MASTER GRADUATION THESIS

Architecture flexibility as renovation generator

POLITECNICO
MILANO 1863

Supervisor: Pierre-Alain Croset
Student: Mijat Nikcevic

SCHOOL OF ARCHITECTURE URBAN PLANNING CONSTRUCTION ENGINEERING
MASTER OF SCIENCE ARCHITECTURE AND URBAN DESIGN
Milano, 15th December 2020

Abstract

La diminuzione delle piccole città causata dalla migrazione dalle zone rurali alle aree con una popolazione altamente concentrata è una tendenza presente in un livello o nell'altro in quasi ogni paese del mondo d'oggi. Questo processo sta lasciando vuote le aree rurali che nel processo diminuiscono senza prospettive di un futuro sviluppo. Insieme al risultato di una tendenza del genere, si sta verificando una maggiore domanda di alloggi a prezzi accessibili. Ma l'alloggio di oggi non è soggetto a cambiamenti più frequenti dello stile di vita e delle esigenze dei suoi utenti, il che aggrava ancora di più il problema. I problemi ambientali causati dal cambiamento climatico, come l'aumento del livello dell'acqua, rappresentano una minaccia maggiore per le aree urbane di tutto il mondo, più che mai.

L' obiettivo di questa ricerca è affrontare queste problematiche molto urgenti e cercare di dargli possibili soluzioni attraverso la specifica proposta progettuale, con sede nella città di Rijeka Crnojevića in Montenegro.
La soluzione introdotta sarà la flessibilità sia a scala architettonica che urbana. Per "Flessibilità" si intende la capacità di un edificio di adattare continuamente la propria disposizione spaziale e la propria struttura alle mutevoli esigenze dei propri utenti (allargamento familiare, attività economica) o ad eventi naturali (stagione delle piene).

L'intervento sarà fatto in tre fasi separate. La prima fase - aggiunta degli edifici persi con l'accento sulla flessibilità e i sulle facciate adattabili. La seconda fase - preservare la memoria speciale del luogo e salvare la sua antica autenticità ristrutturando gli edifici abbandonati. La terza fase - per garantire vivacità e diverse esigenze del luogo, installare moduli mobili in grado di fornire spazio con diverse possibilità di utilizzo.

Introducendo gli spazi adattabili, si potrebbe creare un ambiente più amichevole con molte migliori opportunità per ripopolare e rivitalizzare la città abbandonata.

Abstract

Shrinking of small towns caused by migration from rural to areas with highly concentrated population is tendency which is present in one level or the other in every country of the world today. It is leaving the rural areas empty which in process diminish with no perspective for future development. Together as a result of such a trend, the higher demand for affordable housing is taking place. But housing of today is not prone to more frequent changing of lifestyle and needs of its users, which aggravates the problem even more. Environmental problems caused by climate change like higher water levels are posing greater threat to the urban areas around the globe, more than ever before.

Goal of this research is to tackle these very urgent issues and to try to give possible solutions to them through the specific design proposal, based in town of Rijeka Crnojevica in Montenegro.
Solution introduced will be flexibility in both architectural and urban scale. By "Flexibility" it is referred to the ability of a building to continuously adapt its space layout and its structure to evolving needs of its users (family enlargement, economic activity) or natural occurrences (flood season).

Intervention will be made in three distinctive phases. First phase – adding the lost buildings with the emphasis on layout flexibility and adaptable facades. Second phase – preserving the special memory of the place and saving it's former authenticity by renovating the abandoned buildings. Third phase –to ensure vibrancy and different needs for the place, by installing movable modules that can provide space with different using possibilities.

By introducing the adaptable spaces, more friendly environment with much better opportunities for repopulating and revitalizing the abandoned town could be created.

Table of contents

1. Introduction

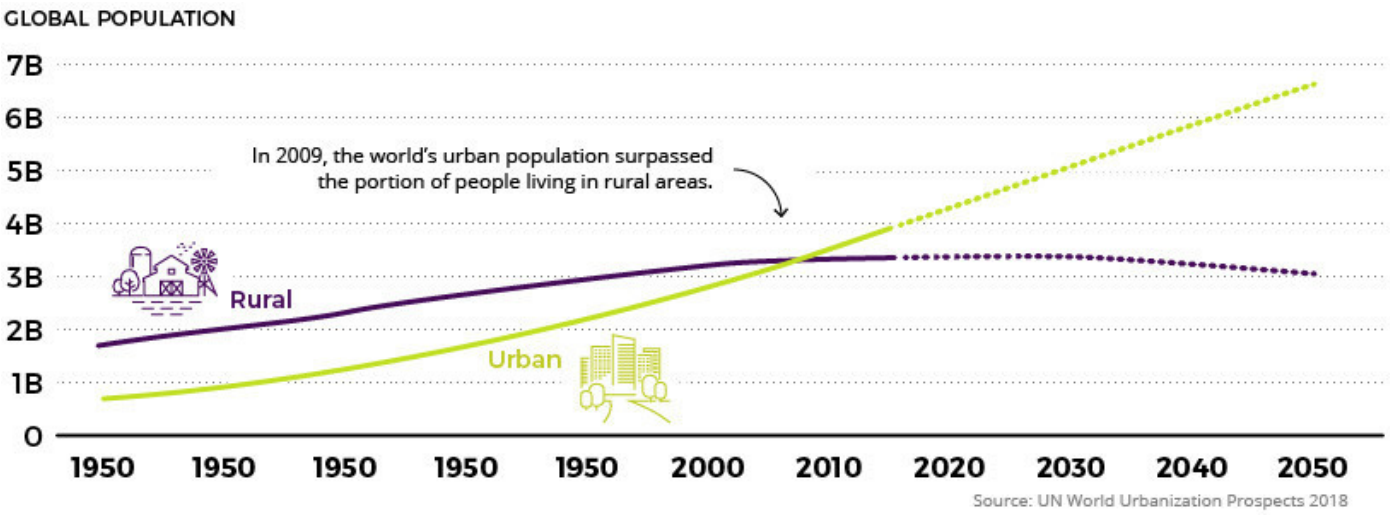


Figure 1: Urban vs Rural population graph.
Source: UN World Urbanization prospects (2018).

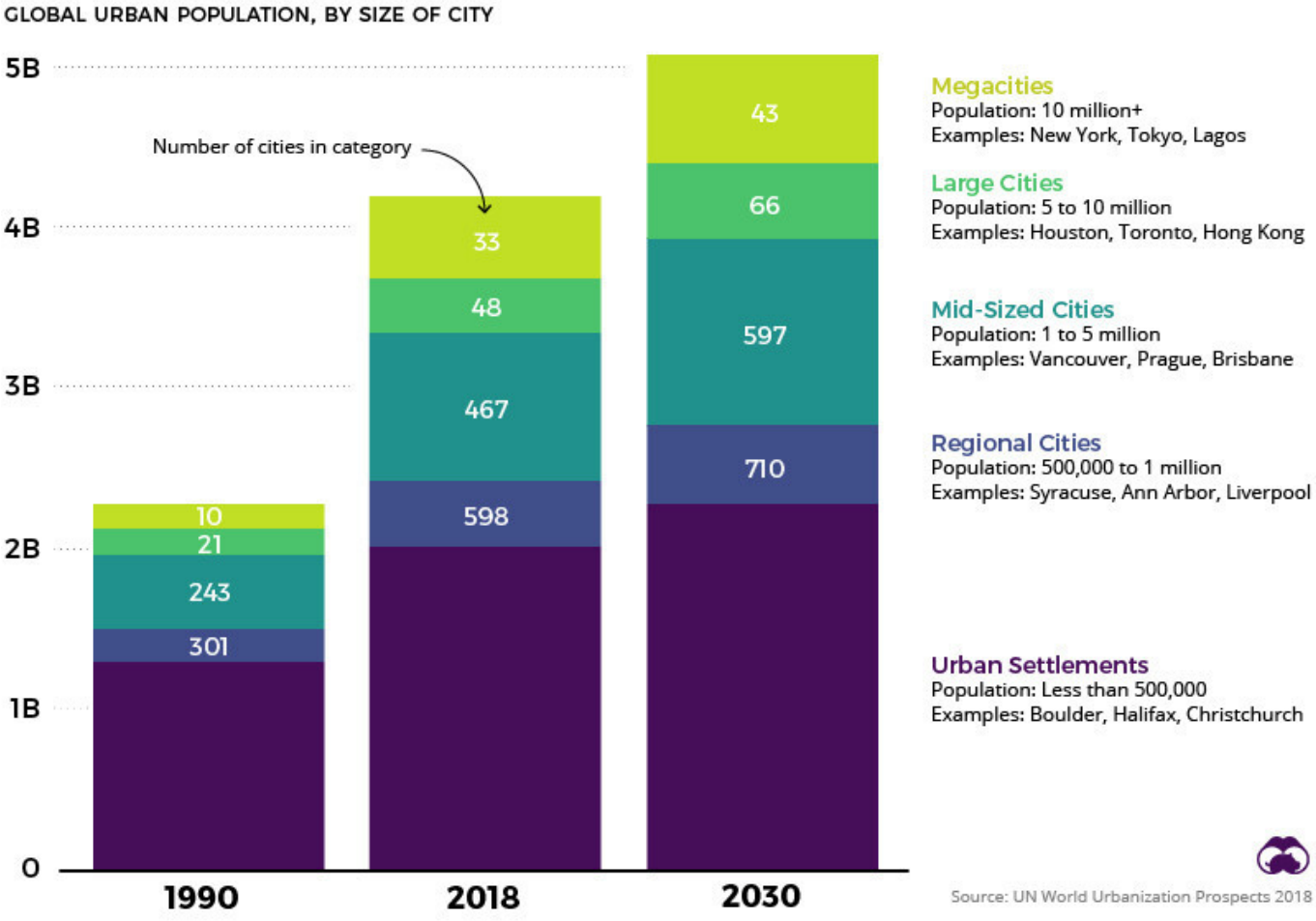


Figure 2: Rise of concentrated metropolises.
Source: UN World Urbanization prospects (2018).

1.1. Trend of disappearing of small and middle size towns

In 20th century there have been exponential rise in urban growth across the world. Metropolitan areas with high concentration people in small area were direct product of massive industrialization, especially after the World War 2. Trend had very well followed on larger scale in 21st century in both developing already developed countries of the world.

In 2018 more than 55% of world population was living in urban areas, most urbanized region in the world is North America with 82% of urban population followed by Latin America 81%. Oceania has 68% of urban population while Asia is little over 50% and the least urbanized part of the world is Africa with 43% of population living in urban regions. [1]
In Europe around 73% of people live in urban areas, and 39% of the population live in metropolitan regions with at least one million inhabitants, it is ranked as third most urbanized region in the world, and it has the longest history of large scale urbanization, starting in 19th century with first and second industrial revolution. [2]

As a direct result of migration to larger urban areas, depopulation of rural areas together small and middle sized towns has taken place. In Italy more then 5000 villages had been abandoned with the rate ever more increasing. Likewise in Spain there is 81% of the urban population, villages and small towns that are still populated had become very rare site.

Known as the "Rural Flight" the migration from villages to dense metropolitan areas had come in the ever greater scope of governments attention.
Bad effects on the overall economy, change of the lifestyle, lack of space available housing in cities and rapid changes of countries demographics urged countries to respond in some way or another. In many countries there have been administrative initiatives to repopulate rural area, with substituted renovations, giving opportunities for easier business opportunities. These attempts had different results, with Austria as an example of reverse trend of decreasing urban population from 1981 to 2010 but without economic regression.[3] The reason were successful government incentives for support of revitalizing and economic development of rural areas.

Technological solutions can certainly help and can shed new light on topic of rural revitalization. Topic requires more accommodating approach and different modalities of solutions.

1 World Urbanization Prospects The 2018 Revision - New York 2018.
2 Urban Europe Statistics on cities, towns and suburbs 2016 edition - Luxembourg 2017.
3 Statistics Explained (http://ec.europa.eu/eurostat/statisticsexplained/) - 27/06/2018.

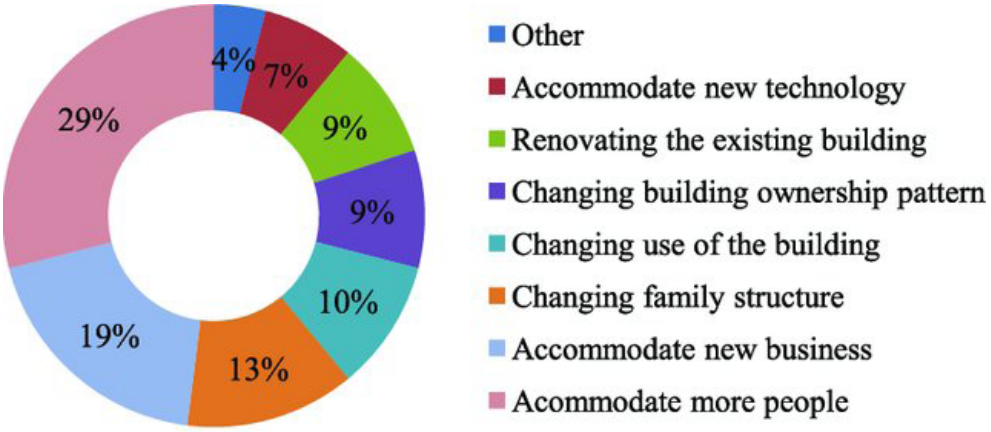


Figure 3: Reasons for layout adaptations
Source: Dhar etal.(2013).

Figure 4,5: Deployable modules of Nakagin Capsule Tower, Tokyo.
Source: ARCHEYES Magazine, 2016.

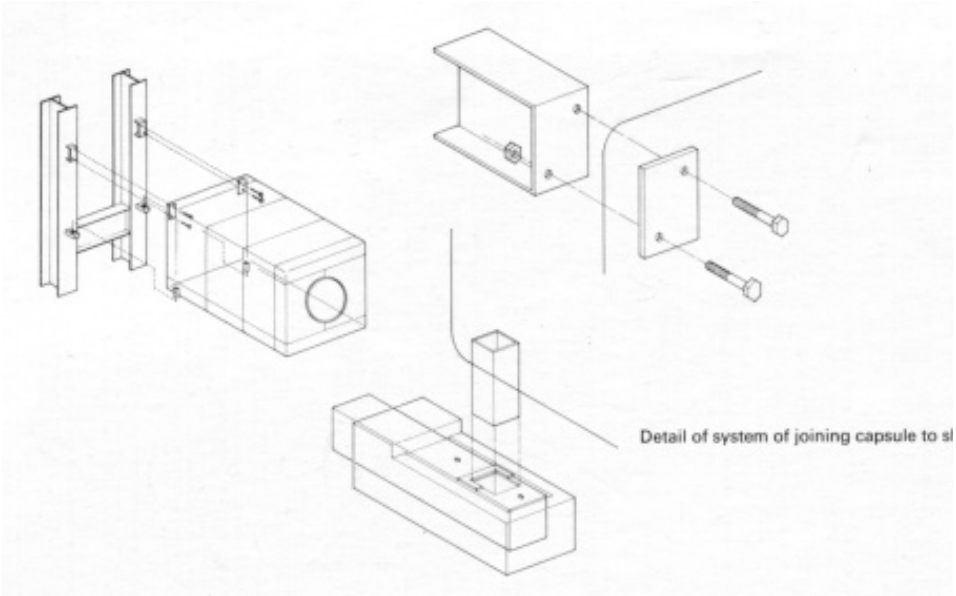


Figure 6: Connecting link between module and construction on Nakagin Capsule Tower, Tokyo.
Source: ARCHEYES Magazine, 2016.

1.2. Housing - inability to adapt to user's changing needs

As consequence of steady urban growth and concentration of population to smaller more densely populated areas around the world, there has been the need for more housing that can respond to increasingly ever changing needs of the residents. Increased demand had lead to shortage of affordable housing and increasing prices at the same time. Larger percentage of existing housing is incapable of answering to different dynamics of living today.
Different approach of family planing and family lifestyle together with more individualized culture has lead to very different needs in housing.
Conversion of spaces in already existing housing units is almost surpassing the cost of already expensive spaces adding to that initial cost of buying one on the preferable location .

Economic sector of today is even more dynamic with constant changes of companies needs. Most preferable options of companies today is renting space rather than buying. It saves investment cost by order of magnitude and it allows flexibility in case of company's growth and need for larger spaces for increasing number of workforce. Company WeWork started reconfiguration existing built spaces into renting spaces for work. Their greatest emphasis was on the flexibility of design.
Today's jobs are loosing hierarchy they once had and are becoming more like a project-based activities with constantly changing of crew dependent of the project.[4]

Ever increasing rate of technological advancement made even harder for already existing buildings to constantly be adapted to different installations and technological requirements. Adding new systems and installations is increasing price of work for considerable amount.
Great number if spaces is deteriorating and it was not planned having in mind such a dynamic social, economical, cultural and demographic changes as of today.

Logic of the problem gives space for the rise of more flexible buildings that will be able to accompany changing demand. Flexibility allows building to be useful for longer time thus expanding ever decreasing lifespans of many modern buildings.
From the modernist movement that saw architecture as living machine[5] to metabolist experimentations on idea of architecture as live evolving organism[6], there have been many proposals for greater flexibility and adaptability of architecture.
To increase flexibility deciding factors, careful classification of possible elements should be considered.
According to study done by Israelsson and Hansson (2009) deciding flexibility factors can be divided into: Hard aspects - have direct impact to flexibility levels - Installations,production, material standards. Soft aspects - have no direct impact to flexibility levels - finance future planning and awareness. [7]
Thorough classification with emphasis on constructive/separating elements and level of possible mobility of building elements itself should take place.
With this method it would be much easier for understanding and planning the exact areas where higher flexibility can ensue.
Technology must not be forgotten, because it plays great pat in downfall of flexibility concepts from the previous century. As Fumihiko Maki, one of the initiators of Japanese metabolist movement, stated that main flaw of the concept was technologically inseparable link between the element - modules and structure. To remove the module it would be needed to intervene on structure, which flawed the concept itself.
Considering price problem of flexible design. Initial price of must by the logic be higher for flexible solution, but the cost would payoff in longer term.

4 Metabolism(S)-Space Flexibility in the 21st Century Stanislas Chaillou, , Harvard Graduate School of Design 2018.
5 Towards a New Architecture, Le Corbusier 1923.
6 Metabolism 1960: the proposals for a new urbanism, Kawazoe N Tokyo, 1960.
7 Metabolism 1960: the proposals for a new urbanism, Kawazoe N Tokyo, 1960.

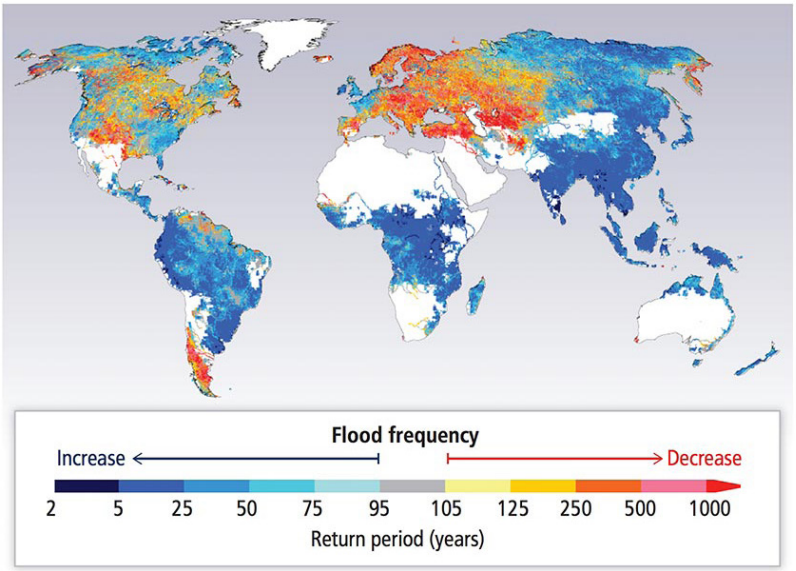


Figure 7: Flood frequency map, worldwide.
Source: Public Health Post, 2018.

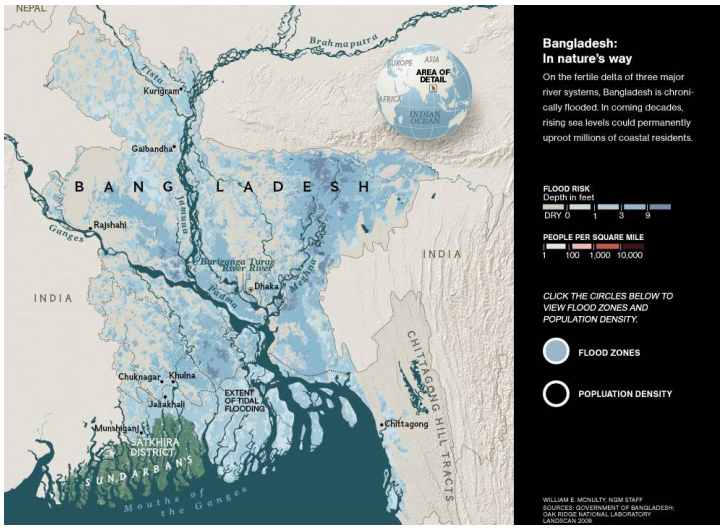


Figure 8: Bangladesh, flodd risk.
Source: Government of Bangladesh, 2009.

Figure 9: Venice, acqua alta, annual high tide.
Source: storymaps.arcgis.com, 2018.

1.3. Architecture resilience to environmental occurrences

With growing effects of Climate change, there has been an increasing urge to plan and build in resilient ways. Accelerating pace of melting ice, and disruption of weather patterns are causing more frequent tidal waves and cyclones. Most of the world cities are built close to the water, the rough estimation is that around 1/3 of world population will be affected. More closer study showed that 634 million people are living in low land areas which are in danger of floods, even in present time.[8]
In some countries it presents disastrous danger like Bangladesh, where 2/3 of population are living under 5m of sea level, and it is a home of 161 million people.

Resilient design by theory should make building able to respond to natural or man made disturbances that can affect some area. Having in mind text above it is easy to understand which kind of resilience is mostly needed today and in the future.
There have been various ways to tackle this problem, it ranges from expensive, national projects like dam system and flooding canals in Netherlands to the more naturalistic approach of growing mangrove forests across the flood prone areas of South Asia and South America.

Can architecture offer effective solution? Having in mind shear complexity of the problem answer is not completely, but it will be great part of the solution.
More aware planing and designing can definitely help in certain amount.

Floods are causing great economical damage to the built environment, most of the buildings are not fitted to deal with flooding.
Some architects are arguing that rising sea levels pose opportunity and will certainly shape architecture and urban planing in the future. Six key strategies for creating environment for flood adapting were outlined.[9] Also referred as six spatial tactics: attenuate - creating supplementary areas that will be able to store incoming water, alleviate - creating structures that can slow done water, restrict - reducing community exposure to flood by preventing water to come, realign - repositioning the important structures, create - generating new landforms where development can take place and embrace - accepting that water will be part of the settlement using it as a design driver and concentrating on buildings, infrastructure and installations adaptation to inevitable reality.
In practice there have been different approaches spanning from elevating the walking ground to making floating settlements.

In Netherland the long flood defense dike was upgraded into multi-functional area. Long dike wall was covered with sand dunes and under it parking, helping to preserve village character.
In Hamburg, renovation project called Hafen City had managed flooding by installing water proof plinths props above the level of flood, enabling water to flow but leaving ground floor water free.
In Norwich, England as part of the CAN (Climate Adaptive Neighborhoods) project, 72 buildings were constructed in flood prone area. They are positioned in strategical position to minimize risk of flooding. Special materials were used to minimize the damage caused made by flooding.
Waterwoningen in Netherlands on outskirts of Amsterdam is designed to ease problem of house shortage. Instead of that it had paved way for new kind of living on water and embracing it instead of avoiding it.

21th century is witnessing the emergent philosophy of "living with water". There is no unique solution which can solve such a complex problem, but a thoughtful combination of possible solutions and initiatives may give results.

8 Nell Greenfildboyce, Morning Post, 2010.
9 Edward Barsley, Retrofitting for Flood Resilience, 2019.

2. Project site analysis

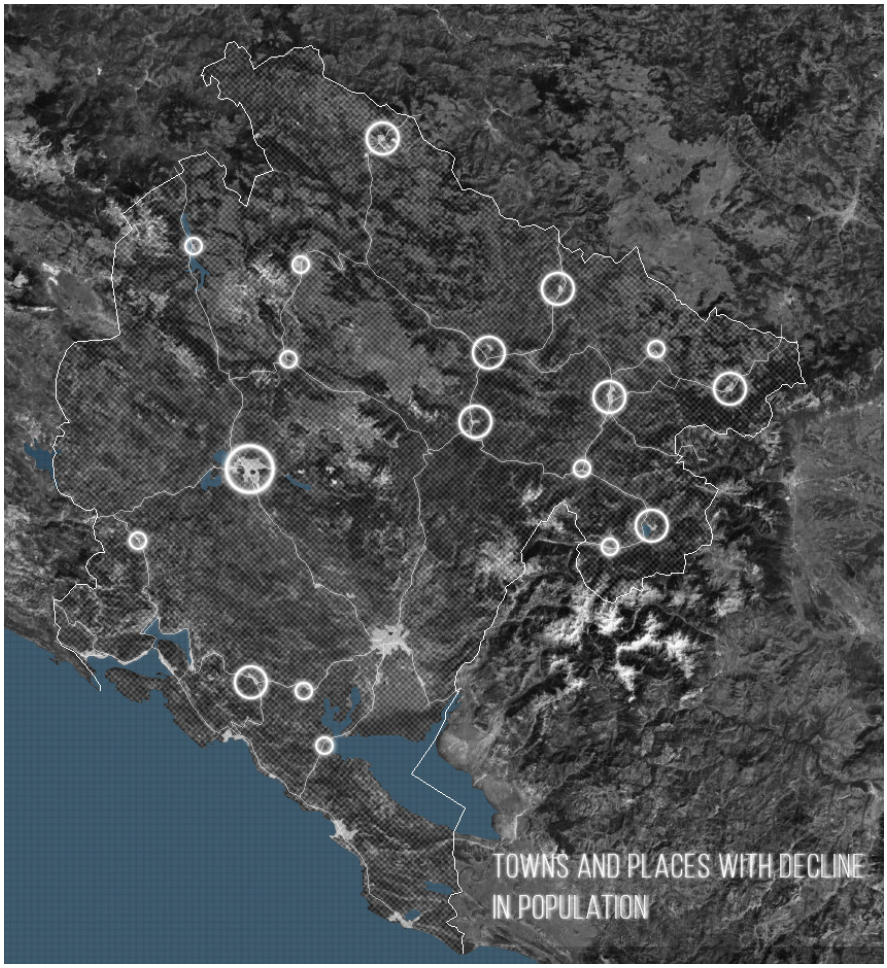


Figure 10: Map of towns in Montenegro with steep decline of population.

