

# Flood-proof living at the riverside

The future of amphibious housing in adaptive and dynamic neighbourhoods in floodplains; the new way of living



Vision booklet

Anouk de Vries



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*This vision booklet is part of the graduation project of Anouk de Vries for the studio Technologies and Aesthetics at the TU Delft. The design for the project is presented to highlight the vision for the new way of living. More construction and research-related information about this project can be read in the accompanying documents.*

# What is amphibious living?

Amphibious living, in the context of housing, refers to residential structures designed to adapt to changing water levels. These amphibious houses are built to remain stable on land during dry conditions but can float on water during floods, rising and falling with the water levels. This innovative approach combines traditional building techniques with modern engineering solutions to provide a resilient living environment in flood-prone areas. The houses feature floating foundations and flexible utility connections that can extend when needed.

Living in amphibious houses minimizes flood damage and provides a solution for the new way of living by creating the possibility to build new houses in areas at risk of floodings. By blending functionality with adaptability, amphibious living offers a practical and forward-thinking response to the increasing frequency of extreme weather events.

Rising sea level

+

deep polder

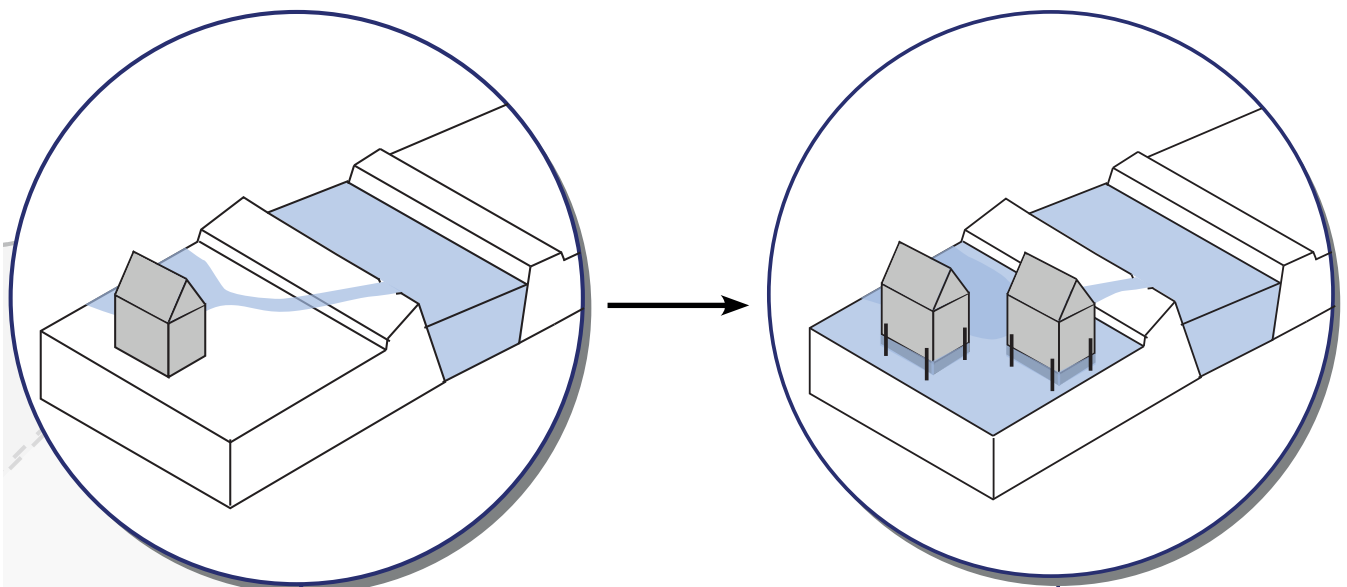
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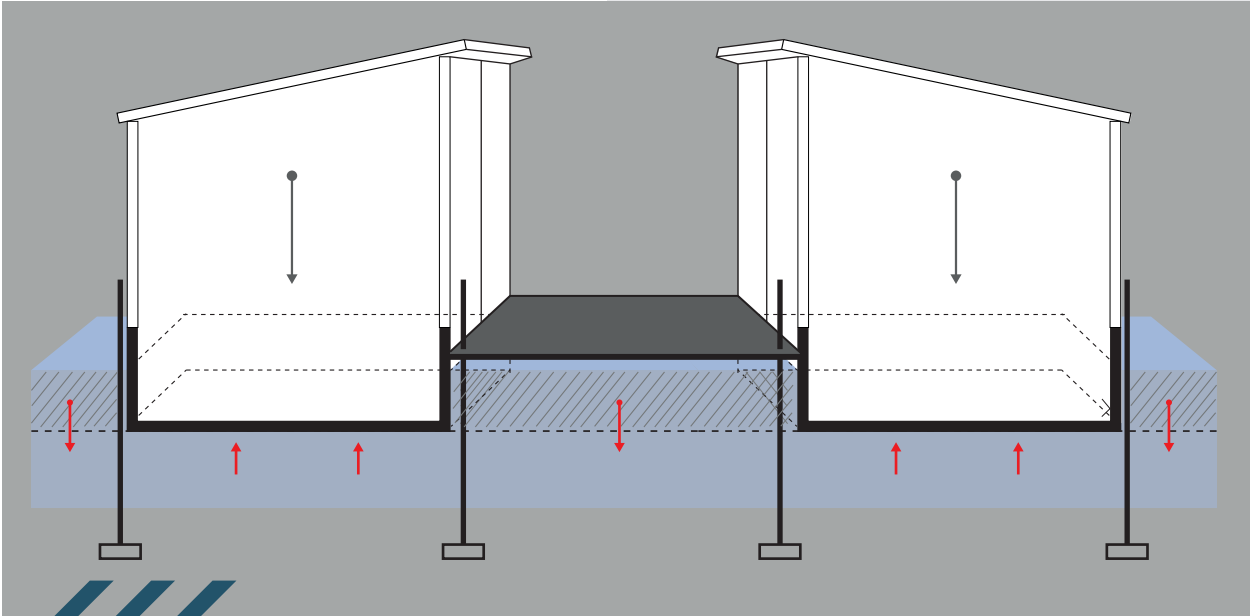
move away

But that is not the solution...

This booklet elaborates on my vision on the new way of living in floodplains, by showing a design approach and by addressing the underlying thoughts behind the project.

What makes living in an amphibious neighborhood appealing?





## Future vision

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In this vision, entire communities are built with buoyant foundations, flexible utility connections, and sustainable materials. These neighborhoods are not only functional but also aesthetically pleasing, fostering a deep connection with the surrounding water bodies. Green spaces, floating gardens, and integrated waterways enhance the quality of life, promoting a sense of tranquility and well-being.

Furthermore, amphibious living serves as a model for climate resilience, showcasing how human ingenuity can create adaptable and sustainable living environments. It offers a proactive solution to rising sea levels and increased flooding, ensuring that communities remain safe and thriving. By embracing this innovative approach, we can build a future where our homes not only coexist with nature but also thrive within it.

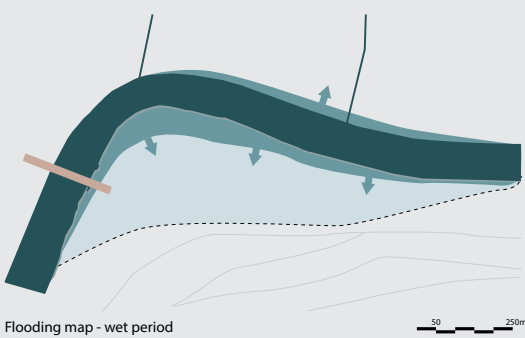
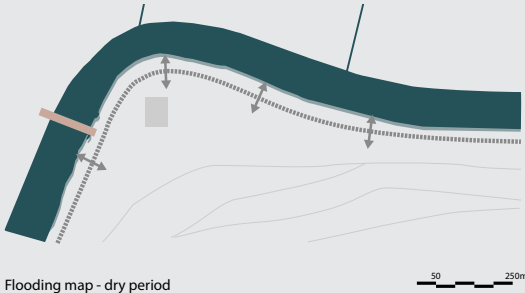
59%

### OF OUR COUNTRY IS AT RISK OF FLOODING

*during periods with high discharge of water from our rivers that flow into our delta*

### 975.000 HOUSING SHORTAGE BY 2030

*But where can we still build if people are increasingly afraid of living below NAP in the future?*



# The new way of living

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## Climate resilience

Amphibious homes are designed to rise with water levels, providing a robust solution to the increasing threat of flooding caused by climate change.

## Sustainable

The houses utilize sustainable materials and energy-efficient technologies, promoting eco-friendly living.

## Innovate and future proof

Due to adaptable and modular construction techniques, the houses remain livable despite environmental changes or change of user wishes.

## Connection to nature

Amphibious neighbourhoods are located in water-rich environments near a river, which enhances the residents' quality of life and offers recreational opportunities.

