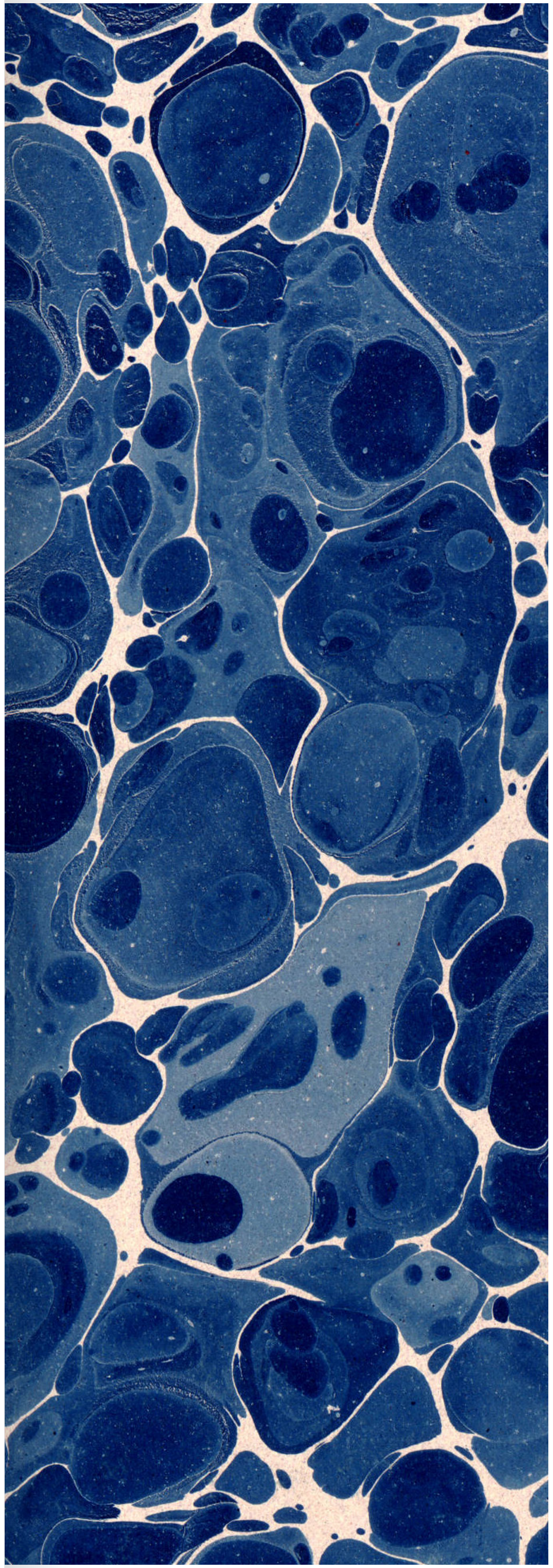
# FROM RUIN TO RESILIENCE:
## ADAPTIVE REUSE AFTER FLOODS

MASTER THESIS

MSc04

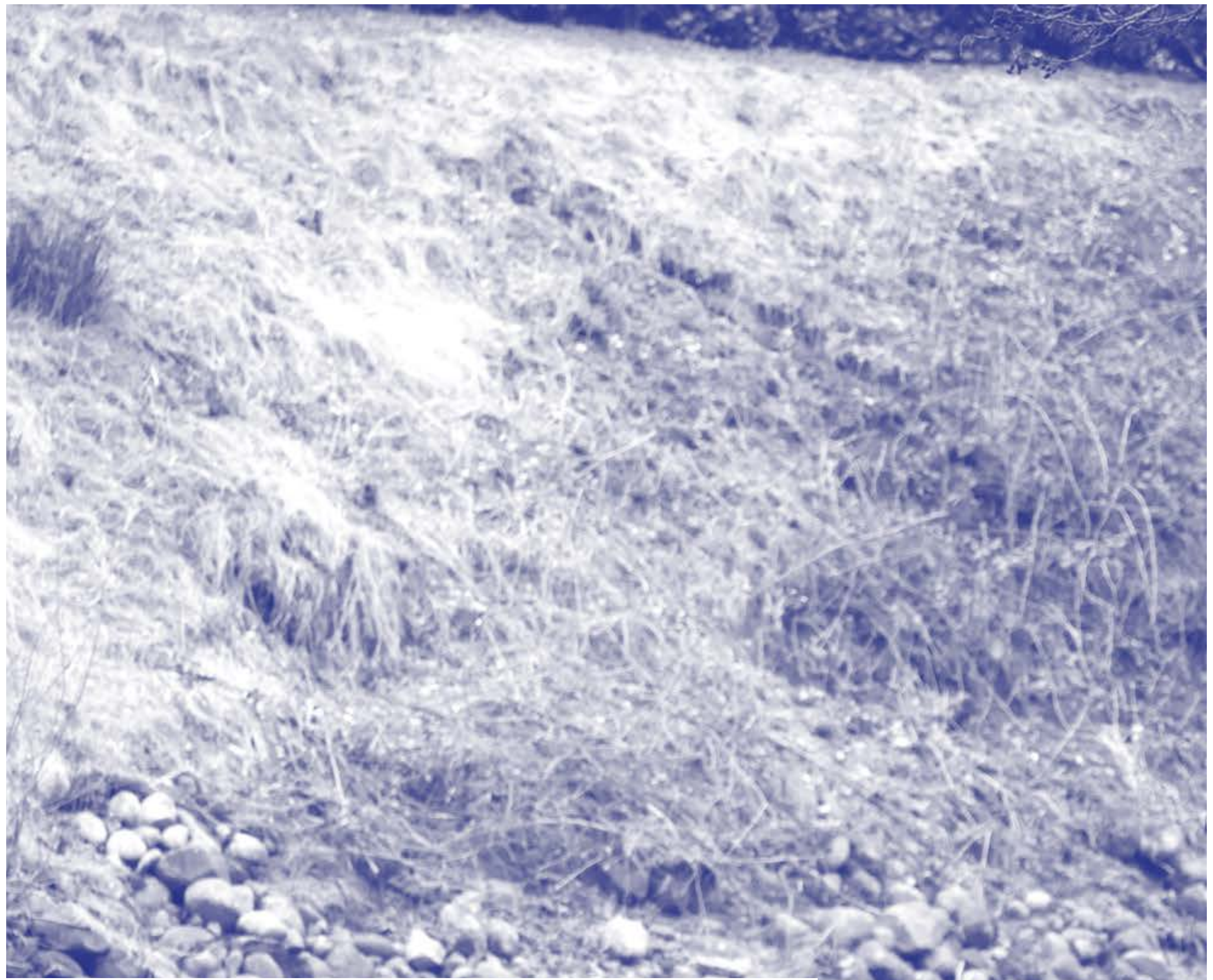
CHARLOTTE BLIGAARD NIELSEN

2025



Increasing flood risk

Material waste



# title paper.

**Project title**
From Ruin to Resilience: Adaptive Reuse After Floods

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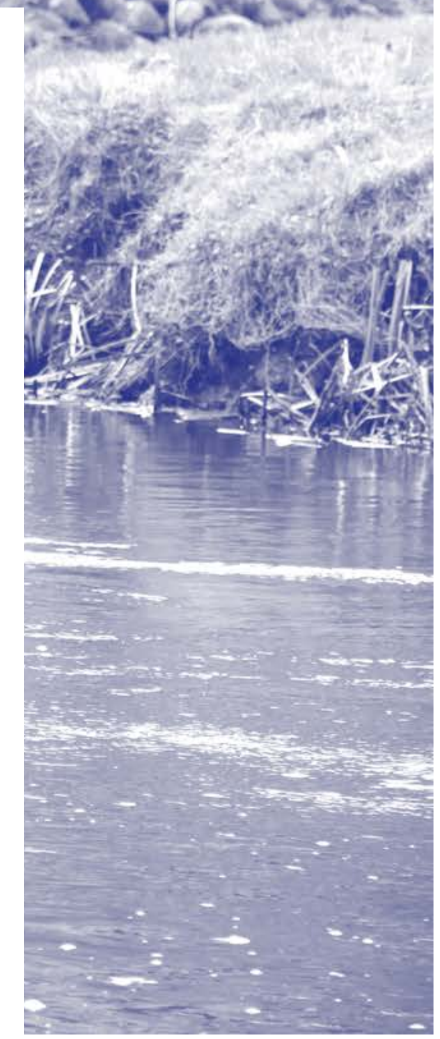

# abstract.

This thesis explores how architecture can respond to increasing flood risks in Denmark, particularly in vulnerable and under-resourced areas such as allotment communities. Flooding not only damages buildings but also generates material waste when structures are rebuilt using conventional methods. Through a hypothetical case in Havekolonien Storaaen, informed by real-world allotment conditions, this project proposes an alternative approach: dismantling a flood-damaged structure and reusing its materials to construct a new flood-resilient building that reframes the flood not as a disaster, but as a unique spatial and sensory experience.

The design is guided by three key focuses: flood resilience, flood experience, and extending material lifetime. The structure is elevated to withstand shallow floods and equipped with a watertight facade system capable of resisting up to 1.5 meters of water. The architecture responds to seasonal change by opening fully in dry, warm weather to dissolve the boundary between house and garden. In contrast, during storms or flooding, the building transforms into a secure refuge, with closed walls and a carefully designed interior atmosphere that embraces water through light, reflection, and sound. Materials from the original building are repurposed based on their physical properties, with all components designed for disassembly, maintenance, and eventual replacement using biobased or recycled alternatives.

The methodology combines an extended Double Diamond model, drawing from Bryan Lawson theory, with site analysis, case studies, material experiments, and environmental simulations. A national survey of 49 allotment owners and one in-depth interview contribute user-specific insights. (Lawson, 2010; *History of the Double Diamond*, no date) (App. 2)

Ultimately, this thesis argues that retreat from flood-prone areas is not the only solution. By embracing water, designing for multiple levels of flooding, and prioritizing long-term material circularity, architecture can offer both resilience and meaning in the face of climate uncertainty.

*content.*

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# READING GUIDE

This report presents a design proposal for a small flood-resilient building situated in the allotment garden community of Havekolonien Storaaen. It investigates how the reuse of materials from existing flood-damaged wooden buildings can inform new resilient architecture that both withstands and embraces the experience of flooding, while extending material lifespans and minimizing waste.

The report is structured to be read in chronological order for the clearest understanding. It begins by introducing the broader challenges of flooding and demolition waste in architecture, followed by a presentation of the hypothetical case used to explore these themes. Through a series of focus points; flood resilience, flood experience, and material lifespan, the report builds a foundation of research, analysis, and design criteria that inform the final architectural proposal.

The design is framed through imagined users and their needs, developed into a spatial program and design drivers. The proposal is then shared, followed by a presentation of the design method, a breakdown of the design process, and finally a reflection on the outcomes and how they may be transferred to other architectural contexts or scales.

Illustrations are placed throughout the report to support the text and can generally be understood on their own with the aid of captions. However, their meaning and relevance are best appreciated when read in connection with the surrounding discussion.

Each chapter is clearly marked and introduced with a summary page to guide the reader. Blue divider pages signal the end of each chapter, creating a rhythm that makes it easy to follow the progression from challenge to concept to solution.

*This report has been proofread with assistance from ChatGPT to ensure clarity, readability, and consistency in language.*



# INTRODUCE THE CHALLENGE

This chapter examines the central societal challenges relevant to this thesis and considers their implications within the field of architecture. It reviews existing ideas and approaches, while also offering a perspective on the debate. Additionally, a design case study is introduced to serve as a basis for investigating these challenges in more detail.

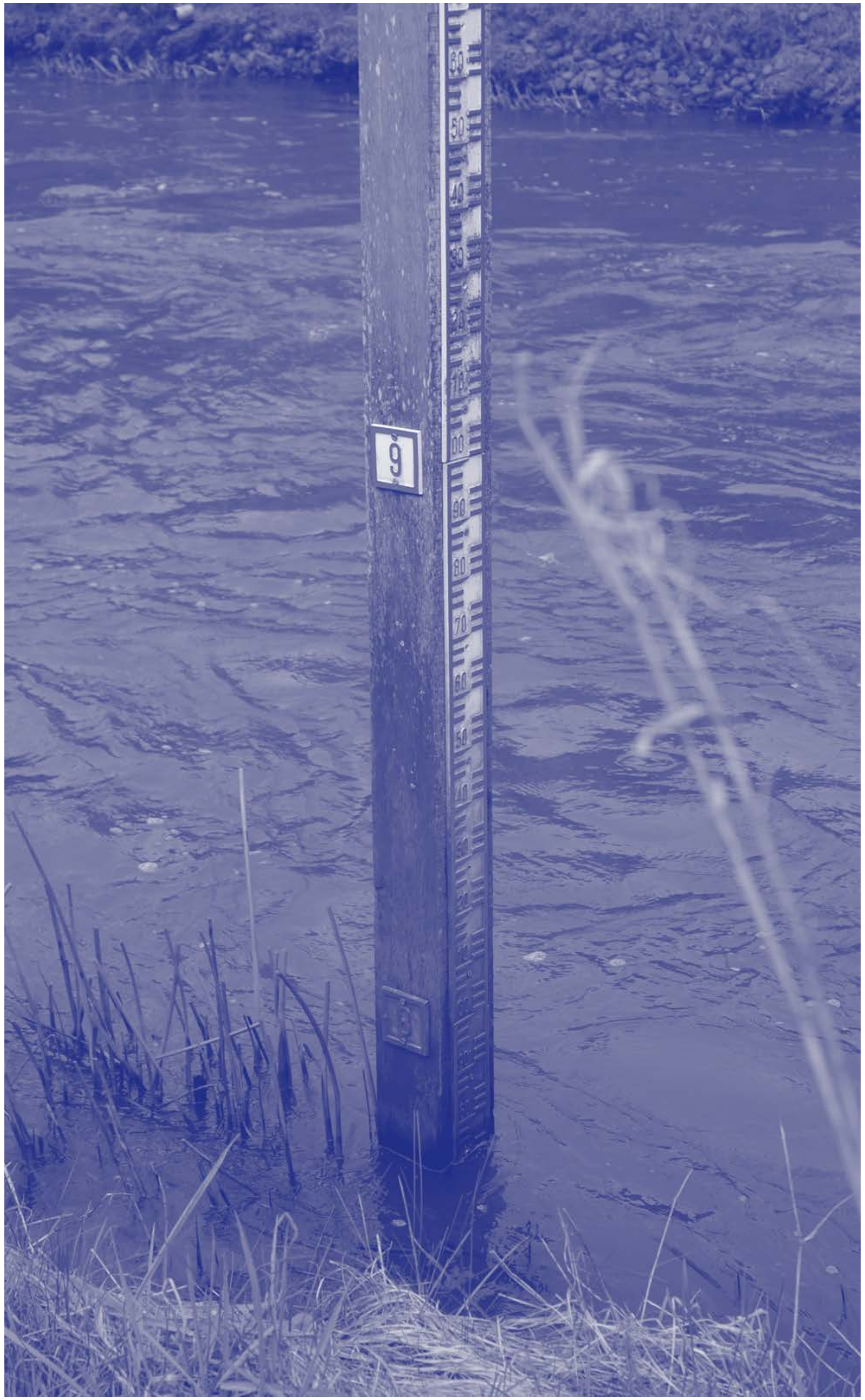
# rising waters.
# rising challenges.

Denmark's geographical position, surrounded by water, has historically shaped the nation's development and identity. This close connection to water has influenced trade and culture but has now turned from a strength into a challenge that requires solutions. Denmark is experiencing a growing trend of extreme weather conditions, including heavy rainfall and flooding, linked to global warming. According to Greenpeace, 2023 became the wettest year ever recorded in Denmark, with 972.7 mm of rainfall, surpassing the previous record of 906 mm (Greenpeace Danmark, 2025). This development indicates a clear link between rising temperatures and more frequent extreme precipitation events.

The rising waters lead to severe problems. Cities and homes are affected by flooding, causing extensive damage and forcing residents to temporarily leave their homes. A report from DTU estimates that the total costs of floods caused by cloudbursts and storm surges could reach 406 billion DKK over the next 100 years if effective climate adaptation measures are not implemented (Jensen, 2024). Repeated flooding not only disrupts lives but also leads to the loss of high-quality building materials. Homes, often constructed with quality materials, are damaged and rebuilt, resulting in significant material waste. According to Dagens Byggeri, construction waste in general accounts for around 35% of the total waste in Denmark, and resource waste in the construction sector is estimated at approximately 10% of total material consumption ('Trist svar om spild: "Det er nemmere, hurtigere og billigere at smide materialerne ud"', 2023). This highlights the need for rethinking building strategies and resilient construction methods.

The construction and building sector in Denmark has a material consumption that is 75% higher than the EU average, with an average of 25.3 tons of materials per capita in 2022 (*Danmark har et større materialeforbrug end EU-gennemsnittet*, 2024). This high consumption leads to significant amounts of waste, adding to climate challenges. Therefore, it is crucial to implement solutions on multiple levels to reduce both material waste, workhours and increase human experience.

*Ill. 1:*
*Photo of Storåen in Holstebro.*
*Photo: Author*



# rising challenges.
# rising debate.

Global warming is a defining challenge of our time, profoundly influencing the architectural field. As extreme weather events become more frequent, architects are tasked with designing resilient structures that minimize environmental impact. The construction industry is a significant contributor to global $CO_2$ emissions, making sustainable practices essential (*EU Taxonomy in 2023 Clarity or confusion?*, no date).

Cities like Copenhagen have adopted large-scale solutions, such as the Cloudburst Management Plan, which uses green infrastructure to manage stormwater (Barandy, 2022) (Københavns Kommune, 2010).

However, building-scale solutions remain limited. Internationally and in Denmark, amphibious houses, floating structures, and homes on stilts have been explored, primarily in areas with constant water exposure (Barandy, 2022). Yet, these solutions are costly and rely on complex technology, making them inaccessible for most homeowners (Rasmussen et *al.*, 2022).

The architectural debate often centers on whether flood resilience should be addressed on a city-wide scale or at the individual building level. Denmark's national planning strategies have identified zones at risk of flooding, some of which are protected by flood defenses, while others are left to adapt or accept flood damage (Hellesen et *al.*, 2010).

This thesis argue that large-scale solutions can overshadow the need for individual resilience, leaving homeowners without accessible options to protect their properties.

Architectural theory is divided on how to respond to flooding. Defensive strategies aim to keep water away from urban areas, protecting infrastructure and cultural heritage. This is crucial for historically significant buildings that cannot be easily replaced (ICOMOS Welcomes the Heritage Adapts to Climate Alliance Initiative, 2024).

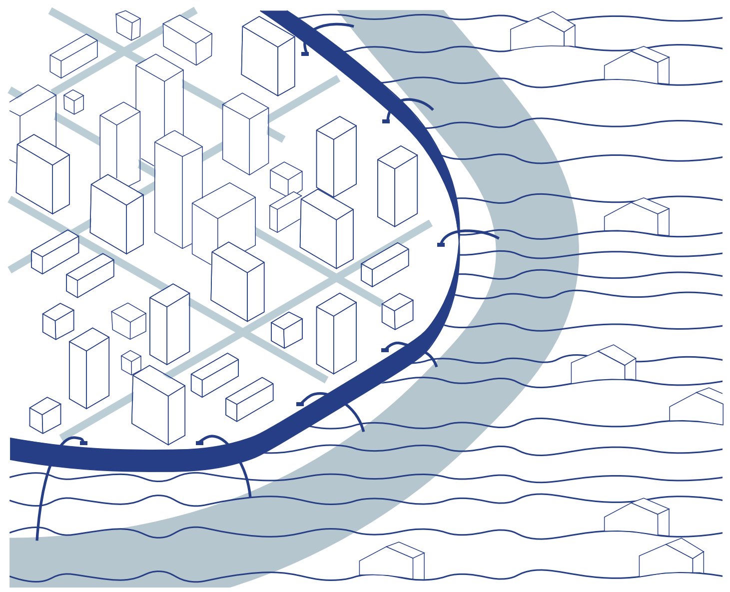
Conversely, other theorists argue for embracing water as a design element, creating adaptable spaces that interact with water rather than resisting it (Dovey, 2010). This debate reveals a deeper question: should architecture prioritize stability or flexibility?



The construction sector's high material consumption is a major sustainability concern. Some architects advocate for designing new buildings with "design for disassembly" principles, allowing future reuse. Others focus on reusing existing materials, as seen in Lendager Group's Ressourcerækker, which repurposed demolished materials ('Resource Rows', no date).

Denmark's waste-to-energy approach, where material waste is used to generate heat, is another strategy. ('From waste to energy', no date). These solutions show a mixture of immediate reuse and future-oriented design.
Anne Beim, a leading Danish theorist, emphasizes an integrated approach, where architecture not only minimizes waste but also adapts to changing environmental conditions (Beim, Zepernick Jensen and Arnfred, 2019). This contrasts with other views that prioritize short-term material reuse without considering future adaptability.

The debate on flooding and material waste reflects a broader question in architecture: Should we design for permanence or prepare for transformation? Current practices demonstrate both innovative and limited approaches. Yet, the true challenge is to envision a future where architecture can adapt without generating excessive waste. This calls for a mindset shift.



*Ill. 2:*
*Sketch of urban priority.*

## rising debate.
## rising opinions.

The architectural discourse around flooding and material waste reveals a clear divide: large-scale solutions aim to shield cities from rising waters, while building-scale solutions focus on individual resilience. Yet, many of these solutions treat water as an enemy, something to be repelled, contained, or avoided. But what if there was another way?

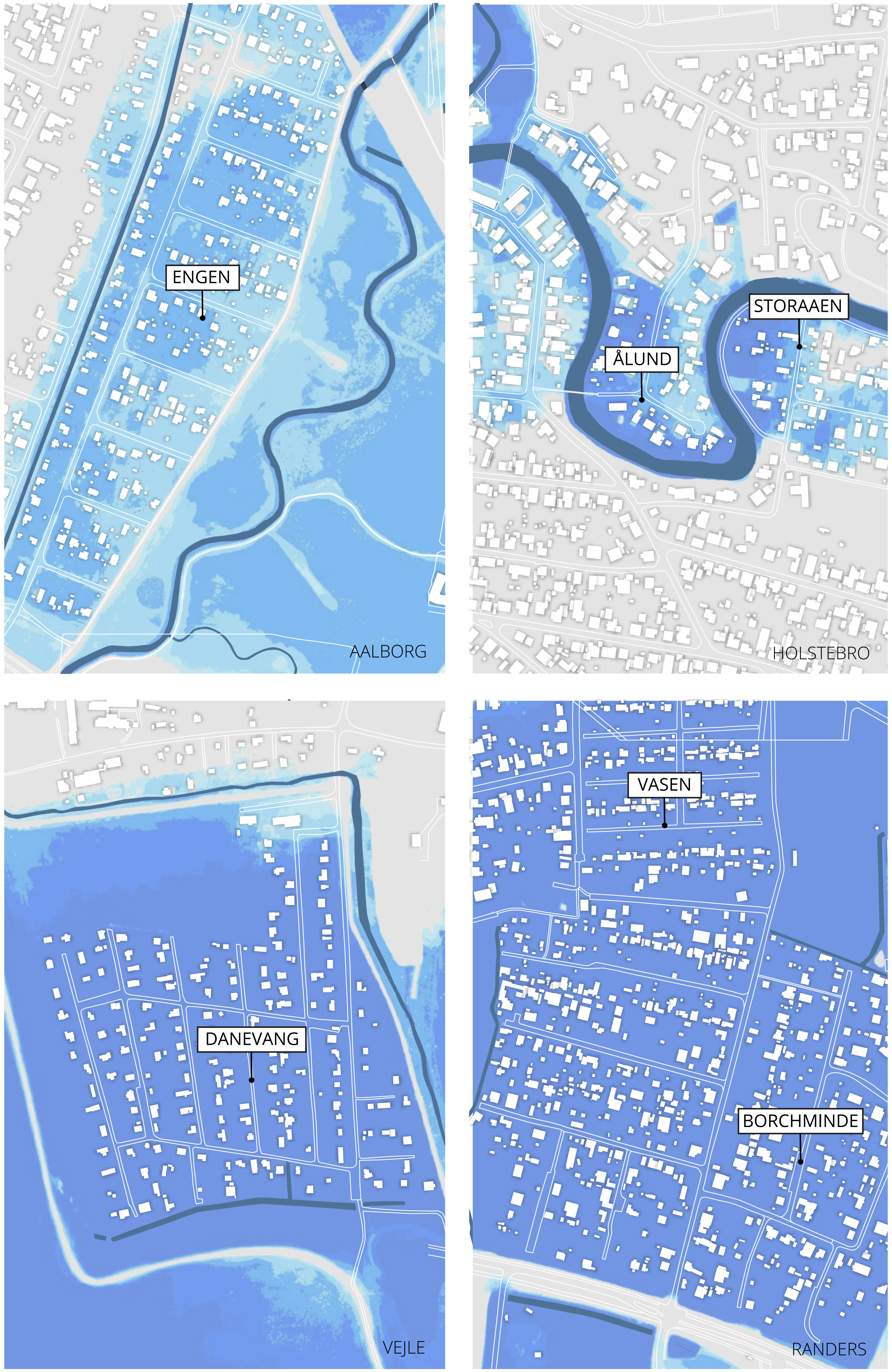
Rather than resisting water, what if architecture could embrace it? What if buildings could not only survive floods but also harness them, transforming these challenges into opportunities for creative design? This manifesto proposes a shift in perspective, from seeing water as a threat to viewing it as a design element, from perceiving material waste as an inevitable loss to recognizing it as a resource for innovation.

This manifesto (Ill. 3) sets a vision for adaptive architecture, one that treats floods not as threats but as catalysts for design, and sees material waste not as inevitable but as an opportunity for creative reuse. But how can these ideas move from theory to practice?

To ground this vision in reality, it is necessary to explore a concrete case, a situation where the challenges of flooding and material waste intersect in a tangible context. Such a case can serve as a testing ground for the principles outlined here, providing insight into how adaptive, resourceful architecture can be achieved in practice.

*Ill. 3: Manifesto.*

**WHAT IF ARCHITECTURE COULD ADAPT** TO THE CHANGING ENVIRONMENT, **INSTEAD OF FIGHTING** IT?
WHAT IF **FLOODS ARE NOT PROBLEMS** TO ELIMINATE, BUT **INSTEAD ARE OPPORTUNITIES** TO DESIGN WITH?
WHAT IF BUILDINGS COULD **THRIVE** ALONGSIDE THESE CHANGES, **UTILIZING WATER** AS A TOOL FOR **TRANSFORMATION**, NOT A THREAT TO RESIST?
WHAT IF YOU ACKNOWLEDGE THAT THE **MATERIALS OF THE PAST WERE MADE TO LAST**, BUT MAYBE NOT IN THE SAME WAY AS INTENDED?
NOT BECAUSE THE MATERIAL HAS FAILED, BUT BECAUSE IT INVITES YOU TO **REPURPOSE** IT IN **DIFFERENT WAYS**.
WHAT IF YOU **SALVAGED AND REUSED THE MATERIALS** FROM EXISTING BUILDINGS **ON-SITE**, INCORPORATING THEM INTO NEW DESIGNS THAT **MEET TODAY'S CONTEXT**?
EVEN IF THOSE MATERIALS HAVE A SHORTER LIFESPAN, COULD THEY BE **USED THOUGHTFULLY**, CREATING DESIGNS THAT MAKE **FUTURE REPLACEMENT EASIER** AND MORE **SUSTAINABLE**?
YOU CANNOT PREDICT FUTURE NEEDS OR CONDITIONS. BUT WHAT IF YOU COULD PREPARE TO **REMAKE BUILDINGS** IN RESPONSE TO CHANGING DEMANDS?
THIS MEANS DESIGNING FOR **FUTURE REUSE OF ON-SITE MATERIALS**, ENSURING THAT YOU CAN **REIMAGINE AND REBUILD** IN NEW WAYS, **WITHOUT** CREATING **UNNECESSARY WASTE**.




- 0.1 - 0.3 m
- 0.3 - 0.6 m
- 0.6 - 0.9 m
- 0.9 - 1.2 m
- > 1.2 m

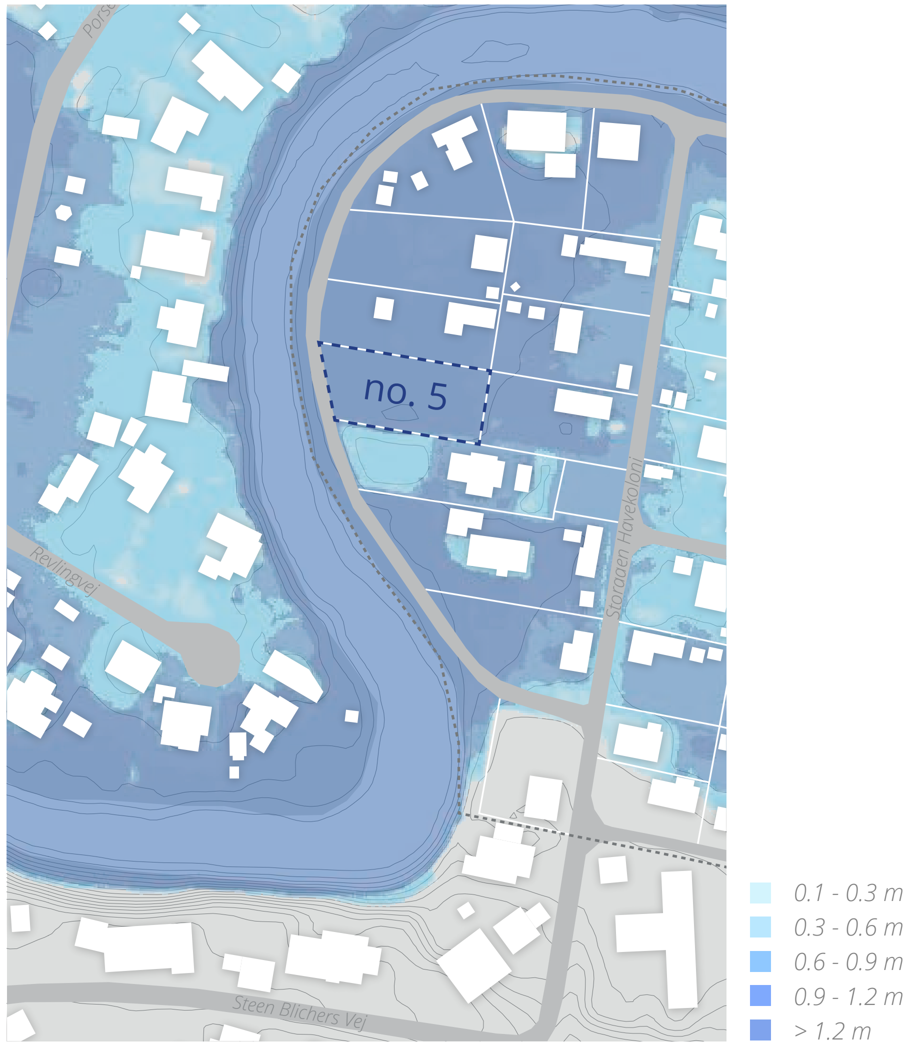
*Ill. 4:*
*Aalborg, Holstebro, Randers, Vejle 1:5.000, 10 cm rainfall, in 10 years. (KAMP - et Klimatilpasning- og Arealanvendelsesværktøj til Miljø- og Planmedarbejdere, no date)*

# rising opinions.
# rising investigations.

In addressing the challenges of flooding and material waste in the built environment, this project focuses on a specific case study within the allotment community of Havekolonien Storaaen in Holstebro Municipality. This selection aligns with the project's manifesto, which advocates for adaptive architectural solutions that embrace environmental changes rather than resist them.

Allotment gardens in Denmark are cherished for their tranquility and close connection to nature, yet they are often situated in areas highly susceptible to flooding. The four examples illustrated in illustration 4, demonstrate the extent of flooding that can occur with just 10 cm of rainfall, a scenario projected to become increasingly frequent over the next decade (Ill. 4). These vulnerable locations highlight the urgent need for resilient design solutions that allow such communities to coexist with rising water levels.


*Ill. 5:*
*Aalborg, Holstebro, Rander and Vejle location on Denmark map.*

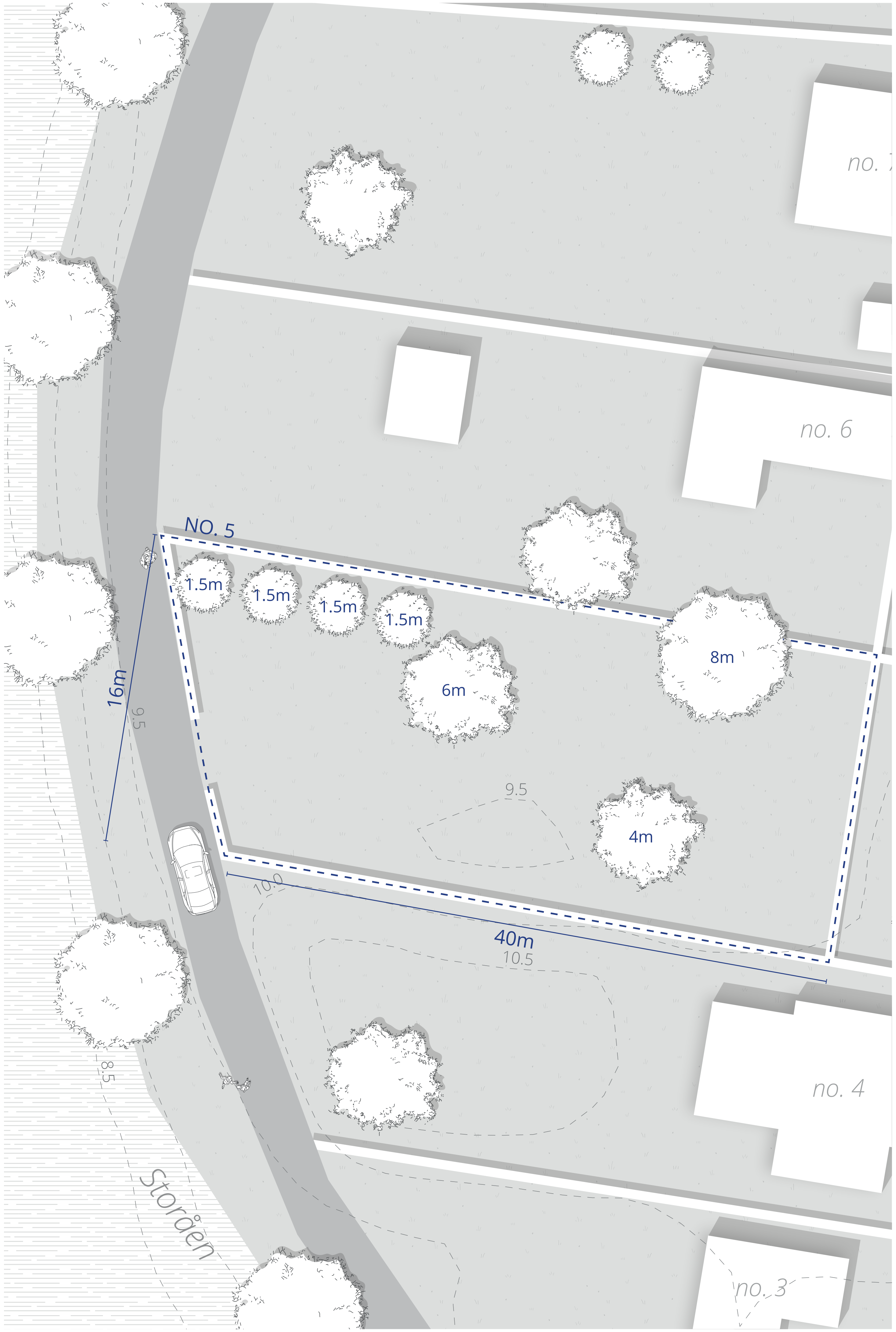


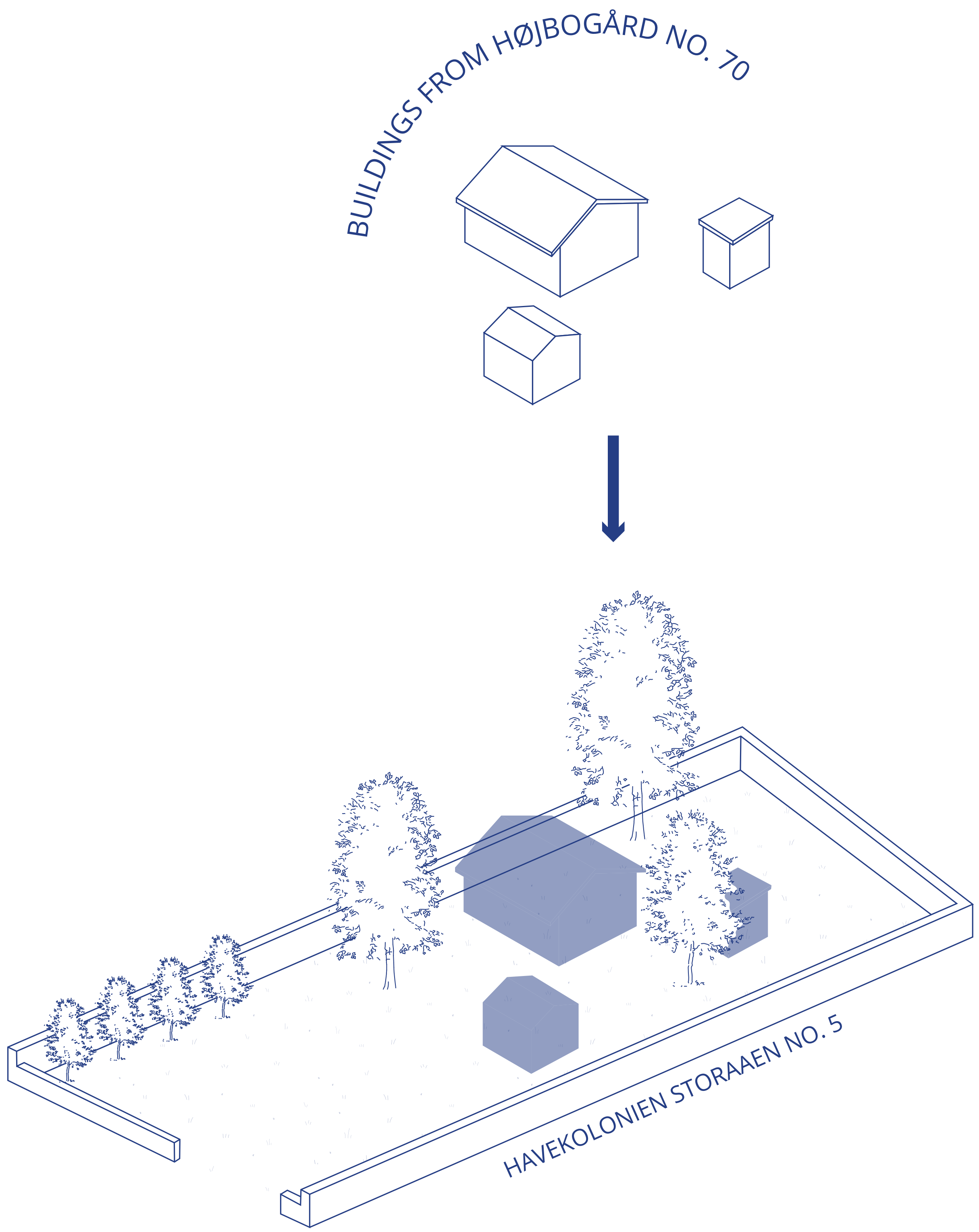

*Ill. 6:*
*Havekolonien Storaaen in Holstebro with design case site in focus.*
*(KAMP - et Klimatilpasning- og Arealanvendelsesværk-tøj til Miljø- og Planmedar-bejdere, no date)*

Among these vulnerable sites, this project specifically focuses on Havekolonien Storaaen in Holstebro. This community has been chosen based on discussions with Holstebro Municipality, the association's chairman, and an interview with the plot owner (App. 1). These insights revealed that this area frequently experiences severe flooding, making it an ideal case for exploring adaptive design strategies.

Within this community, Garden No. 5 has been selected as the primary case study due to its direct exposure to the Storå river (Ill. 6-7). This choice was influenced by both the severity of the flooding and the owner's willingness to participate. The detailed site plan illustrates the garden's layout, including existing trees and terrain, providing a clear understanding of the conditions it faces. This specific plot serves as a prototype for testing resilient architectural solutions that align with the project's goals.

*Ill. 7:*
*Garden no. 5 in Havekolonien Storaaen*
*1:250*






Ill. 8:
Allotment house case put into flood plot case.

To effectively explore how flood resilience and material reuse can be achieved, a representative allotment house has been introduced onto the site of Garden No. 5. This decision was made because the original building was demolished due to flood damage, leaving the site empty. By selecting an existing allotment house from another community, this project can realistically simulate the challenge of transforming a flood-damaged structure.

This specific allotment house was chosen based on a photographic survey of over 100 allotments in Holstebro and Aalborg, ensuring it represents common architectural characteristics found in such communities. These include painted wooden facades, greenhouses, sheds, fiber cement roofing, and traditional windows. This approach allows the project to test how an existing, flood-damaged structure can be transformed into a resilient and sustainable form of architecture, aligning with the manifesto's call to reuse materials and adapt to changing environments.

Choosing an allotment building case for this project is not only relevant because of their vulnerability to flooding but also because they embody a broader architectural challenge: how to achieve resilience and sustainability with limited resources. Allotments are often self-built, low-cost, and maintained by private owners with minimal budgets, making them a perfect testing ground for affordable, adaptable, and sustainable solutions. This means no high-tech solutions.

By focusing on an allotment, the project explores how flood resilience and material reuse can be achieved even in contexts where financial and technical resources are limited. The principles developed here, embracing environmental change, designing for reuse, and maximizing material efficiency, are not only relevant to allotments but can also be scaled up to other building types and urban contexts.

With this case study established, the next section of this project seeks to transform these insights into actionable solutions. The analysis of Havekolonien Storaaen and the challenges of flooding and material waste it faces serve as a foundation for exploring how architecture can turn these problems into opportunities.

***The following will present the problem statement that guides this investigation:***

**This project seeks to investigate how existing flood-damaged small wooden buildings can be reused to construct resilient structures that not only withstand future floods but also celebrate the flood experience, and are designed to extend material life and minimize material waste?**

*- Problem statement*



# EXPLORE THE CHALLENGE

This chapter explores the challenges of flood resilience, flood experience, and extending material lifespan in greater depth. Each section begins with a general exploration of the topic, followed by a site-specific analysis, a review of relevant architectural theories, and a case study where these theories are applied in practice. Together, these investigations will provide insights and strategies to guide the development of a flood-adaptive, resource-efficient design. The chapter concludes with a summation that connects these insights, forming a foundation for the next phase.

# 1 - flood resilience.

### General

As previously mentioned, flooding is an increasing problem in Denmark, particularly in allotment communities. To better understand the impact of flooding, a survey was conducted with 49 allotment owners across the country (App. 2). Among them, 26 reported experiencing periodic flooding. The severity of these floods varied: most reported minor flooding at ground level or between 10-30 cm, but some experienced water levels reaching up to 1.5 meters for several days each year.

This variation in flood severity can be categorized into three scenarios: dry conditions, low flooding, and high flooding. For most, the consequences were limited to minor damage to garden furniture and landscaping. However, some experienced significant damage to their houses and foundations, which would require extensive renovation to maintain the buildings in their original condition. This is particularly challenging when foundation damage occurs, as it is difficult and costly to repair.

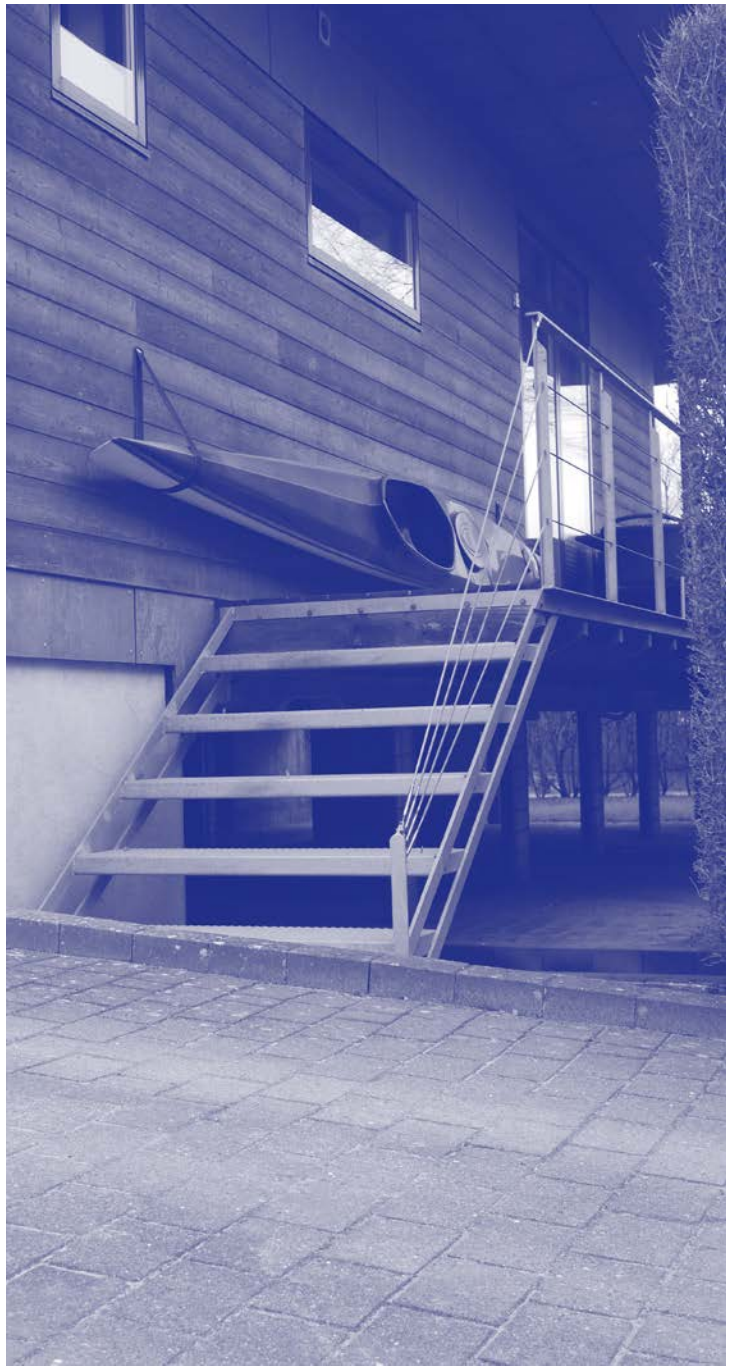
Several respondents also reported moisture problems inside their homes, which can lead to harmful mold growth. This highlights the importance of maintaining a healthy indoor climate to prevent such issues.

When asked about potential solutions, most participants expressed a preference for a pumping system to divert water away from their gardens. This preference is understandable, as it would allow them to prevent flooding without having to rebuild their homes. However, some were also open to alternative solutions, such as using water-resistant materials, constructing floating homes, or building houses on stilts. These options, however, may be limited by local regulations on building height.

Regarding the possibility of building a new flood-resistant allotment house, the responses were divided. About half of the participants were not interested because they preferred upgrading their existing house, while the other half were open to the idea but only if it was financially feasible. This indicates that economic factors are a significant consideration.

Participants were also divided on how to approach the construction process. Around half wanted to build the house themselves, seeing it as part of the allotment experience, while the other half preferred hiring professionals due to a lack of skills or time. This indicates that while active participation in the building process is valued, it is also acceptable to rely on professional assistance when skills or capabilities are limited.





*Ill. 9: Flood resilient allotment house in Holstebro. Photo: Author.*

Finally, when asked whether flood management should be addressed at the individual plot level or the community level, 70% preferred a community-level solution, while 30% favored an individual approach. This preference for community-level solutions may be influenced by the cost of individual measures and the importance of maintaining access to shared pathways within the community. These findings highlight the need to explore community-level flood management solutions before focusing on individual plots.

## Site analysis

In the case of Havekolonien Storaaen, the allotment community is situated within a curve of the Storaa river, making it highly susceptible to flooding. Before exploring flood resilience measures at the individual plot level, it is essential to assess whether community-wide flood protection is feasible (ill. 10).

One potential approach is the implementation of a pumping system to redirect floodwater away from the community. However, for such a system to be effective, it must discharge water to an area where it cannot flow back. Given the site's low elevation relative to its surroundings, this option is unviable, as there is no suitable location for water discharge that would prevent backflow.

Another possibility is constructing a levee or flood protection wall along the riverbank to block direct water ingress. However, this approach has several limitations. Firstly, the site is characterized by a high groundwater level, with groundwater typically located just 1-2 meters below the surface (Ill. 11). This means that even with a levee, rainfall would quickly lead to surface flooding due to the already saturated soil, which cannot absorb additional water. Moreover, such a barrier would obstruct the community's visual and physical connection to the river, a key quality in the area, as highlighted in an interview with one of the allotment owners (App. 1).