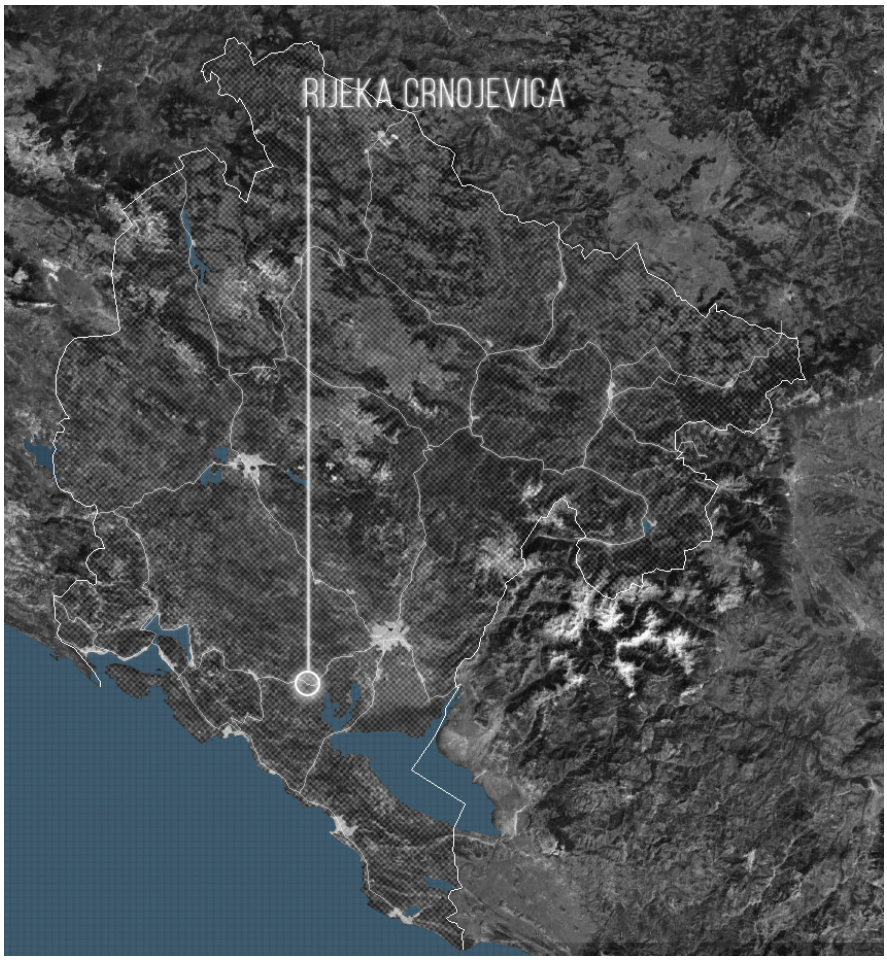


Figure 11: Location of Rijeka Crnojevica in Montenegro.

2.1. Diminishing of villages and small size towns in Montenegro

Montenegro is country with 66,88% of urbanized population, and it makes it very similar to trend in rest of the European countries, where majority of population is living in urban areas. [10]
One third of the country's population is situated in the capital. Most of the other towns and villages are losing population due to the migration in capital or in the coast. Highest trend of loosing population is happening in the northern municipalities. There have been sharp increase from 1981 to 2010.
Reason is mostly economic stagnation of the region and better opportunities in the capital.
Annual net migration in capital is around 1800 people per year, now it makes more then 30% of the population of Montenegro.[11] Throughout history Montenegro was rural country, rise of urbanization had happened in two phases for two different reasons. After World War 2 rapid industrialization efforts had taken pace. Large factories were opening in urban areas, and that had attracted the population, the growth of urban population had steady growth till 90ies. During the period from 1991 to 1999 Montenegro economy had collapsed and national GDP in 1999 was 61% lower then in 1989. [12]Economic collapse and stagnation had turned another wave of migration from the rural areas of the north to the south and central regions.

In 1960ies there were 28 town municipalities with more than 3000 people, today there are only 21. And from these 21, not all towns are with permanent population throughout year.

2.2. Location

Rijeka Crnojevica is one of the places that experienced sharp decline in population.
In 1960ies it had permanent population of 3200 people, and had the status of municipality in Republic of Montenegro. Today has only 175 permanent residents. Majority of population is over 60 years of age.
It lost its municipality status in 70ies and had become part of Cetinje municipality.

It is located between present day Capital Podgorica and Historic Capital Cetinje. In the narrow river valley stretching out from the Skadar lake.
It is a very known touristic location and it is close to the Skadar lake which is protected National Park area. Its surroundings are characterized by natural scenery that attracts lot of tourists annually.

Largest population drain occurred after the construction of modern road between Capital of Podgorica and old Capital of Cetinje, bypassing the town. Thus Rijeka lost previous importance as a stop on the very busy traffic route that once was.

Place was known for fishing industry producing caned fish, river pearls. It was also known as the important agriculture area that was producing large amounts of wine and other products . After economic downfall in 1990ies the industry diminished, in 2018 the last portion of caned fish factory was closed, leaving Rijeka devoted of strong industrial base, and leaving portion of population unemployed.
Today region is part of Montenegrin winery regions as part o economic initiative to revive winery and agriculture. Place also has many touristic potentials.

10 Bureau of Statistics of Montenegro, Podgorica, 2018.
11 Internal migration in Montenegro in 2018, Podgorica 2018.
12 Economic Chamber of Montenegro, Podgorica 2012.

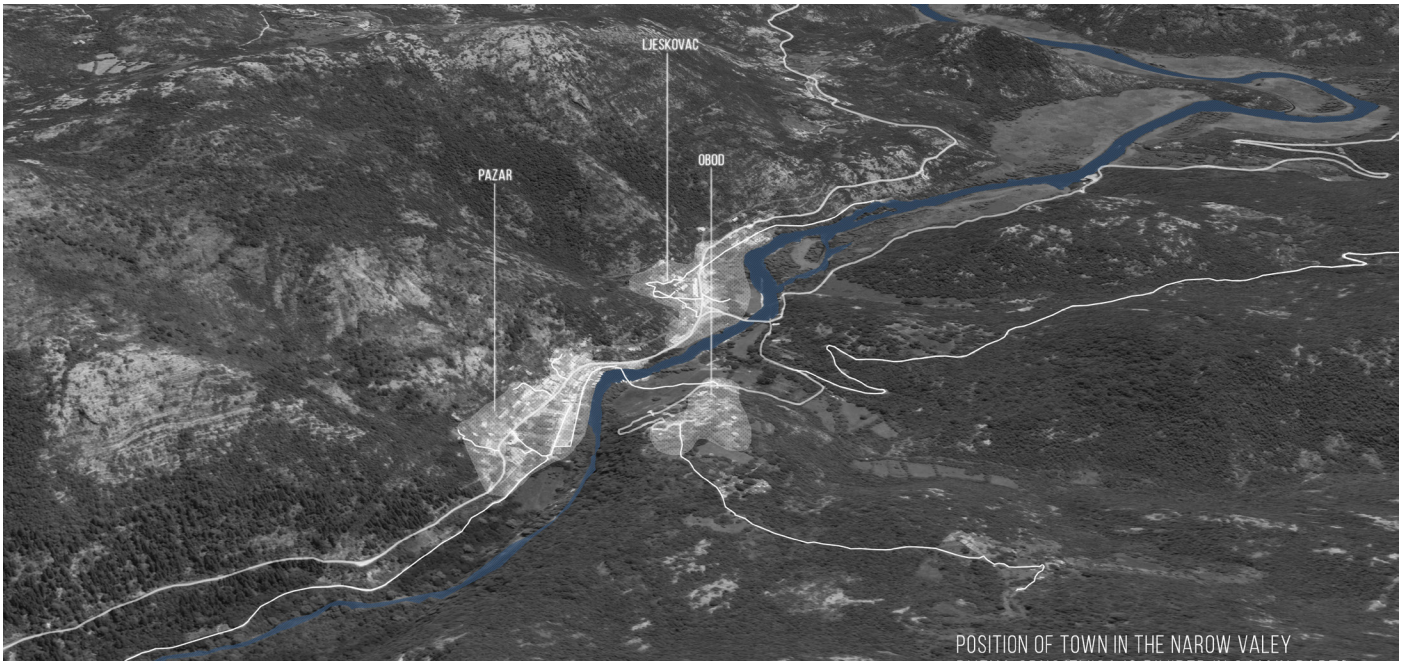


Figure12: showing extent of high tide in the valley where town is located.

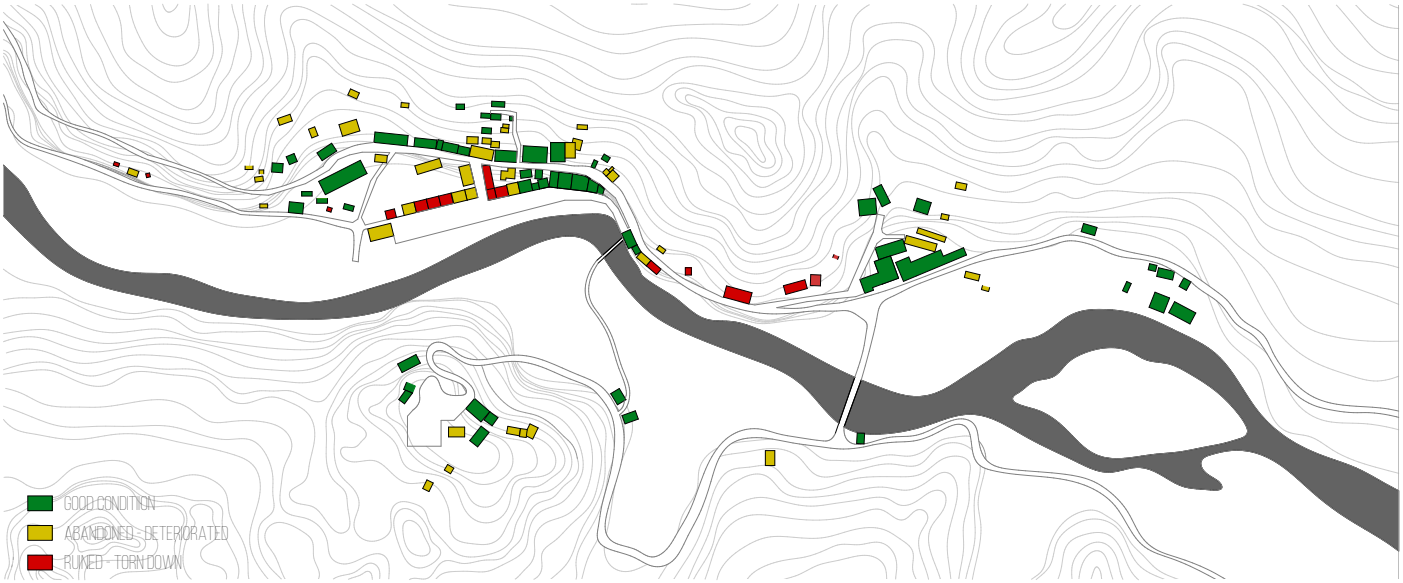


Figure13: Wider area shown with different varieties of lake levels during different seasons.

Figure14: Photographies of town during some noticeable flooding events in 20th century.

2.3. Urban fabric – time-line of the place

Settlement is separated in 3 distinctive parts:

Obod, also called Rijecki grad is settlement on the right side of the river. It is on the highest elevation. It is of radial shape, built on the base of the old fortress.
In center there is a small church with ruins of old for printing house, which has historical importance.
It is the oldest part of the town, originating from 15th century. It was settled during Ottoman invasions on the end of 15th century as a temporary capital. It was a place where first books were printed in Balkans.

Ljeskovac – part on the left side of the river, located on the east. Largest surface covered with the abandoned factory for caned fishes and old royalty summer house.
It does not have planned grid. It is the newest part of the town, first houses were built in the end of 19th century as part of the King's summer house together with the guards house. In 1950ies the factory was built together with the monument complex from WW2.

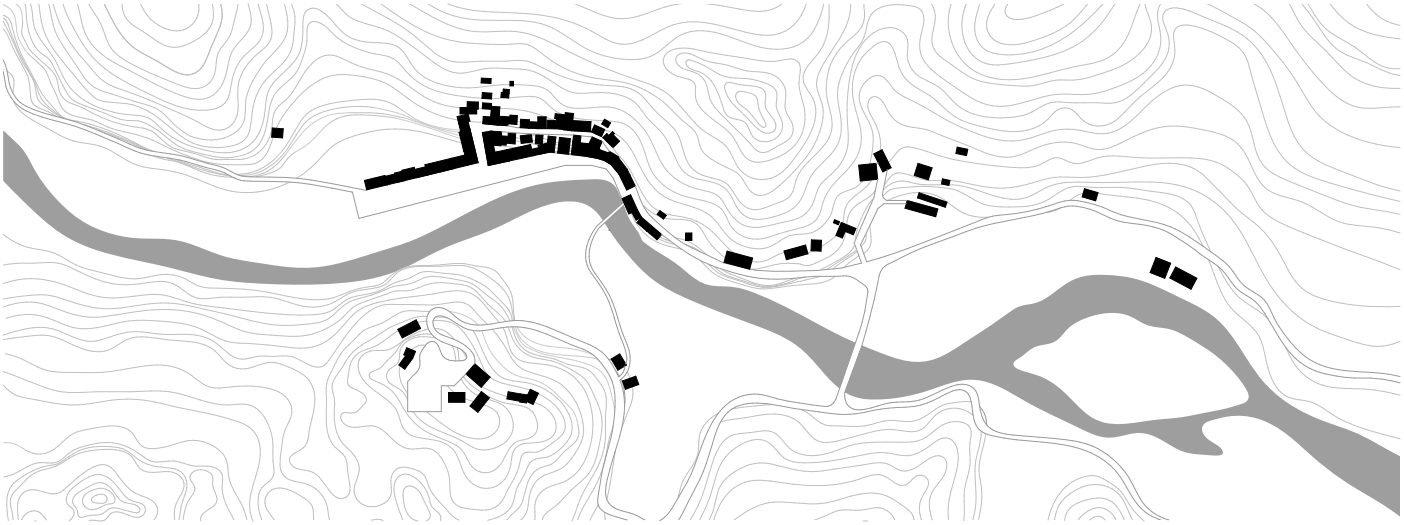
Pazar – main part of Rijeka Crnojevica with highest percentage of built space. It hosts main promenade which had hosted bazaars – markets with many locals in past times. Still it has most of the activity. It is the place of the Old bridge, by which the town is famous for.
It is settled in 16th century and was the center of commerce for surrounding area. It served as the main port of Montenegro till the late 19th century when it got access to the sea coast.

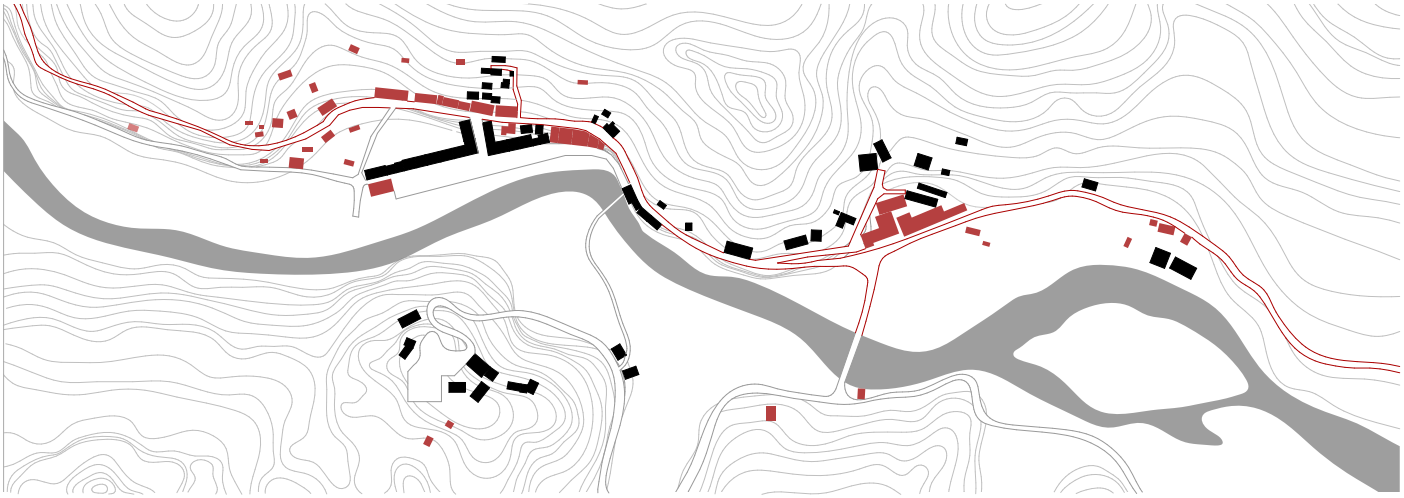
Rijeka is on the intersection of 2 roads. One going in east-west direction, connecting town with the main road leading to regional road connecting two capitals and second going to the south, leading to the regional road southern connecting capital and the coast.

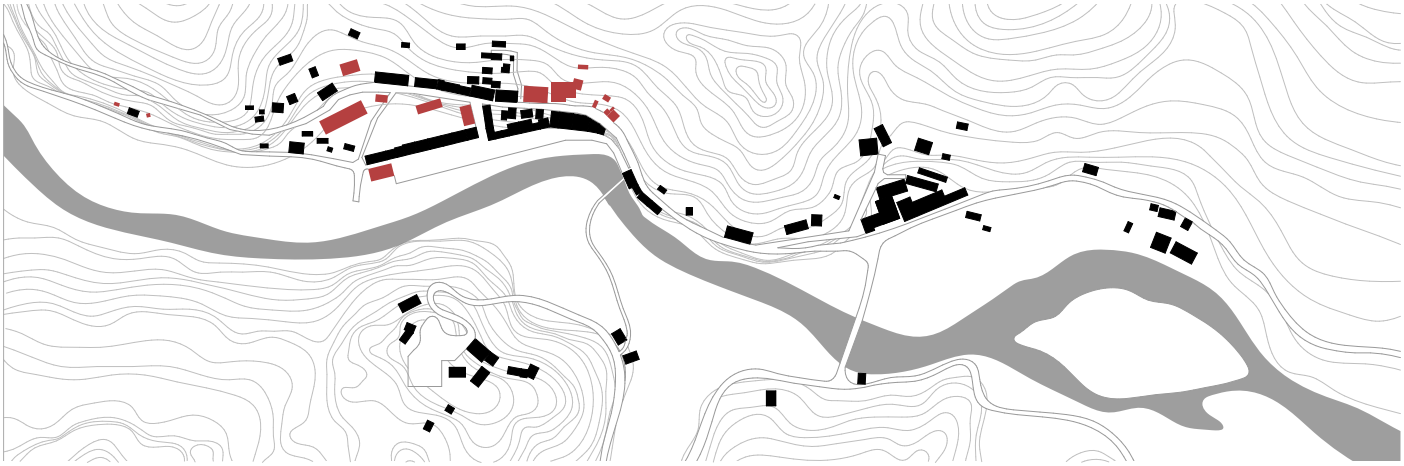
Process of urbanization is reversed; the nature is taking pace. Built fabric is neglected and it is deteriorating, leaving the way for open fields.
Town is populated by by less then 20% percent of its capacity.

Roughly around 50% of built fabric is in the good condition which means it is suitable for living and working activities.
Around 30% of the building are in deteriorated state, which means they are suitable for living but need some level of renovation.
About 15% to 20% of housing are in complete state of ruin, and would need extensive repair or building again.

From the functional aspect, settlement still has ambulance, school and post office. Most of the buildings are made for housing with large number of economic space like restaurants and stores and pubs. There is a number of smaller hotels/apartments with capacity of around 100 beds in total.







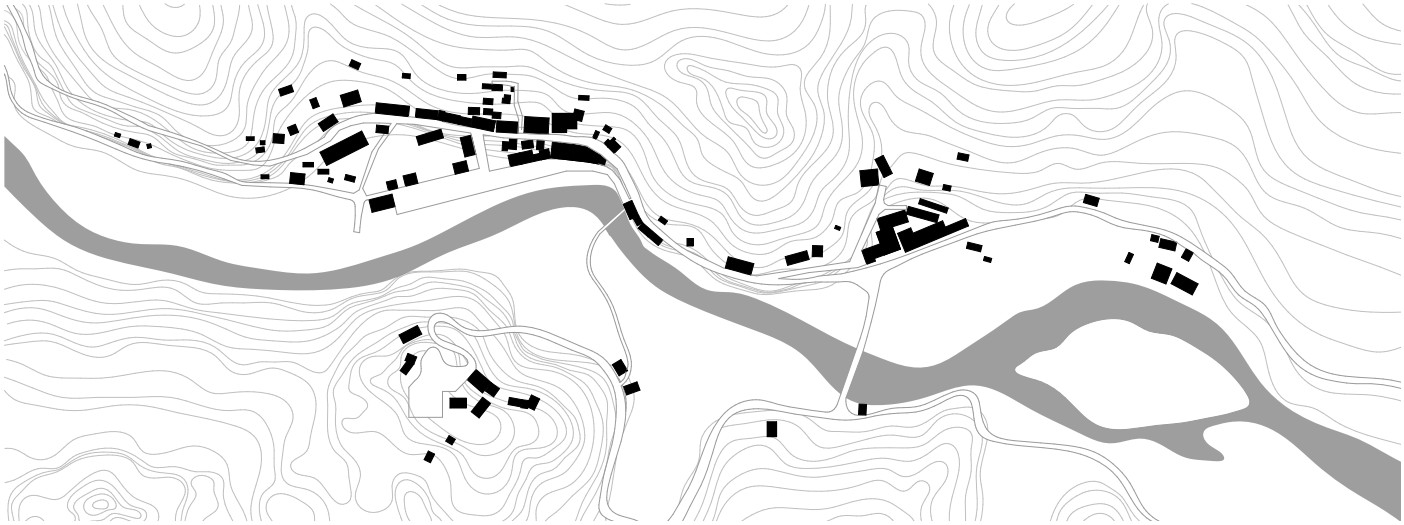


Figure 16: Figure plan year 1910.

On the beginning of 20th century town was very well populated for that period and had formed typical urban features. Because of the very close distance to the capital, less then 10kilometers and with the good position on the western edge of the lake it served as a transport and economic hub for the cross-border commerce between Ottoman Empire and Montenegro with constant traffic from one side to the other.
The main settlement was built on the left side - Pazar with long promenade, and the right side Ljeskovac - served as a king's residence and was left for more industrial development.

Figure 17: Figure plan year 1955.

After WW2, the industrialization has taken hold. With construction of the factory the settlement developed on the right side. The local road that was connecting now new capital - Titograd and old capital Cetinje was reconstructed for larger traffic and was directly going through the settlement. With road enlargement the old cul-de-sac was changed with the long corridor and started to serve as the main direction of towns development. More houses were now concentrated on the upper street then on the riverbank. New crucially important buildings were constructed - municipality building, little hospital, school, and a culture multi-functional center. Riverbank still served as a center of towns public life with frequent weekly markets and water traffic.

Figure 18: Figure plan year 1980.

With the construction of the modern road connecting Titograd and Cetinje, the town lost the importance. After the earthquake in 1979 lot of buildings were heavily damaged and construction of new housing has taken pace again on the upper road, leaving riverbank in neglect.

Figure 19: Figure plan year 2020.

After the economic collapse in the 90ies together with migration to the capital, town continued to deteriorate to the point where the whole left part of the riverbank lost its urban fabric and the space was left for the open field. Now, town resembles more rural area than urban settlement.

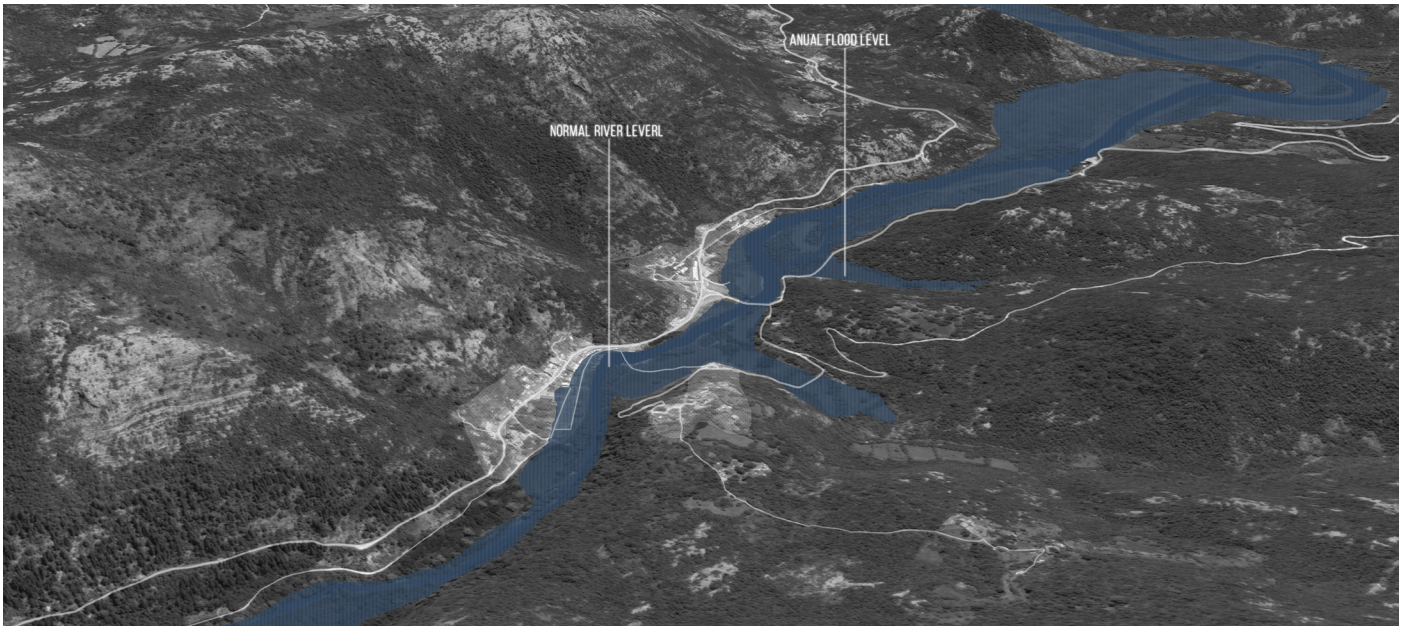


Figure 20: showing extent of high tide in the valley where town is located.

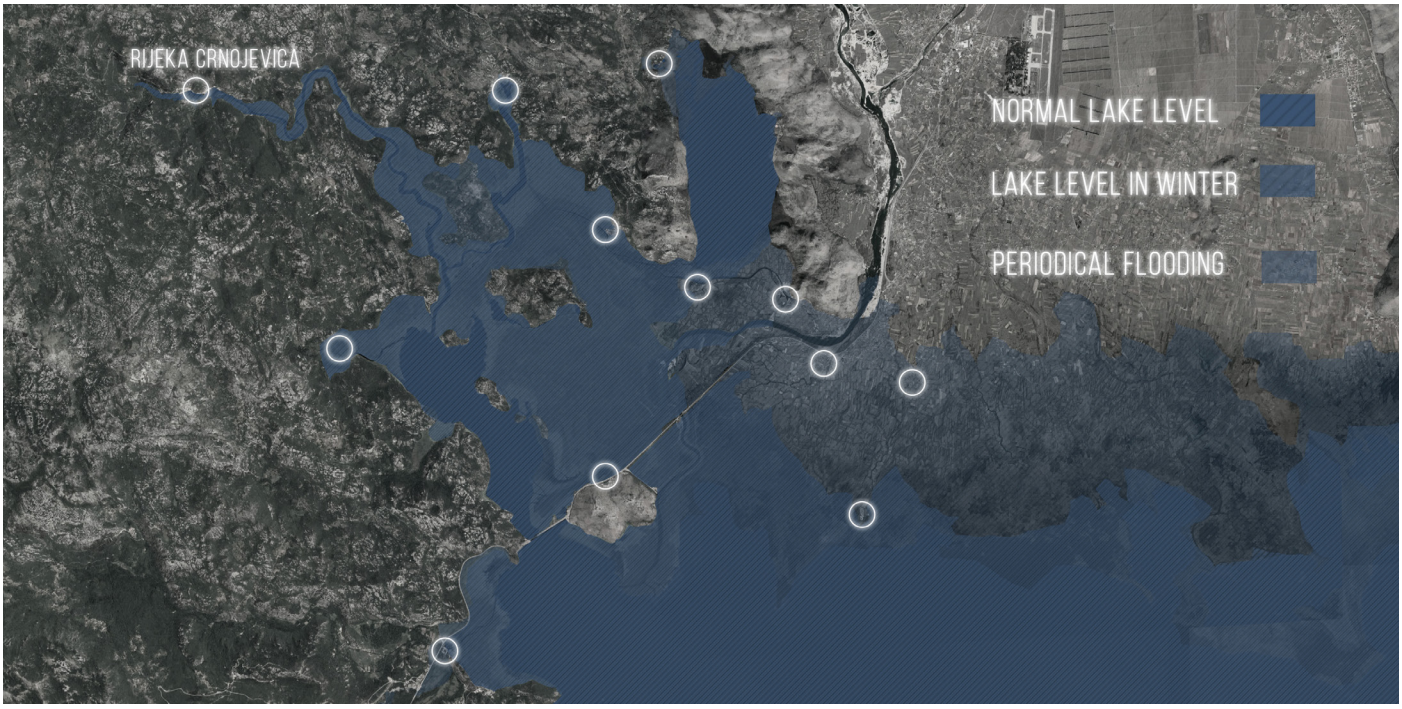


Figure 21: Wider area shown with different varieties of lake levels during different seasons.