## Flexible and adaptable

The flexible design allows these homes to be built in various locations, making them suitable for diverse environments.

## Fast building process

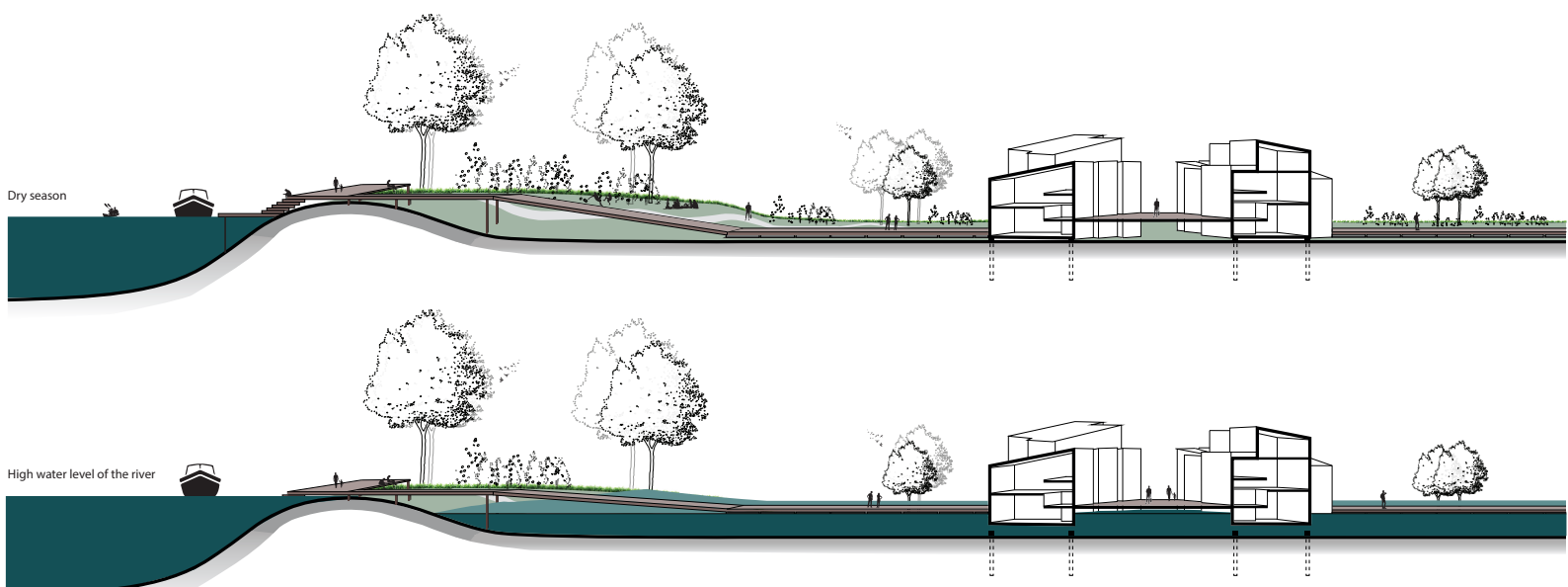
The prefabricated concrete pontoons and wooden facade elements can be assembled very fast on site and offer the opportunity to be connected in different ways and forms.

## Economic benefits

By minimizing flood damage, amphibious homes reduce long-term repair and insurance costs, making them economically resilient.

## Community and lifestyle

These neighborhoods promote a unique lifestyle with features like floating gardens, communal docks, and water transportation, creating vibrant living environments.





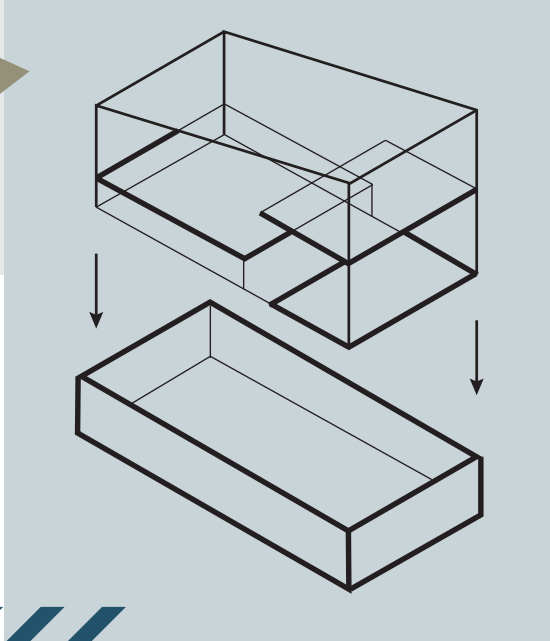
**Entire neighborhoods that rise with the water level can provide a solution for the future**

**HOW IS AN AMPHIBIOUS HOUSE CONSTRUCTED?**

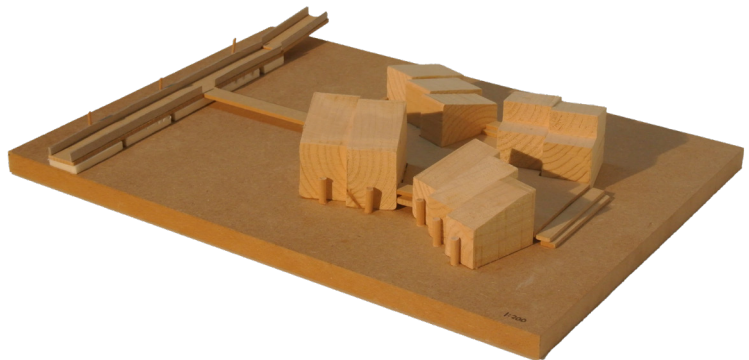
There are multiple ways to let a building float, which is analyzed in the research report. In my design for amphibious housing, the houses are constructed on a buoyant foundation made of concrete. These concrete boxes can be connected to each other to create clusters of houses. These lower parts of the building are designed to be waterproof and resistant to damage from prolonged exposure to water.

On top of the concrete ground floor a lightweight timber construction is placed. This is important for the location of the center of gravity, which affects the stability. The house is anchored to vertical mooring piles, which keep it in place and prevent it from drifting. These mooring piles allow the house to move vertically with the changing water levels.

All the utilities work with an off grid system and are designed with flexible connections.



**Floating concrete basement and the lightweight building construction on top**

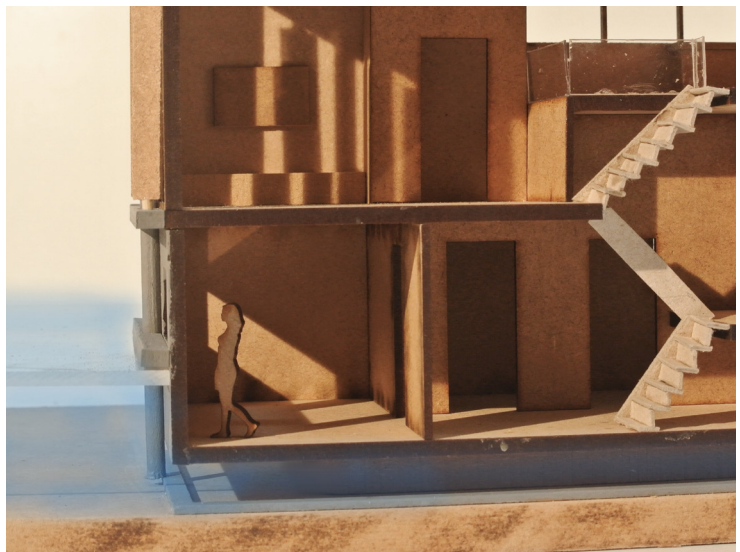


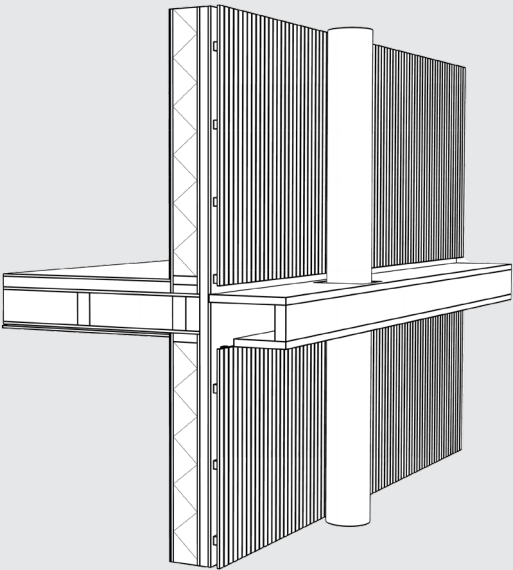
**Connected amphibious houses form a collective living cluster**



## The dynamic living experience

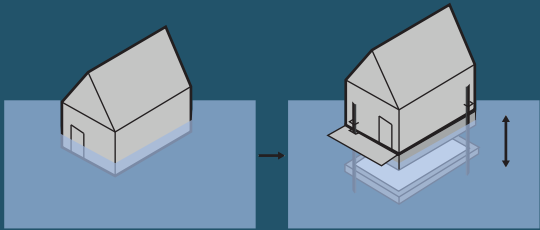
Living in an amphibious neighborhood means experiencing elements which will move and views which will change. For example, the mooring posts that assume different heights in relation to the facade and the stairs which are disappearing under the water. In this design, a tree is located at the middle of the cluster which stands on the ground. When the whole cluster is starting to float, the tree will stay on its same level and will be seen from another height. So, living in an amphibious neighborhood will never get boring.