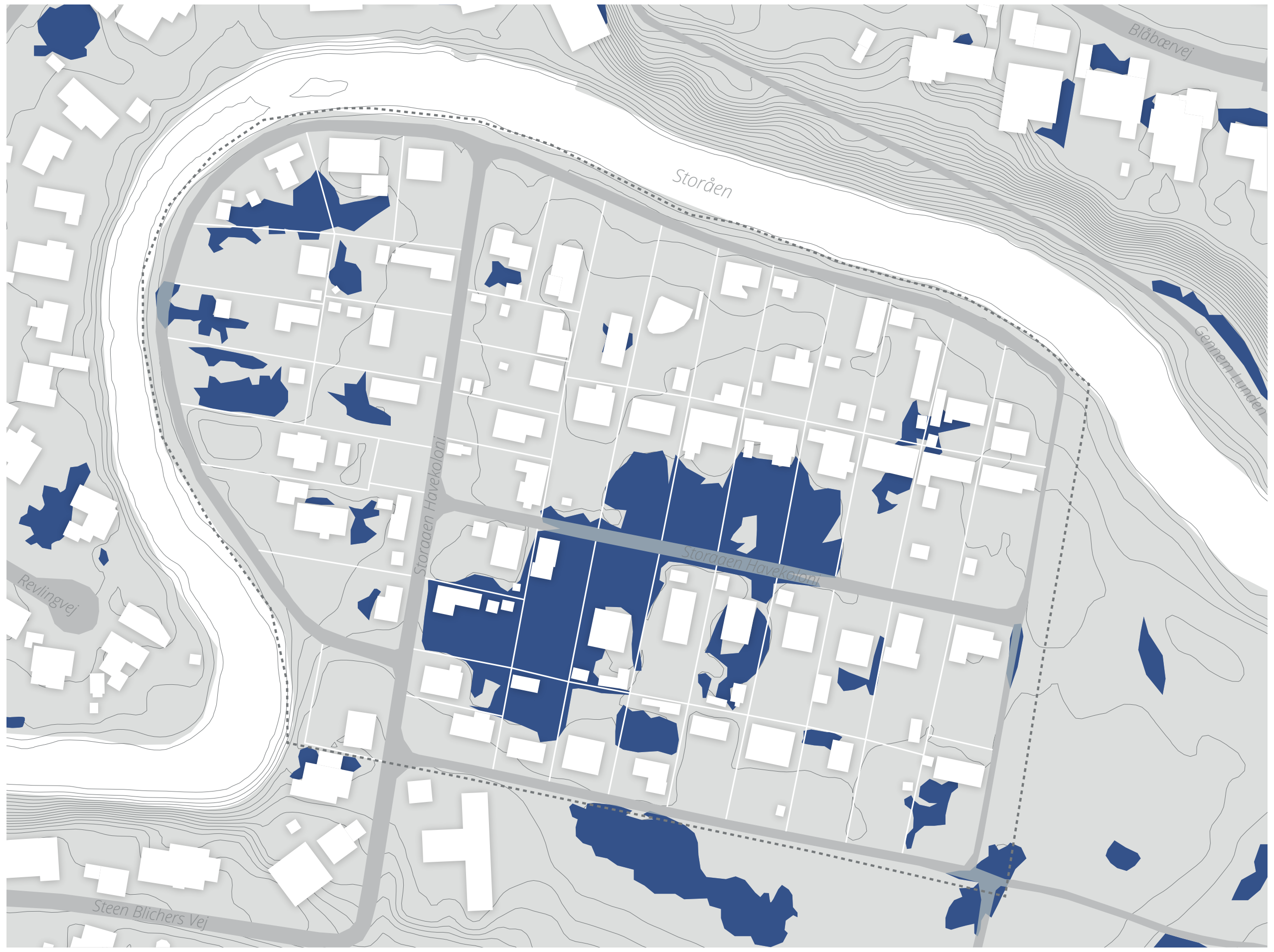
An alternative solution could involve raising the entire site above the expected flood level. While this would maintain both river views and dry conditions, it would require significant earthworks and the complete demolition of existing structures. Additionally, this approach is unsustainable due to ongoing soil erosion, where the river gradually carries away soil, necessitating continuous replenishment.

Given these limitations, it is concluded that community-wide flood protection is not feasible in Havekolonien Storaaen. This aligns with discussions among Havekolonien Storaaen members, who have explored potential solutions without reaching a consensus (App. 1). As a result, flood resilience must be addressed at the individual garden plot level. Designing solutions for single plots can provide adaptable strategies that may later be implemented across multiple plots within the community.


*Ill. 10: Proposed community based solutions on top of photograph from above. Photo: Skråfoto*


1-2 m
2-3 m
4-5 m
5-10 m

*Ill. 11: Mapping of ground water level during the winter season in scale 1:2000. (Klimadatastyrelsen, no date)*




15 mm bluespot
Buildings
0.5 terrain contour
Havekolonien Storaaen boundary

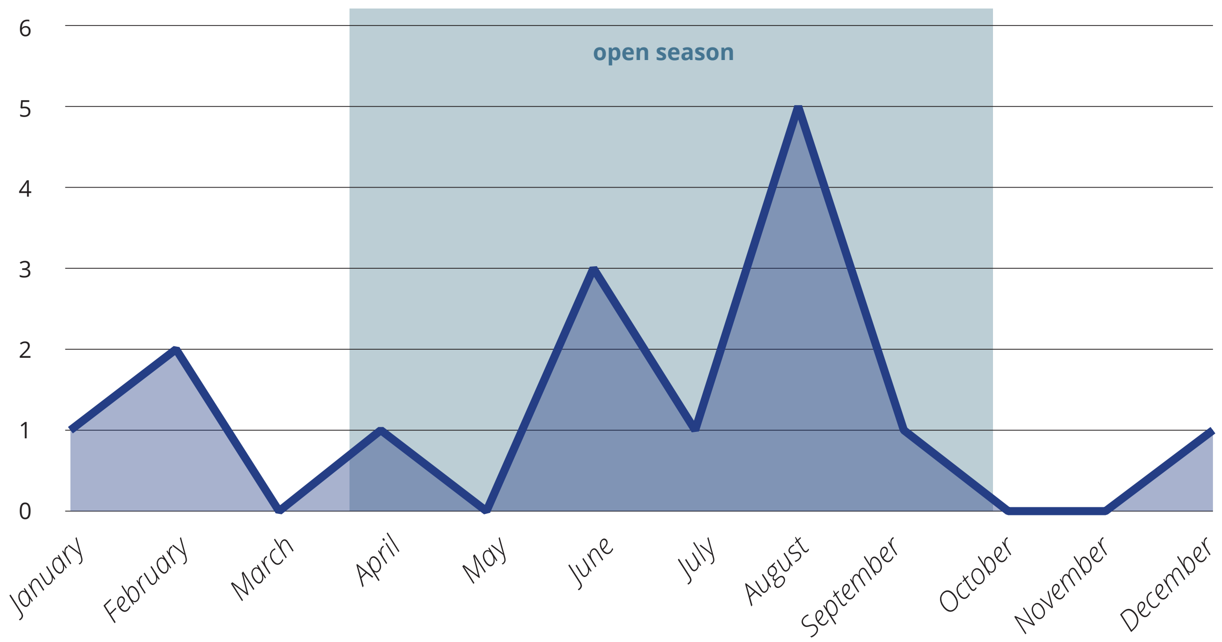
*Ill. 12:*
*Mapping of 15 mm bluespot in scale 1:2000. (Klimadatastyrelsen, no date)*

When designing a flood-resilient solution for an individual plot, it is essential to accurately understand the extent and frequency of flooding. This thesis focuses on Garden No. 5, identified as one of the highest flood-risk plots within the Havekolonien Storaaen community.

Illustration 12 presents a bluespot analysis indicating that this garden experiences surface flooding with just 15 mm of rainfall. Based on survey data from 29 flood-affected allotment owners across Denmark, this typically results in water levels between 10–30 cm (App. 2). Furthermore, Illustration 13 illustrates the number of days per year this rainfall threshold is exceeded, highlighting that the most frequent occurrences align with the allotment's open season. This observation is significant, as it indicates that the design must accommodate flood conditions without disrupting the residents' ability to use and enjoy their garden during the primary season of occupancy.

It is important to note that these analyses focus on surface flooding caused by direct rainfall rather than river overflow. Although there is a connection between the two, previous data (Ill. 6) demonstrate that river flooding becomes a critical issue with rainfall of approximately 100 mm, resulting in water levels of up to 1.2 meters. According to an interview with the plot owner (App. 1), this floodwater is typically still rather than moving with waves, which is relevant to include in the design process.

These insights establish two critical flood scenarios for the design: low-level flooding at 15 mm, resulting in 10–30 cm of water from rainfall, and high-level flooding at 100 mm, leading to 1.2 meters of still water from river overflow. A successful design must therefore be adaptable to both conditions, ensuring functionality and safety in the face of varying flood levels.




*Ill. 13:*
*Rain diagram showing amount of days when it rains more than 15mm in Holstebro based on data from DMI (2024). (DMI, no date)*

When constructing on a plot, owners must comply with the Allotment Law*, the local plan, and the allotment association's specific regulations. These include obtaining approval from the allotment chairman before any construction. However, as this is a hypothetical project, no official approval will be sought. This project is specifically designed for Plot No. 5 in Havekolonien Storaaen, and thus adheres to the regulations of that particular site. Below are listed the most relevant regulations:

- **Building Size:** Only one structure larger than 15 m² is allowed, with a maximum size of 50 m². Additional structures such as sheds and greenhouses must not exceed a combined total of 25 m².
- **Utilities:** Sheds cannot include sinks, toilets, showers, or washing machines.
- **Building Height & Levels:** Structures may only have one floor without an attic space, and basements are not permitted. The maximum height is 4 meters from the existing ground level.
- **Materials:** Exterior walls must be made of wood, and roofing materials must not be reflective.
- **Boundary requirements:** Buildings must be at least 2.5 meters from property boundaries and 8 meters from the riverbank. Heights near boundaries must not exceed 1.4 times the distance to the property line.
- **Land Alterations:** After construction, the site must remain at its original elevation, and the maximum height limit of 4 meters must be respected.

These regulations ensure that all construction within the allotment area is safe, uniform, and compliant with local planning and environmental policies. While this project will consider these constraints, any design element that conflicts with them will be evaluated for potential municipal approval, particularly in relation to flood management. (By-, Land- og Kirkeministeriet, 2007)

** Kolonihaveloven*

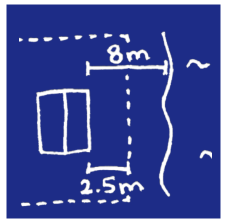
Building size


Utilities

Building height and level


Materials

Boundary requirements




Land alterations

*Ill. 14: The relevant regulations when building an allotment in Havekolonien Storaaen.*

**Theory: Architecture of persistence**

Rather than attempting to resist natural forces through complex technological solutions, a more sustainable and resilient approach is to adapt building strategies to accommodate environmental conditions. This approach aligns with the concept of persistence, as outlined by David Fannon in *Architecture of Persistence* (Fannon, Laboy and Wiederspahn, 2022). Fannon's theory emphasizes that designing for persistence involves creating buildings capable of enduring environmental changes, such as flooding, while maintaining both their functionality and cultural relevance. Central to this idea is the use of durable materials that withstand environmental stresses over time, including repeated exposure to water in flood-prone areas. By prioritizing material durability, buildings reduce the need for frequent repairs, thereby minimizing material waste and extending their lifespan.

Equally important is adaptability. Persistent architecture must accommodate shifts in environmental conditions or user needs without requiring extensive alterations. This flexibility ensures that structures remain useful and relevant despite changes brought on by flooding or evolving occupant requirements. Simplicity in design further supports persistence by making the building's function and maintenance procedures clear. This clarity is especially important in areas at risk of flooding, where easy maintenance can help prevent damage and extend the building's lifespan.

Furthermore, persistent buildings should be firmly grounded in their context. For Havekolonien Storaaen, this means acknowledging the flood risk posed by the nearby river and the high groundwater levels, while respecting the allotment's low building density and height restrictions. By responding sensitively to these local conditions, architecture can achieve contextual integration that supports long-term resilience.

Finally, persistence requires a strategic approach to maintenance. Rather than focusing solely on initial durability, a persistent building anticipates ongoing care and repair, ensuring continuous performance over time despite varying environmental conditions. This perspective shifts maintenance from an afterthought to an integral component of sustainable design.

By critically examining these principles in relation to flood resilience, it becomes clear that successful designs must go beyond resisting water damage. They must also remain functional, maintainable, and contextually appropriate in the face of changing conditions. This theoretical foundation provides a lens through which to evaluate flood-resilient architecture, guiding the analysis of the case studies in the following section, where the extent to which existing buildings embody or fall short of persistence will be explored.

**Case study**

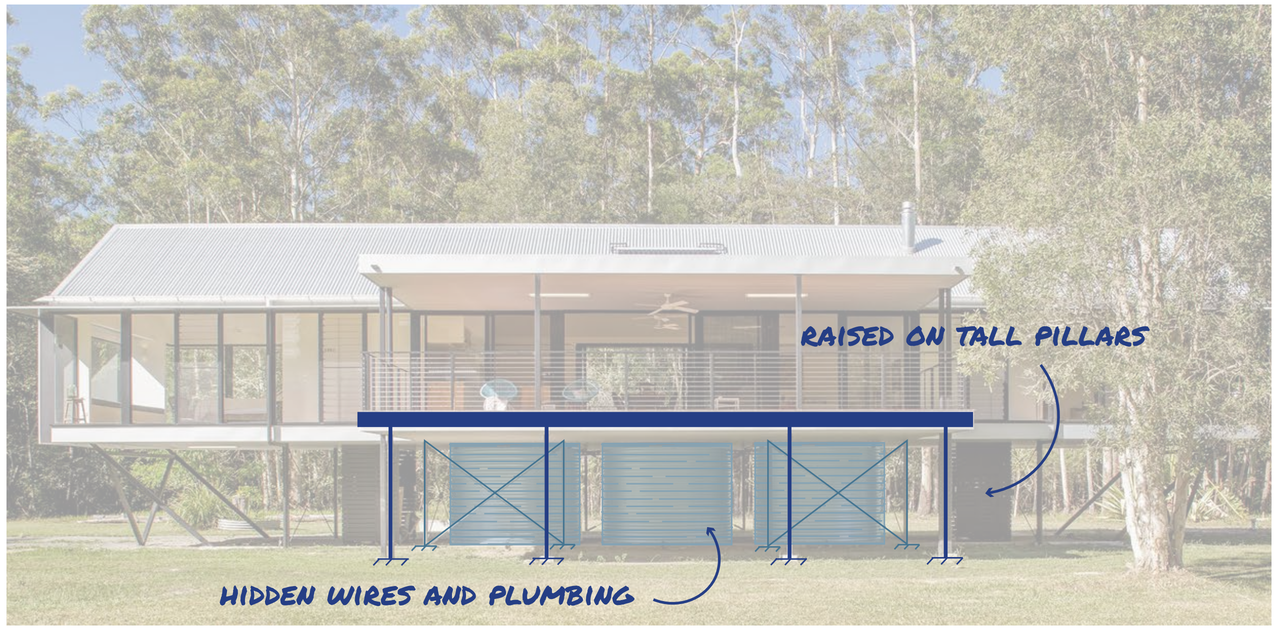
To better understand how architectural design can embody persistence in flood-prone environments, this study examines three houses: the U-House in Japan by Ushijima Architects (Ill. 15), the Platypus House in Australia by Robinson Architects (Ill. 16), and the MFS III – Minne Floating School in Bruges, Belgium by NLÉ (Ill. 17). Each employs a distinct strategy: water-resistant materials, elevated construction, and floating foundations respectively. These approaches offer valuable insights into the principles of durability, adaptability, and contextual integration as outlined by Fannon.

The U-House demonstrates material durability by integrating water-resistant materials such as Japanese cedar and concrete in its lower sections. The design anticipates flooding and aims to minimize damage through thoughtful material selection, thereby reducing long-term maintenance and material waste. However, while this strategy supports durability, it lacks adaptability. The house is built to resist water rather than respond to changing water levels, which limits its functionality in more dynamic flood conditions. The U-House is situated in an area without risk of high flood levels, meaning the entry remains easily accessible, a condition that may not translate well to flood-prone sites like Havekolonien Storaaen. (Abdel, 2022)

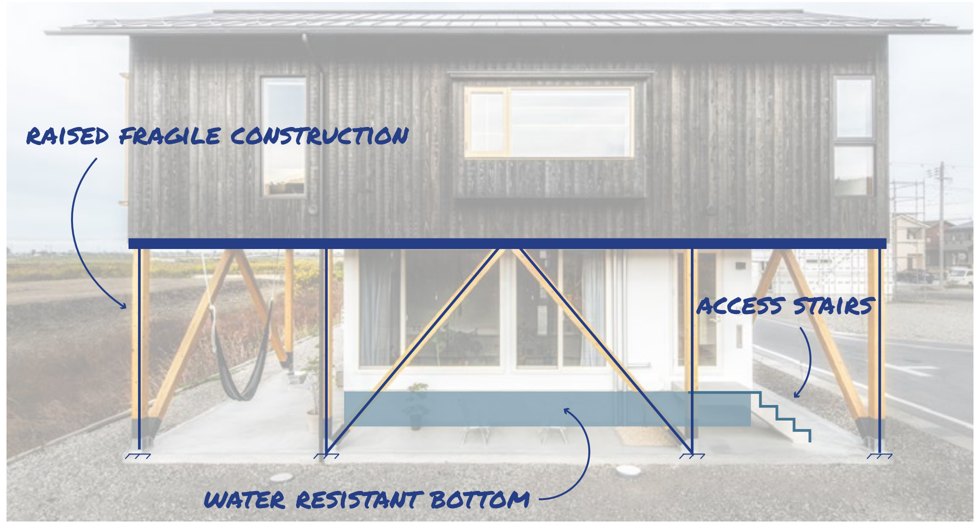
The Platypus House takes a more adaptive approach by elevating the structure above flood level using steel pillars. This strategy effectively protects the building from water damage and demonstrates resilience through avoidance. While this solution performs well in areas with frequent flooding, it poses challenges in contexts with strict height limitations, such as Danish allotment gardens. The elevation also risks disrupting visual and cultural integration with its surroundings, potentially clashing with the low-density character of allotment developments. Additionally, the complexity of the raised structure may reduce simplicity and increase long-term maintenance demands. Nevertheless, this approach allows the house to remain functional without needing to actively adapt during floods, which supports everyday resilience. (*Platypus House / Robinson Architects*, 2016)

In contrast, the MFS III – Minne Floating School represents a highly adaptive strategy by using a buoyant structure that floats in response to fluctuating water levels. Designed by NLÉ as a prototype for amphibious architecture, the structure uses a timber frame on top of a floating platform composed of locally sourced barrels, enabling it to rise and fall with the water. This approach aligns closely with Fannon's principles of adaptability and contextual integration, particularly in flood-prone urban environments. Its lightweight and modular construction minimizes impact on the site while allowing continued function during flood events. However, as with other floating designs, the system requires careful management of details like anchoring, access, and utilities, especially if adapted to contexts where floods are seasonal and water






*Ill. 15:*
*Sketch over Platypus House, designed by Robinson Architects.*
*Photo: © Alain Bouvier.*



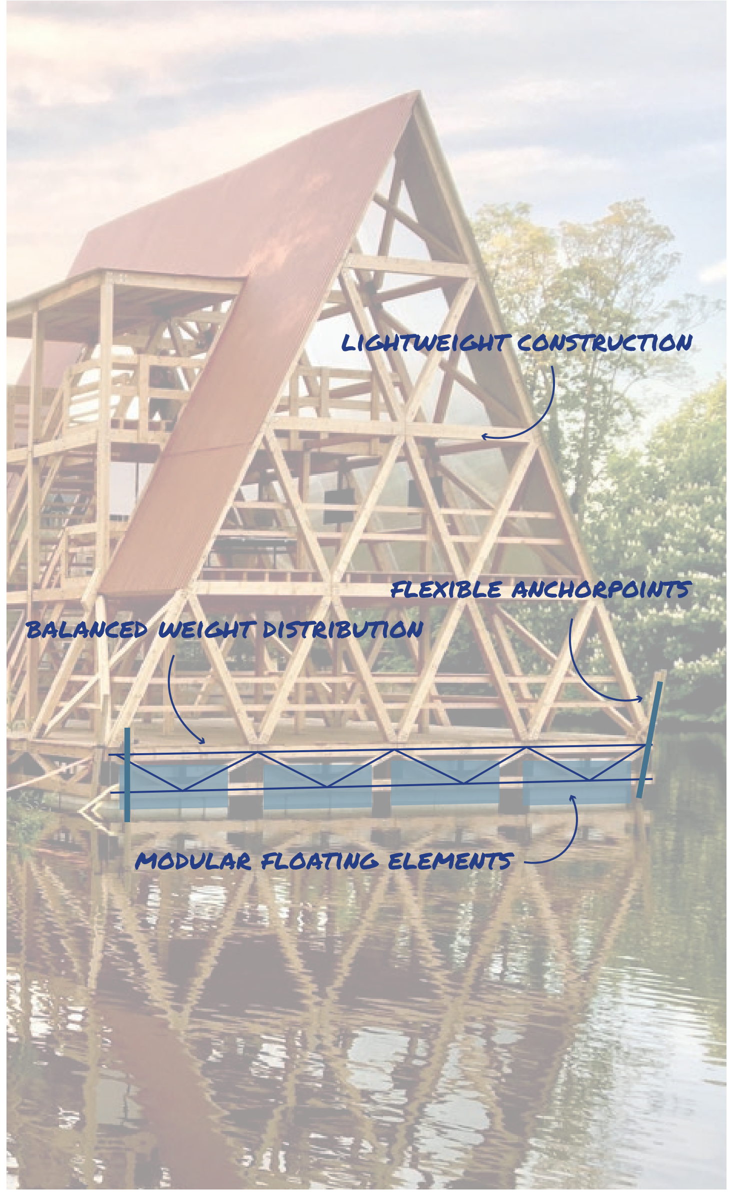

*Ill. 16:*
*Sketch over U-House, designed by Ushijima Architects.*
*Photo: © Shinya Tsujita*

levels vary significantly. In allotment settings, maintaining a functional and accessible entry across variable conditions remains a notable design challenge. ('MFS III – Minne Floating School – NLÉ', no date)

Viewed through the lens of persistence, each case study offers valuable but partial insights. Water-resistant construction supports durability but may lack flexibility. Elevated buildings avoid flood damage but can be constrained by regulatory or contextual factors. Floating structures provide exceptional adaptability but involve complex systems that must be carefully integrated to ensure safety, comfort, and maintainability.

Given the flooding conditions at Havekolonien Storaaen, typically 10 to 30 cm in outdoor areas and occasionally up to 1.2 meters indoors, a hybrid solution offers the most viable path forward. By designing a structure that can withstand up to 30 cm of flooding without the need for adaptation, as seen in the Platypus House, the design remains resilient during most seasonal events. For the rarer occurrences of higher flooding, adaptability becomes necessary, drawing inspiration from the floating foundation strategy. This dual approach allows the design to stay within height restrictions while expanding its functional capacity.

In this hybrid solution, outdoor spaces remain usable during floods up to 30 cm, while indoor areas can function during water levels up to 1.2 meters. Vulnerable areas should use water-resistant materials to reduce deterioration and simplify maintenance. The overall structure must be engineered to withstand moisture and hydrodynamic forces in all conditions. Finally, access must be maintained without damaging the building, ensuring both ease of use and preservation of the structure. Together, these considerations support a persistent architecture that balances durability, adaptability, and integration with the specific needs and constraints of the allotment context.




*Ill. 17:*
*Sketch over MFS III – Minne Floating School, designed by NLÉ.*
*Photo: © NLÉ*

**Sub-conclusion: Flood resistance**

This chapter has shown that individual plot-level solutions are necessary for managing flooding in Havekolonien Storaaen. Based on site analysis, user input, theory, and case studies, the following design criteria are established:

1. **Outdoor use up to 30 cm flood** 1.1
2. **Indoor use up to 1.2 m flood** 1.2
3. **Water-resistant materials in exposed areas** 1.3
4. **Structural performance under flood stress** 1.4
5. **Accessible entry/exit during flood** 1.5
6. **Visual fit with low-rise context, <4 m height** 1.6

These criteria will be used in the next chapter: Frame the design.

# 2 - flood experience.

**General**

Flooding is not only a structural issue, it also affects people emotionally, and financially. The survey conducted among allotment owners across Denmark shows that approximately 58% of respondents report feeling frustrated and worried during flooding events. At the same time, about 27% of participants view flooding as a natural part of the allotment experience and show a more relaxed attitude. This difference may reflect variations in how well their houses are secured, whether they even have structures on their plots, or how emotionally or financially invested they are in the space. (App. 2)

Seasonal differences also play a role. Some survey participants note that they do not mind flooding during the winter if their houses are not damaged. However, summer flooding is seen as more frustrating because it interferes with the primary use of the allotments for leisure, gardening, and relaxation. (App. 2)

The consequences of flooding go beyond emotional responses. It also influences decisions about ownership and long-term engagement with allotment living. The same survey shows that approximately 27% of respondents have considered or would consider selling their allotments if flooding becomes worse, indicating a tangible impact on people's sense of attachment and motivation to maintain their plots. (App. 2)

This aligns with broader patterns seen in the Danish housing market. According to a 2023 YouGov survey commissioned by Realkredit Danmark and Danske Bank, 62% of Danish homeowners believe that properties at risk of flooding or other climate-related events will be more difficult to sell or will decrease in value in the future. This shows a growing awareness of climate risks in housing decisions. (*Stigende risiko for oversvømmelser kan skabe sorte skyer over dele af boligmarkedet*, 2025)

In support of this, research from the University of Copenhagen has shown that property values in Denmark can temporarily fall significantly after extreme flooding. For example, after the 2013 Bodil storm surge, property prices in affected areas dropped by 28–36% over a three-year period before slowly returning to previous levels. This study points out that many homeowners underestimate climate-related risks when buying a property. (*Klimarapport: Boligkøbere glemmer at tjekke risikoen for oversvømmelse*, 2021)

These findings highlight that flooding is not only a physical and emotional challenge for individuals but also a financial concern that can reshape how people view property ownership in vulnerable areas. The combination of emotional strain and economic consequences underscores the need for a new design strategy that not only ensures resilience to flooding but also transforms it into an opportunity to create positive and memorable experiences, turning a recurring challenge into unique architectural potential that raises value both mentally and economically.



**Site analysis: Existing experience**

To design for an experience, it is essential to understand the qualities that define the current condition of the site. As the plot is currently undeveloped, this analysis considers the site without a building in place, allowing the experiential and spatial qualities to be assessed as realistically as possible. Observations are based on a site visit and an interview with the plot owner (App. 1).

*Ill. 18:*
*Havekolonien Storaaen*
*plot no. 5.*
*Photo: Author*

Access to the plot is from the east along a narrow road, which visually frames the allotment gardens on one side and the river on the other. This moment of arrival reflects a unique spatial relationship between cultivated land and flowing water, highlighting the community's close connection to the river. Garden no. 5 is defined by a low hedge towards the road, with a large opening for private parking and an unobstructed view of the river, emphasizing its openness and orientation towards the landscape.

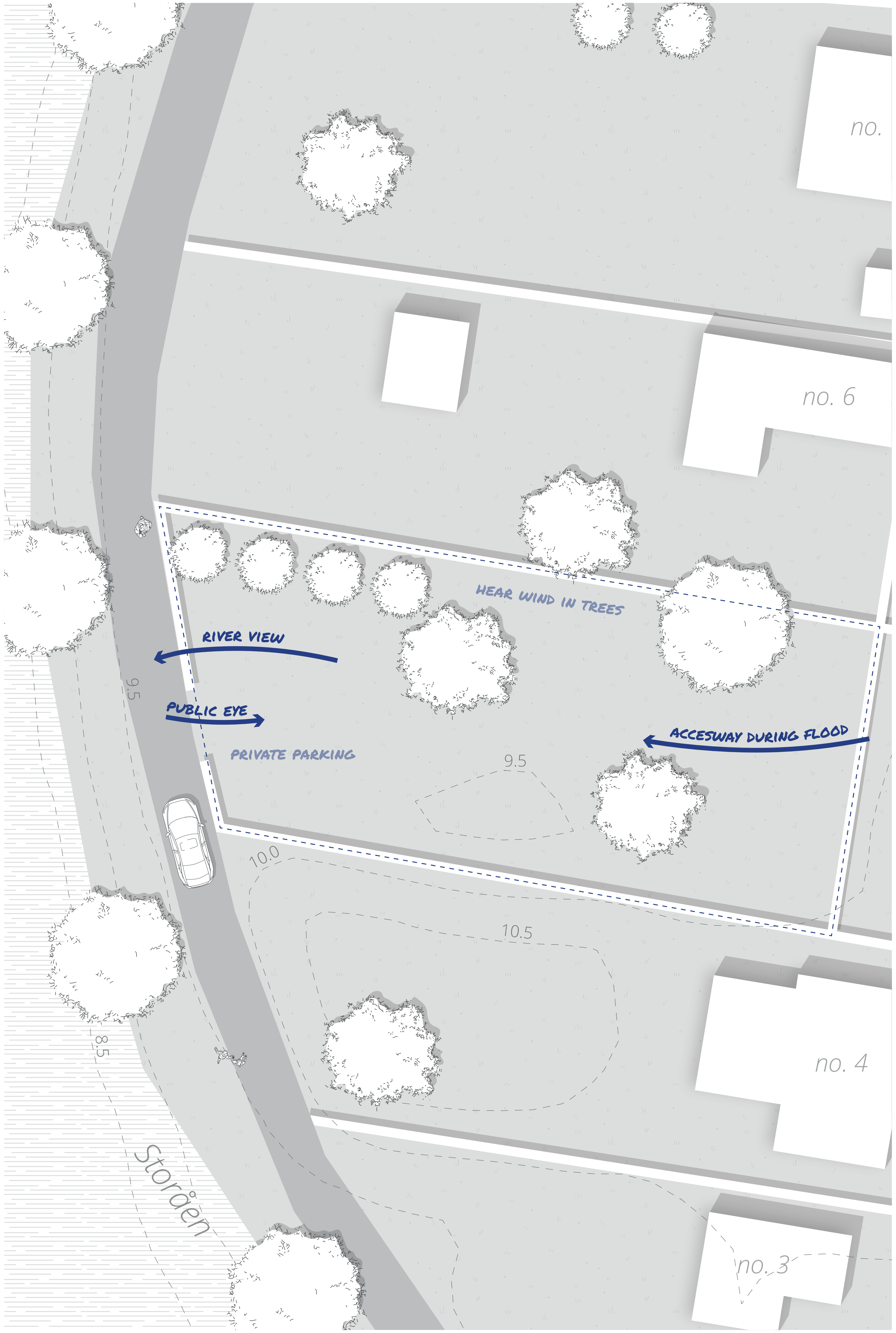
Upon entering the plot, the presence of mature trees dominates the sensory experience. Two large trees stand along the northern boundary, accompanied by a smaller tree towards the south and a row of fruit trees along the shared boundary with a neighboring garden. On the day of the site visit, the weather was windy, and the sound of rustling leaves, birdsong, and distant gushing water created a rich, multi-sensory atmosphere that tied the experience closely to seasonal and climatic conditions.

Spatially, the plot is enclosed on three sides by neighboring gardens, creating a sense of privacy, while the fourth side opens toward the road and river, exposing the site to public view. According to the plot owner, this openness supports a culture of casual interaction, where neighbors and passersby often exchange greetings or engage in short conversations. This reflects a wider social dynamic typical of the allotment community.

The topography of the site appears flat but is slightly lower than the surrounding plots, resulting in Garden no. 5 being one of the most flood-prone in the area. A neighbor to the south has raised their garden significantly with a soil layer to avoid flooding, but such interventions are now prohibited. As a result, the plot remains vulnerable during heavy rainfall and seasonal floods. This condition has led to an informal agreement with the eastern neighbor, allowing the owner to access the plot through their garden during flood events when the main road is impassable. This highlights the importance of access strategies.

Visually, the trees on the plot play a prominent role. While surrounding buildings are uniformly low-rise, single-story structures, the taller trees stand out in the landscape, offering vertical contrast and a sense of rootedness within an otherwise low context.

In summary, the site is characterized by a strong sensory connection to climate and nature, a defined gradient of privacy, visible social interaction, and a unique vulnerability to flooding due to its slightly depressed topography. These qualities form the experiential framework upon which future architectural strategies can build, especially when exploring how a design can both respond to and elevate the presence of water as part of the lived environment. This connection can also be increased by offering the possibility of movement through diverse microclimatic zones.




*Ill. 19:*
*Notes from site visit and interview (App. 1)*
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## Theory: Atmospheres and Eyes of the skin

When exploring architecture that provides a connection to its surroundings by blurring or accentuates the boundaries between indoors and outdoors, the works of Peter Zumthor and Juhani Pallasmaa provide profound insights into how sensory experience shapes our perception of space. Zumthor, in *Atmospheres* (Zumthor, 2006), invites us to consider architecture as a body that we physically and emotionally interact with. His emphasis lies in how materials, light, sound, and temperature collectively create an atmosphere that moves the individual. For Zumthor, beauty emerges not just from visual aesthetics but from a holistic sensory engagement, one where tactile warmth or the subtle play of shadows creates a lived experience. He advocates for experimenting with material relationships and light to shape an intimate dialogue between building and occupant, emphasizing that architecture is temporal and dynamic, guiding movement and evoking emotions through subtle cues.

Juhani Pallasmaa, in *The Eyes of the Skin* (Pallasmaa, 2012), critiques the dominance of vision in architecture and insists on a multi-sensory approach. He reminds us that architecture is not only seen but touched, heard, and felt through the body's entire sensory system. Pallasmaa stresses the importance of tactility, texture, and the intimate warmth that spaces convey through materials and light. His writing highlights how shadows and sound contribute to the depth of spatial experience and how architecture anchors us to memory and time. The hand, for Pallasmaa, is a powerful organ of perception, and a building's textures, weight, and temperature communicate on a bodily level, inviting us to engage beyond the visual realm.

Building on these ideas, creating a quality architectural experience that is worth preserving, and thus minimizes material waste, requires a sensitive response to its surroundings. During pleasant weather, the design should prioritize removing barriers between inside and outside to accentuate the environment and foster a seamless connection. However, when flooding occurs, the building must create a protective barrier that makes the occupant feel safe. At the same time, this barrier should not hide the water but rather accentuate it, turning what could be a negative experience into a uniquely beautiful one by thoughtfully working with light, sound, and visible elements of the water. Importantly, the observer's physical interaction, using their hands to open or close these barriers, heightens awareness of the changing atmospheres and encourages a deeper focus on the surroundings. This sensory engagement leads to a more profound understanding of the environment's dynamics.

This theoretical perspective sets the stage for examining how such barriers can be both created and removed in practice, which will be explored through the case study of Can Lis by Jørn Utzon.



## Case study: Can Lis, Jørn Utzon

Can Lis, designed by Jørn Utzon and completed in 1972, is located on a rocky cliff on the southern coast of Mallorca. The house is composed of a series of pavilions connected by courtyards and open walkways, allowing for a continuous dialogue between the building and its natural surroundings. It is constructed using local materials, primarily a rough golden stone from the island, which visually and physically roots the architecture to its site. This case study explores how Can Lis manages the boundary between inside and outside space, with reference to theoretical ideas by Peter Zumthor and Juhani Pallasmaa. It considers three key aspects: how the barrier between inside and outside is removed; how such a barrier could be reinstated during adverse conditions like flooding; and how the presence of water could be accentuated through architectural means to enhance a sensory experience of comfort and protection. (*Can Lis*, no date)

*Removing the Barrier Between Inside and Outside*
At Can Lis, Utzon removes the boundary between indoor and outdoor space through a series of deliberate design choices. The use of the same rough stone on both interior and exterior surfaces dissolves the visual and tactile distinction between inside and outside. This continuity of material creates what Pallasmaa describes as a multi-sensory environment, where touch, sight, and even smell are engaged simultaneously. The roughness of the stone invites the hand to explore surfaces, reinforcing the physicality of the space and supporting Pallasmaa's argument that architecture should be experienced by the whole body, not just the eyes.

*Ill. 20:
Can Lis designed by Jørn Utzon.
Photo: © Utzon Archives / Aalborg University & Utzon Center*

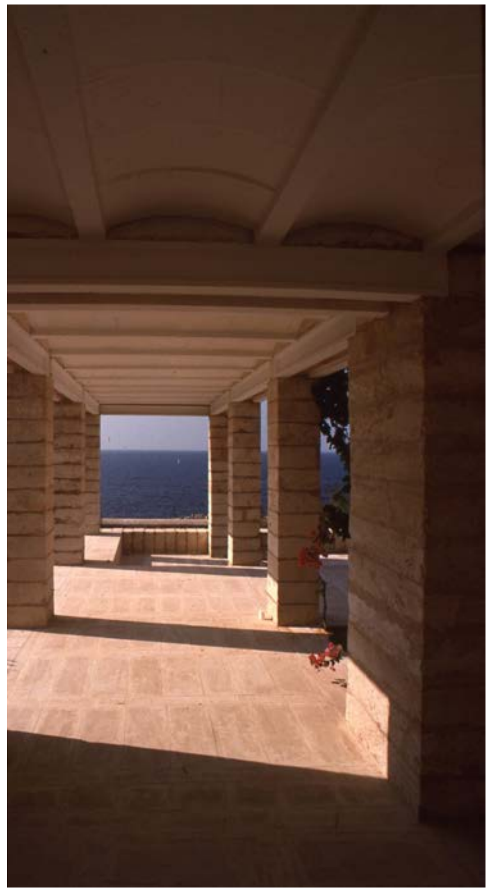
The building's layout further contributes to this sense of openness. Rather than forming a compact enclosed volume, Can Lis is fragmented into smaller volumes linked by outdoor spaces, blurring the division between shelter and exposure. This spatial arrangement produces what Zumthor refers to as a dynamic relationship between the built form and its surroundings. When one moves through the house, the experience is not of transitioning between clearly defined zones, but of moving within a continuum that alternates gently between shaded interior and sunlit exterior.

Large openings, often spanning full sections of the facade, can be completely opened through pivoting or folding doors. When these are open, the line between room and terrace disappears, and the interior becomes an extension of the landscape. The floor materials run uninterrupted from inside to out, further enhancing the sense that the house is not separate from its site but part of it. As Zumthor notes, such material and spatial continuity helps create atmospheres where the architecture is not an object to be viewed, but something to be inhabited sensorially and emotionally.

In addition, the absence of visible window frames removes the expected visual cues of separation. This design move challenges the mind's habitual reading of architecture. The viewer does not perceive a clear frame that divides one realm from another, allowing the mind to imagine that no such division exists. This supports Pallasmaa's critique of architecture's visual dominance and aligns with his idea that architecture should be subtle, drawing the user into a deeper awareness of place through nuanced shifts in material, light, and form.

*Reinstating the Barrier in Flood Conditions*
Although Can Lis performs well in dry and mild weather, it is less adaptable to adverse environmental conditions. If the house were located in a flood-prone area, its openness would no longer feel safe. In such conditions, the architectural boundary must become more visible and assertive to provide both physical and emotional protection. This need for refuge is central to both Zumthor's and Pallasmaa's theories, though neither explicitly addresses flooding. However, their emphasis on emotional comfort and sensory engagement offers guidance.

Zumthor writes that architecture should produce a feeling of safety and intimacy, what he calls "a house as a protective skin." In times of flooding, architecture must shift from openness to enclosure. At Can Lis, this would require the integration of movable barriers that can close off the large openings while still preserving the sensory connection to the outside. These could be solid yet textured shutters that match the stone of the walls, so the building retains its material coherence. The act of closing these barriers by hand also becomes a sensory moment, as the occupant physically engages with the changing atmosphere outside. This manual


*Ill. 21: Can Lis designed by Jørn Utzon. Photo: © Utzon Archives / Aalborg University & Utzon Center*

interaction reinforces the connection between user and space, in line with Pallasmaa's claim that architecture should be experienced through bodily involvement, not just passively observed.

Even when barriers are closed, they don't completely block the connection to the outside. Transparent materials, filtered openings, or small operable windows can maintain a visual and auditory connection to the water while providing protection. By managing the shift from openness to enclosure sensitively, the building can transform flooding from a threat into an atmospheric condition that is engaged with rather than hidden from.

*Accentuating the Beauty of Water During Flooding*
The presence of water, even during threatening weather, can be transformed into a poetic element if handled through careful architectural design. At Can Lis, this is not explicitly explored, but the role of light, sound, and visual framing in the building provides a foundation for imagining how such a strategy could be extended.

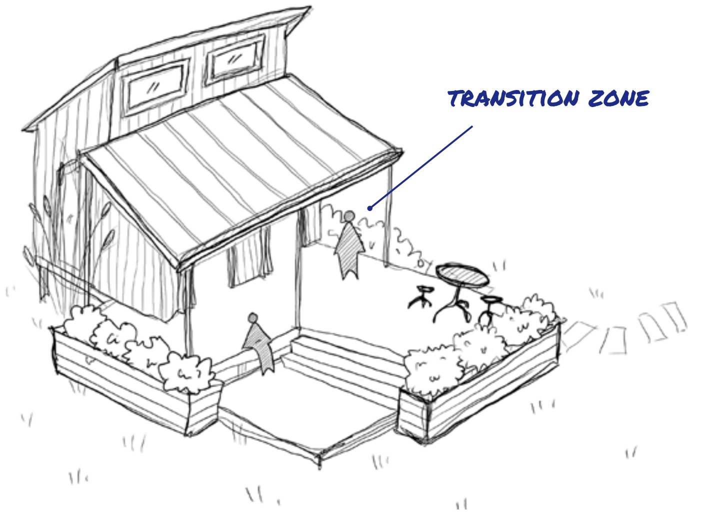
Zumthor places great importance on how light animates architecture. At Can Lis, the building is conceived as a mass of shadow hollowed out by carefully placed openings. Light enters through narrow slits or deep reveals, making its movement across textured stone surfaces slow and expressive. During a rainstorm or flood, these same qualities could be used to capture the reflection of water or the shadow of raindrops on walls and ceilings. If openings are positioned to catch glints of light off pooling water, or if glass surfaces are designed to reveal the rhythmic movement of rain, the experience can become one of wonder rather than discomfort.

Pallasmaa emphasizes how sound contributes to architectural atmosphere. In wet conditions, the sound of rain on stone, or the echo of water droplets falling into a basin, could be amplified subtly by the geometry of the space. Rather than suppressing these sounds, the architecture could shape them to enhance the sensory presence of water. This aligns with the idea that comforting spaces during rain are those that offer both protection and a heightened awareness of nature's rhythms. The sound of rain can become calming, even meditative, when filtered through architectural surfaces that resonate gently.

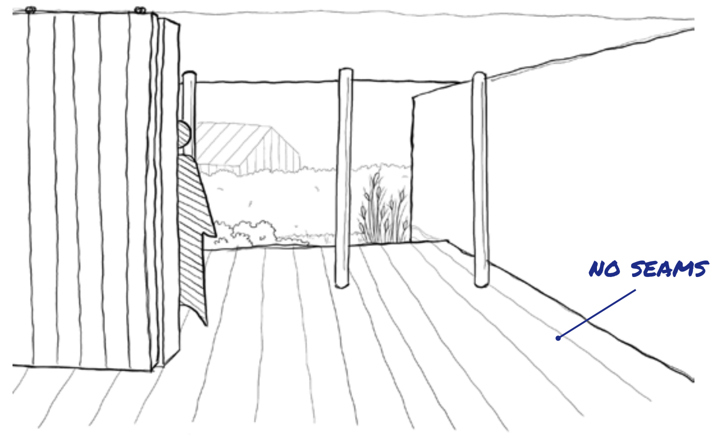
Many people find comfort in watching rain fall outside while being safely indoors. This effect is psychological but rooted in sensory experience: the softness of light diffused through wet glass, the steady pattern of droplets, and the muffled acoustics of a rainy day all contribute to a calming atmosphere. While Can Lis focuses on the dry Mediterranean climate, the principles at work, framing views, using light to create temporal effects, and shaping sound, could be adapted to create this same emotional response in a building that must endure seasonal flooding.



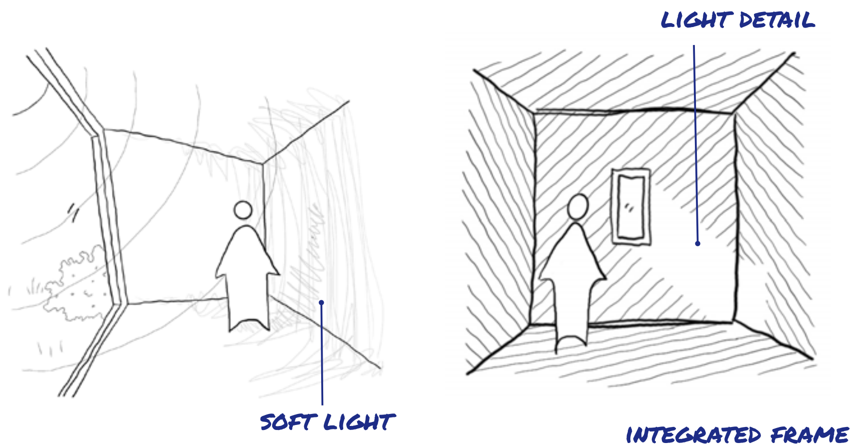
**Spatial blending with transitional zones**



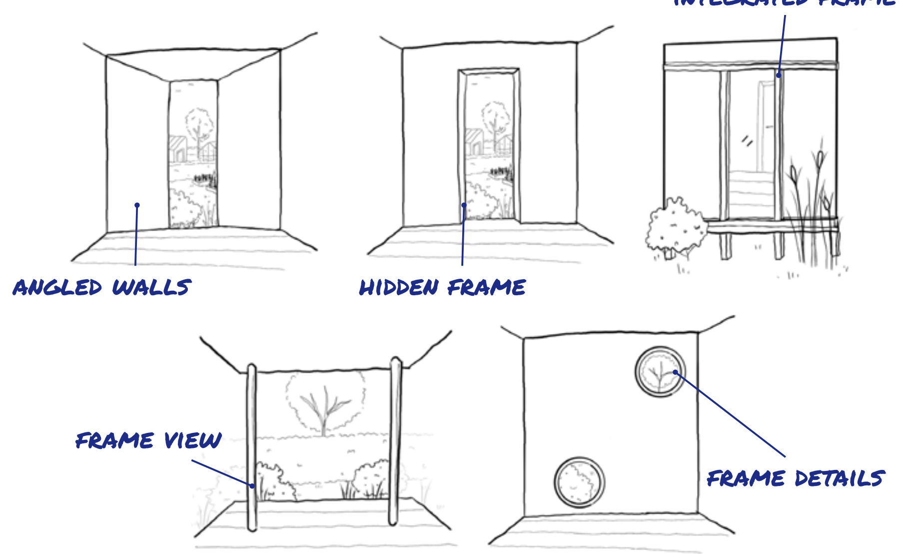

**Material Continuity**




**Light interaction**



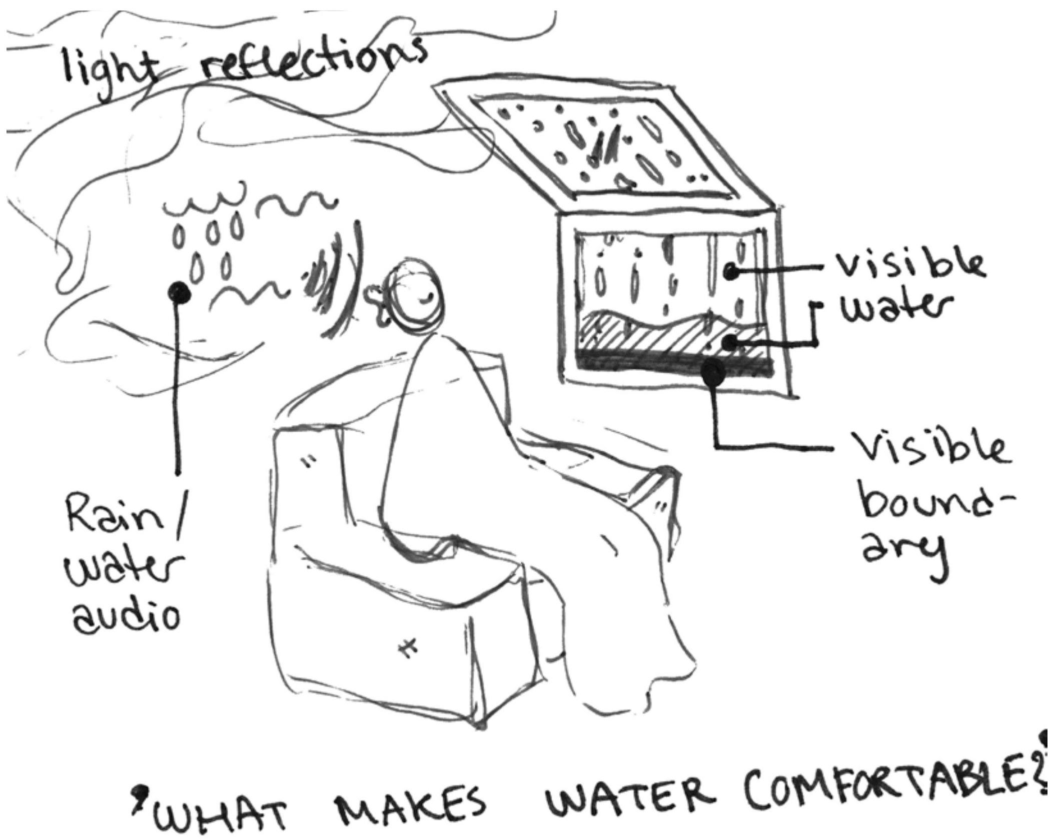

**Views and frames**




*Ill. 22: Design principles to remove barrier between inside and outside.*

*Conclusion*
Can Lis demonstrates how architecture can remove the barrier between inside and outside by blending spatial sequences, materials, and sensory experiences. It allows the landscape to enter the house without interruption, creating an immersive relationship with the site. However, in conditions where water becomes a threat, the building must take on a new role: that of protector. Theories by Zumthor and Pallasmaa suggest that this protective barrier should still support sensory engagement, rather than cut the user off from the environment entirely.

