences and site conditions.

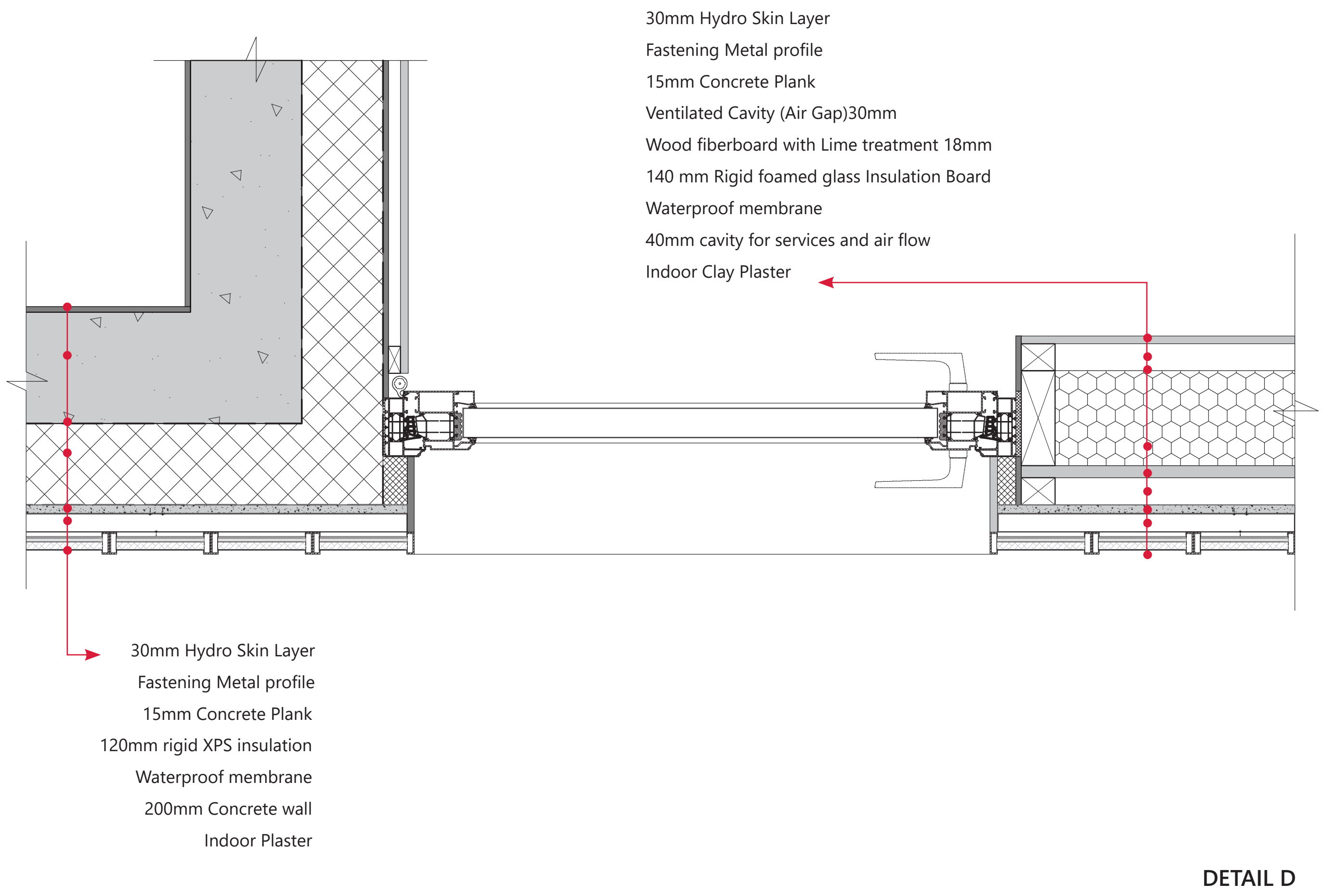
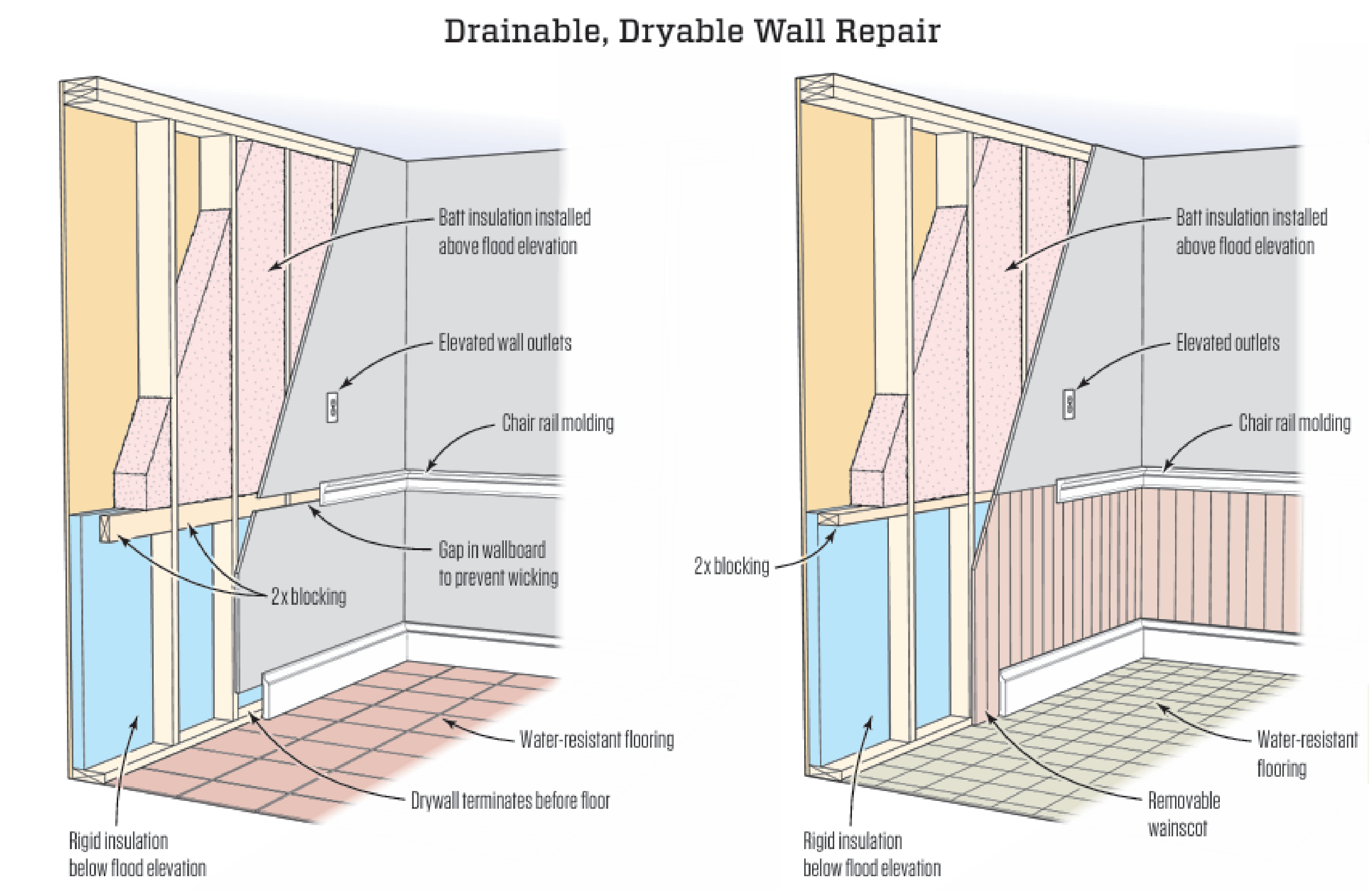