### MOORING POSTS INTEGRATED IN THE FACADE

*These poles ensure that the houses  
cannot make horizontal movements*



## Why live in a collective housing cluster?

- Sense of community
- Benefit from shared facilities in the courtyard
- Social integration and interaction
- Environmental benefits due to shared water and energy system
- Multiple generations can learn from each other
- Sense of safety
- Cost savings due to shared infrastructure

## Collective living

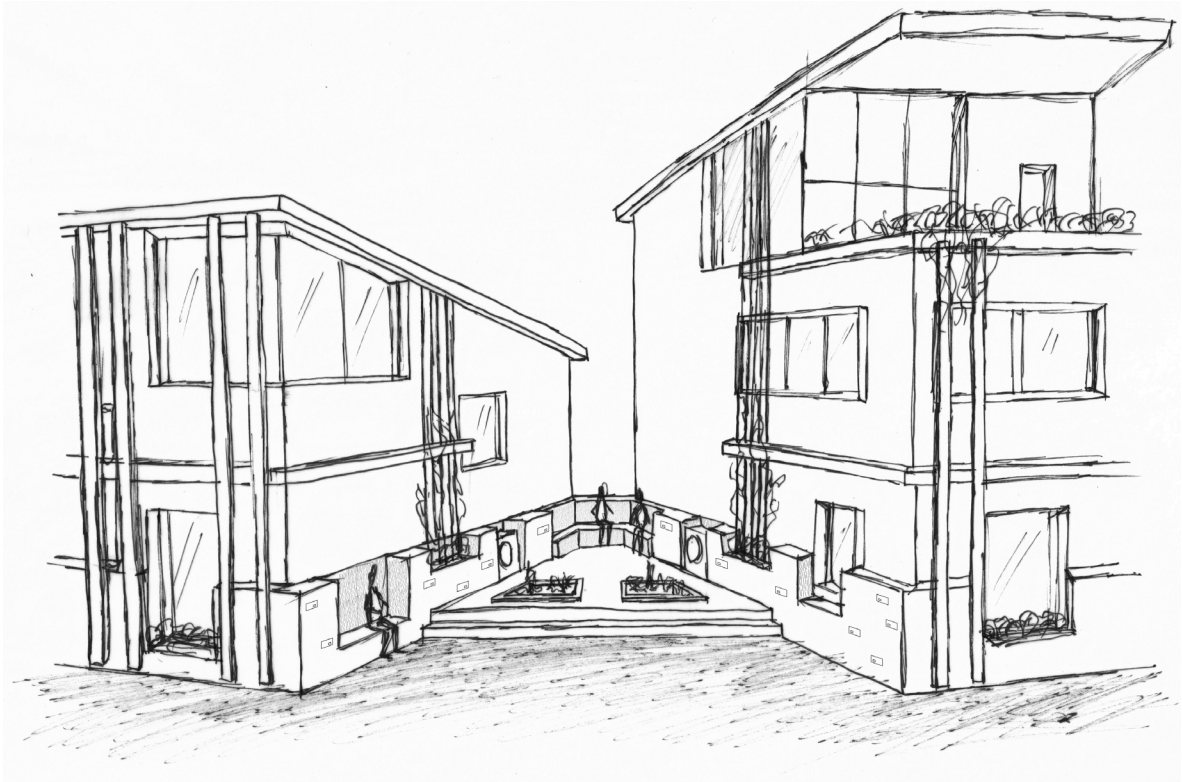


In the design the houses are connected to each other as a housing cluster with a shared inner courtyard. This offers a range of advantages that enhance both practicality and community living in water rich areas.

Firstly, clustering ensures enhanced stability during floating conditions by allowing houses to share anchoring systems and support each other. This collective approach reduces individual movement and enhances overall safety, crucial in areas prone to fluctuating water levels.

Secondly, it maximizes the use of infrastructure such as shared docks, pathways and terraces, making better use of limited land resources.

From a community perspective, connecting amphibious houses fosters a strong sense of neighborhood. Shared pathways, communal gardens, and recreational spaces encourage social interactions among residents, promoting a vibrant community atmosphere.



# Integration into the existing landscape

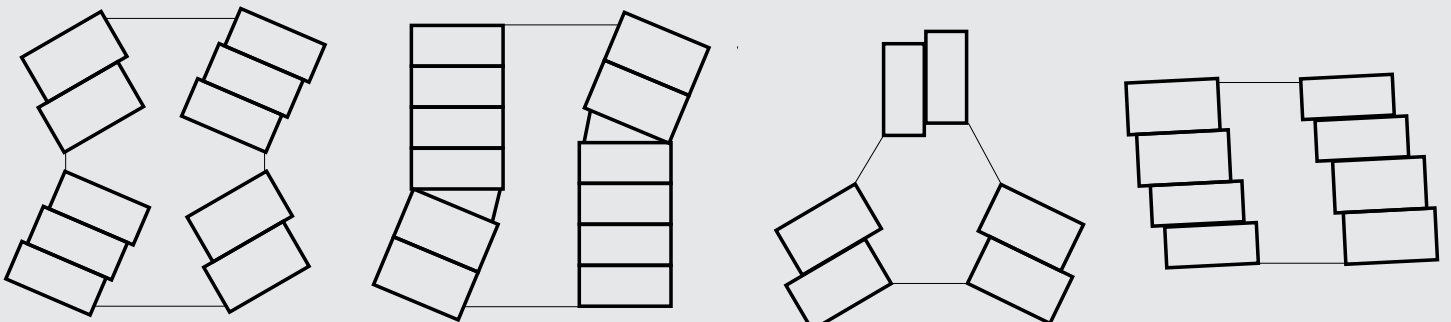
One of my main principles for these amphibious houses is being a guest in the landscape, by minimizing the impact on nature as much as possible. The difference with a typical residential area is that the public ground here consists of the original grasslands, and is not entirely paved. The movable infrastructure is completely demountable and flexible, and can be relocated as needed. Practically, these houses interact with the landscape by adapting to seasonal changes in water levels.

The houses are designed with large glass facades to create a strong connection with the outdoor landscape. This allows the residents to experience how the landscape changes.

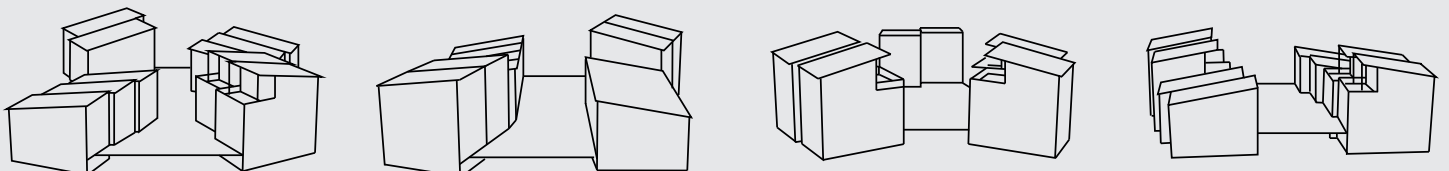
To create a diverse neighborhood, there is the possibility of connecting the houses in various shapes to each other. Due to the flexibility of this principle, it could be applied anywhere in flood-prone areas.