By embracing rather than concealing the presence of water, architecture can transform threatening conditions into moments of beauty and awareness. Through the use of filtered light, textured materials, sound, and tactile interaction, buildings can evoke a sense of safety while maintaining a deep connection with the natural world. In this way, architecture becomes a living part of its environment, constantly adjusting its presence in response to changing conditions, and enriching the sensory experience of its occupants.




*Ill. 23: Sketch showing the comforting aspects of a rainy day.*

**Sub-conclusion: Flood experience**

Flooding affects not only structures but also emotional, sensory, and financial aspects of living. This chapter has explored how a design can engage deeply with these challenges, using site-specific qualities and theoretical inspiration to create meaningful architecture. Based on analysis, theory, and case inspiration, the following design criteria are established:

1. **Remove the barrier between indoors and outdoors in dry periods** 2.1
2. **Enable movement through diverse microclimatic zones** 2.2
3. **Add a protective but sensory-engaged barrier during flooding** 2.3
4. **Accentuate water experience through views, light, and sound** 2.4
5. **Ensure indoor comfort in summer and dry, healthy conditions in winter** 2.5

These criteria will be used in the next chapter: Frame the design.

# 3 - extend material lifetime.

**General**

Flooding events often lead to material waste in Denmark, as buildings and homes that are affected frequently require partial or complete demolition and reconstruction. When floodwaters damage the lower parts of buildings, especially foundations and walls in direct contact with water, these sections often cannot be repaired but must be torn down and rebuilt to maintain structural safety standards. This leads to a considerable amount of building waste annually, although precise national figures specific to flooding-related waste are limited.

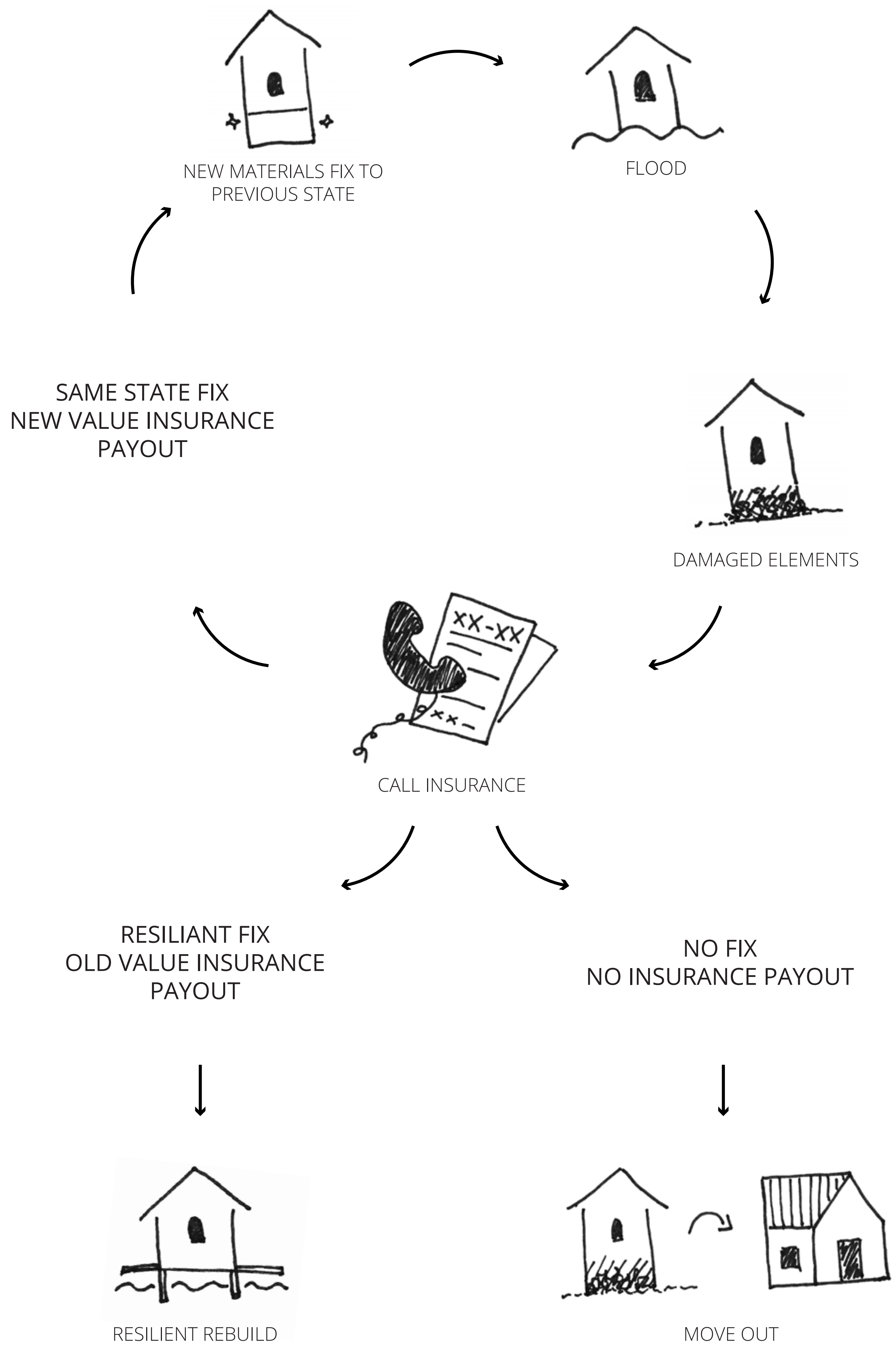
According to a survey conducted among Danish allotment owners (App. 2), several respondents reported that they have already demolished parts of their houses due to flood damage, especially in the sections closest to the ground. Some even indicated that they are considering tearing down their entire house because of repeated flooding problems. This highlights how flood damage can lead to the destruction of building materials and generates significant waste, putting pressure on both owners and waste management systems.

A deeper cause of this waste can be found in current insurance and reconstruction policies. The Danish parliamentary report on insurance rules explains that after flood damage, insurance often requires buildings to be rebuilt to their exact previous state in order to receive compensation covering the costs of new materials. If owners choose not to fully reconstruct the damaged parts, they only receive compensation based on the old value of materials, which is usually insufficient for proper repair. ('De fremtidige stormflods-, oversvømmelses- og stormfaldsordninger', 2017)

This situation creates what can be called a material waste loop (Ill. 24): damaged parts must be demolished and rebuilt to meet insurance requirements, even if alternative, more sustainable repair solutions might exist. The result is the disposal of materials that could sometimes be reused or repaired differently, leading to repeated cycles of waste production after flooding. This loop intensifies material consumption and waste generation, making flood events not only a physical and economic burden but also an environmental challenge.

In summary, the current system of rebuilding requirements and insurance policies contributes to a cycle where flood-damaged buildings produce high amounts of material waste. Addressing this waste loop could be an important step toward more sustainable flood adaptation strategies in Denmark.






*Ill. 24: System with ensurance based material waste loop.*

**Site analysis**

As previously mentioned, the selected site is currently empty and contains no existing structures. To explore how materials from a flood-damaged building might be reused, a hypothetical case study was created. In this scenario, an allotment house from Højbogård 70 in Aalborg is placed on the site to represent a typical allotment house that could experience flooding.

The house at Højbogård 70 was chosen because it is accessible, located in Aalborg, and representative of common allotment housing. It consists of red-painted wooden facade cladding, a corrugated fiber cement sheet roof, a basic wooden load-bearing construction insulated with rockwool, and lye-treated wooden boards for the interior. The foundation is a simple point system using concrete bricks. It also includes wooden windows and a small greenhouse made of glass and metal profiles (Ill. 25).

*Ill. 25:*
*Allotment house in Højbogård 70, Aalborg*
*Photos: Author.*

To determine whether this house reflects typical allotment housing, a photo study of 100 allotment houses in Holstebro and Aalborg was conducted. This study (Ill. 26) shows that painted wooden facades are the most common cladding, with roofs most often covered by roofing felt or corrugated fiber cement sheets. Windows varied from traditional wooden

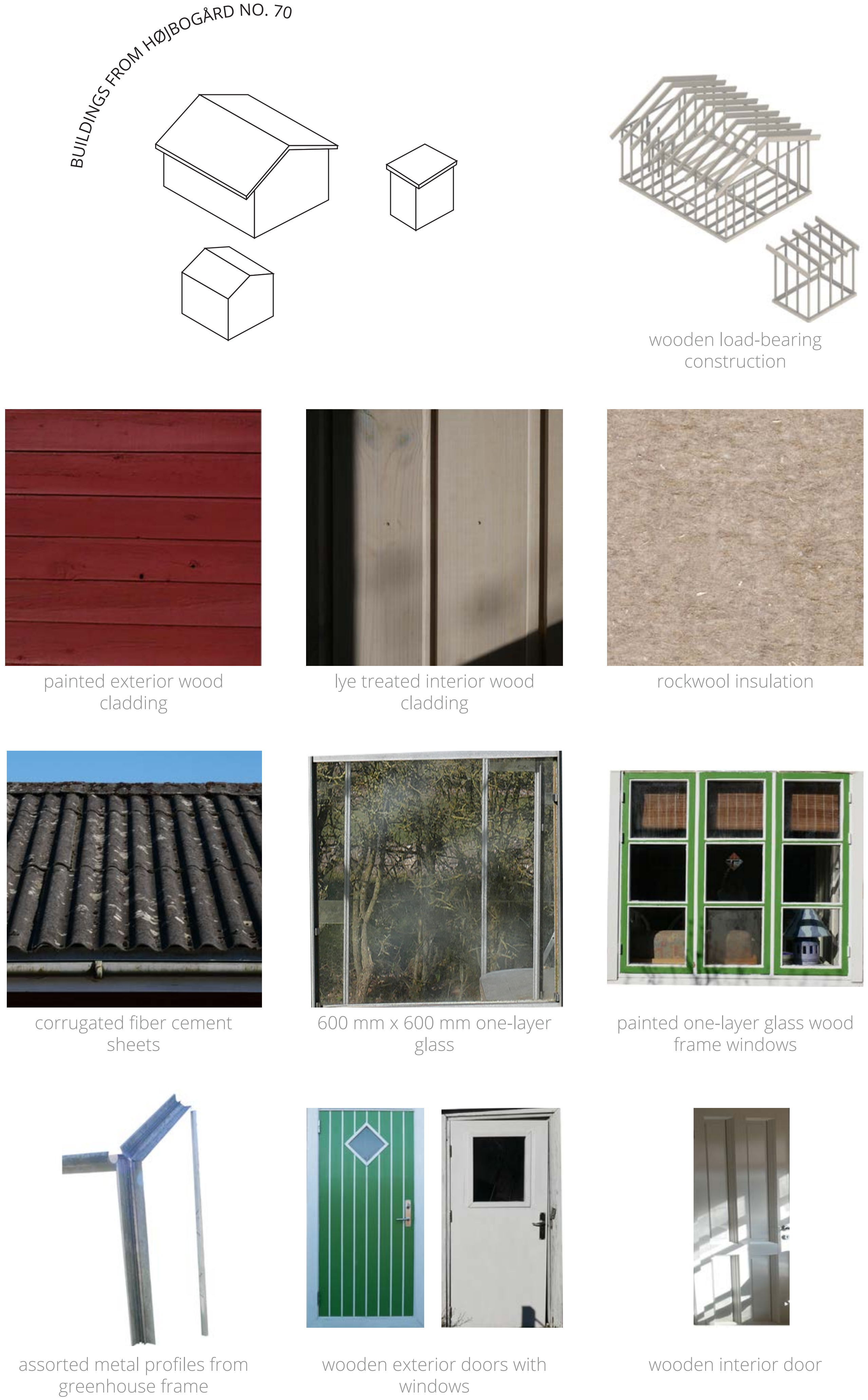
*Ill. 26:*
*Extract of photo study of 100 allotment facades in allotment communities in Aalborg and Holstebro.*
*Photos: Author*

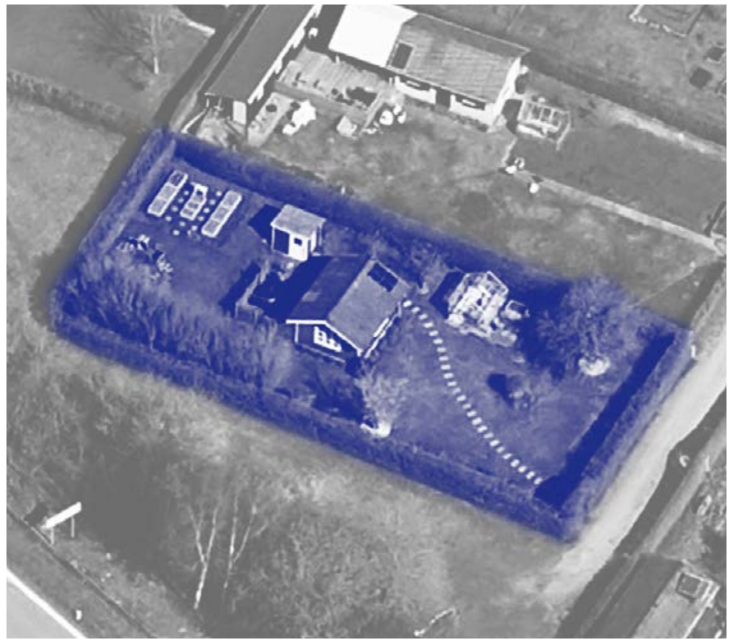
frames to more modern aluminum types, and many houses featured greenhouses similar to the one at Højbogård 70. It is assumed that most of these houses share a similar simple wood structure and interior, as these materials are affordable and widely available in Danish hardware stores.
Based on this evidence, Højbogård 70 was selected to repre-

sent a general allotment house. In this project, it is treated as though it has been relocated to the plot in Havekolonien Storaaen and has experienced flooding up to 1.2 meters in height. A simple 3D model of the house was created in Rhino to estimate the quantity and type of materials present. The building complex consists of a main house, a shed, and a greenhouse, with the main house and shed built using nearly identical materials and methods.

To keep the existing building case applicable to other similar cases in the future, only the typical and abundant materials , from the existing building, were included in the material analysis. The typical materials are based on the photostudy assumed to be: Painted wooden facade boards, corrugated fiber cement sheets, wooden load-bearing structure, single-pane greenhouse glass, painted wooden exterior doors, painted interior wood doors, old single-glazed wooden windows, metal greenhouse frames, lye-treated wooden interior boards, and rockwool insulation. Illustration 27 presents a simplified breakdown of the material quantities. Although these materials are approximately 30 years old, they are still in usable condition. Reusing them in a new, flood-resilient building helps extend their lifespan and demonstrates the potential for repurposing materials from flood-damaged buildings.

*Ill. 27:*
*Materials available on site.*
*Photos: Author*



*Ill. 28:*
*Overview of Højbogård 70*
*Photo: Skråfoto*


*Ill. 29:*
*Denmark mapping of recycled building material shops.*
*(Hjorth and Gregersen, 2024)*

While reused materials from the site are central to this project, it is also necessary to explore what other resources are available nearby. Additional materials may be needed when original components have deteriorated or when specific performance requirements arise.

In Denmark, the demand for affordable housing supports the use of low-cost materials. Reused and recycled building components can lower construction costs and reduce environmental impact. This also aligns with many allotment owners' environmental values (Hjorth and Gregersen, 2024) (App. 2).

According to Anne Beim and others, reusing materials preserves their embedded energy and reduces demand for raw resources, contributing to a lower carbon footprint (Beim, Zepernick Jensen and Arnfred, 2019). For this reason, identifying nearby sources of second-hand materials is a practical step in designing circular buildings.

Illustration 29 maps out the building material reuse centers across Denmark, the location with farthest to a center is about 60 km away in bird distance. The site in Holstebro is 13 km from Skave Nedbrydning, which is a large material reuse center with a large variety of reused materials and objects from demolition sites. Additional resources are available via online marketplaces such as Facebook Marketplace, DBA, and Guloggratis (Hjorth and Gregersen, 2024).

Since availability constantly changes, the design should rely on standard measurements and allow flexibility. Common materials found locally include:

- Timber, beams, plywood, and panel materials
- Interior/exterior doors and window frames
- Clay bricks, concrete roof tiles, and slates
- Metal fixtures, fasteners and insulation

These nearby materials will support the design process, especially when used alongside reclaimed on-site materials. A hybrid approach, combining reused and new renewable materials, can lower costs and environmental impact. Applying Life Cycle Assessment (LCA) methods during selection will help ensure sustainable choices.

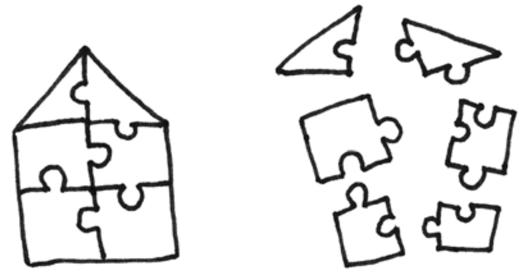
Together, the on-site and nearby material availability analyses establish the foundation for a circular building strategy. This strategy is further informed by theoretical insights into circular construction.

## Theory: Circular construction

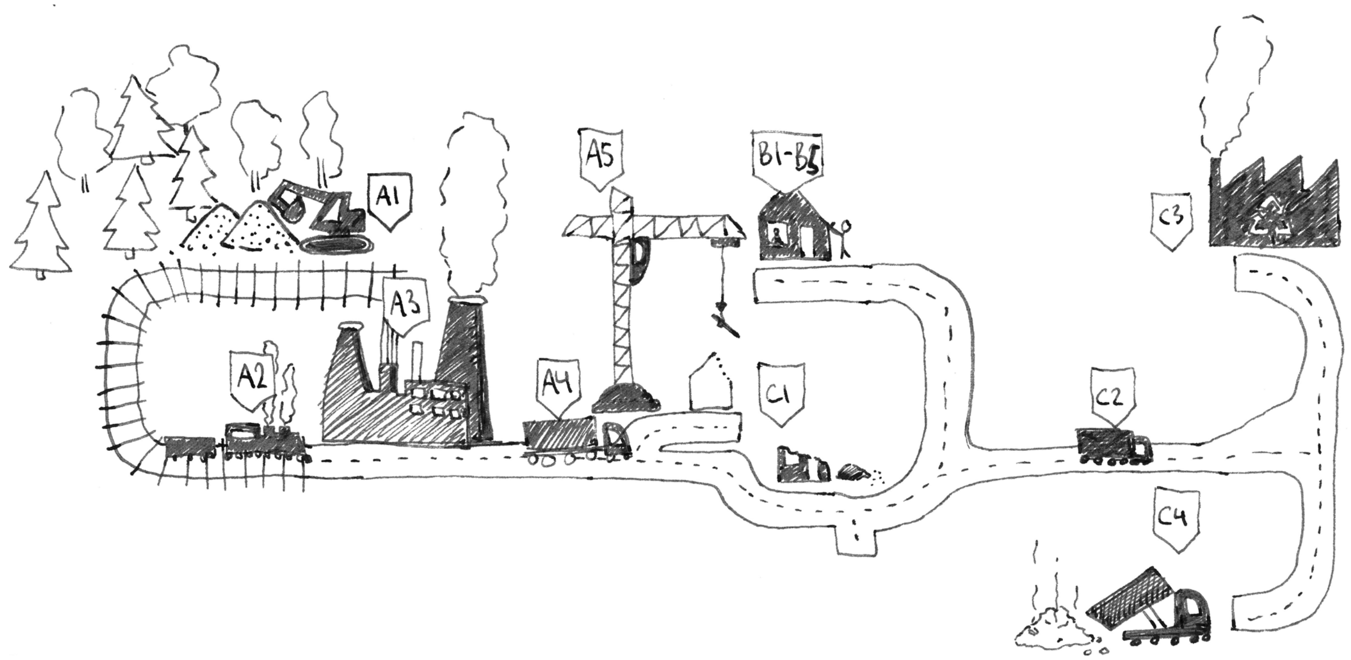
In *Circular construction: Materials, Architecture, Tectonics*, Anne Beim outlines a comprehensive framework for integrating circular economy principles into architectural design (Beim, Zepernick Jensen and Arnfred, 2019). Her approach advocates for a deep rethinking of how materials, constructions, and environmental considerations are brought together throughout a building's life cycle. The built environment accounts for a substantial share of global resource consumption and emissions, 36% of energy use and 39% of $CO_2$ emissions, making circular strategies in construction not only desirable but necessary.

Beim emphasizes the shift from linear to circular thinking, where materials remain in continuous loops, thereby extending their embedded energy and reducing waste. This includes not only reuse and recycling, but upcycling, reversible construction methods, and the prioritization of renewable, bio-based, and low-toxicity materials. Her manifesto introduces a series of tectonic strategies, such as using clean, standard-sized materials, simple and reversible joints, low-carbon solutions, and minimizing the degree of processing required for building components. These approaches allow materials to be disassembled, repurposed, and reintroduced into future construction processes without degrading their value or environmental profile.

Importantly, Beim also argues for a holistic design approach, one that goes beyond material performance to include cultural, contextual, and aesthetic dimensions. Circular construction should not sacrifice architectural expression; instead, the expressive potential of circularity should be cultivated through the visibility of joinery, modularity, and traceable materials. Her emphasis on "design for disassembly" (DfD), life cycle assessments (LCA), and long-term value highlights the role of architecture not only as a spatial solution, but as a strategic intervention in ecological systems and material economies.



*Ill. 30: Design for disassembly sketch.*




*Ill. 31: LCA stages sketch.*

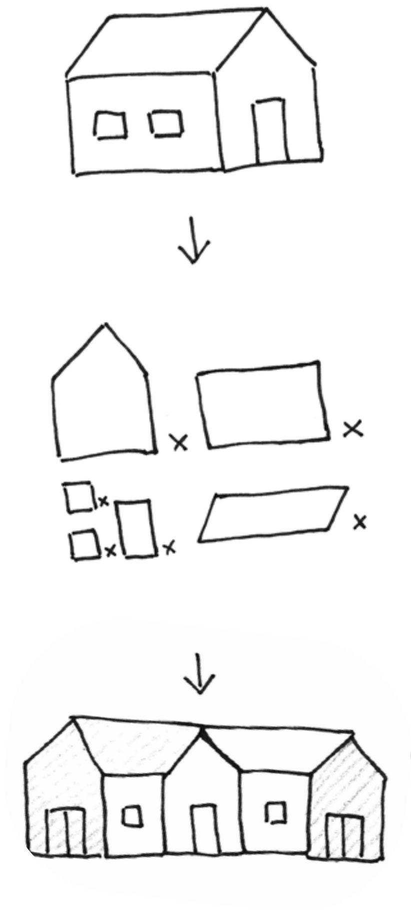
**Case study: Site-specific material reuse**

The following case study is based on a 2024 article published in FRAME magazine, which explores a series of architecture projects that embrace a hyperlocal approach to material reuse (*What if material reuse became site-specific?*, 2024). These projects demonstrate how salvaging materials directly from building sites and their immediate surroundings can reduce carbon emissions, minimize material waste, and foster context-sensitive design. The article features work by practices such as Popma ter Steege Architecten (PTSA), Lucas Muñoz Muñoz, and Lendager Group, each offering a different strategy for on-site material harvesting and adaptive reuse.
Recent architectural experiments by offices such as Popma ter Steege Architecten (PTSA), Lucas Muñoz Muñoz, and Lendager Group offer a practical application of many of Anne Beim's principles, while also revealing key tensions and limitations. These projects focus on mining materials from the building site itself, a hyperlocal reuse strategy aimed at minimizing transportation emissions and increasing material transparency. This approach aligns well with Beim's vision of keeping materials in circular loops, extending their life through creative, context-sensitive repurposing.

In PTSA's Office Full of Waste, an existing 1980s office building was transformed using materials sourced from the structure itself and nearby demolitions. Aesthetic choices were directly shaped by what materials were available, rather than by pre-designed forms. Similarly, in Lucas Muñoz Muñoz's project in A Coruña, technical components such as ducts and ceiling profiles were converted into furniture and shelving, with their former function erased in favour of their physical potential. These cases strongly support Beim's argument that materials should be chosen for their properties, not their traditional roles. By understanding and re-contextualizing what already exists, designers can extend the life and value of components that might otherwise be discarded.

Lendager's The Swan kindergarten illustrates the architectural possibilities and technical complexities of full-scale circular construction. All materials were harvested from two decommissioned schools on site. While this echoes Beim's call for local, low-embodied-energy material sourcing, it also exposes practical challenges. The materials required extensive testing to meet safety standards, and significant labour was needed to sort, clean, and adapt components, tasks that may limit scalability or affordability. These issues raise a critical tension with Beim's vision: while reversible, low-processed construction is ideal in theory, the real-world management of reclaimed materials may involve higher risks, longer timelines, and more complex logistics than anticipated.

*Ill. 32: The Swan designed by Lendager Group. Photo: © Rasmus Hjortshøj*



*Ill. 33: Sketch of on-site material repurpose.*

*Ill. 34: The Swan designed by Lendager Group. Photo: © Rasmus Hjortshøj*

Furthermore, Lendager's design flexibility, which allowed for changes based on unknown material availability, directly supports Beim's notion that architectural thinking must accommodate uncertainty and material unpredictability. This calls for a new aesthetic and tectonic language, one where form follows availability rather than predefined architectural standards. However, unlike Beim's ideal of standardised, easily disassembled elements, some salvaged materials in these projects required bespoke adaptations, undermining the potential for future reuse and increasing long-term material complexity.

This case study analysis confirms several key insights. First, it reinforces the idea that extending a material's life begins with rethinking its value. Rather than seeing materials as tied to their original function, they should be assessed and applied based on their structural and aesthetic properties. Second, it highlights the necessity of reversible construction techniques to allow for disassembly without unnecessary waste, as emphasized by Anne Beim's tectonic principles. Lastly, it points to the importance of future-proofing material decisions: materials should not only be reused now, but their eventual substitution must be considered in the design. Choosing a new version of the same material in the future could be environmentally worse if more sustainable alternatives are available. Thus, material strategies must be open-ended, allowing for replacement with improved options when the time comes.

In this way, Anne Beim's theory and the reviewed case studies together support a design methodology that is grounded in the site, responsive to material availability, and open to future circular interventions, a critical foundation for designing resilient structures from flood-damaged materials in a changing climate.



**Sub-conclusion: Extend material lifetime**

Flooding doesn't just destroy homes, it fuels a cycle of material waste due to rigid insurance protocols and reconstruction norms. This chapter explored how a circular design mindset can interrupt that loop by reusing existing materials and designing for long-term adaptability. Drawing from site analysis, theory, and case studies, the following design criteria emerge:

1. **Repurpose the majority of existing materials** — 3.1
2. **Assemble components for easy disassembly and replacement** — 3.2
3. **Design connections to allow more sustainable material substitutes over time** — 3.3
4. **Use visible joints and assembly methods** — 3.4
5. **Design with material unpredictability in mind** — 3.5

These criteria will be used in the next chapter: Frame the design.

# CHAPTER SUMMATION

Over the course of the last three chapters, the design investigation unfolded through an increasingly layered understanding of what it means to build in a flood-prone landscape. The first chapter approached flooding as a spatial and logistical condition, something to adapt to through positioning, programming, and resilient circulation. But resilience alone proved insufficient. In the second chapter, the focus shifted to the sensory and emotional experience of flooding: how architecture can mediate between exposure and protection, and how water's presence might become an atmospheric quality rather than a threat. The third chapter turned to the material dimension, proposing a more regenerative approach to construction, one that accepts wear, embraces unpredictability, and extends material life through adaptability and care.

These three perspectives; resilience, experience, and material reuse, are interrelated and suggest that flood adaptation should be approached not as a singular technical challenge, but as a holistic design problem. Together, they inform a series of design criteria that will be used in the following chapter to frame the architectural response. These criteria aim to connect spatial, sensory, and material strategies into a coherent design that responds to both site-specific conditions and long-term sustainability.



# FRAMING THE DESIGN

This chapter outlines the foundation for the design by introducing the intended user and identifying the key functions and spatial needs of the building. Based on survey data, five personas are developed to represent the diversity among allotment owners, helping assess the long-term relevance of the design. A generalized user, derived from the average responses, serves as the main reference for the proposal. The chapter also defines the design drivers and criteria developed from earlier research, setting a clear direction for the design process.

# user.

As this project is based on a hypothetical design case, there is no specific client. To ensure the proposal remains grounded in reality and relevant to the intended context, a general user has been developed based on the user survey conducted with 49 allotment owners across Denmark (App. 2). This general user represents an average profile, chosen to reflect the most common needs, values, and usage patterns found among survey respondents. Designing for a general user supports the development of a realistic, adaptable solution that can accommodate the majority of current and future allotment owners (Ill. 35).

The general user is a couple in their late 40s to early 50s who regularly stay overnight during the open season (March to October) and visit occasionally during the closed season. They seek a comfortable and healthy indoor environment, are affected by seasonal flooding, and use their allotment for growing vegetables, relaxing, and socializing. While they are open to professional construction help, they also value being involved in the building process.

Functionally, they require indoor spaces for sleeping, cooking, dining, and relaxing, as well as storage and sanitary functions. Outdoors, their needs include zones for gardening, guest accommodation, and varying microclimates such as sun, shade, and shelter from wind. Their values emphasise a strong connection to nature, use of repurposed materials, and a balance between privacy and community.

In addition to the general user, five personas were created to reflect the range of allotment owner profiles identified through the survey (Ill. 36). These personas were used to evaluate how future changes in ownership could affect the building's use and longevity. A key insight from this analysis is the importance of flexibility and personalization. The building should allow for customization to suit individual visual preferences and functional demands, increasing the likelihood of long-term use and potentially minimizing material waste. For example, the ability to accommodate both a double bed and two mattresses allows flexibility for singles, couples, and small families. The aesthetics of the building should also be possible to personalize by changing color of some elements and make it possible to use standard furniture to personalize the rooms. Similarly, the capacity to adapt outdoor privacy, whether through open views or enclosed spaces, enables the building to suit a range of social and spatial preferences.

These findings inform the design drivers and criteria developed later in this chapter, ensuring the final proposal is not only tailored to one user type, but robust and adaptable enough to serve a variety of future occupants.

*Ill. 35: User based on the allotment owner average answers. (App. 2)*

**User Description**

- *A couple (50 and 48 years)*
- *Living there during the open season*
- *Visit a few days in the closed season*
- *Flood issues with existing allotment house*
- *Rotten foundation from flooding*
- *Garden ruined by flooding*
- *Does not mind paying for professionals*
- *Wants to be involved in the construction process*

**Allotment purpose**

- *Growing their own vegetables*
- *Relaxing in a structured garden*
- *Hosting guests when the weather is nice*
- *Using the place for overnight stays and a change of pace*

**Facility demands**

- *Open rooms inside the house*
- *Storage inside and outside*
- *Kitchen*
- *Toilet*
- *Shower*
- *Sleepover space for 2*
- *Dining space for 2*
- *Lounge space for 2*
- *Greenhouse*
- *Garden beds*
- *Outdoor area with room for guests*
- *Outdoor zones: sunny, shadow, and wind-still*

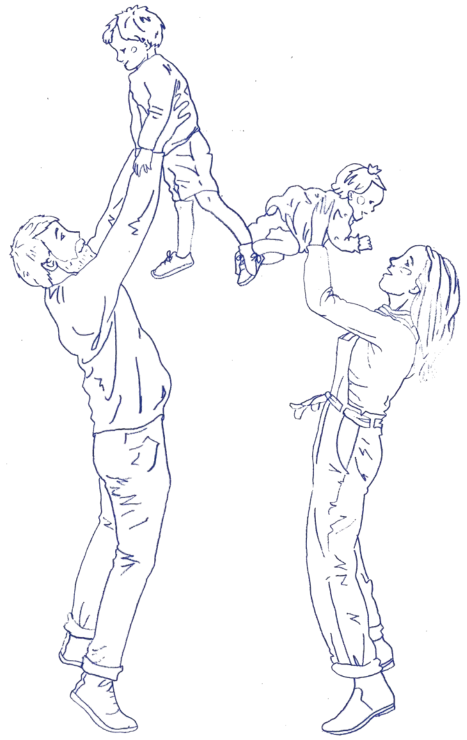
**Values and indoor climate**

- *Strong connection to nature*
- *Enjoys the feeling of being in nature*
- *Prefers natural, site-reflective aesthetics*
- *Likes using repurposed materials*
- *Values privacy but open to friendly contact*
- *Needs a healthy indoor climate all year*
- *Wants comfort in open season*
- *Open to adding heat pump or electricity later*

## 1
## the artist.

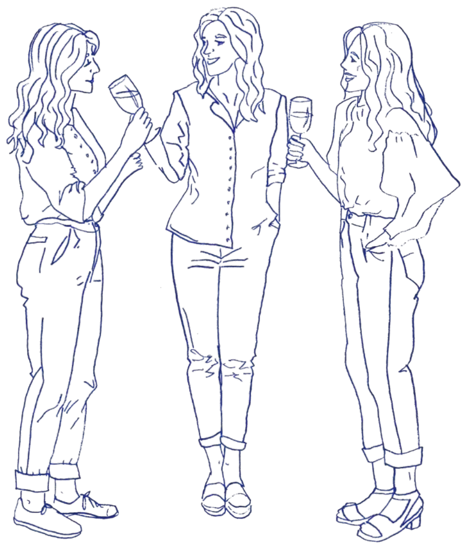
**Aesthetics:** Colorful and unique
**Owner:** One
**Purpose:** Atelier
**Privacy:** No public privacy
**Indoor preference:** Open ro-oms
**Stay:** Lives there in the summer
**Functional necessities:**
Few sleeping (1) - Atelier - Toilet - Shower - Storage inside - Small communal space - Small kitchen

## 2
## playful family.



**Aesthetics:** Traditional
**Owner:** Family with two adults and two children
**Purpose:** Play
**Privacy:** No public privacy
**Indoor preference:** Closed ro-oms
**Stay:** Weekend stay (summer), Day stay (winter)
**Functional necessities:**
Many sleeping (4) - Toilet - Show-er - Big communal space - Small kitchen

## 3
## social friends.



**Aesthetics:** Modern and mini-malistic
**Owner:** Three friends
**Purpose:** Social guests
**Privacy:** Total public privacy
**Indoor preference:** Closed ro-oms
**Stay:** Sleeps over a few nights in the summer
**Functional necessities:**
Toilet - Shower - Big communal space - Many sleeping (8) - Big kit-chen - Storage inside

## 4
## DIY couple.

**Aesthetics:** Sustainable reuse
**Owner:** Couple
**Purpose:** Kitchen garden
**Privacy:** Semi public privacy
**Indoor preference:** Open ro-oms
**Stay:** Lives there all year
**Functional necessities:**
Few sleeping (2) - Atelier - Toilet - Shower - Storage inside - Small communal space - Small kitchen - Greenhouse

## 5
## coffee sisters.

**Aesthetics:** At one with nature
**Owner:** Two sisters
**Purpose:** Relax and grow flowers
**Privacy:** Total public privacy
**Indoor preference:** Open
**Stay:** Daily stays all year
**Functional necessities:**
Toilet - Small communal space - Small kitchen - Outside storage - Greenhouse

## general.

- Important to have a contact to nature
- Use recycled or reused materials in an easy way
- Possibility to adapt house and garden to own style preference
- Indoor climate should reflect the durance and season of stay
- Different microclimatic zones outdoors
- A new building should be affordable
- Possible to build the house without profes-sionals
- Possibility to repurpo-se parts of an existing allotment house

*Ill. 36:*
*Allotment personas and general preferences.*

# facility program.

To better understand the user's needs and preferences in the spatial design, a program of required functions has been developed (Ill. 37). Instead of using a traditional room-based approach, the program focuses on facilities. This shift is necessary due to the 50 m² size limitation for allotment houses, which calls for a more flexible and unconventional approach to space planning.

By working with facilities rather than fixed rooms, it becomes possible to combine and arrange them in multiple ways, allowing for more spatial efficiency. The program is also divided according to which facilities can be placed outdoors and under what conditions. This is inspired by the Can Lis case study, where the boundary between indoor and outdoor spaces is softened. Instead of separating interior and exterior with movable barriers, the aim here is to allow some indoor functions to be exposed outdoors when weather permits. This can reduce material use and improve the spatial experience. Additionally, the program categorizes facilities based on their required level of privacy. Some functions can be openly visible, while others need protection from view or complete enclosure. This categorization supports decisions about where and how each function should be placed within the site.

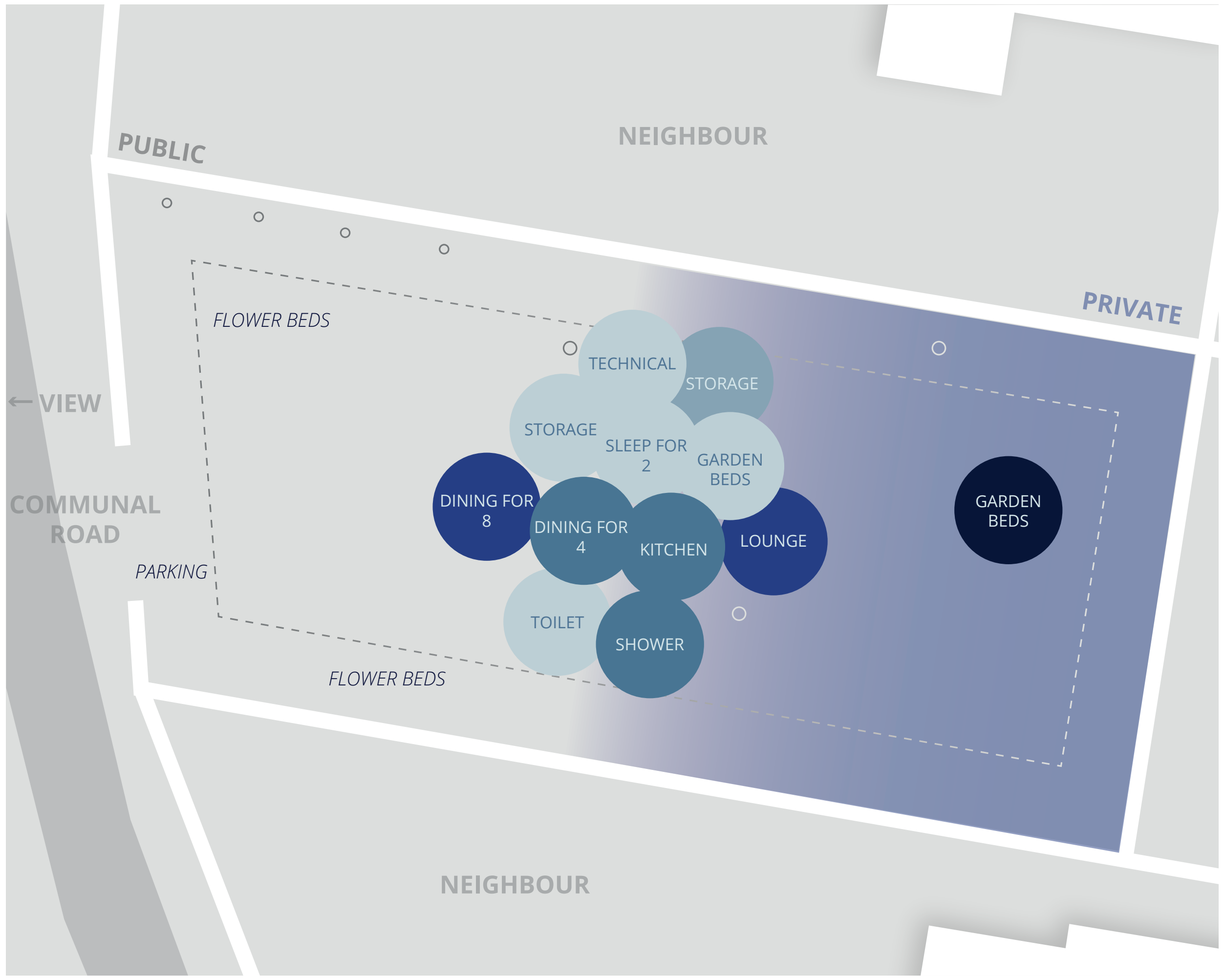
*Ill. 37: Facility program divided into outside exposure and privacy.*

| Type | Night | Warm/wet | Cold/wet | Warm/dry | Cold/dry | Privacy | Note |
|---|---|---|---|---|---|---|---|
| *Technical* | Inside | Inside | Inside | Inside | Inside | Yes | |
| *Sleep for 2* | Inside | Inside | Inside | Inside | Inside | Yes | |
| *Toilet* | Inside | Inside | Inside | Inside | Inside | Yes | |
| *Storage 1m2* | Inside | Inside | Inside | Inside | Inside | Yes | |
| *Garden beds* | Inside | Inside | Inside | Inside | Inside | No | Greenhouse temp. |
| *Storage 4m2* | Inside | Inside | Inside | Covered | Covered | Yes | |
| *Dining chairs and table for 2* | Inside | Covered | Inside | Outside | Inside | No | |
| *Kitchen* | Inside | Covered | Inside | Outside | Inside | No | |
| *Shower* | Inside | Covered | Inside | Outside | Inside | Yes | |
| *Dining chairs and table for 8* | Outside | Covered | Covered | Outside | Outside | No | |
| *Lounge* | Outside | Covered | Covered | Outside | Outside | No | |
| *Garden beds* | Outside | Outside | Outside | Outside | Outside | No | |

# facility diagram.

Based on the facility program, a spatial diagram has been created (Ill. 38). While such diagrams are typically abstract representations of relationships between functions, in this case, the facilities have been placed directly onto the site. This is done to avoid endless theoretical combinations and to ground the design in the specific spatial and climatic conditions of the site.

Placing the facilities spatially makes it possible to consider factors such as levels of privacy and sun exposure. Each facility is color-coded according to the earlier program and positioned in relation to others. During this process, a natural division between public and private zones emerged. This helped further refine the placement of each function, ensuring that the design supports both practical use and experiential qualities, such as comfort, privacy, and a meaningful connection to the garden.




*Ill. 38: Facility diagram placed on site.*

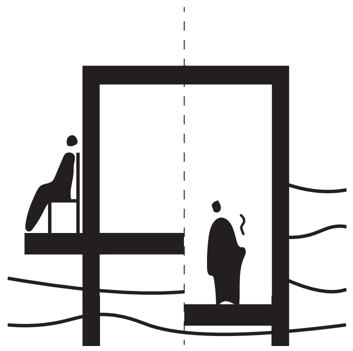
# design drivers.

The design drivers are based on the research done throughout the project, including site analysis, theory, case studies, and user insights (Ill. 39). They help define what the design should focus on and what kind of values it should support. These drivers are meant to guide the design process and make sure the final proposal fits the everyday needs of allotment owners while also responding to environmental challenges.

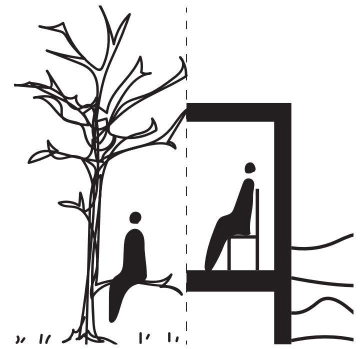
The first driver, **Low Flood, No Fuss – High Flood, Adjust**, focuses on making the building useful even when there is flooding. The idea is that the house should still work well when water levels are low and be able to adapt when the water rises higher. It's about accepting that flooding happens and finding smart ways to deal with it, instead of trying to stop it completely.

The second driver, **Garden Extension – Garden Refuge**, looks at how the building connects to the garden. In dry periods, the garden should feel like an extra room; open, inviting, and part of the garden. But when flooding happens, the building should offer protection, comfort, and a clear boundary.

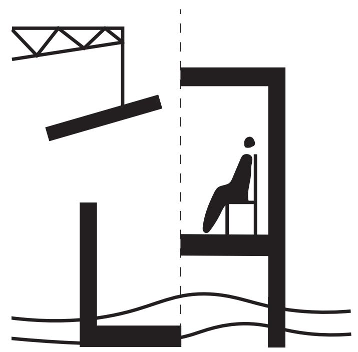
The third driver, **From Past Materials – Toward Future Methods**, focuses on sustainability over time. It supports the reuse of materials from the existing building, while also making it easy to change or upgrade parts of the house in the future. This approach helps reduce waste and gives future owners the chance to make replacements without unnecessary waste.



LOW FLOOD, NO FUSS - HIGH FLOOD, ADJUST



GARDEN EXTENSION - GARDEN REFUGE



FROM PAST MATERIALS - TOWARD FUTURE METHODS

*Ill. 39:*
*Design drivers.*

# design criterias.

The design criteria are developed by exploring the problem through site studies, theory, case inspiration, and general research. They are used to steer the design in the right direction and make sure it meets both practical needs and long-term goals. The criteria help evaluate design decisions throughout the process and ensure the final result supports flood resilience, good user experiences, and sustainable use of materials.

See the design criterias in illustration 40.

*Ill. 41: Sketch.*

*Ill. 40: Design criterias.*

**1**

**Low Flood, No Fuss - High Flood, Adjust**

**1.1** *Outdoor use up to 30 cm flood*

**1.2** *Indoor use up to 1.2 m flood*

**1.3** *Water-resistant materials in exposed areas*

**1.4** *Structural performance under flood stress*

**1.5** *Accessible entry/exit during flood*

**1.6** *Visual fit with low-rise context, < 4 m height*

**2**

**Garden extension - Garden refuge**

**2.1** *Remove the barrier between the indoors and outdoors in dry periods*

**2.2** *Enable movement through diverse microclimatic zones*

**2.3** *Add a protective but sensory-engaged barrier during flooding*

**2.4** *Accentuate water experience through views, light and sound*

**2.5** *Ensure indoor comfort in summer and dry, healthy conditions in winter*

**3**

**From Past Materials - Toward Future Methods**

**3.1** *Repurpose the majority of existing materials*

**3.2** *Assemble components for easy disassembly and replacement*

**3.3** *Design connections to allow more sustainable material substitutes over time*

**3.4** *Use visible joints and assembly methods*

**3.5** *Design with material unpredictability in mind*

# CHAPTER SUMMATION

This chapter has laid the foundation for the final design proposal by establishing a realistic user profile, identifying key spatial and functional needs, and defining the design priorities through targeted drivers and criteria. Using data from a national survey of allotment owners, a general user was developed to represent the most common values and usage patterns. This approach ensures that the design proposal is not only tailored to a typical allotment user but also adaptable to the wide range of future users identified through the development of five additional personas.

Through the facility program and facility diagram, the thesis rethinks conventional room-based planning by focusing on flexible facilities, with careful attention to their relationship to climate, privacy, and outdoor exposure. These tools help to strategically organize the site in a way that responds to environmental conditions while supporting meaningful user experiences.

The design drivers: **Low Flood, No Fuss – High Flood, Adjust, Garden Extension – Garden Refuge, From Past Materials – Toward Future Methods**, set a clear direction for how the building should respond to flooding, enhance the indoor-outdoor relationship, and support sustainable material use over time. The associated design criteria translate these ideas into actionable goals to guide the design process.

Together, these elements address the central problem of this project: **How existing flood-damaged small wooden buildings can be reused to construct resilient structures that not only withstand future floods but also celebrate the flood experience and are designed to extend material life and minimize material waste.** The chapter frames the design response to this challenge, and the following chapter presents a proposal shaped by these principles, an architectural solution grounded in both research and real-world relevance.



