AS THE WATER RISES

amphibious housing in a rural setting

A study on rural architecture and amphibious structures and how they can correlate.

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Master Thesis

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ABSTRACT

As a response to the severe flood that hit rural communities in South-east Europe in May 2014, this thesis aims to explore how a modernisation of these regions can be achieved that upholds the local identity and provides rural communities with adequate protection from changing water levels and future floods.

The thesis therefore proposes an amphibious house within the architectural and social context of the rural region of Slavonia, Croatia.

In the event of a flood the amphibious house, which is equipped with a buoyant foundation, will rise safely above water and float. As water withdraws, the house is designed to settle back into the same place. The key in the project is to ensure continuity in the every day life; before, during and after a flood. Thus design strategies are proposed that reduces and controls damages, maintains access in the event of a flood, ensures quick recovery and strengthens local identity.

The thesis includes research on amphibious structures, readings on local building traditions, an analysis on the structural organisation of a rural community and a proposed design of an amphibious house.

The amphibious house does not only establish a new building technique in the rural regions of Slavonia, but offers a different picture of how a rural community should and can develop. By highlighting traditional heritage through modern architecture, and having rural structures acting as the New Frontier of responsible and sustainable development, rural areas can shift their perception of being out-dated into being seen as valuable and innovative as urban regions. It is a design proposal and strategy that can be implemented in all rural regions of Europe, creating resilient communities and safeguarding local heritage. It emphasises on a new method of flood risk management, shifting the attention from providing solutions in urban settings to the involvement of rural communities as well.

CONTENT

Image: Boris Kovačev

INTRODUCTION

In May 2014 severe floods hit southeast Europe. Over a period of three days the equivalent of three months of rain washed over the region of Croatia, Bosnia and Serbia and caused significant social and economic damage. Several rivers rose and flooded surrounding valleys. In some areas the water levels rose by 3.5 meters (*www.ifrc.org, 2014*). In Croatia, it was the rural region of Slavonia that was hit the worst. An area of over 210 km^2 was covered with water (*www.ifrc.org, 2014*) and around 15 000 people were forced to leave their homes (*World Health Organization, 2014*).

Changing water levels is a concern for most people of the world today and Croatia is no exception. As climate change takes hold, it is likely to see the scale and frequency of floods increase (*Huber, Gulledge, 2011 s. 3*). During the whole of 2014 Croatia was struck by three major floods.

Rural regions in Croatia, such as Slavonia, are however not only facing heavy rainfalls and overflow of rivers. As we live in a world of increasing urbanisation, rural heritage and its architecture has become neglected and to a greater extent overthrown by urban architecture. Rural communities and buildings are considered undesirable and are being replaced with structures that have little or no relationship to the context. According to the architect Zdravko Živković there is an on-going process of erasing the local architectural identity in the rural areas which has left residents with little or no understanding left for the built and natural environment of their region and hence nothing left for them to relate to (*Živković, 2013 s. 9*). Flood managment or flood methods that are used to reduce or prevent overflows of water in urban regions are not applicable to the challanges that rural regions are facing. The economic, structural and environmental circumstances are not the same, therefor the way of building can and should not be the same. Flooding is a natural phenomenon, nevertheless is it important to create an understanding of the fact that many of the disasters that follow are due to human activity. Building with materials that prevents water from evaporating and keeps absorption to a minimum is one of them. An inappropriate river management and construction in flood plains that reduce their capacity to absorb floodwaters is another (*www.klimatanpassning.se, 2014*). In rural areas the traditional building practice was handed down. The skill of constructing, the choices of materials, the design and spatial organisation and the location of the building was all based on an understanding of the building practise and why it was addressed in such way. Until World War II. After the war, rural areas and rural classes were socially and economically disregarded, the traditional knowledge was abandoned and new materials embarked on the scene. The models were the suburban settlements. After that, critics say, whole communities lost their identity and local context which resulted in a sense of hopelessness and vulnerability (*Živković, 2013 s. 8*).

Without a historical context and traditions we can not create an identity, not fulfill our obligations or orient ourselves in the presence. In order to create resilient, sustainable communities, an understanding of the past, future and the present needs to be established. As rural settlements in the region of Slavonia are facing new challenges, both climate-wise and social, an opportunity is offered to impose a new strategy for the built environment of these regions. A strategy that offers a different picture of how a rural community should and can develop. A strategy that focuses on responsible design and a resilient community at the same time as it promotes a particular region.

1.1 Aim and question

Is it possible to create architecture that nurture the well being of rural communities and safeguards the rural heritage at the same time as it provides adequate and innovative protection from changing water levels and future floods? And can that help change the understanding of the built and natural environment?

The aim of my thesis is to propose an amphibious structure within the architectural and social context of the rural region of Slavonia.

1.2 Delimitation

Since this thesis wanted to cover both traditional architecture and amphibious structures, time limitations acquired to keep all technical explanations on a research level. Accordingly I had to narrow the focus and concentrate on the architectural solutions and realisations of the design proposal. Weight distribution and exact calculations of the buoyant foundation is hence not taken into consideration. Technical solutions are given by referring to existing research and executed projects. Extensive research and testing has been carried out on the subject of amphibious structures throughout the years proving that the method works. However, additions have been made in this thesis in order to suit the specific needs of the site and of the proposal.

Consequently the focus of the thesis lies in how to incorporate traditional heritage, cultural and structural, into a modern, innovative design. Moreover, it highlights new methods of flood risk managements, shifting the attention from providing solutions in an urban setting to the involvement of rural communities as well.

1.3 Reading instructions

The thesis is divided into four parts. After an Introduction with aim, question and delimitation, follows a chapter with the background on the subject. The background starts of with a presentation on what floods are, why they occur and the impact they have on both human and nature. The current state in Europe regarding floods and flood risk management is brought up, whereupon the vision of the project is declared. After that the site of the proposal is revealed through the estimation of future floods within the national borders of Croatia and the depiction of the history and architecture of the specific region.

Part two presents the theory on amphibious structures with realised examples. Here the buoyant foundation is explained and the reason of choosing amphibious housing over other flood-preventive solutions is given.

Therafter the design proposal is presented, reconnecting to the theory presented in previous chapter and the traditional building practise of the region. A design proposal on an individual level is put forward, however a suggestion on how the community at large should manage the built environment in order to stay resilient against flooding is also proposed.

The last part of the thesis contains a discussion and conclusion where I evaluate the decisions that have been taken and solutions that have been applied to the design. The question whether the design is applicable in the specific setting is put forth and what weaknesses lies in the proposal.

02 background

a natural disaster
a flooded Europe
a vision

BACKGROUND

2.1 A natural disaster

Floods are the most common natural disasters in Europe. Over the course of ten years, between 1998 and 2009, Europe suffered from more than 200 major floods. During those intense floods 1126 people lost their lives and about half a million needed to relocate. Since 2009 catastrophic floods have and will continue to increase drastically, both with higher frequency and impact. As a result it is estimated that the costs of floods in Europe, during the upcoming three decades, will rise from four billion euro a year to over 23 billion euro. (ec.europa.eu, 2015)

Heavy rainfall is the leading cause of inland flooding. In May 2014, over a period of three days, three months of heavy rain fell over the Balkan region generating the worst floods in the history of the region since rainfall measurements began 120 years ago. The surplus of water quickly overwhelmed the drainage capacity of the river Sava and the embankment was breached. In the rural region of Slavonia, Croatia, an area of over 210 km^2 was covered with water and around 15 000 people were forced to leave their homes (International Sava River Basin Commission, 2015).

Floods are of natural descent. They become disasters however when they are of unusual proportion or when they occur unexpectedly, such as flash floods. Most floods are slow, taking days to develop which give residents enough time to prepare or evacuate. The damages however can still be as extreme as with flash floods (ec.europa.eu, extreme weather, 2015).

Experts classify floods according to their likelihood of occurring in a certain period of time. A hundred-year flood, as the one that struck the Balkans in May 2014, is an extremly extensive, damaging flood that would theoretically take place once every century. In reality however, the classification means that there is a one-percent chance that such a devastating event could happen in any given year. Hundred-year floods have in recent decades been globally occurring with alarming regularity. (nationalgeographic, 2015)

2.2 A flooded Europe

In November 2007 the European Union initiated a directive on Flood Risk Assessment and management with the intention to "*reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity*". By 2013 each Member State of the European Union was required to make an evaluation and identify the river basins and coastal areas within the country that are of potential flood risk. Maps of the extent of flooding and humans at risk in the areas were made and flood risk management plans, such as how to reduce flood risk, protect from flood risk and prepare for floods, were estab-

lished by each member state (ec.europa.eu, 2015).

In an effort to ease and redirect unavoidable floods, the main precaution made by governments and societies has been flood-resistant structures, such as levee systems, dikes and dams. Recent floods though have highlighted the vulnerability of societies and a more sustainable and responsible development has been integrated into the discussion of an efficient flood risk management. Instead of only resisting floods, it has been identified that the aim should be to reduce the likelihood and the impact of them.

The inappropriate usage of materials in the built environment is considered to be one of the main reasons of the increase in scale of floods. Water has simply nowhere to go. Measures such as decreasing the usage of paved surfaces, introducing materials that let precipitation through, creating passages and space for water to gather in, reduces the risk of flooding. Furthermore, deciduous trees are known to be a good method in order to regain control over changing water levels. Their roots work as a stabilizer and prevent erosion; moreover they absorb a huge deal of water when it rains. Green areas and vegetation are therefor of great importance in the built environment in order to keep water at a manageable level (*klimatanpassning.se, 2014*).

MAIN REASONS FOR FLOODS' INCREASE IN SCALE

MATERIAL PREVENTING INFILTRATION

X *Building materials that prevent water from evaporating and keeps absorbation to a minimum is frequently used in the built environment.*

DISRUPTING FLOOD PLAINS

X *Inappropriate river management and construction in flood plains reduces their capacity to absorb flood waters.*

WATER PASSAGES

X *There are fewer, or none, passages and depressions in the built landscape that can collect, move and slow water down.*

INCREASE OF HEAVY RAIN

X *Due to climate change, an increase of heavy rainfalls are expected, resulting in embankments being breached.*

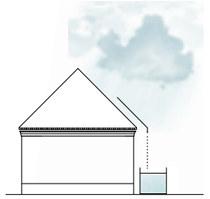
2.3 A vision

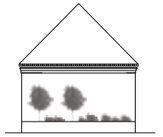
My vision is to create a design that reconnects rural communities and individuals to the local context and the regional identity at the same time as it provides necessary tools for a life in risk of floods. The key is to ensure continuity in the every day life; before, during and after a flood. In other words the design minimises the consequences of a flood and provides rural communities with strategies of modernisation that highlights local and regional identity rather than erasing them.

The goal is therefore to propose strategies that reduces and controls damages, maintains access in the event of a flood, ensures quick recovery and strengthens the local identity. My proposal accomplishes this by the amphibious structure that keeps property safely above water when needed and allows for the early return of the resident in the aftermath of a flood. To ensure quick recovery, the home is equipped with its own water and food supply. Easy access in case of emergency

is incorporated into the design in order to get residents fast into safety or keep connected with the community during the state of emergency.

Seeing the house as a space and structure of cultural and regional belonging, the design will act as a statement of rural structures being as high regarded, valuable and innovative as urban 'modern' structures. Letting rural communities become the "new frontier" of development, a responsible and sustainable development that create resilient communities.


WATER HARVESTING

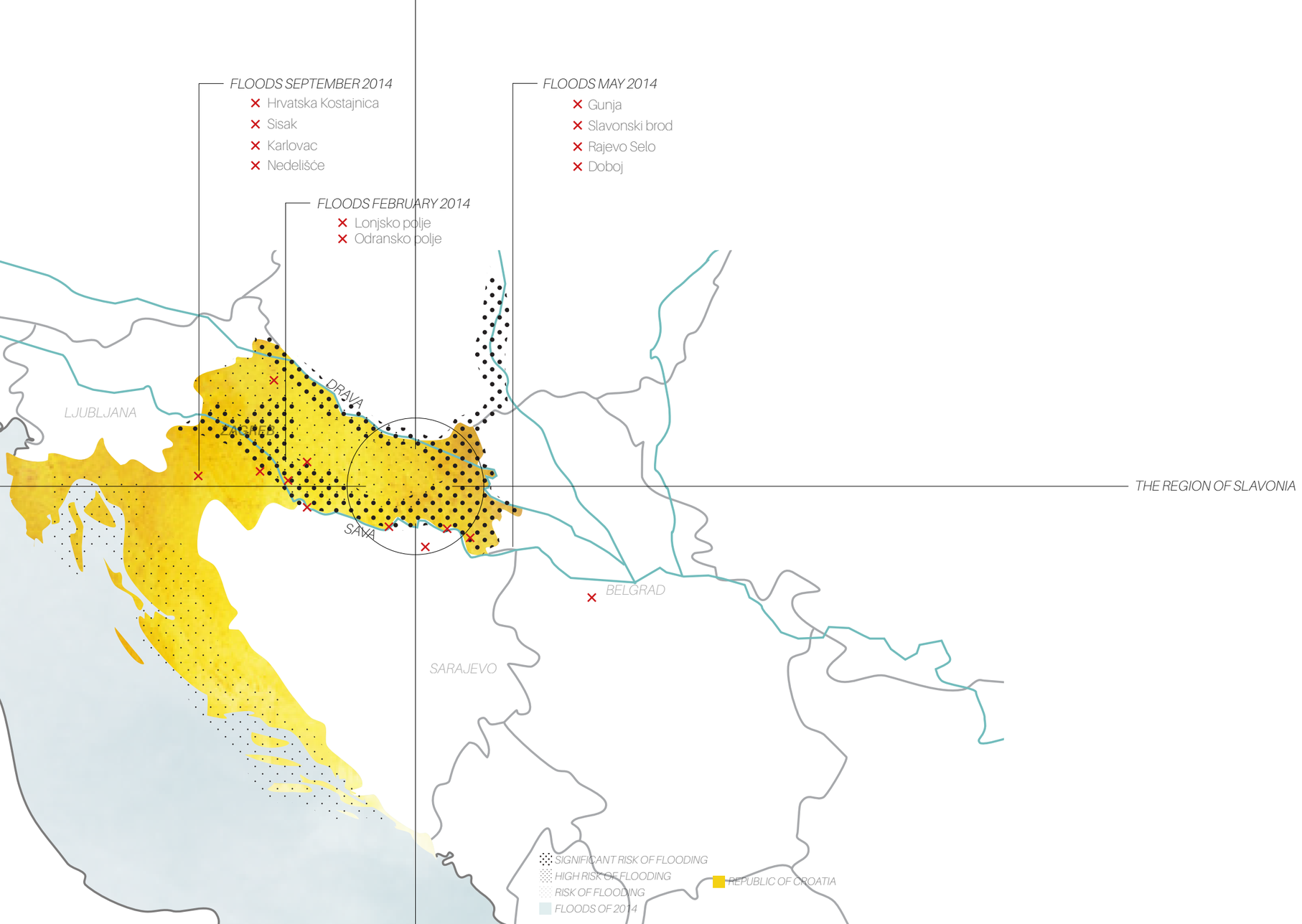

SHELTERED GARDEN/ GREEN HOUSE


MODERNISE TRADITIONAL ARCHITECTURE


EMERGENCY GATHERING POINT

03 site

Croatia estimates
the village of Podravska Moslavina
the architecture of Slavonia