## THE DIFFERENT CLUSTER CONFIGURATIONS



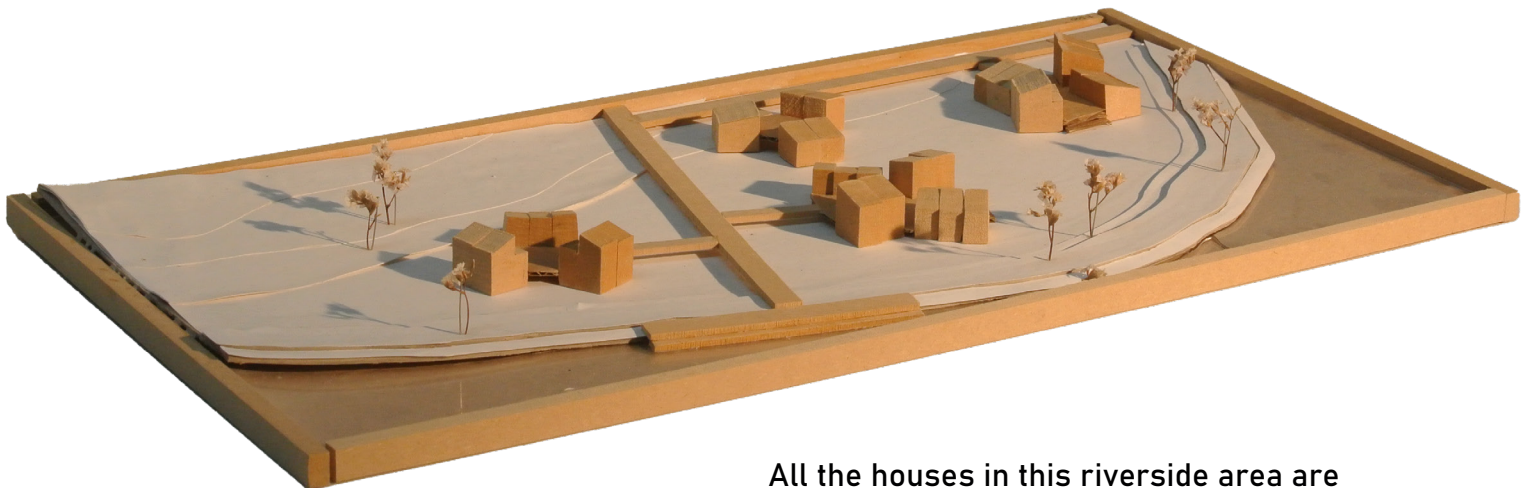
Floorplans



3D views

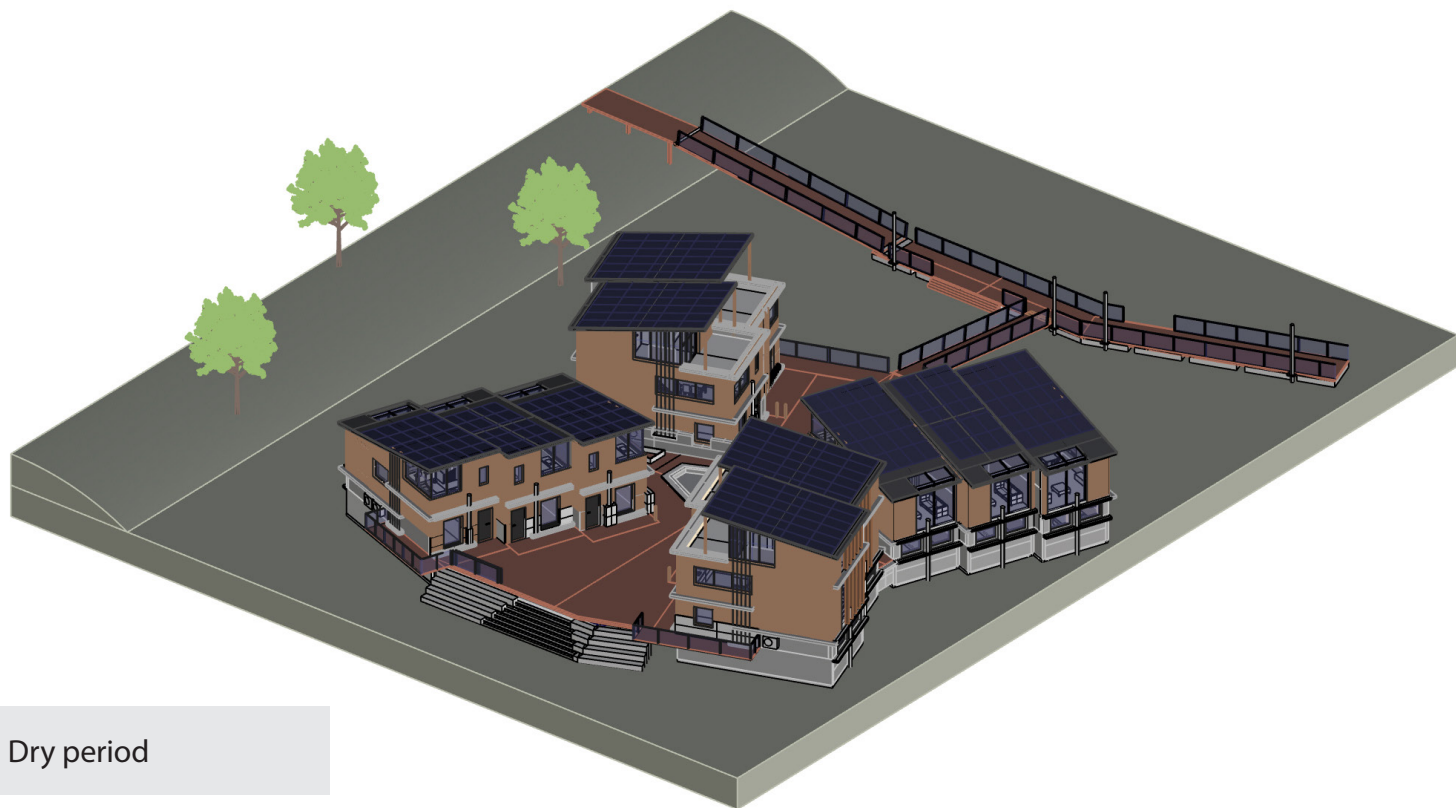


Example of what a floodplain with multiple amphibious housing clusters could look like.

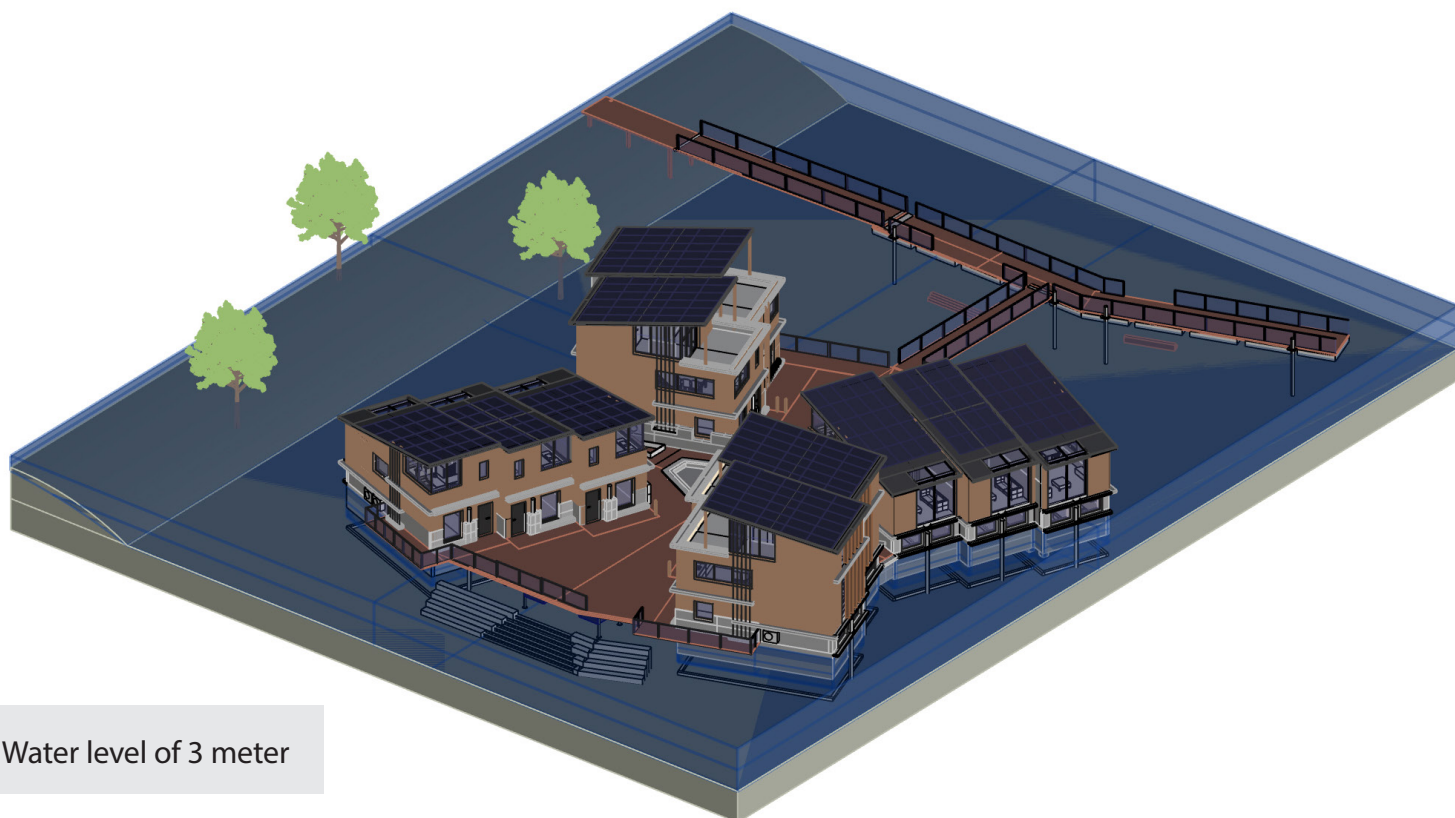


All the houses in this riverside area are connected to the floating infrastructure .