Figure 183. Plan Detail (Authors own diagram)

A key flood-resilience strategy incorporated in the floodable zones of the houses is the "wash-and-wear" construction approach. This method employs water-tolerant materials in the lower wall sections to facilitate rapid and efficient post-flood recovery. Features include removable wainscoting, rigid insulation installed below the flood level, elevated electrical outlets, and water-resistant flooring, all designed to minimize flood damage and enable swift cleaning, drying, and reoccupation.

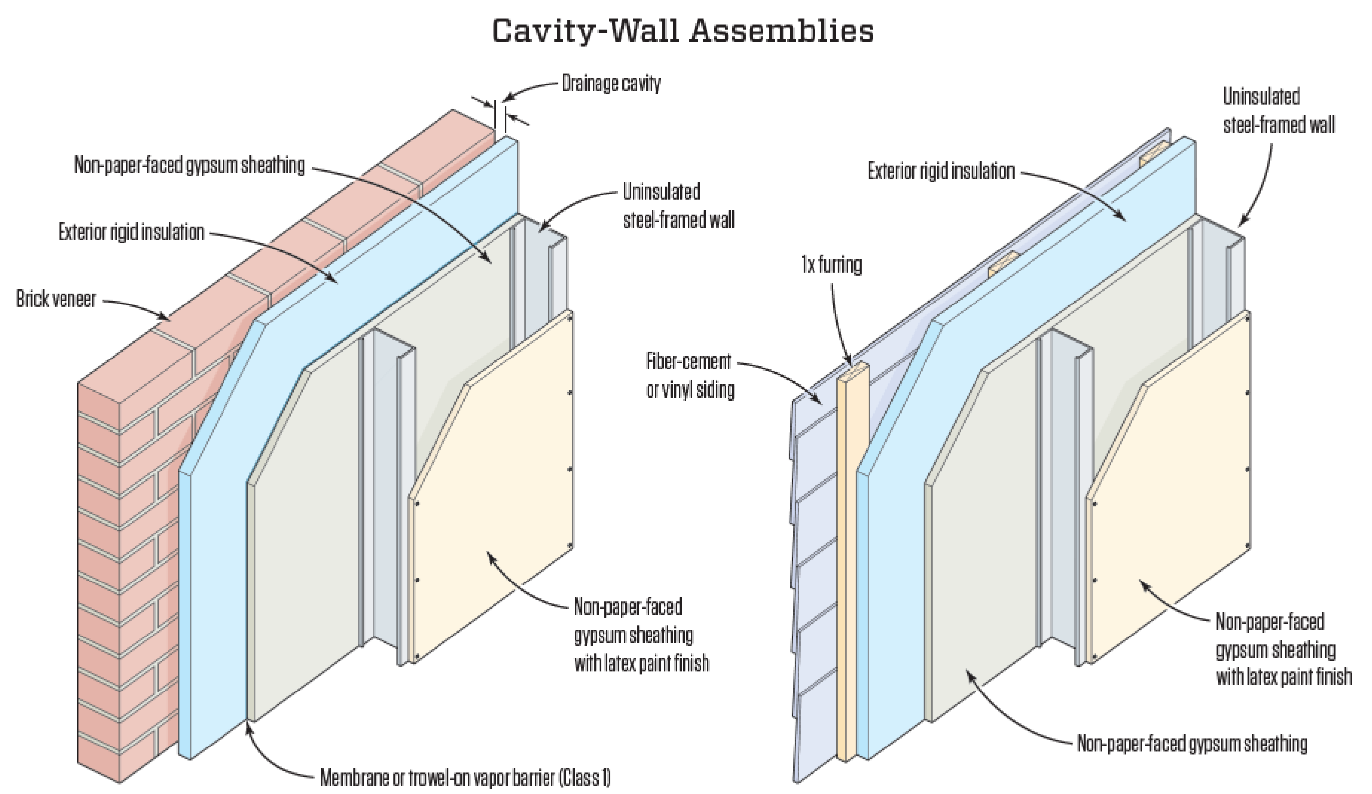
This strategy offers a cost-effective and incremental form of wet floodproofing, particularly suitable for dwellings that cannot be elevated due to site or regulatory constraints (Cushman, 2017). Beyond its practical benefits, the wash-and-wear approach introduces a new paradigm for flood adaptation, envisioning a sustainable coexistence with water that addresses the increasing frequency of extreme flood events while promoting resilient, environmentally responsible living.



(Figure 184. The drawing above illustrates the "wash-and-wear wall" concept for flood repair on existing homes advocated by Professor Claudette Reichel, director of the Lousiana State University (LSU) Ag Center's "LaHouse" project, and included by FEMA as a suggestion in the agency's advice for repairing flooded homes. Upper portions of the wall are left as is, while lower portions receive flood-tolerant materials. If flood recurs, lower portions of the wall will be easier to clean, dry, and put back into service. (Cushman , 2017))