SITE

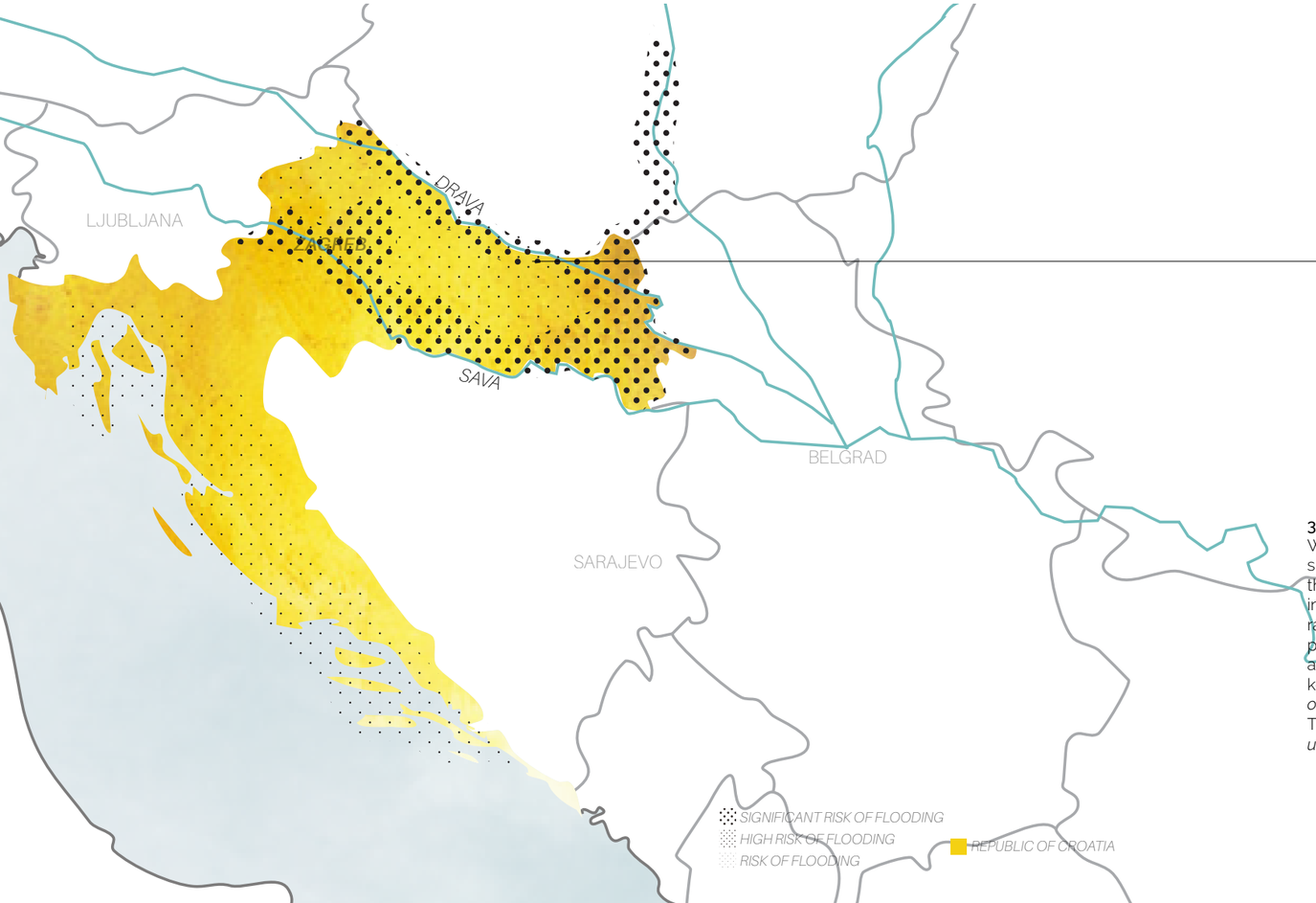
3.1 Croatia estimates

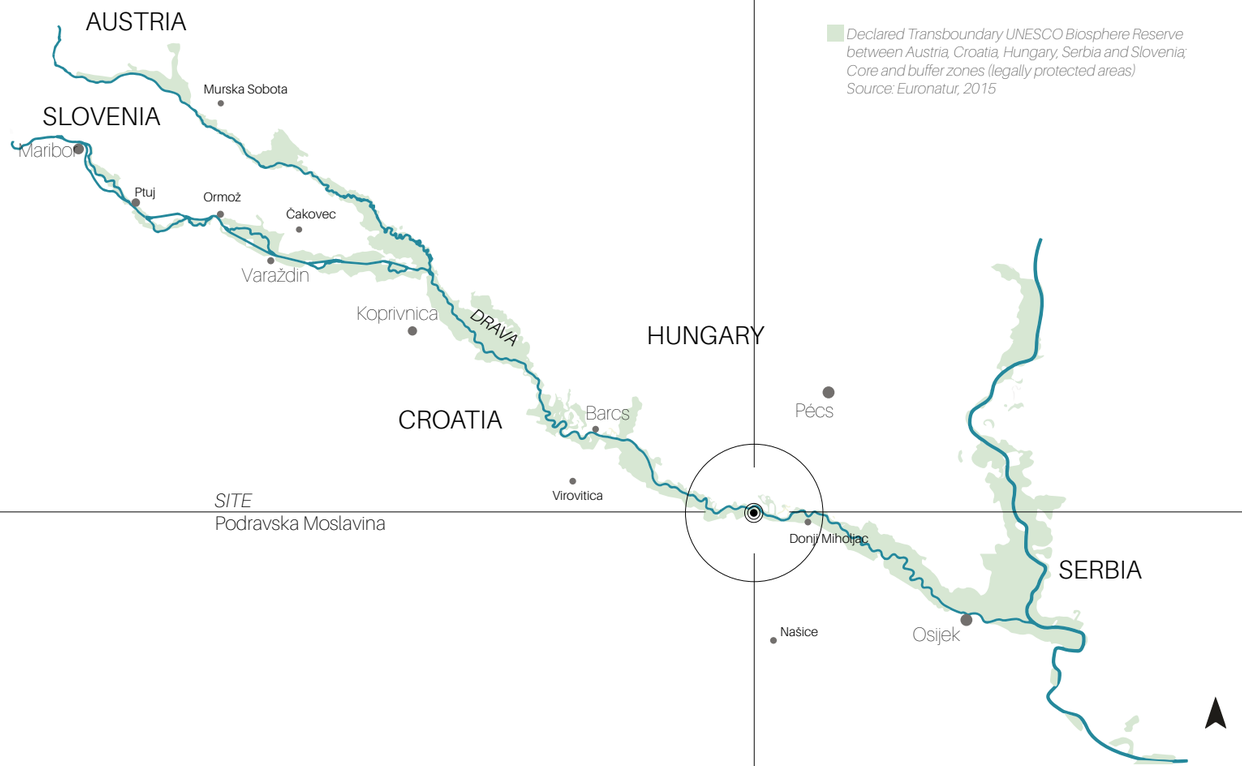
In addition to the large coastal shoreline of the Adriatic Sea, there are two major rivers that flow through Croatia. In the Flood Risk Assessment Directive the Croatian government identifies a large part of the country as being in danger of flooding, both coastal and inland (*Hrvatske vode, 2013*).

The river Drava, which has its source in Italian South Tyrol, is an important tributary of the Danube and passes through Croatia, forming most of the border to Hungary, before it joins the Danube near the city of Osijek in Eastern Croatia (*www.euronatur.org, 2015*).

The river Sava creates the border between Bosnia and Herzegovina, stretching itself all the way from Slovenia in the north to Serbia in the East. In May 2014 the embankment of the river Sava was breached after a week of heavy rain, affecting 3.5 billion people in Serbia, BiH and Croatia. During that same year of 2014, Croatia suffered big damages from three different floods. Heavy rains and melting snow caused the waters in the areas along the two rivers to rise fast and unexpectedly.

The region of Slavonia, with its dominantly flat landscape, is situated in-between the two main rivers.





Declared Transboundary UNESCO Biosphere Reserve between Austria, Croatia, Hungary, Serbia and Slovenia; Core and buffer zones (legally protected areas)
Source: Euronatur, 2015

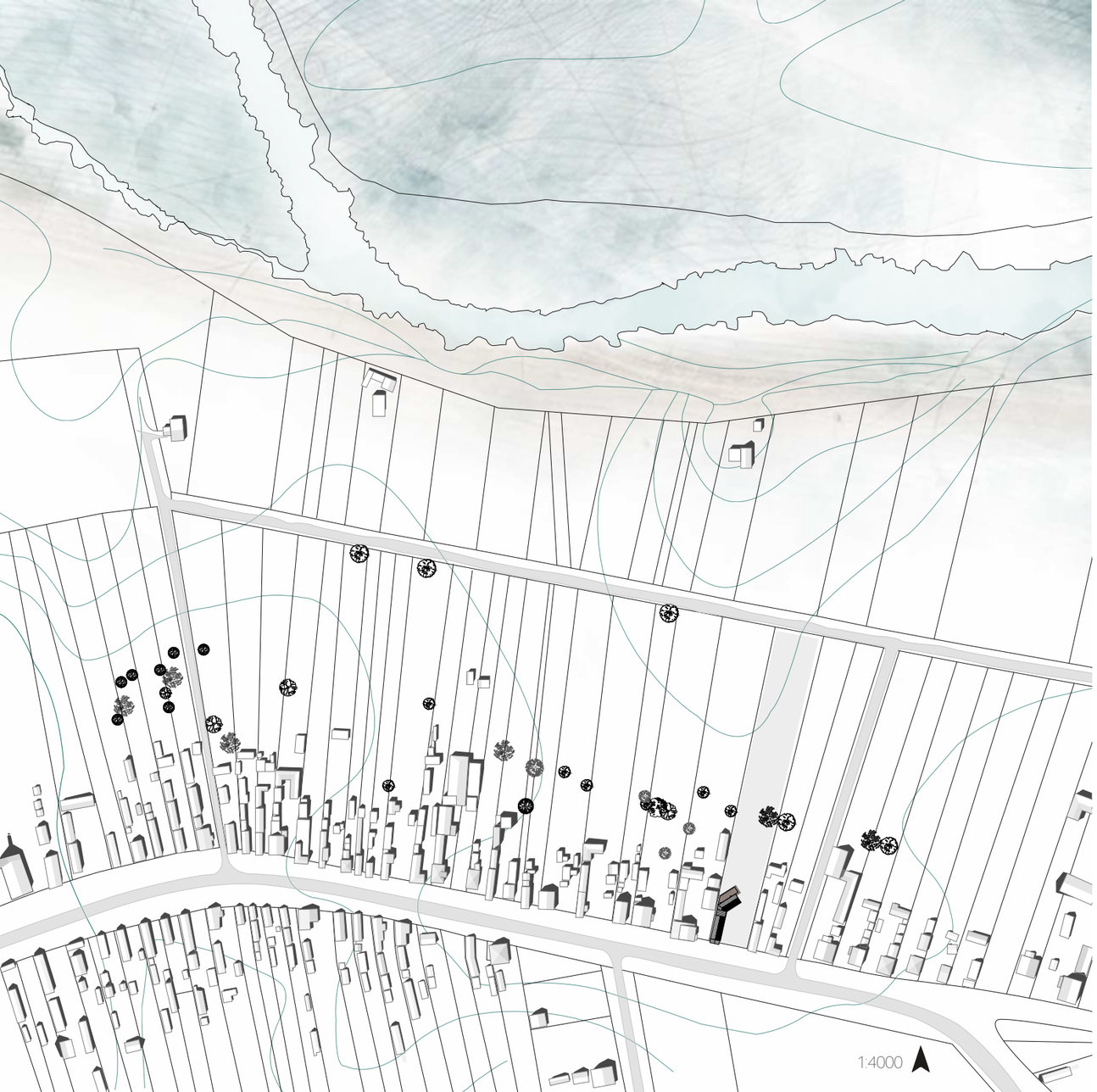
3.2 The village of Podravska Moslavina

With its approximately 1500 inhabitants, the village of Podravska Moslavina is a traditional Slavonian village situated, like many others, along the river Drava. Since July 2012 however, the village is also situated inside an UNESCO Biosphere Reserve (*Unesco, 2015*) which puts the rare river and wetland landscape between Hungary and Croatia under protection. The areas along the Drava and the Danube were classified as a Biosphere Region because of the extent to which the areas had kept their traditional, natural and cultural landscape (*www.euronatur.org, 2015*), as well as the rich habitat of plants and animals in the area. The purpose of a Biosphere Reserve is to "*help preserve the natural values of the floodplain region*" and "*provide a possibility for the revival and modernization of floodplain management*" (*Unesco, 2015*) A flood risk management plan that does not include extensive physical measures upon the river landscape itself is therefor needed. The region is characterised by cultivated land and village areas, cattle grazing and hay making, forest management, sand and gravel extraction, diverse types of industry and ecotourism (*Amazon of Europe, 2015*). And the village of Podravska Moslavina is part of it all with its extensive agriculture and traditional living.

RIVER DRAVA

THE VILLAGE OF PODRAVSKA MOSLAVINA

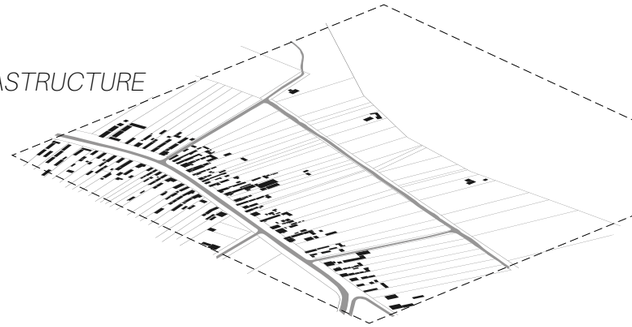
SITE OF PROPOSAL



the built and natural environment

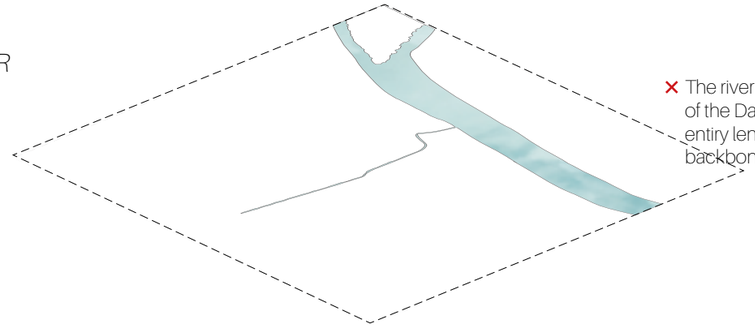
current conditions

INFRASTRUCTURE



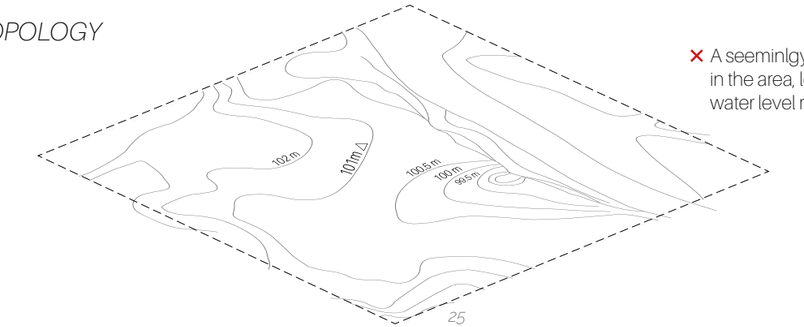
- Parcels of cultivated land run almost all the way up to the river basin. A main road (state road - an important route) cuts through the village.