Figure 22: Photography of the last flood event in 2018.

2.4. Flooding

Floods pose constant problem not just in town but in its surroundings. Even though town is placed on the river, it is actually elongated bay of the Skadar Lake. River water level fluctuate according to level of the lake.

There are two types of tides, annual ones that do not pose a great danger and are about 40 - 60 centimeters on the level of the main promenade. They enter in the ground floor of the buildings, and are annually repaired. Damage they cause is close to 1000 euro per building.
Second type, are unusually high tides that happen every 15 to 20 years.
As the answer to such tides residents are building ground floor in materials that water resistant, and with replaceable pavement.
Problem make the unusual high tides, that can struck and there have been many examples of high water levels, more then 2 meters high from the level of promenade. It pose a significantly greater damage to the settlement.

Whole basin of the Skadar lake is affected by flooding, Rijeka is just one of many settlements on the lake shore that is hit with high tides.
On the second map from up to down, on the previous page, it is shown the area of the lake that is affected and the various levels of lake during the flood season. It is visible that many settlements are affected by the floods, it hits around 15 thousand people from the Montenegrin side. From the Albanian side it is way more because of the higher density of settlements, it is close to 100 thousand people.

Response to high tides were not effectively met on both sides of the border. There were Montenegrin plans for water level regulation project at the end of 19th and beginning of 20th century but due to economic inabilities of Montenegrin state and Ottoman disinterest that ruled over large part of the lake, the plans were left only on the paper. In 20 century there was joint Yugoslavia - Albania plans for water regulation projects, but due to the deteriorating relations during Cold war, it also left undone.
On the architecture level, local tradition is to put houses on the high columns with ground floor free of any content. In more populated places houses are built with ground floor with the economic functions that are used for restaurants or storage spaces. They are mostly made of water resistant material, with combination of cut stone walls and removable pavement or parquet.
More on the resilience of housing in the Lake area was not done.

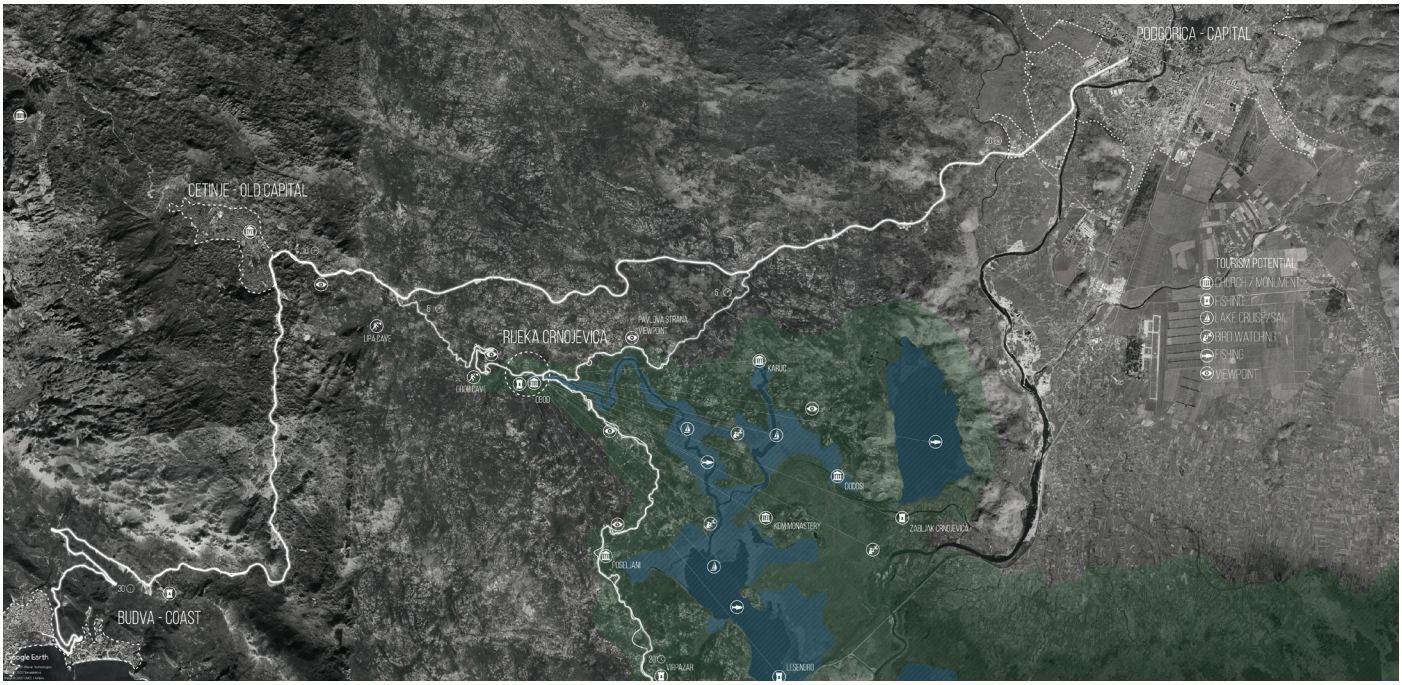


Figure 23: Location of Rijeka Crnojevica, touristic potential of the place.

Figure 24: Production of caned fish

Figure 25: Abandoned factory.

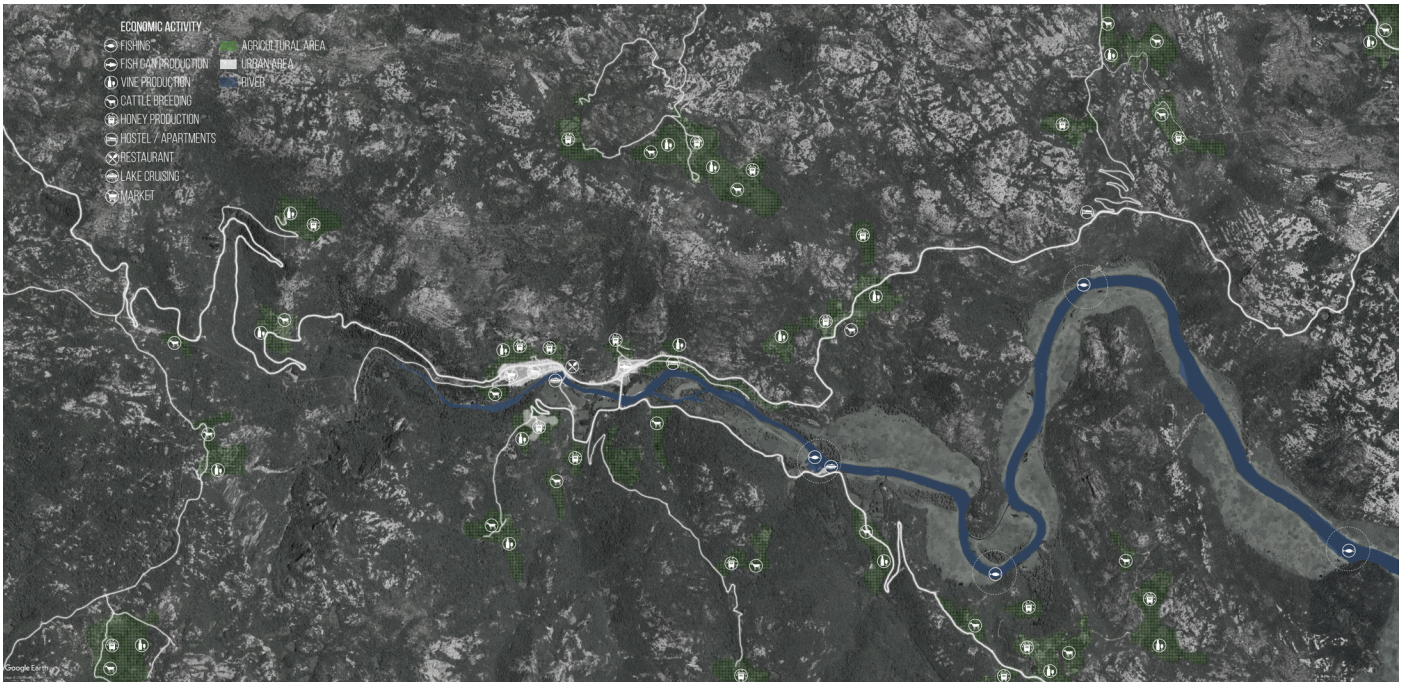


Figure 26: Map of agriculture potential of surroundings of Rijeka Crnojevica

2.5. Opportunities

Even though most of the industry had diminished from Rijeka, the place thanks to it's position holds many economic opportunities. Mild climate, agricultural fields in surrounding, fishery potentials and historical importance make Rijeka Crnojevica very attractive place not just for tourism but for other economic activities.

Touristic potential:

Located only about 10 minutes ride from the historic capital of Cetinje which is touristic attraction and about 20 minutes ride from the Capital of Podgorica it has favorable position for tourism development.
It is situated on the western tip of Skadar lake National park which is touristic attraction because of its landscapes, wildlife and historical monuments which are situated there. Nearby Obod cave is also the alpinistic and speleological attraction but it is in state of neglect.
Lipa cave, one of the most famous speleological sites in Balkans is only 15 minutes away.
The settlement itself possess a number of historical monuments and is of important historical significance. Authentic local architecture together with agricultural fields and preserved nature is very attractive place for tourists.
Rijeka lacks touristic infrastructure, there are no hotels working. Only small hosting places and private apartments are in circulation.

Industry - manufacturing potential:

During the last 30 years, Rijeka has lost all the industrial, manufacturing base. Last portion of factory that was producing caned fish and river pearls had shut down in 2018. This industry was employing 1/3 of population of the settlement.
Together with state's protection of the lake and fishing ban, perspective for factory revival of factory is not great. There were talks for conversion of the factory's building into art/culture center.

Agriculture potential:

By the municipality plan, surrounding of Rijeka is considered as Vine region and agricultural area. Its mild climate and arable land makes it great for development of agriculture.
Vineyards,, orchards and other agricultural fields are very common and are representing the bigest revenue of the region. Livestock of goats and sheep is also considerable together with honey production it makes very important product of the municipality.

Figure 27: Rijeka Crnojevica in 2020.

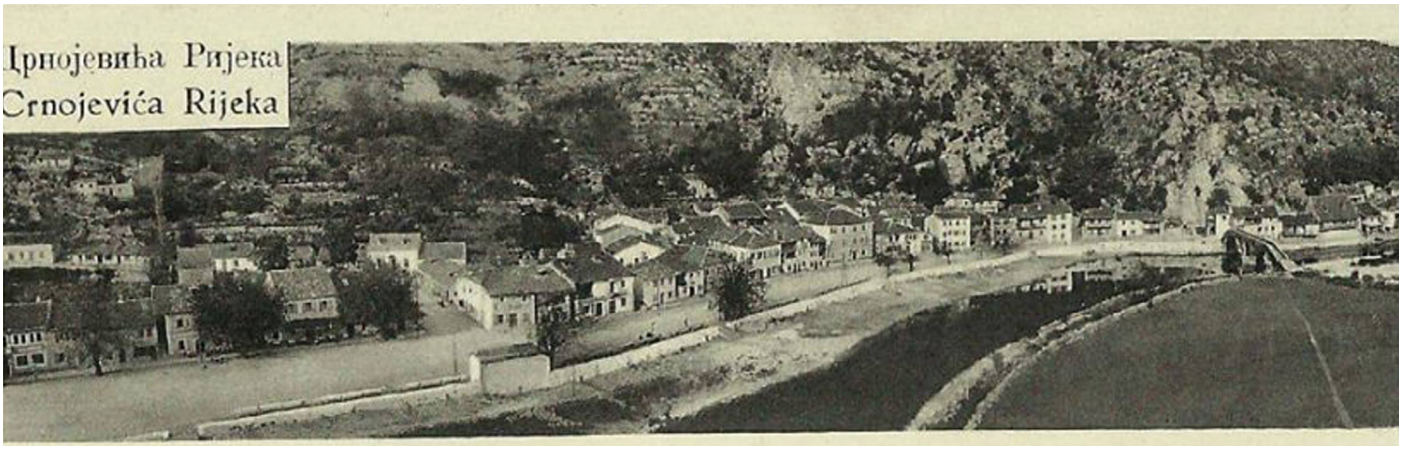


Figure 28: Rijeka Crnojevica in 1930.

Figure 29: Rijeka Crnojevica in 1890.

2.6. Resident's opinion

The interview with the resident of Rijeka was conducted, theme - How you sees the problems and potentials of the place?

He is a permanent resident and owner of the restaurant located in the promenade.

Biggest problem for the settlement as he sees are - lack of the good road that can connect Rijeka with the main road, existing one is too narrow and needs extensive repair.
National Park for him, causes many problems because it forbids many activities that are essential to the economic activity of the place (agriculture, fishing), illegal methods of fishing, lack of overall care for the settlement from the Cetinje Municipality.
One of the problems as he stated are the annual smaller floods (similar to Venice), so every year he spends around 1000-1500 euro on repairs of the ground floor. Lack of opportunity and interest for younger people to come back.

Opportunities he sees in tourism and potential of the lake and historic/cultural importance of the place. Most of the visitors are foreigners and they use the place as the base for lake exploring (cruises, canoes..). He stated that many people who are retired had come back and are building/ rebuilding houses and are trying to popularize town's potential.

By his account, fish factory while it was working with lake resources was good but as the lake has lost lot of its fish fund, they started importing the fish and could not make any profitable business.

Floods posed constant problem not just in town but in its surroundings. There are annual floods that that are part of the lake water cycle, in town it goes about 50cm annually and riverbank is covered together with ground floor. Resident's answer on that are stone walls and waterproof paving to low done the damage as much as possible.

Problem make the unusual high tides, that can struck and there have been many examples of high water levels, more then 2m high. It pose a significant damage to the settled area around the lake and in town itself.

Figure 30: Rijeka Crnojevica, riva.

Figure 31: Rijeka Crnojevica, lost built fabric.

Figure 32: Rijeka Crnojevica, promenade.

Figure 33: Rijeka Crnojevica, old bridge.

Figure 34: Rijeka Crnojevica, ruins of former hotel Obod.

Figure 35: Rijeka Crnojevica, house line.

3. Flexibility as a solution

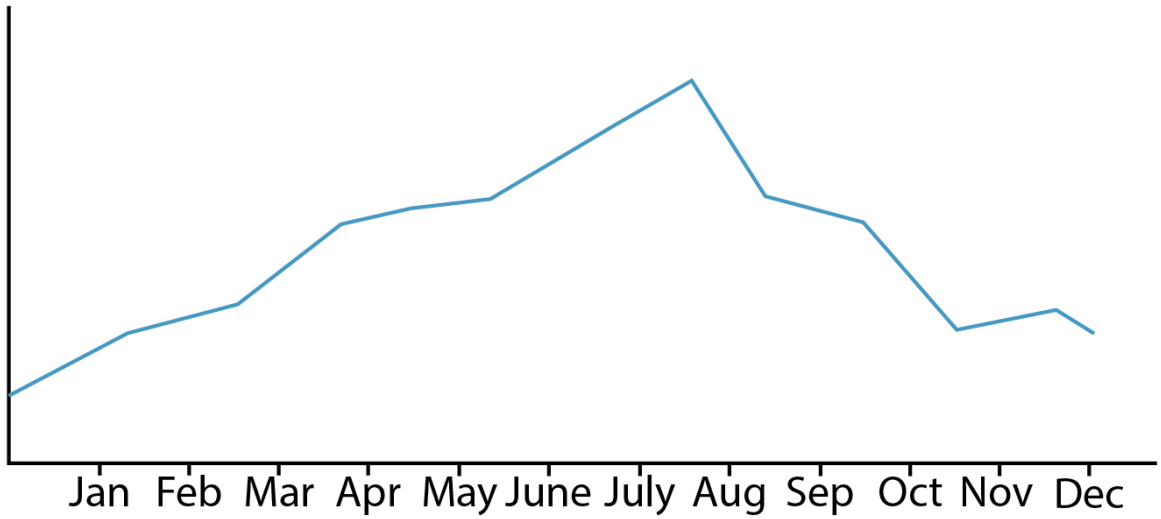


Figure 36: Annual amount of tourist activity.
Source: Municipality of Cetinje, 2018.

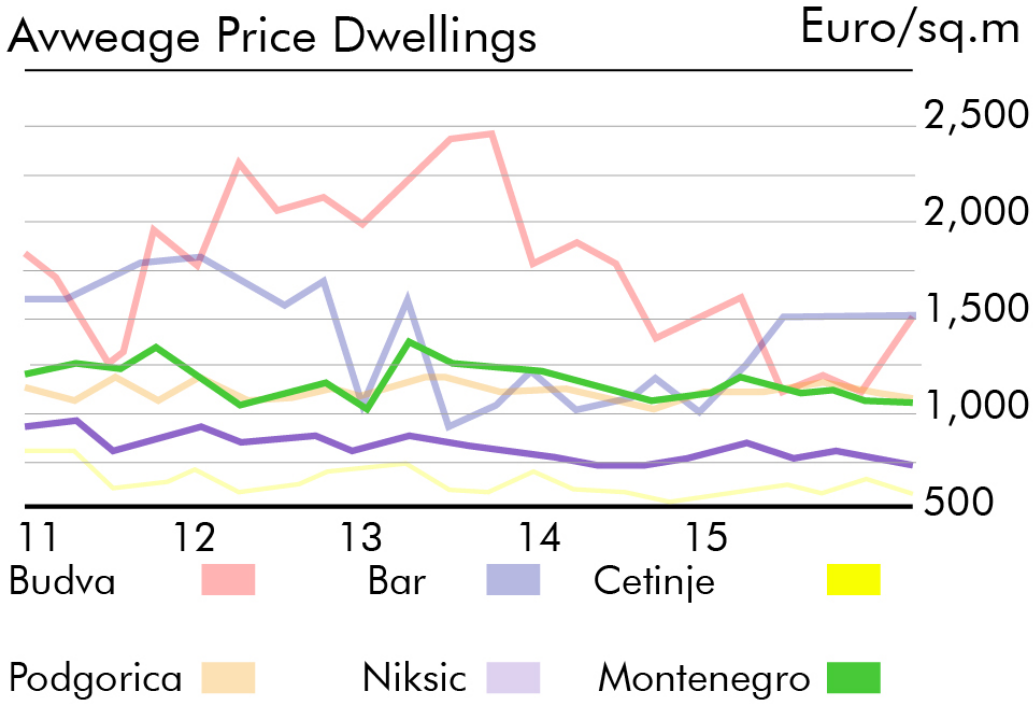


Figure 37: Average price of sq/m in Montenegro.
Source: Municipality of Monstat, 2018.

3.1. Flexibility as the economic generator

How can flexible – adaptable housing enable and create more friendly environment with much better opportunities for repopulating and revitalizing the chosen location.
By "Flexibility" it refers to the ability of a built space to continuously adapt its space layout and its structure to evolving needs of its users (family enlargement, economic activity) or natural occurrences.

Having in mind the economic and demographic situation of town from the chapter above, case study would be concentrated toward flexibility as the generator of town's renovation.
Main reason of Rural Flight is the economic opportunities that the life in larger urbanized areas is offering.

If we consider that some portion of people is willing to go back to the countryside, probable answer in Montenegro would be the older generation. Mentioned population who had finished their working careers is more willing to go back to village life because the tempo and cost of living suits them more. Also, it allows them to initiate small scale economic activity, manifested in agriculture and in some cases tourism. On the graph - image (number) it is visible that average square meter prices of apartments are under the average of Montenegro.

If one individual decides to buy portion of land for a cheap price and wants to build a house, it requires considerable amount of initial expense. And if the individual wishes to begin economic activity by using the evident tourism potential of the place, must build new space or re-adapt the already existing ones, and it again requires the new expense. If economic activity (café, shop, hostel) works expense return is assured, but it requires very optimistic projection. As this kind of activity is the longer-term investment and in case of bad touristic season or flooding (which this area is prone to every 15 – 20 years) it is very risky endeavor. Especially if flooding happens the whole renovation must occur, which requires totally new re-adapting or even in some cases rebuilding. From this calculation we can clearly see that this is very risky and questionable investment both in short- and long-term view.

No town is a static place or a system with constant dynamics. Its dynamics depend from the time of day and the year. Rijeka is a touristic place, and the number of people fluctuates drastically throughout different periods of the year.

As the location attracts lot of tourists annually, it is very compelling to use tourism as one of the main factors for generating the small and medium scale economic activity from the actual residents of the place.

But as seen from the graph Figure , not whole year has the same amount of tourist activity, therefore the need for the maximum amount of accommodation is not the same.
Inserting flexible buildings in this case is economically very valuable because it allows using space according to visitation dynamics.
From the architectural and analytical point of view, the main question is which elements can be made flexible. No building is totally monolithic object which is impossible to divide into many different functional layers.

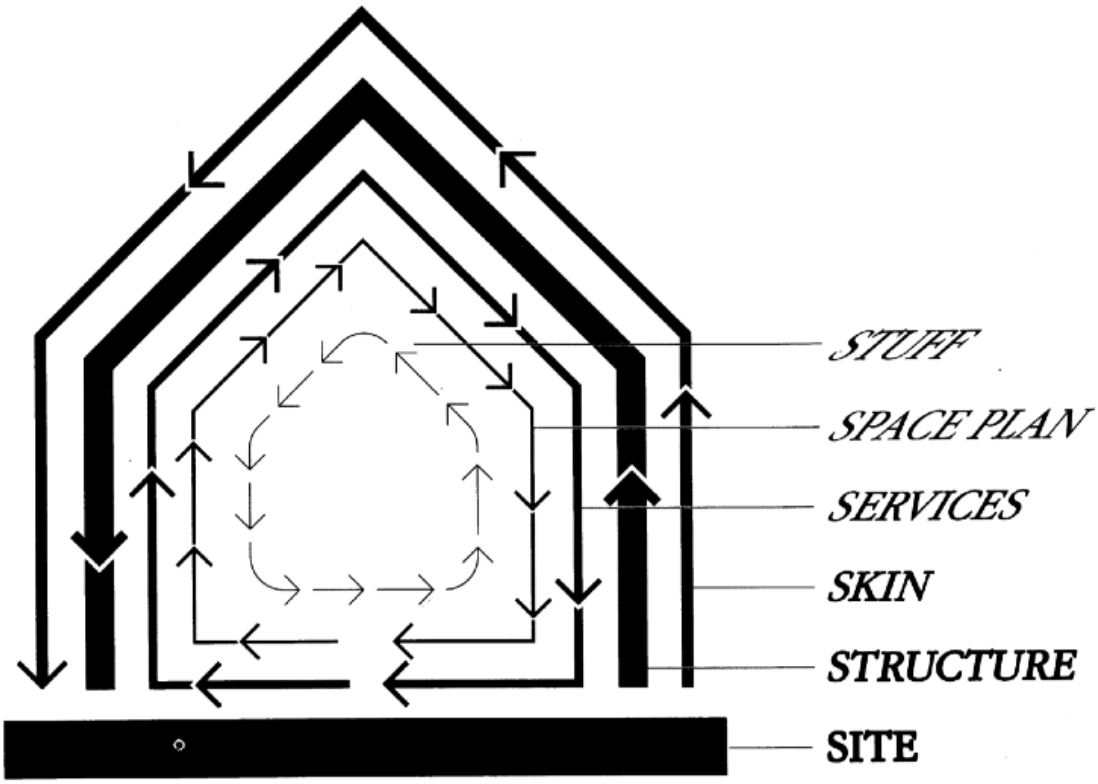


Figure 38: Different building layers.
Source: http://stanislaschaillou.com/articles.html.

3.2. House as the sum of layers - Frank Duffy

From the architectural and analytical point of view, the main question is which elements can become flexible. No building is totally monolithic object which is impossible to divide into many different functional layers.

British architects Frank Duffy defined building as a set of different layers of different durability. Layers are next (quoted).[13]

Site
This is the geographical setting, the urban location, and the legally defined lot, whose boundaries and context outlast generations of ephemeral buildings. "Site is eternal." Duffy agrees.

Structure
The foundation and load-bearing elements are perilous and expensive to change, so people do not. These are the building. Structural life ranges from thirty to three hundred years (but few buildings make it past sixty for other reasons).

Skin
Exterior surfaces now change every twenty years or so, to keep up with fashion or technology, or for wholesale repair. Recent focus on energy costs has led to re-engineered skins that are air-tight and better-insulated.

Services
These are the working guts of a building: communications wiring, electrical wiring, plumbing, fire sprinkler systems, HVAC (heating, ventilating, and air conditioning), and moving parts like elevators and escalators. They wear out or obsolesce every seven to fifteen years. Many buildings are demolished early if their outdated systems are too deeply embedded to replace easily.

Space Plan
The interior layout—where walls, ceilings, floors, and doors go. Turbulent commercial space can change every three years or so; exceptionally quiet homes might wait thirty years.

Stuff
Chairs, desks, phones, pictures; kitchen appliances, lamps, hairbrushes; all the things that twitch around daily to monthly. Furniture is called mobile in Italian for good reason.

If disassemble the building in this way we can see that some layers as space plan, skin, services are actually very likable subject to changes, and as they are made in a very static way, it is very hard to change them in some efficient manner. We can argue that they can easily be made much more flexible even though they are mostly considered in today's architecture as a very massive and static elements. Elements like walls can easily be made flexible and can bring greater freedom in the dynamic organization of space.

Because of different rates of change of its components, a building is always tearing itself a part(quote).

Possibility to specify which elements can easily be targeted for higher degree of flexibility is of utmost importance for concerning flexible design.

13 Stanislas Chaillou, Metabolisms - Flexibility in 21st Century, Harvard Graduate School of Design, 2018.

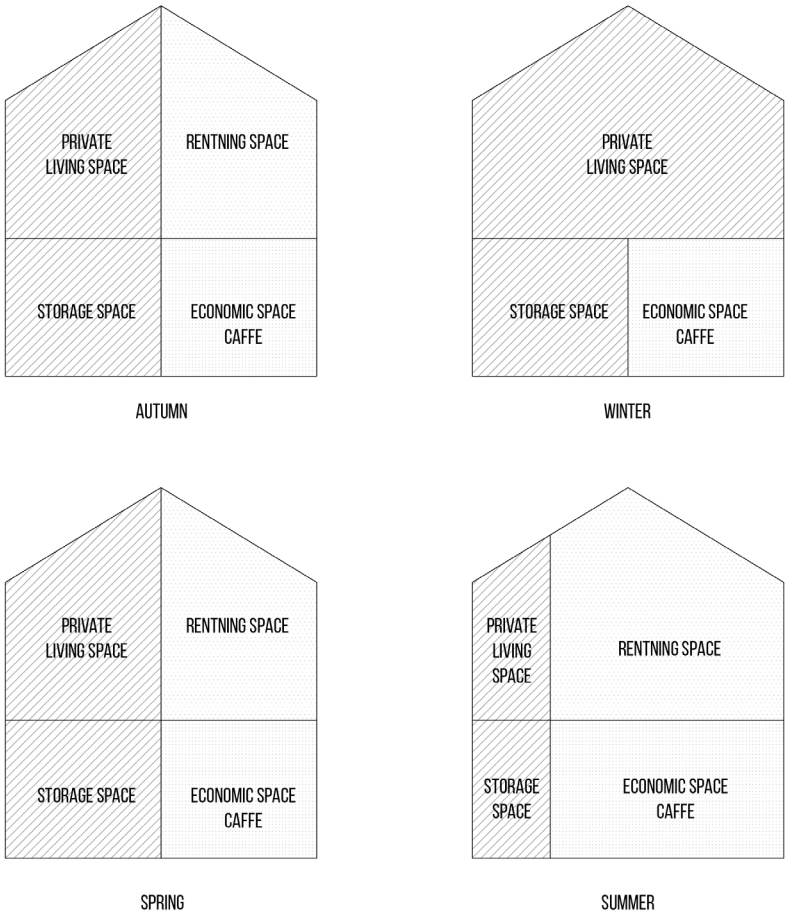


Figure 39: Elasticity of house spaces with change of seasons.