# The two scenarios



Dry period



Water level of 3 meter



## Accessibility

by high water

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At high water levels, the jetties are the first to float, requiring only a shallow water layer of 30 centimeters. When the water level exceeds 1.40 meters, the houses begin to float as well. The inner courtyard, equipped with its own pontoons, starts floating simultaneously with the houses. The mooring poles and access stairs remain securely fixed.

## 3m

### **WATER RISE IN THE FLOODPLAIN**

*An extreme scenario, but the houses still remain usable and accessible in this case.*

*The courtyard will always remain above water and provide access to the homes.*

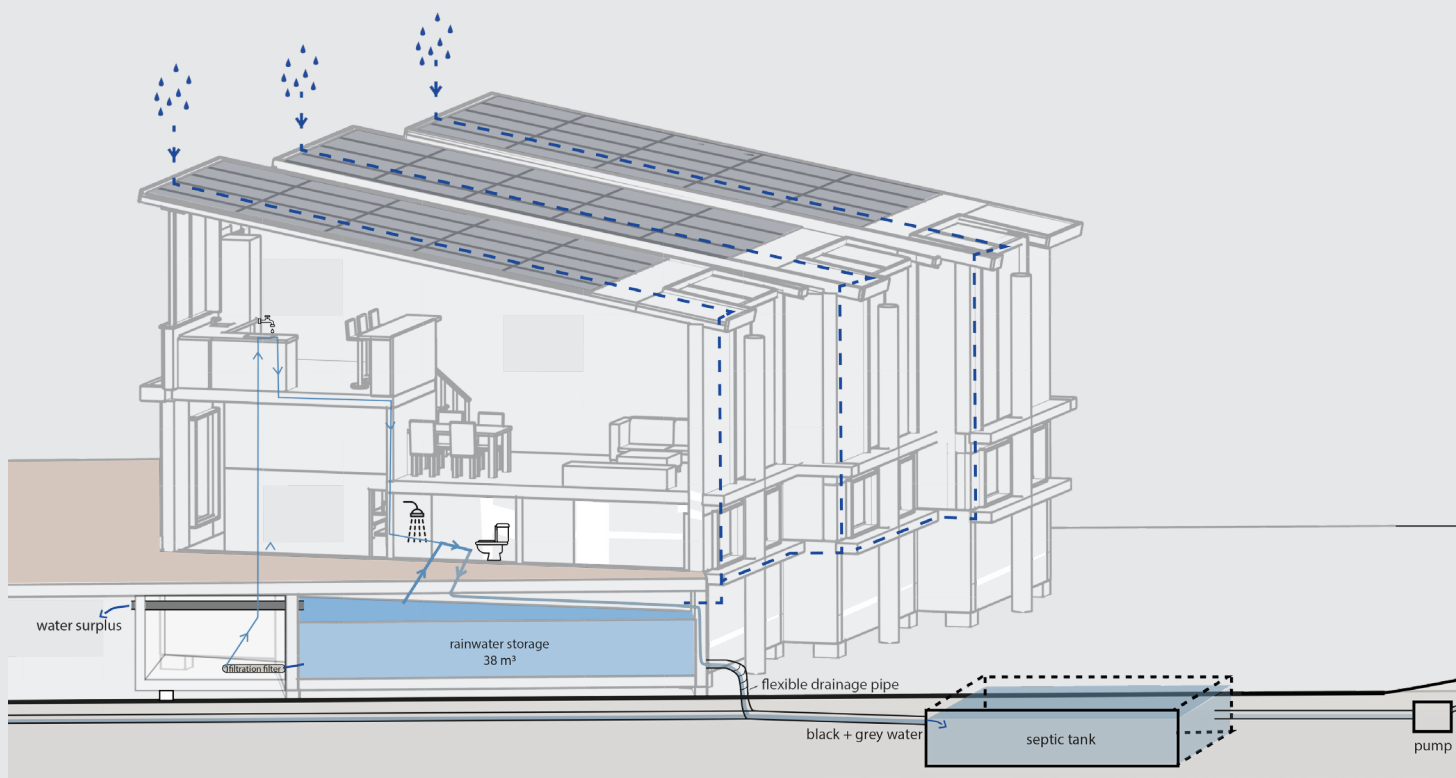
**BY A WATER LEVEL OF 1,4 METERS  
THE HOUSES WILL START TO FLOAT**

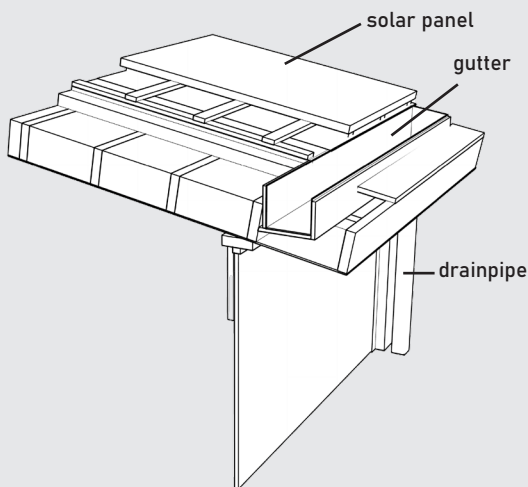
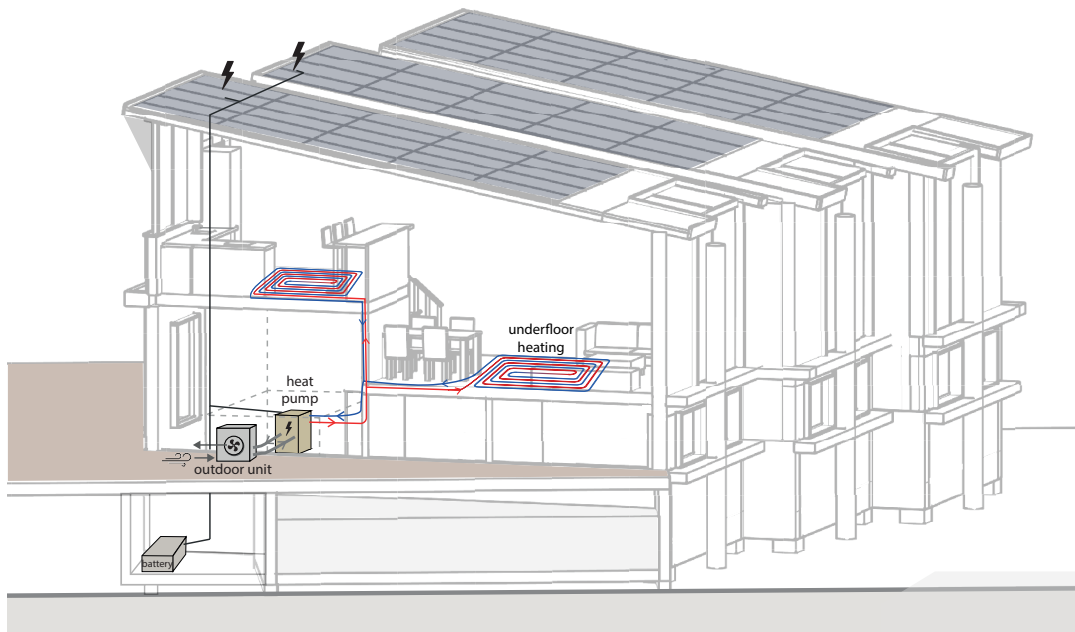
# Environmental aspects and off grid living

The adaptability of amphibious housing supports biodiversity. By allowing human habitation in flood-prone areas without disrupting natural water flows, these homes help preserve wetlands and other aquatic habitats. Furthermore, amphibious housing aligns with climate resilience goals. As climate change increases the frequency and severity of flooding events, these homes offer a practical solution for communities looking to adapt sustainably. In combination with an off grid climate system, this solution is a future proof and independent housing concept.

## RAINWATER STORAGE AND HELOPHYTE FILTER

Rainwater is stored in large tanks under the courtyard of the housing cluster. This water will be used for drinking water and domestic use, after being filtered. The wastewater will be drained into the river due a natural process, where a helophyte filter is used. This system utilizes the natural processes of wetland plants (helophytes) to filter and purify the water. Next to cleaning the water it also enhances the local ecosystem and provides additional environmental benefits.





## OFF GRID CLIMATE SYSTEM PRINCIPLES

### Passive house shading

Sun shines indoors during the winter, and shading during the summer

### Solar energy (integrated panels in roof)

Use of smart grid system, electricity can be shared. Houses are energy neutral.