RIVER



- The river Drava, an important tributary of the Danube, flows along almost the entiry length of the village, acting as its backbone.

TOPOLOGY



- A seeminlgy flat landscape is dominant in the area, letting floods pour in as the water level rises.

schematic overview of the built environment

structure of the village

- ✕ conifers are not as goog as decidiuous trees in that to absorb a huge deal of water when it rains
- ✕ traditionally a bench is placed in front of the property creating a semi public area
- ✕ a high gate encloses the private property, physically and visually.

- ✕ In Slavonia, with its dominantly flat landscape, canals along the whole of the settlement where excavated in order to provide protection against floods. Today however, these canals are more often left overgrown, depriving them from their soul purpose.

3.3 The architecture of Slavonia

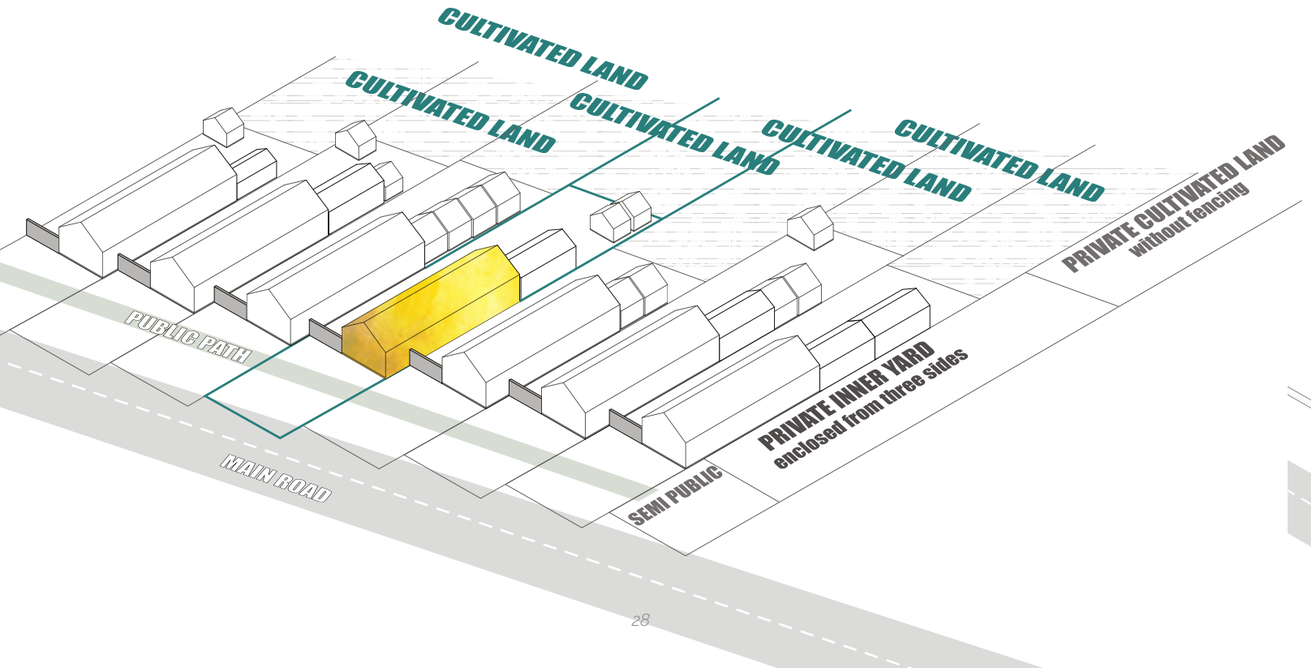
Originally settlements in Slavonia were mainly linear with houses on one or both sides of the main road. Typically the main house consisted of three rooms aligned in one row. Rooms for agricultural purposes, such as storage and barns as well as the main toilette, continued further down into the yard as separate structures. Every structure served its specific purpose; one room for smoking ham and sausages, one room for brewing the traditional brandy, one room for storing crops. During the warmer part of the year a 'summer' kitchen was needed in order to keep the main house from overheating, as well as it helped keeping the main house clean. Still today, a summer kitchen is considered both practical and desirable (*Živković, 2013 s. 88*).

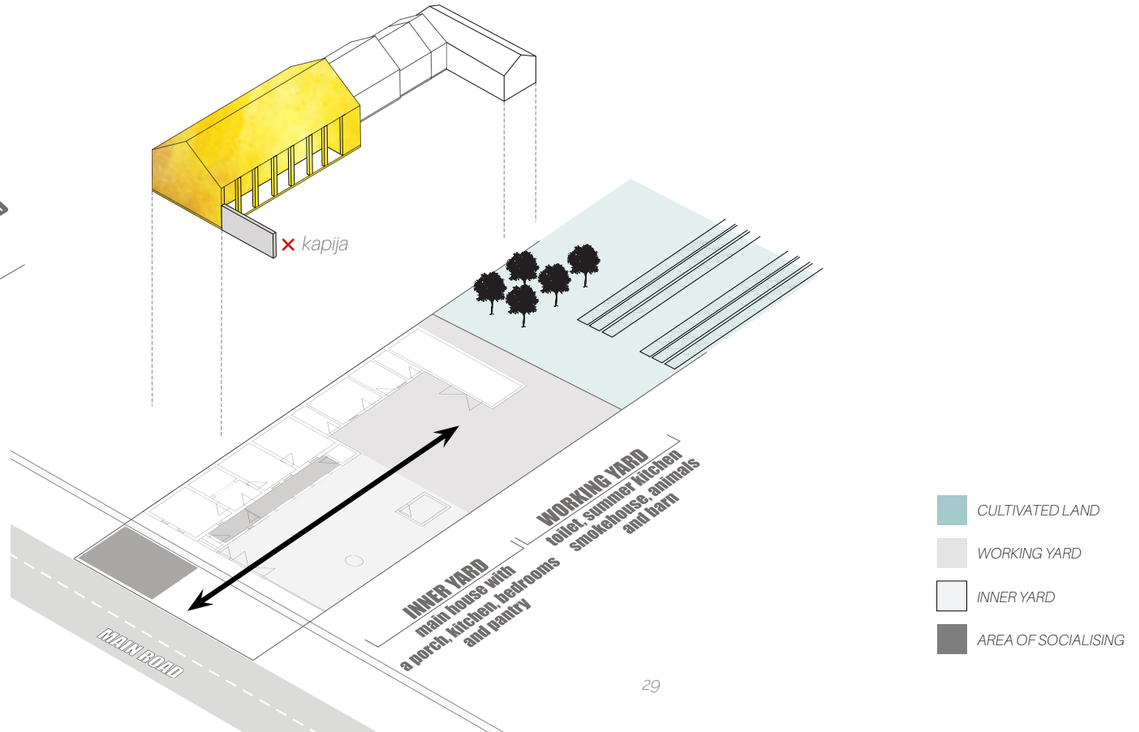
The house faced only its own inner yard, turning the backside towards the neighbouring parcel thus creating a natural border between parcels. There were no windows onto the neighbouring plot (*Živković, 2013 s. 89*). The plot of the house was divided into the inner yard and the working yard, ending in a long parcel of cultivated land. The yard was the working and living area, moreover it was the family's intimate area.

A significant element of the typical Slavonian house was, and still is, the porch that stretches itself along the front of the main house. The porch protected the area in front of the door from rain, snow and sun, as well as it protected the wooden walls of the house from the weather. Furthermore it acted as a connection between the rooms of the house. The porch varied in executionsize and style. In latter days they have become more and more enclosed, with or without windows, turning into a corridor rather than a porch.

The very typical gable is the only part of the house that is visible from the street. A large, high gate encloses the yard, keeping outsiders from looking in and creating a very enclosed private area for the household. It is in front of the house and in front of the gate, called *kapija*, that social life takes place. Usually a small wooden bench is placed in between the house and the street, creating a semi-public area (*Živković, 2013 s. 95*).

The gate, *kapija*, opens up a straight axis from the main street all the way to the cultivated land farthest down the parcel. This is an important axis since it provides access for heavy machinery to and from the working yard.

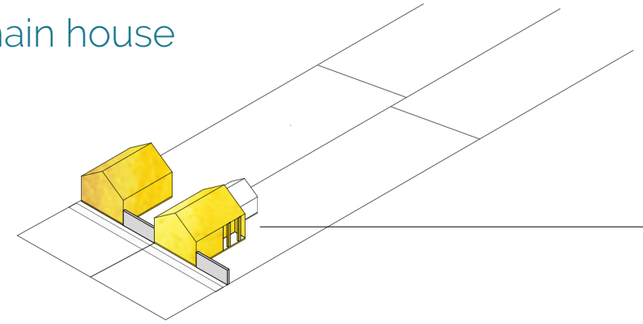




development of the main house

18TH CENTURY

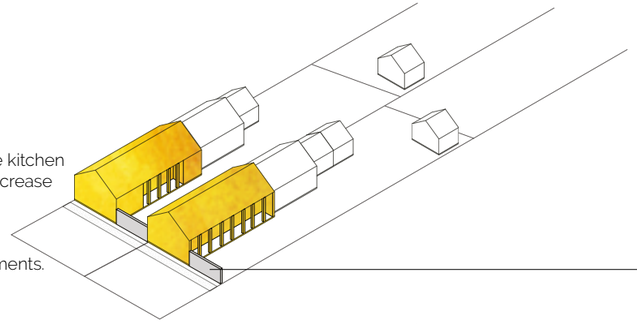
one-room family house with an enclosed inner yard develops into a two-room house and the start of the typical Slavonian porch



the main house is placed in the front of the parcel, towards and directly on to the public pathway. Additional small houses and rooms are placed further down into the yard.

19TH - 20TH CENTURY

main house is extended with room for the kitchen and additional bedrooms, as well as an increase of rooms for agricutlural purposes down the yard. Furthermore, the porch is given a prominent status and takes on different designs with or without ornaments.

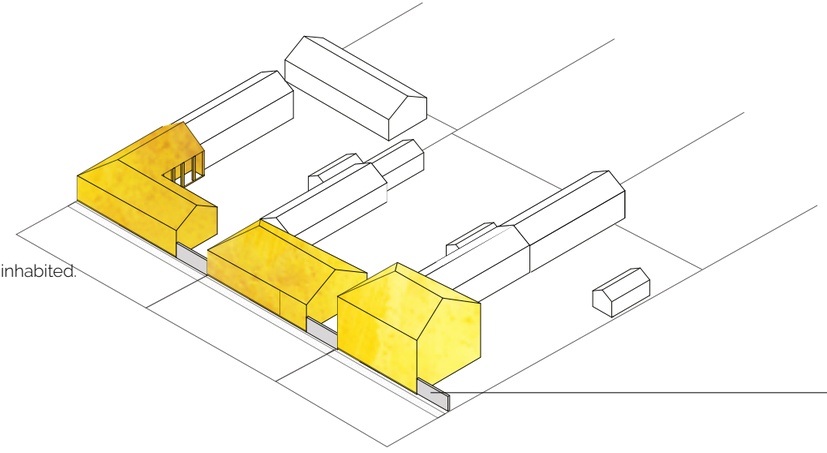


a 1.8m high gate seperates the private inner yards from the public path way and street, thus keeping outsiders within a distance both physically and visually.

social contact is made in front of the gate that leads into the inner yard. Most houses have a little bench on the tiny lawn in front of the house. Since the public path crosses this part of the parcel, this is where social gatherings happen.

OTHER HALF OF 20TH CENTURY

the traditional house is replaced with larger single storey houses. In recent years, two-storey houses have become a standard, however often incomplete with a second floor that is uninhabited.



the high gate is still very much present in a Slavonian village

street views from the village of Podravska Moslavina

various types of the typical Slavonian gable

social interaction occur in front of the high gate and gabel, or on benches traditionally placed in front of each house.

04 amphibious

amphibious structures
precedents

AMPHIBIOUS

4.1 Amphibious structures

Houses that are amphibious have been around for a while and are nothing new to the architectural discourse. Conversations and research have been carried out for years on this alternative strategy that allows otherwise conventional structures to rise and float when needed, consequently avoiding the devastating capitulation of incoming floodwaters.

What keeps an object floating is called buoyancy. Push a floating object down while it is in water and it will sink a bit, let it go and it will bounce back. An object will remain buoyant and float on water if the weight of the object is equal to the pressure of a body of water. If the object is too heavy or too dense, it will sink. Moreover, the object needs to stay upright in order to stay afloat.

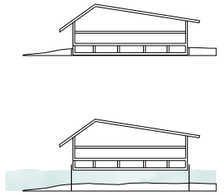
Amphibious houses are equipped with a buoyant foundation. Under usual circumstances, the house rests firmly on the ground, however when a flooding occur the foundation lets the house float as high as necessary to remain safely above water. A vertical guidance system prevents the house from tilting, keeps it from floating away and helps it settle back into the same place as water withdraws. An amphibious structure rather works with floods than against them and as opposed to many other flood mitigation strategies it preserves the communities vital connection to the street and surroundings. Rather that permanently elevating the houses high of ground, the house only rises in case of severe flooding (*English, 2009*).

In rural Louisiana, amphibious structures have been around since the 1970's, in the Netherlands a whole neighbourhood contains amphibious houses, in Bangladesh one out of bamboo has been made and in August 2015 the very first International Conference on Amphibious Architecture, Design and Engineering is expected to take place in Bangkok, Thailand.

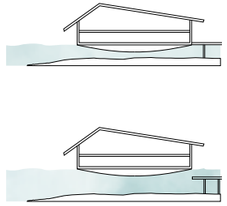
as the water rises, a conventional house gets flooded

a conventional house with a buoyant foundation rises with the incoming water

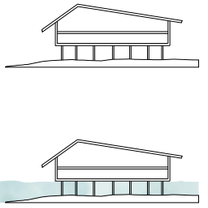
dynamic vs. static solutions in the event of a flood



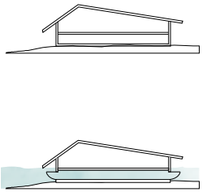
↕ an amphibious strategy is a dynamic solution working with changing water levels rather than against. Under normal circumstances the house acts like a conventional house on ground.



↕ a floating structure that is always in contact with water restrains residents by disconnecting them from the street and the surroundings.



— elevated structures keep houses safe from water, however it is a static solution with a limit on how high the flood can rise. There is no guarantee the house stays above water level at all times. Furthermore, a house on pillars changes the typology of a neighbourhood.