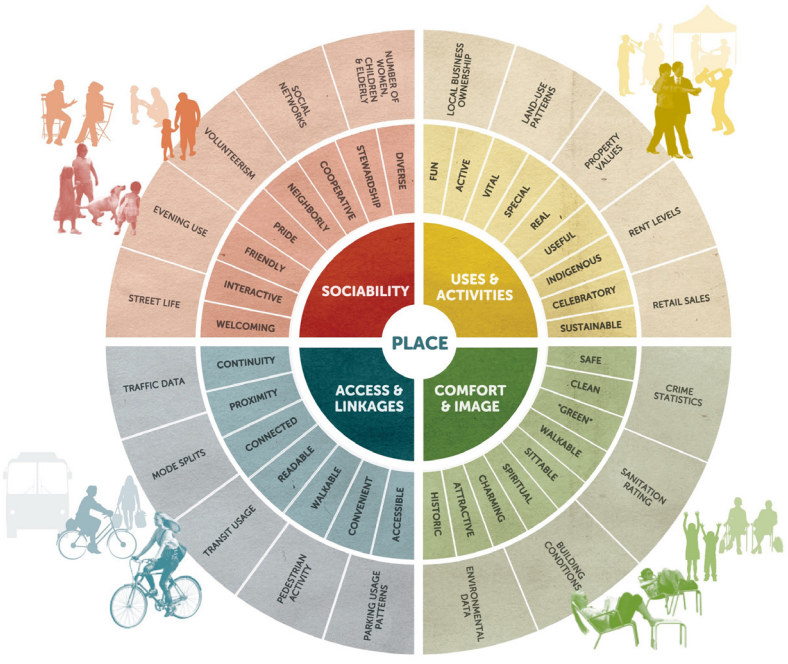


Figure 40: Aspects that make public space attractive.
Source: Project for Public Spaces, New York, 2019.

3.3. House dynamics

More than 90% percent of built space in Rijeka is consisted of housing.
According to local typology ground floor is used for the economic purposes (restaurants, bars, shops,..) or as a storage facilities. While upper floors are used for living.
Tourism holds the greatest potential so most of the houses are fitted to suport renting activity.

I If the users want to change the layout of the house, to accommodate larger number of rooms for example, the whole renovation must take place, which includes tearing down the existing walls and adding the new ones. These works take lot of money and time.

There are many cases on the coast that many people who are renting privately the apartments are sacrificing their own comfort by renting even their very own living space that they the fully maximize the revenue during the peak of the season, usually July and August. Or they make their living space very small, and when there are no guests it stays empty.

Solution with flexible layout allows much smarter usage of the private/renting space according to real time needs and can allow the space for greater varieties of activities.

In the image, previous page it is shown the greater elasticity of housing layouts. It is visible that highest amount of renting space is during the summer, from end of May to the middle of September, with peak in July and August, according to the image (number).
Equal percentage of private and renting space is during Autumn and Spring seasons. While highest percentage of private space is in Winter season, when tourist activity is on the minimum.

3.4. Open space dynamics

Central part of Rijeka is the riverbank. It serves as the town's square and it is part with the highest concentration of activity.
To revitalize Rijeka's economy, the place must attract people not only for the economic reasons but also because of attractiveness of place itself.
Making public square vibrant and attractive place is one of the main prerequisite for growing the tourist attractiveness and the economic aspect.

Activity of the square fluctuates dependent from the seasonal level. Highest activity is recorded in summer season, according to Touristic activity graph. Many activities are
Walkway promenade, market place, exhibition space, sport playground, storage space for boats, etc, are just few activity scenarios for which is the riverbank suitable for.
Because of anuall flooding is usually covering the whole area of the square, giving extra dynamics to the case.

Having these facts in mind, there is a clear need for the highly flexible public space that is able to adapt to constant changes of the activity content.
Same principals applied for the house functional elasticity, should be involved in the public space, that can successfully answer town's needs.

Figure 41: Example of movable walls in Japan.
Source: Aki Hamada Architects, 2017.

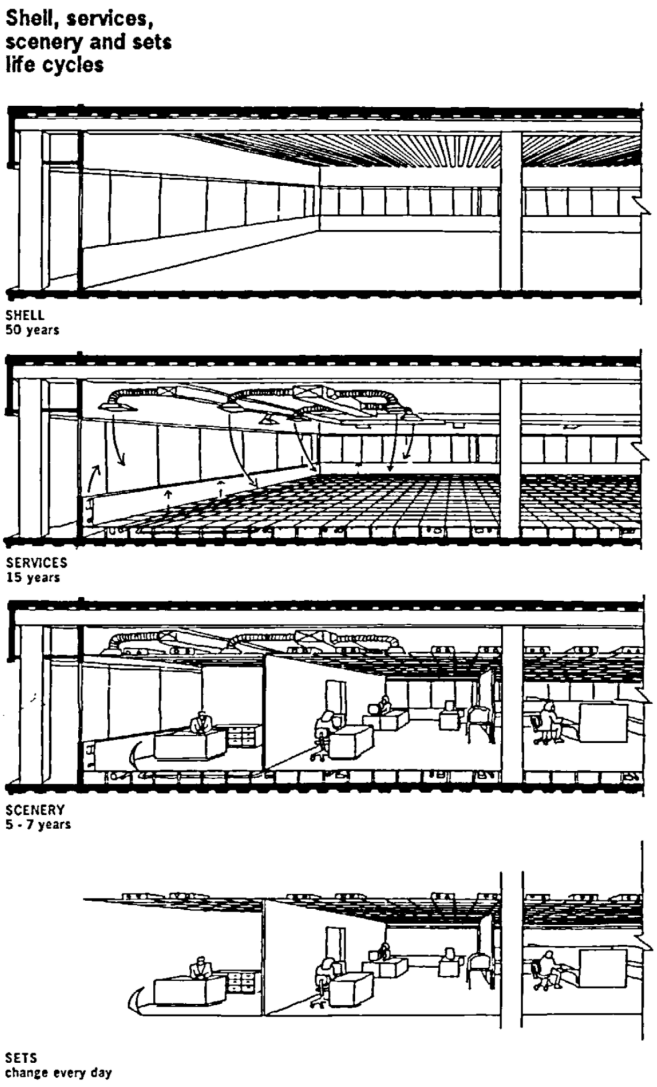


Figure 42: Change of different architecture layers trough time.
Source: Project for Public Spaces, New York, 2019.

3.5.Elements Qualification - static and movable elements

To enable flexibility of the building first, the qualification of the elements must take place.

Which ones have possibility to be movable and which ones do not?

According to Frank Duffy's definition of building as the set of layers, it is possible to conclude which layers are applicable to usual change - mobility.
Site, structure and services because of its features are not prone to moving.
More closely, site is not prone to change in this case. While structural elements like - Constructive walls, beams, slabs together with services - insulations can not be movable because of their role in the static system of the building.
Services that include water system installations, sewage system installations and heating system installations must be static. Other services can be considered movable.
Due to the ever changing rate of technological advancement, services connected with water and sewage would be considered as the static elements, and would be projected in solid places.

Space plan and stuff are very prone to changes, because of that they would be considered as movable elements.
Pavement due to very easy possibility of replacement should be considered as movable.

Considering space plan, partition walls are elements that change their positions frequently, which is due to family enlargement or some other needs.
Skin which covers openings as doors and windows are movable by their function alone.

Stuff all the free elements like furniture, etc should be considered movable.

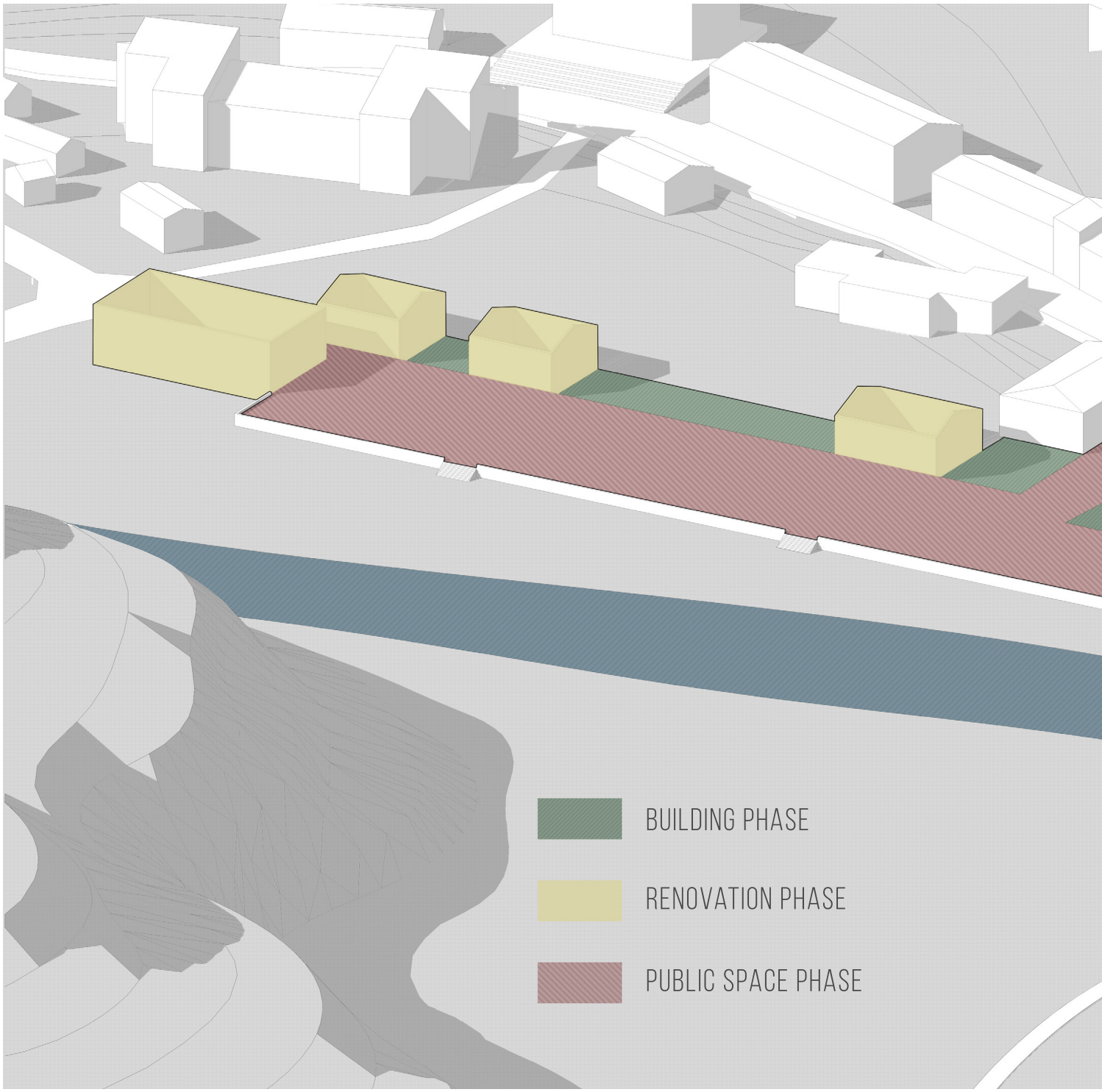
3.6. Phases of intervention

Intervention would be done in the west part of Rijeka, Pazar. On the west end of the promenade there is part which is in state of neglect and needs extensive renovation.

Intervention will hold 3 distinctive phases:

1. Building – adding new buildings

Area where the buildings had been torn down would be filled with newly constructed buildings.
With construction of new buildings, very clear public square would be defined.
Accent to buildings would be flexible layout and flexible facades, that are able to adapt to different usage scenarios.

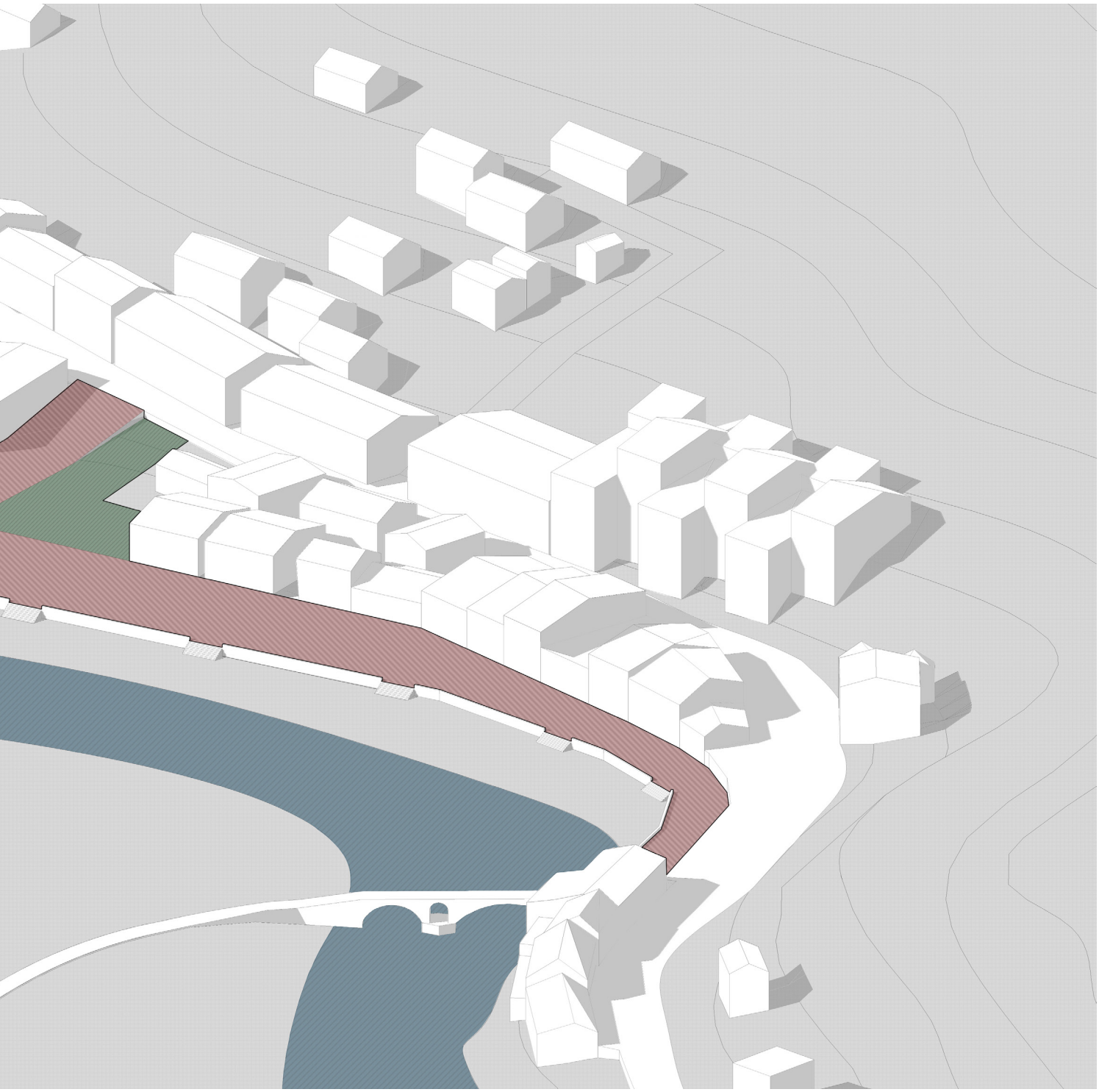


2. Restoration – renovation of abandoned buildings

Buildings that were left abandoned and in deteriorated state would be renovated according to flexibility principals established in this chapter.
Renovation would take place due to preserving the memory and authenticity of the place.

3. Public space - designing adaptable public space

Public square would be renovated, the new riverbank would serve as the place of socialization. It would be constructed in the way that it can adapt to the constant changes and different occasions, in that way it would be generator of town's overall revitalization effort.
In the project there would be extensive use of new technologies, hope is that in this way more opportunities would be brought into rural area and town itself.



Figures 43: Plan of intervention.

4. Building – flexibility in the real design


AREA OF INTERVENTION


AREA OF INTERVENTION


PUBLIC SPACE
ADDED BUILDINGS

4.1. Filling the empty space

First phase of intervention is construction of new buildings in the space that was left empty due to deterioration of the former buildings.
To bring back the urban fabric and look of the town, the construction of the new buildings is necessary.
Buildings would follow the line already established by the rest of the built space.

Height of the buildings would be the same with the rest of buildings in line. The height would be ground floor and one upper floor.

Form of the buildings would follow the strict shape of the already existing houses on the promenade.

Similarly to the local typology of the place, the buildings would be consisted of two separate spaces in different floors.

On the ground floor, the space for the economic activities would be placed (restaurant, shop, storage space, etc..).
The floor above is for housing .

Filling the voids in-between the buildings is way to close the now open borders of the main public space - promenade and create clear line of housing.

Architecturally clearly defined space would be established. Defined space enclosed from 3 sides would serve for creating attractive public space and it would again back the sense of urbanity in the settlement, which was lost with destruction of the previous buildings.

Figures from the previous page, order from up to down:

Figure 44: Area defined for the construction of new buildings.

Figure 45: New buildings placed in the arranged empty space. Buildings are set in the line. Shape and height are in accordance with the rest of the buildings in line.

Figure 46: Newly constructed buildings will close and make defined public space.

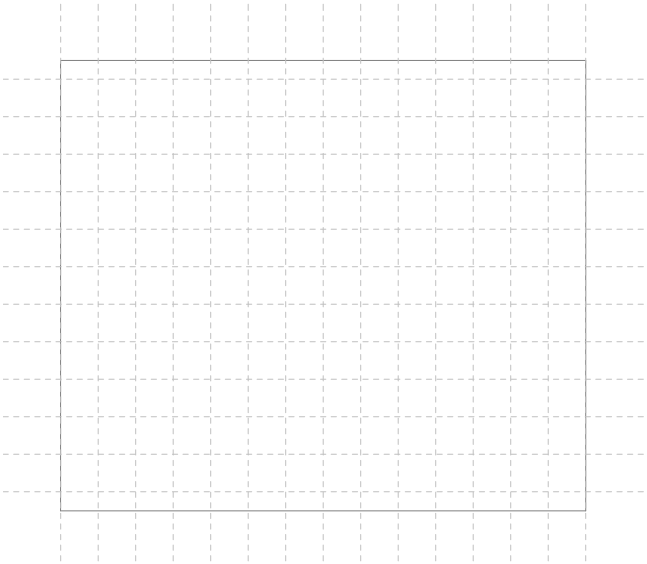


Figure 47: Grid 1mx1m,14mx12m

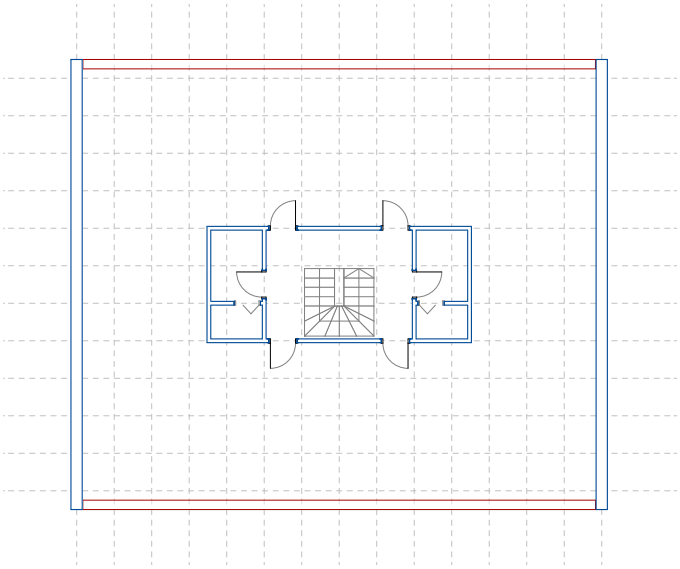


Figure 48: Facade - movable

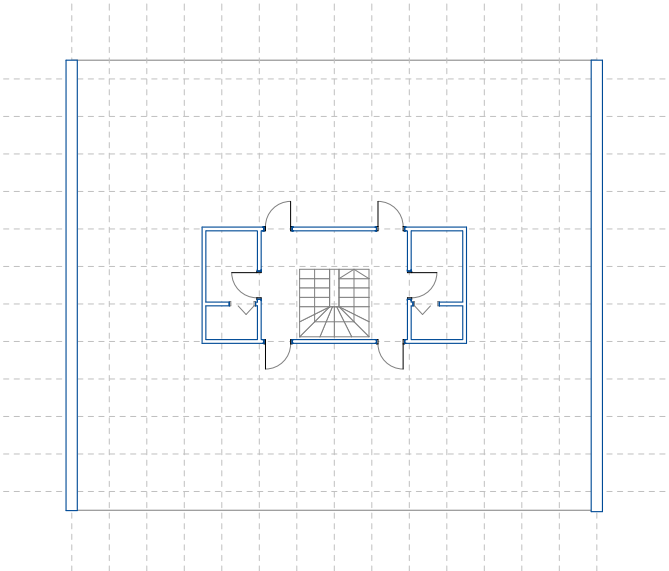


Figure 49: Static elements
- load bearing walls, installations .

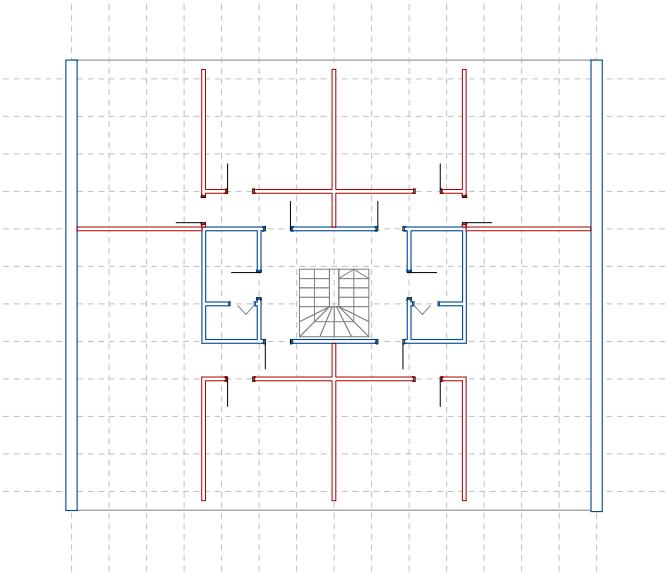


Figure 50: Movable elements - partition walls

4.2. Grid – static/movable elements

Changing of the house functions throughout the year, depends from the amount of touristic activity. As the location attracts lot of tourists annually, it is very compelling to use tourism as one of the main factors for generating the small and medium scale economic activity from the actual residents of the place.

But as seen from the graph not whole year has the same amount of tourist activity, therefore the need for the maximum percentage of space for accommodation is not the same throughout the year, it varies.

Inserting flexible buildings in this case is economically very valuable because it allows using space much more reasonably.

To achieve flexibility, first must be concluded which elements would be flexible and which static. No building is totally monolithic object which is impossible to divide into many different functional layers.

First step is making grid, elements should have a strict set off rules in this case grid of 14x12m divided by 1x1m squares by which different variations can be made.

Second step is to set constructive load-bearing walls on the sides with core made for vertical communication. In the core the services and installations are set. Both of mentioned walls are considered of a static nature.

Third step is setting the partition walls from the core to the sides. These walls are movable and would be moved within specific range according to the residents needs.

Fourth step would be setting of the facade that can be adapted to ever changing interior layouts, so the facade must also be movable.

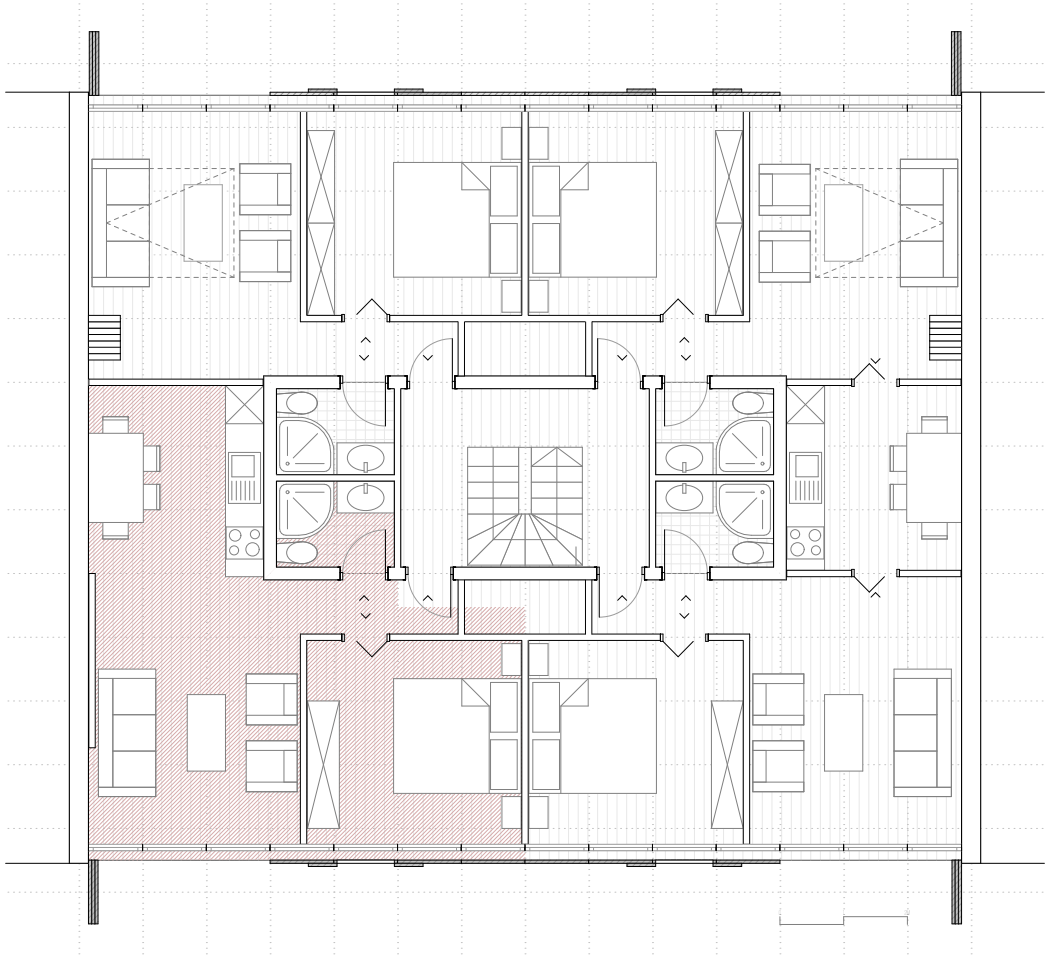


Figure 51: Summer period.