### Ventilation unit

Provides fresh air 24/7, with heat recovery

### Helophyte filter

Biological drainage into river with helophyte plants on the dike

### Continuous insulation

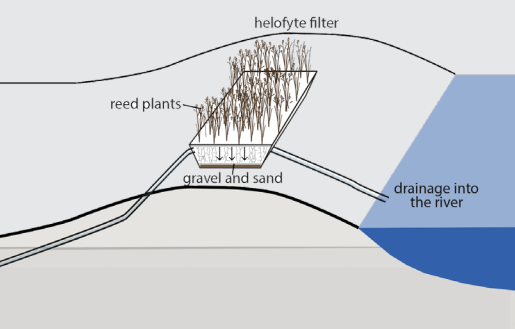
Limitation of thermal bridges

### Underfloor heating

Cooling and heating system with air-to-water heat pump

### Rainwater collection

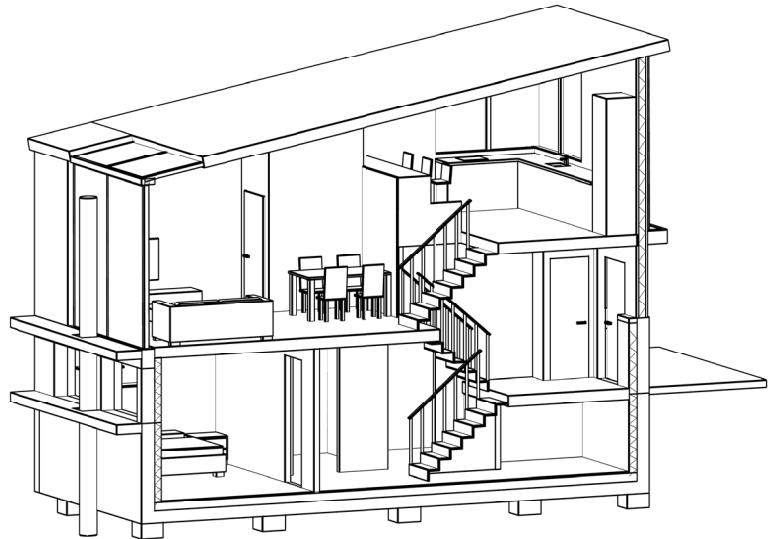
Reused for drinking water and domestic water use, more energy efficient



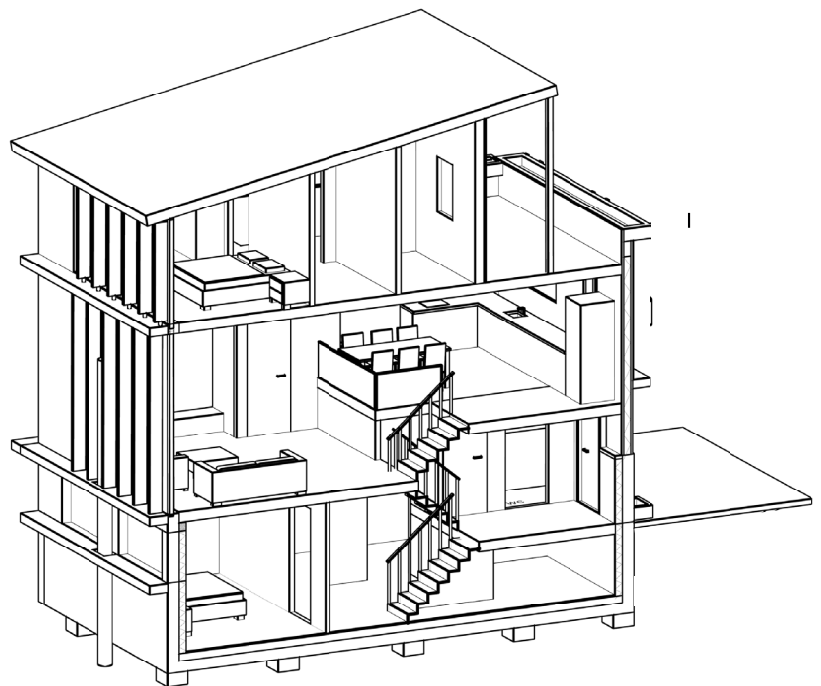
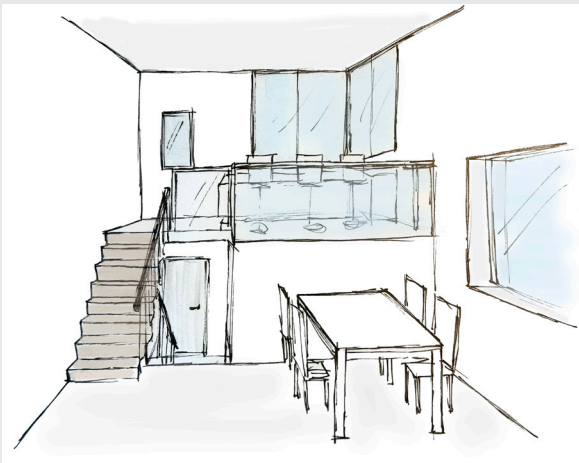
# The housing type variations

## WHAT MAKES THESE HOUSING TYPES UNIQUE?

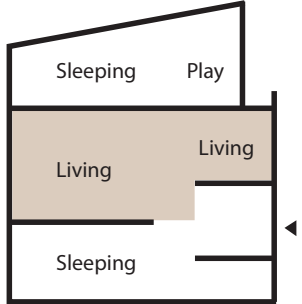
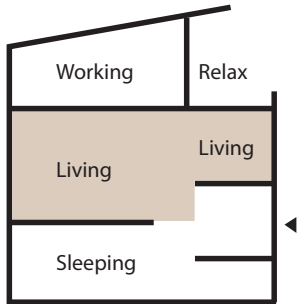
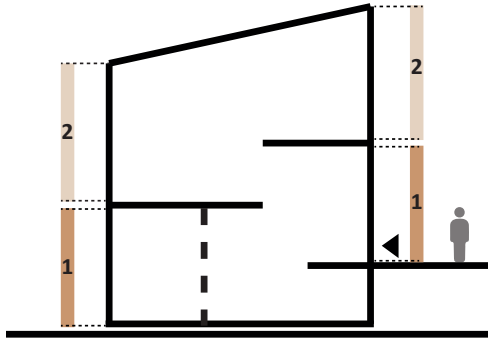
The design consists of two different housing types to offer a variety of houses and let multiple target groups live together. The houses all have a sloping roof with the high side facing the courtyard, so that two full floors are visible both from the courtyard level and from the ground floor level. This has led to a split level house, with the entrance at the courtyard level. The bedrooms are in the concrete ground floor and on the first floor there is the living room. The split level layout creates a visually interesting and functional home environment. The division provides a separate living area within the home while maintaining an open flow.



**TYPE 1**  
2-3 persons  
76,4 m<sup>2</sup>



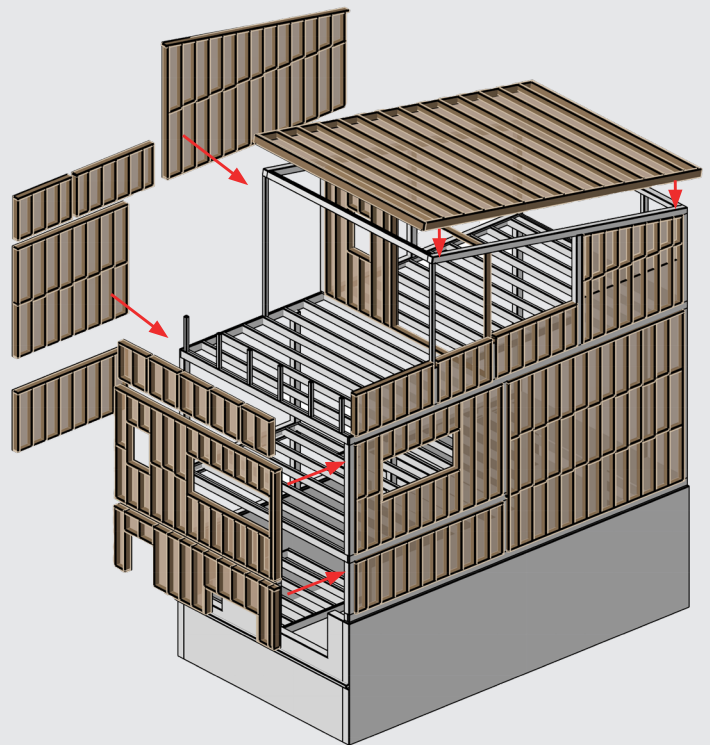
**TYPE 2**  
4-5 persons  
135 m<sup>2</sup>