— one solution is to let water pass through the house, in order to re-direct waterflows. The force and destruction of the flood is then decreased. Water resistant material on the first floor is, needless to say, essential. Moreover, the first floor should be cleared from all important property.

4.2 Precedents

Different examples of amphibious structures and buoyant foundations have been carried out throughout the years. Some cost-effective, like the case in Louisiana or Bangladesh, and others more technically equipped like the BACA house on the River Themes in London. Usually the houses are equipped with utility lines that either have self-sealing breakaway connections or have long, spiralled umbilical lines.

There are two different methods carried out in the Lift House by Prithula Prosun situated in Dhaka, Bangladesh. The structure exists out of two houses where one has a hollow ferrocement foundation and the other has a bamboo frame foundation filled with used plastic water bottles. The service spine of the house is a static structure that provides the vertical guidance and stability to the two amphibious bamboo houses. The service spine also contains shared composting toilet and a water harvesting system that collects and filters rainwater through a biosand filtration (*Prithula, 2011*).

The Float House in New Orleans' Ninth Ward, by the Make it Right Foundation, is projected to sustain its own water, survive floodwaters and be able to be manufactured as low-income housing. Like the New Orleans shotgun house, the Float House sits on a 1.2 m base. It rises vertically on two guideposts placed within the interior construction and is able to float up to 3.5 meters as water levels rise. In the event of a flood, the framework of the house acts as a raft. The guideposts act as masts, anchored to the ground by two concrete pile caps supported by six 13.7 m deep piles (*www.dezeen.com, 2009*).

In the village of Maasbommel in the Netherlands a series of amphibious houses by Dura Vermeer were constructed in order to show how people in floodplains can lead a life filled with water and still be ensured a continuity of everyday life. The houses are placed on floating concrete casings and secured, against strong winds and waves, with permanent mooring posts driven deep into the ground. These guide the building to rise up and back down when the river changes levels. When there is no flood, the houses rest on the riverbank. As ordinary houses they have basements, decks and small gardens all supported by their foundation. Flexible pipes for electrical, water and sewer lines will continue to provide even in the event of a flood (*urban green-blue grids, 2009*).

On the Themes in London, a lightweight timber-framed structure by Baca Arhcitects sits inside an excavated "wet dock" made from steel sheet with a foundation of a waterproofed concrete hull. As vertical guideposts, four posts are placed on the side of the house, allowing it to slide up and down when needed. The garden is terraced in order to give signal when a flood is occurring. As the two first terraces fill with water the house should begin to rise (*Baca Architects, 2015*).

In Raccourci Old River, Louisiana, a design has been used for over 30 years, where polystyrene foam blocks are used as a retrofit measure to accommodate rising and falling levels of the wetlands (*English, 2009*). Furthermore, At Louisiana State University Hurricane Center a non-profit research initiative called The Buoyant Foundation Project was founded in 2006 with the purpose of designing and realizing retrofitable buoyant foundations for New Orleans. Research and development testing for various construction process and material options are being carried out. In their design a structural steel frame attaches floatation blocks to the underside of the house. Four vertical guidance poles, exterior to the house, act as telescoping tubes that allow the house to move up and down to any depth as a function of the length of guideposts. The tops of the poles are attached to the steel frame. The house is equipped with utility lines that either have self-sealing breakaway connections, for gas and sewer, or long, spiralled umbilical lines for water and electrical. When the area is flooded, the flotation blocks lift the house, carried on the steel frame, but is prevented by the poles to drift away (*www.bouyantfoundation.org, 2015*).

The Lift House, Dhaka, Bangladesh

The Float House, New Orleans, USA

Amphibious houses, Maasbommel, the Netherlands

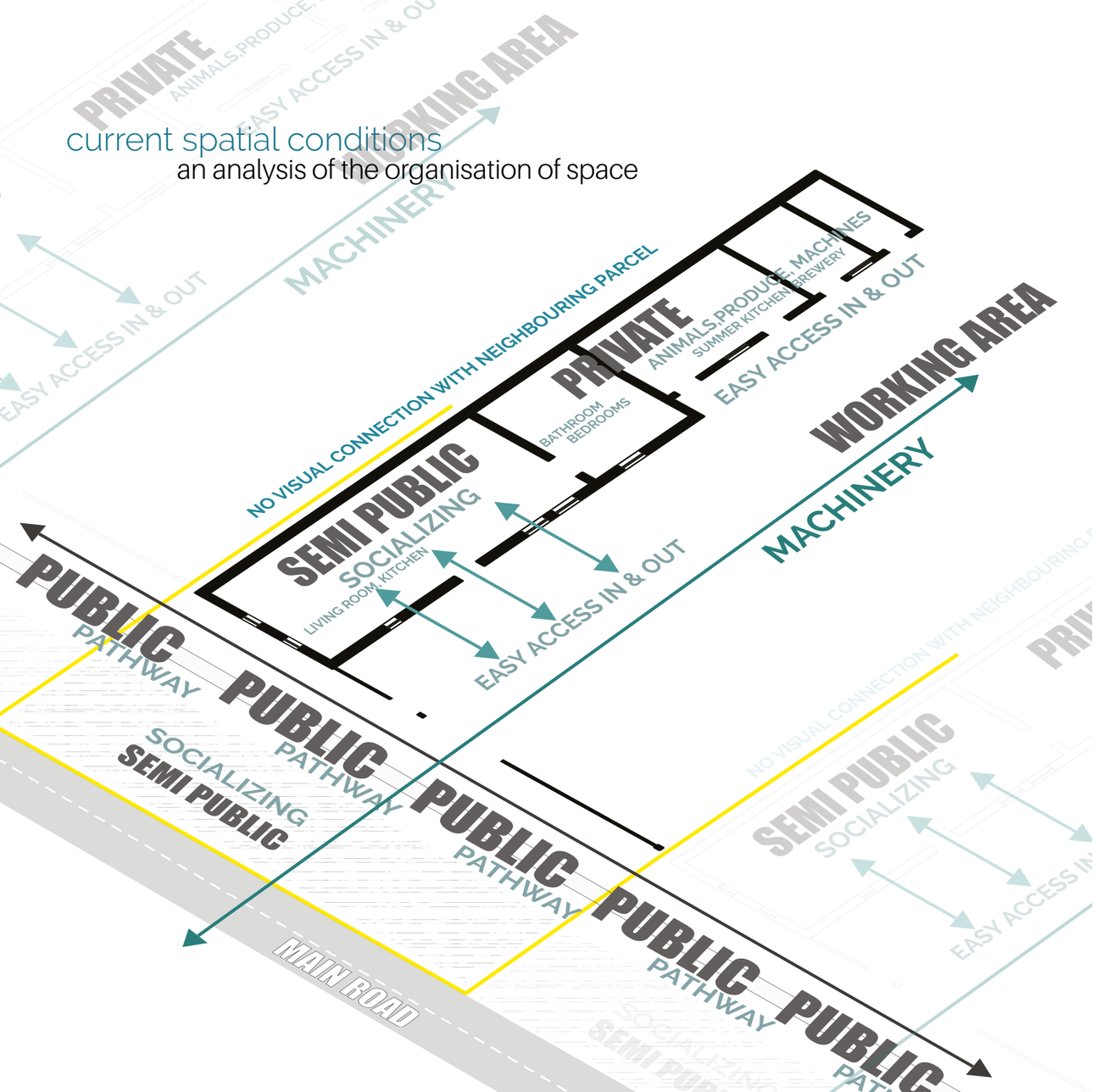
Amphibious house, London, UK

Retrofitted amphibious house, Louisiana, US

05 concept

current spatial conditions
proposed building functions
design strategy

current spatial conditions
an analysis of the organisation of space



5.1 Current spatial conditions

The living and working culture of the region demands an easy access in and out of the house. The yard is of great importance since that is where most hours of the day are spent and where the households livelihood exists.

It is the kitchen and dining room that serve as the principle room for gatherings (entertaining guests). Since the livingroom and dining area usually exist within the same room, a large part of the house is considered to be semi-public, meaning used for entertaining and having visitors. Seperated rooms such as bedroom and bathroom are considered to be highly personal and private.

As written before it is in front of the house that social life takes place, creating a semi-public area between the house and the main street. The semi-public area though is abruptly fenced off from the private inner yard through the presence of the high gate and gable which create a wall towards the paveway and the community.

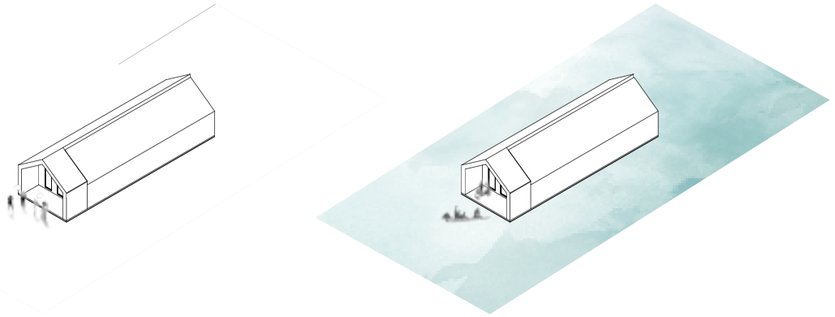
It is essential to keep a minimum of an 8 meters passage between the house and the neighbouring house. This leaves enough room for a large truck or tractor to be able to pass through, connecting the main street with the working yard and cultivated farm land down the parcel.

proposed building functions
public - semi public - private

BEDROOMS	*PRIVATE*
BATHROOM	
STORAGE	*FLOOD RELATED PROGRAMME*
FARMING	
UTILITY ROOM	
LIVING ROOM	*PRIVATE*
TOILETTE	
PANTRY	
KITCHEN	*SEMI-PUBLIC*
DINING ROOM	
GABLE	*PUBLIC + FLOOD RELATED PROGRAMME*

design strategy
maintain access in the event of a flood

THE GABLE
The one part of the house that stays in contact with the street during all times.

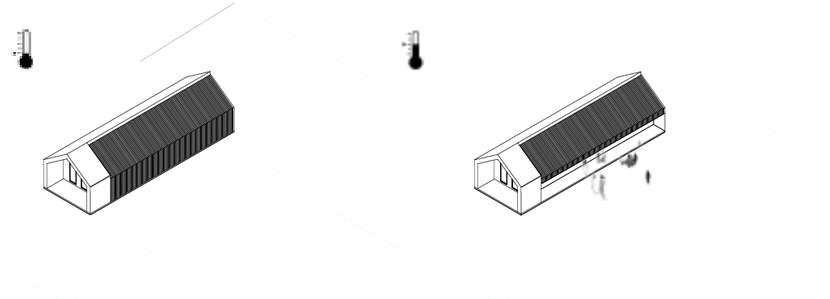


In the proposed design the gable substitutes the traditional bench usually positioned in front of the house. During normal circumstances, it emphasizes the function of a social meeting point.

During a flood, as a response to having a safe gathering point and easy access, the gable acts as an open platform reachable for rescue teams. It does not act as the entering point of the house, but an access from the house in case of a flood.

design strategy
strengthen local identity

THE PORCH
The strongest feature in the façade is the traditional porch that has been given an upgrade.

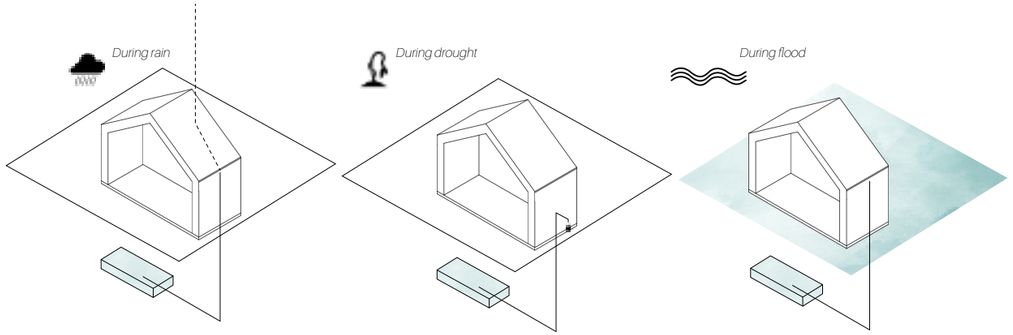


During colder days, the porch is shut close, creating a double- façade situation.

Natural ventilation is created with the ability to open up the structure by way of the porch. In doing so the porch lets the house extend on to the inner yard, creating an easy transition between inside and outside, letting the porch be a part of the yard when needed.

design strategy
ensure quick recovery

THE WATER HARVESTING
Water harvesting tanks contributes to a quick recovery.



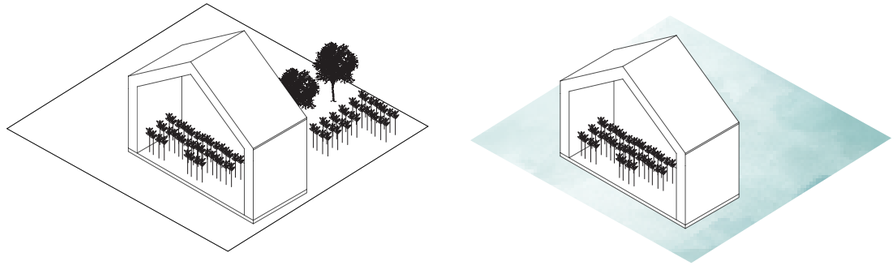
Water is easily collected from the roof as it rains, leading it underneath the house where water harvesting tanks are situated.

A water harvesting system enables residents to be prepared in case of a drought.

In the event of flood, fresh water is contained and stored in the tanks.

design strategy
reduce and control damage

THE FARMER'S GARDEN
A smaller green house incorporated into the design.



As an addition to the traditional farming taking place at the farthest end of the yard, some crops, vegetables and fruits can be cultivated in an area within the amphibious house itself. This way, everyday crops and produce are closer at hand as well as it provides a safety in case of a flood.

As water rises and covers the cultivated parcel, the farmer's garden, incorporated into the amphibious house, ensures part of the crops of the household to be safely above water, thus contributing to a faster transition back to a 'normal' life.