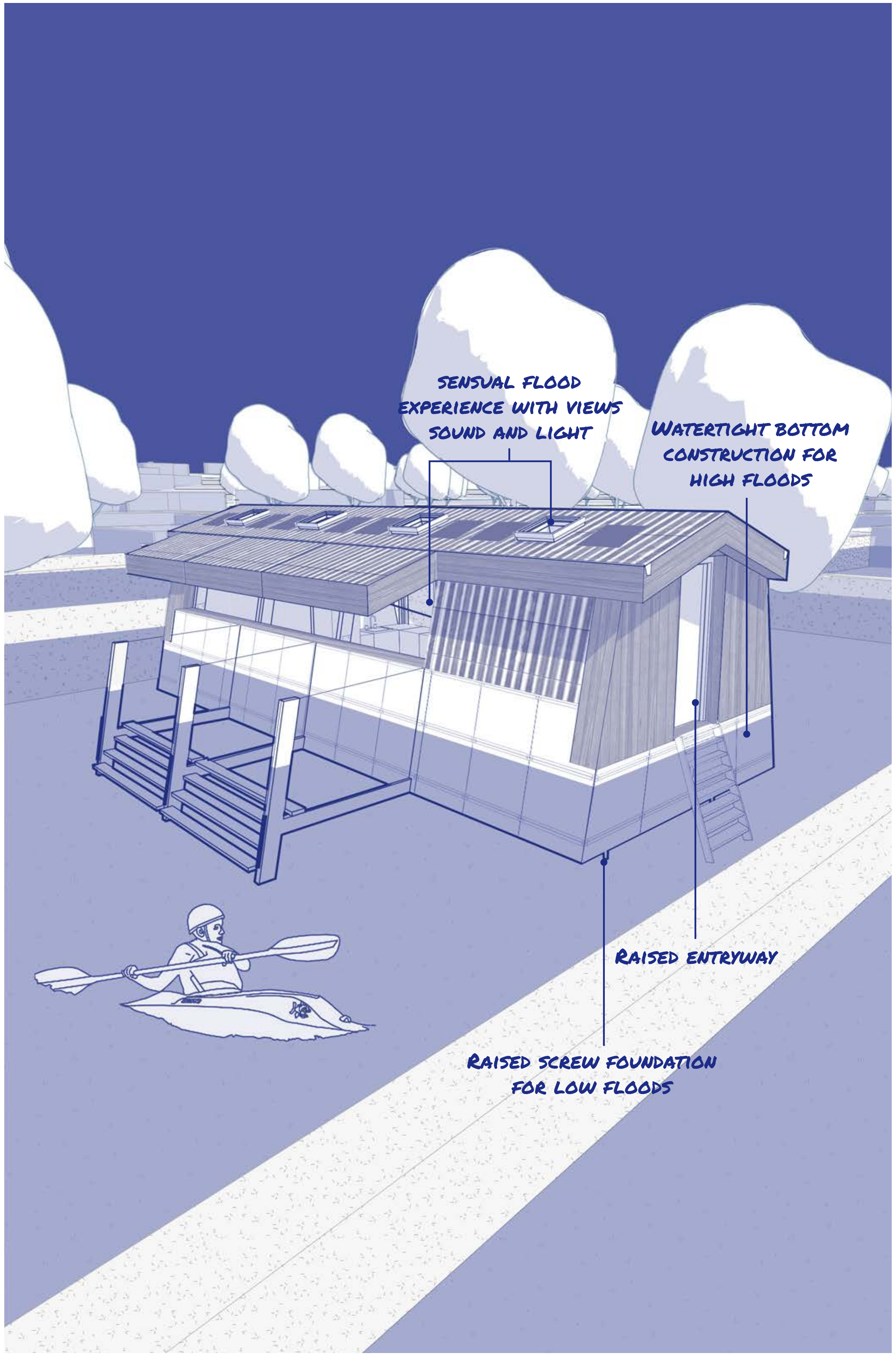
# SHARING THE DESIGN PROPOSAL

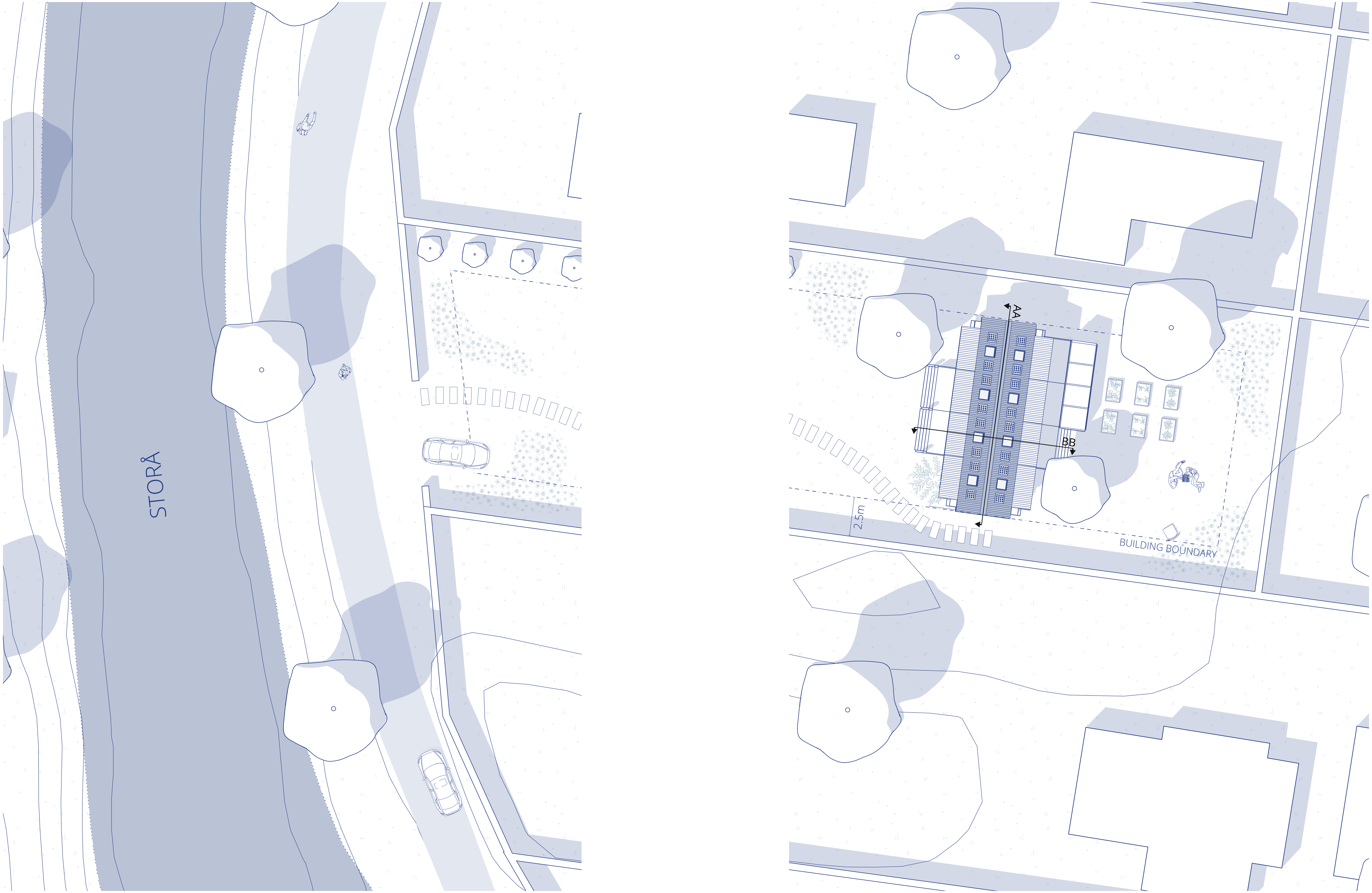
Based on the overall design framework, a structured design process has been carried out, leading to the development of a design proposal. This chapter presents the proposal as a potential solution to the design challenge previously introduced: a flood-prone allotment garden in Havekolonien Storaaen. The proposal is the outcome of an in-depth investigation into reducing the consequences of recurrent flooding and addressing the associated material waste. It focuses on three key aspects: enhancing flood resilience, creating a meaningful flood experience, and extending the lifespan of existing materials.

The proposed design solution is a low-rise house constructed with a dual foundation system. A raised screw foundation accommodates more frequent, low-level flooding, while the building itself can be sealed watertight to withstand flood levels up to 1.2 meters. A raised entryway at the end of the building ensures accessible and safe entry and exit during flood events. The low profile of the building ensures that it blends into the existing context without dominating the landscape, demonstrating that flood resilience can coexist with subtle architectural expression.

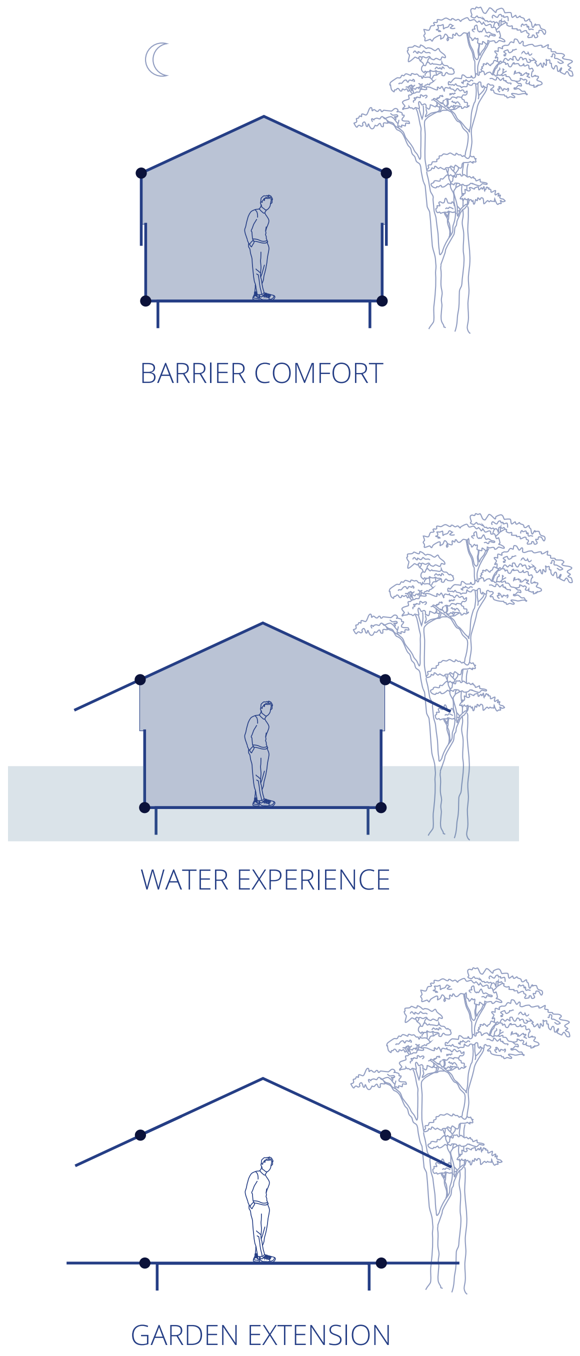
*Ill. 42: Rendering during a high flood.*

*Ill. 43: Perspective view during a high flood.*





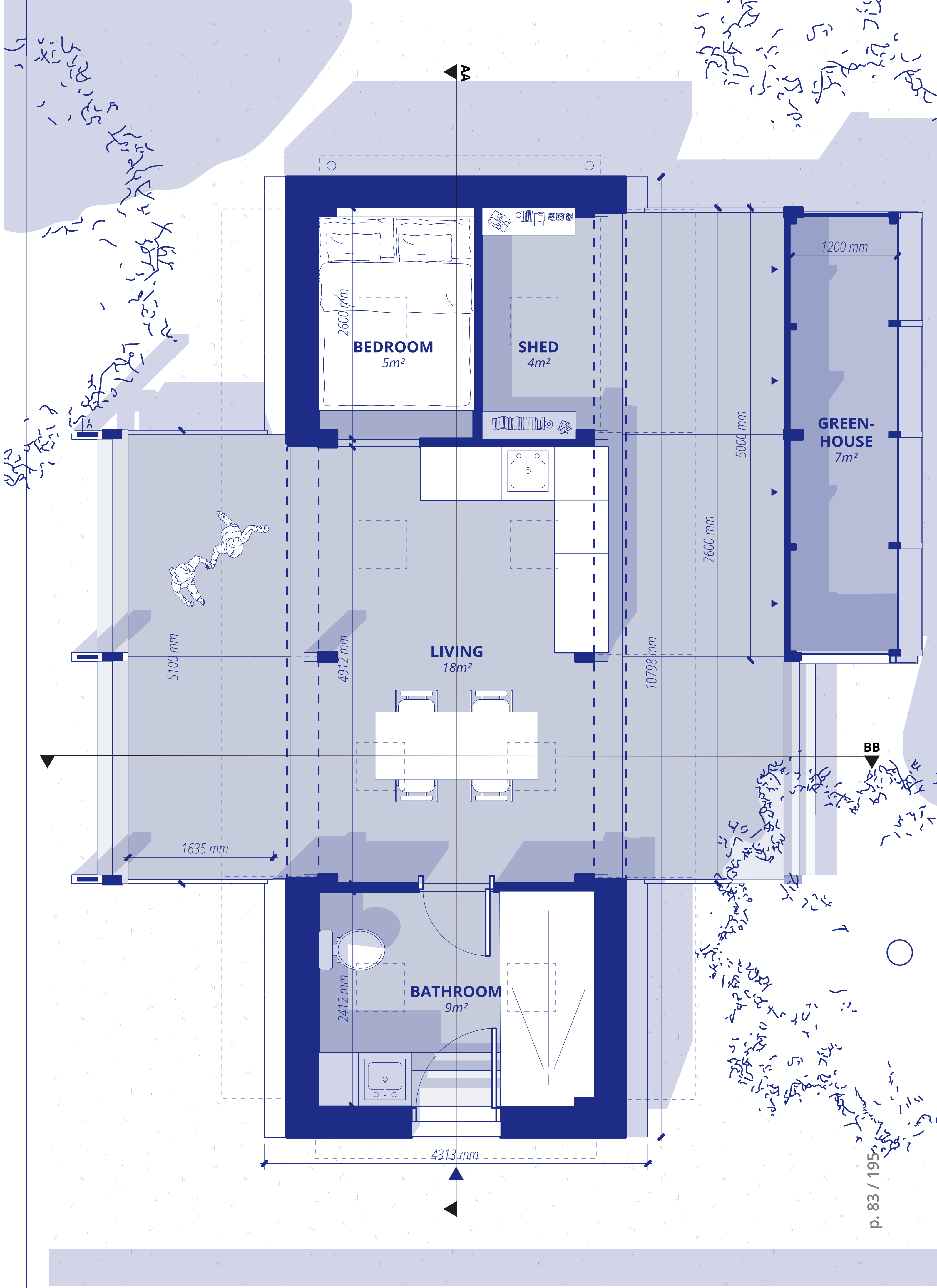

*Ill. 44:*
*Situation plan*
*1:200*




*Ill. 45:*
*Concept of three stages.*

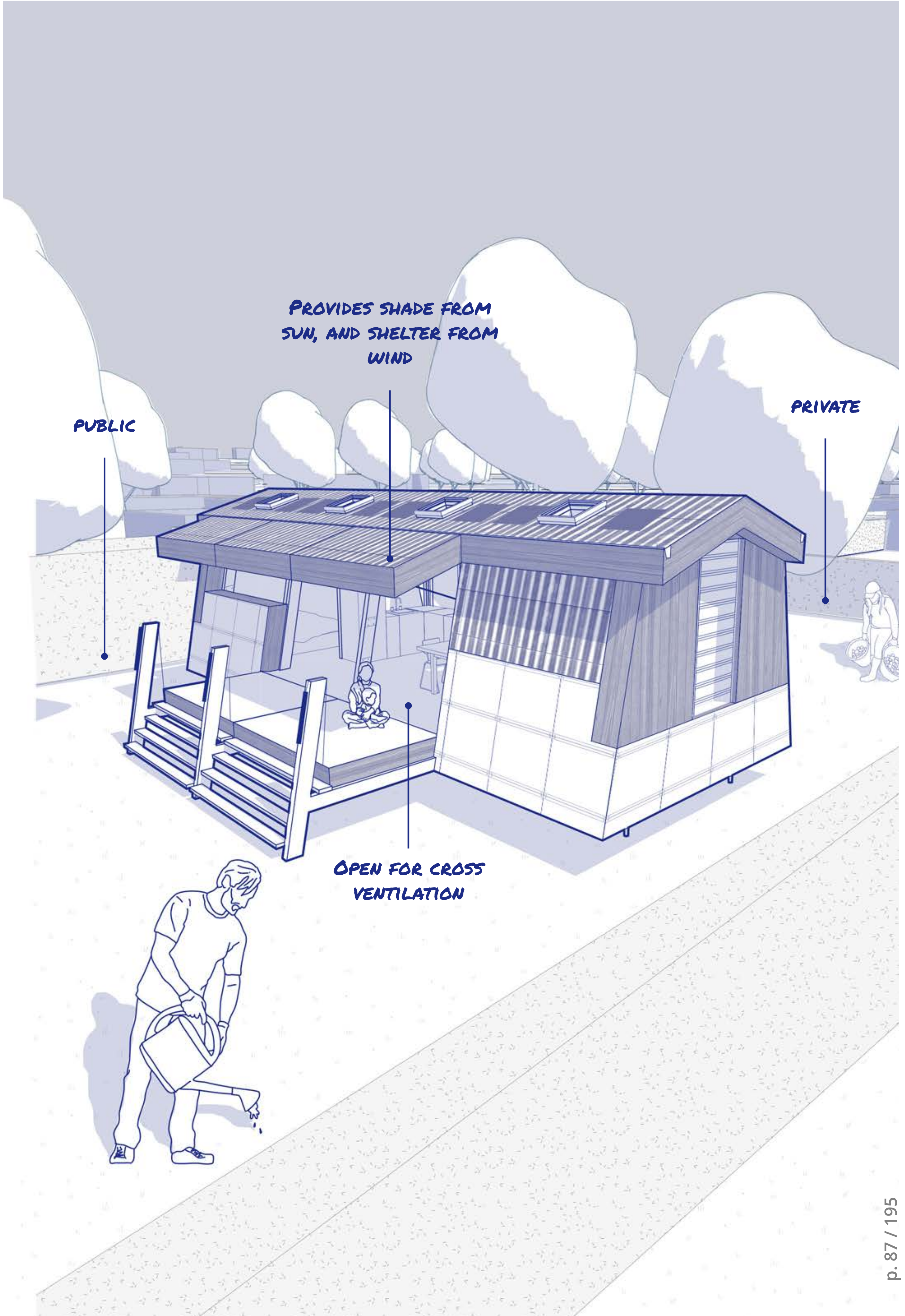
The design concept is centered around spatial adaptability, allowing the building to transform between three configurations through flexible wall openings. When fully closed, it provides privacy and protection. In a semi-open state during flooding, it reflects water light onto the overhang, transforming a potentially stressful event into a calm and atmospheric experience. When fully open, the structure dissolves the boundary between indoors and outdoors, becoming an extension of the garden. This responsive spatiality strengthens the user's connection to nature and embraces the flood as an integrated part of everyday life, rather than an interruption.

*Ill. 46:*
*Plan drawing*
*1:250*



*Ill. 47:*
*Rendering during a flood..*

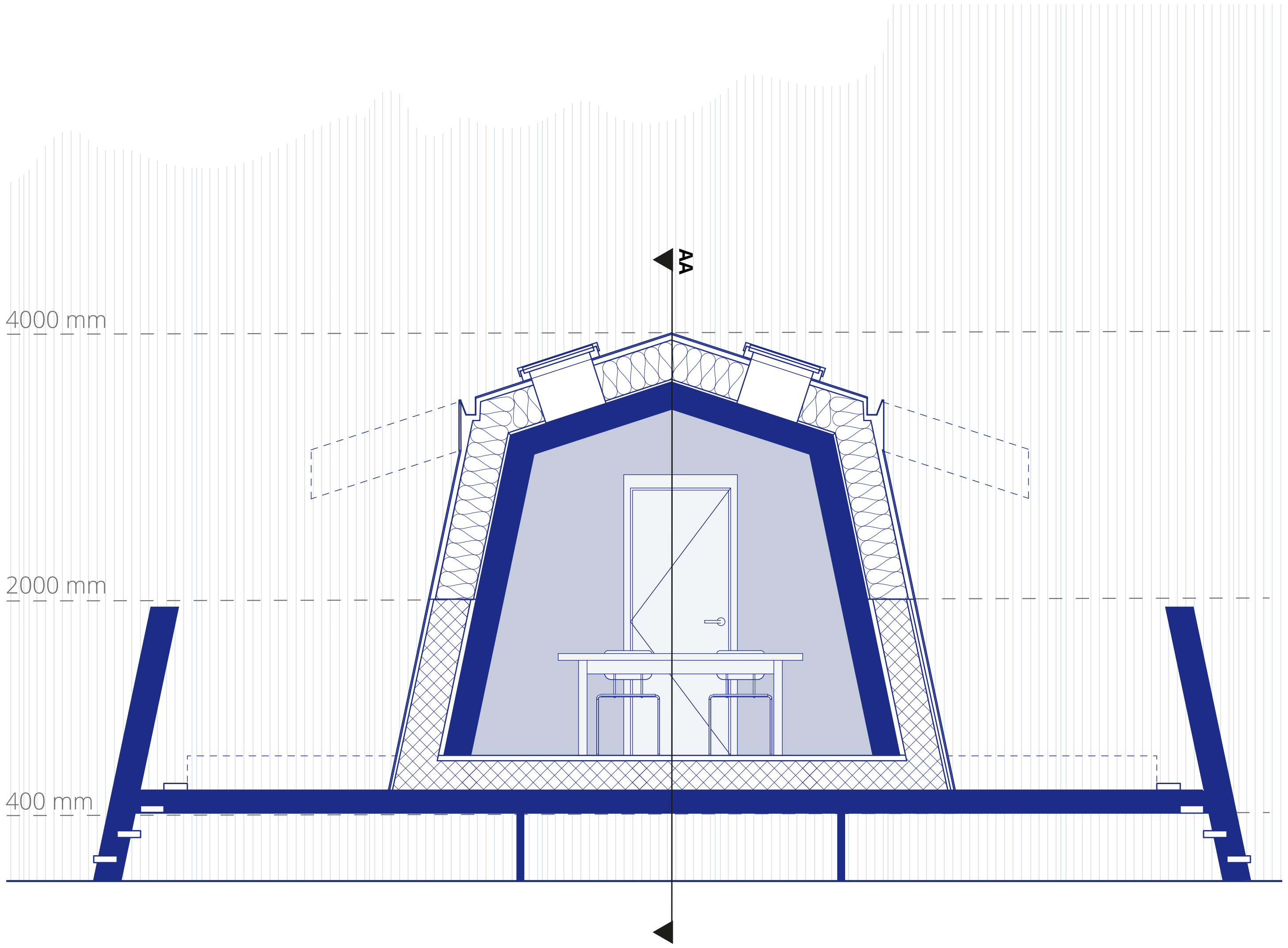
*Ill. 48:*
*Rendering during a dry period..*




The building can also operate in hybrid states, offering shaded or wind-protected spaces tailored to specific weather conditions or user preferences. The building's placement clearly separates private and public areas, accommodating different preferences. External stairs ensure easy access to the raised living area, and the wall systems open effortlessly using counterweights below and gas springs above. Skylights along the roof ridge distribute daylight evenly, minimizing harsh interior/exterior contrasts. These decisions aim to enhance well-being and comfort, while reinforcing the theme of a structure that adapts with and responds to its environment, rather than resisting it through rigidity.

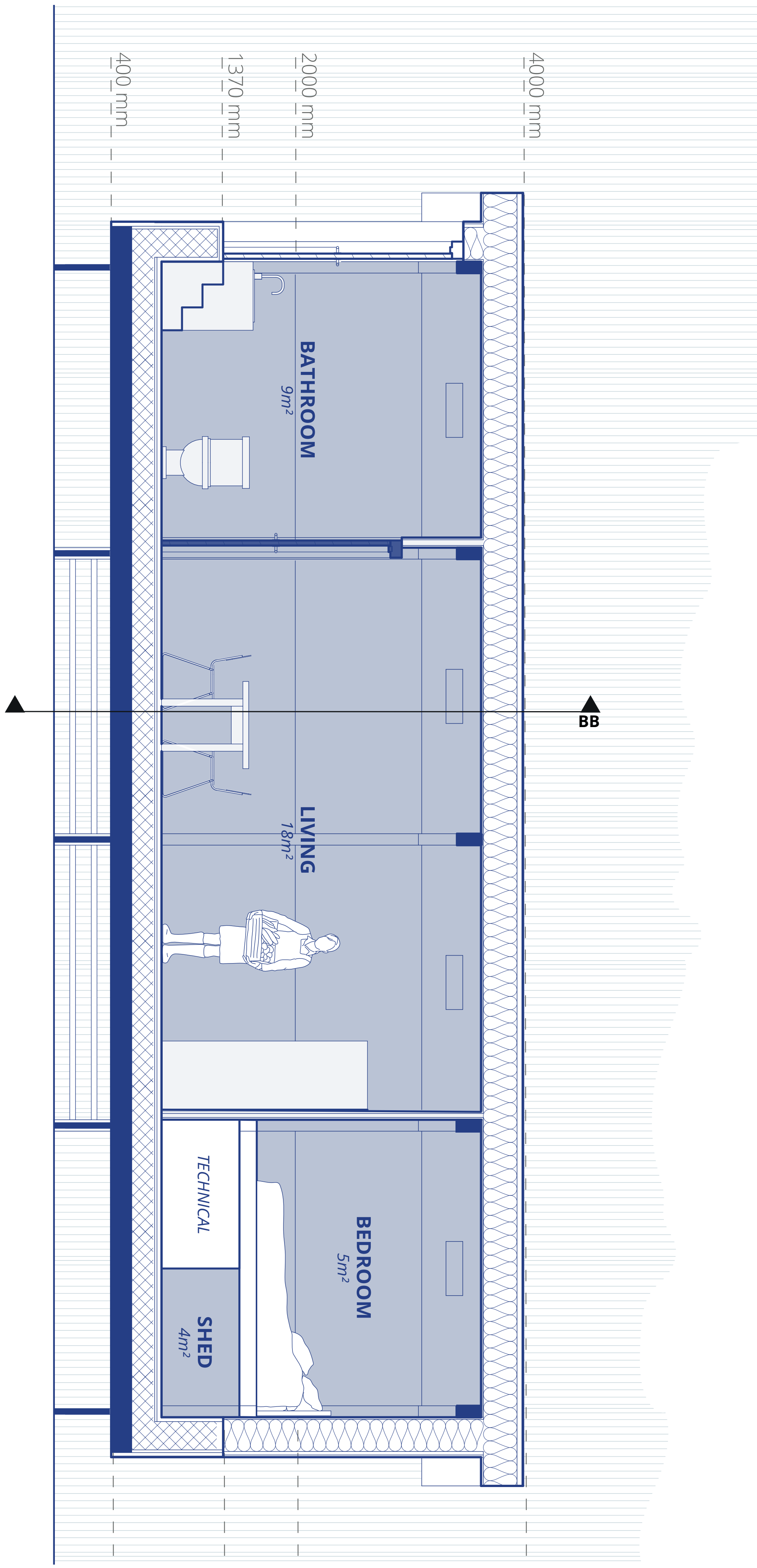
*Ill. 49:*
*Render showing flexibility.*

*Ill. 50:*
*Perspective view during a dry period..*




Ill. 51:
Section BB
1:50

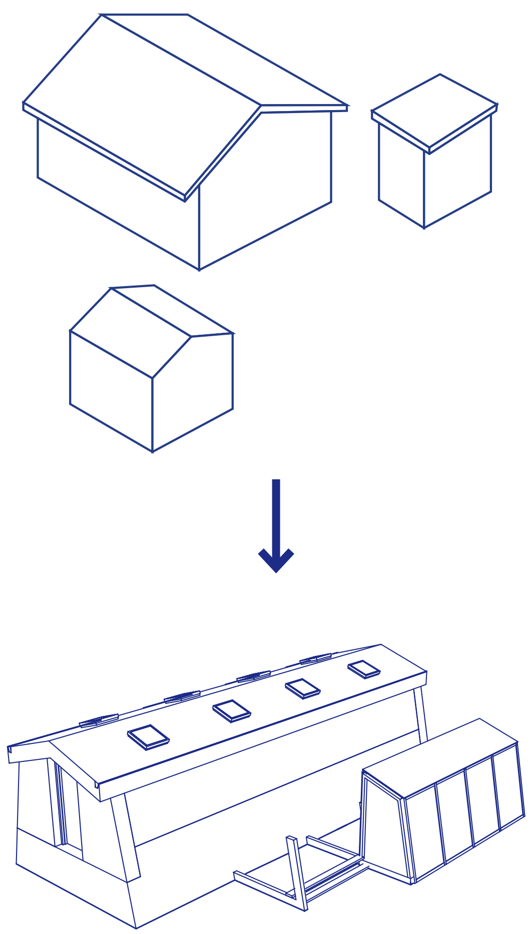
Slanted exterior walls provide structural support against lateral water pressure, contributing to the building's resilience in extreme flood events. A hidden gutter system is integrated into the roof design, enabling upper wall openings while creating space for water flow. The upper openings feature a drip edge that visually emphasizes rainfall from inside the building, enhancing the experiential relationship with water while protecting the cladding by diverting water away from the facade. These detailing choices connect technical performance with the sensory dimension of living with water.



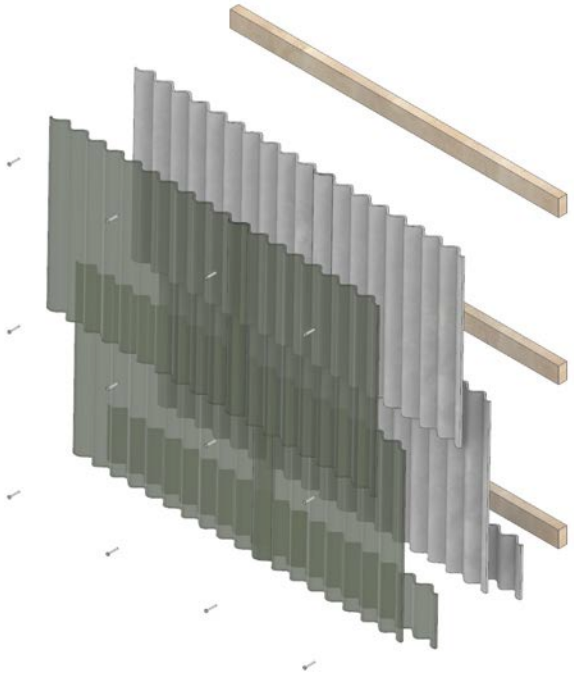

Ill. 52:
Section AA
1:50

# 85% OF THE USABLE EXISTING MATERIALS IS REPURPOSED

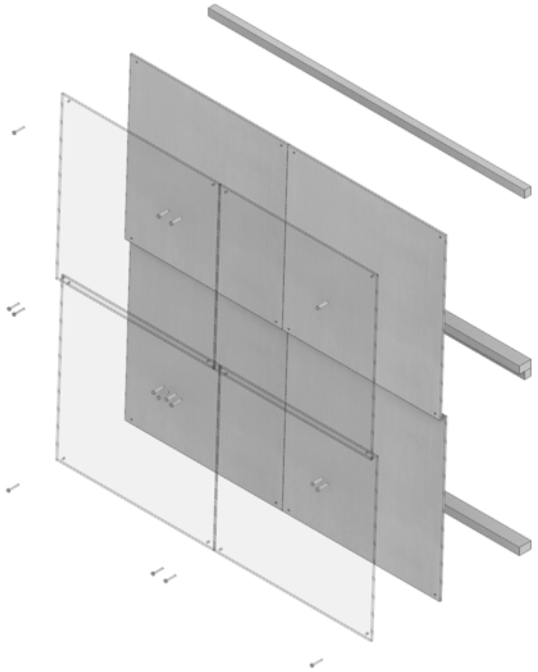
Material reuse is a core strategy in the proposal. Existing materials from the original building are repurposed: greenhouse glazing becomes reflective cladding that amplifies light interactions, old cladding boards are reimagined as flooring, and painted roof sheets offer personalized expression. These choices reduce environmental impact while enriching the material identity of the project. The approach illustrates how adaptive reuse can foster architectural quality and character, rather than compromise it.



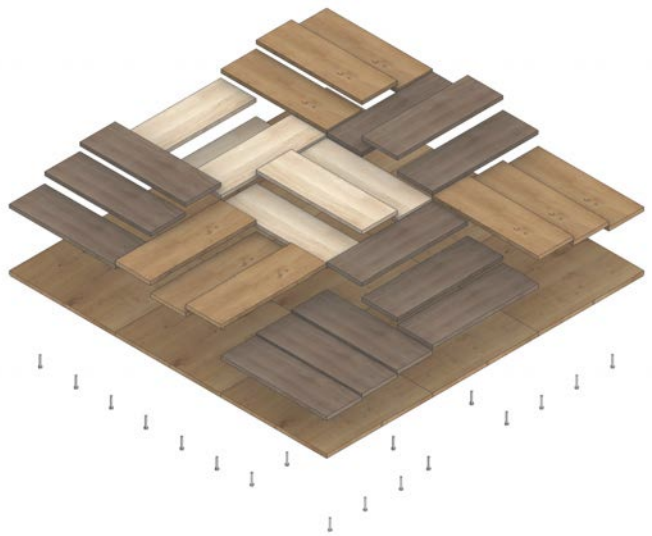
*Ill. 53: Rendering from the public eye.*



*Ill. 54:*
*Assembly method of repurposed corrugated fiber cement sheets for roofing and exterior cladding.*

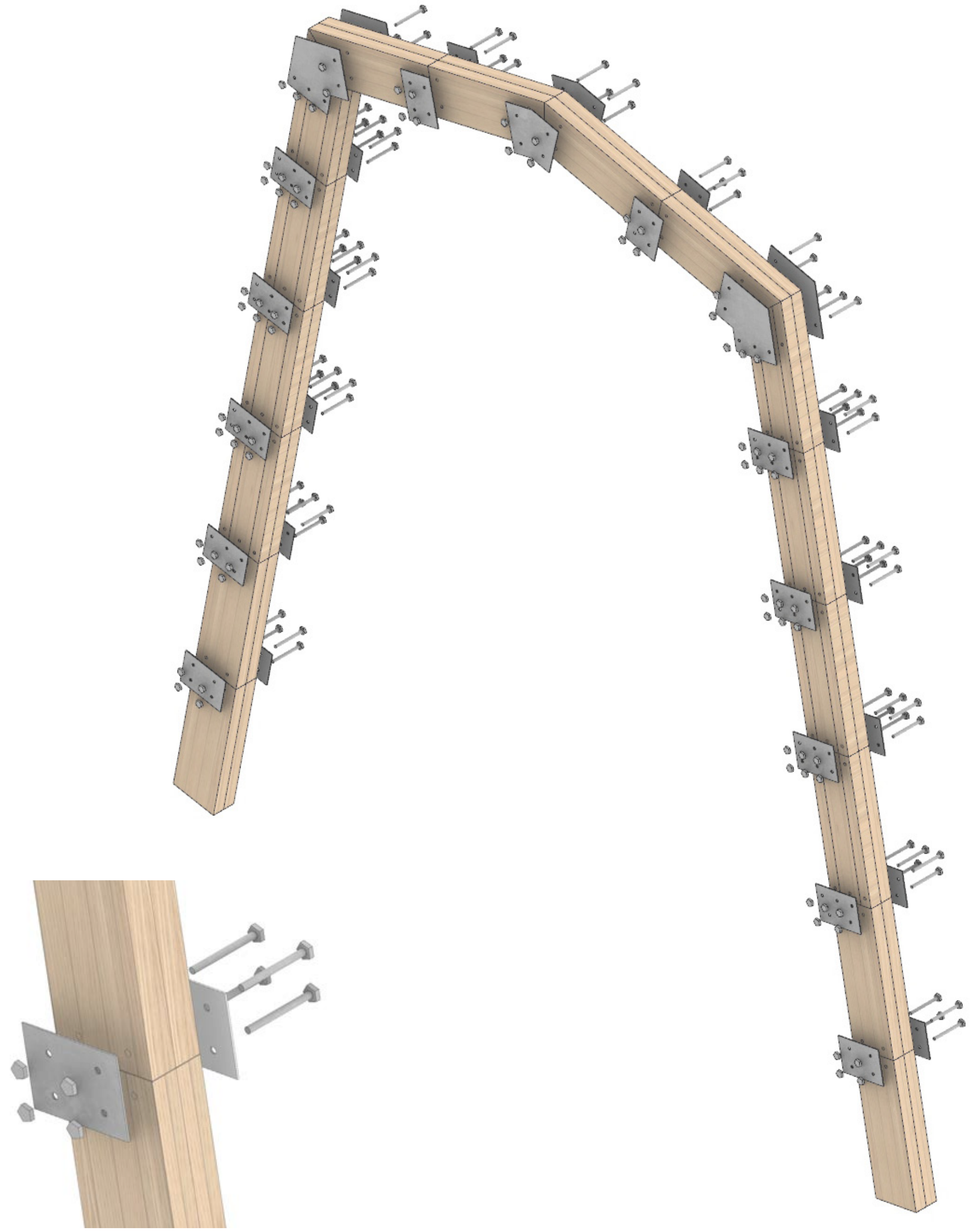


*Ill. 55:*
*Assembly method of repurposed greenhouse glass for water durable exterior cladding.*



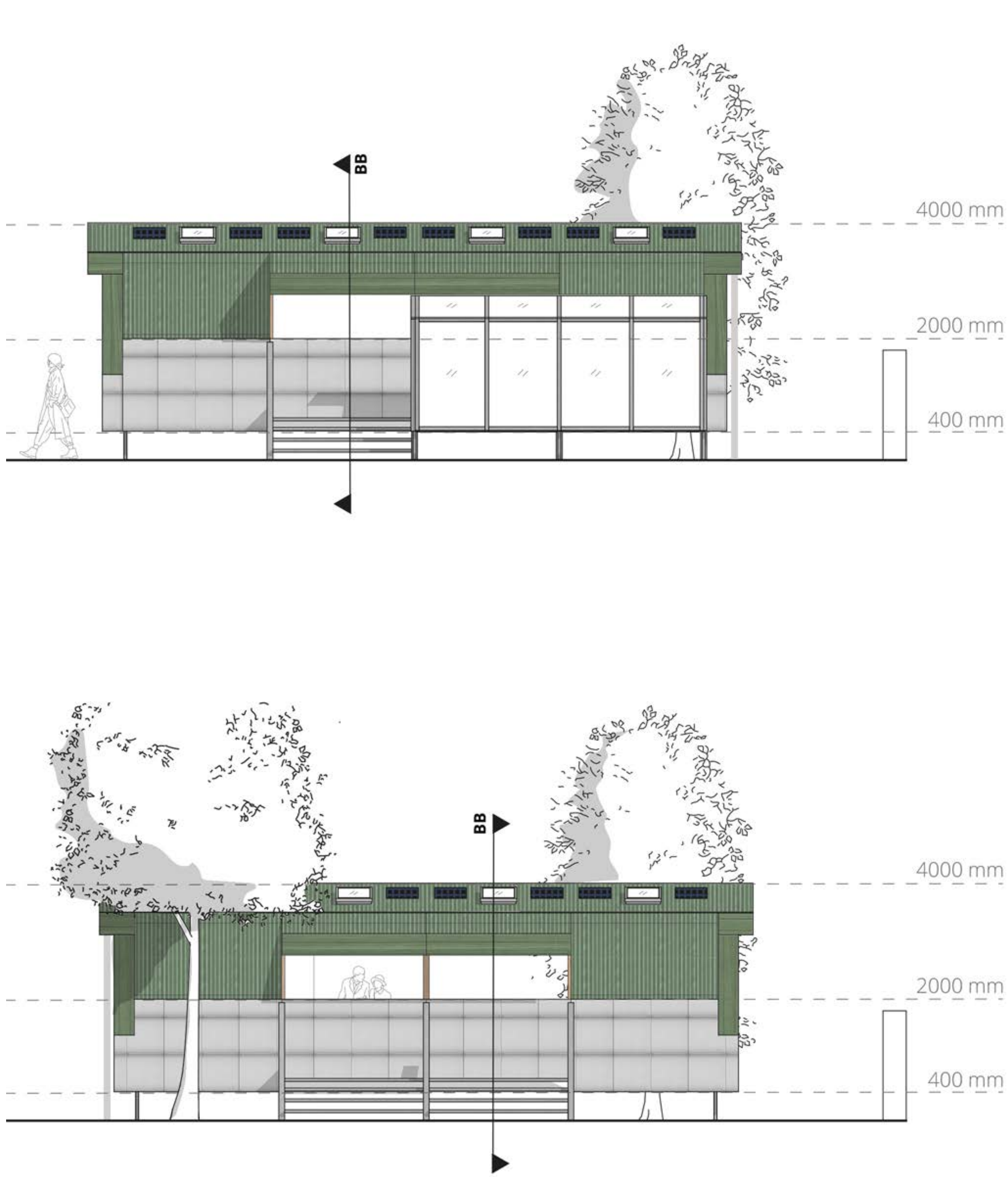
*Ill. 56:*
*Assembly method of repurposed painted exterior wooden cladding for interior flooring.*

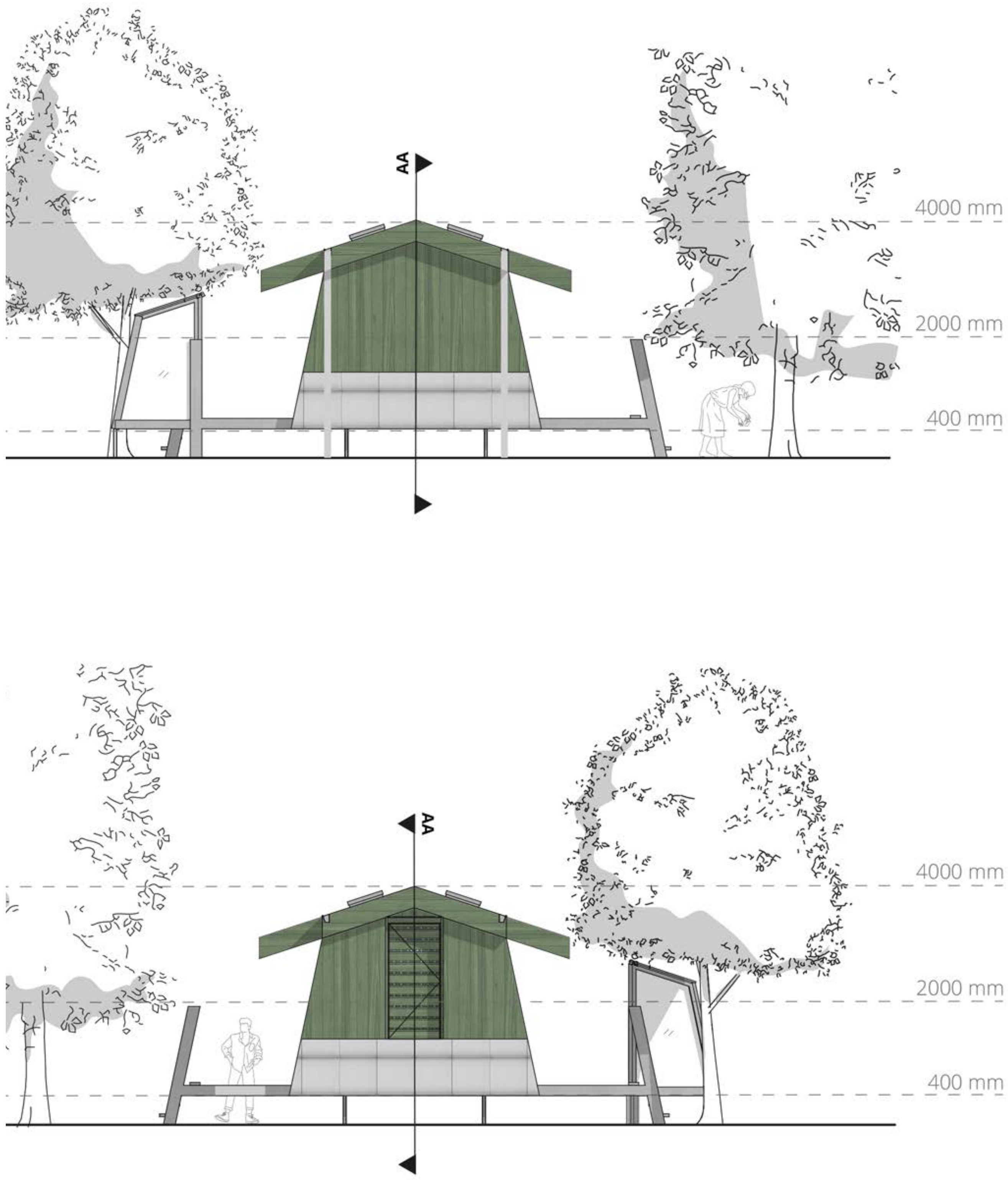




*Ill. 57:*
*Assembly method of the repurposed wooden load bearing construction.*

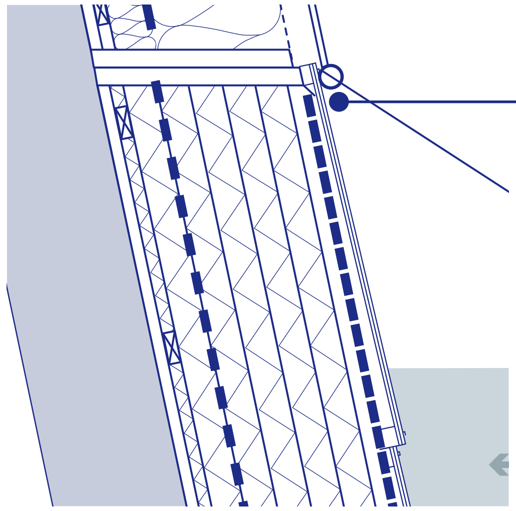
The structure is designed for easy disassembly and future adaptability. Materials are assembled using reversible systems, allowing for damage-free replacement or upgrading. This supports a long-term strategy in which components can be replaced with reused or biobased alternatives, assuming similar performance. The building's modular dimensions further support this approach, ensuring that the architecture can evolve with future climate, material, or occupant needs , a vital quality in an age of environmental uncertainty.

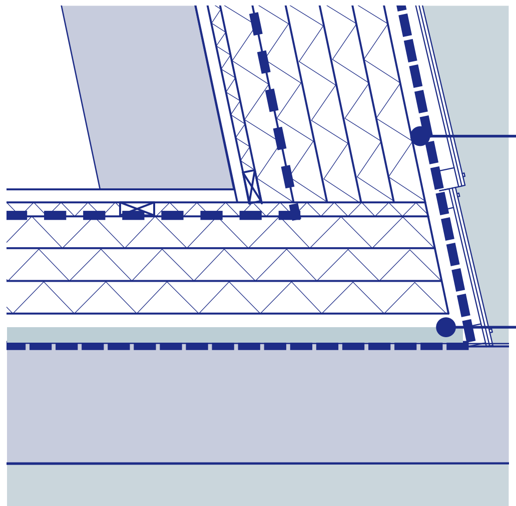



*Ill. 58:*
*Top - East elevation*
*Bottom - West elevation*
*1:100*

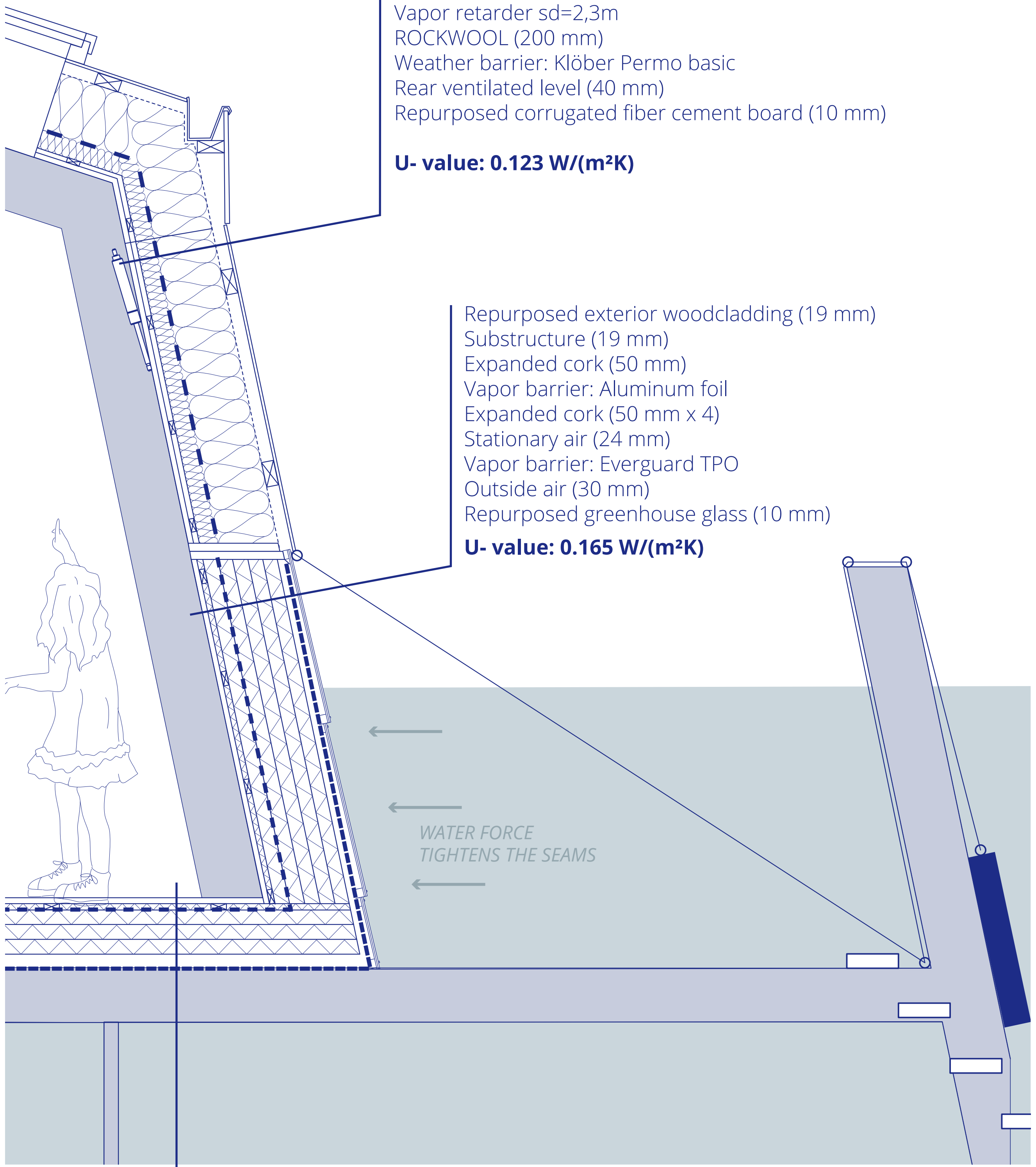
*Ill. 59:*
*Top - North elevation,*
*Bottom - South elevation*
*1:100*




*Ill. 60:*
*Expanded details for water tightness.*

To ensure watertightness, the flood-exposed portion of the structure is sealed using a 100% pressure-tight vapor barrier (TPO). Raised weep holes enable vapor to escape, and a water trap at the base collects and safely releases floodwater. The load-bearing wood structure is protected inside the insulated envelope, while galvanized steel elements at the base reinforce the building against buoyancy and hydrostatic pressure. Water-durable insulation and cladding materials further safeguard the envelope. These technical systems work together to ensure that the building not only withstands flooding, but also adapts to it, promoting both durability and occupant peace of mind.