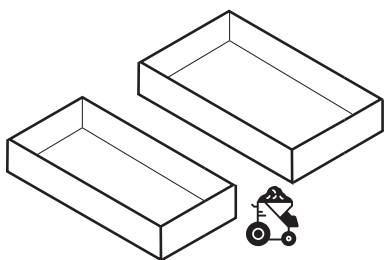
Flexibility in the split level layout

# Prefab construction

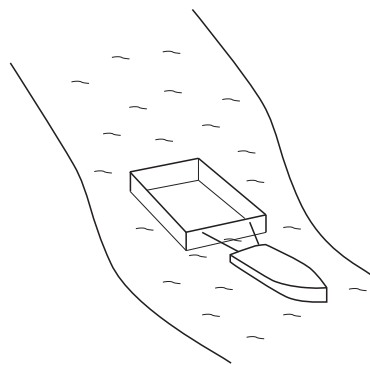
- Reduced construction time
- Weather independence due to minimal on-site construction
- Design flexibility
- Scalable solutions by larger needs



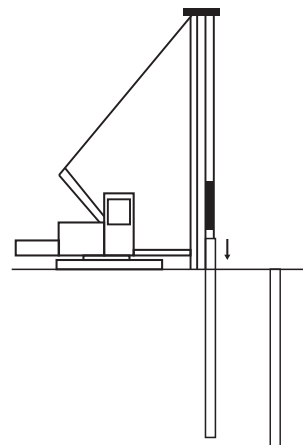
**1. Concrete pontoons are manufactured in the factory**



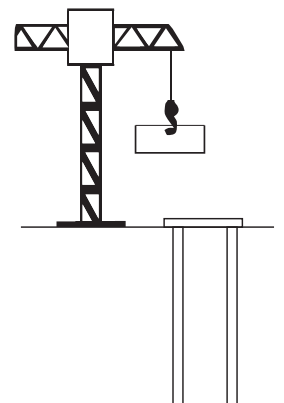
**2. Transported via river**

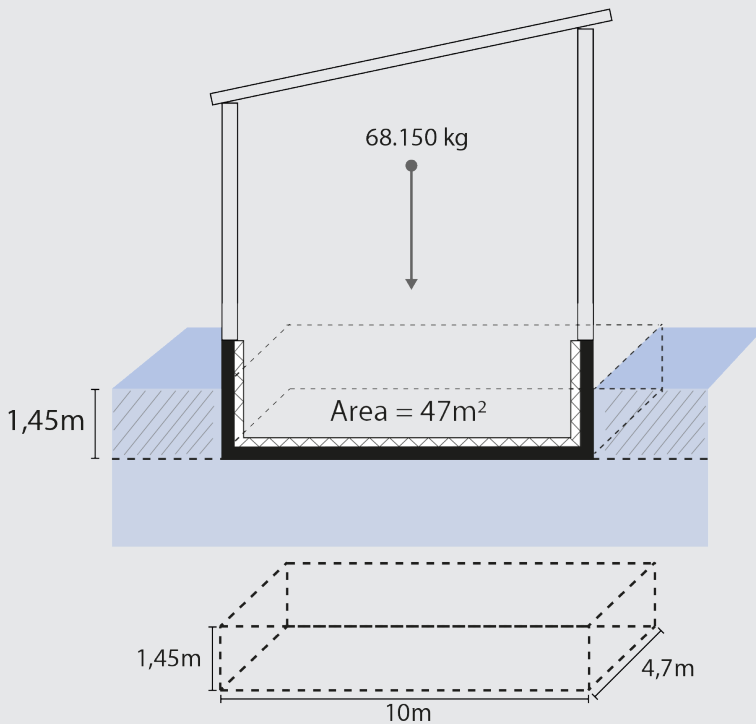


**3. Foundations placed on construction site**



**4. Pontoons placed on foundations with a crane**





## Archimedes' principle

Calculation example Type 1 by depth of 1,45m

$$V_{\text{displaced water}} = A * h_{\text{depth}}$$

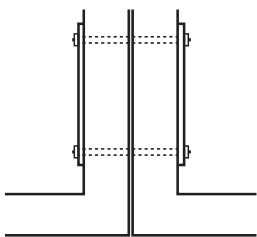
$$V = 47\text{m}^2 \times 1,45\text{m} = 68,15 \text{ m}^3$$

$$F_{\downarrow} = F_{\uparrow}$$

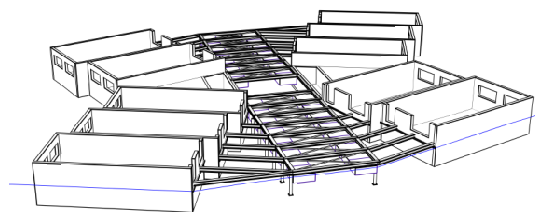
$$M_{\text{pontoon+building}} [\text{kg}] = V * 1000 [\text{m}^3]$$

$$M = 68,15 * 1000 = 68.150 \text{ kg}$$

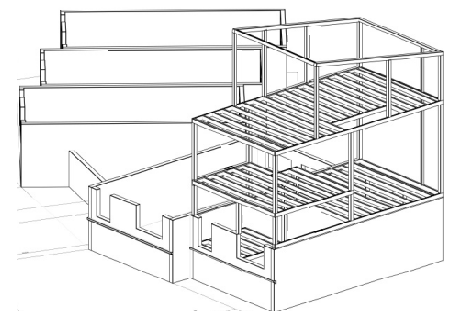
**5. pontoons connected to each other with steel wires**



**6. Courtyard structure constructed on-site**



**7. Timber frame skelet built on the pontoons on site**

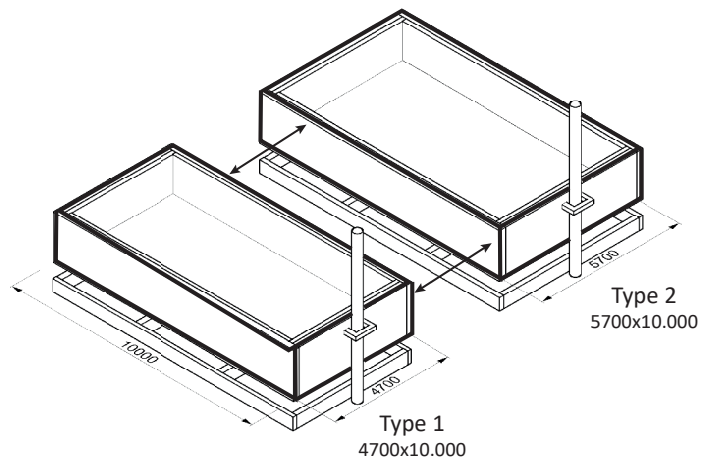


# Expandable applicability in floodplains throughout the country

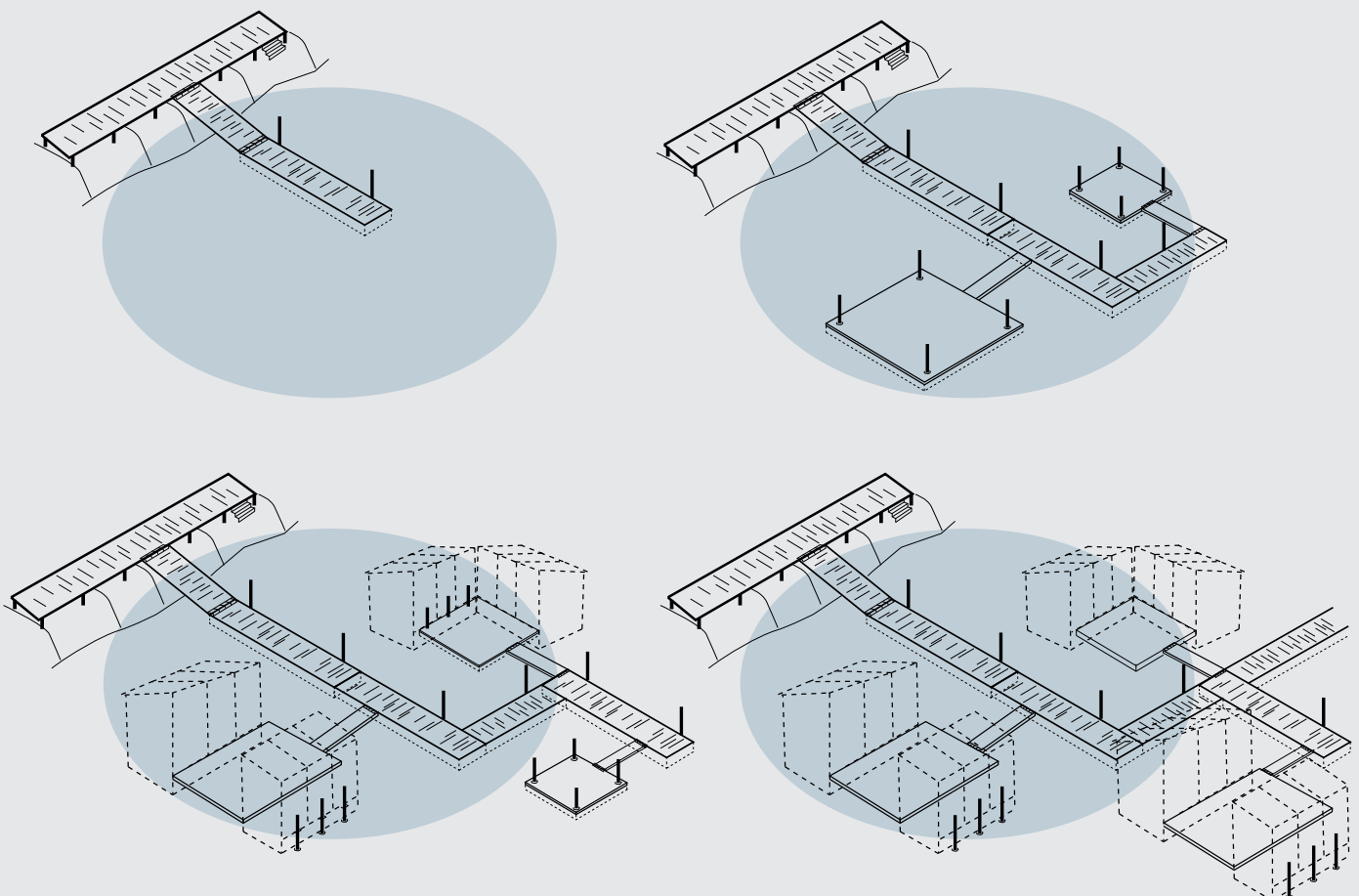
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The modular infrastructure and housing construction of the amphibious neighborhood offer expandable applicability throughout the floodplains of the Netherlands. Designed to adapt seamlessly to fluctuating water levels, these amphibious homes and their associated infrastructure can be easily assembled, disassembled, and relocated as needed. This flexibility makes it possible to implement these housing solutions in various flood-prone areas. When the demand for housing increases, new homes can be quickly added due to the prefabricated construction system.