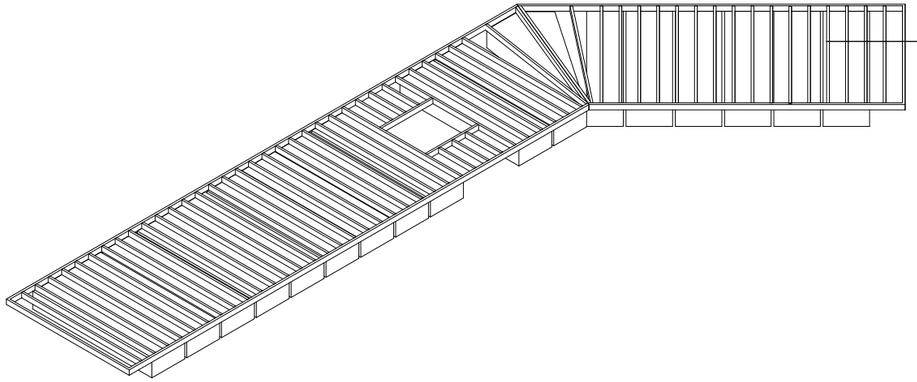
06 design proposal

buoyant structure
strategy of shape
programme
section a-a
buoyant foundation
façades
water harvesting
porch
gable
model photos
a future development

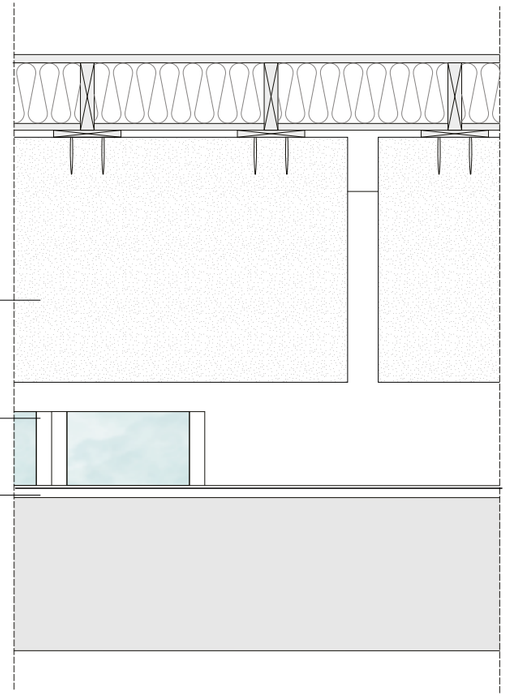
1:100 East façade normal state

buoyant structure

the floor joists with polystyrene foam blocks



In the design proposal polystyrene foam blocks, coated with water proofing, are attached to the floor joists. The blocks act as the buoyant foundation and keeps the house safely above water during a flood.



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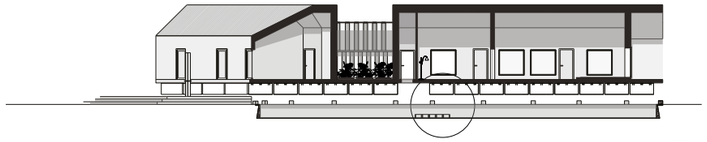
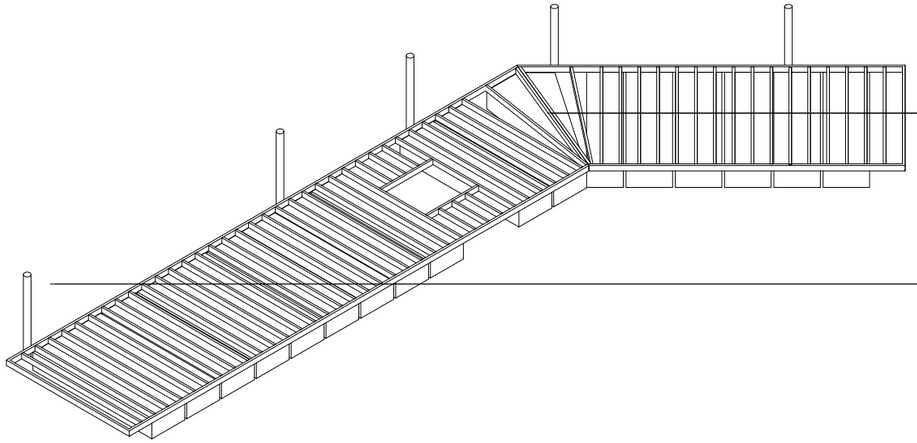


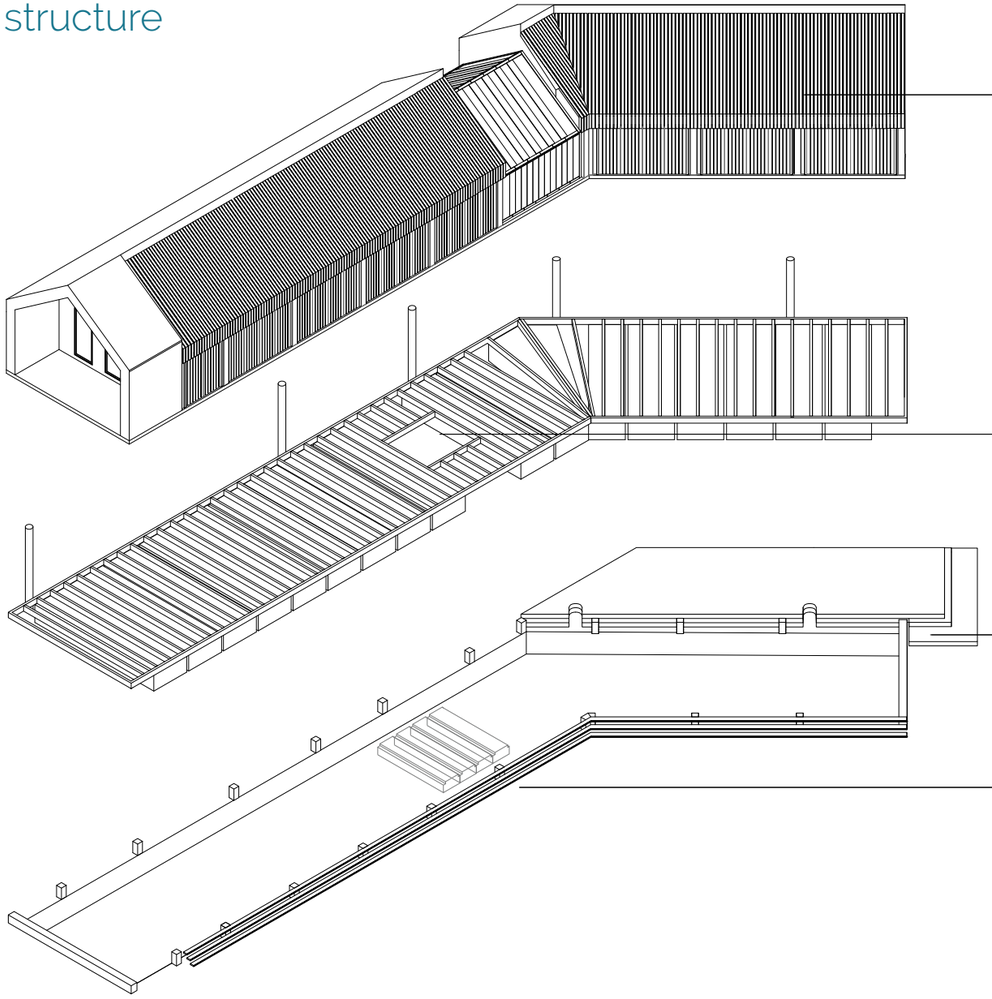
buoyant structure
vertical guidance systeme



the floor joists are divided into two separate bodies connected with a breakaway connection in order to rise and move separately as the water flows below

along the backside of the house five poles have the role to guide the house vertically when needed, letting the house move up and down as water levels changes. They keep the house directly above its original position during a flood. The framework of the house is attached to these poles with metal arms

buoyant structure



a *new* Slavonian type house

the amphibious house is equipped with utility lines that either have self-sealing breakaway connections or long, spiralled umbilical lines refering to solutions made in previous amphibious projects. A hatch has been placed in the utility room leading underneath the house in case repairment is needed or a reattachment of utility lines after a flood.

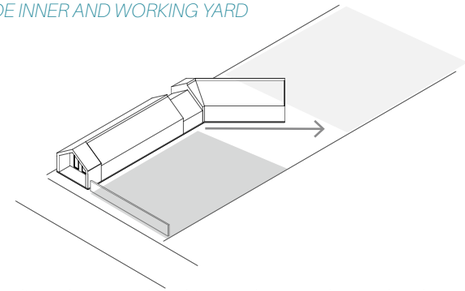
staircases surround the house, creating a barrier for unpredictable floating objects during a flood

the house is slightly elevated on plinths in order to let water through to the buoyant foundation. Since pervious concrete is used in the basin, water that rises from the subsoil during a flood is not hindered and lets the hosue rise slowly

water harvesting tanks are placed underneath the house in the 1m deep basin, created to hide the buoyant foundation. Pervious concrete is used in order to let water runoff infiltrate into the subsoil

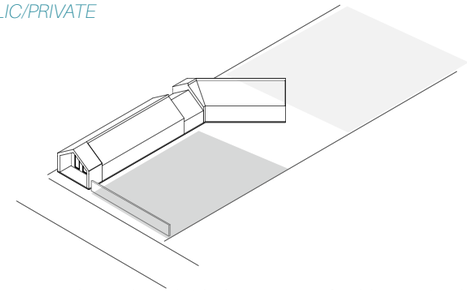
strategy of shape

DIVIDE INNER AND WORKING YARD



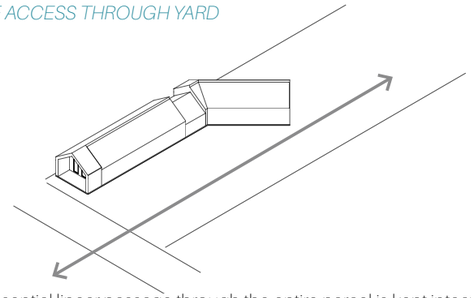
The traditional inner and working yard are emphasized and seperated by a rotation of the back part of the amphibious house. With that the house encloses the inner yard and creates an additional private nook on the backside.

PUBLIC/PRIVATE



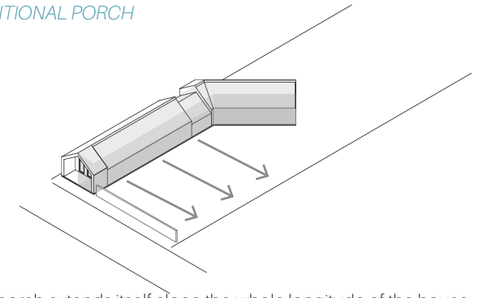
The house and parcel are divided into zones of public, semi-public and private areas. The area infront of the house and closest to the street are used for various degrees of socializing, whilst the rooms further down the house are more within a private note.

FREE ACCESS THROUGH YARD



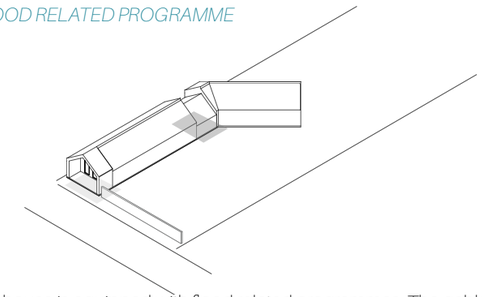
An essential linear passage through the entire parcel is kept intact since heavy machinery need to pass through.A minimum of 8 meters is required.

TRADITIONAL PORCH



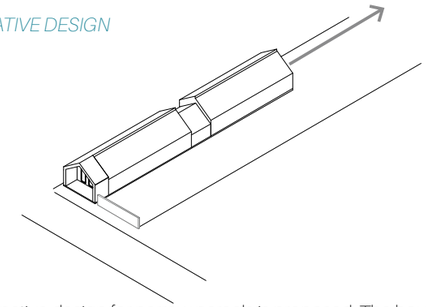
The porch extends itself along the whole longitude of the house and has the option to open up entirely when needed, softening the transition between house and yard.

FLOOD RELATED PROGRAMME



The house is equipped with flood related programmes. The gable acts as a platform for easy access and in the centre of the house, water, food and utilities are stored.

ALTERNATIVE DESIGN



An alternative design for narrow parcels is proposed. The house contains the same programme and functions, but has the porch end in a large covered deck that faces the working yard.

A possibility to place a summer kitchen along the short side of the house.

- *BEDROOM x2*
- *BATHROOM*
- *MASTER BEDROOM*

PRIVATE

- *FARMER'S GARDEN*
- *UTILITY ROOM*

FLOOD RELATED PROGRAMME

- *LIVING ROOM*
- *TOILETTE*
- *PANTRY*

PRIVATE

- *KITCHEN*
- *DINING ROOM*

SEMI-PUBLIC

- *GABLE*

PUBLIC +
FLOOD RELATED PROGRAMME

6.3 Programme

A direct connection between the yard and all of the rooms of the house lets the household keep watch on what happens on the premises, as well as it redefines the division between house and yard, The traditional porch is extended along side the whole longtitude of the house and is upgraded with foldable doors which provides the possibility to open up and increase air flow through the house during hot days. When closed, a double facade situation is created. Furthermore, the openable porch allows for an extension of the private into the inner yard if wanted. As previously written, the Slavonian household spends a considerable amount of time out in the yard.

Farmers depend on their land and the fruit it bares with it. By incorporating a smaller green house, a farmer's garden, into the design, the occupants are provided with a first aid base kit of produce in case of a flood, as well as cuttings to re-establish the cultures out in the garden after a flood.

A utility room with a hatch that leads underneath the structure enables access to the water harvesting system and all utility lines, such as sewer, in order to reconnect them after a flood as well as enabling usual maintenance.

Permeable paving is introduced and used as ground cover. Since conditions require hard surfaces in the inner yard, due to the usage of heavy trucks and tractors on a regular basis, permeable paving is a good substitute to paved material such as concrete. Small paths are also excavated in order to lead water away from the yard. Permeable paving allows rainwater to pass through and back to the ground water supply.

The dining room and kitchen are turned into one combined open space in order to create a large area suited for various gatherings, as well as it provides most inlet of daylight. The dining room is separated from the kitchen only through a slight elevation. The living room is equipped with a sliding door in order to entirely detach from the kitchen, furthermore it has its own entrance. From the dining room a glass door gives access onto the gable.