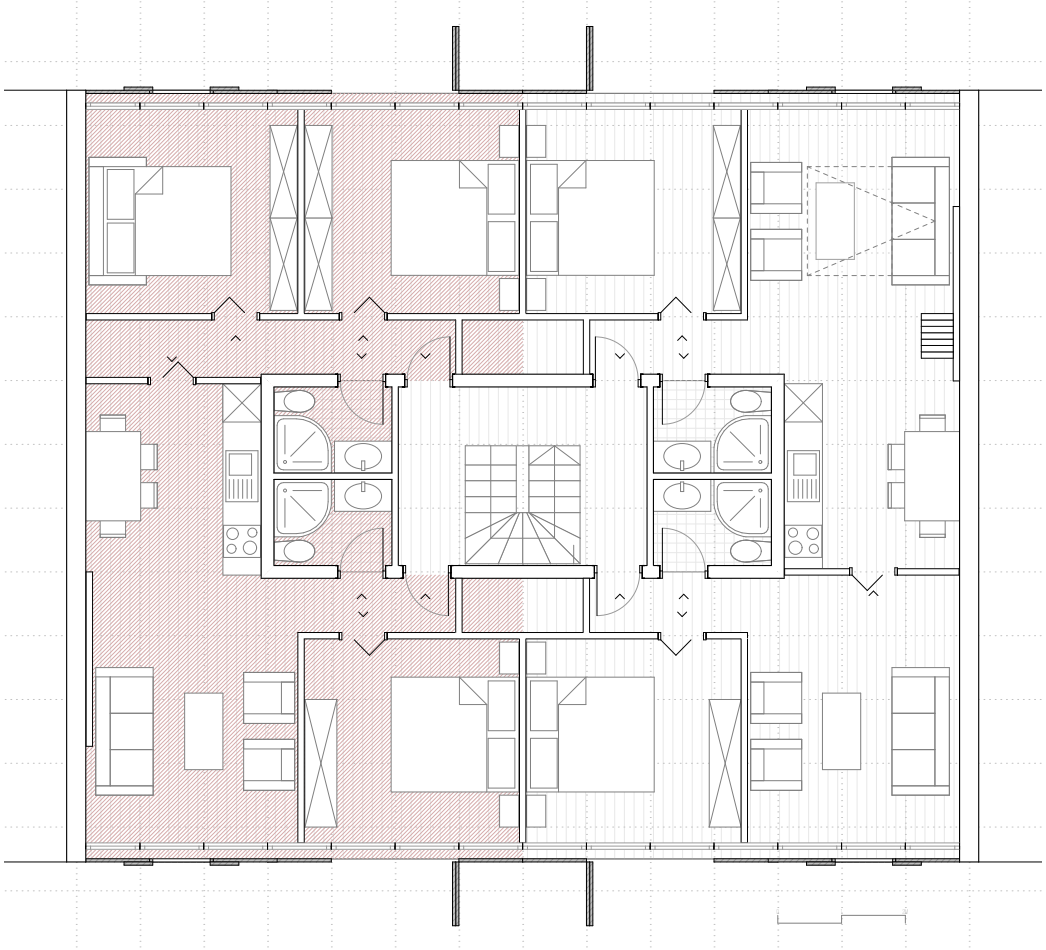


Figure 52: Spring period.

4.3. Flexibility of typical layout

Housing part - First floor

The amount of touristic activity and greater demand for hosting space is directly influencing the ratio of private and renting space in the house. Movable walls are giving freedom of change in the layout according to the real time needs.
Flexibility in the layout gives opportunity for residents to use renting potential much more efficiently, with less preparations, according to the situation.
Changes in the layout happens together with different seasons. Amount of private space can range from 25% in summer to 100% in winter.
Elasticity of the space is enabled trough the careful positioning of static and movable elements.
Static elements are positioned in the central part and they constitute the core. Because of the load bearing capacity, installations and the vertical connections - stairs, the core must be static.
Having static elements packed in the central point of the house, the amount of freedom for the elements in the layout is maximized.

Figure 51: Summer period.
It is the period with the highest amount of tourist activity.
The red shade represents the private - housing part, while the unshaded one is showing the renting part. Residential space is minimized to the 1/4 of space.
Ratio of residential space is 25% toward the renting space that is 75%.

Figure 52: Autumn, spring period.
Period with medium amount of tourist activity. In this time of the year, there are intensive preparations for the summer season.
There is medium amount of tourists but they are mostly there on daily basis.
Private part is larger than in summer season and it is around 1/2 of the space.
Ratio in the spring period is 50% for the private/housing space and 50% for the renting space.

Figure 53: Autumn period.

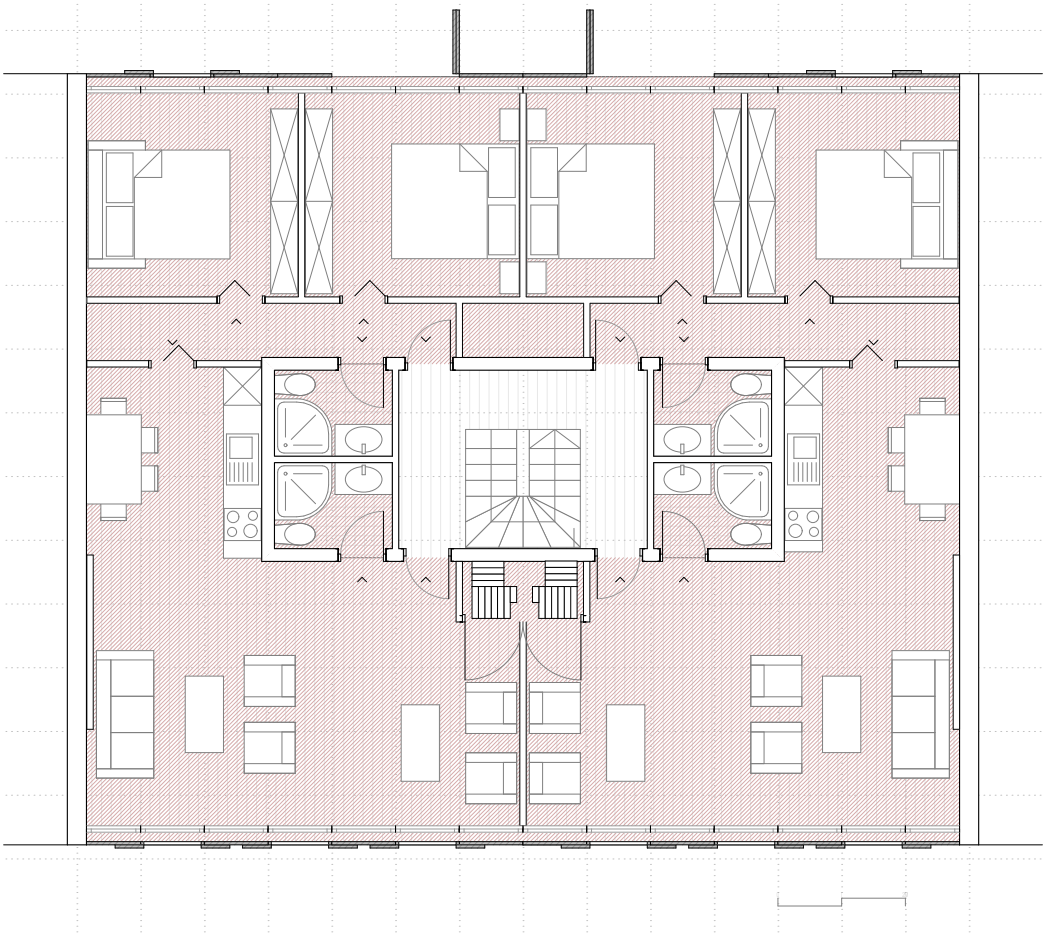


Figure 54:Winter period.

Figure 53: Autumn, spring period.
Medium amount of tourist activity. In this time of the year, there are intensive preparations for the winter seasons, use of storage spaces is on its peak. There is still some amount of tourists but they are mostly not there for the longer time.
Ratio for the private/housing space is 50% and for the renting space is 50%.
There is variation in layout of housing/private space, where instead of 3 rooms there are two with larger living room.

Figure 54:Winter period.
It is the period with the lowest amount of touristic activity. Visitations that are longer than one day are very rare, so it is not economically viable for renting.
Ratio of housing/private space goes from 75% to 100% in this period.

Figure 55: Annual flooding season.

Figure 55: Annual flooding season.
Because of the rising lake water level, ground floor is not usable in this period.
100% of the space in the first floor is used for the housing/private purpose.
There is a change in the layout because of the inventory that is stored from the ground floor.
There has also been change in the position of entrance stairs from core to the side of the house because of rising water levels The new stairs are installed for easier entering in the house.

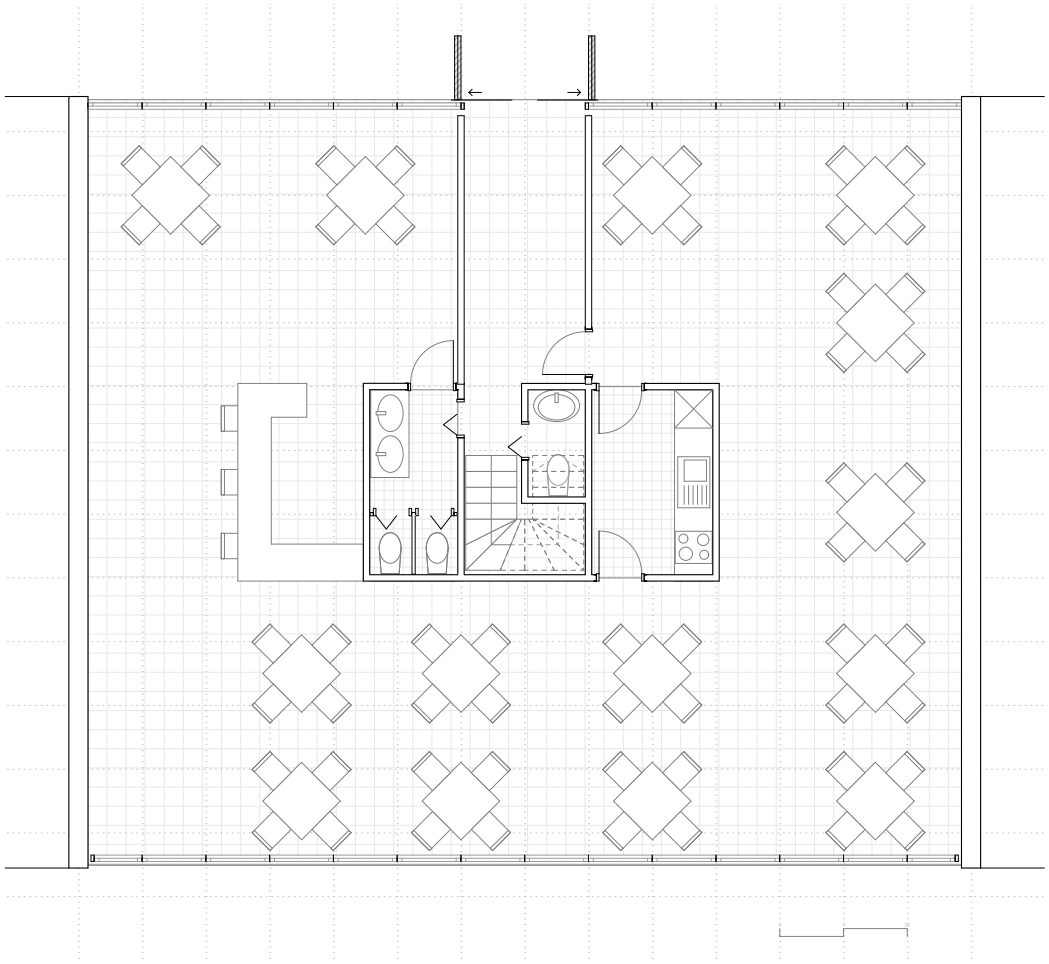


Figure 56: Summer period.

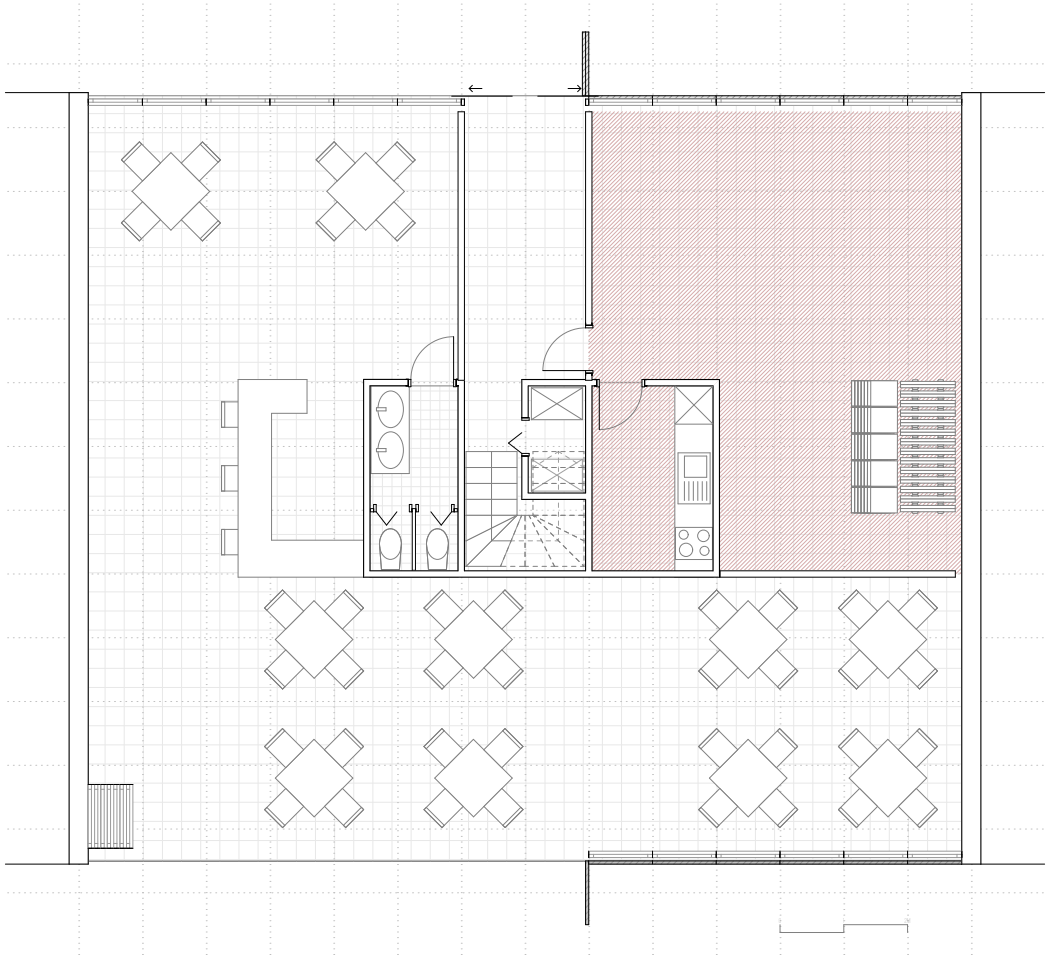


Figure 57: Spring period.

Ground floor

According to traditional housing typology in the surrounding, first floor is planned for housing while the ground floor is planned for the economic activities. Following trend of touristic activity the ratio of the space used for certain kind of activities changes according to the situation.
Space is mainly made for the economic activities varying from the coffee shops, stores, restaurants. The space can easily be transformed into the storage area and it can serve as the garage.

Figure 56: Summer period.
Period of the highest amount of tourists enables development of economic activity.
Whole ground floor space is used for the economic activity, in this case it is used as the restaurant.
100% of the space is used for the stated purposes.

Figure 57: Spring period.
It is the period with medium amount of touristic activity.
75% of space is used for the economic activity (restaurant in this case) and 25% is used as a storage space or a garage because of many filed and preparatory activities that are done during the spring season.

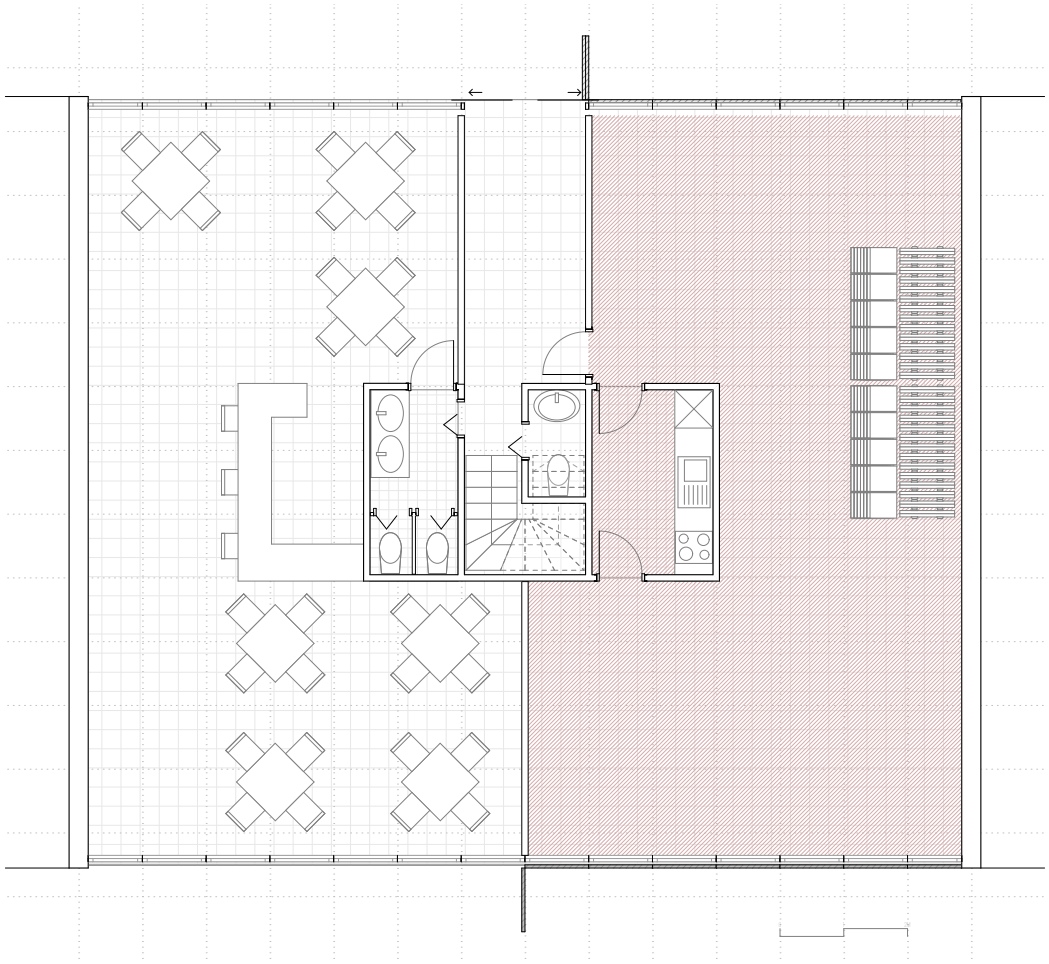


Figure 58: Autumn period.

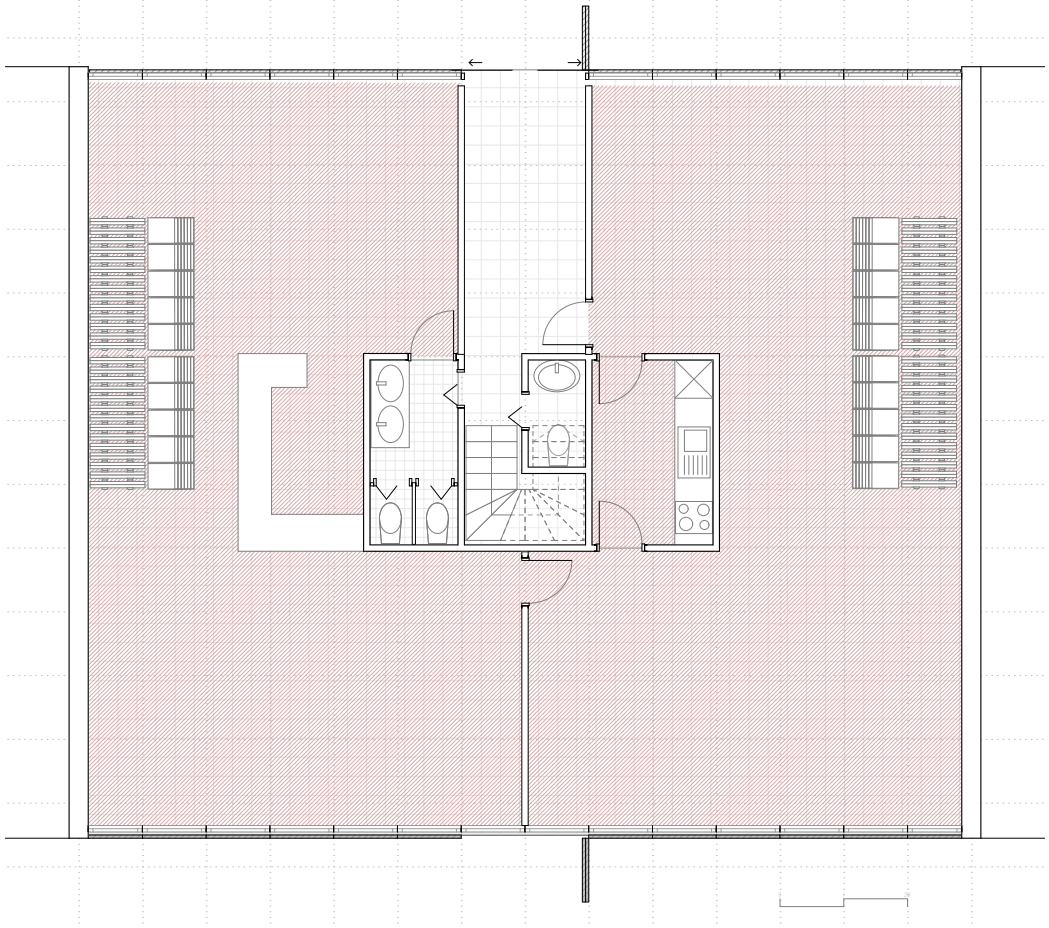


Figure 59: Winter period.

Figure 58: Autumn, spring period.
It is the period with medium amount of touristic activity.
50% of space is used as the economic space (coffee shop in this case) and another 50% as a storage space or a garage.
This type of the layout can also be used during the winter season to keep the business working.

Figure 59: Winter period.
Lowest amount of touristic activity. Due to the absence of visitors during the winter season, having the economic spaces in Rijeka is not completely viable.
Around 100% of space is used as the storage space or a garage.

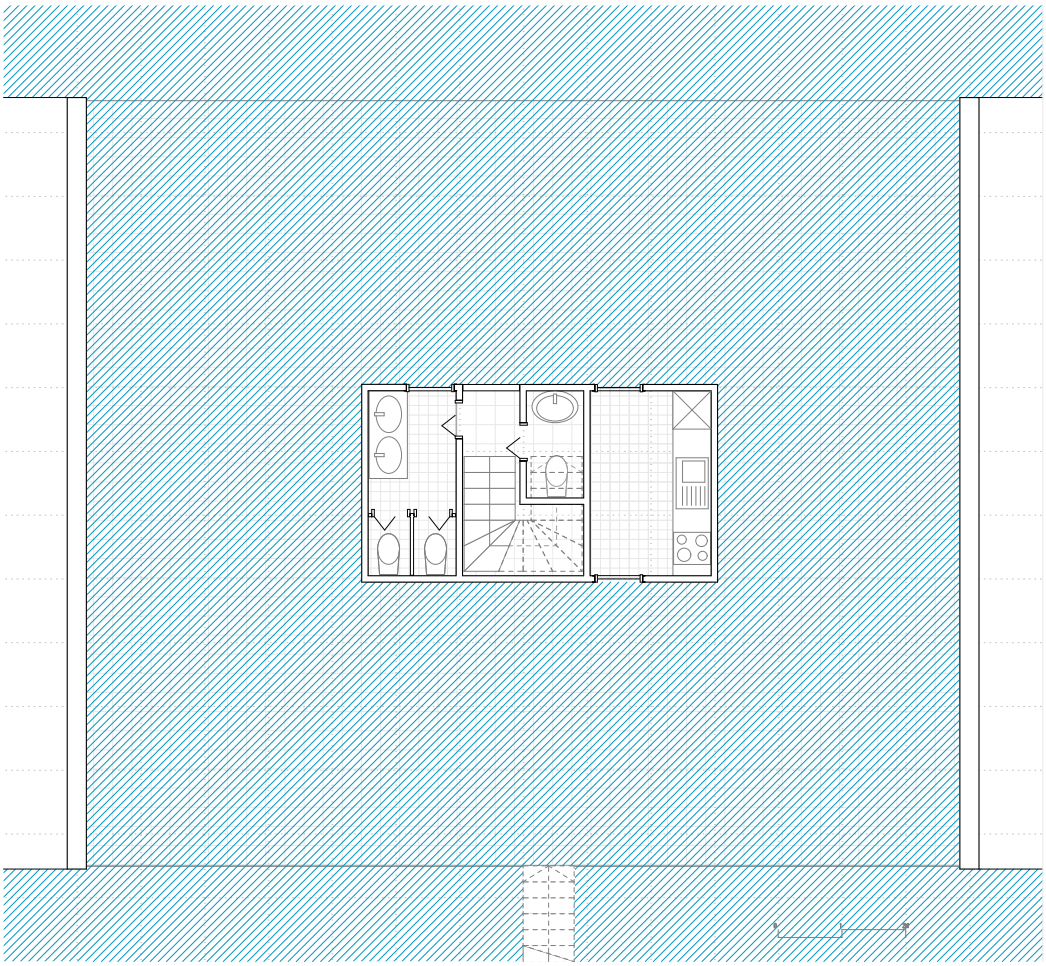


Figure 60: Annual flooding season.

Figure 60: Annual flooding season.
Due to the annual high tides, to minimize the damage, complete inventory will be moved and brought to the storage space and on the upstairs. Core is completely closed, while the facade is moved higher up and removable floor is also stacked and moved.
The position of entrance stairs is also changed. Due to the rising of water level there is not enough space to go trough, so the new montage stairs are brought from the side and serve as the temporary entrance.

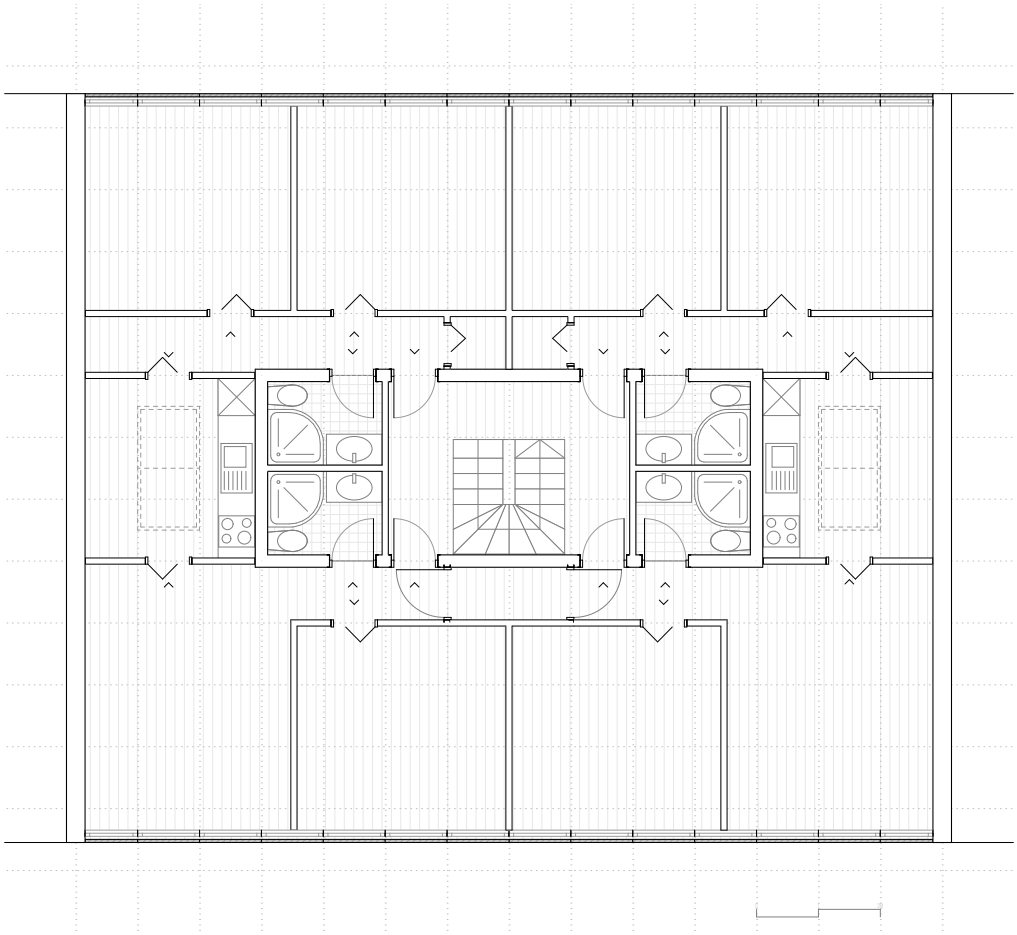


Figure 61: First stage.