*Ill. 61:*
*Detail of construction*
*1:20*

# CONCLUSION

This project shows that flooding does not have to be only destructive or feared, but can become a meaningful and even beautiful part of architecture. By combining a raised foundation for small flood events with a watertight, closable envelope for higher water levels, the design provides a practical and low-tech way to live with water. It also challenges traditional material use by prioritizing the reuse of flood-damaged wooden buildings already on site. Beyond reuse, the project considers what happens after future floods and generations by designing for future changes and replacement of materials. This approach extends the life of valuable materials and helps reduce waste.

Designing a building that can resist flooding both from the outside and inside was more complicated than expected. Managing moisture and water pressure required close attention to every joint and layer. However, once this system was solved, most of the construction used familiar materials and simple building methods. Installing vapor barriers requires professional skill to ensure tight seams, but the majority of the building can be built with well-known techniques. Although the exact cost has not been calculated and will vary, reusing materials and keeping processing to a minimum helps keep expenses down. Using expanded cork insulation, TPO membranes, and steel frames adds some cost, but these are still more affordable than complex high-tech solutions. Most building rules are followed, except for the wooden facade, which is less durable against water. Still, given the flood challenges, it is reasonable to expect that authorities could approve this choice.

To extend the material lifetime, it has been important to include that the design is allowing current and future owners to adapt or change the building without destroying quality materials. This is done by designing the building for easy disassembly and offering flexible options for privacy through the building placement and adjustable openings. The garden remains simple, and the roofing color can be changed to suit owner preferences. These choices support the long-term preservation of materials and allow users to personalize their space.

Overall, the design addresses the main goals of the project by providing a way to live with different levels of flooding, keeping outdoor spaces usable in smaller floods and protecting the building during more serious flooding. It balances open, garden-connected living with safe shelter when needed. It also supports material reuse and prepares for future material replacement. These principles guided the entire design process to meet technical, environmental, and user needs while creating a resilient and meaningful experience of flooding.

An important part of the design is the way it embraces the flood experience itself. The qualities of water during floods, such as the reflections of light on the building's overhang, the movement and sound of water, and the changing visual patterns, create a unique sensory environment. These aspects offer a new kind of experience that can only be fully appreciated in flood-prone or water-rich areas, turning water from a threat into a positive sensory experience.

This thesis encourages a new way of thinking about materials and flood-prone sites. Materials should be valued for their physical qualities and potential for reuse, not just their original function. Designing with reused materials also requires planning for their future replacement with recycled, new, or bio-based options. Instead of avoiding flood-prone areas, buildings can be designed to adapt to different flood levels, starting with simple raised foundations and scaling up to fully protective enclosures. This approach creates buildings that are resilient, flexible, and inspiring. Most importantly, this work shows that architecture can transform the experience of flooding from something feared into something rich, sensory, and meaningful.



# SHARING THE DESIGN METHOD

This chapter outlines the methodology and methods applied throughout both the analysis and design phases of the project. It begins by presenting an overview of the design process through a diagram that brings together several theoretical approaches used to guide the work. This diagram serves as a visual structure for understanding how the process has unfolded and how different tools and perspectives have informed each step.

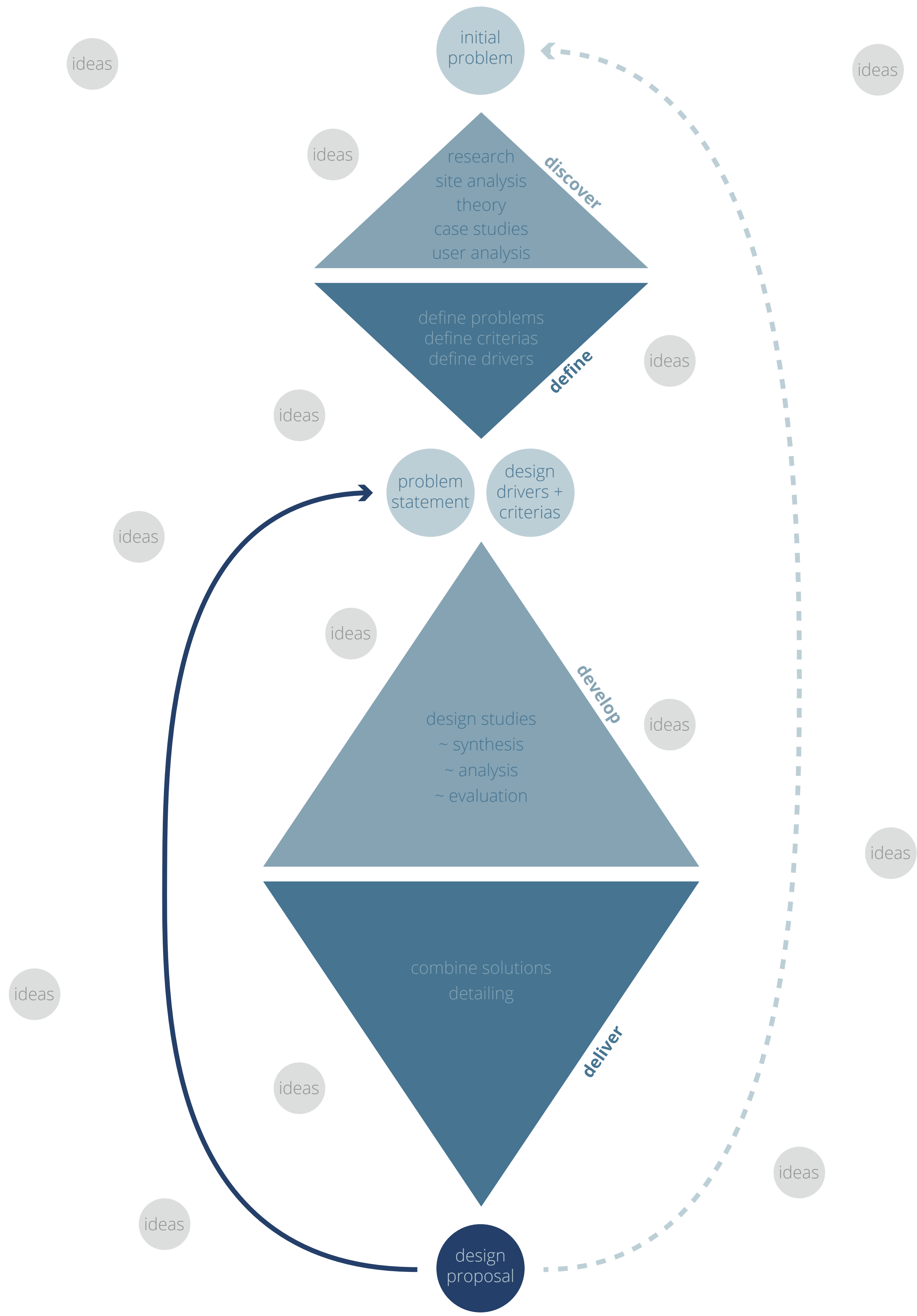
Following the diagram, the chapter provides a closer look at the individual phases of the design process. Each phase is described in terms of its specific focus, the methods used, and how these contributed to shaping the project's direction. Together, the methodology and methods described here form the foundation for a structured and reflective design process that connects theoretical knowledge with practical exploration.

# methodology.

The methodology of this project combines different approaches and theoretical frameworks to support the creative design process. Architectural design is inherently complex and constantly evolving. As Professor of Architecture Bryan Lawson explains in *How Designers Think*, the design process is flexible and can be understood as an ongoing dialogue between problem and solution. This dialogue is shaped by cycles of synthesis, analysis, and evaluation (Lawson, 2010).
However, implementing such an open-ended approach within the constraints of a time-limited project can be challenging. To provide a structured yet adaptable framework, this project integrates Lawson's perspective with the Double Diamond design model. The Double Diamond model, developed by the Design Council, divides the design process into distinct phases, helping to manage the workflow while allowing for iteration (*History of the Double Diamond*, no date).
Illustration 62 presents a customized version of this model, incorporating both phase-based structuring and the flexibility of iterative steps.

This methodology allows for spontaneous idea generation throughout the process. As new insights emerge, they are integrated as sources of inspiration in the design development. While user involvement is a key aspect of many design processes, this project does not actively engage users continuously. Instead, it relies on early-stage input, gathering information through an in-depth interview with the site owner and a nationwide survey of 49 allotment holders across Denmark. These insights are later revisited and reflected upon to guide the design direction and ensure that the outcome remains grounded in user needs and preferences.

Rather than co-designing with users, the findings are distilled into design drivers, personas, and criteria that guide and test design decisions. This approach focuses on designing with the user in mind, ensuring that the final proposal is adaptable and meaningful to a broad group of allotment owners. A continuous dialogue with a supervisor and a sparring partner, supports the reflective and evolving design process.
This methodology represents an experimental approach to architectural design. The project serves as a test case to evaluate how well it balances structured planning, user research, and creative freedom.




*Ill. 62:
Customized version of the Double Diamond model used as a design process diagram.*

## Methods

To provide a deeper understanding of the methodology, this section expands on each phase of the model (Ill. 62) and outlines the specific methods implemented throughout the design process. The process is informed by the Double Diamond model (History of the Double Diamond, no date) and Bryan Lawson's framework of analysis, synthesis, and evaluation (Lawson, 2010), which support an iterative exploration of problems and potential solutions. The four main phases; Discover, Define, Develop, and Deliver, are used as a structure, though steps are revisited and adapted as insights unfold.

### Discover

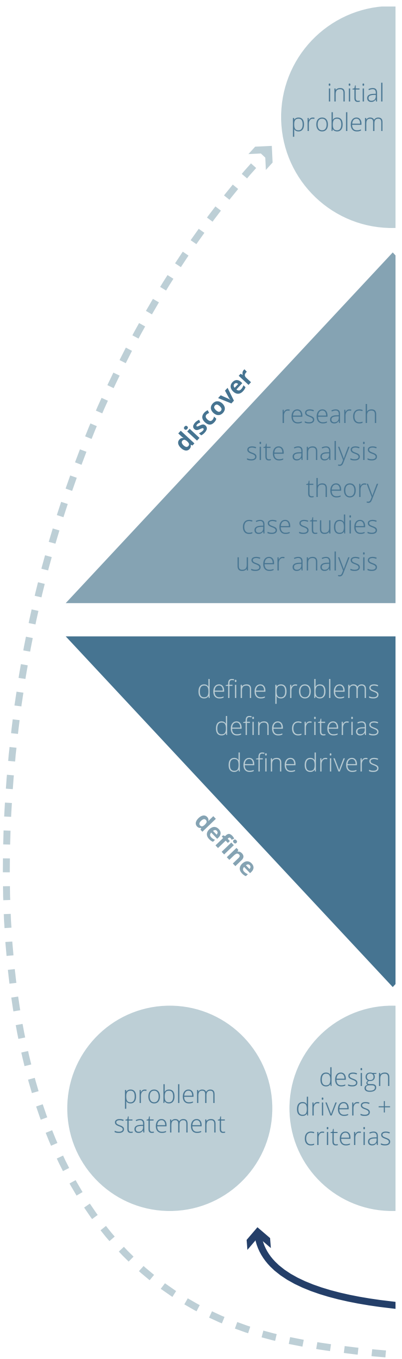
This phase focuses on identifying and understanding the design problem. Initially, a literature review was conducted to investigate two primary challenges: flooding and material waste. To gain further insight, an in-depth interview with the site owner was carried out, alongside a survey distributed to 49 allotment owners across Denmark. These methods provided a broader perspective on user experiences, preferences, and needs.

In addition to user research, site analysis, focus relevant theory and casestudies were conducted. This included for example flood mappings and material studies, focusing on the potential of reused or repurposed materials. Early findings were organized into three key problem categories: flood resilience, flood experience, and extending material lifetime. These categories guided deeper research into relevant theoretical frameworks and site-specific challenges. Case studies were selected and analyzed based on their relevance to these themes and were used to explore how theory could be implemented in practice.

### Define

In the Define phase, insights from the Discover phase were synthesized to frame the project. A clear problem statement was developed, supported by a manifesto inspired by Anne Beim's *Circular Construction: Materials, Architecture, Tectonics* (Beim, Zepernick Jensen and Arnfred, 2019). The manifesto serves as a basis of this thesis purpose and design direction.

To direct the development of solutions, design drivers were formulated, broad conceptual directions that emerged from the research into the three main categories. These drivers, inspired by Bryan Lawson's notion of design guidance, translate complex problems into actionable frameworks for design. Furthermore, a comprehensive set of design criteria was developed. These criteria emerged from the accumulated research, interview insights, and survey data, and serve as evaluative tools for design decisions moving forward.




*Ill. 63: Zoomed in illustration of discover and define phases.*


*Ill. 64: Zoomed in illustration of develop and deliver phases.*

### Develop

This phase focuses on the iterative generation and refinement of design solutions. Based on the problem statement, design drivers, and criteria, a series of design studies were conducted. Each design study follows a three-step cycle: synthesis, analysis, and evaluation (Lawson, 2010). The studies range in scale and depth, from conceptual sketches and material experiments to simulations and detailed calculations. The studies are not uniform; some focus on spatial qualities, while others explore technical or environmental aspects. Certain studies led to new ideas and additional studies, creating an evolving design process. While personas developed from the survey were used to reflect on user relevance, the users were not directly engaged in this phase. The iterative nature of the process means that the project loops back into earlier phases as new insights emerge.

Spontaneous ideas that arise during any phase are captured and recorded visually to be integrated when relevant. This ensures that creative impulses are not lost, even if they are not immediately implemented. The process remains open-ended, reflecting the complexity of architectural design.

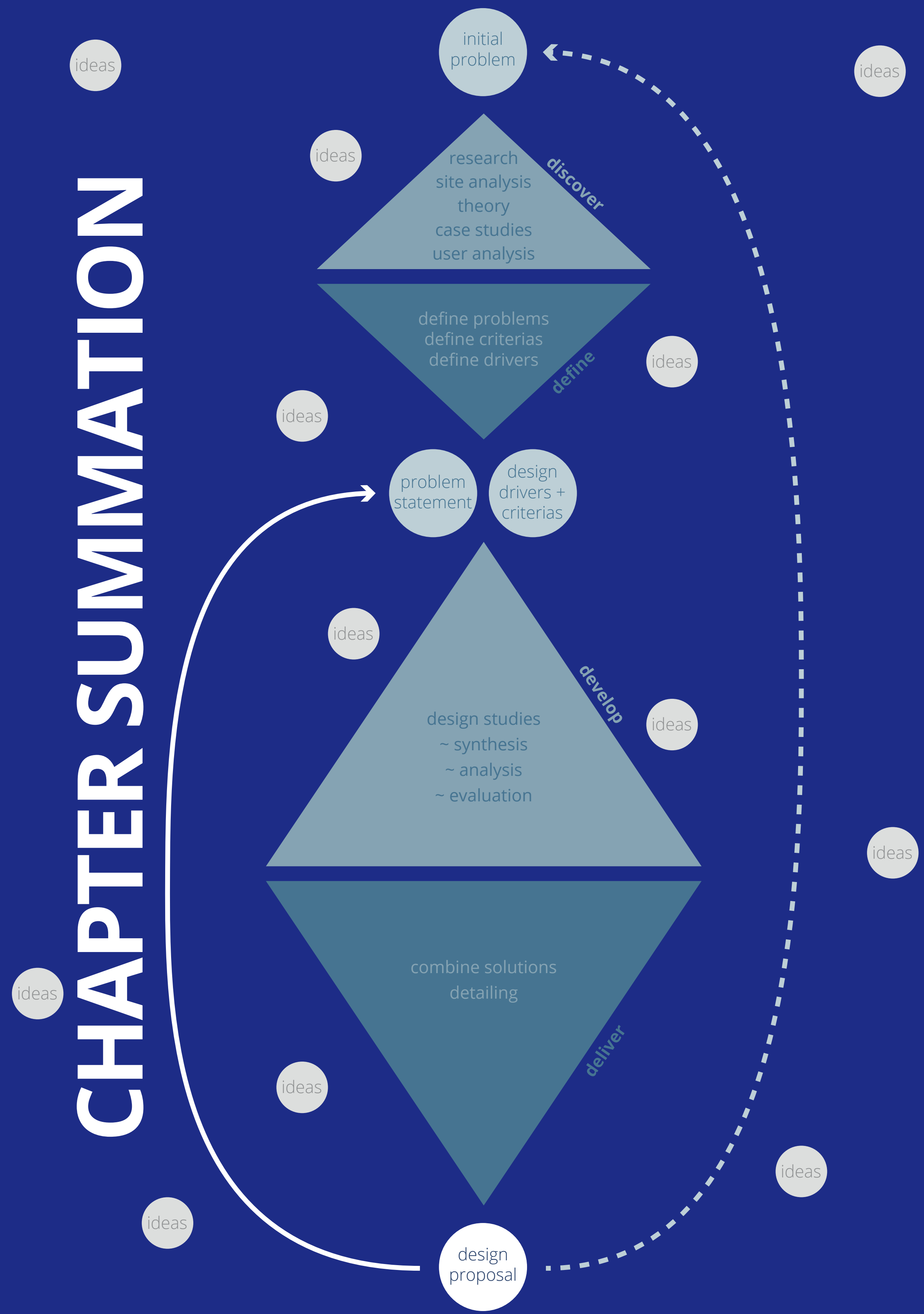
### Deliver

Rather than concluding with a final, fixed proposal, this phase aims to synthesize and test combinations of the developed design studies. Designs are evaluated collectively to identify potential integrations and synergies, sometimes resulting in more detailed development, such as 3D modeling to test spatial or material fit. This process often leads back to additional studies, as new challenges or opportunities are identified through testing. The design proposal at this stage remains flexible and subject to further refinement. The manifesto and design criteria continue to provide direction, ensuring coherence with the original intentions. While direct user feedback is not collected at this stage, previous user research remains a foundation for evaluation, ensuring the design stays aligned with user needs.

The four phases outlined above do not follow a strictly linear path but instead function as iterative cycles. The project continually revisits earlier phases as new insights develop and as design studies evolve. The Double Diamond model provides an overall structure, but the dynamic nature of architectural design necessitates flexibility and responsiveness.

New methods and tools are adopted as needed throughout the process, depending on the challenges at hand. This adaptable and research-driven approach enables both creative exploration and grounded decision-making, ensuring that the project responds meaningfully to its context, user base, and environmental challenges.

# CHAPTER SUMMATION






# SHARING THE DESIGN PROCESS

This chapter presents the design process behind the final architectural proposal. The structure follows the three previously established focus areas: flood resilience, flood experience, and extending material lifetime. Within each focus area, relevant design studies are presented and organised into three phases: synthesis, analysis, and evaluation. This format is intended to clarify an otherwise complex and iterative process by highlighting the key studies that directly informed the final design. However, it does not capture every interrelation between the different topics or design decisions not reflected in the final outcome. Each study responds to specific design criteria developed in the previous chapter, which were grounded in problem formulation, site analysis, and case study research. The criteria addressed in each study are marked using small visual icons, referencing the associated design driver and criteria number. The result in each study is marked with a: ✗

1.1
1.2
1.3
1.4
1.5
1.6

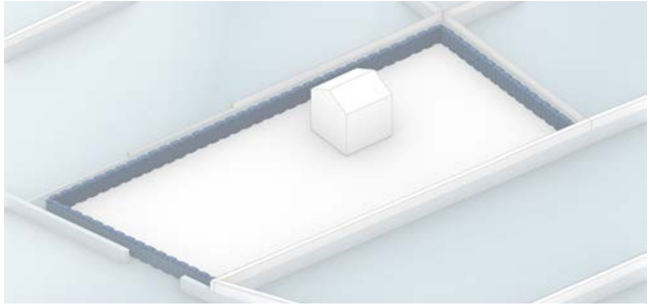
# plot or plateau.

*This design study explores whether the entire plot can be flood-secured up to 1.2 meters by shaping water-resistant materials in exposed areas to meet the required structural performance under flood stress, while also maintaining accessible entry and exit routes during flooding and keeping the overall building height below four meters. The aim is to test whether a fully site-based flood strategy is feasible within these constraints, or whether the focus should instead shift toward selectively securing the building itself and/or specific outdoor zones. The study investigates how far integrated material and spatial strategies can be pushed before such compromises become necessary.*

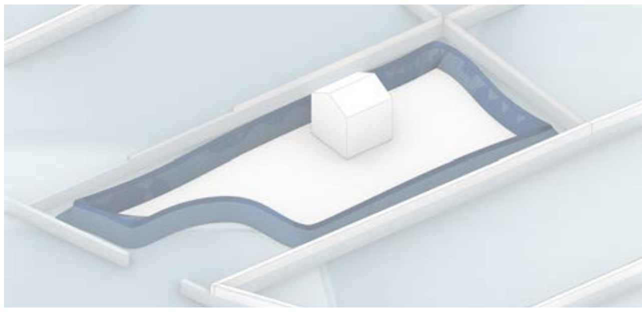
Six different strategies were developed and tested in Rhino 3D (Ill. 65). Four of them aim to secure the whole plot using different types of barriers or systems: a raised hill, a water-tight fence, sandbags, and a tank-based water pumping system. The other two strategies focus on protecting only the building and a smaller outdoor area using raised, water-resistant foundations. Each strategy was compared based on how well it handles floodwater, whether it allows for access, its visual impact, how it affects privacy, how much work it takes to maintain, its connection to nature, and how it influences the overall height of the building.

Two strategies were clearly ruled out: the tank system is too large and unrealistic for this site, and sandbags are not integrated, need a lot of manual work, and don't connect well to the landscape. The water fence is also not ideal, it blocks views and movement, is visually intrusive, and expensive to build. The raised hill has some potential, especially as a partial solution, since it could blend with the landscape and stay visible or usable during floods, but it may not be enough on its own. The two most promising directions are the raised building foundation and the raised plateau that includes outdoor areas. These options are more integrated and allow for better control over access during floods. The next step will be to refine these two strategies, especially looking for ways to reduce their height and test different layout options, while moving away from trying to secure the full site.

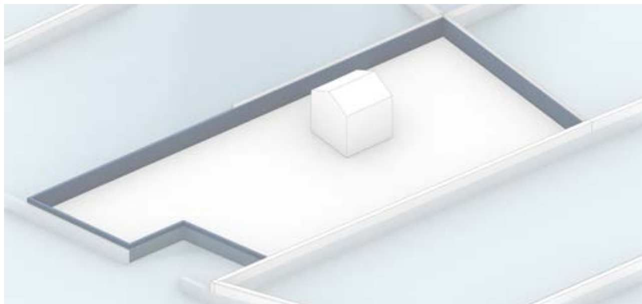
SANDBAGS



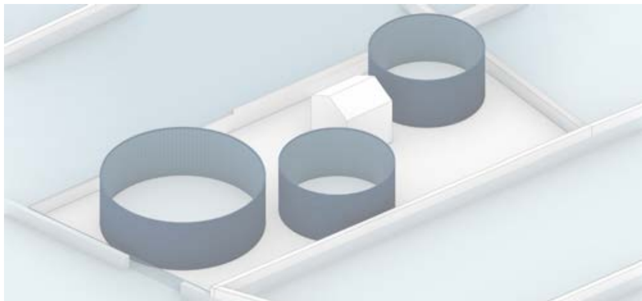
LEVEE



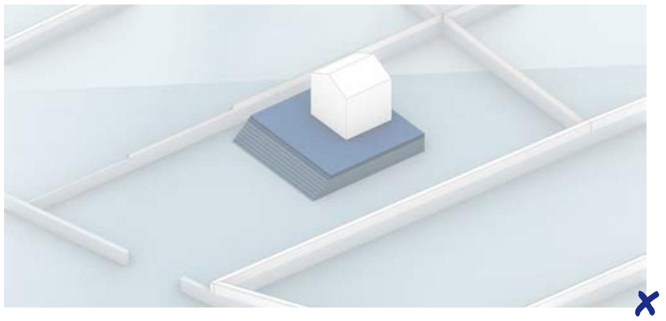
HILL



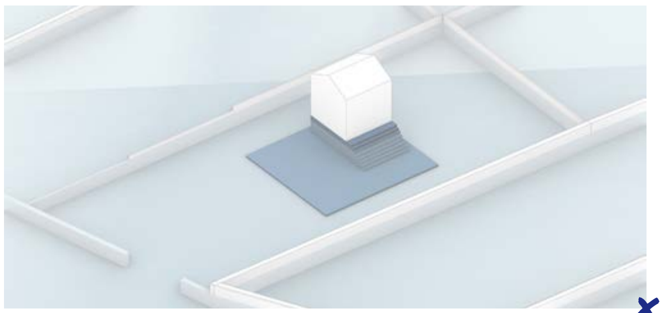
4m TANKS
WITH PUMPS



RAISED PLATEAU



RAISED BUILDING



*Ill. 65:
Six flood management strategies.*

# foundation.

*To address the challenge of designing for both outdoor use during shallow flooding (up to 30 cm) and indoor use during more severe flood events (up to 1.2 m), this study explores a foundation strategy that remains structurally stable under flood stress while keeping the overall building height within a 4 m limit. The intent is to create a layered ground condition that adapts to different flood levels without compromising usability or safety. This synthesis builds on site-specific flood data, design criteria from the framing chapter, and inspiration from flood-resilient case studies.*

Six foundation strategies were developed and modeled on the site in Rhino, drawing from three case-based foundation types: floating, pillar-supported, and water-resistant (Ill. 66). Each approach was studied in both dry and wet conditions to understand how it functions and feels across seasons. The models were used to compare how the foundations perform technically, how they affect access and experience, and how they fit within height and construction limits. Attention was also given to how the foundations support a connection to nature and how realistic they are to build with the technical resources available.

Each strategy was evaluated based on how complex it is to build, how much maintenance it requires, how well it responds to seasonal flooding, whether it fits within the 4 m building height, the kind of spatial experience it creates, and how realistic it is to construct using available tools and knowledge.

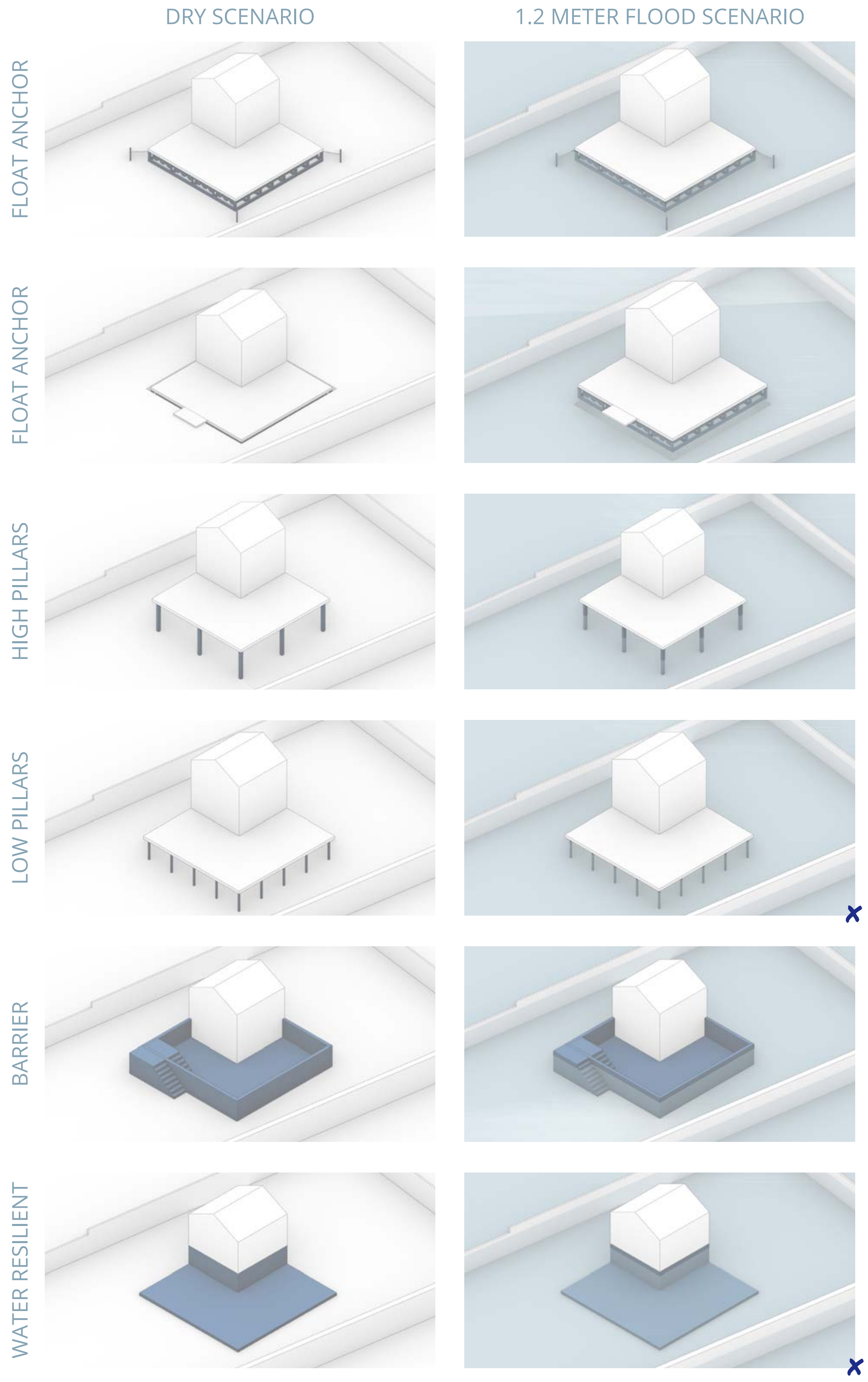
Three strategies were ruled out: the high pillar exceeds height limits and feels disconnected from the surroundings; the two water-resistant base types are too technically demanding and do not support natural water flow or outdoor use. The most promising approach combines a low pillar foundation that raises the building 40 cm above ground, just above the level of shallow flooding, with a water-resistant and water-tight facade cladding is applied up to a height of 1.5 meters to protect indoor areas during taller floods. This combined approach meets the flood protection goals without relying on complex systems like floating structures and helps the building stay visually and physically connected to the site. To make this work, the entrance will be raised to ensure access during floods. Next steps will include refining the transition between the raised foundation and the cladding, and testing entryway solutions that remain functional in both wet and dry conditions.

1.1

1.2

1.4

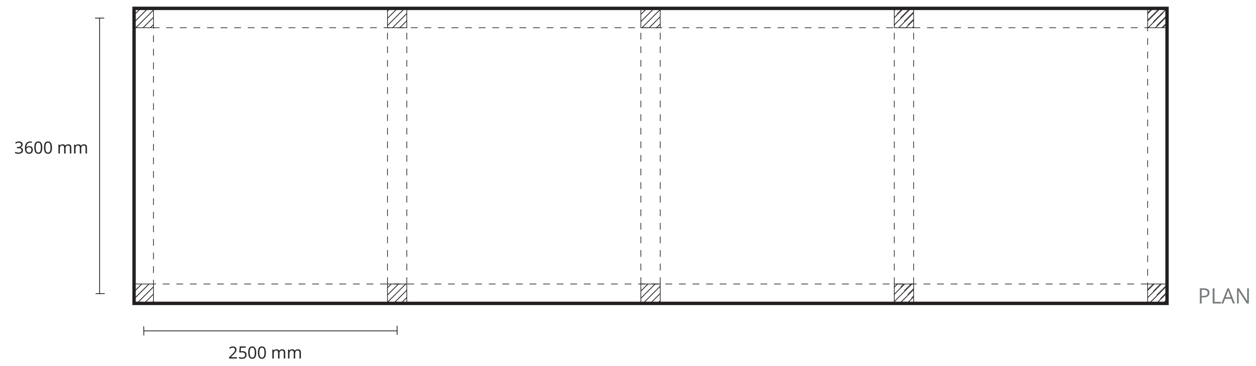
1.6




*Ill. 66:*
*Six foundation strategies.*

1.4

1.6

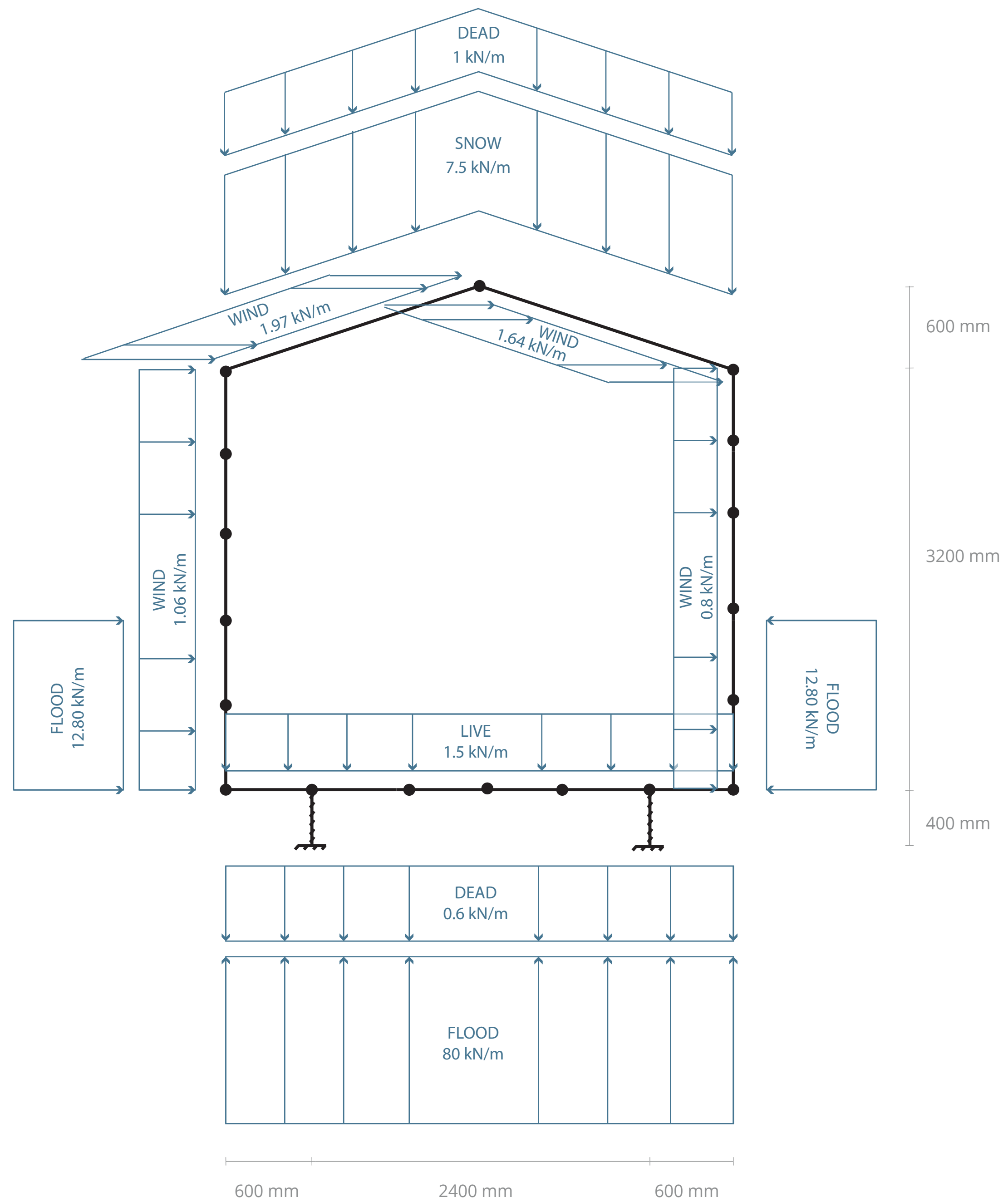



*Ill. 67:
Distrance between frames and width of frames used in the dimensioning.*

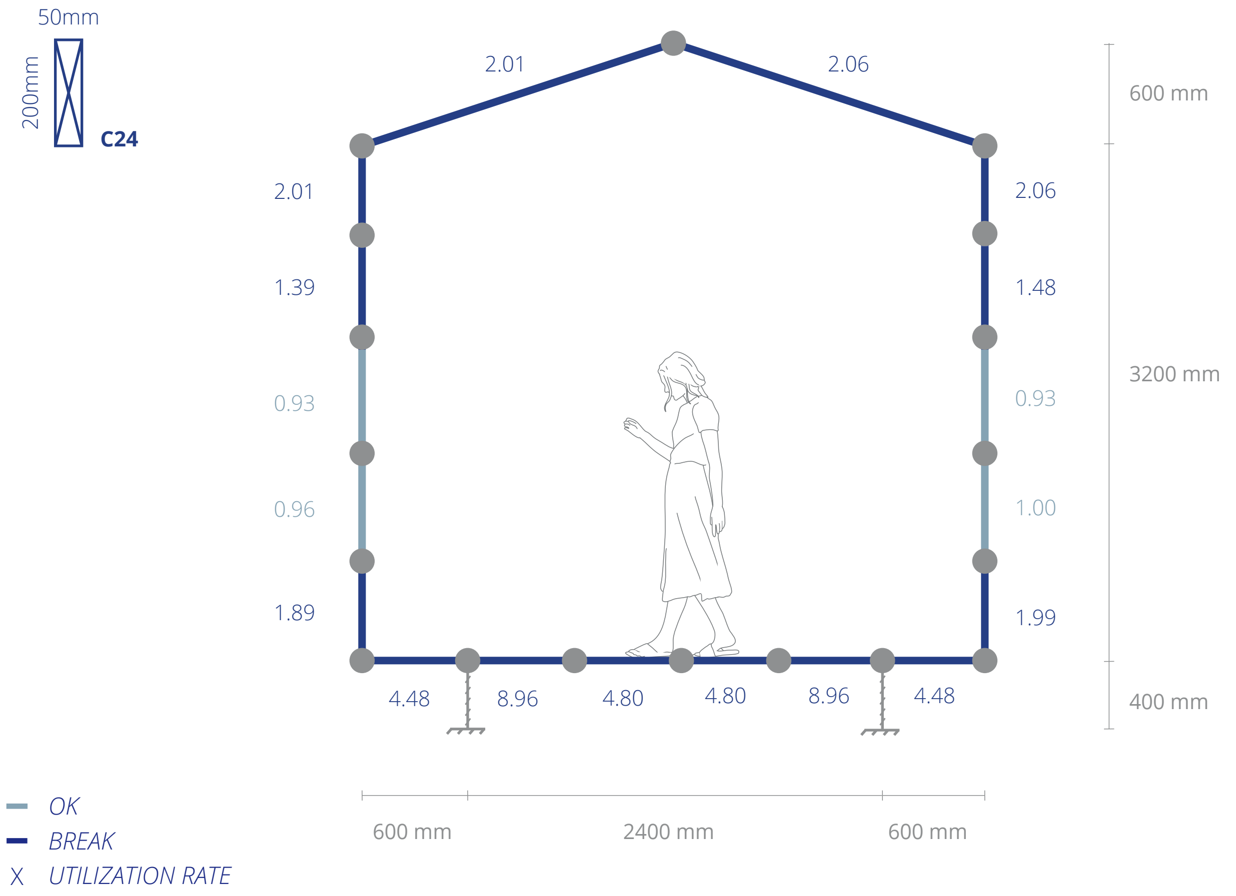
# construction shape.

*To meet the combined requirement of structural flood resilience and visual integration in a low-rise context, this design study investigates a construction strategy that can withstand the horizontal and vertical forces of flooding while maintaining a maximum building height below four meters. The aim is to explore architectural and structural systems that balance performance under water stress with sensitivity to the scale and character of the allotment site. This synthesis responds to site-based height restrictions and flood-level data while addressing design criteria related to resilience and contextual integration.*

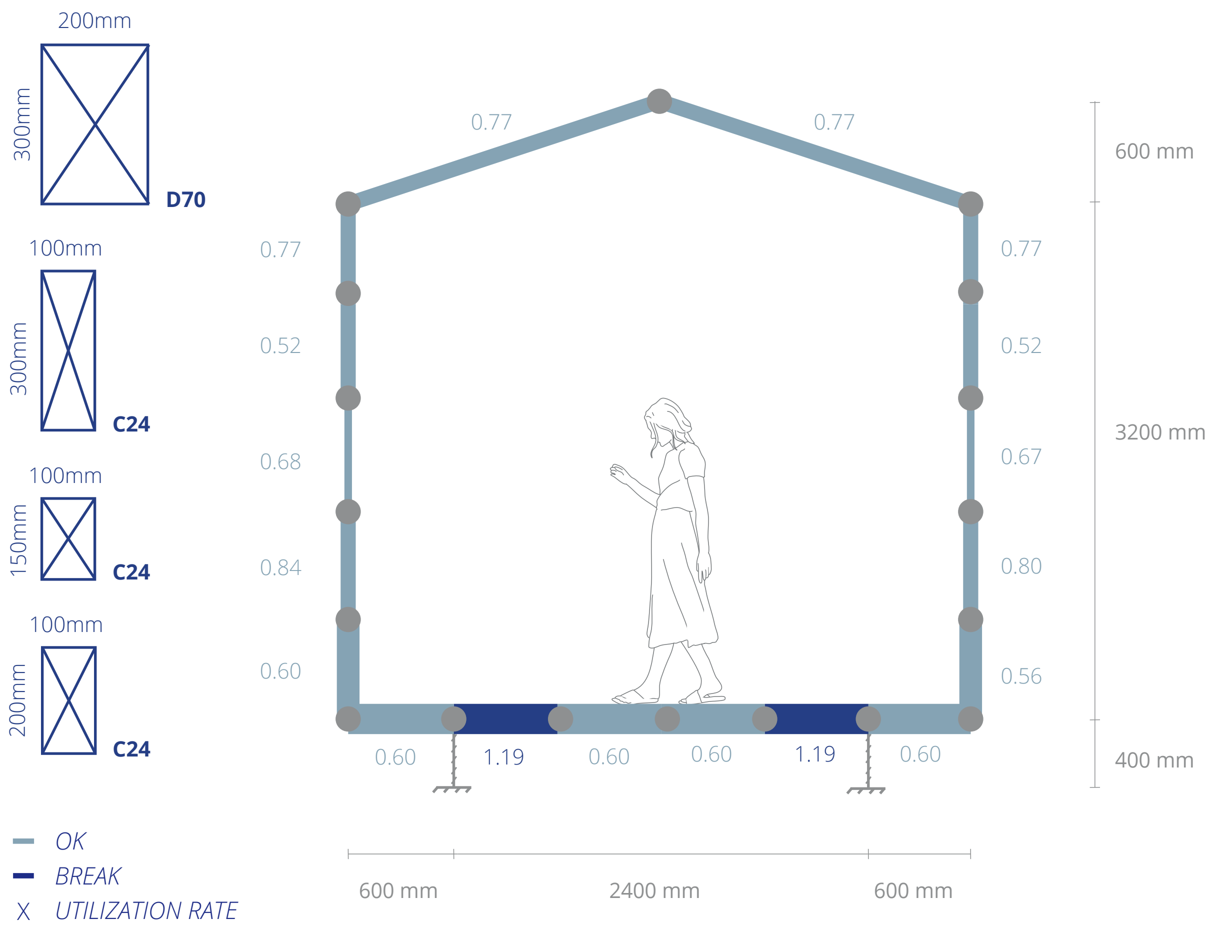
A structural frame was modeled and tested in Robot Structural Analysis, applying a simulated water load at 1.2 meters. The initial frame design used C24 wood, based on materials assumed to be reused from the existing building. The frame spacing (2.5 meters) was determined by the program layout. The foundation system was designed with ten M16 Twister screw foundations, 1500 mm in length with 1100 mm below ground, based on previous foundation studies and dimensioning calculations (App. 4). The first structural test used uniform wood profiles throughout the frame, but analysis showed uneven utilization rates, some members were overdimensioned while others were overstressed. This led to the use of varied wood profiles depending on the load requirements. However, floor beams consistently failed under buoyancy forces. Attempts to solve this by switching to stronger C50 wood profiles still resulted in some elements being overstressed, even after applying safety factors. As a result, steel was introduced for the floor beams (HPE 180), while the rest of the frame was kept in wood. Later iterations also explored slated columns to improve structural performance and simplify assembly.



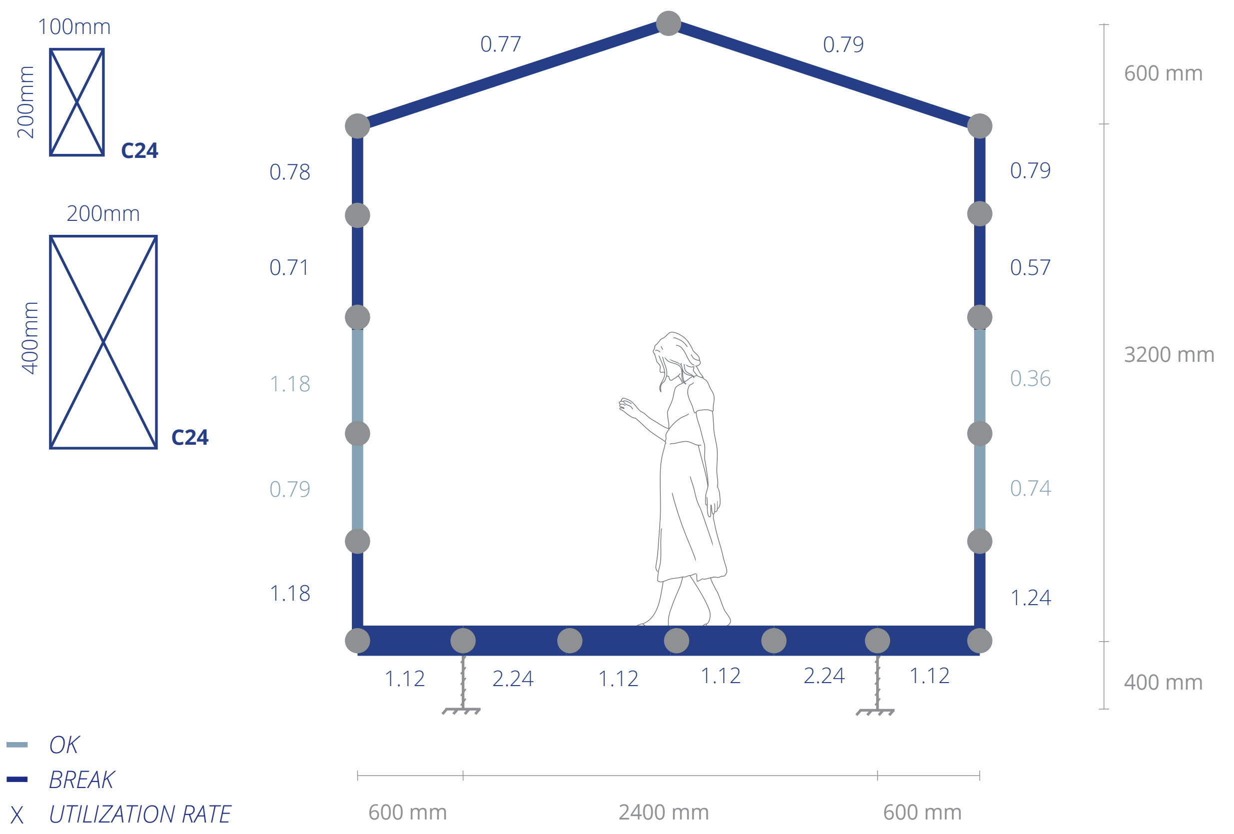

*Ill. 68:
Load combination used in the dimensioning of the frames.*



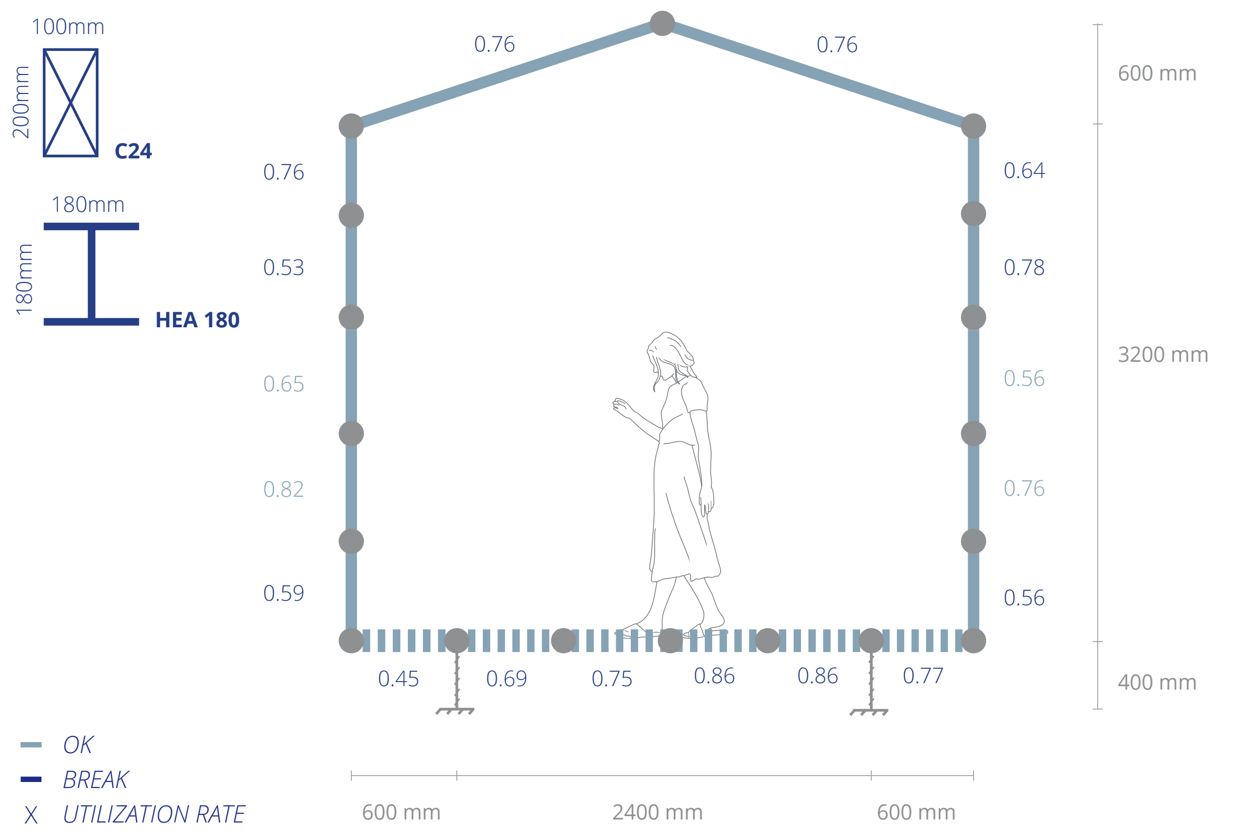

Ill. 69:
Same size profiles.