The destinctive gable has become concave, creating an open terrace suited for an emergency gathering point during a flood.

section a-a
during a flood

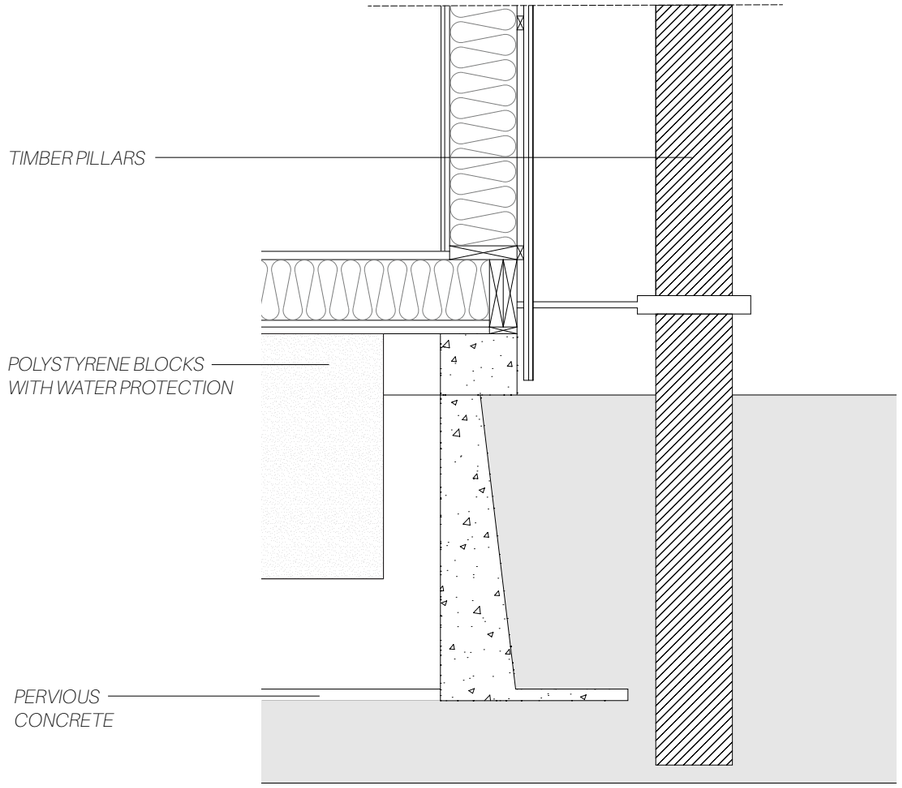
the majority of pervious concrete will function well with little or no maintenance, however sometimes specific maintenance is required to maintain its efficancy

the hatch in the utility room provides access underneath the house in order to serve the water harvesting system, as well as re-connect utility lines after a flood

from the dining room access onto the gable

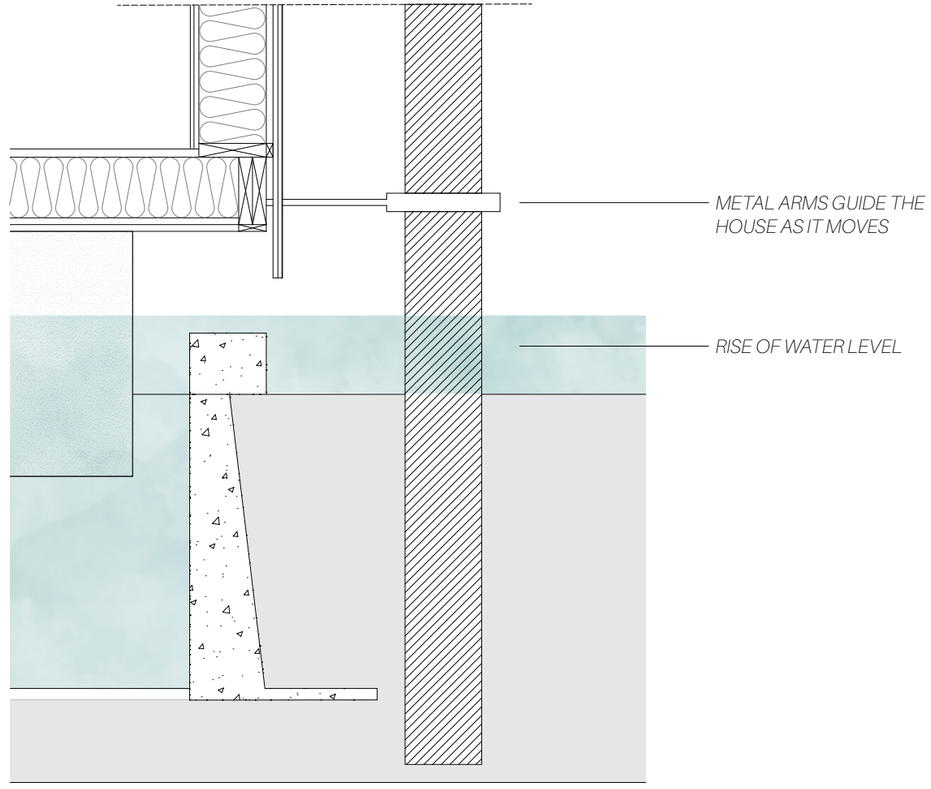
1:100

buoyant foundation
during normal state



1:20

buoyant foundation
during a flood



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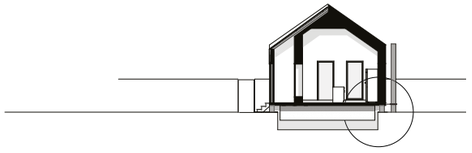


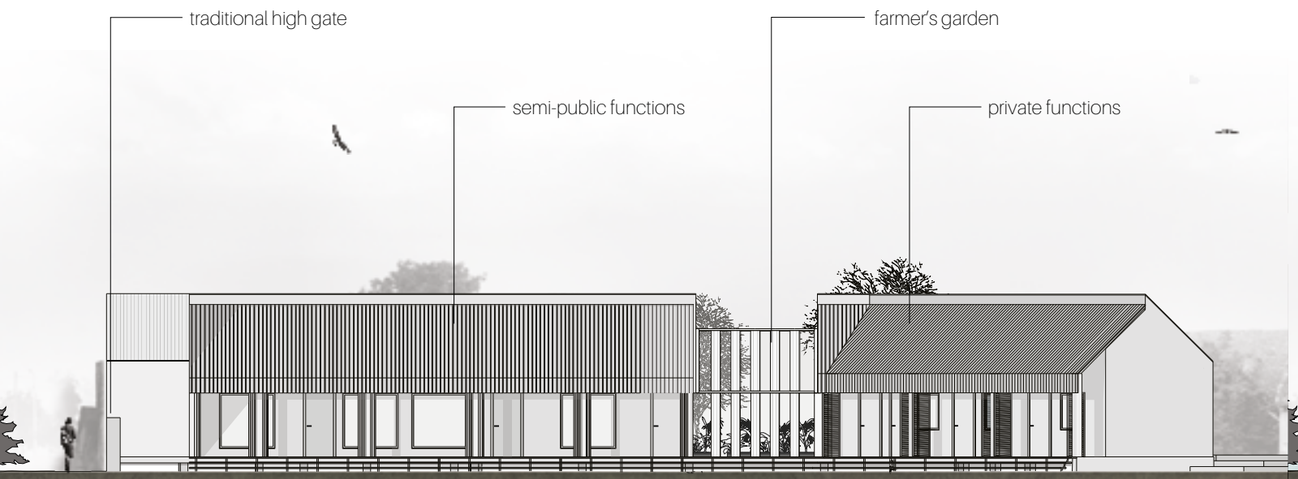
façades
with and without the rise of water level

6.5 Design
The design of the house establishes a new relationship to the old traditional material of oak by letting it be the strongest feature in the façade. In order to have a lightweight building the house is made out of a wooden structure that is cladded with clay plaster, as the façades in the region usually are. The porch however, situated along side the entire longitude of the house, is entirely made out of wooden boards of oak. Once again oak is brought into the homes of the locals, giving it a prominent first row position. The original steepness of the roof is kept intact.

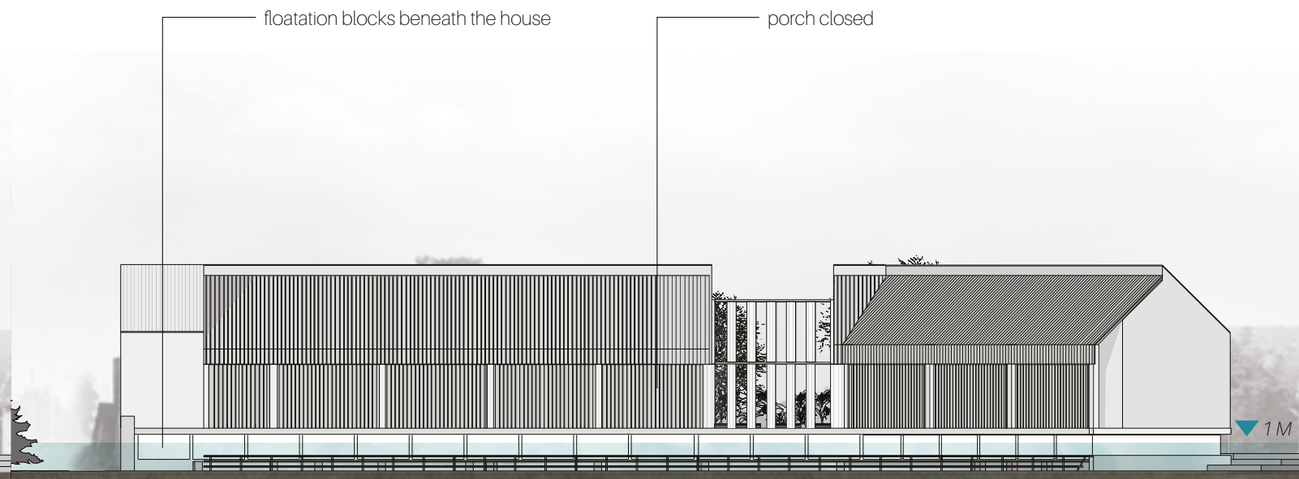
The angle of the house serves a purpose of enclosing the yard and differentiate the inner yard from the working yard. It also creates an additional enclosed and intimate private space behind the house that lets the household extend further into the yard without comprimising the size of the working yard. Furhtermore, the deck ensures that debrease does not get underneath the house as it floats, a function that the staircase along the entire front side of the house has as well.

Rooms that are of a more semi-public function, such as dining room, kitchen and living room, are placed in the front of the house closest to the street. Private facilities such as bathrooms and bedrooms are placed in the back of the house, further down the yard. In order to have a separation between them and creating a stronger sense of private and public, a farmer's garden is placed in-between. With an estimatet rise of 1 m during a flood, the house will float above waters as shown in the drawing below, keeping the property from any larger damages.

A scarcity of windows retains the house from overheating during long hot days. Large windows are placed along the whole front of the house in order to maximise the inlet of daylight and are easily covered when needed by closing the entire or parts of the porch.



EAST FAÇADE normal state 1:200



EAST FAÇADE during a flood 1:200

a deck behind the house creates an enclosed private area, additionally the deck blocks debrease from getting underneath the house during a flood as the house is raised

the house is divided into two separate structures in order to rise independently from each other and avoid tension

the closeness and connection to the neighbourhood and public pathway is kept intact in the new design

1 M

WEST FAÇADE normal state 1:200

the *kapija* ensures privacy, both physically and visually

with an elevation of 510 cm the gable can be used as a place to sit on, emphasizing the gable as a social meeting point and substituting the bench usual situated in front of each house in the village

6 m

0 2 4 6 8 10 20

SOUTH FAÇADE normal state 1:200

as the house rises with the flood, the gable act as an emergency gathering point, enabling boats and rescue teams easy access