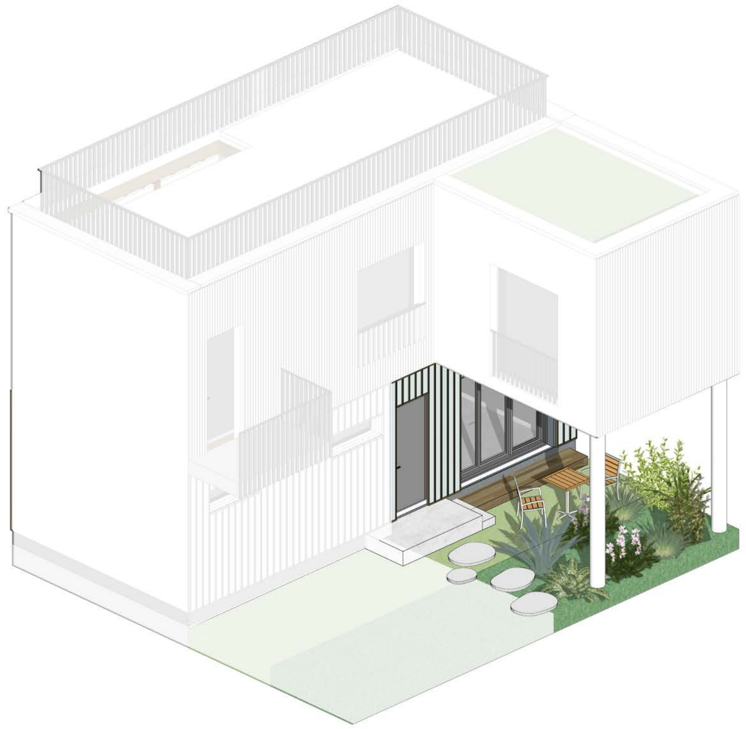
While materials such as galvanized steel are often preferred for their superior water resistance and durability, the primary objective of this research was to prioritize sustainable and environmentally friendly alternatives. When evaluating steel versus wood construction, factors including embodied energy, carbon emissions, manufacturing impact, cost, and weight were carefully considered. These assessments demonstrated that wood offers significant environmental advantages, outweighing the benefits of steel in this context. Consequently, wood was selected as the exemplar structural material for this flood-resilient design solution, aligning with the project's commitment to low-impact, regenerative architecture.

	Timber frame construction (Robinia Wood)	Galvanized steel frame construction
Embodied Carbon	–7,830 kg CO_2e (stored)	43,500 kg CO_2e

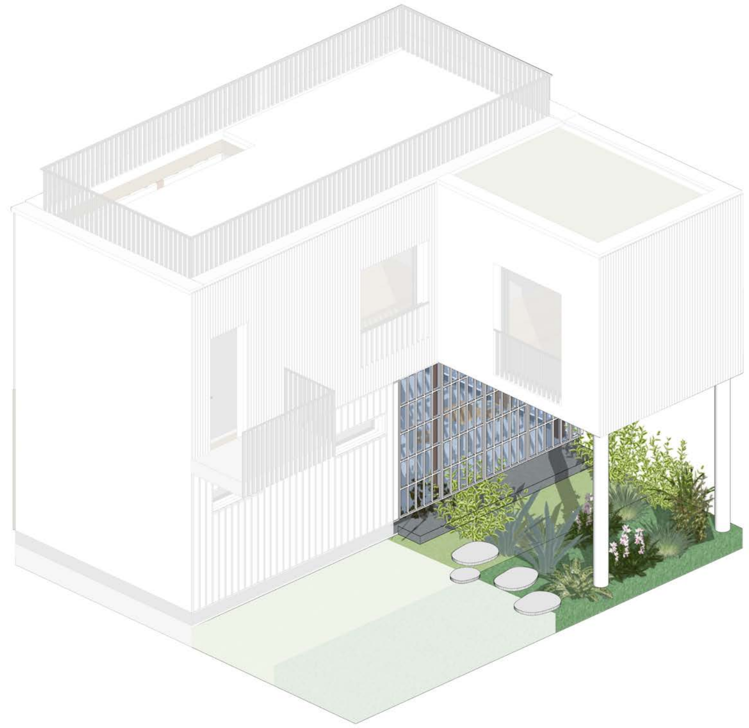


(Figure 185. Above is a rendering of two drainable and dryable cavity-wall assemblies proposed by building-science expert Joe Lstiburek after Hurricane Katrina. The wall designs share several key characteristics: No water-sensitive materials are used in the construction; exterior cavities are drainable and vented to the exterior; and interior cavities can be opened to allow passive or fan-forced drying in the event of a flood, by removing strips of wall material at top and bottom. Lstiburek cautions, however, that floodwaters are usually "filthy," requiring the interior side of the wall to be opened up, scrubbed, rinsed, and disinfected. (Cushman, 2017))

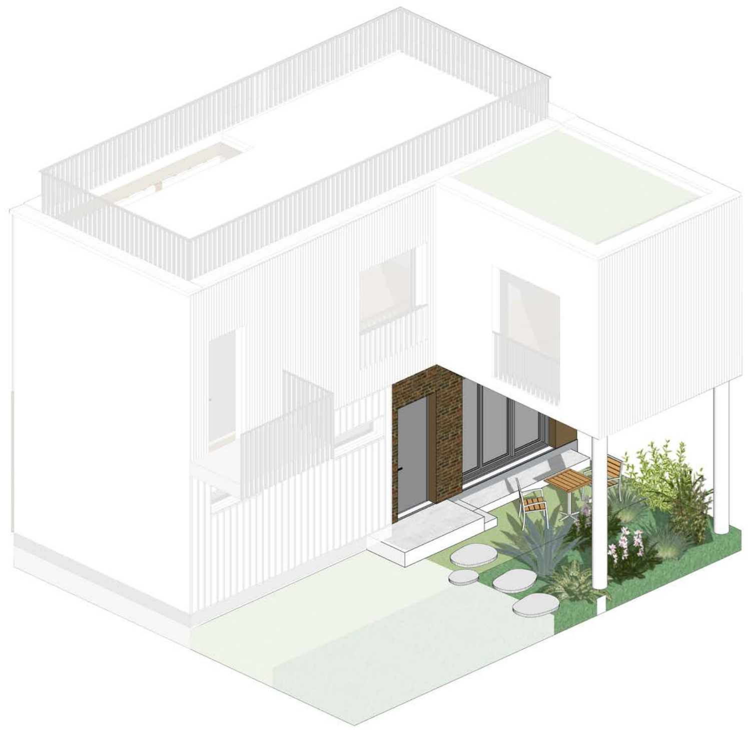
The design of the floodable zone was envisioned as a flexible framework, allowing end-users agency in defining the spatial and material articulation of their built environment. Residents were offered the opportunity to co-design this transitional space based on their preferences and risk tolerance. Possible adaptations included transforming the area into a semi-enclosed winter garden, constructing more robust enclosures using durable materials such as brick, stone, or in-situ concrete, or opting for elevated stilt structures using lightweight wooden planks that permitted water permeability. This participatory approach enabled inhabitants to choose how they engage with periodic inundation, fostering a resilient and personalized architectural response to fluctuating hydrological conditions.