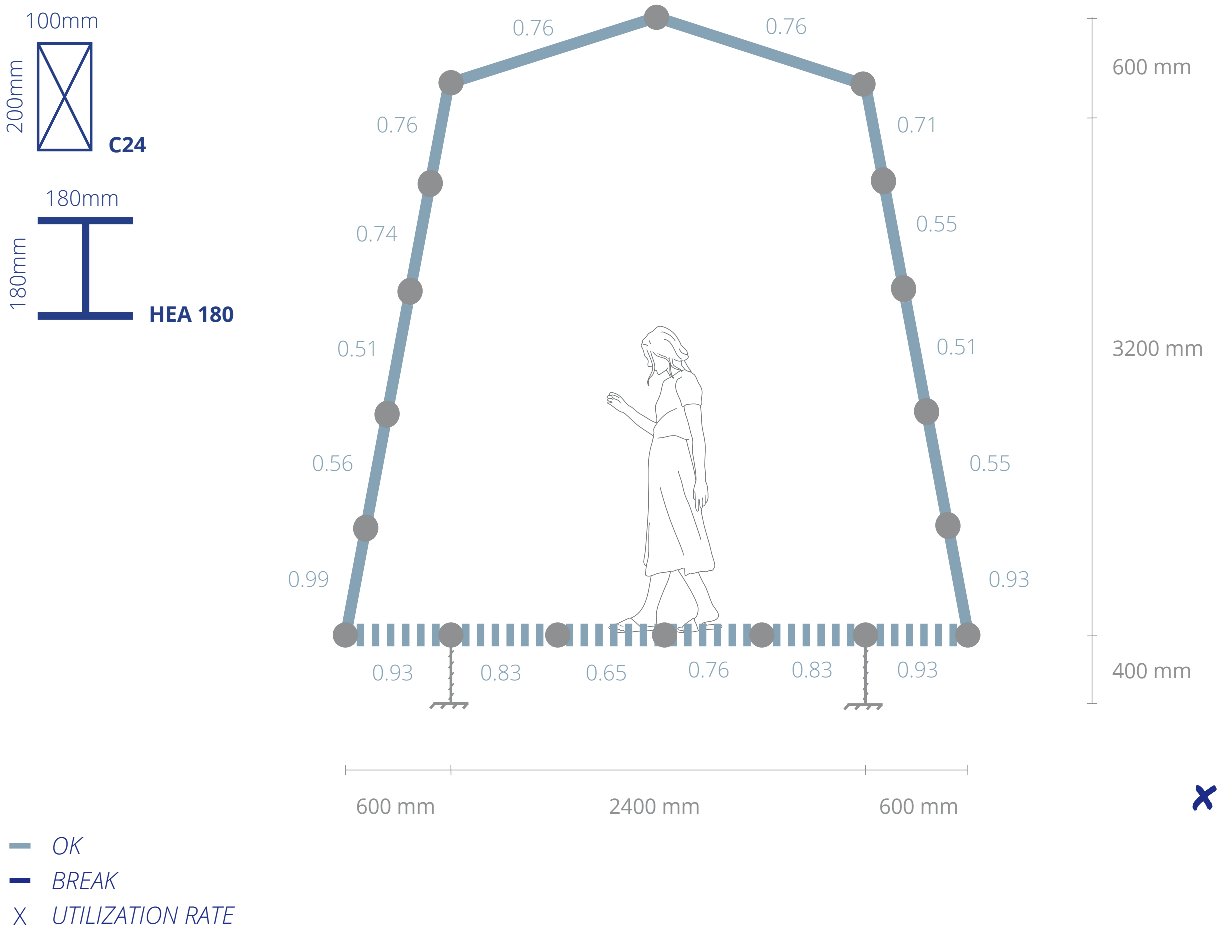

Ill. 71:
Different profiles and
stronger wood in floor.




Ill. 70:
Thicker profiles in floor.




Ill. 72:
Steel beam in floor and
same wood profile.




*Ill. 73:*
*Slated coloumns and same profiles with steel beam in floor.*

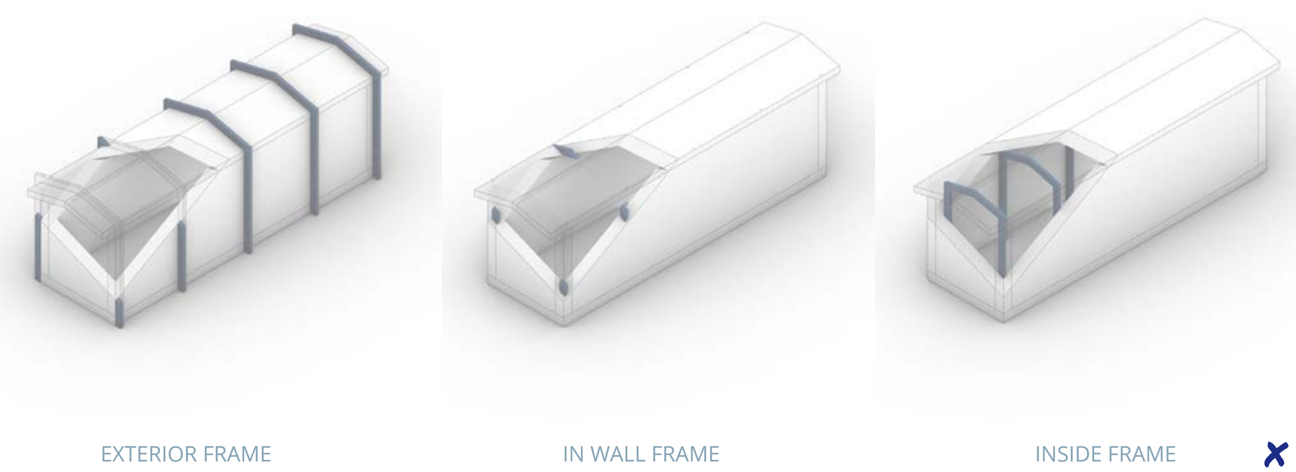
The analysis showed that a lightweight wood-only frame was not strong enough to resist the buoyant and lateral flood forces, especially in the floor structure. Heavier wood profiles improved performance slightly but didn't meet safety thresholds. Switching to steel floor beams made the frame structurally sound and much faster to calculate and optimize. However, this introduced variation in profiles throughout the structure, making construction more complex. By introducing slanted columns, the design achieved better resistance to lateral forces and allowed for more consistent use of wood profiles above the floor beams, using 100x200 mm sections throughout. The slanted geometry also supports better light reflection in water conditions and improves how openings rest on the frame. In the final design, a hybrid structure was chosen: steel floor beams (HPE 180), wood framing (100x200 mm), slanted columns, and screw foundations. This combination meets flood and height constraints while staying grounded in reused materials where possible and maintaining a cohesive visual language.

# watertight.

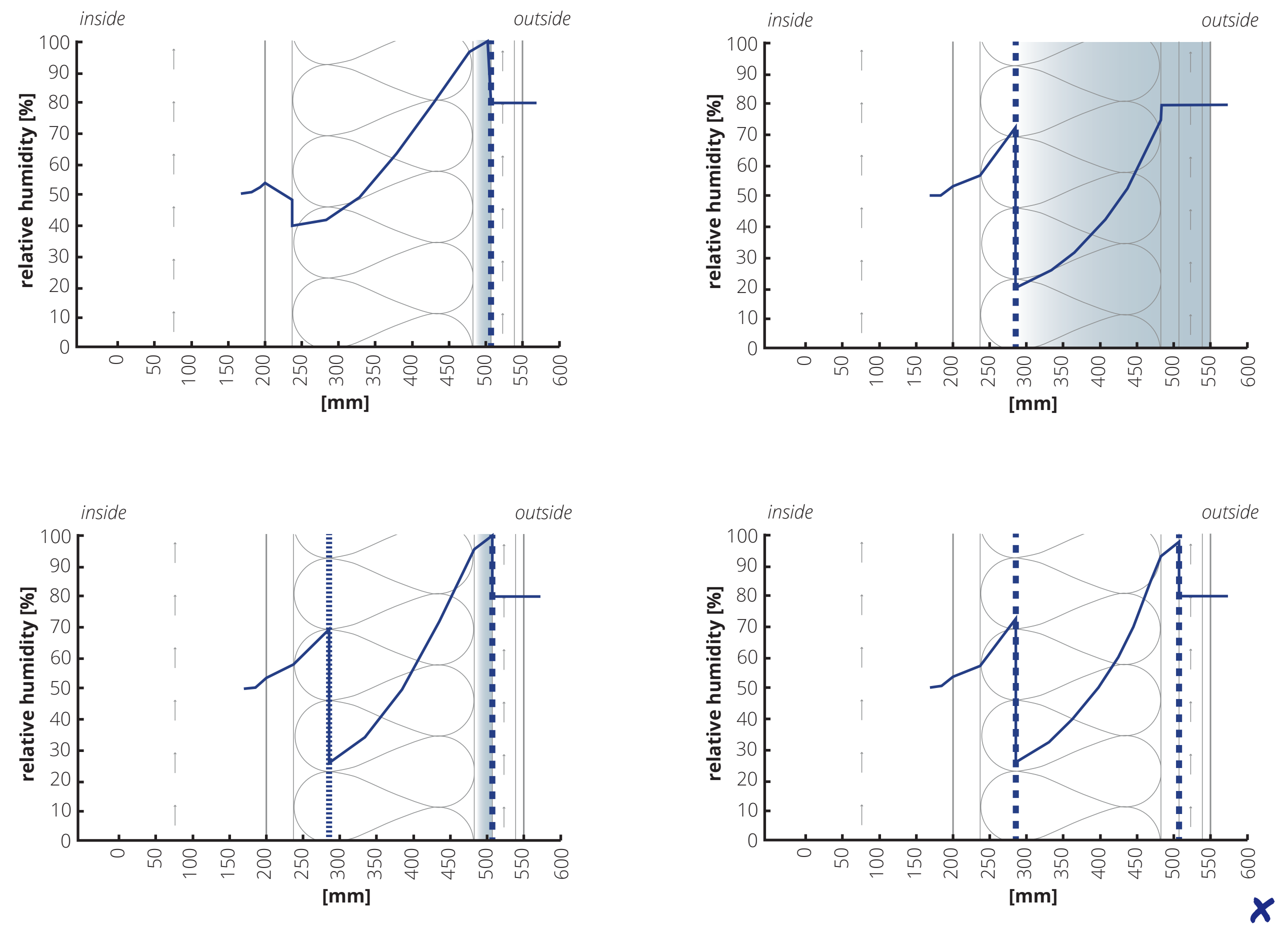
*This study explores how a construction can remain watertight during flooding by strategically applying water-resistant materials in exposed areas. The goal is to find materials and building details that stop water from getting in, so the inside stays dry during floods and the materials last longer.The synthesis is guided by flood level projections, durability assessments, and the framing criteria concerning protection and maintenance under water exposure.*

Three aspects were studied. First, the placement of the load-bearing structure was tested in three locations: on the outside, in the middle, and on the inside of the wall and roof (Ill. 74). These options were evaluated for moisture resistance, durability, and visual effect, using C24 wood as the base material. Second, different positions for the vapor barrier were tested using UBAKUS software to simulate moisture and condensation behavior (Ill. 75). The goal was to find a setup that prevents both external flood water and internal moisture from causing damage. Third, the study looked at how trapped moisture could escape from the construction, since water might enter from below during floods, traditional drainage methods had to be adapted (Ill. 76).

Placing the load-bearing structure on the outside would expose it to direct water contact, requiring either special coatings or more water-resistant materials, which would increase environmental impact and make reuse difficult. The middle placement poses a risk because moisture trapped inside the wall could damage the structure without being noticed, possibly leading to failure. The inside placement was chosen, since it keeps the structure dry, works well with door and window openings, and extends material lifespan, even if it takes up more space. For the vapor barrier, a fully watertight layer on the outside combined with a vapor retarder on the inside was selected. This setup prevents water from entering and still allows internal moisture to escape, avoiding pressure build-up or condensation traps. To manage any water that does get in, the wall is designed with a built-in water trap at the bottom that holds water safely and drains it once openings are opened after the flood. Vent holes are placed above the flood level to allow water vapor to escape when conditions are dry. This combination of material strategy, barrier placement, and drainage detailing offers a practical and protective solution for flood-resilient construction.

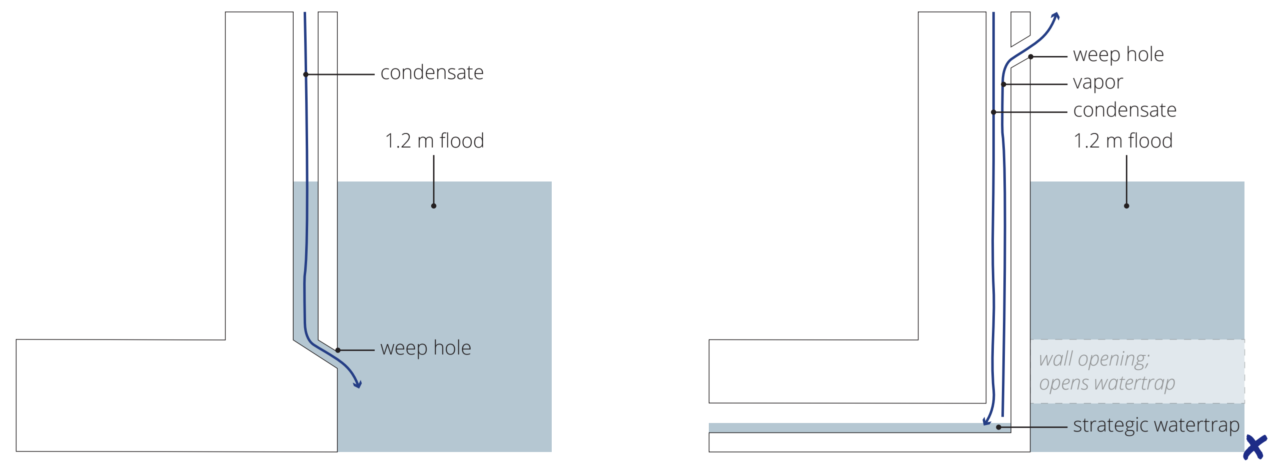



*Ill. 74: Aesthetical and practical strudy of frame constructi-on placement.*




*vapor barrier*
*100% watertight barrier*
*relative humidity (%)*
*condensate*

*Ill. 75: Study of vapor barrier type and placement.*



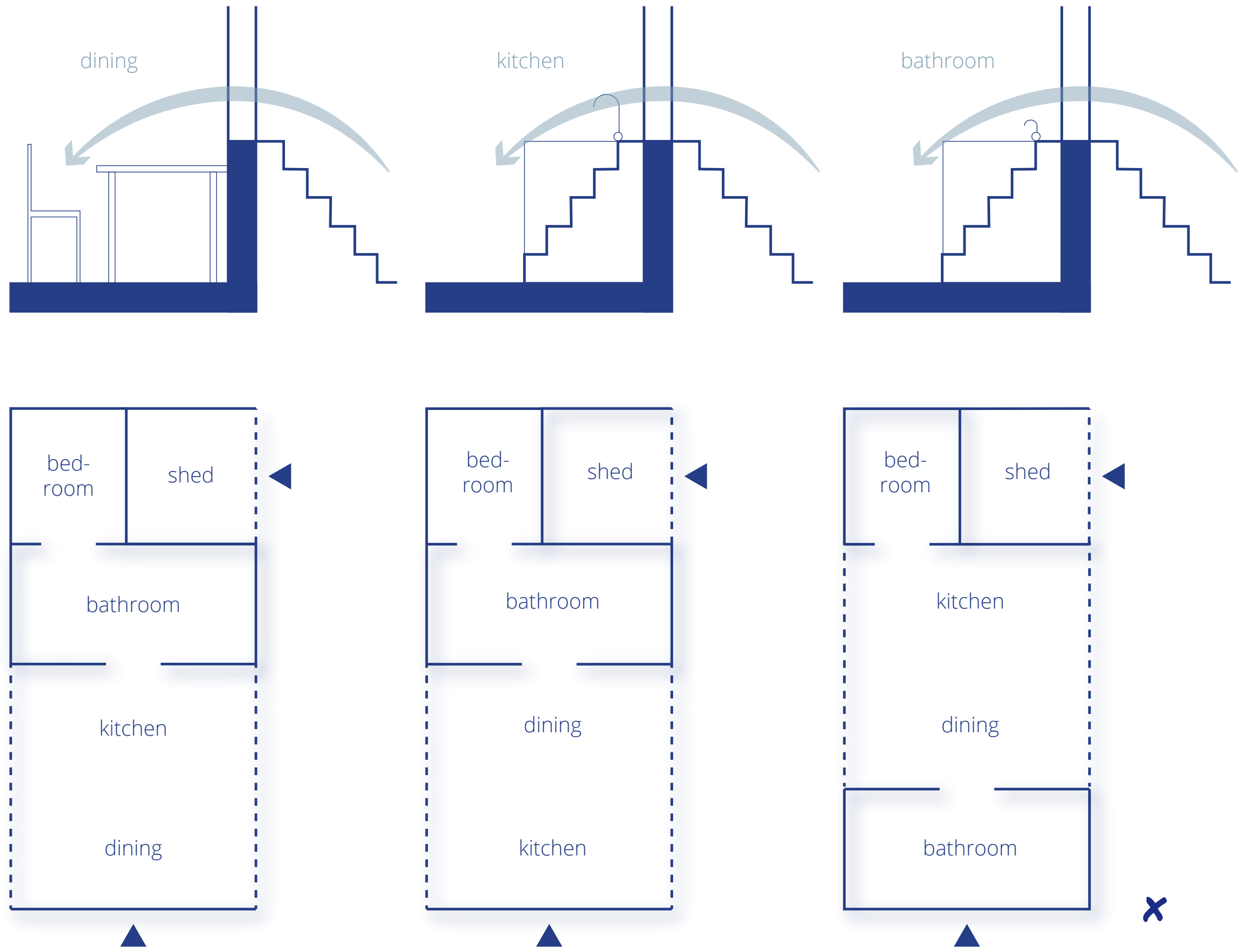

*Ill. 76: Traditional water management with weephole vs. flood adapted version.*

# entryway.

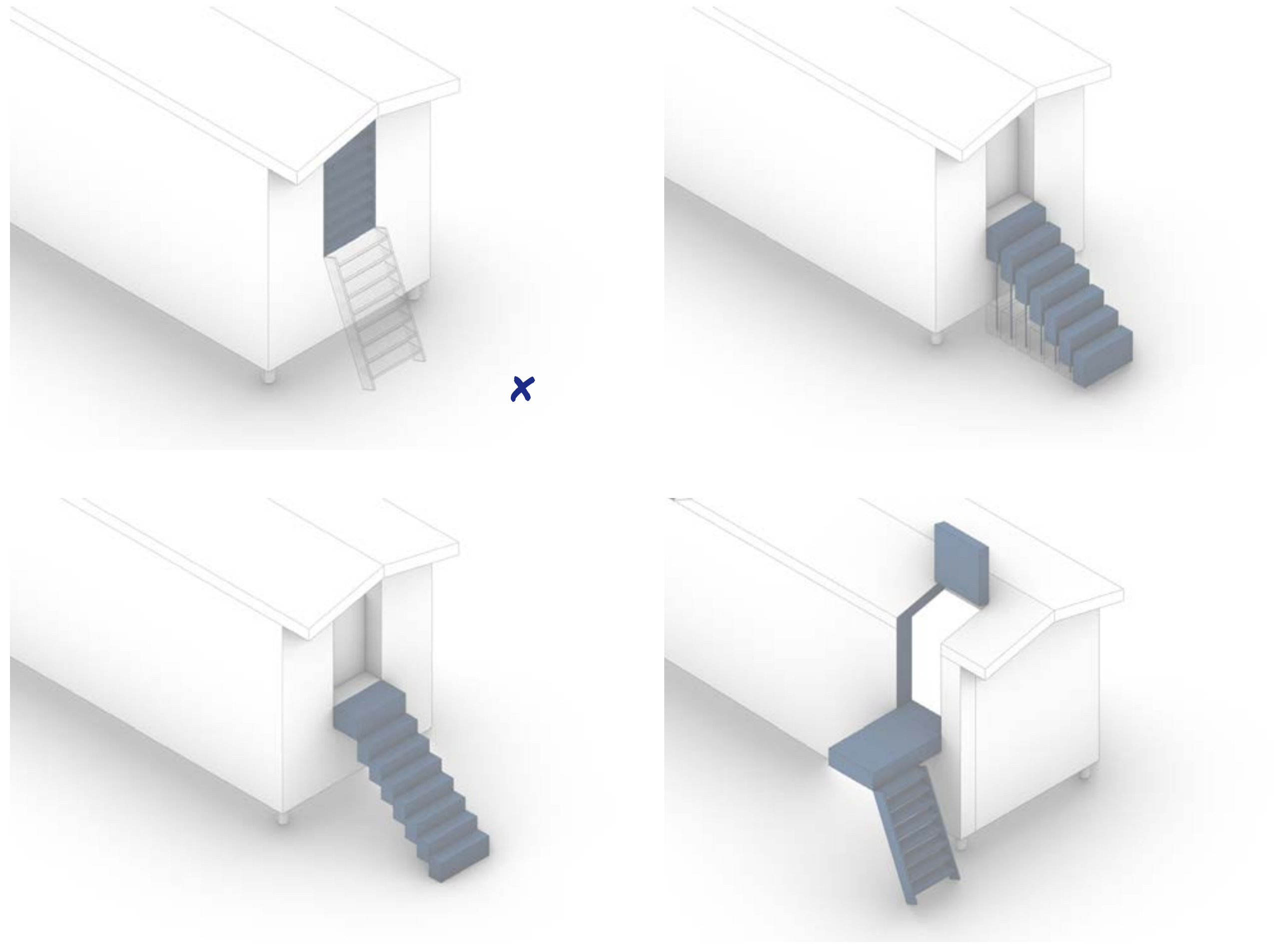
*The focus of this study is to design access and exit routes that function both during flood events and dry conditions, without causing deterioration to interior materials. The intent is to investigate entry solutions that adapt to water levels, maintain user safety, and protect adjacent construction elements. This synthesis builds on flood depth mapping, interior finish durability, and user movement patterns, addressing criteria on resilience, and circulation.*

The placement and design of the entrance were investigated through two parallel studies: one focused on how the entrance fits into the floor plan (Ill. 77), and the other on how users can physically access a door located 1.5 meters above ground level (Ill. 78). Due to flood height requirements, the entry point had to be elevated, and with the building's 4-meter maximum height and saddle roof (as established in a previous design study), only the low ends of the building could accommodate the entrance. Three suitable interior locations were identified based on circulation patterns: the dining room, kitchen, and bathroom. Each option was modeled in Rhino to evaluate usability and spatial impact. Four exterior access strategies were also explored; floating stairs, roof access, visible stairs, and hidden stairs, to understand their technical feasibility, spatial integration, and visual impact.

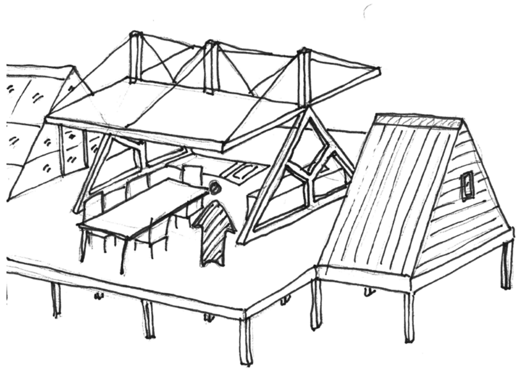
Access through the dining room would allow a direct path to a chair and table, but would likely be uncomfortable for the intended users, who are around 50 years old, and would raise hygiene concerns by requiring shoes on furniture. The kitchen option offers dual use of steps as drawers, but exposes wooden flooring to wet shoes, which may shorten its lifespan. The bathroom entry emerged as the most practical: it has water-resistant tiled flooring and is not a high-traffic area during storms, making it both durable and discreet, especially as it serves only two users. For the exterior approach, floating stairs were ruled out due to their mechanical complexity, stability issues, and unsuitability for use in dry or low-flood conditions. Roof access was incompatible with the overall facade and required overly complex detailing. The hidden stair was selected as the best solution, it remains concealed when not in use, protecting it from water exposure and fitting well with the building's visual language. Although it requires some simple mechanics, it is a practical and integrated solution that balances function, aesthetics, and durability.



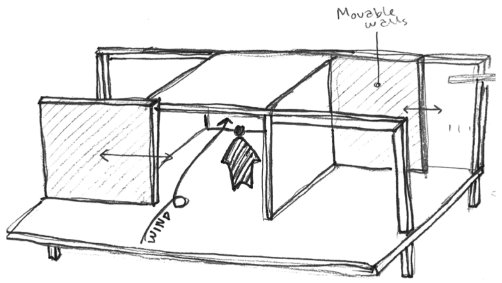

*Ill. 77: Section and planview of three layouts with focus on the entrance.*



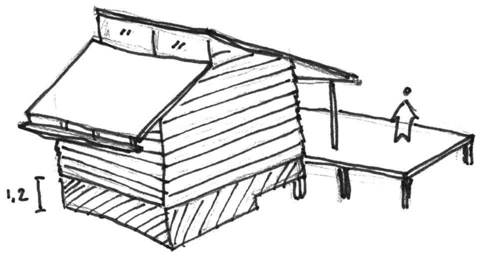
*Ill. 78: Four entryway strategies.*



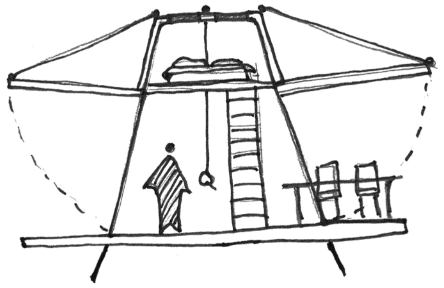
EXTERIOR TRANSISTION BETWEEN ROOMS



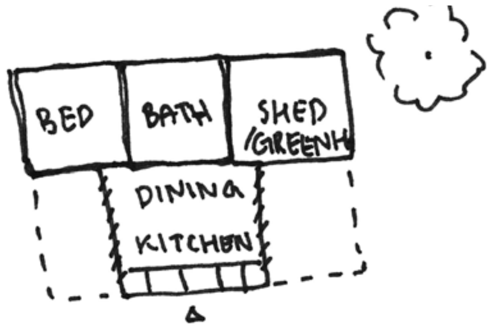
MODULAR BUILDING WITH FLEXIBLE WALLS



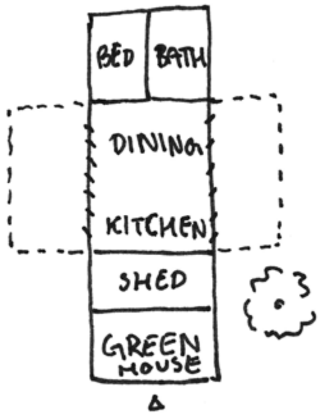
MULTI LEVEL BUILDING



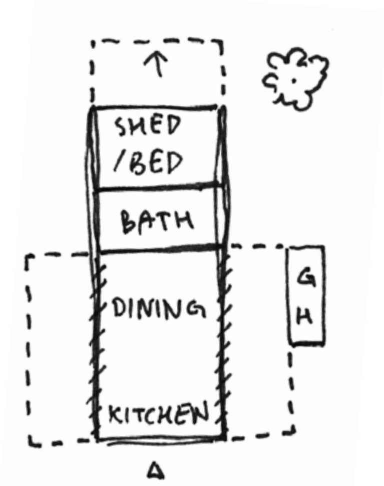
RAISED BED AND OPEN LIVING AREA



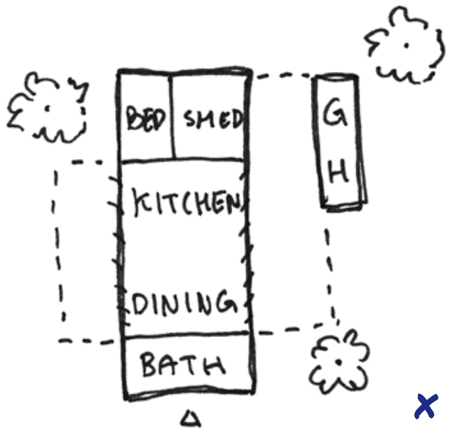

T-SHAPE




LONG WITH ALL FACILITIES




LONG WITH OPEN END




LONG WITH OPEN MIDDLE

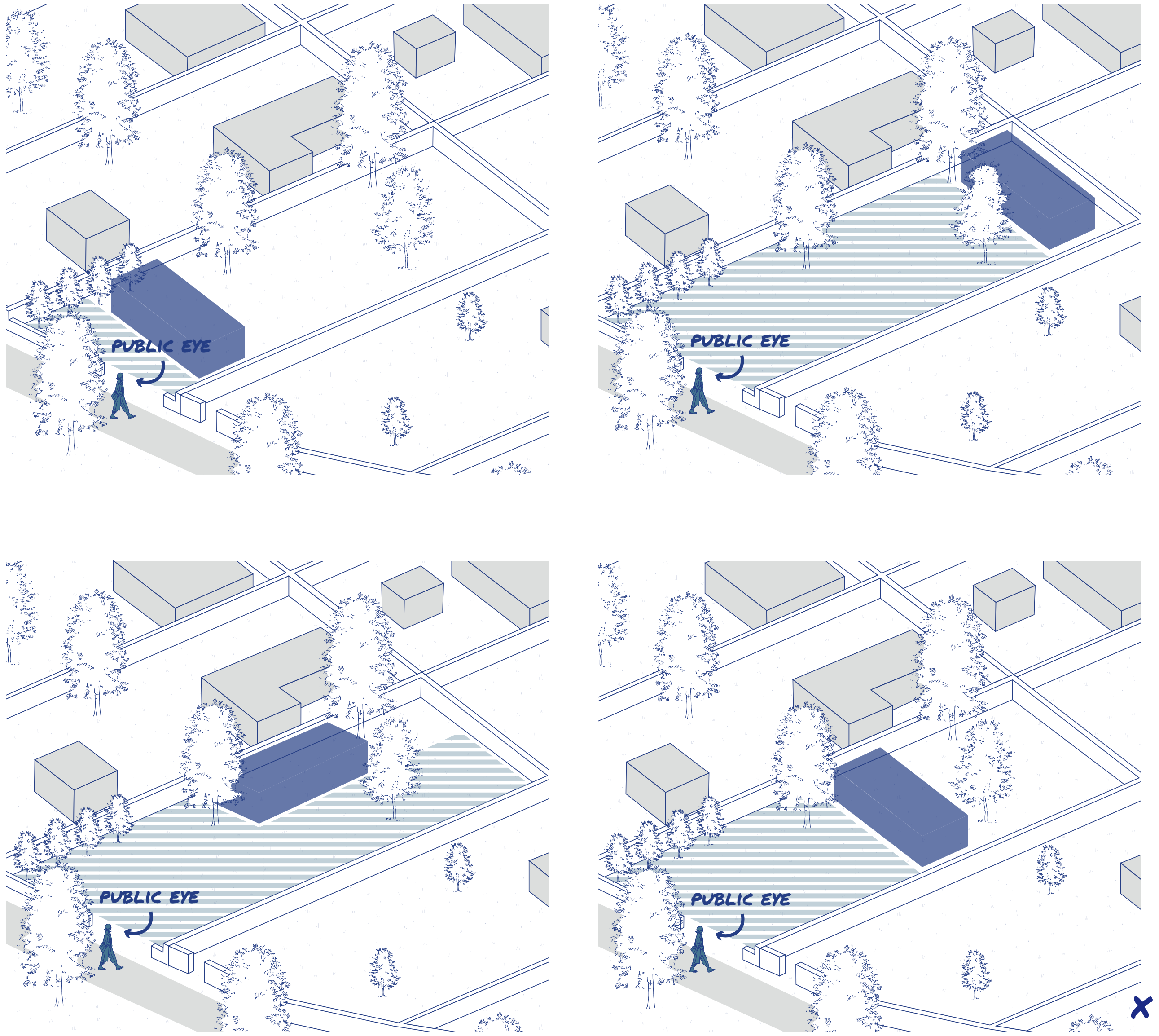
*Ill. 79: Eight programming strategies.*

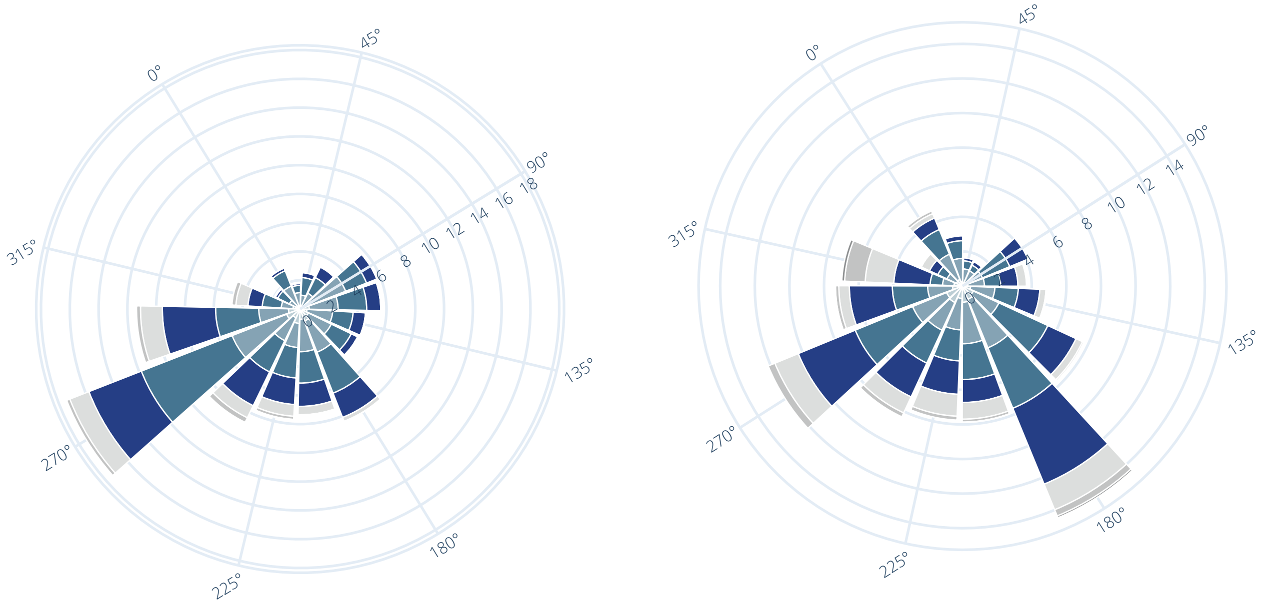
# programming.

*This study explores how the building's spatial program can support safe access and exit in both flood and dry periods, while also enabling a dynamic relationship between indoors and outdoors. The goal is to organize spaces that can open up in dry seasons and be enclosed during floods to ensure protection, while facilitating movement through diverse microclimatic zones. The synthesis draws from user needs, climate data, and spatial case precedents, responding to criteria that relate to resilience, comfort, and experiential richness.*

Eight different layout types were tested throughout the design process, starting with hand sketches and later modeled in correct dimensions in Rhino or Revit (Ill. 79). These options were continuously adjusted as the project developed. The design decisions were based on how well each option connects with the outdoor surroundings, how it responds to the 4-meter height limitation, how simple the construction would be, and how easy the building would be to adapt for different future users. Although an earlier diagram defined the distribution of facilities, the study intentionally explored alternatives beyond this framework to discover other solutions that still meet the overall goals of protection, usability, and openness.

Some of the early layout types placed the transitions between rooms outside the building, which created strong outdoor connections but also resulted in a large footprint and a dominating presence in the garden. A modular house with flexible, moving walls was also tested, but this approach didn't support the intended connection to the surroundings and offered a type of flexibility that became unnecessary once the design for disassembly was chosen as the main future strategy. A layout with a raised bed and foundation offered better outdoor flow but ended up exceeding the height limit if interior comfort was to be maintained, and would also cause issues with neighbor privacy. A T-shaped plan was considered, but due to the small size of each room, the layout turned into more of a compact square and didn't allow for a meaningful connection to the garden. A multilevel house used the available height more efficiently but introduced unnecessary spatial complexity without offering any clear benefit. Eventually, the long linear layout was chosen. It allowed for full operability on both sides of the building, aligned well with the construction strategy, offered simplicity in both structure and use, and ensured strong interaction with the surrounding landscape. It also responded well to microclimate needs by offering cross-ventilation and daylight access.




building mass
public view

*Ill. 80:*
*Four building placements on the site.*

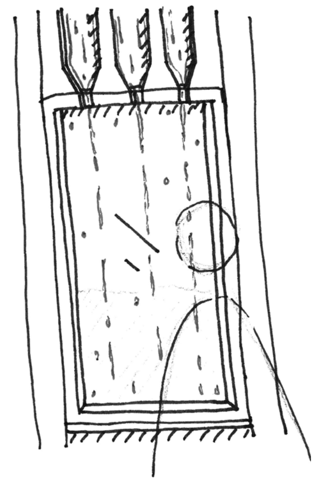
0.5 - 1.5 m/s
1.5 - 3.3 m/s
3.3 - 5.5 m/s
5.5 - 7.9 m/s
7.9 - 10.7 m/s
10.7 - 13.8 m/s
13.8 - 17.1 m/s
>17.1 m/s

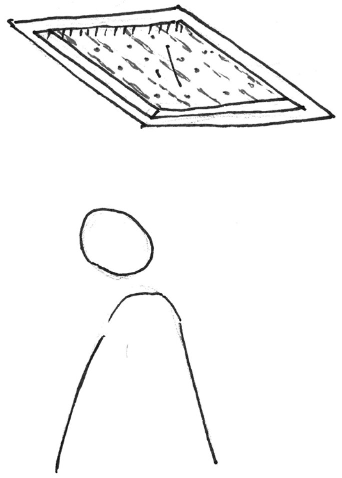
*Ill. 81:*
*Right - Wind rose for the opening season (April to October) in Holstebro.*
*Left - Wind rose for the closed season (November to March) in Holstebro.*
*(Betti et al., 2023)*

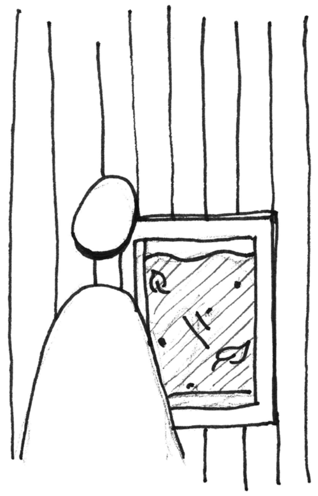
**Placement on site**

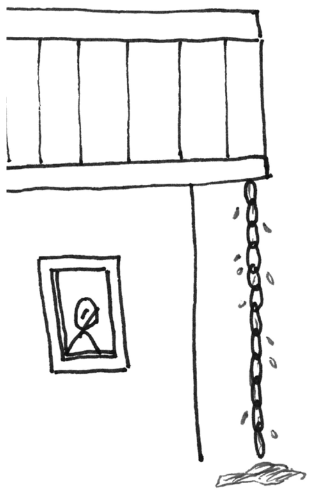
To determine the most suitable building placement, four scenarios were drawn onto the site plan and tested through simple 3D modeling in Rhino (Ill. 80). These scenarios were evaluated in terms of how they connect to the garden, how they affect the privacy of outdoor areas, and how effectively they allow for natural ventilation based on local wind directions during summer months (Ill. 81).

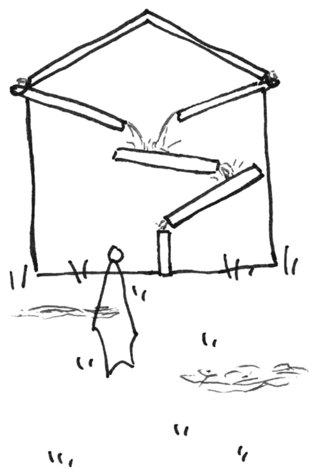
Placing the building at the front of the plot makes the remaining garden space more private, as the house blocks views from the street. In contrast, placing it along the back or side exposes most of the garden to public view, reducing the feeling of privacy. A middle placement naturally splits the garden into a more public zone at the front and a more private area toward the back. This flexibility in garden use is important, as future owners may have different preferences for how open or private the space feels. When considering the physical connection to the garden, the middle placement also performs better, as most of the building's facade directly faces open green space rather than boundary hedges. From a microclimate perspective, both the front and middle placements are better aligned with wind directions, allowing long facades to face east and west and enabling effective natural cross-ventilation. The other placements either orient the shorter facades to the wind or place the building against a tall hedge, reducing airflow. Based on this, the middle placement was chosen as it provides the best overall combination of privacy, garden interaction, and climate responsiveness.

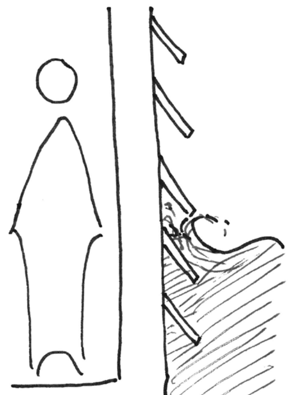

Visual: Shape waterdrops with funnel design and see landscape

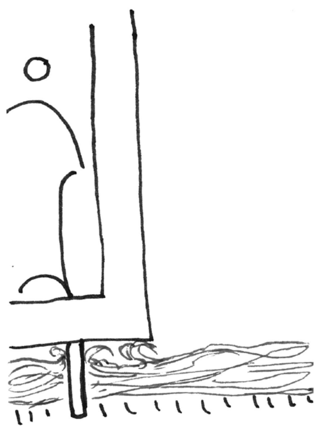

Visual: Water drops and see sky

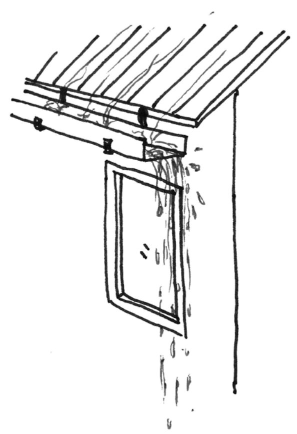

Visual: Window under water

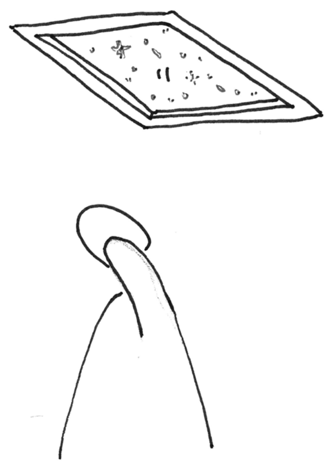

Sound: Water chain


Sound: Falling water pipe design


Sound: Hollow texture in facade


Sound: Clucking water under plateau


Sound: No end on gutter


Sound: Raindrops on skylight window

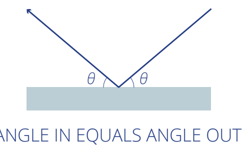
*Ill. 82:*
*Visual and sound strategies for accentuating the flood experience.*

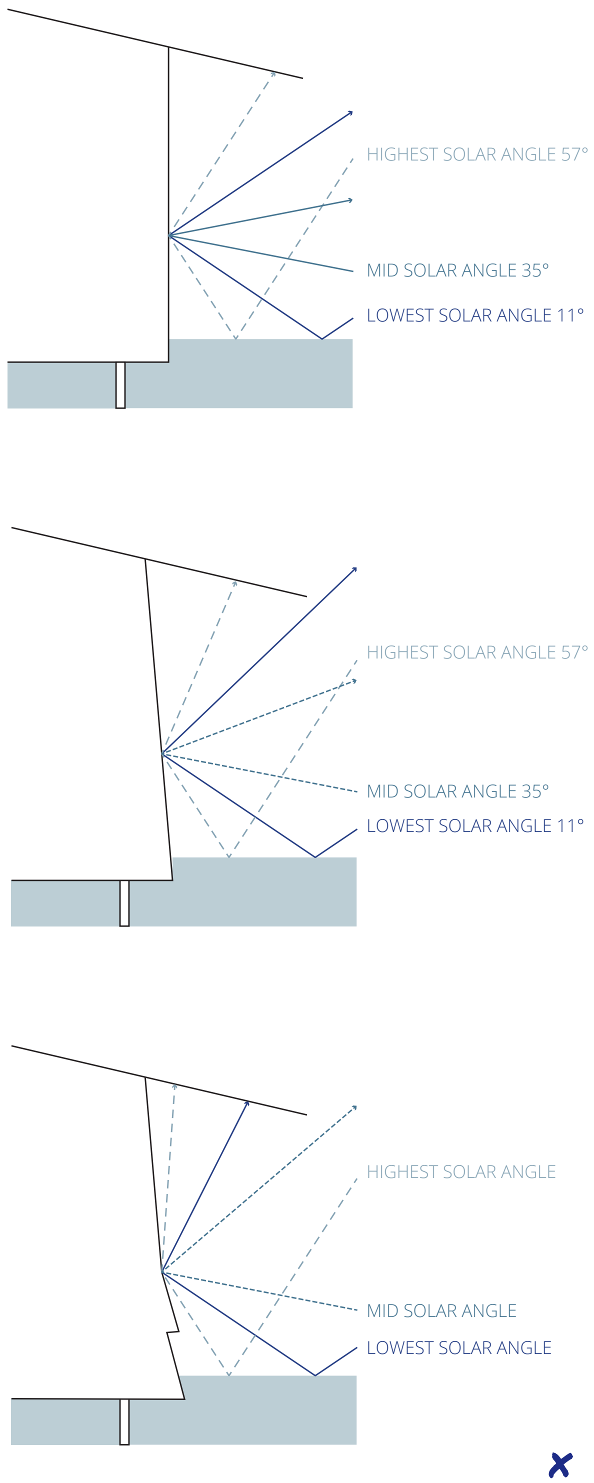
# sensual water.