7 m

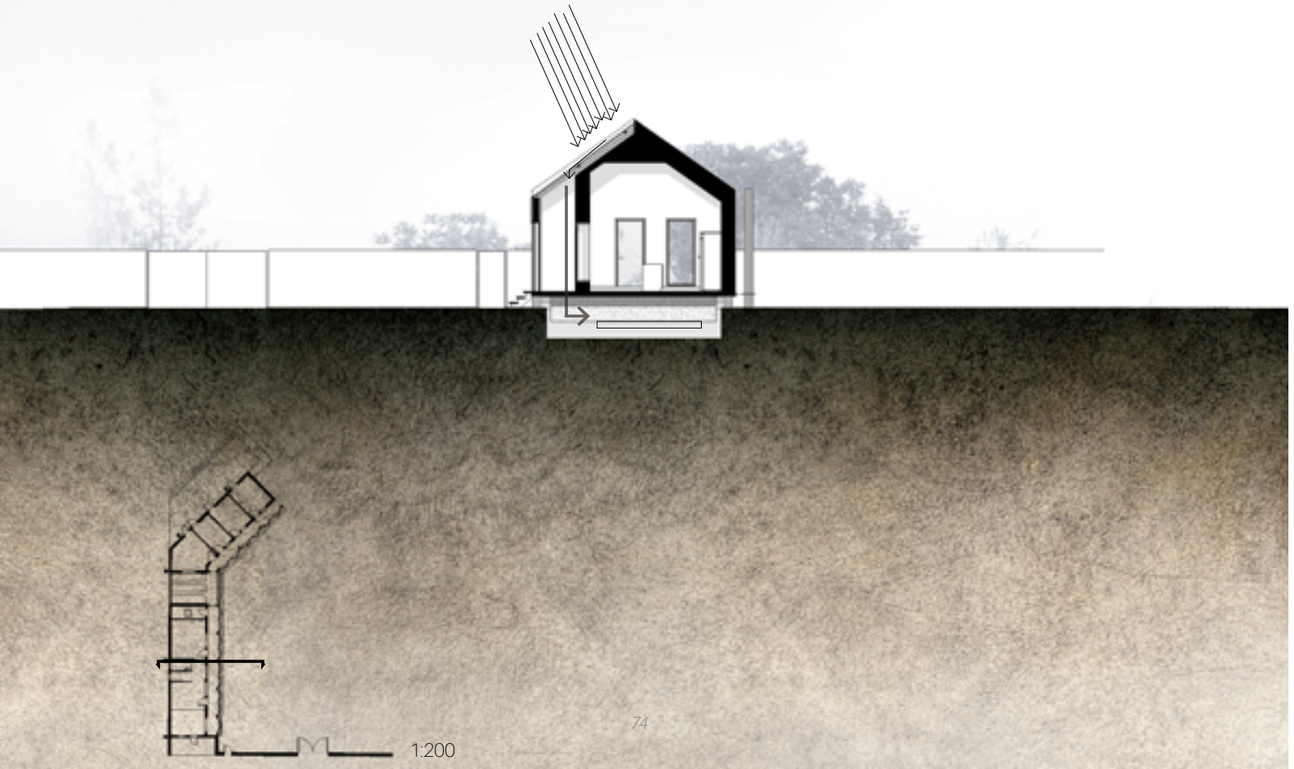
1 M

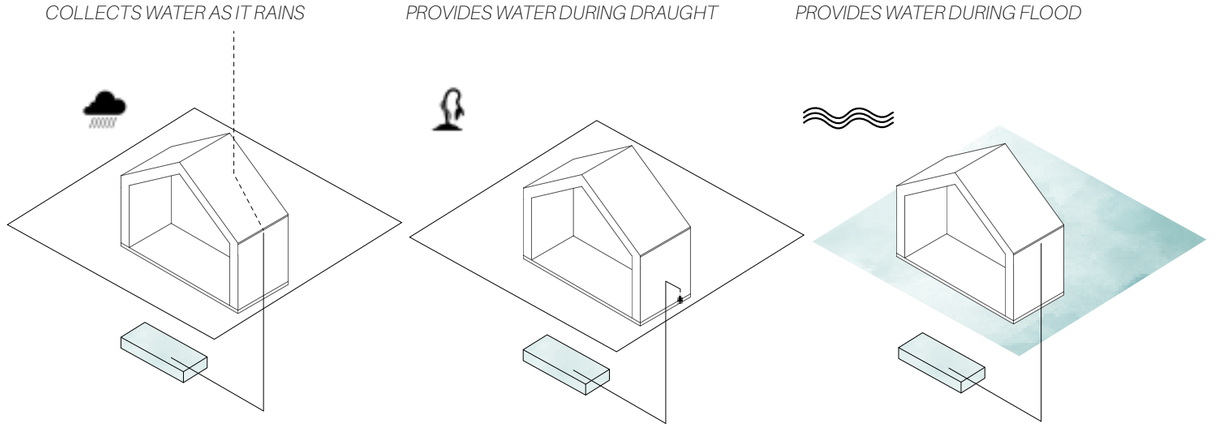
SOUTH FAÇADE during a flood 1:200

section b-b
water harvesting principle

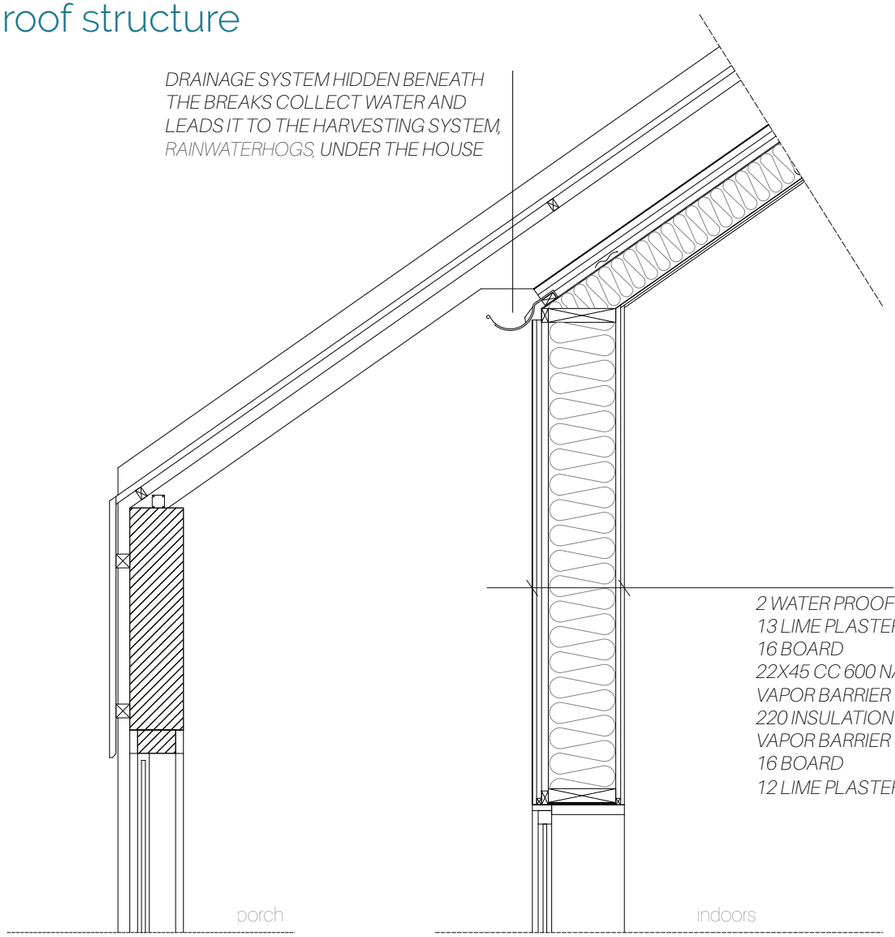
6.6 Water harvesting system

The wooden boards that make the porch are all ofsetted from each other in order to create a light situation shown in the image on the right. Light filters through the natural gaps and illuminates the space softly. In order to provide residents with water before, during and after a flood, a water harvesting system is put in place. Since gaps are created between the boards, an opportunity is embraced where the drainage system is hidden in-between the roof of the house and the breaks of the porch. Because water is let through, the gutter is placed beneath the roof of the porch, collecting water from the roof of the house only. The water is then lead to the water harvesting system situated underneath the house. As a water harvesting system an established product named Rainwaterhog has been chosen. *Rainwaterhogs* have the capacity of storing 187 litres of rainwater, water for drinking, and grey water, per tank. They are designed to screw together and to configure in any orientation.





roof structure



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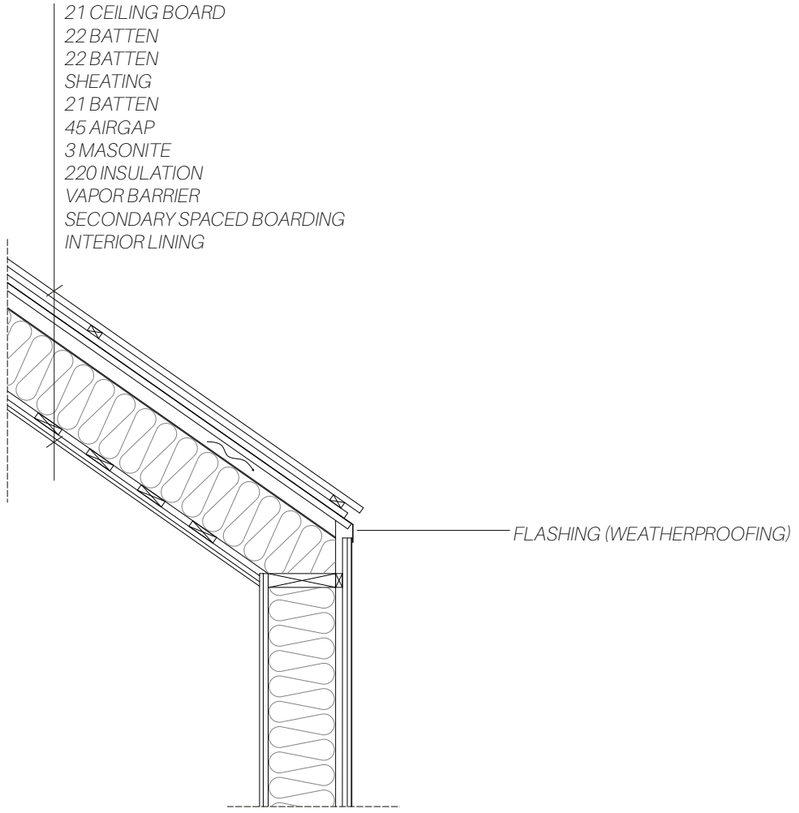

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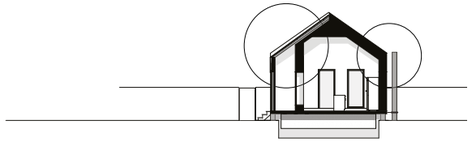
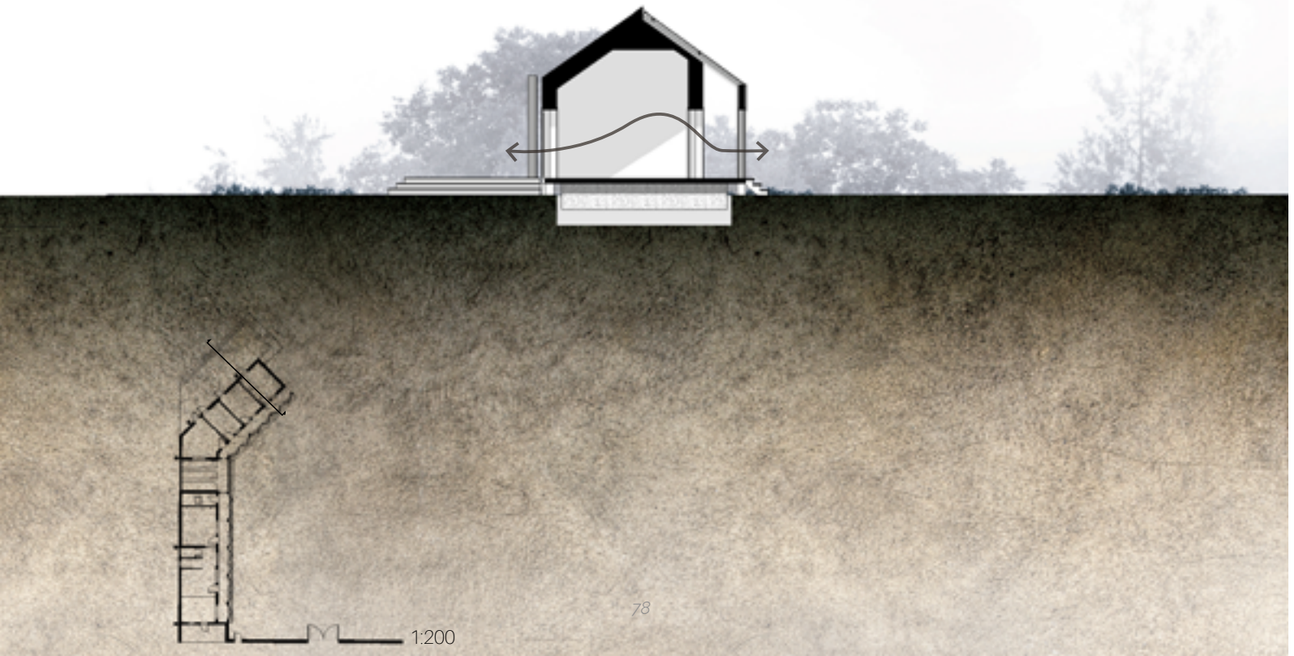


section c-c
function of the porch

6.7 Porch
Because of the regions continental climate, meaning long winters with precipitation and hot summers, the traditional porch is here updated with foldable doors that provide the possibility of opening up the entire space during warmer days. Natural ventilation is created with the ability to open up the structure through the porch. As with traditional buildings, the amphibious house has no windows facing the neighbouring parcel. The back wall of the house continues to create a natural border between the parcels. By rotating the back side of the house in a slight angle, a backspace is created that traditionally is not achieved. Doors and windows are then placed in such way that an increase in airflow can be attained through the house. Additionally, the opening up of the porch lets the house extend on to the inner yard, creating a more easy transition between inside and outside, letting the porch be a part of the yard when needed. As the porch is closed it creates a double façade situation.



the gaps of the staircase provide the water free access underneath the house, as well as it keeps the excavation below the house partly hidden

permeable ground cover in the inner yard lets water pass through into the soil

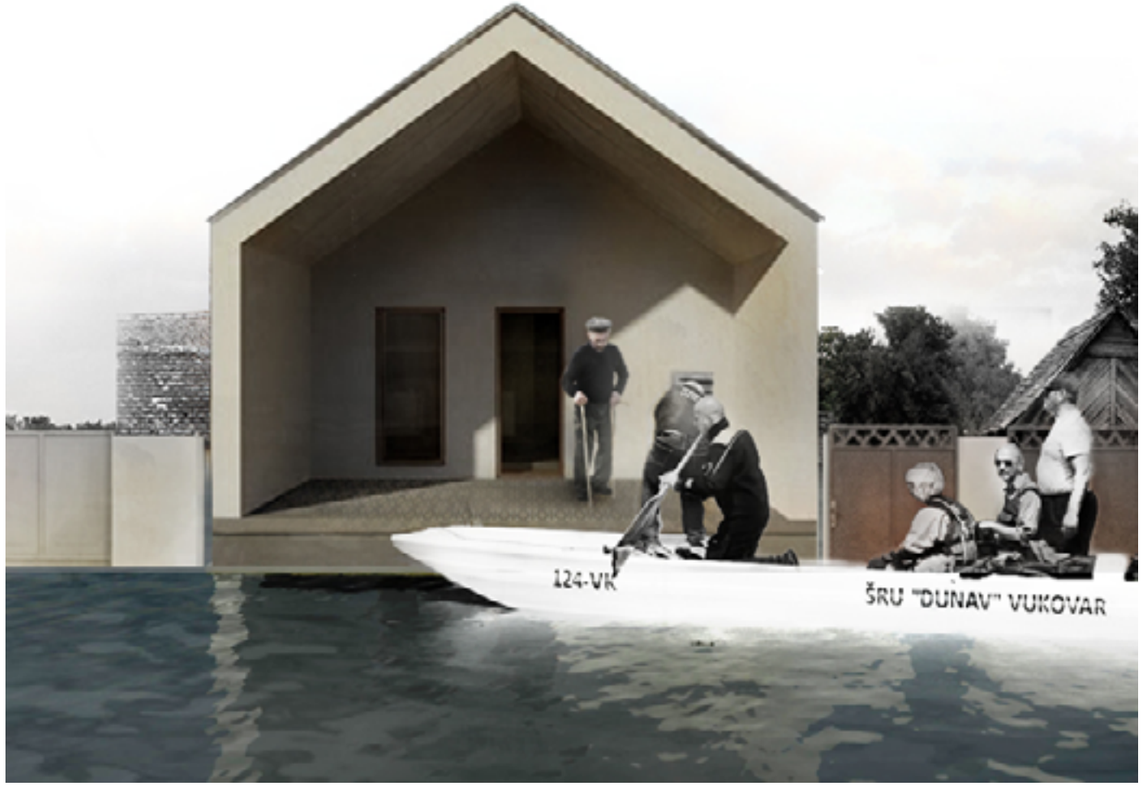
hidden drainage system

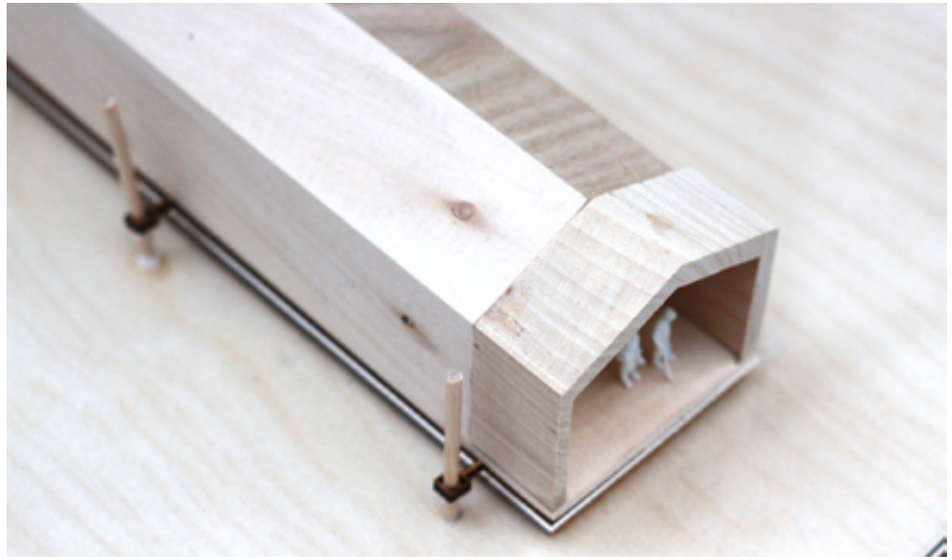
farmer's garden included in the amphibious structure

gable
with and without the rise of water level

6.8 Gable

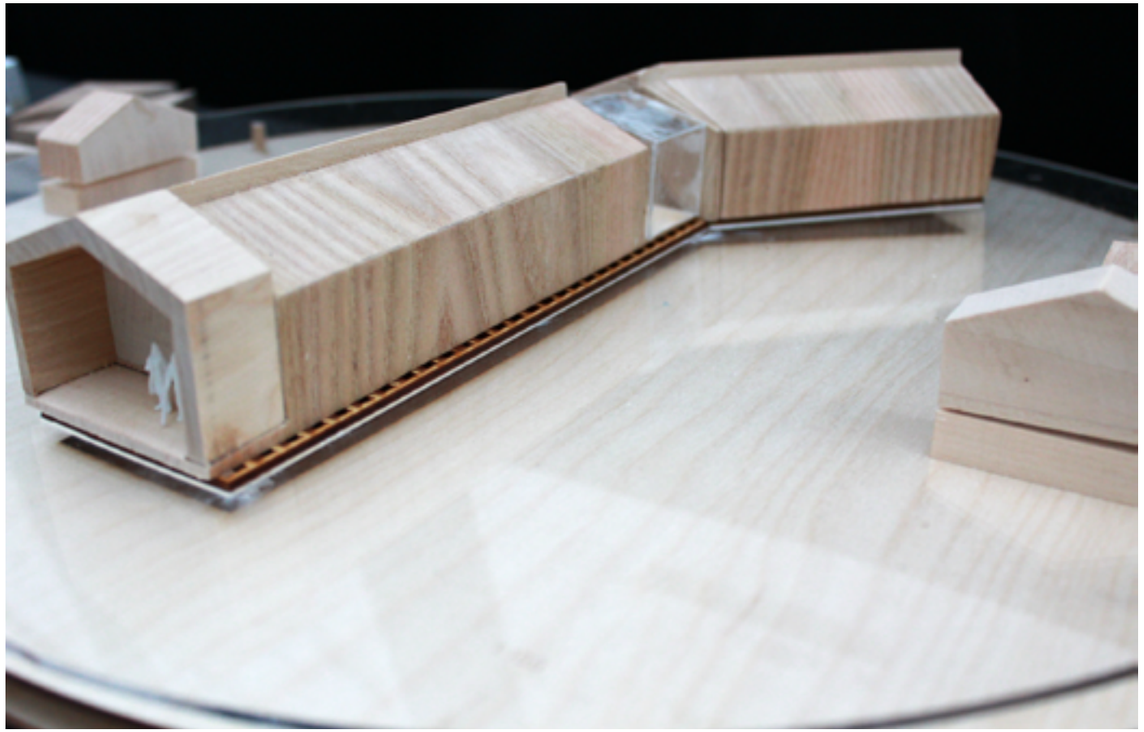
From the dining room there is access onto the gable through a glass door. This does not act as the entering point of the house, but an access from the house on to the street in case of a flood. The gable then acts as an emergency gathering point. Furthermore, the gable substitutes the bench that is traditionally placed in front of the house. With an elevation of 510 cm the gable can be used as a place to sit on, emphasizing the gable as a social meeting point and substituting the bench usual situated in front of each house in the village. Moreover, it tones down the abrupt division between yard and community that the traditional high gate and gable create.