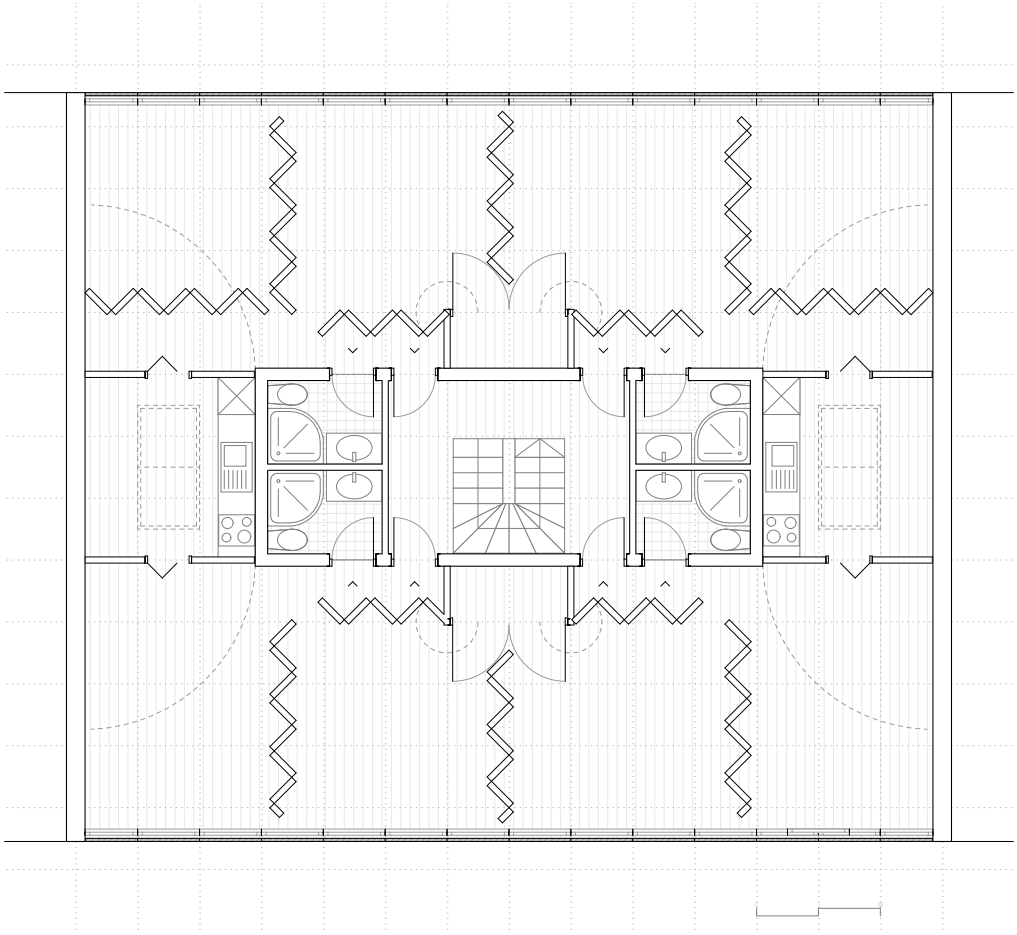


Figure 62: Second stage.

4.4 Layout dynamics

How floor plan actually works?
On the images on the left side are shown inner working of the layouts. Flexibility is managed trough system of folding partition walls that are able to be moved into the cabinet.
Also the interior is followed by flexible facade that is also able to be folded and to be moved on the sides.

Figure 61: First stage.
All the partitions are in normal elongated position serving as the usual walls. Facade is completely closed.

Figure 62: Second stage.
Wall are starting to fold up in the direction which leads towards the stacking closet.

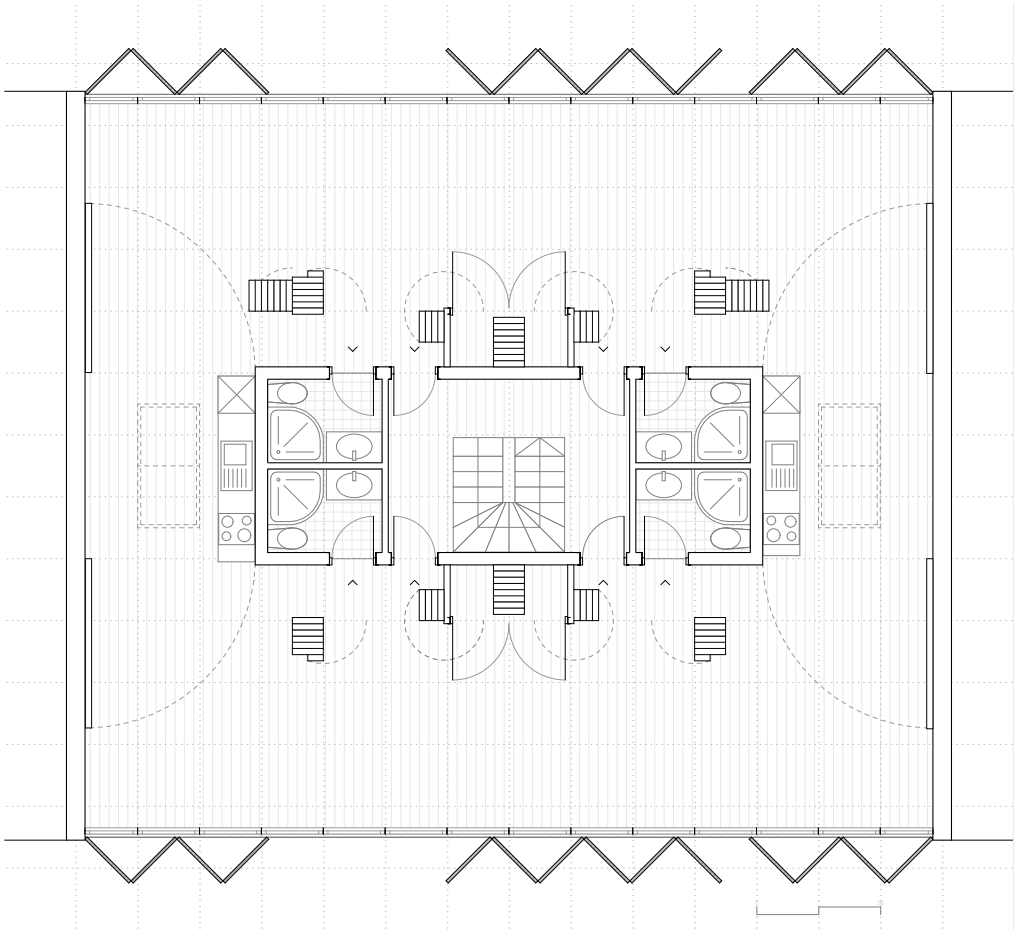


Figure 63: Third stage.

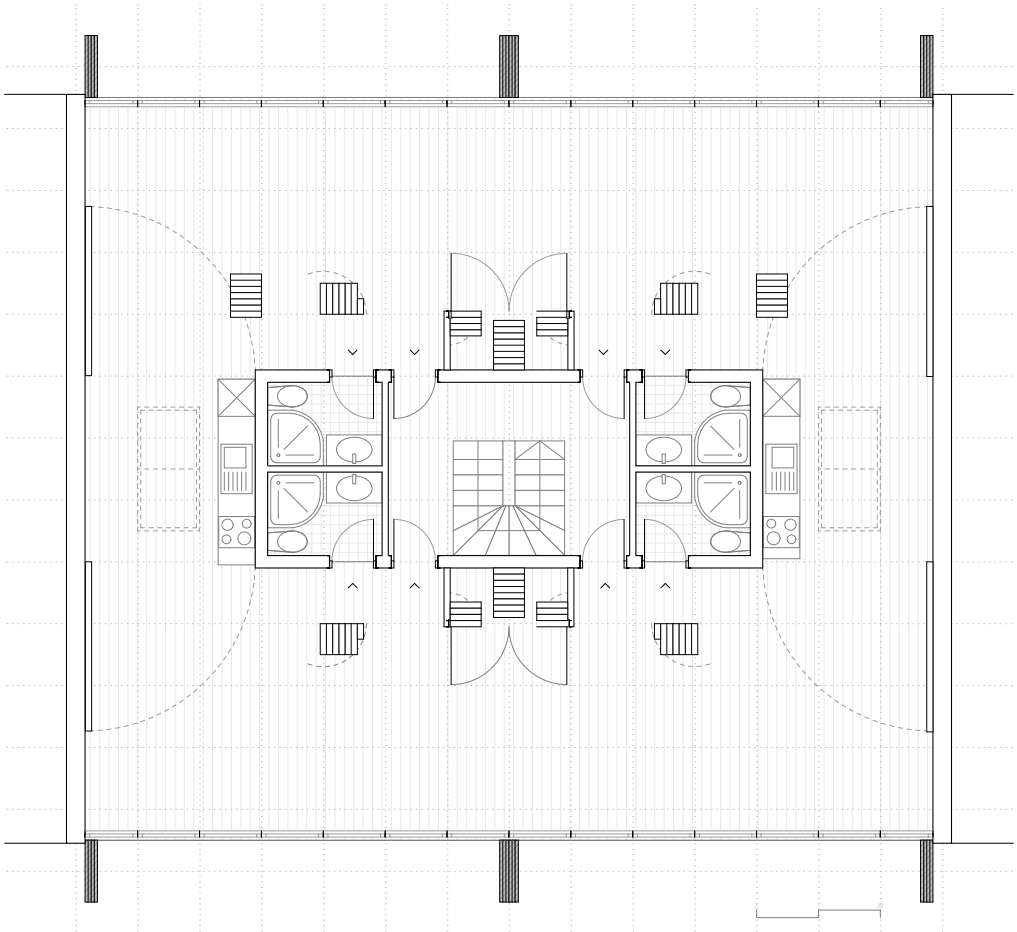


Figure 64: Fourth stage.

Figure 63: Third stage.
Walls are folded into one position and are waiting for the rotation. Walls moving in vertical direction is already stacked in the closet.
Following the walls, the outer layer of the facade - brise soleils are starting to fold in the horizontal direction toward the load bearing walls.

Figure 64: Fourth stage.
Walls are rotated and are waiting for the further movement toward the stacking closet.
Outer layer of the facade is folded.

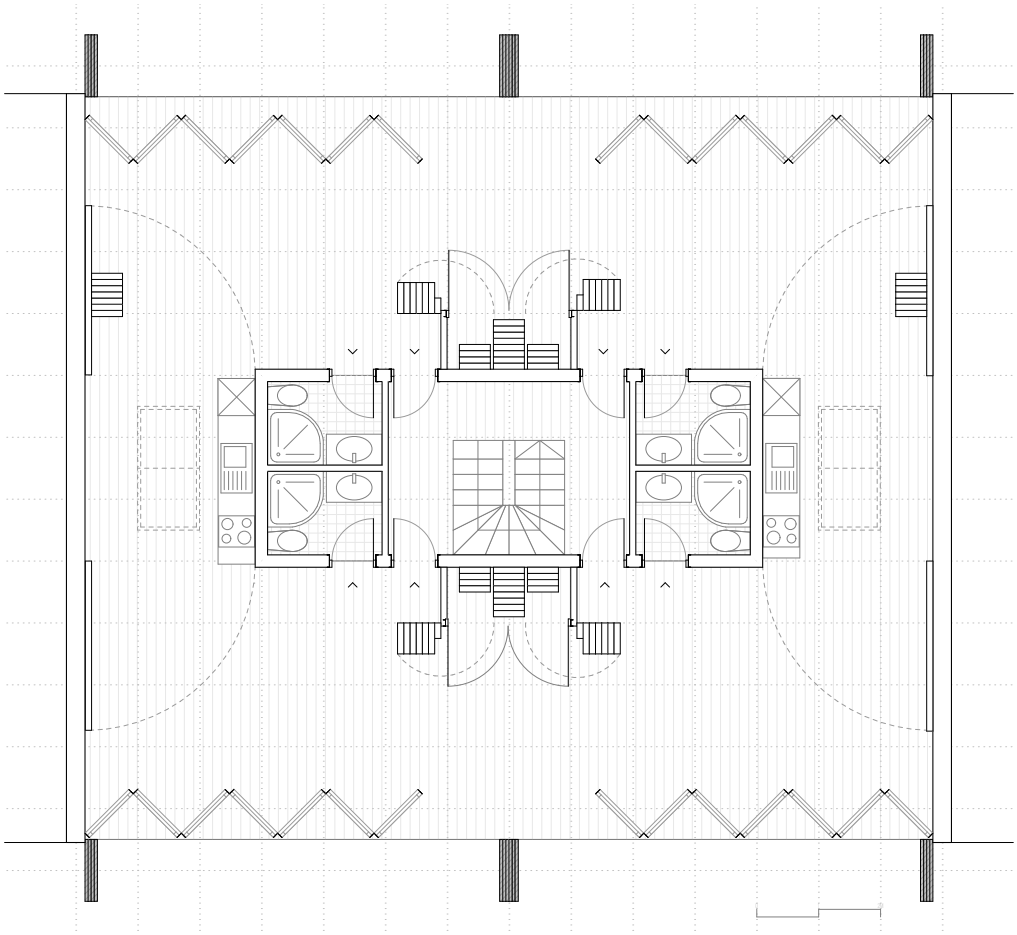


Figure 65: Fifth stage.

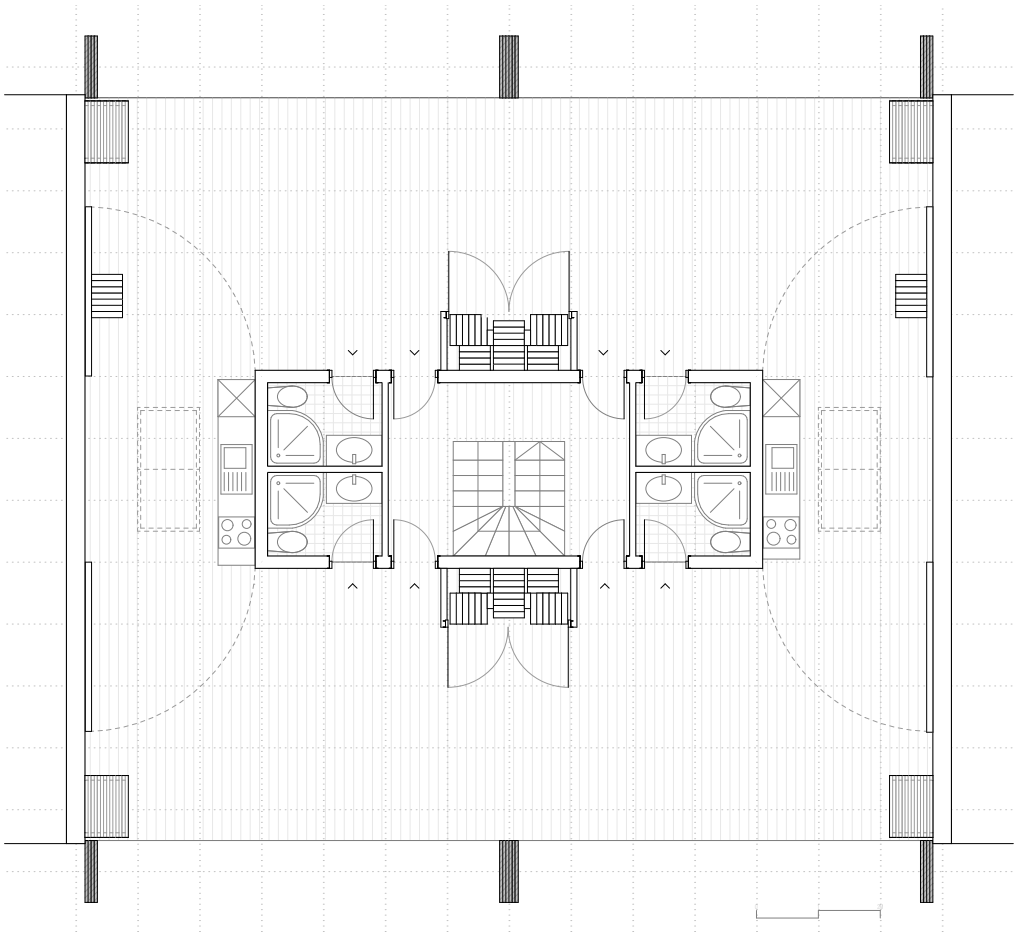


Figure 66: Sixth or the final stage.

Figure 65: Fifth stage.
Walls are rotated and are waiting for the further movement toward the stacking closet.
Half of the walls are already stacked in the closet.
Inner facade part - windows are starting to fold in the horizontal direction toward the constructive load bearing walls.

Figure 66: Sixth or the final stage.
The last walls are moved and stacked into closet. Space is completely free from the partition walls.
Inner layer of the facade is folded on the sides, next to the load bearing walls.

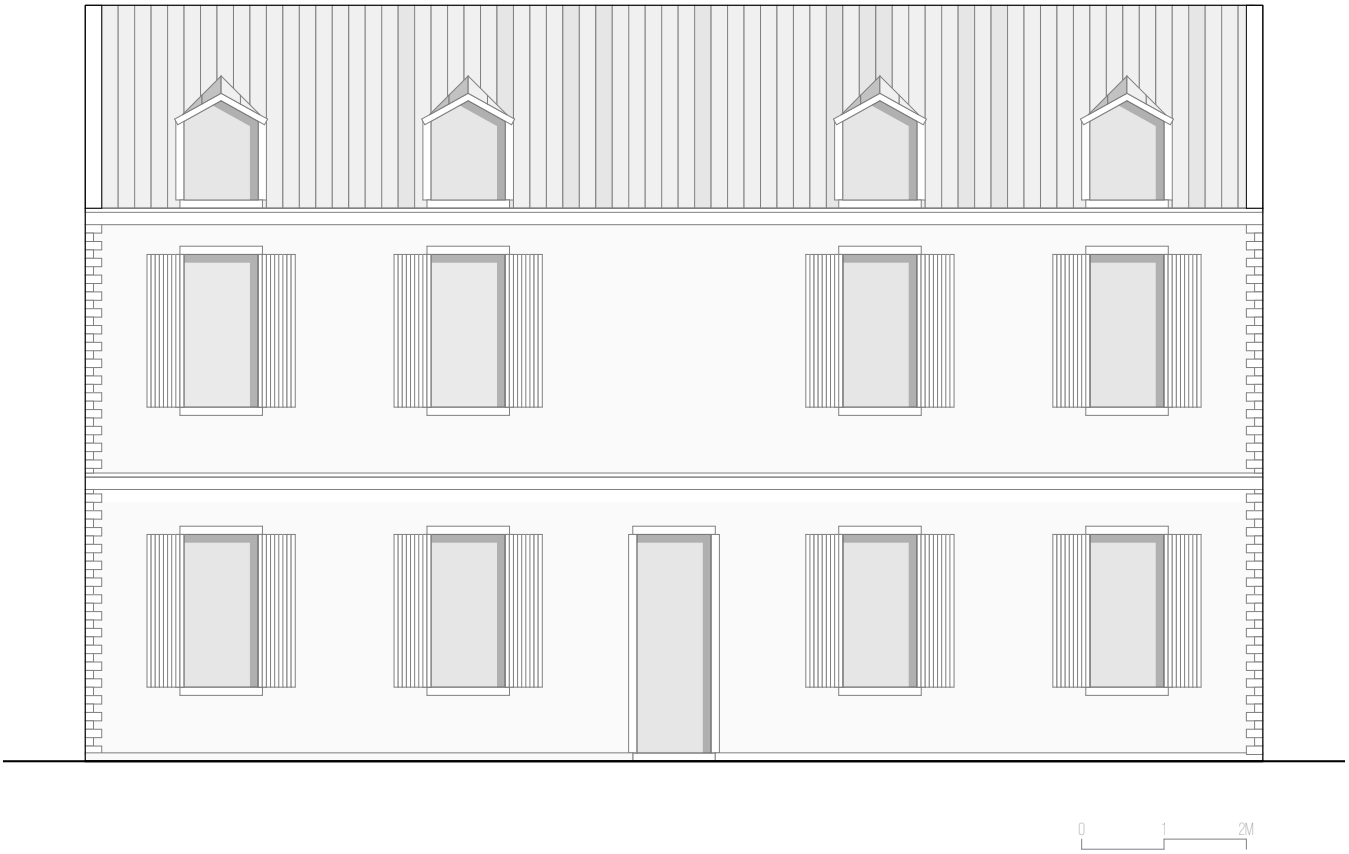


Figure 67: Traditional facade.

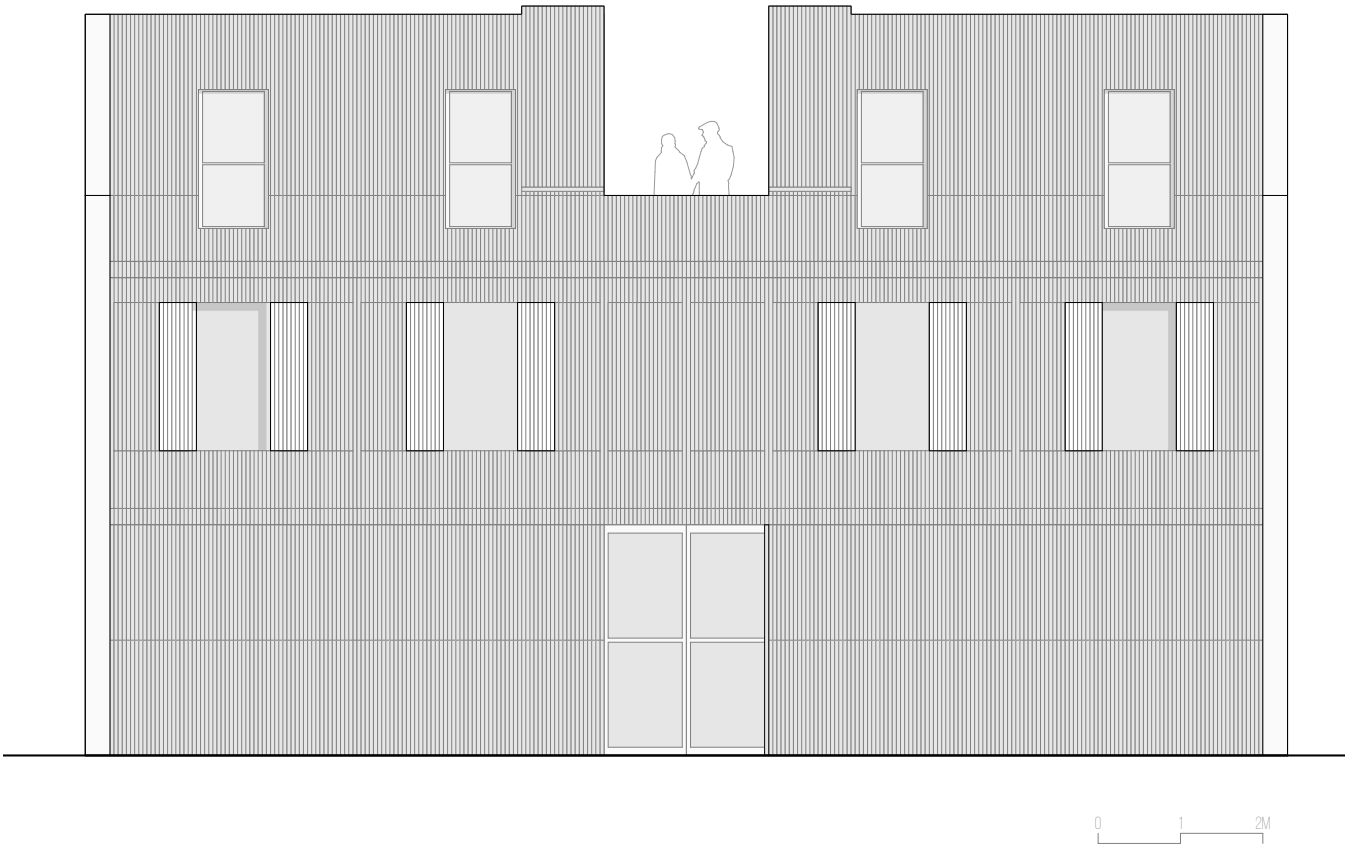


Figure 68: Representative facade.

4.5. Changing facade – according to dynamics of the interior

Flexible, ever changing interior layout is driving the facade to be flexible as well. Changing of the rooms inside is pushing the change in the opening. Position of windows must change with the position and size of the room inside.
Flexible facade is natural answer to such a changes of interior.

Even though facade is flexible and requires modern technology for the achievement of that goal, it is following the traditional style of building.
Facade would mimic the authentic style of local architecture.

Figure 67: Traditional facade.
On the image on the left side, typical building style is visible. House which is facing street on the sides and it is positioned in continuous line with the other buildings. Entrance is mostly positioned in the middle with windows equally positioned on the sides. There is characteristic slope gabled roof with mansard windows following disposition of windows beneath. Every window has two blind shutters. Houses are made of stone but are covered with mortar. Lines that visually separate floors are visible.

Figure 68: Representative facade.
Facade is made out of vertically positioned brise-soleils stacked in mostly two sections on two floors. They are separated with horizontal stripes made out of also vertical elements.
Facade is following the authentic housing style. Disposition of window openings on the wall and on the roof. Also it is following the entrance doors closely in the center.
Even though it is made out of movable brise-soleils, to mimic the authentic look of typical housing and to better control light that is entering inside, there are additional openings in the brise-soleils that serves as the window and are mimicking the blind shutters of the typical house in the line.
On the roof there is a visible opening. That is part of the also movable roof that can be opened and used as an open garden.
Facade on the ground floor is opening in vertical direction in case to prevent flood from damaging it, while the facade on the first floor is opening horizontally to the opposite sides.

Figure 69: Closed facade.

Figure 70: Variant.

Figure 69: Closed facade.
From the many variants of the facade, closed one is the initial one.
Brise-soleils that are stacked horizontally are able to completely close or to completely open. This way, the freedom is given to the residents who are able to control influx of the light and level of privacy from the external views. Roof windows are the only open parts.

Figure 70: Variant.
Variant of the facade that mostly resembles typical housing. Four windows on the first floor are open, while the ground floor is closed with open entrance. Even though ground floor is opening vertically, there is possibility for the entrance to be open horizontally.

Figure 71: Variant.

Figure 72: Variant.

Figure 71: Variant.
Variant of the facade with half open ground floor. That is usually case during the autumn or the spring season. It is visible vertically opened facade on the ground floor.
On the first floor it is visible horizontally opened facade on two places.

Figure 72: Variant.
Variant of the facade with closed ground floor and open roof for the roof garden.

Figure 73: Variant.

Figure 74: Variant.

Figure 73: Variant.
Variant of the facade with closed half open ground floor and open roof for the roof garden.

Figure 74: Variant.
Variant of the facade with closed half open ground floor and closed roof.