*This study investigates how sensory experiences during floods can be accentuated in architectural detail while maintaining a sense of comfort and safety indoors. The goal is to heighten awareness of the surrounding water through design elements such as material transitions, acoustic filters, and filtered views, without compromising psychological or thermal comfort. The synthesis is rooted in sensory theory and criteria on atmospheric quality and emotional resilience.*

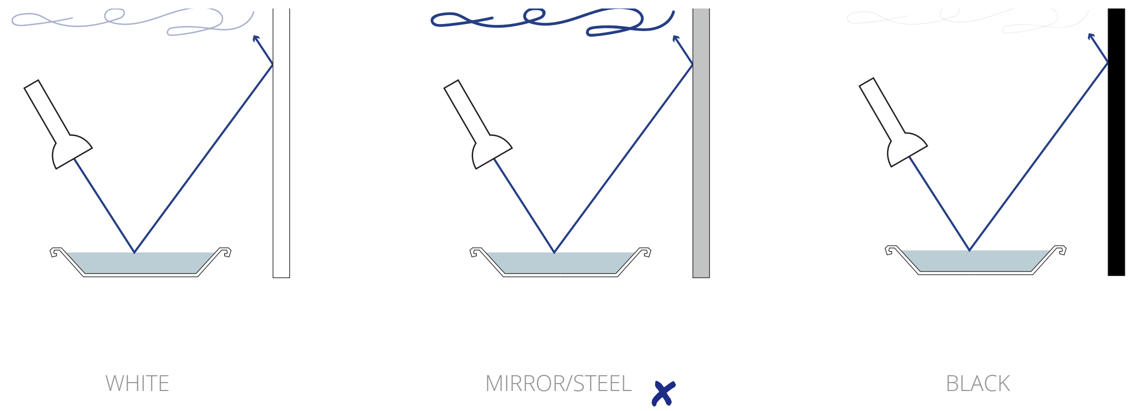
Building on the reversed study of Can Lis and the idea that rain can create comfort when experienced from a safe interior, this study explores how water sounds and views can be used to heighten sensory engagement during floods. Six sound-related strategies and three visual approaches were explored through sketches and spatial intuition (Ill. 82). The acoustic concepts focused on how rainwater interacts with architectural surfaces to create atmospheric soundscapes, such as through hollow facades or clucking effects under raised platforms. Visual strategies included skylights that shape raindrops into patterns, submerged windows, and framed views of floodwater, each offering varying degrees of connection to the water outside. These methods aim to make flooding an experiential element rather than purely a threat, while maintaining comfort and control for the user.

From the visual investigations, the skylight using shaped rain patterns was found to be the most practical and atmospheric solution, offering a subtle and poetic experience without requiring additional maintenance or risk. Submerged windows were dismissed due to their dependency on external conditions and the likelihood of becoming dirty. The outward views were acknowledged as valuable for situational awareness but should be framed as a choice, allowing occupants to either confront or withdraw from the visual impact of flooding, depending on their comfort level. Among the acoustic strategies, all were considered feasible with proper detailing, though the hollow facade texture would require sufficient ventilation and the ability to be cleaned if dirt accumulates. The clucking sound beneath the raised structure was passively integrated and aligned with the chosen foundation strategy. Ultimately, these details aim to transform flooding from a purely threatening condition into a sensory, spatial, and atmospheric quality, enhancing user experience while still prioritizing durability and resilience.




*Ill. 83:*
*Solar angles and light reflection angles on three facades.*




*Ill. 84:*
*Water reflection experiment with three different materials to reflect light upon.*

**Water reflection**

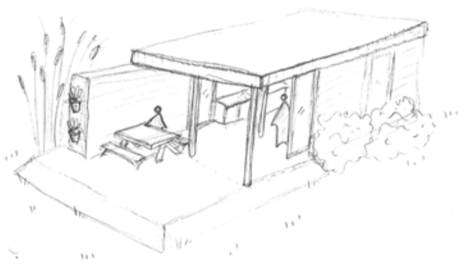
Building on the earlier study of Can Lis and the comforting interplay of light and water during rainy weather, this part of the study focused on how light reflections from floodwater can animate the architecture and amplify sensory engagement. The aim was to direct water reflections onto the underside of the roof overhang rather than the facade, creating a dynamic, fluctuating play of light that enhances the spatial atmosphere without glare or discomfort. The investigation considered the angles of sunlight throughout the year in Denmark and how these interact with reflective surfaces at different inclinations (Ill. 83).

To understand this dynamic, a small-scale experiment was conducted in a dark room using a water bath, a flashlight, and three surface types; a mirror-like metal, a white matte surface, and a black matte surface, to observe how reflected light behaves and which materials are most effective (Ill. 84). The experiment helped test three conceptual angles of facade and cladding orientations, as illustrated in scenario diagrams.

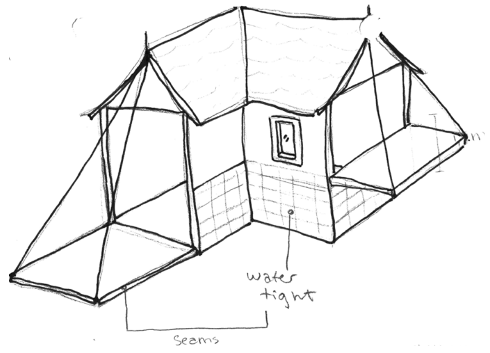
The study concluded that conventional vertical facades reflect very little light onto the overhang, especially during the low-angle sun conditions. Angled facades performed better, particularly when paired with slanted or profiled cladding that can catch and redirect light more effectively. Of the configurations tested, the combination of angled facade and angled cladding yielded the strongest and most consistent reflections. Material selection was also critical: reflective metals significantly outperformed white or black surfaces, confirming that surface properties play a major role in the effectiveness of the design.

Potential concerns about glare or visual disturbance during dry periods were also addressed. Since the reflections are cast upward onto the underside of the overhang, the viewer would have to stand extremely close to the reflective surface to experience direct glare, an unlikely scenario in typical use. Moreover, the presence of light reflections beneath the overhang helps balance the darker zone typically created by roof shading, softening the transition from interior to exterior and enriching the visual atmosphere without adding artificial lighting. This integration of reflected light supports both psychological comfort and spatial vibrancy, even during the otherwise sombre context of flooding.

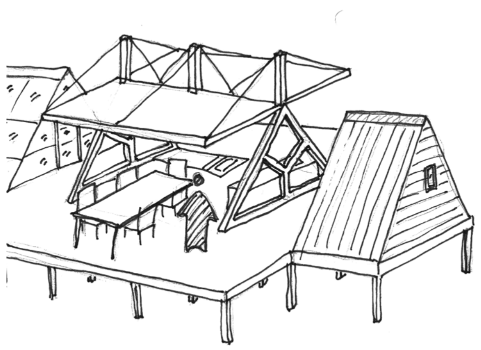
2.1
2.2
2.3
2.4
2.5



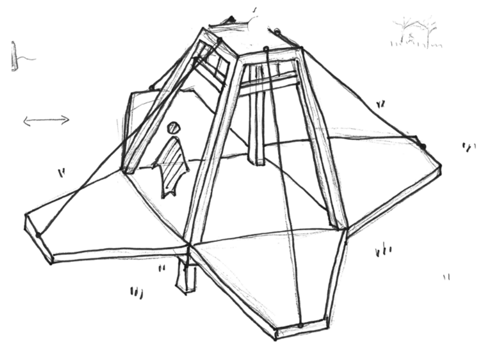
DOORS



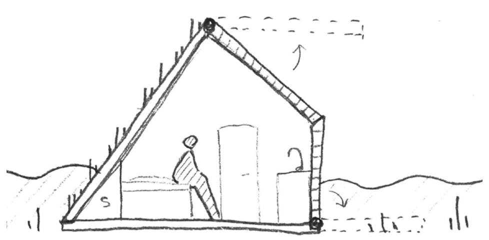

DIFFERENT LEVELS



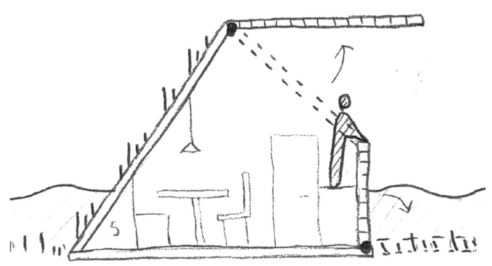
TOP HUNG



BOTTOM HUNG



SPLIT ✗



SPLIT ✗

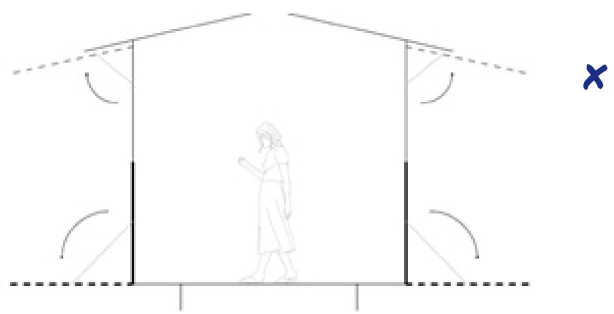
*Ill. 85:*
*Five opening strategies.*

# openings.

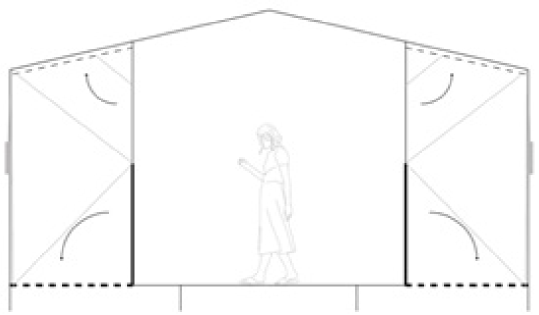
*This design study examines how a flexible barrier can both open completely to the surroundings in pleasant conditions and transform into a protective enclosure during floods or harsh weather. The aim is to maintain visual and sensory engagement with the surroundings; using views, sound, and light, while providing climate control and physical protection. The synthesis engages with criteria on adaptability, tactility, and sensory experience in relation to climate response and flood events.*

Five strategies for transforming interior rooms into exterior spaces during dry periods were explored (Ill. 85). These were tested through sketches and evaluated based on their ability to eliminate the barrier between inside and outside while still offering protective closure during floods. A key evaluation point was how well each approach could support the desired sensory experiences, such as allowing light reflections into the space.

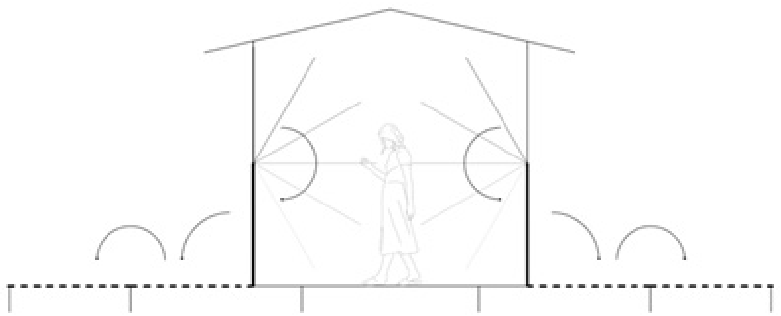
Traditional doors were found to be the least effective, offering little flexibility or sensory connection. A top-hung, tent-like structure had a smooth indoor-outdoor transition but blocked light reflections. A bottom-hung design provided a strong connection to the outside but required either complex glazing or awkward split panels to function during floods. A half-opening platform created a unique flood experience but lacked comfortable headroom and was better suited as an entry feature. The most promising solution was a two-part opening where one panel lifts up to become an overhang and the other folds down into a terrace. This design reduced material use, eliminated the need for a separate overhang, and allowed for flexibility in both open and closed states. It was chosen as the final strategy, with a note that the exterior cladding must be durable enough to withstand exposure.



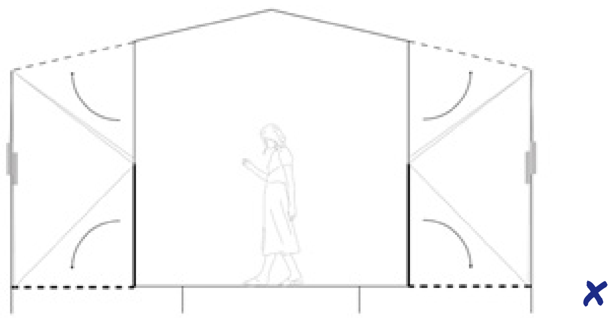
GAS SPRINGS



COUNTERWEIGHT WITH OVERHANG



FOLDABLE



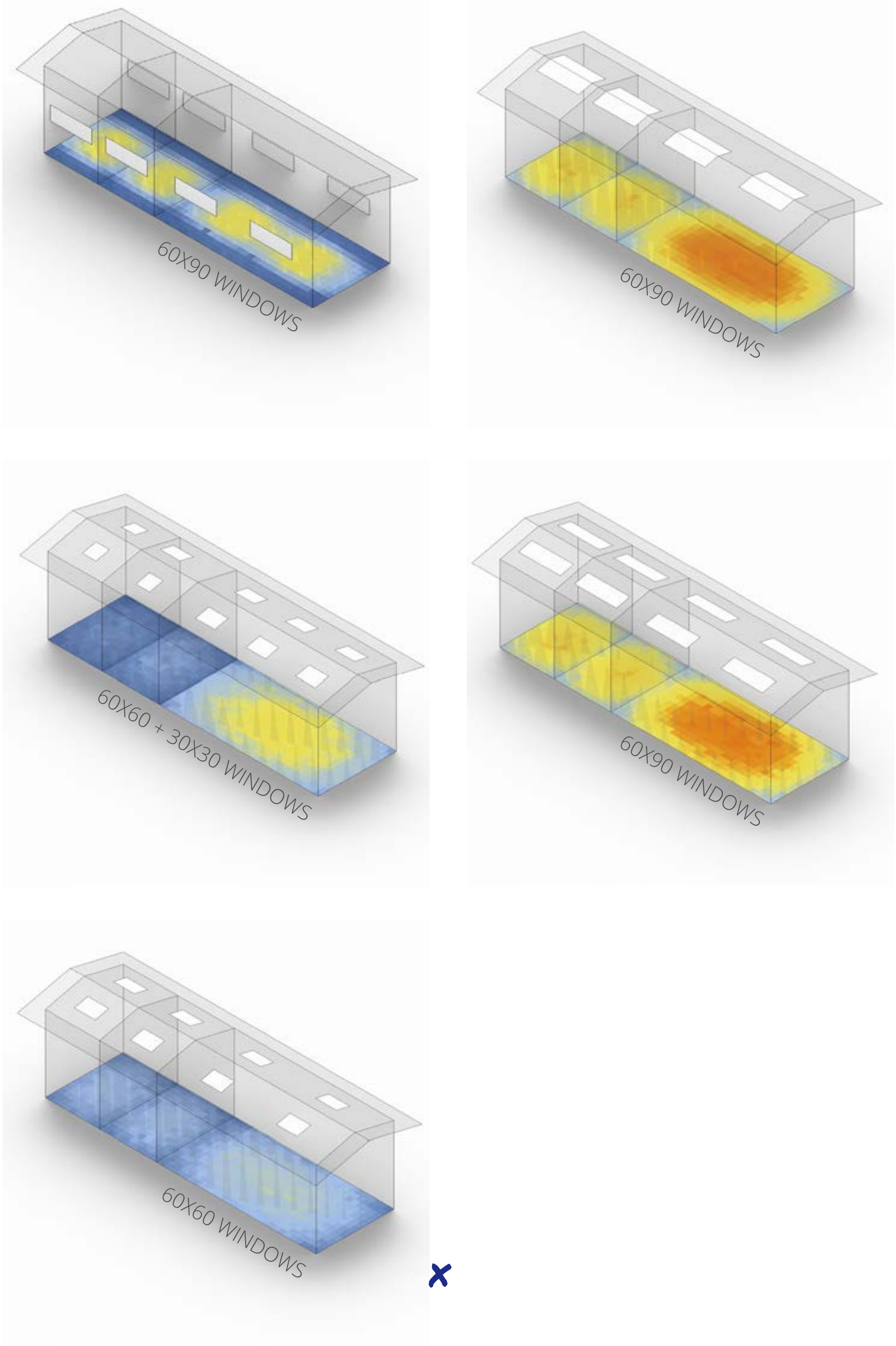
COUNTERWEIGHT WITHOUT OVERHANG

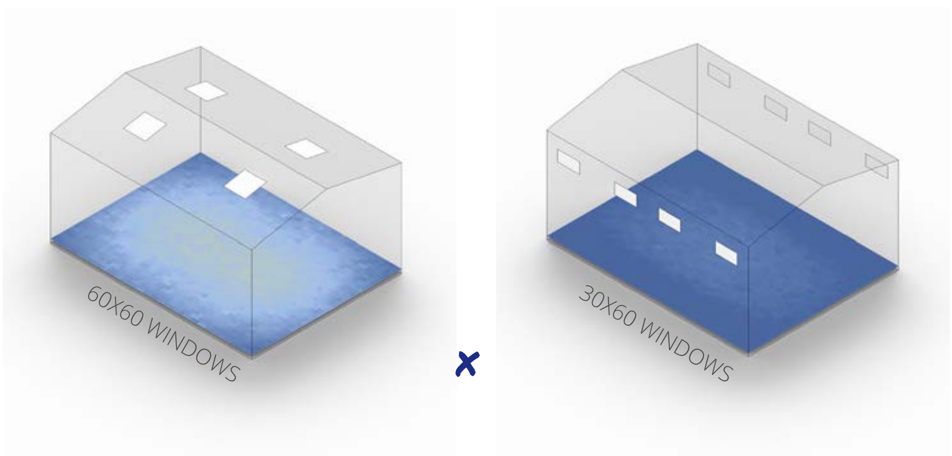
*Ill. 86:*
*Four opening mechanism strategies.*

**Opening mechanism**

Following the decision to use a two-part folding wall, four opening mechanisms were tested (Ill. 86). These were analyzed based on ease of use, physical effort, safety, and how they affect the use of the terrace space when closed.

The counterweight system was selected for the lower panel because it allows for manual operation without requiring electricity and avoids redundant materials. However, exposed wires from the counterweight would interfere with the terrace when not in use. To resolve this, a combination system was chosen: the bottom panel uses a counterweight, while the top panel is operated with a gas spring similar to the ones used in greenhouses, but in a larger version. This avoids trip hazards on the terrace while still supporting manual operation. A fixed overhang is avoided in these areas since the wall itself functions as one when open, though fixed overhangs may still be used in sections where this system isn't implemented.




# daylight.

*Here, the focus is on designing daylight to enhance the architectural experience during both open, dry periods and enclosed, flooded conditions. The study explores how daylight can support openness and visual connection when the building is open, and still provide richness, variation, and calmness when it is closed. The synthesis responds to criteria involving light quality, experiential shifts, and climate-driven adaptability.*

The study was divided into two parts. In the first part, the goal was to achieve a daylight factor of at least 3% in most rooms, using simulations in Rhino with the Grasshopper daylight plugin (Ill. 87). Several scenarios were tested, comparing skylights and side windows. Skylights proved significantly more effective in delivering daylight. The initial design used 90x60 cm skylights placed centrally, but this gave too much light. The windows were then reduced and repositioned, first as 60x60 cm in the living room and 30x30 cm in smaller rooms, but this caused unbalanced lighting. A final scenario using uniform 60x60 cm skylights, centered on each roof side, provided a soft and balanced daylight distribution just above the minimum requirement.

In the second part, indoor climate simulations showed that skylights contributed significantly to overheating in summer (Ill. 88). As a test, the same window area was moved to the facade to reduce heat gain, but this failed to meet daylight requirements unless the openings were enlarged. However, increasing window size on the facade caused unacceptable overheating in the climate simulation.

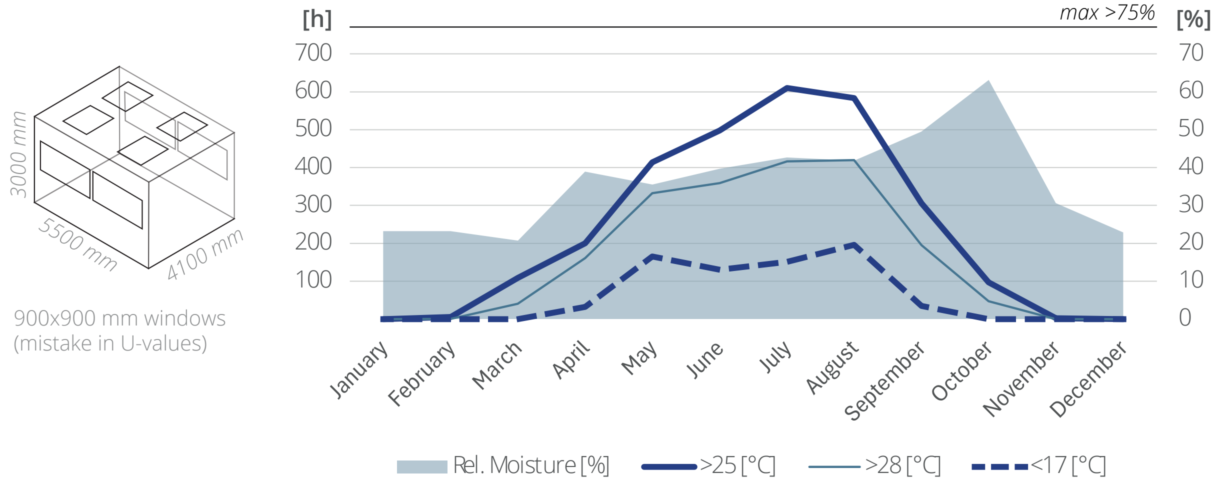
10 %
9 %
8 %
7 %
6 %
5 %
4 %
3 %
2 %
1 %

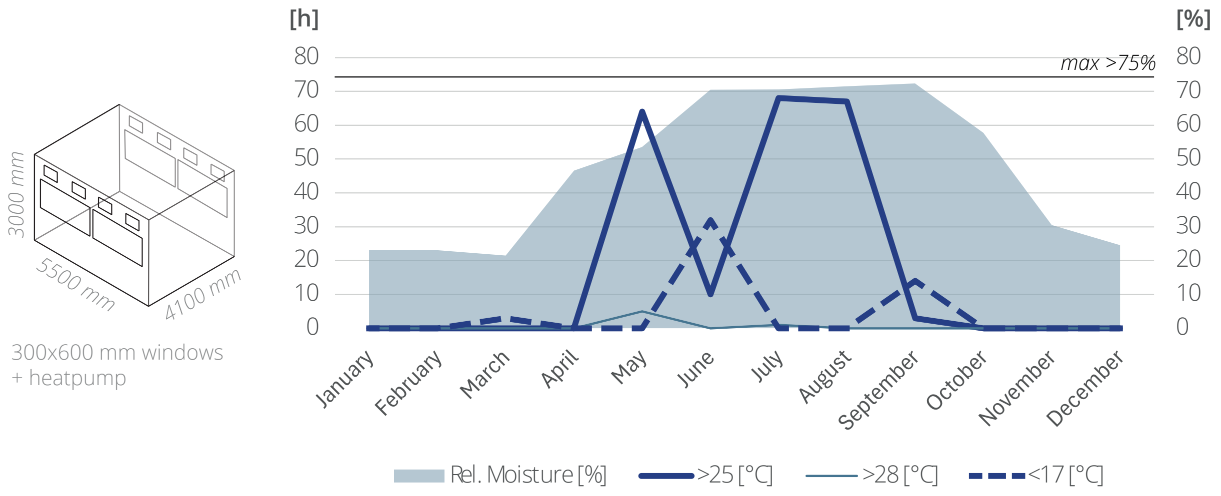
*Ill. 87:*
*Five daylight studies with different strategies.*

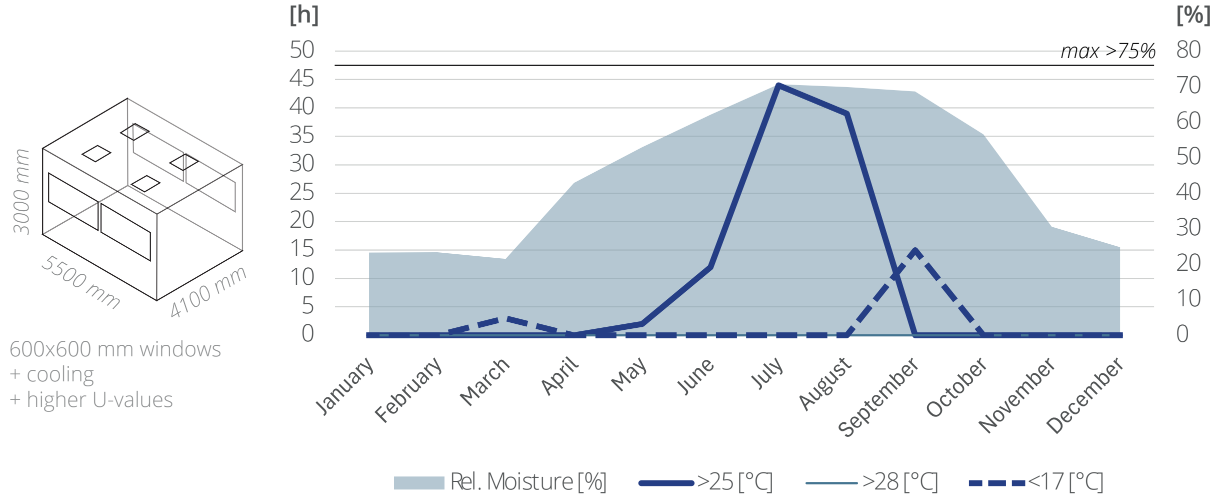
10 %
9 %
8 %
7 %
6 %
5 %
4 %
3 %
2 %
1 %

*Ill. 88:*
*Two solar studies based on indoor climate simulation design process.*

Skylights were clearly more effective than side windows for meeting daylight criteria and highlighting the water's light reflections during floods. The final configuration, 60x60 cm skylights in all rooms, centered on opposing roof pitches, created a soft and even daylight experience while staying just above the minimum daylight factor. This ensures that during floods, light reflections remain visible and atmospheric without overexposing the space. Despite some heat gain, side windows were not a viable alternative due to their lower daylight performance and higher risk of overheating when enlarged. Therefore, the 60x60 skylights were chosen as the final solution.



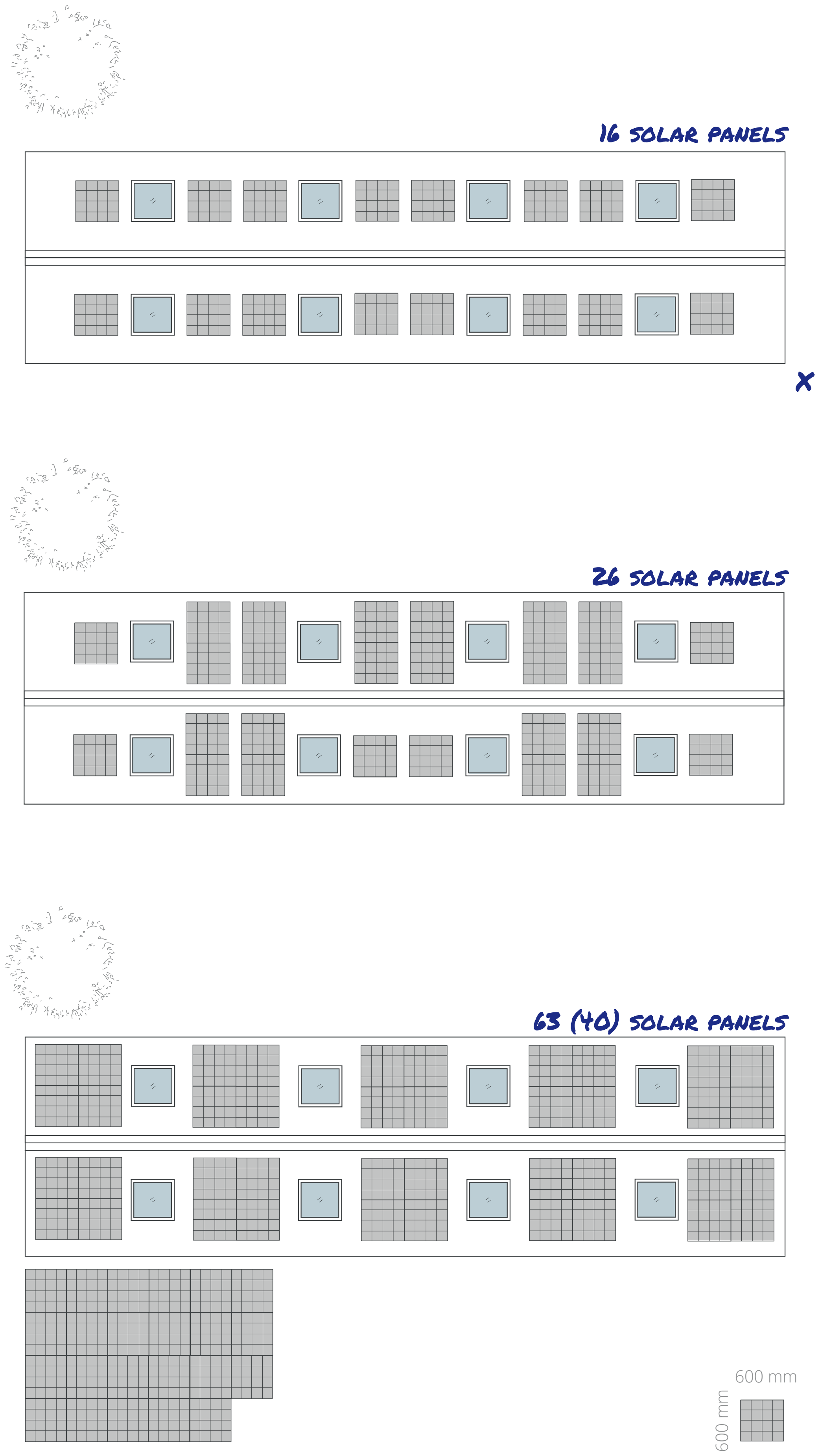

*Ill. 89:*
*Three indoor climate simulation results from BSim with three different design versions.*

# indoor climate.

*This study addresses how the design can ensure a comfortable indoor environment during the open summer season, and a dry, healthy interior during the closed winter period. The goal is to enhance the experience of occupancy while minimizing material degradation caused by humidity, condensation, or temperature fluctuations. The synthesis is informed by seasonal usage patterns, climatic analysis, and criteria concerning comfort and maintenance.*

The climate performance was tested through BSim simulations of a simplified building model using known U-values, infiltration rates, ventilation options, and a load of four people. The simulations were based on closed walls, with venting possible only through the top half of the facade (Ill. 89). The analysis followed Danish building regulations, including maximum hours above 25°C and 28°C in summer, and maintaining relative humidity (RF) below 75% year-round to avoid mold growth. The initial iterations, without heating or cooling, showed high humidity, overheating, and too many hours below 17°C, making it clear that passive measures were not sufficient. A heat pump was added for winter, while side windows were introduced to reduce summer overheating. Skylights were reduced in size from 90x90 cm to 60x60 cm based on daylight studies. The heat pump was later replaced by a reversible air-to-air heat pump to allow cooling in summer, powered in principle by solar panels. U-values were corrected after a mistake was discovered, which helped reduce overheating in the simulations.

The final configuration met most performance criteria: 97 hours above 25°C (below the 100-hour limit), no hours above 28°C, and only 15 hours below 17°C, mainly at night in September, which is considered acceptable. The relative humidity remained under 75%, avoiding risk of mold, and indoor comfort was maintained across both seasons. The combination of smaller skylights, side ventilation, and a reversible heat pump proved to be an effective strategy. While several iterations and minor adjustments were explored, the key steps involved refining the window design, improving the heat pump strategy, and correcting the false U-values. Window shading was tested but had minimal impact and is therefore not included in the final solution. The study concludes that climate control can be balanced using targeted active and passive strategies tailored to seasonal needs.




Ill. 90:
Three solar panel strategies illustrated on the roof.

# energy.

*This energy design study explores how the building's energy needs can be met through solar energy, with a primary focus on achieving seasonal self-sufficiency during the open period (April to October). The aim is to ensure the building remains energy-efficient and environmentally responsible while aligning with its intended seasonal use and maintaining architectural quality. The study uses BSim simulation data, real-world solar radiation figures, and building use scenarios to assess total energy consumption and the effectiveness of solar panel configurations, including winter performance and aesthetic integration.*

Energy demand was calculated based on BSim simulations from the year 2025, including heating (5409.56 kWh), ventilation, coils, humidification, and other building services (App. 5). Additional loads such as hot water (1500 kWh/year for 4 people), lighting, cooking, and miscellaneous use were included, leading to a total estimated energy consumption of 9119.78 kWh/year. A solar setup with 26 polycrystalline panels (0.6 x 0.6 m) facing east and west at a 13% roof inclination was calculated. Each panel provides approximately 288 kWh/year, giving a total of 7488 kWh/year under idealized annual conditions (800 kWh/m²/year). Since, solar production in winter months is substantially lower,  approximately 25% of summer radiation, that is included in the calculations. To realistically cover year-round living in the house with a higher consumption using solar only, 63 panels would be required, which exceeds the available roof space and conflicts with the design intent.

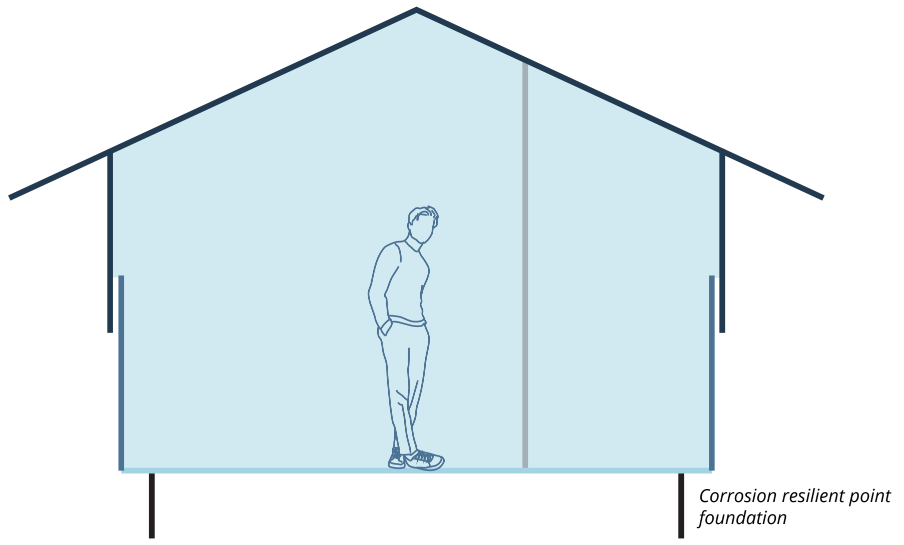
To align energy production with the building's seasonal function and architectural rhythm, a total of 16 solar panels was selected. This number allows for a coherent and elegant roof composition, avoids overdimensioning, and still produces a significant amount of energy, more than enough for summer season operation (covering about 164% of the summer energy demand). While 26 panels would improve coverage, the jump to 63 panels for full-year independence is not realistic or desirable for this project. For potential future owners who might choose to occupy the house year-round, despite zoning not permitting it, the building can either be connected to the energy grid or extended with more panels if space allows. However, both options would compromise the architectural expression. Additionally, the indoor climate design is not sufficient for year-round use, as comfort and humidity levels are only optimized for seasonal occupation. A full re-evaluation of the climate strategy would be necessary if year-round living were to be considered.

# material choices.

*This study explores how the majority of materials from the existing structure can be repurposed in the new design. The aim is to reduce environmental impact, preserve site memory, and establish a low-carbon material palette that aligns with circular design principles. The synthesis responds directly to criteria on sustainability, local reuse, and resource-aware construction.*

The study was carried out in Excel to manage a broad dataset and allow for comparison across various material parameters. Initially, materials available on-site were listed, limited to those that were commonly found and available in larger quantities. Each material's relevant properties, such as thermal behavior, structural potential, and moisture resistance, were recorded along with their dimensions and quantities (Ill. 92). A sectional diagram of the building (ill. 91) was used to map where specific material properties were required. A schedule then compared available site materials with the necessary materials in the new construction (ill. 93). The selection hierarchy prioritized on-site reuse, followed by external recycled materials, and lastly, new materials if no reused options met performance needs. Each potential material match was annotated to indicate if it was suitable as-is or if additional treatment, processing, or specific assembly techniques were needed.

The final material selections demonstrate a high level of reuse, aligning with the project's sustainability objectives and minimizing the carbon footprint. Most structural and surface components were resolved using site-found or second-hand materials. Certain elements, such as bathroom tiles, had to be sourced from repurposed off-site suppliers due to unavailability on-site. Only a few new materials, such as screw foundations and vapor barriers, were deemed necessary after evaluating environmental performance and construction requirements (App. 3). These were carefully selected through smaller focused studies that balanced technical properties with ecological impact. The resulting material palette, shown in ill. 93, embodies a contextually sensitive and resource-efficient construction strategy that aligns with the project's circular design goals.




1) Cladding (weather durable)
2) Weather resistant barrier
3) Insulation and load bearing construction
4) Vapor barrier
5) Wire/pipe room
6) Interior cladding

1) Cladding (reflective, ventilated, water durable)
2) 100% watertight barrier
3) Insulation
4) Vapor retarder
5) Load bearing construction
6) Wire/pipe room
7) Interior cladding

1) Cladding (ventilated, water durable)
2) 100% watertight barrier
3) Insulation
4) Vapor retarder
5) load bearing construction
6) Wire/pipe room
7) Flooring

1) Interior cladding
2) Insulation and load bearing construction
3) Interior cladding (water tight)

*Ill. 91: Necessary materials in the new construction.*

| Material | Thermal conductivity (λ-value) | Density / Weight per m² | Compressive / tensile strength | Rain / Flood resistance | Dimension [cm] | Quantity |
|---|---|---|---|---|---|---|
| **1. Painted exterior wooden boards** | ~0.13 W/mK | ~10–12 kg/m² | Low–moderate tensile/ compressive | Poor in flooding (swells, rots); fine in rain with ventilation | >60 | 23 m2 (45m2 incl. flood damaged) |
| **2. Corrugated fiber cement sheets** | 0.8–1.0 W/mK | ~13–17 kg/m² | High compressive, low tensile strength | Excellent in rain and flood | i:100x60, ii: 50x60, iii: 100x30, iiii: 50x30 | i: 30, ii: 6, iii: 12, iiii: 6 |
| **3. Wooden load-bearing structure** | ~0.13 W/mK | ~15–25 kg/m² (varies) | High (e.g. C18/C24 grade timber) | Degrades in flooding unless treated | i: 5x20 (>2m), ii: 10x10 (>1.5m), iii: 5x10 (1.85m), iiii: 5x5(>0,6m) | i: 71m, ii: 30m, iii: 34m, iiii: 125 |
| **4. Single-pane greenhouse glass** | ~0.96 W/mK | ~10–15 kg/m² | Very low (fragile, brittle) | Resists water, breaks under pressure | i: 60x60, ii:30x60 | i:48, ii: 12 |
| **5. Exterior wooden door w/ single-pane glass** | ~0.13 W/mK (wood) / 0.96 (glass) | ~20–30 kg/m² | Moderate | Poor in floods (swelling) | 200x90 | 1 |
| **6. Interior painted wood door** | ~0.13 W/mK | ~15–20 kg/m² | Low–Moderate | Very poor in water (delaminates) | 200x75 | 1 |
| **7. Old single-glazed painted windows** | ~5.0 W/m²K (very poor insulation) | ~15–25 kg/m² | Low | Poor flood resistance, okay in rain | 140x190 | 3 |
| **8. Greenhouse metal profiles (aluminium/steel)** | ~50 W/mK (high thermal bridge) | ~3–8 kg/m² | High compressive, low tensile | Good against water, depends on coating | | i:16, ii: 4, iii:4 |
| **9. Interior lye-treated wood boards** | ~0.13 W/mK | ~10–15 kg/m² | Moderate | Poor water resistance | >50 | 86 m2 |
| **10. Old Rockwool insulation** | 0.037–0.042 W/mK | ~2–5 kg/m² | No structural strength | Useless if flooded, works only when dry | - | 440m3 |

*Ill. 92: Existing materials with their quantities and properties.*

| | Available materials | Roof Cladding | Wet zone insulation | Dry zone insulation | Load Bearing | Vapor barrier | Interior Cladding | | Reflective Ext. Cladding | Watertight barrier | Underside (Ventilated) | Point Foundation | Bathroom Cladding | Flooring |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Primary materials:*** *On-site materials* | *Painted exterior wooden boards* | ! If sanded/varnished | X | X | X | X | ! If sanded/ varnished | | ! Only with reflective sealing | X | ! Only with sealing | X | ! If sanded/varnished | ! If sanded/ varnished ✗ |
| | *Corrugated fiber cement sheets* | ! If cleaned and varnished ✗ | X | X | X | X | X | | X | X | OK | X | X | X |
| | *Wooden load-bearing construction* | X | X | X | OK ✗ | X | ! Rough finish | | X | X | ! Only with sealing | ! Only with sealing | ! If sanded/varnished | ! If sanded/ varnished |
| | *1-layer greenhouse glass* | X | X | X | X | X | X | | ! Only with special system ✗ | X | !If well supported | X | X | X |
| | *Exterior wood door (w/single glazing)* | X | X | X | X | X | X | | X | X | X | X | X | X |
| | *Interior painted wooden door* | X | X | X | X | X | X | | X | X | X | X | X | X |
| | *Old wooden single-glass windows* | X | X | X | X | X | X | | ! Only with sealing on frame | X | X | X | X | X |
| | *Greenhouse metal profiles* | ! As substructure only | X | X | X | X | ! As substructure only | | ! As substructure only | X | ! As substructure only | X | X | X |
| | *Lye-treated interior wood boards* | X | X | X | X | X | OK ✗ | | X | X | ! Only with sealing | X | ! Only with sealing | ! Only with sealing |
| | *Old rockwool insulation* | X | ! If dry | OK ✗ | X | X | X | | X | X | X | X | X | X |
| ***Secondary materials:*** *Recycled materials (primarily from Skave nedbrydning)* | *Floorboards* | ! If sanded/varnished | X | X | X | X | OK | | ! Only with reflective sealing | X | X | X | ! Only with sealing | OK |
| | *Tiles* | OK | X | X | X | X | OK | | ! Only with special mounting system | X | OK | X | OK ✗ | OK |
| | *Windows* | X | X | X | X | X | X | | ! Only with sealing on frame | X | X | X | X | X |
| | *Doors* | X | X | X | X | X | X | | X | X | X | X | X | X |
| | *Insulation* | X | ! If dry | | X | X | X | | X | X | X | X | X | X |
| | *Roof tiles* | OK | X | X | X | X | ! Cleaning + Takes up a lot of space | | ! Only with reflective sealing and special mounting system | X | ! Only with special mounting system | X | ! Cleaning + Takes up a lot of space | X |
| | *Brick* | ! Only with special mounting system | X | X | OK | X | OK | | X | X | X | ! Frost risk | X | OK |
| | *Gutters* | X | X | X | X | X | X | | ! Only with special mounting system | X | OK ✗ | X | X | X |
| | *Gypsum* | X | X | X | X | X | OK | | X | X | X | X | X | X |
| | *Wood (boards, construction, etc.)* | ! If sanded/varnished | X | X | OK | ! Not efficient or water durable | ! If sanded/ varnished | | ! Only with reflective sealing | X | ! Only with sealing | ! Only with sealing | ! If sanded/varnished | ! If sanded/ varnished |
| ***Tertiary materials:*** *New materials* | ∞ | ∞ | Expaned cork *(App. 3)* ✗ | ∞ | ∞ | Uncoated aluminium foil *(App. 3)* ✗ | ∞ | | ∞ | TPO *(App. 3)* ✗ | ∞ | M16 Twister Screw Foundation *(App. 3)* ✗ | ∞ | ∞ |

*Ill. 93:*
*Available materials vs. needed materials for the new construction.*

3.1
3.2
3.3
3.4
3.5

# material repurposes.

*This study investigates how reclaimed materials from the existing building can be reassembled using visible and reversible connections that support future disassembly and replacement. The design anticipates variations in reused material dimensions and conditions by incorporating adaptable detailing and modular construction principles. The goal is to extend the building's lifespan by enabling future users to substitute worn or outdated components with more sustainable alternatives. Aesthetics, construction logic, and user understanding are integral, as the design aims to promote transparency and flexibility in both structure and material expression, aligning with broader criteria on adaptability, low-carbon reuse, and long-term sustainability.*

The study focuses on three key material systems: the roof cladding (using on-site reclaimed corrugated fiber cement sheets), flood-resilient exterior cladding (using single-pane greenhouse glass), and interior flooring (repurposed painted exterior boards). For each component, three assembly strategies were developed and assessed based on longevity, disassembly potential, LCA performance, and aesthetics, as illustrated in 94-99. These strategies considered both physical connection techniques and additional materials needed, such as fixings or sealants. The assessment used a weighted matrix to determine preferred options across categories, with ties noted when criteria were closely matched. Aesthetic analysis emphasized material compatibility and surface rhythm to ensure visual coherence across reused components. Beyond design resolution, a comparative life cycle analysis was conducted between reuse-oriented assemblies and conventional new-material solutions. The analysis showed that reclaimed materials, when used in modular, replaceable systems, result in significant reductions in Global Warming Potential (GWP). However, reused components often have shorter service lives, necessitating careful planning for future replacement. Sensitivity analysis confirmed that even with a 20% shorter lifespan, the reuse approach remained more environmentally favorable.

| Glass cladding: Color methods | | |
|---|---|---|
| **Paint backside of glass** | **Metal sheet behind glass** | **Nothing** |
| Can not be removed and the color can only be choosen once and is difficult to maintain. Becomes mixed material and difficult to recycle. | Extra material, but easy to change and recycle. Reflect the light from water more efficiently and gives a more intense expierience. | The TPO membrane behind is exposed to UV light. |

*Ill. 94: Back material evaluation for greenhouse glass cladding.*

| | | Assembly method | Maintenance method | Disassembly method | Lifetime |
|---|---|---|---|---|---|
| **Roof cladding: Corrugated fiber cement sheets** | 1 | 1) Screw out 2) Assembly with screws | Algae cleaning | 1) Screw out *Can be reused as is *Does not ruin surrounding materials *Same material and easy to recycle | ~20 years |
| | 2 | 1) Screw out 2) Cut into smaller pieces 3) Make new holes 4) Assembly with screws | Algae cleaning | 1) Screw out *Can be reused as is *Does not ruin surrounding materials *Same material and easy to recycle | ~20 years |
| | 3 | 1) Screw out 2) Sand 3) Paint 4) Assembly with screws | Algae claning + Paint | 1) Screw out *Can be reused as is *Does not ruin surrounding materials *Becomes a mixed material and difficult to recycle | ~30 years with quality paint |
| **Exterior wall cladding: 1-layer greenhouse glass** | | **Assembly method** | **Maintenance method** | **Disassembly method** | **Lifetime** |
| | 1 | 1) Demount glass 2) Cut wood profiles 3) Assembly profiles with screws 4) Slide glass in profiles | Clean glass | 1) Demoount glass 2) Demount profiles *No surrounding materials are ruined *Same material for easy recycle (undless window is painted) | Glass ~100 years, Wood ~10 years |
| | 2 | 1) Demount glass 2)Cut profiles 3)Drill holes in glass 4)Mount profiles 5) Mount glass with bolts | Clean glass | 1) Demount glass with bolts 2) Demount profiles *No surrounding materials are ruined *Same material for easy recycle (unless window is painted) | Glass ~100 years, Galvanized metal ~35 years |
| | 3 | 1) Demount glass 2) cut profiles 3) bend hangers 4) mount hangers with screws onto profiles 5) Mount glass onto hangers | Clean glass | 1) Demount glass 2) Demount profiles *No surrounding materials are ruined *Same material for easy recycle (unless window is painted) | Glass ~100 years, Galvanized metal ~35 years |
| **Flooring: Painted exterior wooden boards** | | **Assembly method** | **Maintenance method** | **Disassembly method** | **Lifetime** |
| | 1 | 1) Demount with jemmy 2) sand 3) screw onto floor 4) varnish | Sand and varnish for a few years | 1) Unscrew *Can be reused for same purpose *Does not ruin the surrounding material *If recycled the varnish/paint can be sanded down | ~15 years |
| | 2 | 1) Demount with jemmy 2) cut into same length 3) Cut wood panels 4) Screw boards onto panels 5) Varnish 6) Mount tiles onto floor | Sand and varnish for a few years | 1) Take up with sucking 2) Unscrew *Can be reused for same purpose *Does not ruin the surrounding material *If recycled the varnish/paint can be sanded down | ~15 years |
| | 3 | 1) Demount with jemmy 2) mount wood seperators in floor with screws from side 3) cut boards lengthwise 4) place painted boards sideways close together on floor 5) sand 6) put organic glue and sawdust in holes 7) sand 8) varnish | Sand and varnish for many years | 1)Pull up the sections with a jemmy 2) Unscrew the section dividers *Does not ruin surrounding material *difficult to recycle due to the glue, but if it organic glue it might work *Can be reused as is | ~25 years |