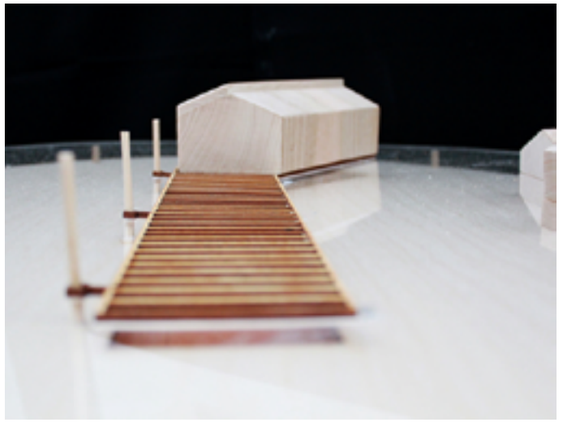


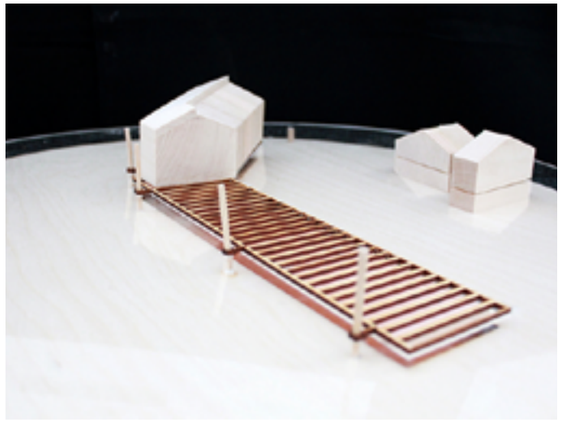


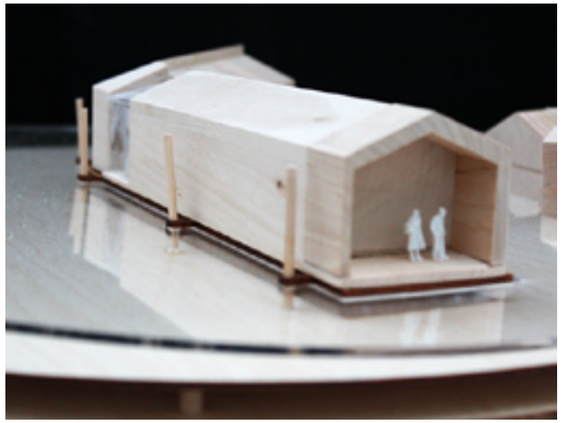
model photos

an elevated platform of transparent acrylic glass illustrates
an estimated 1.8 m rise of water level.









6.9 A future development

There are actions to be made on several planes in order to manage the flood risk of the area. With a holistic approach, the issue can be handled on different levels. The amphibious structure can provide security and resilience on an individual level, but by getting the whole community involved, the subject is highlighted and an broader understanding of the issue can be achieved. Introducing and incorporating material that have flood effective properties, such as permeable ground material, decidious trees and reestablish canals along the village, is a way to create a resilient community.

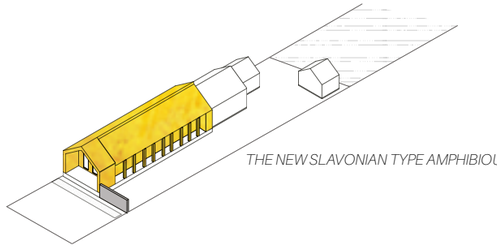
Existing buildings can undergo a transformation where the buoyant foundation is gradually retrofitted into the design. Rather than replacing them with *new* Slavonian type houses, they can get equipped with a gable that act as a rescue platform and a buoyant foundation.

PARCEL LEVEL: an amphibious structure on a straight line or partially angled will get occupants ready for a flood on an individual level. The usage of permeable material as ground cover will furthermore reduce the risks.

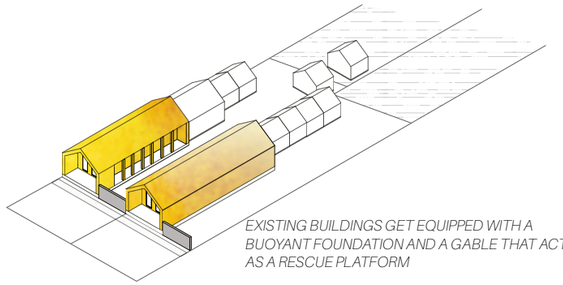
STREET LEVEL: replace paved drives with permeable material

NEIGBOURHOOD LEVEL: introduce deciduous trees in front of each house, along the whole community

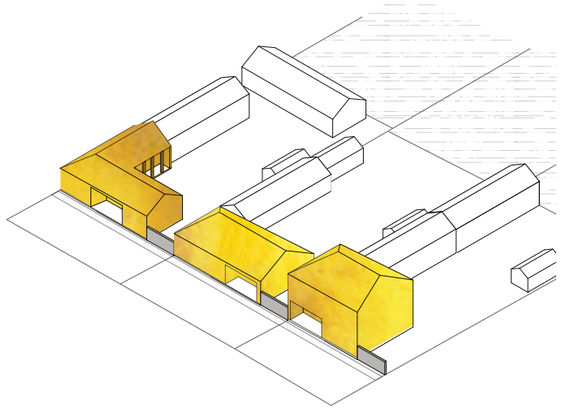
COMMUNITY LEVEL: maintain the traditional canal system along the main street as well as on all back streets. Furthermore, hightlight and encourage the usage of organic material and keep traditional building techniques alive



THE NEW SLAVONIAN TYPE AMPHIBIOUS HOUSE



EXISTING BUILDINGS GET EQUIPPED WITH A BUOYANT FOUNDATION AND A GABLE THAT ACTS AS A RESCUE PLATFORM



07 analysis & discussion

08 conclusion

ANALYSIS & DISCUSSION

The intention with the thesis is to accomplish a desgin that reconnects rural communities and individuals to the local context and the regional identity, simultaneously as it provides necessary tools for a life in risk of floods. The result is a design that minimises the consequences of a flood, at the same time as it revitalises rural architecture. This is partly achieved through the buoyant foundation that not only protects property from rising water levels, but also modernises and reassess the rural region and its way of living. By establishing four strategies early on in the project, the vision of an architecture that both protects its inhabitants and promotes the local context was reached. The proposed design needed to be able to reduce and control damages, maintain access in the event of a flood, ensure quick recovery and strengthen the local identity. This was concretised through the incorporation of a water/food supply, the bouyant foundation, the gable that reconnects to traditional and regional social behaviour as well as it introduces a new function, the use of traditional material and the rethinking of regional design elements such as the porch and programme of the house.

The amphibious structure is proposed as a solution to a flood prone region. In the case of the specific village of Podravska Moslavina, the likelihood of being struck with a catastrophic flood, like the one that hit South Slavonia 2014, is slim. One can argue that the reason to introduce an amphibious structure in that area is therefore irrational, adding to expenses and labour. The design is not only an amphibious structure; it also conveys a more sustainable approach to the built environment. Using natural materials such as wood and clay, highlighting the quality in building out of necessity and not volume, and through the introduction of water harvesting, the community is given tools to create a more sustainable development in the region. With a sustainable development comes a sustainable future. Additionally, the thesis exposes the need of maintaining traditional canal systems, the beneficial factors of planting more deciduous trees along the street and the negative factors of having too much paved surfaces. Small measures that lead to great results and keeps the community ahead of flood risks. The buoyant foundation is thus seen as an optional modern addition on an individual level. With that said, there is still a one-percent chance that a massively destructive flood should happen in any given year.

The proposed design enables occupants to have continuity in the every day life, by having the amphibious structure working with the flood instead of standing against it. The population of the region has always had, and still have, a strong connection to its rich land that is characterized by its very flat landscape. Permanently elevating houses high of ground would be a fairly easy solution construction-wise, however, it also means a change in the typology and morphology of the region and a disconnection between occupants and the cultivated land. As established in the thesis, social interaction traditionally occurs in front of the house, at the gable, and if elevated that interaction would be lost. In pursuance of ensuring occupants closeness to their land, as well as of aesthetical reasons, the buoyant foundation is lowered into an excavation underneath the house.

An amphibious structure keeps a property safely above water. In a rural setting, where additional smaller houses and rooms are separated from the main house, the question of what to include in the amphibious structure arises. In the design proposal, a choice has been taken to have characteristic functions, such as the farmer's garden and pantry, integrated into the family house in order to safeguard them. In the event of a flood, barns and other utility rooms will have to submit to the incoming water. This is due to the consideration of the future development of the region. In ten to twenty years, the percentage of population earning its livelihood from crops and livestock will most likely decrease, leaving additional rooms on the traditional parcel without functions. The design proposal consequently concentrates on a house suited for a rural setting, but not necessary including all functions of a rural home.

Although utility lines that have self-sealing breakaway connections or long, spiralled umbilical lines, are not the most accessible alternative, the design proposal has tryed to stay as easy and cost-effective as possible. Another take on the solution would be to for example exclude the bathroom from the amphibious foundation. As the water rises, the bathroom stays behind and floods. In the end it is cheaper to redo one room than a whole house.

An issue that has not been thoroughly dealt with in the thesis is how to prevent objects from getting stuck beneath the house as it is elevated. The force of the floods is known to move massive objects with great distances. A possibility to safely get underneath the house is provided through the utility room, furthermore starecases are strategically placed along three out of four sides of the house carrying out some blockage. Still there is no gaurantee that the house will not be hindered by unpredicted objects on its way down. Furthermore the amphibious house is designed with two seperate structural bodys in order to rise seperatly and thus prevent overstraining. Two seperate bodys of house and floor joists relieves tension and keeps the house intact as it settles back down.

In trying to maintain access and provide a quick recovery during and after a flood, the programme of the gable, the integrated water harvesting system and farmer's garden is established. A devastating flood however causes not only enormous damages on an individual, physical or economical level. The dramatic event leaves its mark within a social and cultural aspect as well since a flood detaches people from their ordinary life and local context by creating chaos and resulting in a notion of being lost. For this reason a stregthening of local identity it is of great importance. The thesis takes its starting point through the study of local and regional architecture. In contrast to most other reports and research carried out on amphibious structures, this thesis has a purpose of anchoring the design proposal to the local context. The usage of traditional material and the original frame and composition of the house is a result there of. It highlights the revitilising of tradtional design elements through the proposed design.

Regional building types are specifically designed and equipped to withstand specific demands of a specific area. Therfor they are a vast source of knowledge and insipiration in order to achieve the best and sustainable solution. Building traditions and techniques however have always evolved and need to continue to do so in order to reflect the social, economical and natural environments of a country. A modernisation of the rural community is therefore necessary, which the thesis and the amphibious house demonstrates, but it has to include what was previously stated - a local context and sustainable approach. Moreover, having a modern design proposal linked to the local context is a way of regaining the status of rural communities being a source of knowledge and erase the notion of rural communities being outdated or old-fashioned.

In the end a more holistic approach is also proposed, looking at how the community at large can become more resilient towards changing water levels. This is done by revealing a know-how on appropriate material usage and methods that help decrease the damages in case of a flood. By getting the whole community involved, the subject is highlighted and an broader understanding of the issue can be achieved. As for the future, these strategies can slowly take place, expand and transform the community into a resilient one.

CONCLUSION

Is it then possible to create architecture that nurture the well being of rural communities and safeguards the rural heritage at the same time as it provides adequate and innovative protection from changing water levels and future floods? And can that help to change the understanding of the built and natural environment?

The response to threat is an opportunity to renew and revitalise our communities through a creative and imaginative modernisation. By broadening the perspective and increasing the awareness of the built environment and culture, people can be inspired to have a more resilient lifestyle. By creating architecture that includes and upholds traditional building, at the same time as it promotes new techniques and solutions, the well being of rural communities and the safeguarding of rural heritage, with all its knowledge, can be ensured. The amphibious house does not only establish a new building technique but offers a different image on how a rural community should and can develop. The proposed design vigorously demonstrates how rural architecture and amphibious structures can and should correlate.

Seeing the house as a space and structure of cultural and regional belonging, this thesis acts as a statement of rural structures being as high regarded, valuable and innovative as urban 'modern' structures. The rural communities can act as a "new frontier" of development, a now responsible and sustainable one.

It is not only possible to create architecture that sees to the prosperity of rural regions simultaneously as it provides fair protection from future climate changes, it is necessary. We are heading towards a change of scenery living-wise, building-wise and climate-wise and we need to be smart and sensitive about it. Proper solutions specifically proposed for specific regions with specific conditions are needed. The soloution that is applicable in the Eastern parts of rural Croatia is perhaps not suitable for coastal regions, or European cities for that matter. Nonetheless, the amphibious house suitable for Slavonia could evolve and be applied in other rural inland regions of Europe that are encountering the same problems and the same future conditions as Slavonia. At least the same approach should be applied - to have rural architecture and amphibious structures correlate, creating a sustainable future for rural communities and resilient societies.

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