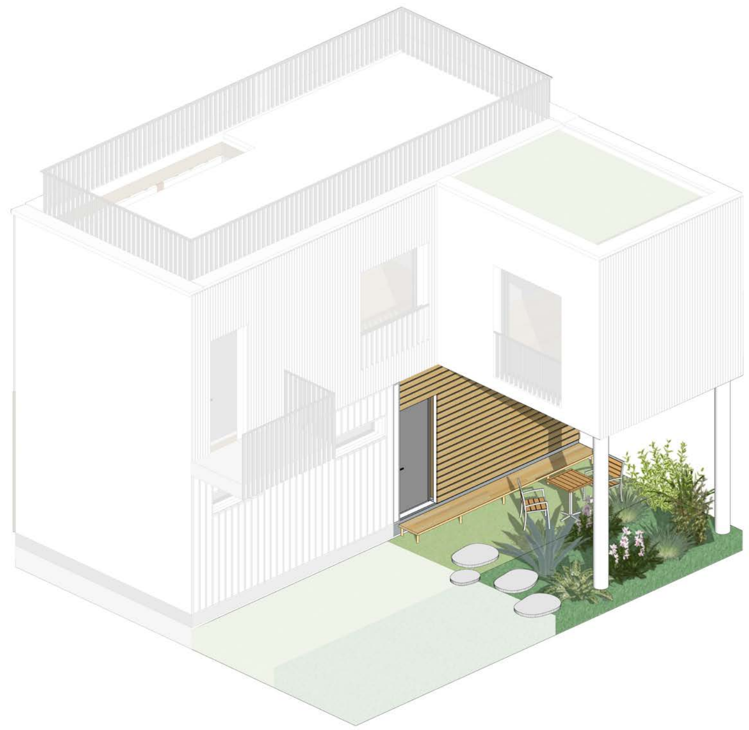
Wash and wear construction



Winter Garden



Brick Wall construction



Wooden planks

Figure 186. Other Possible choices in usage of the floodable area (Authors own diagram)

MANAGERIAL FRAMEWORK

Figure 187. Data Collection (Authors own diagram)

Stakeholder analysis

	Stakeholder	Role	Interest	Influence	Design Impact
Primary Stakeholders	Residents/ End Users	Future inhabitants of the housing units	High – require adaptable, resilient, and affordable housing that encourages community living	High – their needs drive housing typologies, layout, adaptability, and communal integration	Creation of modest, modular, adaptable units; communal spaces; spatial hierarchy for them
	Municipality of Midden Delfland	Local government responsible for spatial planning, water management, housing policy	High – interested in resilient urban development and long-term flood management for housing	High – governs zoning, water systems, and implementation	Guide design feasibility, integration with existing water infrastructure, zoning allowances
	Water Boards (Waterschappen)	Regional authorities managing flood defense, water levels, and water quality	High – responsible for maintaining safe water levels and approving designs impacting water systems	High – can approve or block water-integrated design strategies	Influence on floating/ amphibious housing, floodable landscapes, and helophyte systems integration
	Architects and Engineers (Here Myself)	Professionals involved in design development and execution	Medium – seek innovative and sustainable solutions	Medium – collaborate on detailing, materiality, and technical feasibility	Supported exploration of sustainable construction techniques, spatial strategies.
Secondary Stakeholders	Environmental Agencies (e.g., Rijkswaterstaat)	Policy makers for water and land management	High – focus on ecological impact and long-term resilience	Medium – advisory role in ecological design criteria	Encourage nature-based solutions, landscape restoration, and water purification systems
	Local Communities / Neighborhood Associations	Surrounding residents of Tanthof	Medium – affected by potential development, lifestyle changes, and access	Medium – may influence municipal support through advocacy or resistance	Inspire inclusion of soft thresholds, public spaces, and non-invasive water management
	Academia / TU Delft	Research and innovation in flood-resilient design	Medium – focus on experimentation and precedent creation	Medium – supports conceptual framework and validation	Experimentation with seasonal flooding adaptation, community design methods
Secondary Stakeholders	Material Suppliers (e.g., Accoya, Hydro-Skin developers)	Provide innovative building materials Provide innovative building materials	Low – focused on product testing and exposure	Low – can indirectly shape material choices	Supporte use of sustainable cladding, lightweight water-tolerant membranes
	Insurance Companies	Assess risk and offer flood coverage for homes	Low – respond to long-term performance of design	Medium – may influence construction standards in flood zones	Encourage integration of passive strategies and robust floodproofing systems
	Policy Makers / EU Flood Resilience Programs	Frame guidelines and provide funding for resilient urbanism	Medium – promote climate adaptation and innovation	Medium – can enable or fund implementation	Supportive of experimental resilient prototypes in wetland contexts

Choice of Materials

To determine the most suitable structural material for the flood-resilient housing units, a comparative analysis was conducted, focusing on key performance factors such as cost-efficiency, environmental sustainability, and long-term durability. The selected materials—galvanized steel and Robinia wood—were chosen for their ability to withstand water exposure to a significant degree. For consistency and clarity, the evaluation was based on the standard Module A framework, allowing a direct comparison of the environmental impact and lifecycle performance of each material.

Module A total built up area : 87m²

Robinia Wood Structure

1. Volume of Robinia wood per m²

Based on timber frame or CLT-style construction:
Common structural timber use: 0.08 – 0.12 m³/m²

Taking the average: 0.10 m³/m² as a moderate structural estimate
Assumption: 0.10 m³ of wood needed per m² of floor area

2. Total volume of Robinia

Volume (m³) = 87 m²×0.10 m³/m²= 8.7 m³
Volume (m³)=87 m²×0.10 m³/m²=8.7 m³

3. Mass of Robinia

Density of Robinia (Black Locust): ~700 kg/m³ (a dense, rot-resistant hardwood)
Mass (kg)=8.7 m³×700 kg/m³=6090 kg

Galvanized Steel Structure

1. Steel required per m²

Light steel frame construction typically uses: 20–30 kg of steel per m²
Assumption: 25 kg/m² as a realistic steel frame baseline

2. Total steel required
Mass (kg)=87 m²×25 kg/m²=2175 kg

Therefore, material needed for Module A 87m² house is about :

Robinia wood = 6090 kg
Galvanized steel = 2175kg

A. Cost Calculations :

Robinia Wood Structure:

Cost of a plank of 4mx0.18x0.20m in Netherlands = €43.90 (Maartenvl, 2025)
Volume=4×0.18×0.20=0.144m³
Planks per m³= 0.1441 ≈6.94planks

Cost per m³=6.94×43.90≈€304.77

Cost 6090 kg = 8.7m³×€304.77≈€2,651.50

Therefore, Robinia would cost ≈€2,650

Galvanized Steel Structure

Mass required = 2,175 kg (from: 87 m² × 25 kg/m²)

Cost per kg ≈ €3.50 (for galvanized structural profiles) (Galvanizing cost per kg, n.d.)