The two concrete box sizes



## Modular infrastructure and homes create a system which can be applied everywhere

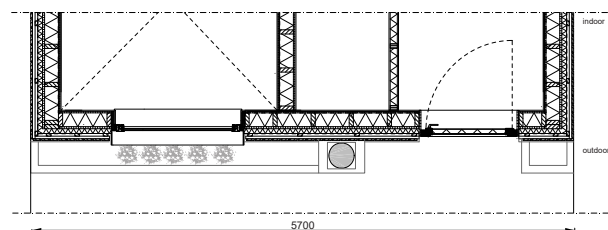




**A possible design for a riverside area**

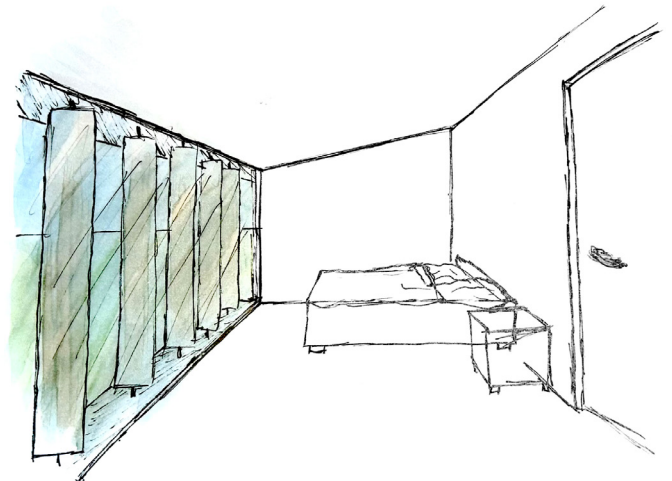
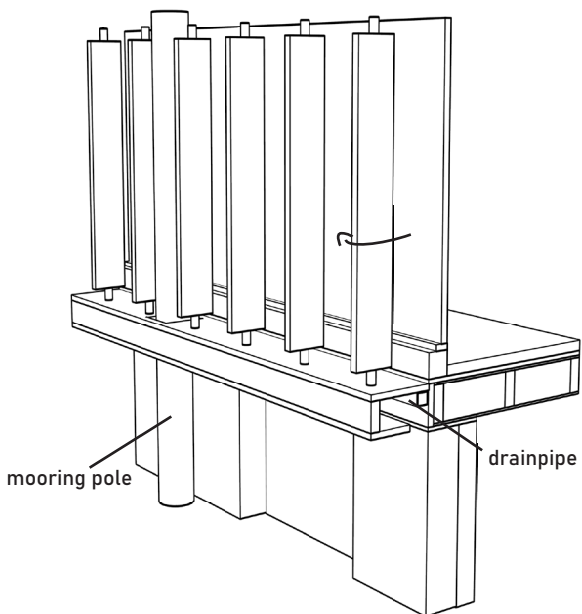


# Facade aesthetics and functionality



The relationship between aesthetics and construction elements is reflected in the facade. For example, the mooring post that is integrated in the structure of the horizontal facade elements. Moreover, the transition from concrete box to wooden facade reflects the function of the floating capability. The decking is attached halfway to the concrete box, just above the water level and so that there still can be windows on the ground floor.

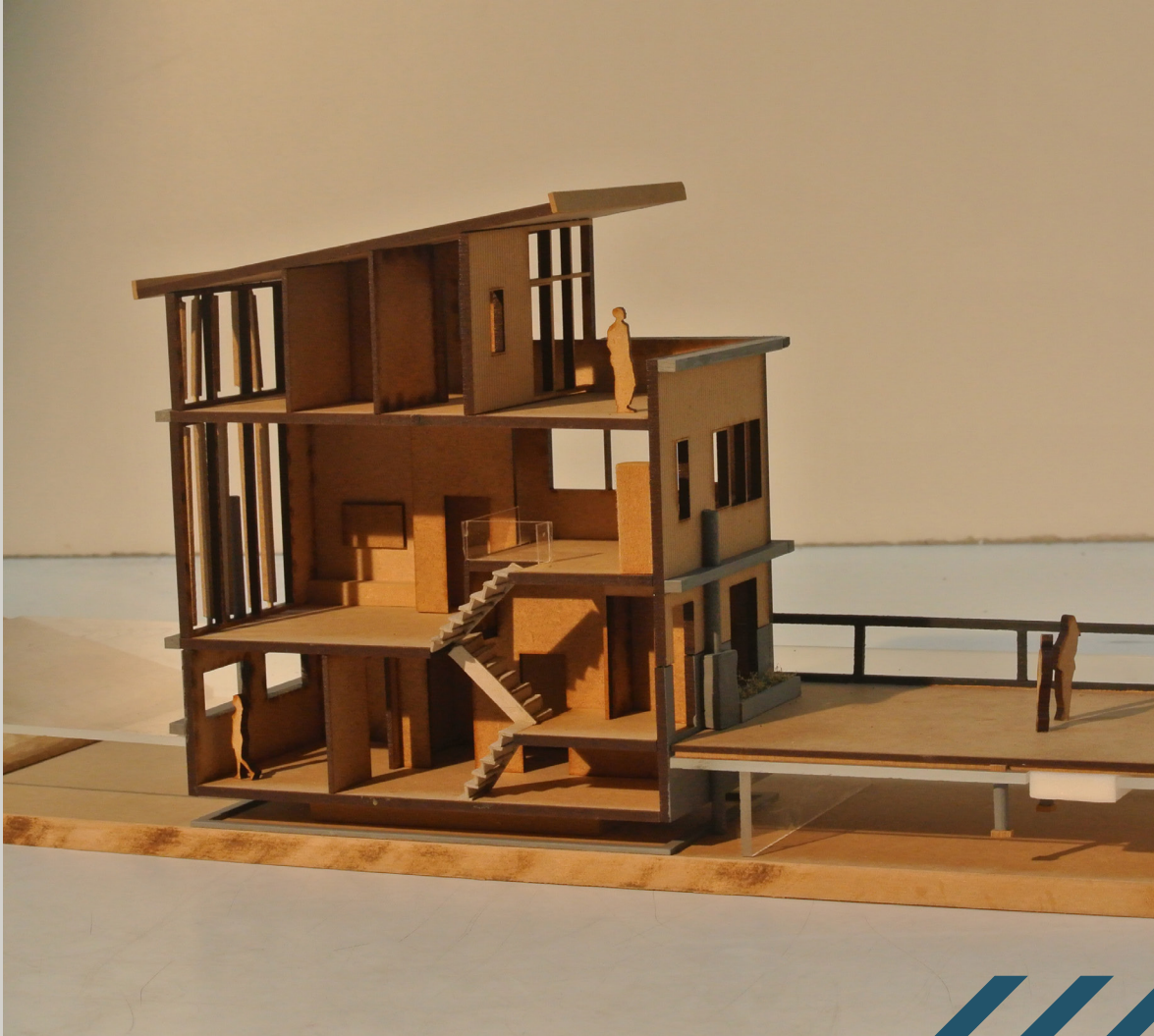
# Rotating sunshading



Ready for the new way of living?







Vision Booklet

FLOOD-PROOF LIVING AT THE RIVERSIDE

MSc Architecture - TU Delft