*Ill. 95: Assembly evaluation of the 3x3 options.*


*Ill. 96: Aesthetical study of the different options and combinations.*

| Roofing: LCA | | | | | |
|---|---|---|---|---|---|
| *No.* | *Description* | *Processing* | *Instal-lation Materials* | *Estimated CO2 Emissions per Unit (kg CO2eq)* | *Method* |
| 1 | Reused fiber cement roof panel (60x100 cm) | Removal, algae cleaning, reinstallation with new screws | 4 screws (20 g steel) | 0.05 | Electricity: 0.1 kWh × 0.242 kg $CO_2$/kWh = 0.024 kg $CO_2$eq; Screws: 0.02 kg × 1.5 kg $CO_2$/kg = 0.03 kg $CO_2$eq; ***Total: 0.054 kg $CO_2$e*** |
| 2 | Reused fiber cement roof panel cut to size (30x25 cm) | Removal, algae cleaning, cutting, drilling, installation | 2 screws (10 g steel) | 0.07 | Electricity: 0.2 kWh × 0.242 kg $CO_2$/kWh = 0.048 kg $CO_2$eq; Screws: 0.01 kg × 1.5 kg $CO_2$/kg = 0.015 kg $CO_2$eq; ***Total: 0.063 kg $CO_2$eq*** |
| 3 | Reused fiber cement roof panel with painting | Removal, algae cleaning, painting, installation | 4 screws (20 g steel), 0.1 L paint | 0.30 | Electricity: 0.15 kWh × 0.242 kg $CO_2$/kWh = 0.036 kg $CO_2$eq; Screws: 0.02 kg × 1.5 kg $CO_2$/kg = 0.03 kg $CO_2$eq; Paint: 0.1 L × 1.81 kg $CO_2$/L = 0.181 kg $CO_2$eq; ***Total: 0.247 kg $CO_2$eq*** |

| Exterior cladding: LCA | | | | | |
|---|---|---|---|---|---|
| *No.* | *Description* | *Processing* | *Instal-lation Materials* | *Estimated CO2 Emissions per Unit (kg CO2eq)* | *Method* |
| 1 | Greenhouse glass (60x60 cm) with wooden profiles | Removal, cutting, sanding, oiling, installation | 2 wooden profiles (5x5x60 cm), 4 screws, 0.05 L oil | 0.25 | Electricity: 0.3 kWh × 0.242 kg $CO_2$/kWh = 0.073 kg $CO_2$eq; Screws: 0.02 kg × 1.5 kg $CO_2$/kg = 0.03 kg $CO_2$eq; Oil: 0.05 L × 1.4 kg $CO_2$/L = 0.07 kg $CO_2$eq; ***Total: 0.173 kg $CO_2$e*** |
| 2 | Greenhouse glass (60x60 cm) with metal profiles | Removal, cutting, drilling, installation | 2 metal profiles (2x2x60 cm), 4 screws, 4 bolts | 0.40 | Electricity: 0.4 kWh × 0.242 kg $CO_2$/kWh = 0.097 kg $CO_2$eq; Metal: 0.5 kg × 2 kg $CO_2$/kg = 1 kg $CO_2$eq; Screws and bolts: 0.1 kg × 1.5 kg $CO_2$/kg = 0.15 kg $CO_2$eq; ***Total: 1.247 kg $CO_2$eq*** |
| 3 | Greenhouse glass with metal profiles and hooks | Removal, cutting, bending hooks, installation | 2 metal profiles, 4 hooks, 4 screws | 0.45 | Electricity: 0.5 kWh × 0.242 kg $CO_2$/kWh = 0.121 kg $CO_2$eq; Metal: 0.6 kg × 2 kg $CO_2$/kg = 1.2 kg $CO_2$eq; ***Total: 1.321 kg $CO_2$eq*** |

| Flooring: LCA | | | | | |
|---|---|---|---|---|---|
| *No.* | *Description* | *Processing* | *Instal-lation Materials* | *Estimated CO2 Emissions per Unit (kg CO2eq)* | *Method* |
| 1 | Reused wood planks (flooring) | Removal, sanding, installation, oiling | 0.1 L oil, new screws | 0.18 | Electricity: 0.2 kWh × 0.242 kg $CO_2$/kWh = 0.048 kg $CO_2$eq; Oil: 0.1 L × 1.4 kg $CO_2$/L = 0.14 kg $CO_2$eq; ***Total: 0.188 kg $CO_2$eq*** |
| 2 | Reused wood planks (OSB backing) | Removal, sanding, OSB cutting, installation | 0.1 L oil, OSB 0.5 kg, new screws | 0.23 | Electricity: 0.3 kWh × 0.242 kg $CO_2$/kWh = 0.073 kg $CO_2$eq; Oil: 0.1 L × 1.4 kg $CO_2$/L = 0.14 kg $CO_2$eq; OSB: 0.5 kg × 0.5 kg $CO_2$/kg = 0.25 kg $CO_2$eq; ***Total: 0.463 kg $CO_2$eq*** |
| 3 | Reused wood planks (sideways) | Removal, sanding, installation, glue, oiling | 0.1 L oil, 0.2 kg organic glue | 0.34 | Electricity: 0.3 kWh × 0.242 kg $CO_2$/kWh = 0.073 kg $CO_2$eq; Oil: 0.1 L × 1.4 kg $CO_2$/L = 0.14 kg $CO_2$eq; Glue: 0.2 kg × 2 kg $CO_2$/kg = 0.4 kg $CO_2$eq; ***Total: 0.613 kg $CO_2$eq*** |

*Ill. 97: LCA evaluation of the different options.*

| Aesthetic evaluation based on illustration XX | | |
|---|---|---|
| **Roofing** | *1* | The texture is nice. The color makes the building seem cold and uninviting especially with the combination with no vertical windows. Not possible to personalise the expression. |
| | *2* | The texture becomes too busy and the building does not look balanced. The busy look overplays the garden. The color makes the building seem cold and uninviting especially with the combination with no vertical windows. Not possible to personalise the expression. |
| | *3* | The texture is nice and not overpowering. Good to be able to personalise the expression with color. |
| **Exterior cladding** | *1* | The vertical appearence does not match that the building should apear as low as possible in order to fit into the garden and not stick out. |
| | *2* | The horisontal look makes it appear lower and fits the long facade. |
| | *3* | The horisontal look makes it appear lower and fits the long facade. |
| **Flooring** | *1* | It could work, but a bit much with the same dimensions as the other wall cladding. |
| | *2* | Too busy and removes the attention away from the garden |
| | *3* | Creates a nice balance between the lye treated cladding with another profile |

*Ill. 98: Aesthetical evaluation of the different options and combinations.*

| Final evaluation and choice | | | | | |
|---|---|---|---|---|---|
| | Lifetime | LCA | Aesthetics | Chosen | Comment |
| *Roofing* | 3 | 1 | 3 | 3 | |
| *Exterior cladding* | 2,3 | 1 | 2,3 | 2 | Lowest LCA |
| *Flooring* | 2 | 1 | 3 | 2 | |

✗

*Ill. 99: Final overall evaluation and visual result.*

| Material replacement over time | | | | |
|---|---|---|---|---|
| Element | Current Material (Reused) | Estimated Lifespan | Future Replacement (Repurposed) | Future Replacement (New Biobased) |
| Exterior Cladding | Reclaimed green-house glass (60×60 cm), reflective but not insulated | ~30 years | Polished or mirro-red reclaimed metal panels (e.g. from old facades, elevator doors) | Bio-based reflective panels using algae-in-fused bio-resin or glazed mycelium with reflective coating |
| Roofing | Reclaimed corru-gated fiber cement sheets (100×60 cm) | ~100 years | Repurposed corru-gated metal roofing or similar asbe-stos-free cement panels from demo-litions | Bio-based corrugated hemp-lime composite sheets or bio-resin/ fiber blend shaped to match original profile |
| Flooring | Reclaimed exterior wood planks moun-ted to wood tiles | ~25 years | Reclaimed decking boards or dismant-led façade planks (treated for interior use) | FSC-certified ther-mo-treated wood or compressed bamboo planks mounted using reversible wood tile system |

*Ill. 100:*
*Future material replacement both with a bio-based and new replacement options.*

Based on the multi-criteria assessment, Option 3 was selected for the roof cladding. While it scored lower in LCA due to the addition of paint, it provided the longest projected lifespan and allowed for user personalization. This flexibility is important to accommodate future owners with different aesthetic preferences; otherwise, the risk of full material replacement increases. Aesthetically, the chosen roof finish offers more vibrancy and avoids a cold, industrial appearance. For the exterior cladding, Option 2 was selected due to its balanced performance, offering superior durability compared to wood, secure yet reversible mounting, and favorable LCA outcomes. It also contributed to the building's horizontal expression, helping it sit low in the landscape and blend into the allotment context.

For interior flooring, Option 3 was initially preferred, but its disassembly complexity prompted a shift to Option 2, which allows easier replacement of damaged boards. Despite a slightly worse environmental performance, it offered a better balance of repairability and visual quality, unlike Option 1, where exposed fasteners compromised the design's refinement. Finally, the long-term plan involves replacing each component at the end of its service life with newer, more sustainable alternatives. This is enabled by the modular assembly logic and the design's structural openness. While reused materials come with maintenance challenges, they offer a lower carbon footprint, by removing the transport and production cost, economic savings over time, and greater adaptability, positioning reuse as the more sustainable architectural choice in this context.

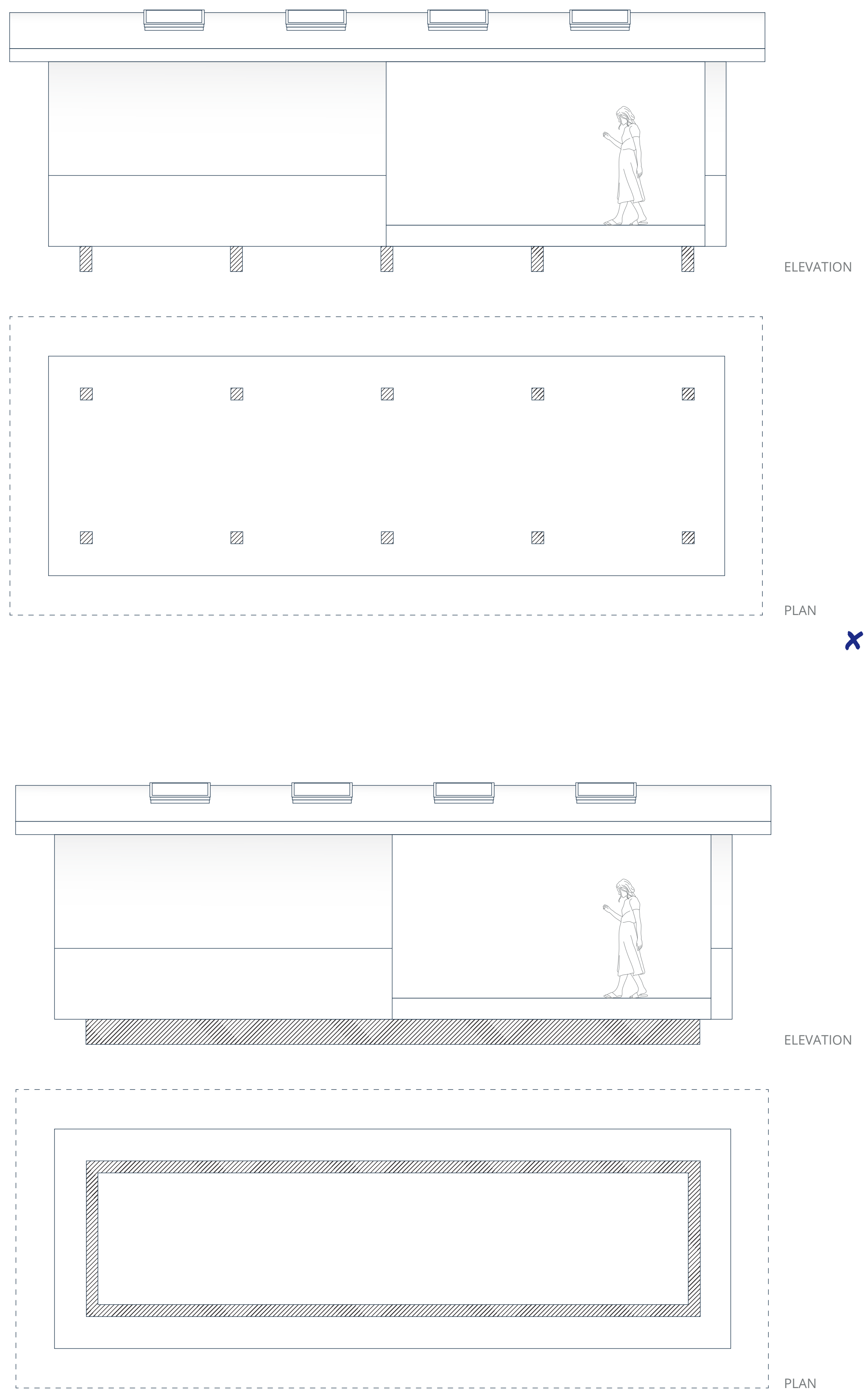
# construction.

*This study explores how repurposed structural elements from the original building can be used to create a resilient new load-bearing structure that meets standard building demands while also withstanding flood-related forces. The design embraces circular economy principles, aiming to reuse as much of the existing structural wood as possible and assembling it in ways that enable disassembly and material recovery at the end of its life. The assembly strategy incorporates metal brackets and bolted connections, making the structural system both robust and visually clear. These visible joints not only aid in understanding how the structure is put together but also support user engagement with potential future repairs, replacements, or adjustments. The synthesis draws from structural feasibility studies, resilience considerations, and circular design frameworks introduced during the framing phase of the project. Central to the approach is the idea of flexibility, accommodating variation in reclaimed material sizes and conditions while ensuring the integrity of the structure under both static and dynamic loads, including buoyancy forces from flooding.*

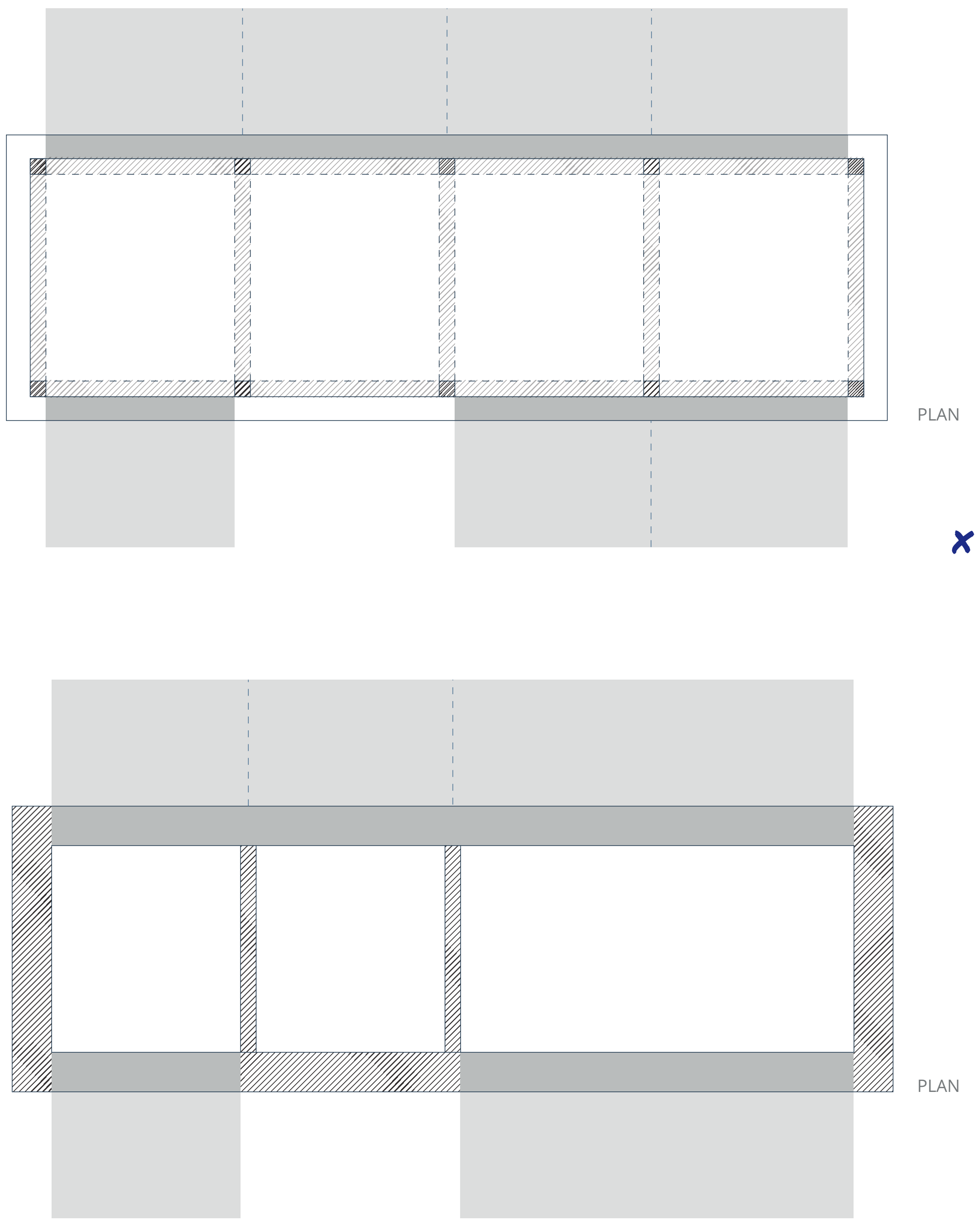
Several structural strategies were examined to determine their suitability for supporting reuse, durability, and disassembly. The first study compared foundation types, focusing on point foundations (e.g., screw piles) versus line foundations. Factors considered included material consumption, impact on the site, potential for disassembly, and aesthetic integration with the allotment context (Ill. 101).

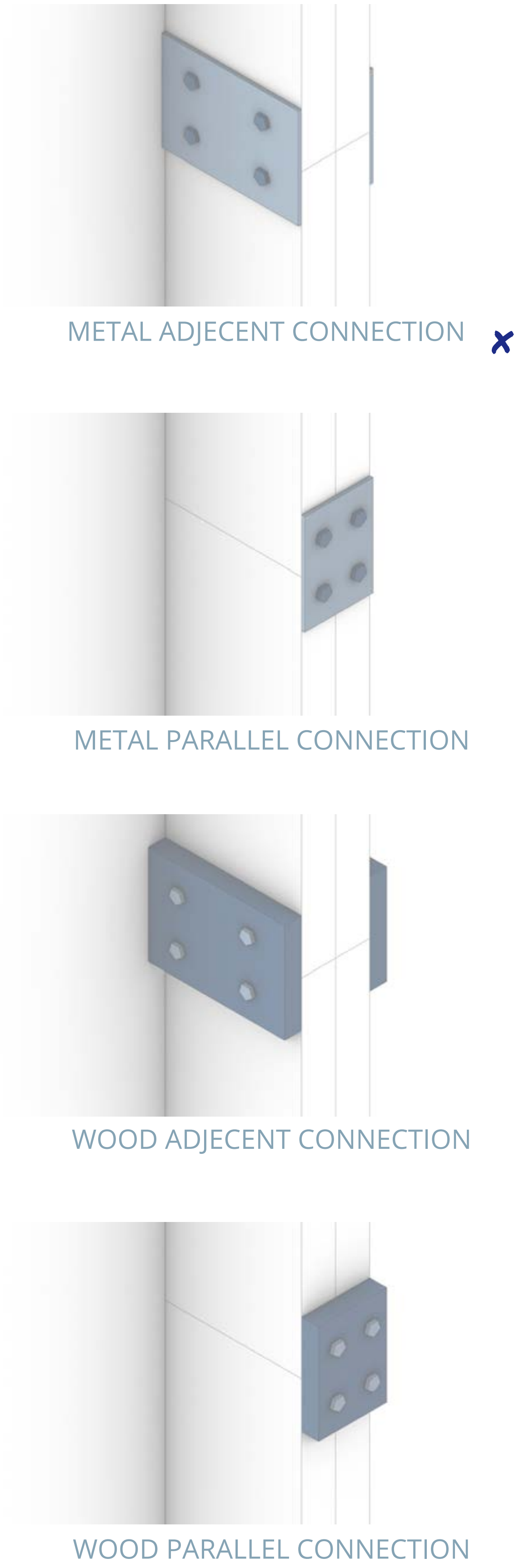
Next, two construction systems were analyzed: column/beam and plate construction (Ill. 102). The comparison addressed compatibility with reclaimed materials, flexibility of wall openings, and effects on interior layout.

Following this, the structural frame concept was investigated using reclaimed wooden load-bearing elements. The study explored assembly methods, frame placement, and material combinations to create consistent frame designs (Ill. 103). An Excel model was used to test different configurations of existing wood profiles and quantities to develop symmetrical frames (Ill. 104).




*Ill. 101:*
*Point or line foundation.*




*Ill. 102:*
*Frame or plate*
*construction.*

*Ill. 103:*
*Frame construction*
*assembly methods.*

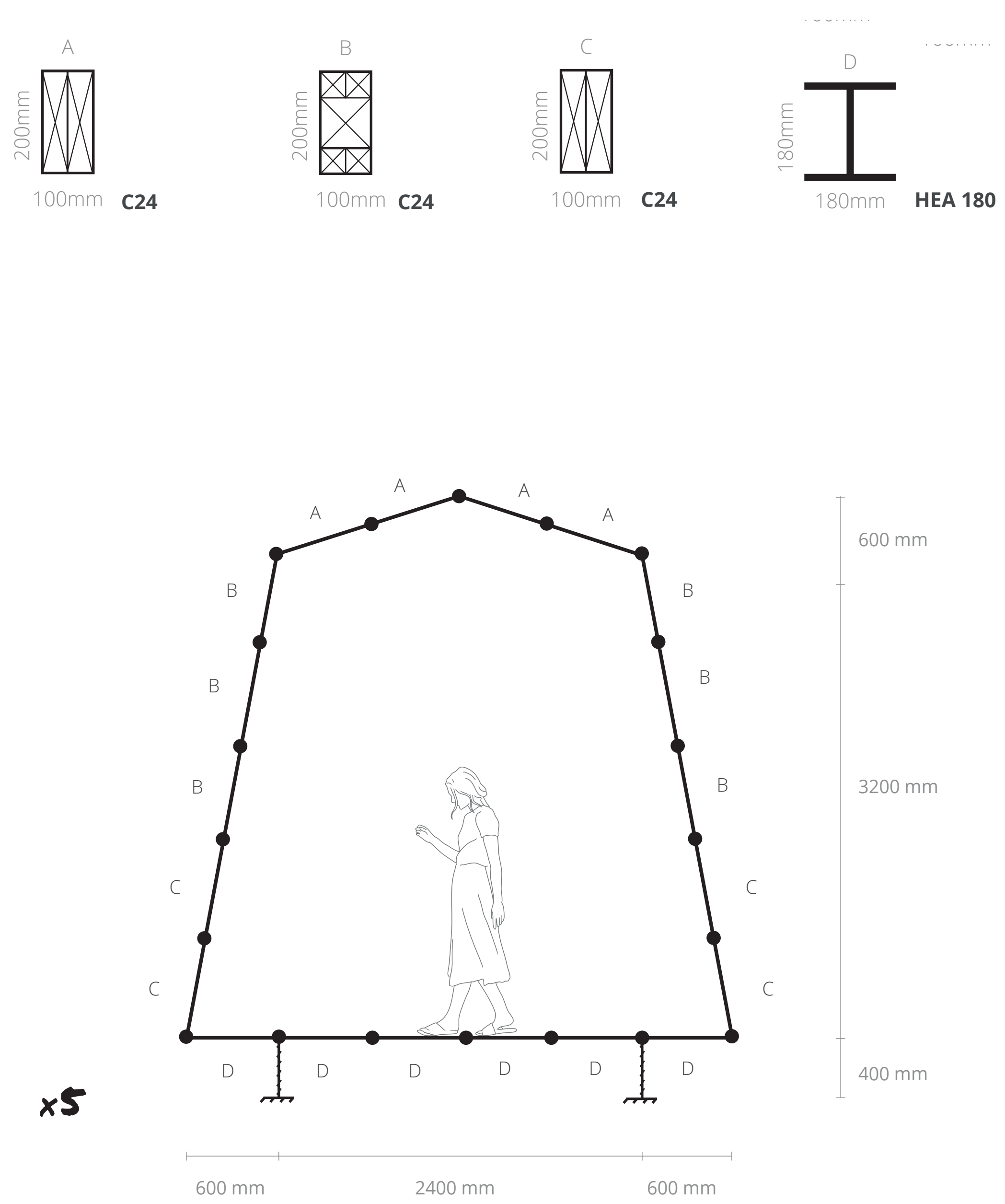
Point foundations were selected over line foundations because they use less material, disturb the site less, are easier to disassemble, and visually fit better within the allotment environment (Ill. 101). Although line foundations can provide extra storage and space for mechanical systems, they require more complex waterproofing and interrupt the natural site more.

The column/beam construction system was chosen due to its better compatibility with reclaimed materials, support for modular and flexible wall openings, and ability to allow a flexible interior layout (Ill. 102). Plate construction presented challenges with spanning, limited flexibility, and required load-bearing interior walls, which contradicted the design goals.

The final structural system is a frame construction using repurposed wooden load-bearing elements (Ill. 103). The Excel-based material study helped identify an optimal configuration that combined smaller reclaimed parts into larger composite profiles, ensuring structural consistency and symmetry across frames (Ill. 104). These configurations aligned with dimensioning requirements detailed in the project (p. 110).

Metal brackets were chosen for structural joints due to their strength and ease of disassembly. Their placement on adjacent sides makes the construction logic clear and supports reversible assembly, aligning with reuse and transparency goals.

In summary, the structure successfully integrates reclaimed materials, modular assembly, and flood resilience, demonstrating how circular construction principles can be implemented without sacrificing structural integrity or architectural quality.




*Ill. 104:
How the new frames are constructed out of the available amounts of wooden load bearing construction elements.*

| Reuse of wooden load-bearing structure | | | |
|---|---|---|---|
| *Available amount profile dimension* | *Available amount* | *Available amount* | *Remaining amount* |
| 50 mm x 200 mm | >2 m | 71 m | 8,6 m |
| 100 mm x 100 mm | >1.5 m | 30 m | 12 m |
| 50 mm x 100 mm | 1.85 m | 34 m | 34 m |
| 50 mm x 50 mm | >0.6 m | 125 m | 17 m |

# PROCESS REFLECTION

This project has followed a structured and iterative design process, grounded in the methodological approach outlined earlier. Using the Double Diamond model as a guiding framework and drawing on Lawson's theory of design as a dialogue between problem and solution, the process was planned to move through the phases of discovery, definition, development, and delivery. However, as with most complex design investigations, the actual progression deviated in both direction and timing.

The Discover and Define phases were particularly time-consuming and presented unexpected challenges. Initially, the project was anchored in a specific interview with an allotment owner who was meant to serve as the user in a site-based case study. However, as the process unfolded, it became clear that this site was already under redevelopment, which introduced the risk of the project becoming too closely influenced by an existing design. This realization forced a change in direction, shifting the project from a concrete site to a more general design challenge. While the site-specific insights gained from the interview were still useful, especially for understanding local constraints, the real breakthrough came with the introduction of a hypothetical case. This new case was informed by survey responses from 49 allotment owners across Denmark and allowed for a more targeted yet imaginative exploration. Without much existing research on this user group, the survey became a key method for avoiding generalizations and grounding the project in realistic, user-informed perspectives.

In retrospect, the absence of a clear project aim in the early stages led to an overly generalized design approach. Attempting to solve all problems for all personas resulted in modular but detached proposals, lacking contextual depth. It was only when a specific case was developed, even though it was hypothetical, that the project began to feel anchored, and design decisions could be made with greater clarity and relevance. This shift exemplifies how the flexibility of the Double Diamond model supported the process: when the project needed to change course, the model provided a clear map of which areas needed to be revisited before progressing.

The design development phase also revealed something about the working style. It became clear that a pragmatic and structured way of working aligns well with the three-part design studies; synthesis, analysis, and evaluation, but can also be a limitation. The tendency to think about consequences and feasibility early on sometimes restricts the breadth of what is explored, especially when trying to test more speculative ideas. While the structured approach helped manage complexity, some design opportunities emerged outside the framework of predefined studies. Allowing space for these intuitive ideas, and then retrospectively organizing them into the design logic, was an important learning.

Working with reused materials introduced another level of reflection. While the starting point was to explore how on-site materials could be repurposed, the investigation evolved into broader questions about material lifespans and future adaptability. If a repurposed material reaches the end of its life, should it be replaced with the same, even if more sustainable alternatives exist? How can a design process accommodate uncertainty in material availability while still planning responsibly for the future? These questions revealed that material reuse is not only a matter of circularity but also a challenge of long-term thinking.

In conclusion, the process did follow the overall methodological structure, but in a more dynamic and non-linear way than first anticipated. Ideas were discarded and revisited, problem framings evolved, and the balance between structure and flexibility became central to the work. If the process were to be repeated, it would be advisable to begin with a clearer problem definition and case framework. Still, the value of allowing early ambiguity to lead to better-informed decisions later is recognized. Perhaps most importantly, this process has shown that successful design is not just about finding answers, but about learning how to refine the questions.



# SHARING THE DESIGN REFLECTION

This chapter provides a critical reflection on the design proposal developed throughout the thesis, evaluating how well it meets the original goals and exploring its broader relevance. The reflection is structured around four key themes: design performance and potential for further development, flood resilience, the sensory and spatial experience of flooding, and strategies for extending material lifetime. Special attention is given to how the principles demonstrated in this project may inform future architectural practice and contribute to discussions on adaptive, circular, and context-sensitive design approaches.

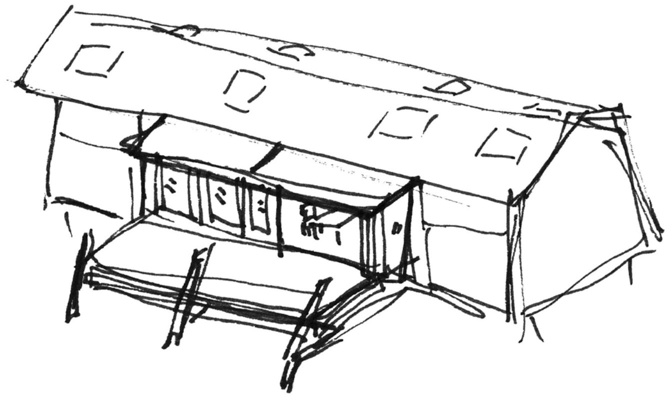
# design reflection.

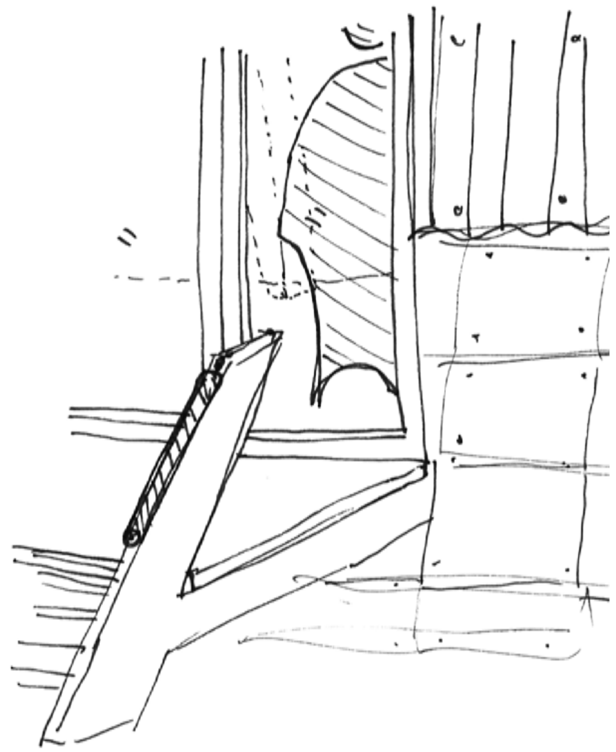
The design proposal successfully integrates the three key design drivers: *Low Flood No Fuss/High Flood Adjust, Garden Extension/Garden Refuge, and From Past Materials/Toward Future Methods*. These drivers have meaningfully shaped both the architectural concept and its execution. The design drivers were prioritized with flood resilience as the foremost concern, as the solution will improve user experience and reduces material waste. Material waste reduction was the second priority, since the flood experience can be created in many ways beyond material-saving strategies. For example, between different methods of flood resilience, the chosen double foundations were preferred over high pillars because the latter would create too dramatic a separation from the garden and water experience.

The building is elevated 40 centimeters on galvanized screw foundations, providing passive protection against low-level flooding without significantly impacting user accessibility or the surrounding outdoor environment. However, the long-term structural response of screw foundations under repeated wetting and varying soil conditions remains a topic for further study. For more severe flooding, the building envelope can be sealed to resist water up to 1.5 meters, supporting the project's goal of offering security without relying on a permanently elevated form that might feel disconnected or awkward during dry periods. This water-tightness, especially at seams, requires technical refinement before implementation.

Spatial transformability is central to the design, offering three configurations: fully open, half open, and fully closed. These states allow the building to adapt physically and atmospherically to changing climate conditions. The fully open mode removes barriers between inside and outside, continuing materials onto the terrace to create intimacy with the garden. The half open mode amplifies the flood experience through angled walls and reflective cladding, enhancing water reflections and sound, offering a poetic reinterpretation of flooding. The fully closed state provides comfort and security at night. The building also acts as a garden extension, bridging private and public outdoor zones. Further development could focus on passive design strategies to improve indoor climate regulation without a cooling demand. Another potential evolution is a double envelope system with an operable outer facade and transparent inner layer such as folding glass doors (Ill. 105), allowing weather protection without losing the connection to the garden. This is especially relevant in Denmark, where the weather varies a lot.

Regarding material reuse and circularity, the proposal repurposes 85% of materials from the existing building. Greenhouse glass is used as exterior cladding and painted wooden cladding as interior flooring, showing a deep engagement with material properties over traditional use. However, relying on specific existing materials presents challenges for future replication if those materials are unavailable. Alternative materials with similar properties would need to be identified as stated previously. Additionally, some materials, like glass cladding, were there were an insufficient amount to cover the facade, there was a need to add new glass panels, which should have been avoided and the future replacement material should have been used instead. Further testing is also necessary to confirm if smaller laminated timber sections can replace large solid wood profiles without compromising structural integrity.





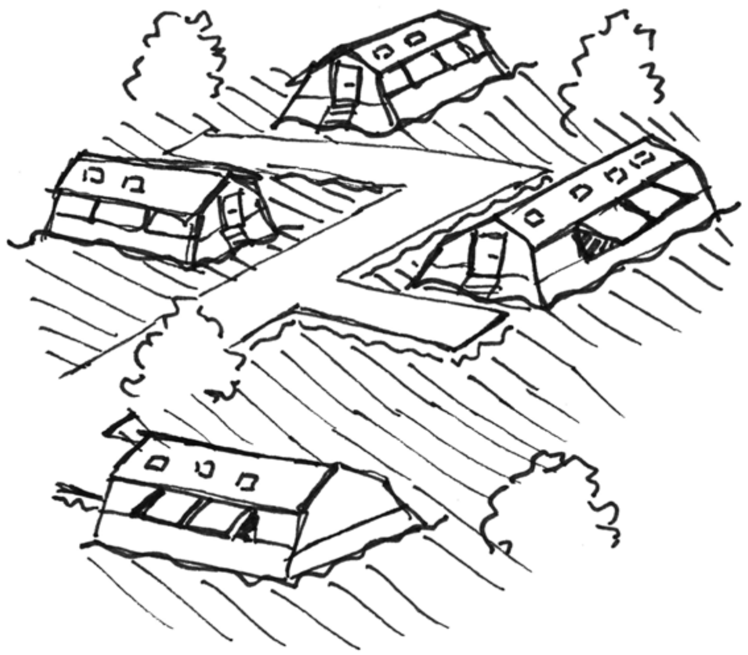
*Ill. 105: Sketches of the double-envelope system.*

# 1 - flood resilience.

The project presents a two-tiered flood resilience strategy. For frequent low floods, the screw pile foundations elevate the building while preserving the usability of the surrounding terrain. For severe floods, the building envelope can be actively sealed to withstand water levels up to 1.5 meters. This approach avoids the visual and practical drawbacks of raising the entire structure on high pillars, which would disrupt scale, accessibility, and the connection to the landscape.

This strategy is particularly suited for regions with periodic but varied flood intensities and sensitive visual contexts. It also offers potential scalability from small garden pavilions to larger residential buildings. For larger scales, a double facade system with an operable external waterproof skin and internal doors could balance spatial continuity and protection.

To enhance this concept beyond the individual building scale, flood adaptive accessways could be implemented, for example, as floating platforms similar to illustration 106. Such accessways would improve everyday usability during floods, avoiding reliance on kayaks or waders, which are impractical and inconvenient even if the building itself remains secure. These adaptive pathways would emphasize that flood-prone areas are designed not only for resistance but also for harmonious living with the climate. This approach would be most relevant for allotment communities, clusters of summer houses, or residential groups connected through shared flood-prone zones. Crucially, these areas must be linked to adjacent zones with lower flood risk to enable practical access.



*Ill. 106:*
*Sketch of the design proposal in a larger scale with a floating accessway.*



# 2 - flood experience.

This project shifts from traditional room-based architecture to a focus on adaptable functional facilities that can transform with climate and season. The three spatial configurations; fully open, half open, and fully closed, promote flexibility and deepen the emotional engagement with the environment. By encouraging users to respond actively to environmental conditions, the design fosters a meaningful connection with natural flooding processes.

The project aligns with contemporary architectural discussions on climate adaptation by embracing flooding as an opportunity for enhanced experience and atmosphere rather than a threat to resist. This reflects a broader movement toward designs that balance adaptability and beauty, challenging the notion that climate resilience must compromise aesthetics.

Additionally, the design resonates with the growing global interest in compact living, such as the tiny house movement (Mechlenborg, 2024). By prioritizing only necessary facilities, the small-scale building (32 $m^2$ interior) offers an affordable, efficient, and manageable lifestyle that encourages occupants to spend more time outdoors. The design extends interior space into the garden, creating a feeling of spaciousness and shifting the relationship between dwelling and nature. While the design fits well within the allotment context and small household structures, it is less suited for significant changes in family size due to limited interior flexibility.

In contemporary society, where minimizing energy, material consumption, and land use is increasingly important, this design demonstrates how small living spaces can meet essential needs while enhancing quality of life. However, the climate in Denmark poses practical challenges for extended outdoor living, and further development could address these realities.

# 3 - extend material lifetime.

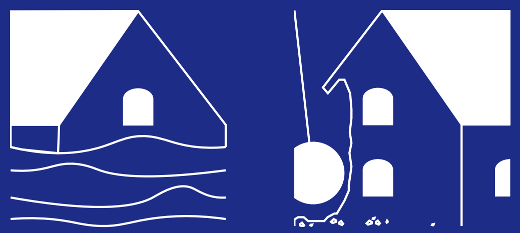
A core aspect of the proposal is the strategic reuse of materials from an on-site structure. This approach reduces environmental impact and creates a historical and emotional continuity in the new building. Materials were selected based on their properties and lifespan rather than traditional roles. For example, greenhouse glass was repurposed as exterior cladding, and painted wood was transformed into interior flooring, requiring detailed understanding of performance characteristics.

Challenges include the limited durability and environmental impact of some reused materials. In these cases, bio-based alternatives introduced from the start may provide a more sustainable path. If this would be implemented in another case, it would be crucial with an early integration of material assessments is critical to maintain a coherent vision balancing reuse with long-term sustainability.

Legal and regulatory limitations also affect reuse. In Denmark, reused materials must comply with building regulations and often require documentation (*Dokumentation efter BR*, no date). Moreover, despite high demolition rates, Denmark lacks sufficient infrastructure and market mechanisms to support the reuse of quality building materials. Reports from Industriens Fond and Teknologisk Institut highlight the need to make reused materials economically competitive and accessible (Industriens Fond, no date).

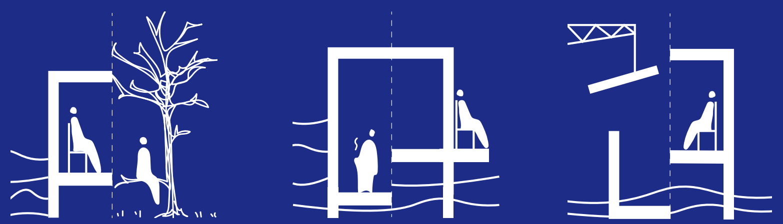
Scaling this approach would benefit from creating material databases for existing buildings prior to demolition. Such databases would document material types, quantities, and properties, informing early design decisions based on properties rather than conventional material uses. Although more complex and costly, this method adds contextual care and storytelling to new designs that cannot be replicated with new materials. Importantly, designs must also plan for future replacement of materials with low-emission alternatives to ensure ongoing sustainability.

*Ill. 107:
Used material details.
Photos: Author*

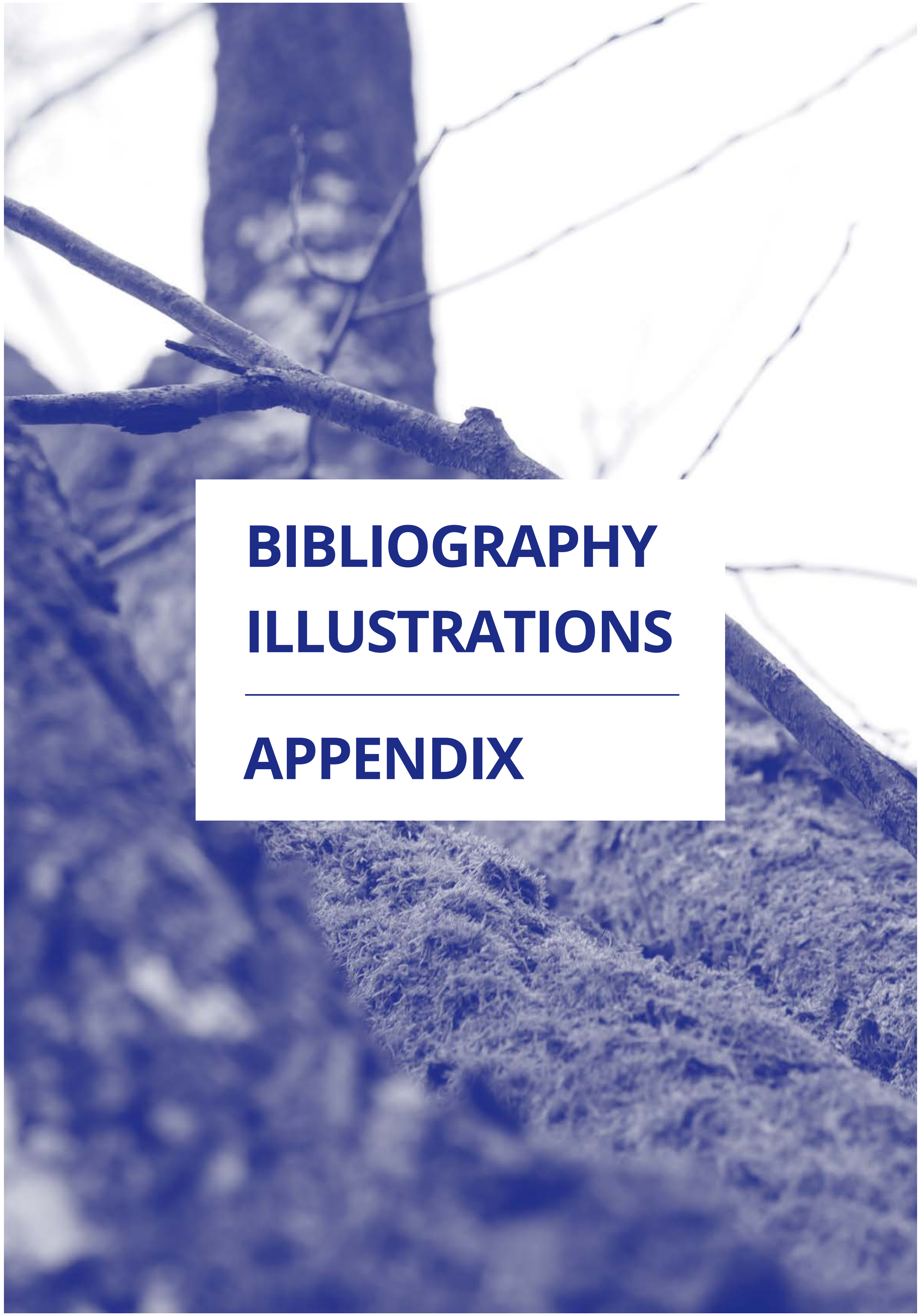


# FINAL THOUGHTS

This thesis explores how small-scale architecture can meaningfully engage with climate resilience, material reuse, and spatial adaptability through a design proposal situated in a Danish allotment context. By integrating transformable spatial configurations, dual flood protection strategies, and repurposed building materials, the project demonstrates how architecture can shift from defensive climate adaptation toward a more poetic engagement with environmental conditions. Rather than treating floods as threats, the design reframes them as opportunities for sensory and spatial enrichment. At the same time, it challenges conventional material hierarchies by focusing on property-based reuse, promoting a circular mindset grounded in both pragmatism and aesthetics. Although further technical refinements are needed, particularly in relation to indoor comfort and long-term water-tightness, the proposal ultimately positions architecture as an active participant in its ecological and cultural context. As such, it offers a replicable and evolving strategy for building in an era shaped by uncertainty, material scarcity, and changing environmental conditions, in alignment with circular economy principles promoted by the Danish Centre for Circular Economy in Construction (*Dokumentation efter BR*, no date).







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# ILLUSTRATIONS

# APPENDIX

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# illustrations.

*All illustrations not mentioned here are created by the author. All the photos listed below are approved for use in this thesis by the respective rights holders.*

**Illustration 4**
*Aalborg, Holstebro, Randers, Vejle 1:5.000, 10 cm rainfall, in 10 years.*

Source: https://kamp.klimatilpasning.dk

Edit: The map is created by the author and the analysis is created by KAMP

**Illustration 6**
*Havekolonien Storaaen in Holstebro with design case site in focus.*

Source: https://kamp.klimatilpasning.dk

Edit: The map is created by the author and the analysis is created by KAMP

**Illustration 10**
*Proposed community based solutions on top of photograph from above.*

Source: https://dataforsyningen.dk

Edit: Blue filter and sketches are applied by the author

Rights holder: GeoDanmark, CC BY 4.0

**Illustration 11**
*Mapping of ground water level during the winter season in scale 1:2000.*

Source: https://dataforsyningen.dk/

Edit: The map is created by the author and the analysis is created by Dataforsyningen

Rights holder: Klimadatastyrelsen

**Illustration 12**
*Mapping of 15 mm bluespot in scale 1:2000.*

Source: https://dataforsyningen.dk/

Edit: The map is created by the author and the analysis is created by Dataforsyningen

Rights holder: Klimadatastyrelsen

**Illustration 13**
*Weather diagram showing monthly averages*

Source: https://www.dmi.dk

Edit: Data is from DMI, but diagram and data selection is by the author

Rights holder: DMI

**Illustration 15**
*Sketch of Platypus House, Robinson Architects*

Source: https://www.archdaily.com/783541/platypus-house-robinson-architects

Edit: White filter and sketches are added by author

Rights holder: © Alain Bouvier and Robinson Architects

**Illustration 16**
*Sketch of U-House, Ushijima Architects*

Source: https://www.archdaily.com/993775/u-house-in-irie-ushijima-architects

Edit: White filter and sketches are added by author

Rights holder: © Shinya Tsujita and Ushijima Architects



**Illustration 17**
*Sketch of Makoko Floating School III, NLÉ*

Source: https://nleworks.com/case/mfsiii/

Edit: White filter and sketches are added by author

Rights holder: © NLÉ

**Illustration 20**
*Can Lis designed by Jørn Utzon.*

Source: https://utzon-archives.aau.dk/

Edit: None

Rights holder: © Utzon Archives / Aalborg University & Utzon Center

**Illustration 21**
*Can Lis designed by Jørn Utzon.*

Source: https://utzon-archives.aau.dk/

Edit: Multiple photos put together

Rights holder: © Utzon Archives / Aalborg University & Utzon Center

**Illustration 28**
*Overview photo of Højbogård 70.*

Source: https://dataforsyningen.dk

Edit: Cropping and blue and grey filter are applied by the author

Rights holder: GeoDanmark, CC BY 4.0

**Illustration 29**
*Denmark mapping of recycled building material shops.*

Source: https://www.bolius.dk/her-kan-du-koebe-genbrugsmaterialer-10121

Edit: The locations and names are from the source, but the mapping and design is made by the author

**Illustration 32**
*Photo of The Swan, Lendager Group*

Source: https://www.detail.de/de_en/kindergarten-bei-kopenhagen-von-lendager?srsltid=AfmBOooEMM2MrAb0oIUCaezcIgcTN-fwXihYpm_zRhKZflOYo4xE5ZP7b

Edit: Cropping

Rights holder: © Rasmus Hjortshøj

**Illustration 34**
*Another view of The Swan, Lendager Group*

Source: https://www.detail.de/de_en/kindergarten-bei-kopenhagen-von-lendager?srsltid=AfmBOooEMM2MrAb0oIUCaezcIgcTN-fwXihYpm_zRhKZflOYo4xE5ZP7b

Edit: Cropping

Rights holder: © Rasmus Hjortshøj

**Illustration 81**
*Right - Wind rose for the opening season (April to October) in Holstebro. Left - Wind rose for the closed season (November to March) in Holstebro.*

Source: https://clima.cbe.berkeley.edu/

Edit: Different color scheme

Rights holder: CBE Climate Tool

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