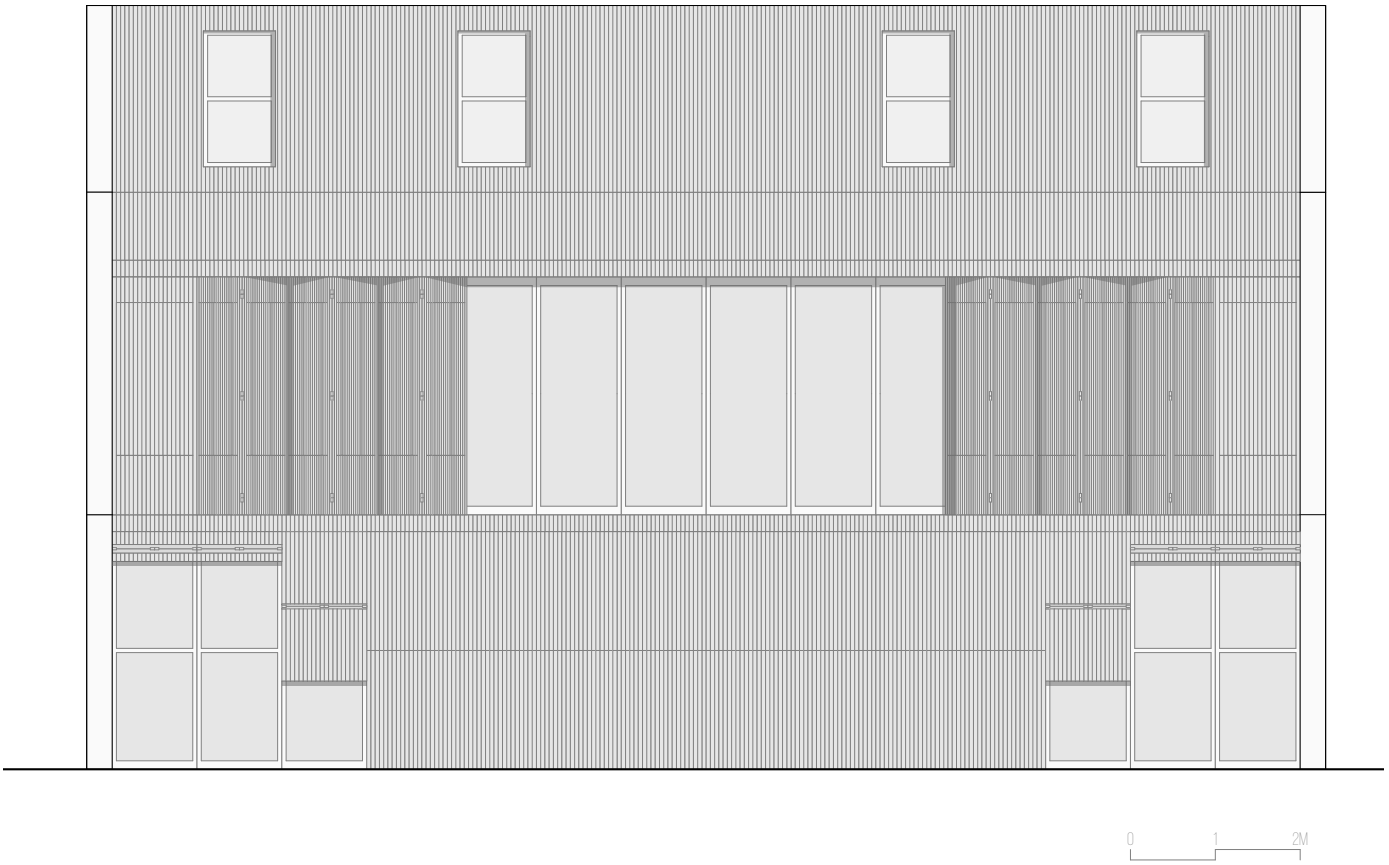


Figure 75: Variant.

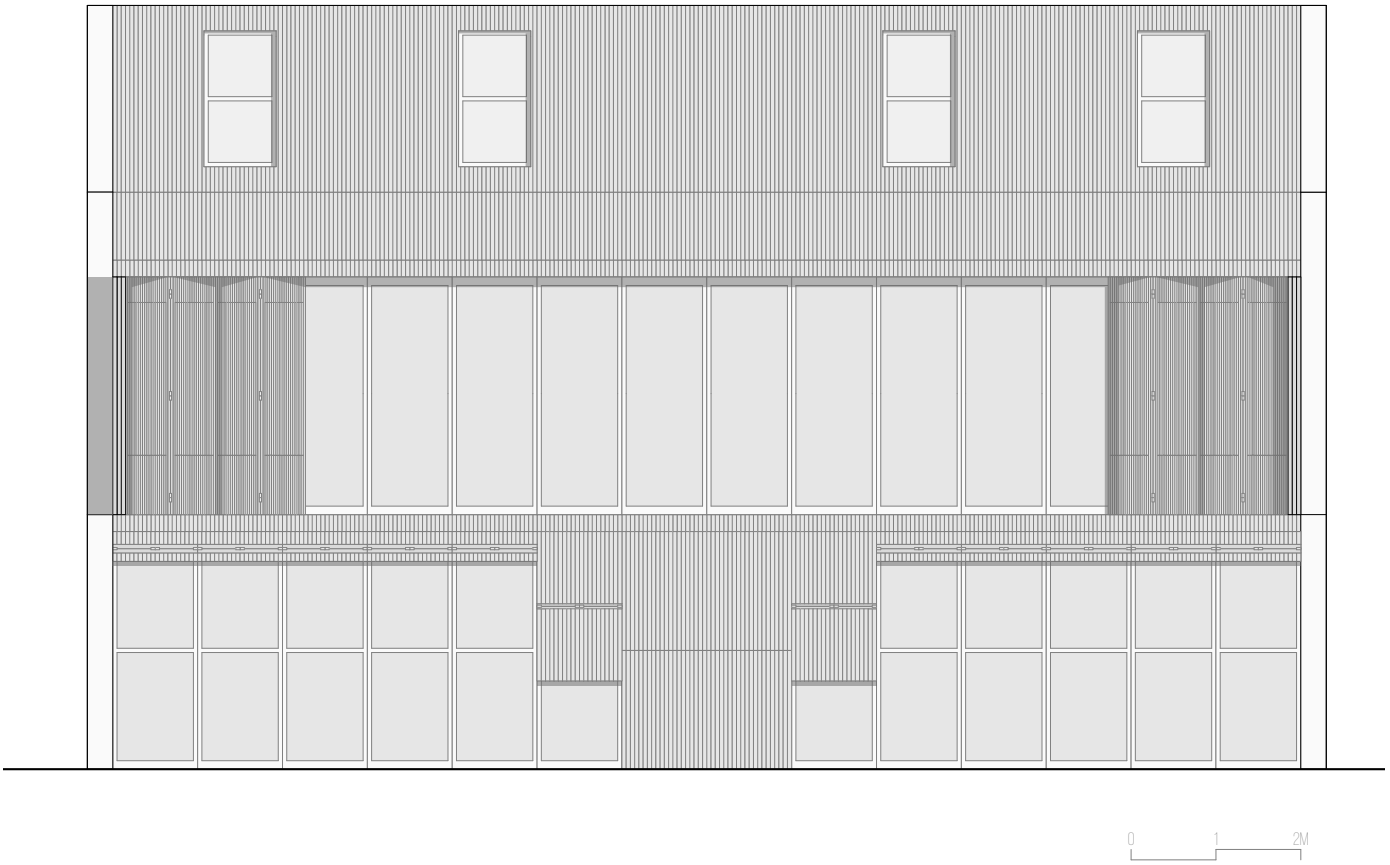


Figure 76: Variant.

Figure 75: Variant.
Variant of the facade with simultaneously opening of the ground floor and first floor.

Figure 76: Variant.
Variant of the facade with simultaneously opening of the ground floor and first floor.
Different direction of the openings on ground and first floor.

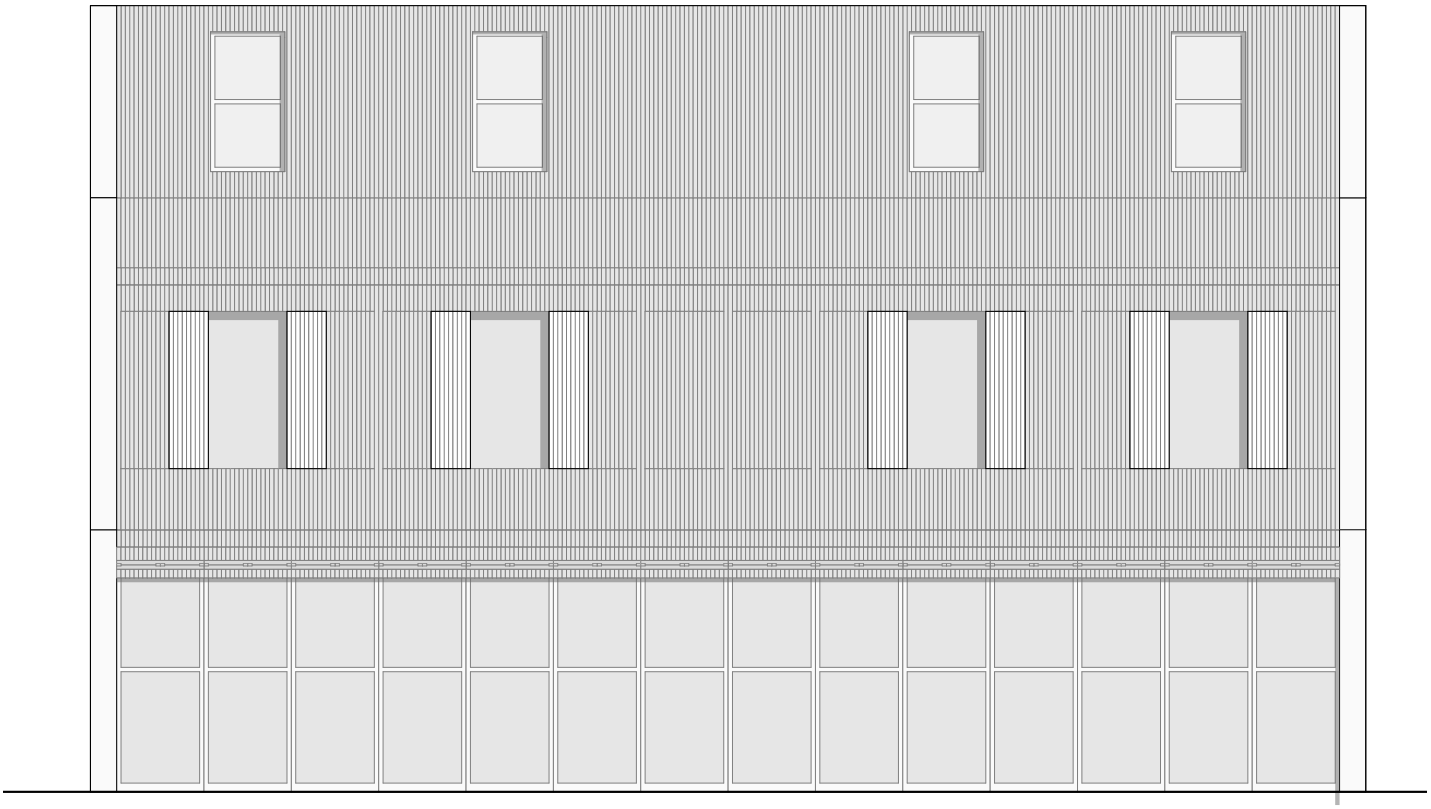


Figure 77: Variant.

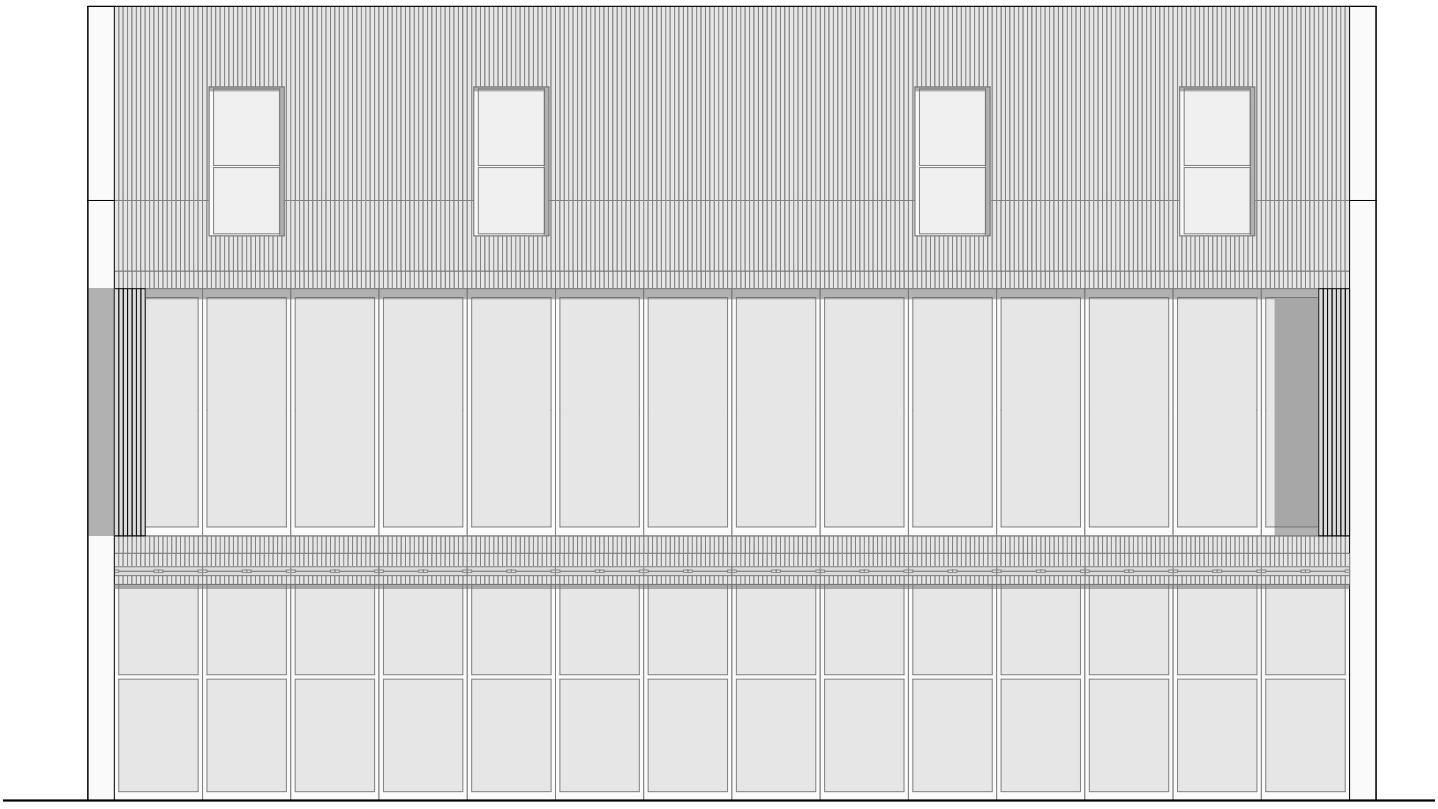


Figure 78: Variant.

Figure 77: Variant.
Variant of the facade with totally open ground floor and open windows on the first floor.
Scenario during day, when the restaurants/stores are open.

Figure 78: Variant.
Variant of the facade that is completely open on the both floors.
This variant is rarely in use.

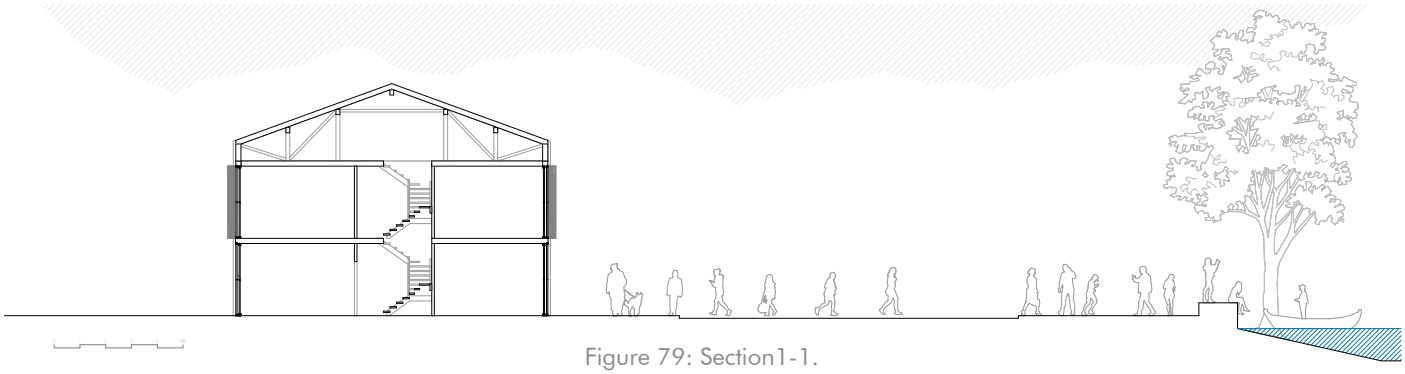


Figure 79: Section1-1.

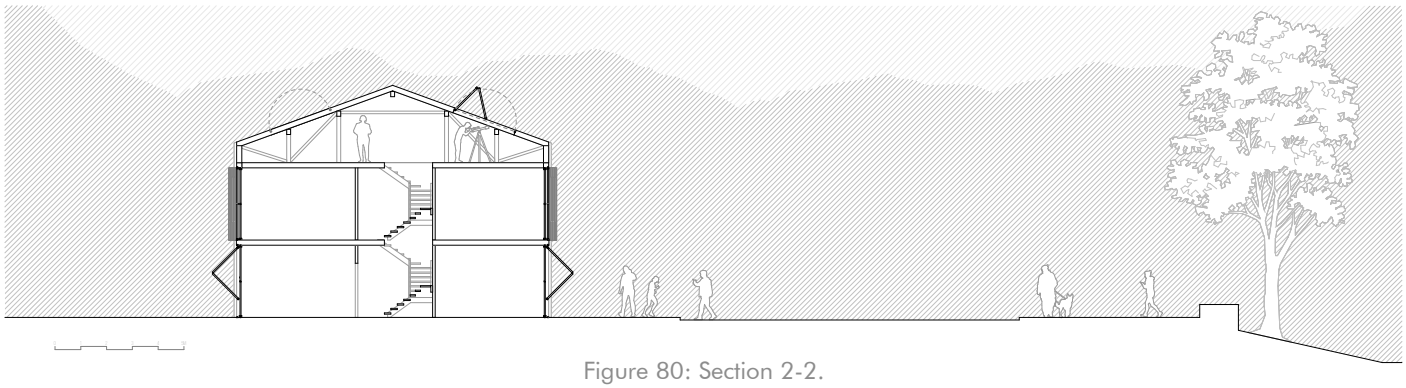


Figure 80: Section 2-2.

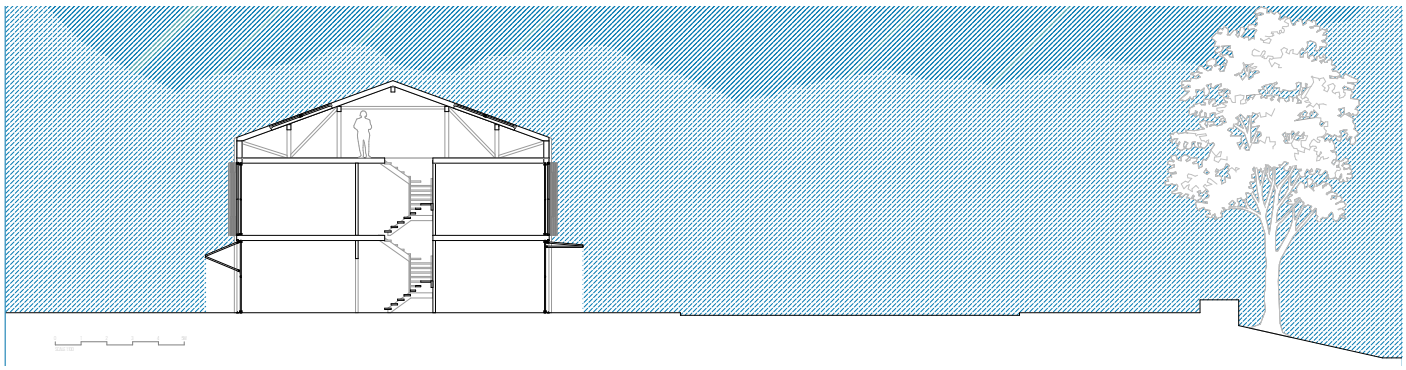


Figure 81: Section 3-3.

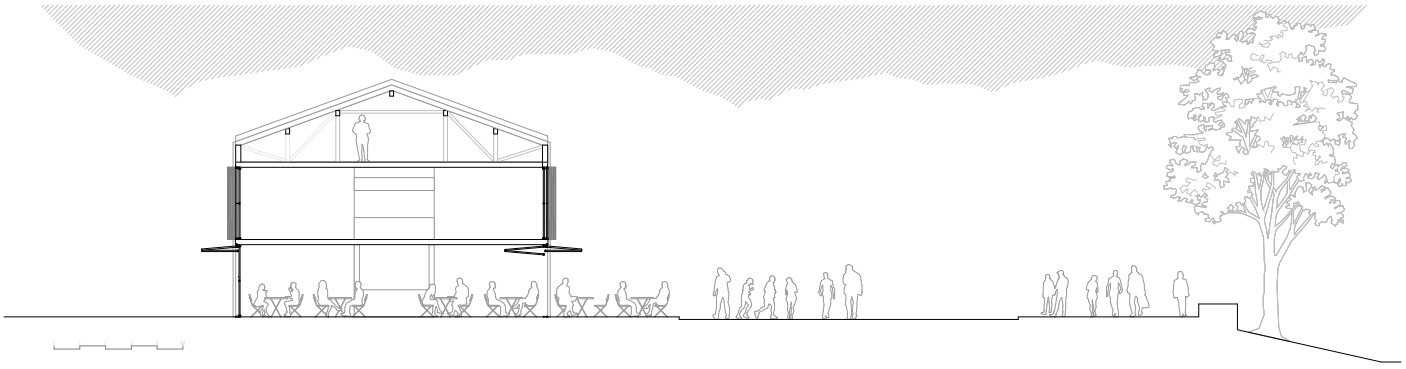


Figure 82: Section 4-4.

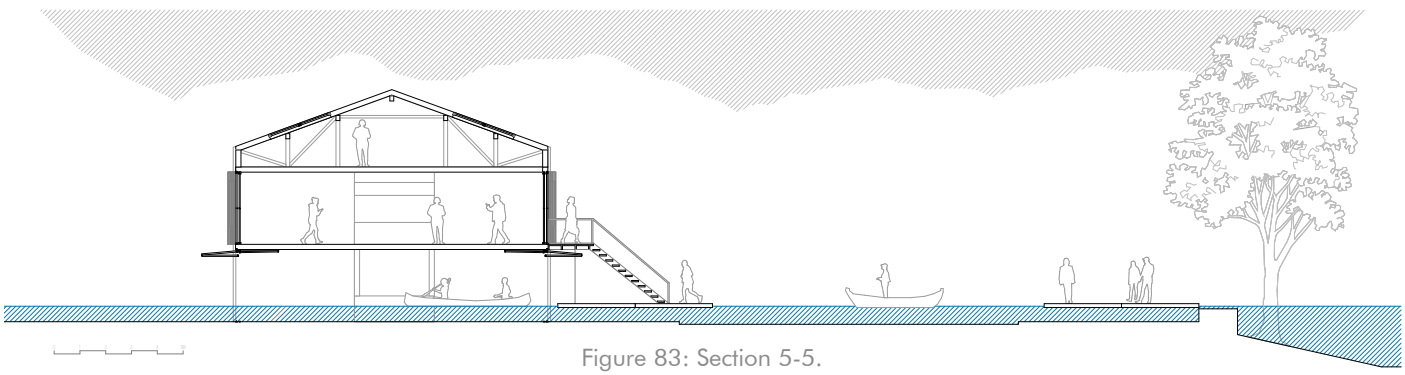


Figure 83: Section 5-5.

4.6. Response to flood - section

Building openness shown in different situations trough sections. Building is consisted of ground floor, first floor and rooftop that can be used as the living or storage space. All three levels are connected with central core.

Figure 79: Section1-1.
Building closed towards the outside, during the winter season.

Figure 80: Section 2-2.
Building with open windows on the roof.

Figure 81: Section 3-3.
Building with open both, ground and first floor .

Figure 82: Section 4-4.
Building with open ground floor. Space made for restaurant inside and outside.

Figure 83: Section 5-5.
Building during the flood. Ground floor is open to let water go trough. Entrance is moved to the facade on the first floor with prefabricated stairs that are going from pontoons.

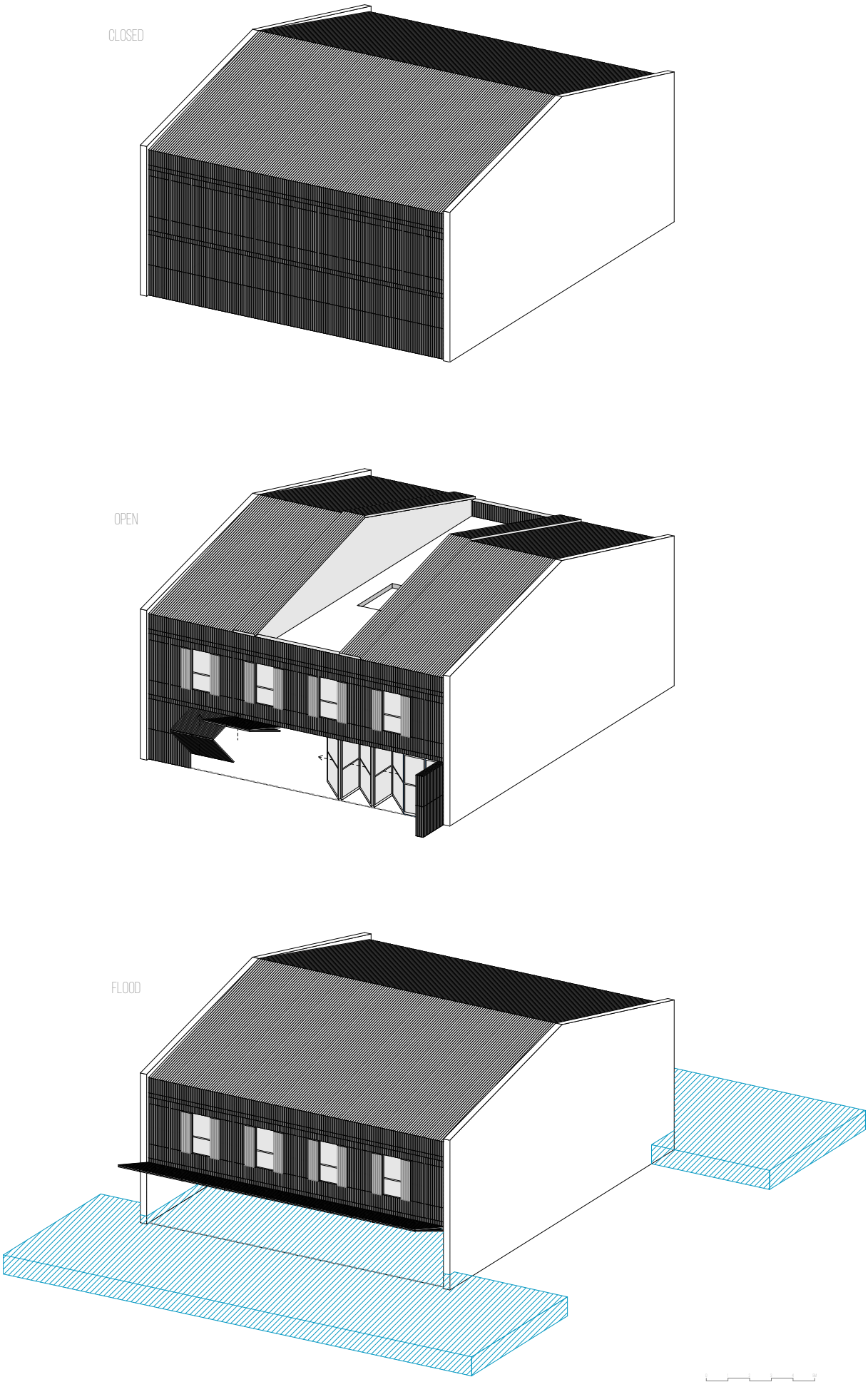


Figure 84: House as the changing entity.