Cost Steel =2,175 kg×3.5€/kg = €7,612.50

B. Embodied Carbon Calculations :

Robinia Wood Structure:

Mass = 6,090 kg (from: 8.7 m³ × 700 kg/m³)

Carbon footprint per kg = −0.9 kg CO_2e/kg (Robinia stores carbon during growth, hence negative emissions)

Embodied Carbon Robinia
=6,090kg×(−0.9 kgCO_2e/kg)=−5,481 kg CO_2e

Galvanized Steel Structure

Mass = 2,175 kg

Carbon footprint per kg = +2.5 kg CO_2e/kg (includes mining, smelting, rolling, and galvanizing)

Embodied Carbon Steel= 2,175kg×2.5kg CO_2e/kg = 5,437.5 kg CO_2e

Embodied Carbon Steel
=2,175kg×2.5kg CO_2e/kg=5,437.5kg CO_2e

	Timber frame construction (Robinia Wood)	**Galvanized steel frame construction**
Cost Estimate	€2650	€7612.50
Structural Weight Estimate	6090 kg	2175 kg
Embodied Carbon	–5,481 kg CO_2e (stored)	5437.5 kg CO_2e
Energy in production	12,180 MJ (low impact)	76,125 MJ (very high)
End of Life Reuse	Biodegradable or reusable	Recyclable (but energy-intensive process)
Durability	High (naturally rot-resistant)	Very high (especially with galvanization)

Hence making wood construction the favorable choice for design solutions in this scenario.

SYNTHESIS

Figure 188. Floods are coming (Authors own diagram)

REFLECTION

Relation between your graduation project topic, your master track (A, U, BT, LA, MBE), and your master programme (MSc AUBS)

My graduation project, Waterscapes of Resilience, explores how flood-resilient housing can support both environmental sustainability and community well-being in the context of the Dutch delta. The project investigates how architectural design can embrace water not as a threat but as a central, shaping force in creating inclusive, adaptive living environments. This aligns directly with the Architecture track at TU Delft, which emphasizes the role of the architect as a spatial thinker and social actor capable of addressing urgent societal and environmental challenges through design.

The project is also deeply embedded in the broader MSc Architecture, Urbanism and Building Sciences programme, which advocates for interdisciplinary thinking and a systems approach to the built environment. My design explores the intersection of architecture, ecology, and urban systems by integrating water management strategies, circular material use, and spatial configurations that foster collective living and ecological sensitivity.

Furthermore, the studio's theme of "Ecology of Inclusion" is reflected in my project's emphasis on social resilience—how shared infrastructure, flexible housing typologies, and adaptive landscapes can promote community interaction, equity, and long-term sustainability. The project therefore synthesizes architectural thinking, urban ecological awareness, and systemic design strategies, fully engaging with the intellectual framework of both my track and the master programme.

Influence of research on design/recommendations and influence of design/recommendations on research.

My research and design were in a continuous, reciprocal dialogue throughout the graduation process. Initially, I set out to explore how housing could respond to the dual challenge of flood risk and social inclusion, and this shaped the foundation of my design approach.

Early inspiration came from the ZUS plan for Tanthof, which proposed allowing water to reclaim parts of the landscape. This shifted my mindset to see flooding not as a problem to be solved but as a spatial and ecological opportunity—one that could shape both the architecture and the community fabric of the area.

A range of international case studies deeply influenced how I approached the design in its early stages. Projects from Bangladesh, India, Vietnam, Australia, and the UK presented different flood-resilient housing strategies—especially the use of stilts and elevated structures. These examples prompted me to initially explore lifting the housing units off the ground, creating a sense of safety and separation from flood-prone terrain.

However, as the design evolved, I began to examine precedents like ground-based housing in the UK and US, which offered strategies for creating active, floodable ground floors—spaces that could flood occasionally without severe damage, while also hosting public or communal uses. This led to a key shift in my project: rather than just elevating the homes, I focused on designing a resilient ground plane that remains accessible and useful even under fluctuating water conditions.

Dutch precedents like Schoonschip and IJburg were also instrumental. Schoonschip, as a self-initiated floating community in Amsterdam, showed how water-based living can be combined with community governance, shared systems, and energy circularity. IJburg demonstrated the urban scalability of living with water, inspiring me to consider how adaptive housing strategies can function not just on an individual scale but as part of a broader, connected urban fabric. These examples helped me ground my speculative ideas within the existing Dutch policy and design culture.

In terms of structure and materiality, I looked to flood-resilient housing in Houston and Pakistan, where practical, affordable, and climate-responsive solutions were used to build for long-term survival in high-risk zones. These studies helped me define more sustainable construction strategies, including modular systems, repairable materials, and flexible infrastructure.

The study of works of Van Eyck , Hertzberger and Belapur Housing by Charles Correa helped me reframe the social aspect of the project with concepts of transition and spatial hierarchy, offering a model for community-scaled housing with shared open spaces, walkable layouts, and mixed-use programming. This influenced my design of cluster-based housing units that can adapt over time, accommodate multiple family types, and foster stronger social bonds.

Overall, the relationship between research and design in this project was not linear—it was iterative and layered. Research gave me the tools to make informed design decisions, while the design process constantly pushed me to refine my research in response to practical, spatial, and ecological challenges.

Approach, your used methods, used methodology

I see the value of my way of working in its integrative, research-driven, and iterative nature. From the outset, I approached the project not merely as a design task but as an opportunity to rethink the relationship between architecture, ecology, and community—closely aligning with the "Ecology of Inclusion" studio theme. My methodology allowed for a dynamic dialogue between theoretical exploration, precedent study, spatial experimentation, and contextual understanding.

Initially, my design was directly influenced by international case studies, particularly from flood-prone regions like Vietnam, Bangladesh, and India. These precedents strongly indicated the use of stilt-based housing as an effective flood-resilient strategy. Based on this, my early design iterations—including the Phase 2 proposal—envisioned the entire village raised on stilts to protect from seasonal flooding.

However, building a physical model for Phase 2 became a turning point in my process. It revealed how the elevated design left dark, unused, and potentially contaminated space underneath the housing units. This was a critical contradiction to the core values of my project—accepting and coexisting with the land as it is, rather than resisting or disengaging from it. It challenged me to rethink how to create a flood-resilient environment that remained grounded—both physically and conceptually.

In response, I began reworking the scheme to explore hybrid strategies: partially grounded homes that could withstand occasional flooding, selective use of stilts where necessary, and structures that could be submerged during wet seasons, such as buildings in or near lakes. This shift in design thinking allowed for a more diverse set of typologies and a richer, more nature-integrated spatial narrative. The ground was no longer a void to be avoided but became a vital, shared plane for community interaction, ecological processes, and resilience.

Throughout, I combined site-specific research—such as hydrological analysis, desynchronization studies, and frameworks like the Dutch ZUS plan—with a comparative case study approach. Lessons from local precedents like Schoonschip and IJburg further rooted my design in the Dutch context. I moved fluidly between drawings, sectional studies, physical models, and simulations to test housing clusters against changing water levels, community use, and ecological dynamics.

Methodologically, the constant feedback loop between research and design was key. Research was not just a starting point but an active engine for design development, and design challenges, in turn, deepened the scope of inquiry. This iterative process helped me develop a conceptually coherent, technically grounded, and spatially responsive proposal.

In the end, I believe my approach allowed for a transformation in the design—from a generic flood-proofing strategy to a context-sensitive, ecologically inclusive, and community-oriented vision. It embraces the complexity of climate adaptation, housing needs, and environmental justice through a layered and evolving methodology.

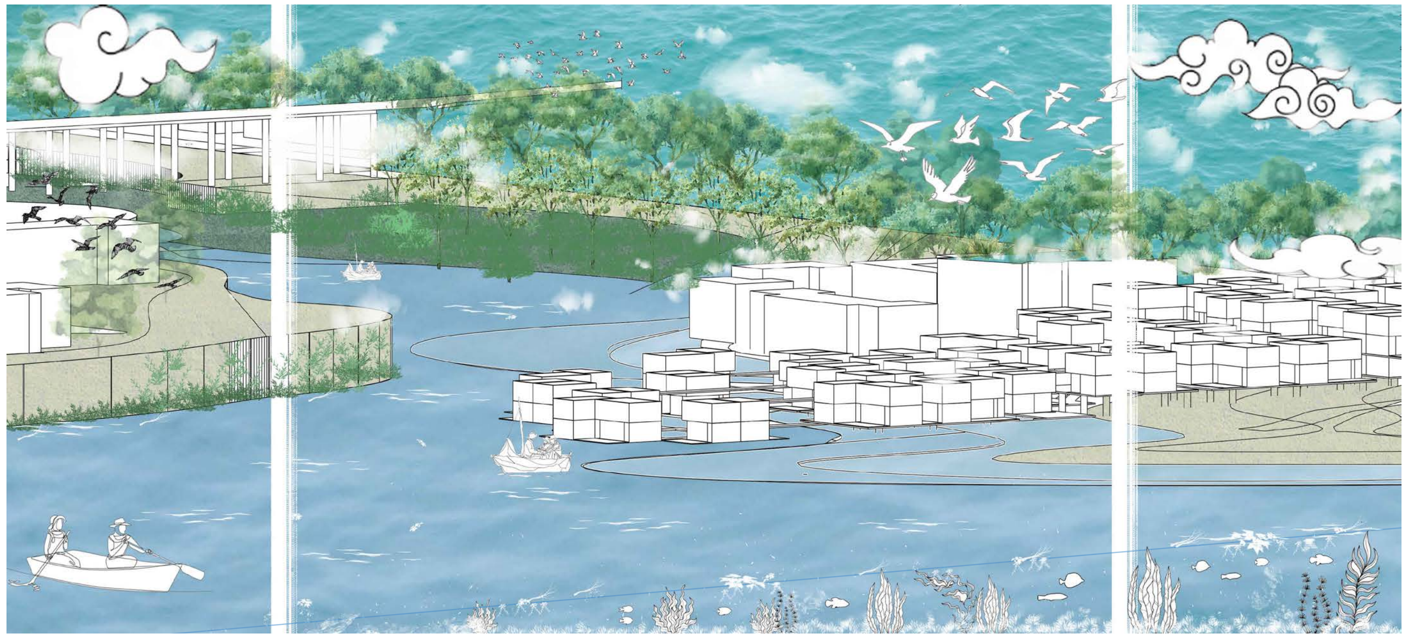


Figure 189. Cover image of Phase 2 (Authors own diagram)

Figure 190. Housing typologies at Phase 2 (Authors own diagram)

Figure 191. Level variations of topography and massing at Phase 2 (Authors own diagram)

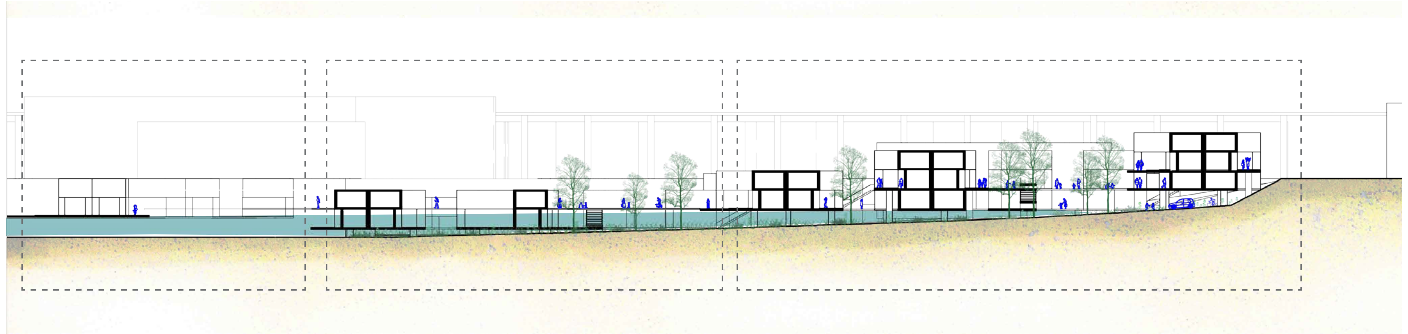


Figure 192. Section of dwellings at Phase 2 (Authors own diagram)

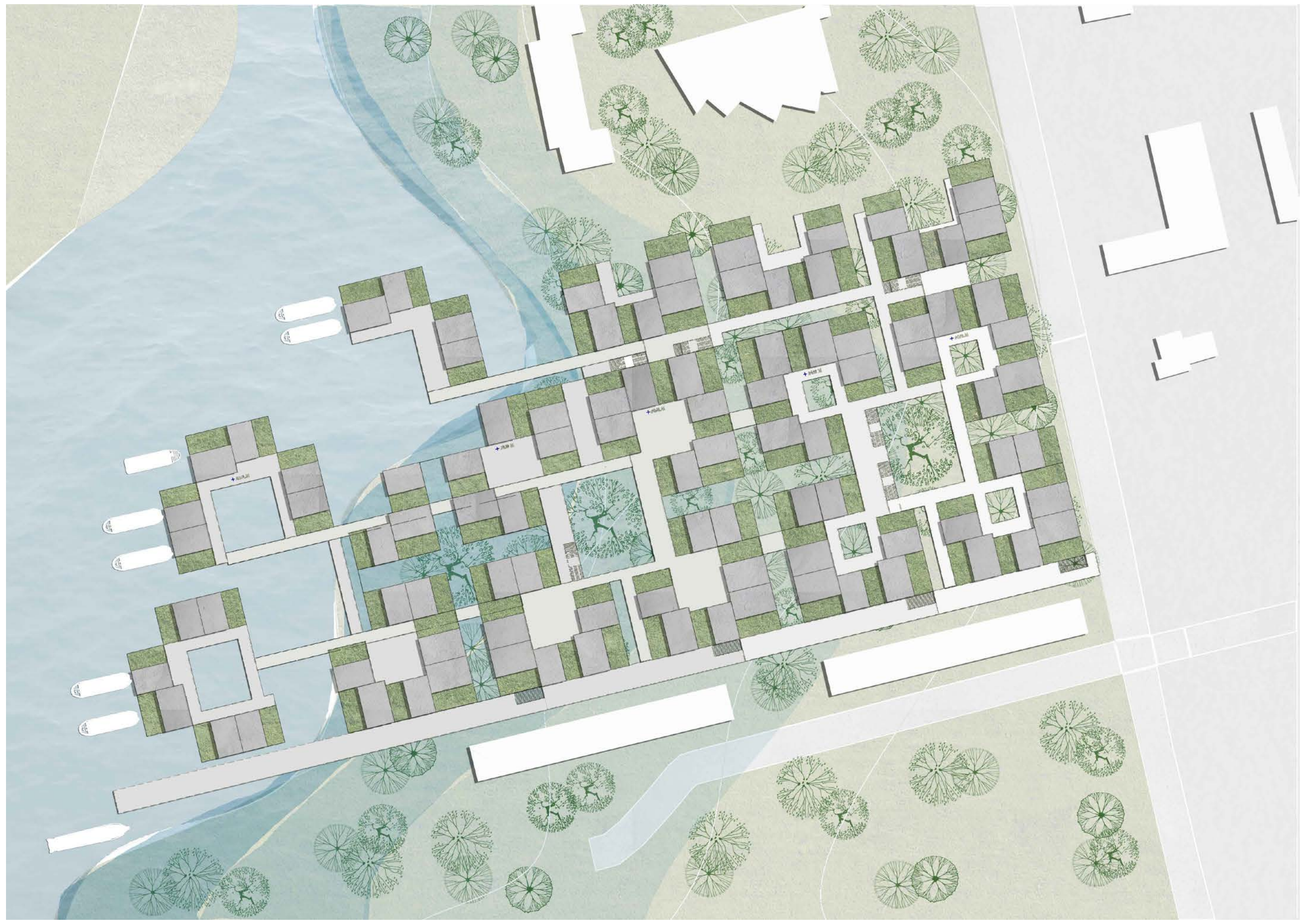


Figure 193. Dwelling arrangement at Phase 2 (Authors own diagram)

Academic and societal value, scope and implication and ethical aspects

I see both academic and societal value in Waterscapes of Resilience as a project that not only tackles pressing challenges—climate change, housing shortages, and social inequality—but also proposes a paradigm shift in how we design with nature.

Academically, the project contributes to emerging discourse on climate-adaptive urbanism and ecologically integrated housing design. It emphasizes the idea of accepting the natural topography as it is—rather than flattening or resisting it—and enhancing it through nature-based solutions such as helophyte systems for water purification, retention landscapes, and seasonal flood adaptation strategies. This shifts the narrative from controlling nature to coexisting with it, aligning with contemporary environmental ethics and regenerative design thinking.

The integration of climate strategies—like water-sensitive urban design, passive cooling, modularity, and community-based resource sharing—shows how housing can serve as a catalyst for broader ecological and spatial resilience. The project also brings academic value by linking case study research (from countries like Bangladesh, India, Vietnam, and the Netherlands) with grounded design interventions specific to the Dutch delta, especially in response to the ZUS plan for Tanthof. Societally, the project addresses key issues facing the Netherlands: a need for 1 million new homes by 2035, worsening flood risks, and a growing disparity in access to affordable housing. By proposing cluster-based, adaptable housing embedded in a water-based landscape, the project offers a more inclusive, environmentally conscious, and scalable model of living. It recognizes housing not just as shelter, but as a platform for community resilience, shared infrastructure, and ecological care.

The ethical dimension is central. The project resists the logic of profit-driven, risk-averse development by asking: How can we build not just for safety, but for dignity, equity, and ecological balance? Rather than reinforcing existing hierarchies, it proposes a future where communities live with water, adapt together, and share resources—creating more just and resilient urban ecologies.

Ultimately, Waterscapes of Resilience advocates for a design ethos that is inclusive, adaptive, and regenerative—one that challenges extractive mindsets and promotes spatial justice through both architectural and environmental means.

Value of the transferability of project

The core strength of Waterscapes of Resilience lies in its framework-based approach, which makes the project highly transferable across different geographic and social contexts facing similar challenges of flooding, housing scarcity, and ecological degradation.

Rather than offering a one-size-fits-all design, the project proposes a set of adaptable spatial principles—such as building with the topography, integrating seasonal water systems (like helophyte fields), designing floodable ground planes, and clustering housing around shared public spaces. These strategies are not site-specific but context-responsive, making them applicable to coastal, deltaic, and low-lying urban areas globally.

The design is especially relevant for regions experiencing rapid urbanization under climate stress—such as parts of South Asia, Southeast Asia, and even parts of the U.S. like Houston or New Orleans. In these areas, there is a pressing need for affordable, flexible, and water-adaptive housing solutions that support both social cohesion and ecological function.

Additionally, the transferability is enhanced by the project's modular and scalable housing system, which can be adapted for different densities, income groups, and governance models. It allows for phased implementation, incremental expansion, and adaptation to local material and construction practices—making it suitable for bottom-up initiatives as well as policy-driven developments.

From a policy and planning perspective, the project contributes to discussions on how to embed climate resilience and social inclusion into mainstream housing production. Its design framework aligns with both Dutch spatial planning agendas and global sustainable development goals, making it relevant to practitioners, municipalities, NGOs, and academic institutions involved in urban transformation.

In summary, the value of the project's transferability lies not in replicating its exact form, but in the strategic logic it offers: to design with water, to build in tune with natural systems, and to house communities in a way that is inclusive, resilient, and regenerative.

Tensions or contradictions between environmental resilience and social inclusion

One of the core tensions I encountered was between environmental resilience strategies—like elevating housing or designing for seasonal inundation—and the desire for ground-level inclusivity and social interaction. For example, many global case studies suggested lifting homes on stilts to avoid flood damage, but this often led to disconnected or privatized ground planes, reducing the potential for communal life and accessibility, especially for the elderly or those with limited mobility.

To address this, I studied ground-based flood-resilient housing models from the UK and US that used active floodable ground floors as social and flexible spaces. I adapted these strategies in my design to allow the ground to flood seasonally, while creating elevated yet accessible communal zones and shared infrastructure. This balance allowed me to embrace the landscape's dynamics without sacrificing human-scale interaction or inclusion.

By integrating climate-adaptive systems like helophyte wetlands and designing for flexibility in use and ownership, I found that these apparent contradictions could be transformed into opportunities—where resilience becomes not just about physical safety, but also about social adaptability, equity, and long-term liveability.

Role of the architect in the context of climate change and social inequality

Working on Waterscapes of Resilience fundamentally expanded my understanding of the architect's role—not just as a form-giver or space-maker, but as a mediator between ecological systems, social needs, and spatial justice. I began to see architecture as an agent of change that must work with natural processes rather than control or resist them. This shift in thinking made me more aware of the ethical responsibilities of design—especially in flood-prone and socially fragmented contexts like the Dutch delta, where climate vulnerability and housing scarcity intersect. I also realized that the architect's work is deeply embedded in larger systems—policy, community agency, and environmental stewardship. Designing housing was no longer just about individual units, but about shaping resilient ecosystems of living that include water, care work, community space, and climate adaptation. This has redefined my approach to design as being not only about aesthetics or efficiency but about equity, inclusion, and co-existence with the natural world.

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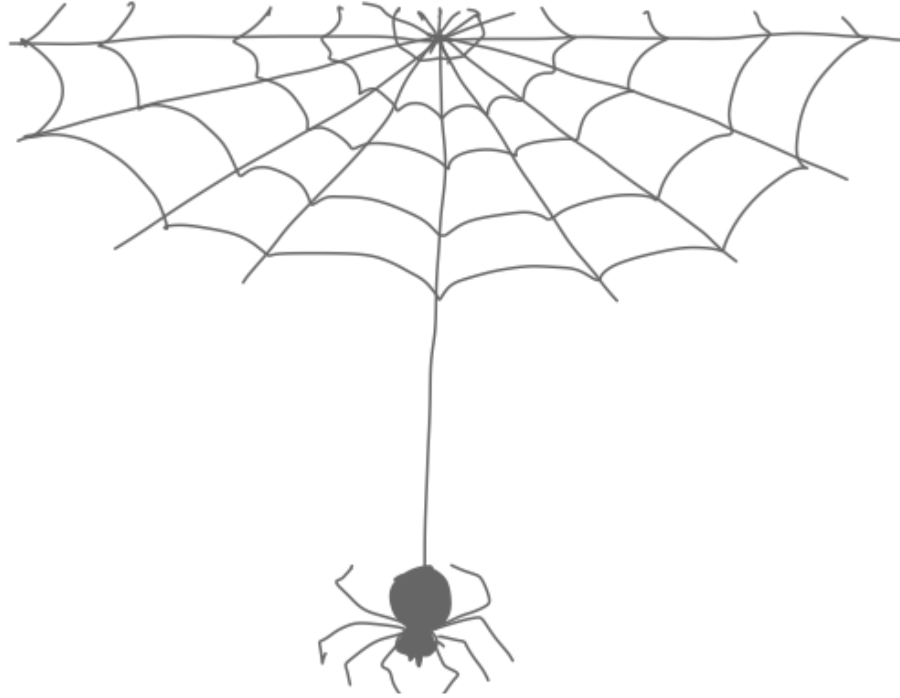
Don't worry, spiders,

I keep house

casually by the river

Kobayashi Issa (1763-1828)



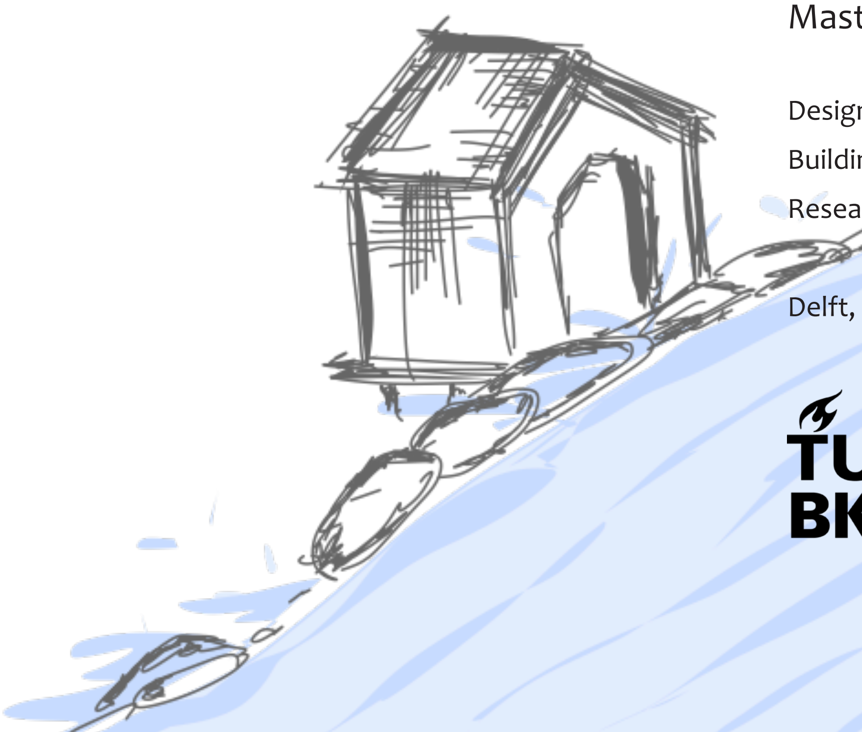


Figure 194. Interpretation of Kobayashi Issas poem (Authors own diagram)

Waterscapes Of Resilience

Harmonizing Nature and Flood Resilient Community Living

Diya Sharma : 5929083

Advanced Housing Studio (AR3AD100)

Ecologies of Inclusion

Master's Thesis, Delft University Of Technology

Design Mentor : Oly Klijn

Building technology Supervisor : Ruurd Kuijlenburg

Research Supervisor : Brook Teklehaimanot

Delft, The Netherlands, 20 June 2025

TU Delft BK Bouwkunde