4.7. Construction

House is made to be as flexible as possible. Facade is the most flexible part. It can go from totally closed to totally open.
Roof can be open. During the annual flood, facade and the walls on the ground floor can be moved in the dry area.

House is made out of 3 levels.
Ground floor with flexible partition walls and facade and static inner core and walls on the sides.
First floor, which also has flexible partition walls and flexible facade.
Roof that can be used for daily activities and has certain amount of flexibility with roof that can open and be used as an open garden.

House construction is made out of components with different amount of mobility. House is modular in nature. They are divided into to categories, flexible and static.

Naturally all the load bearing components are static ones and are made out of reinforced concrete. Foundations, ground floor walls on the sides together with core and pillars are static reinforced concrete elements.

Concrete is used for all the load bearing components in a ground floor, as a solid foundation from down to the first floor. There is also the factor of flood that can cause damage onto those elements and because of it concrete was considered as the best solution.

In the first floor beams, slab and side walls are made out of concrete but other elements are mostly made out of wood. Wood was chosen because of lightness and on the first floor there is no danger of damage caused by flooding.

Roof is made completely out of wood, except the side walls. It is done to ease the weight and because of the flexibility with opening the roof.

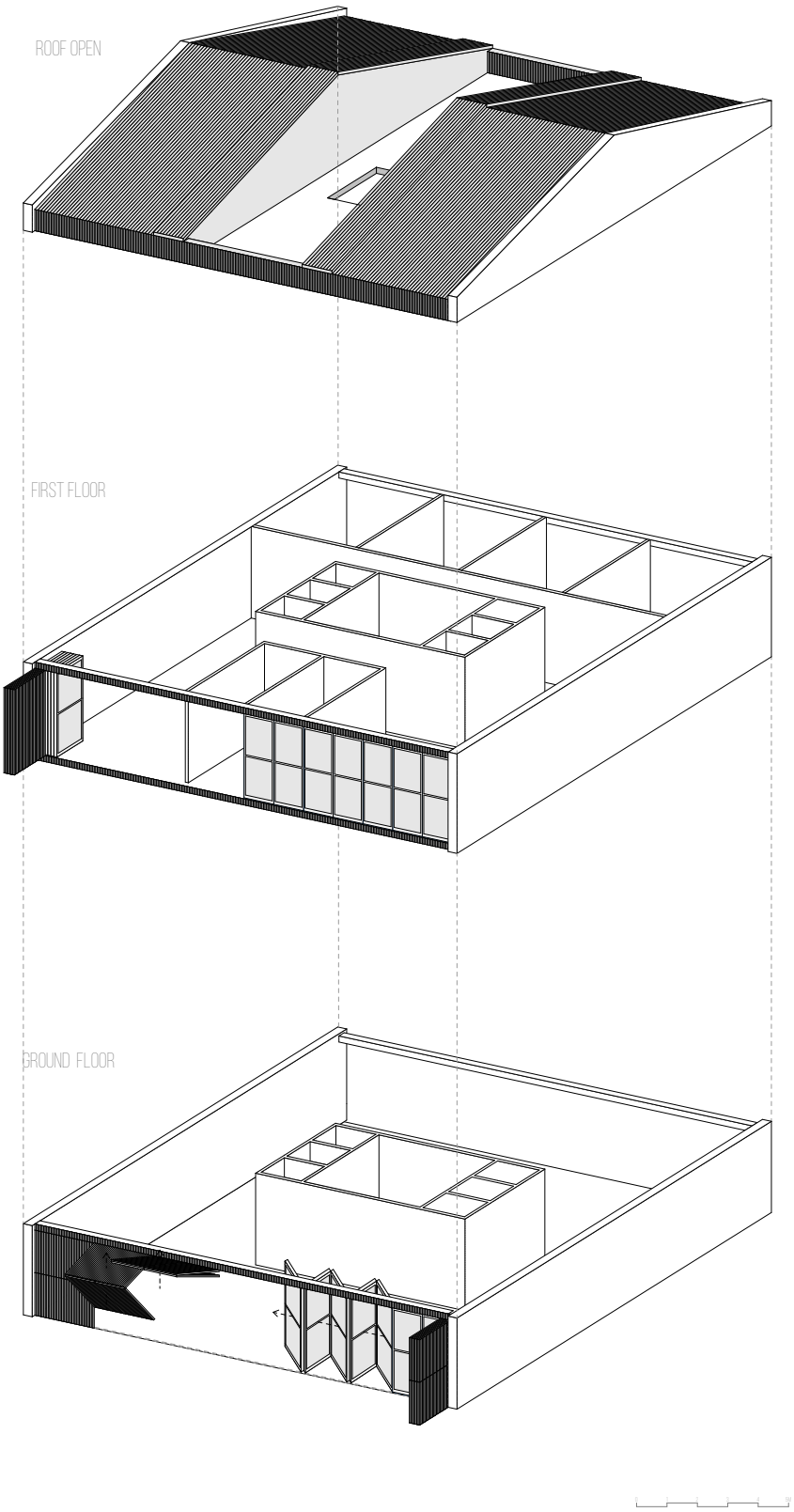


Figure 85: All the house floors shares some amount of mobile elements.

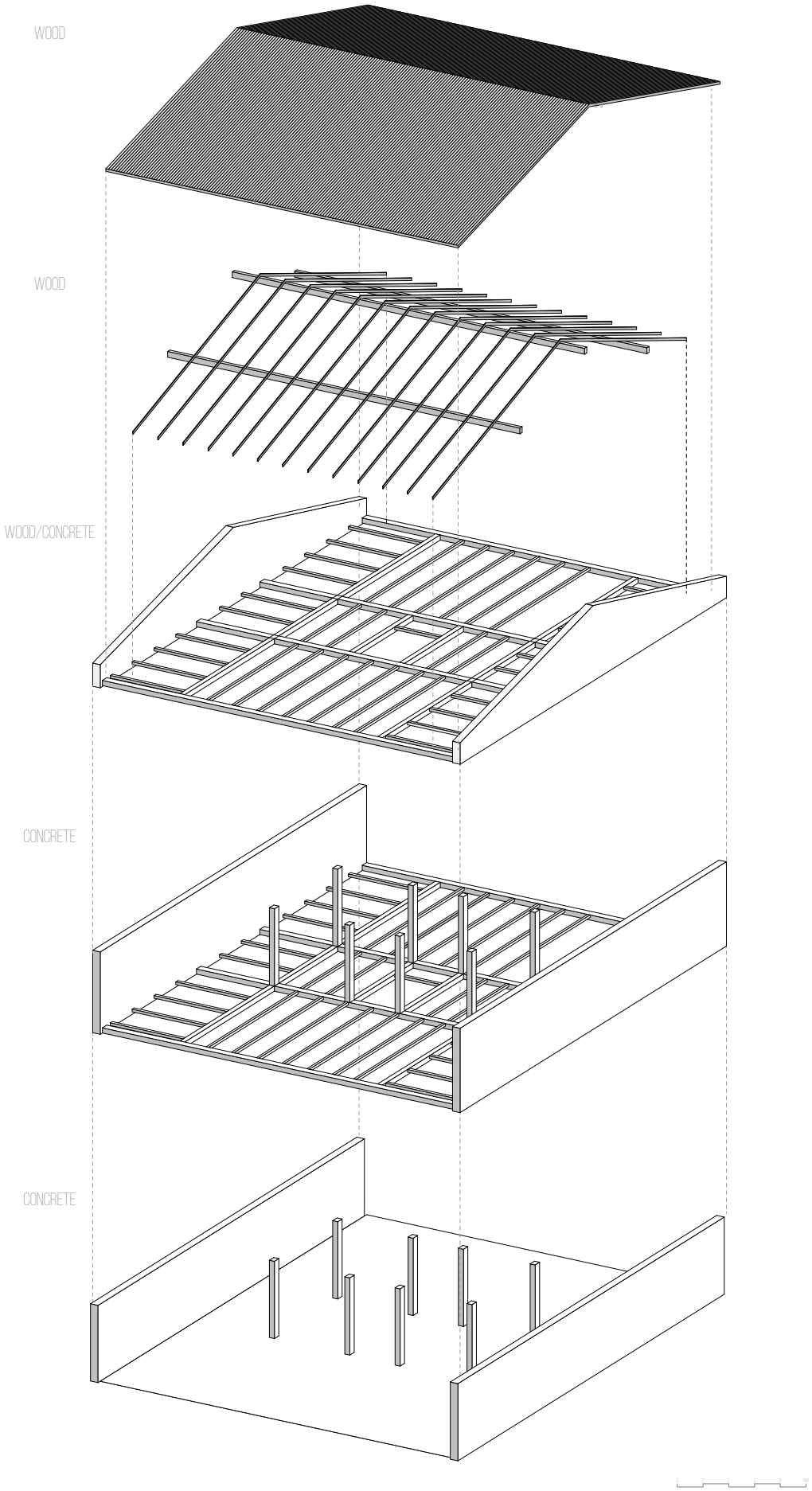
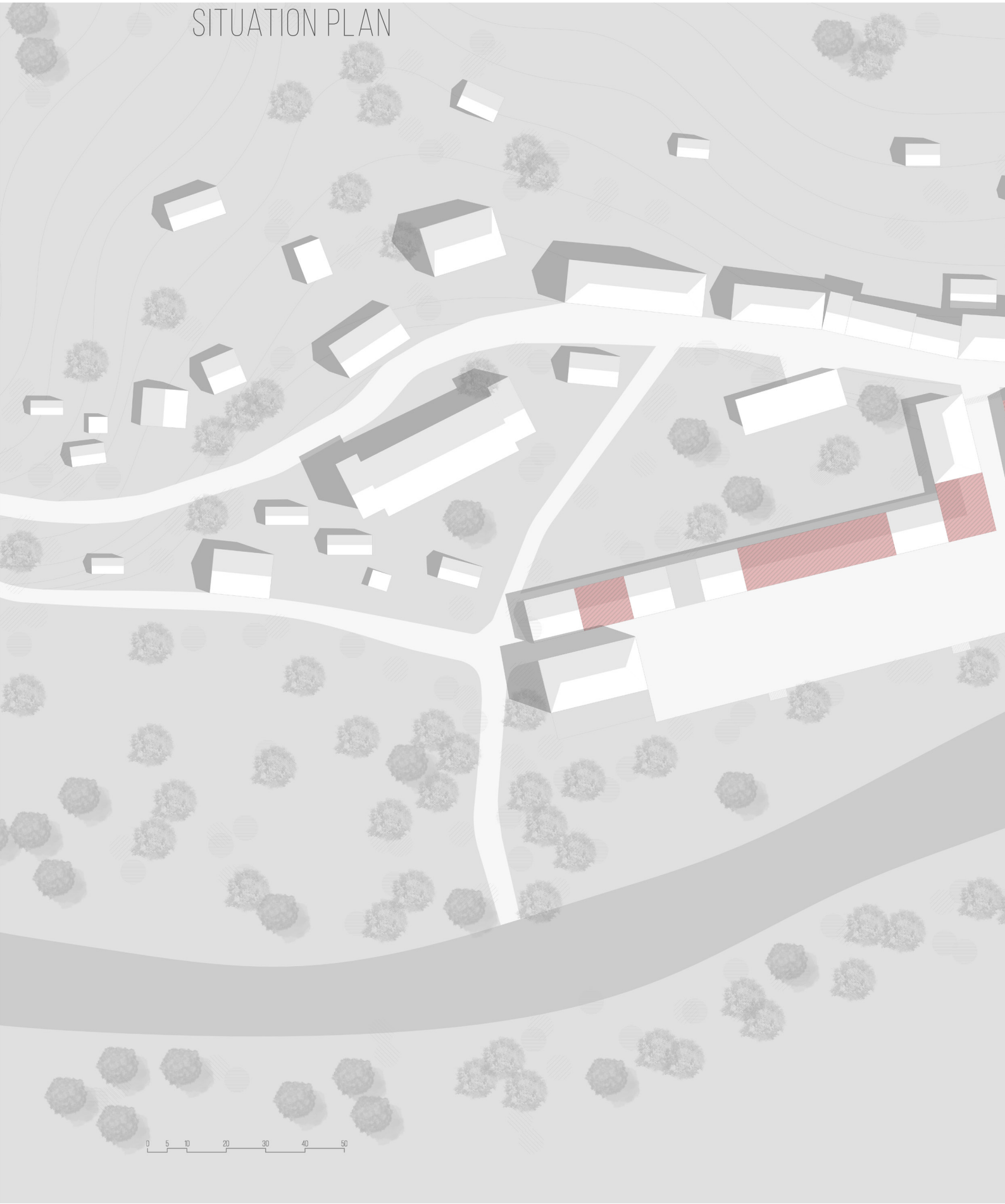


Figure 86: Construction of the house - lighter with the altitude.

4.8. Situation



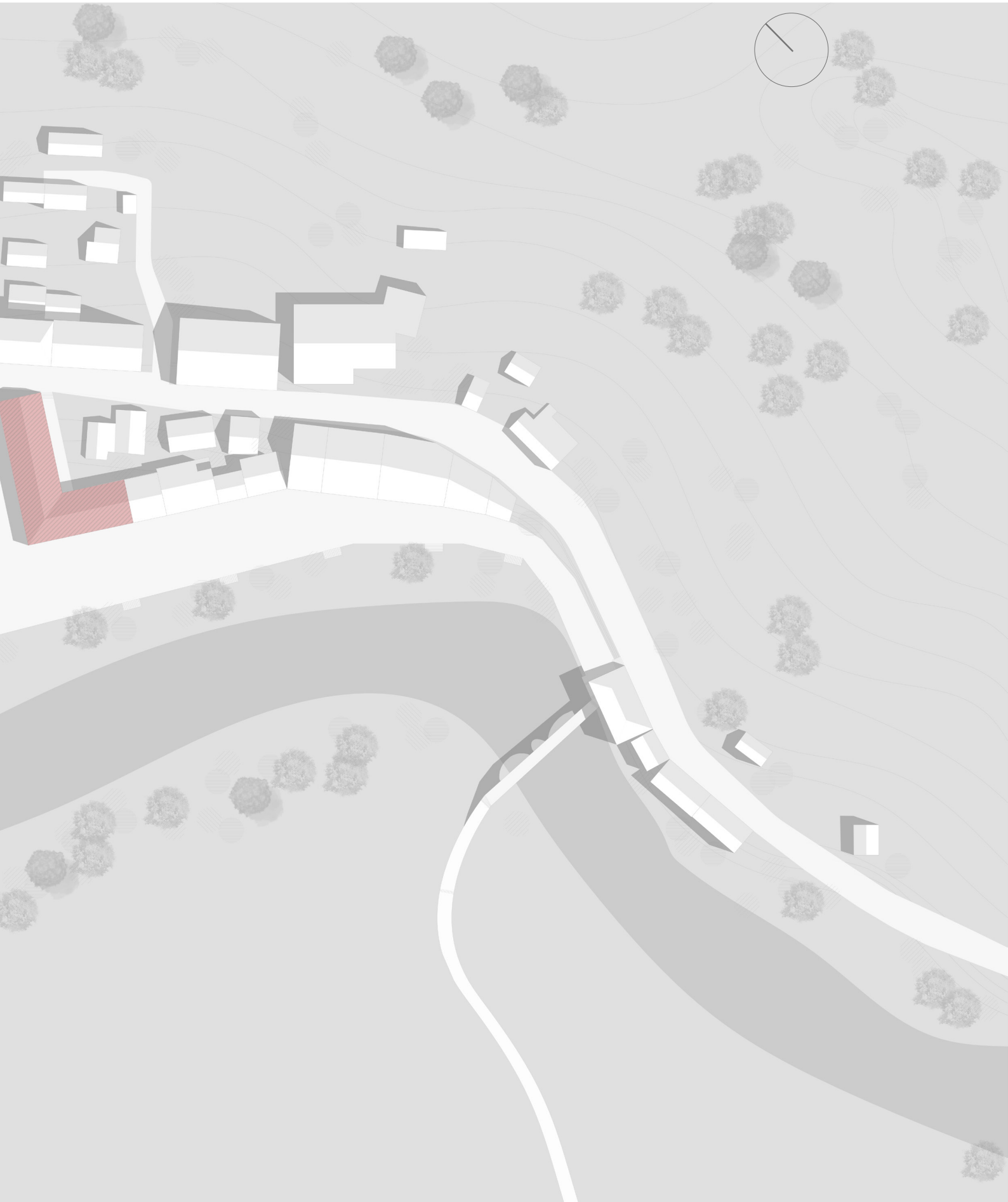


Figure 87: Figure plan of built space.

GROUND FLOOR PLAN

Figure 88: Figure plan of ground floor.

FIRST FLOOR PLAN

Figure 89: Figure plan of first floor.

4.9. Different scenarios - axonometric of built space overall

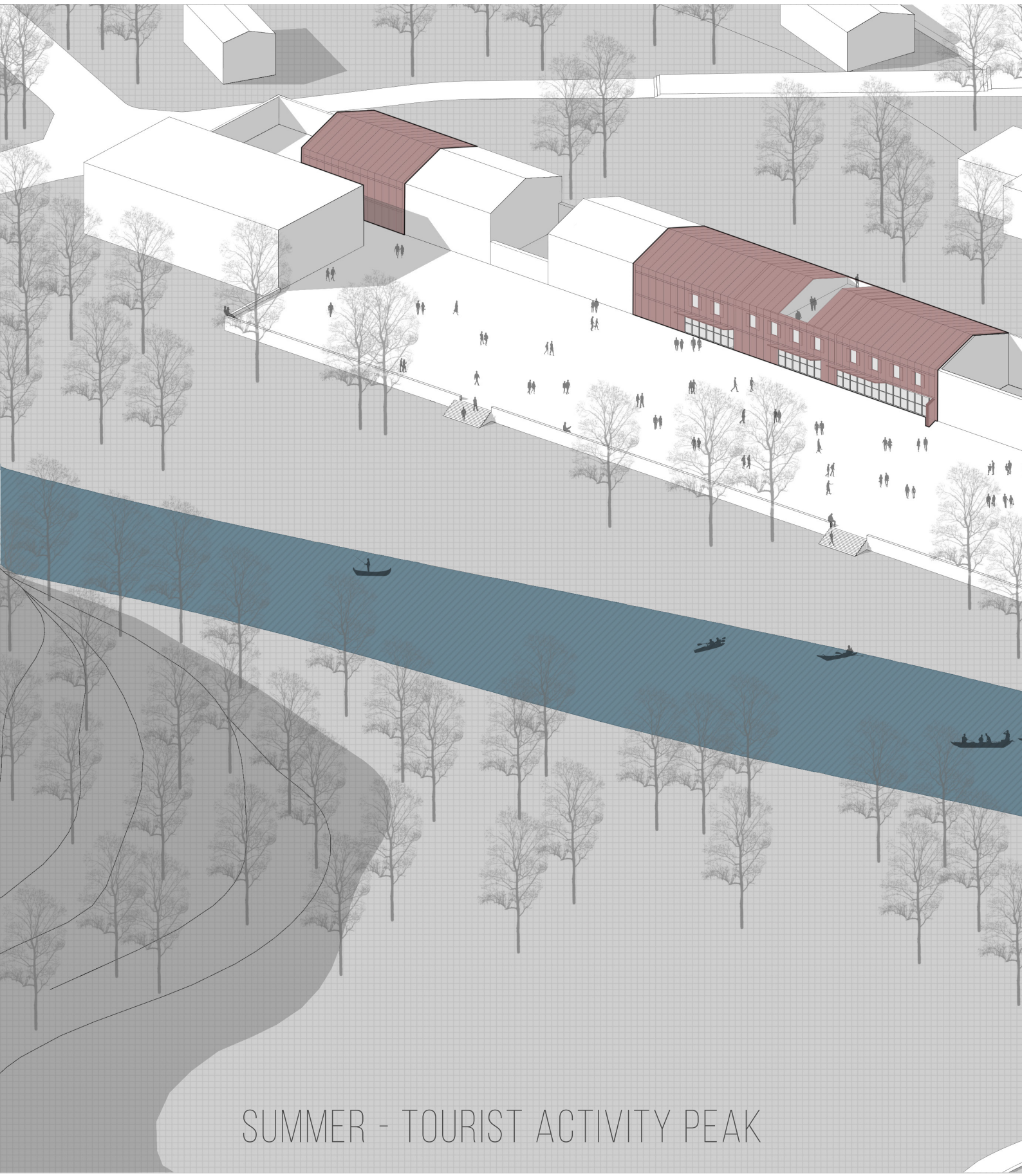
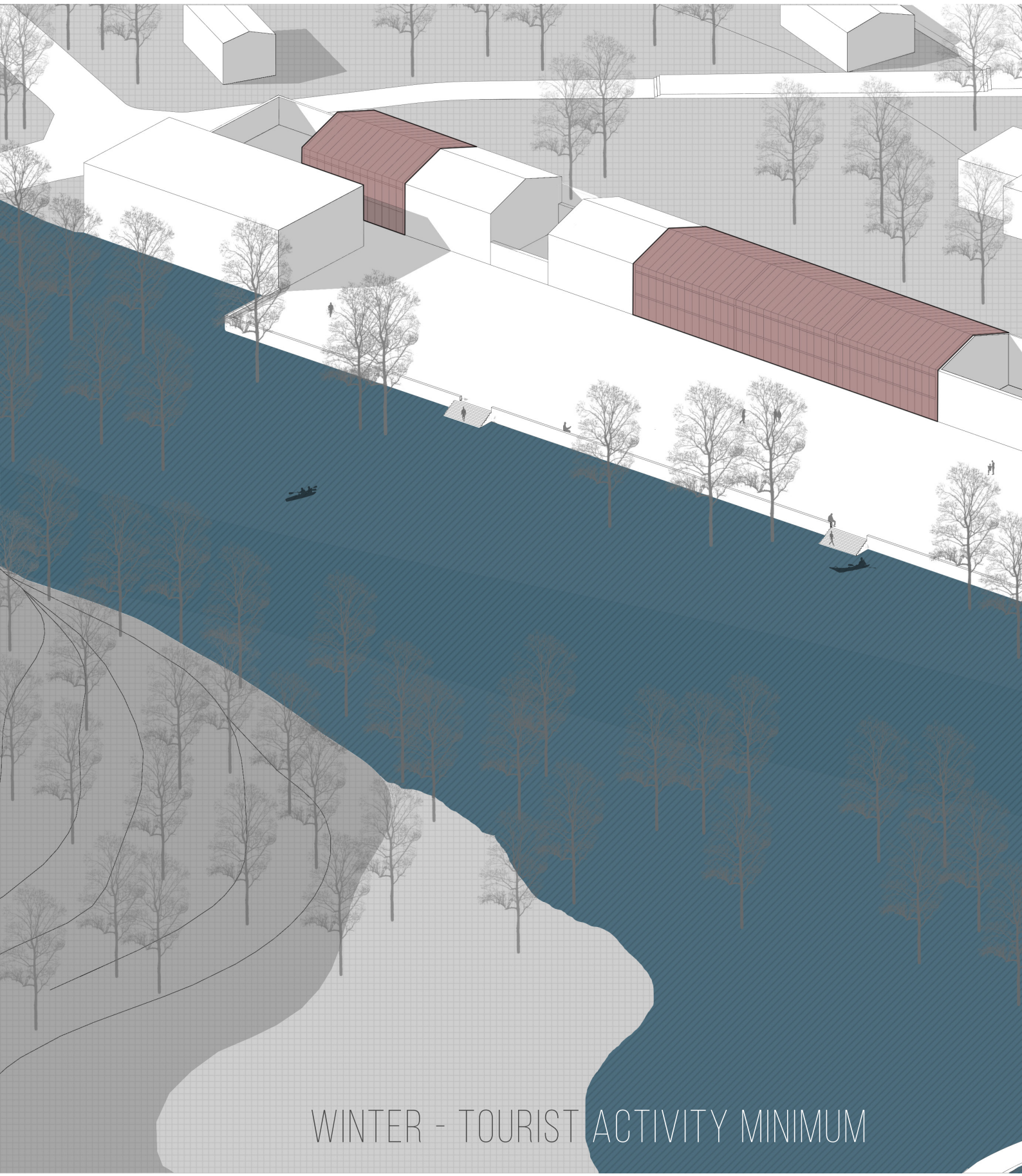


Figure 90: Summer season houses open.


WINTER - TOURIST ACTIVITY MINIMUM

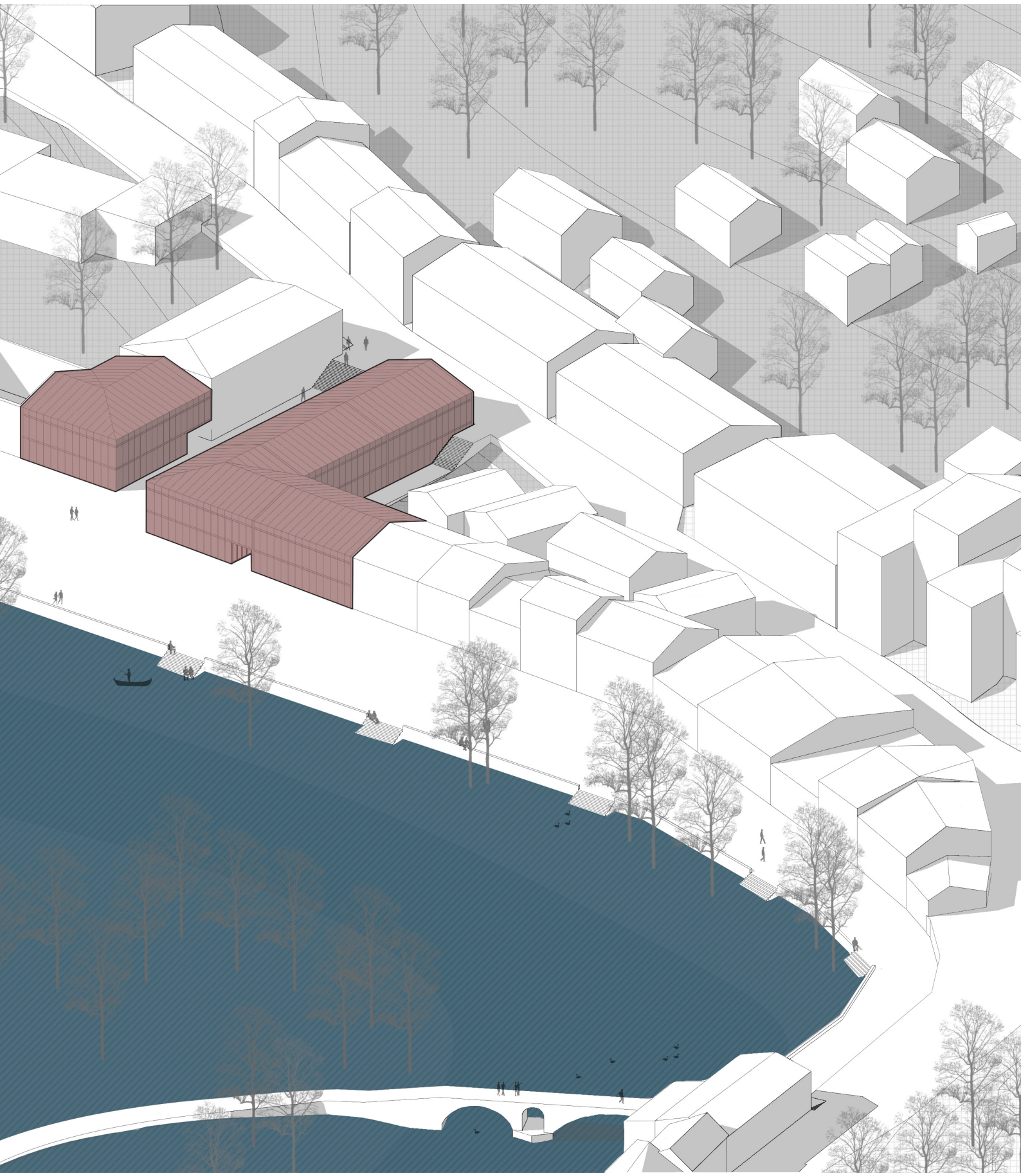
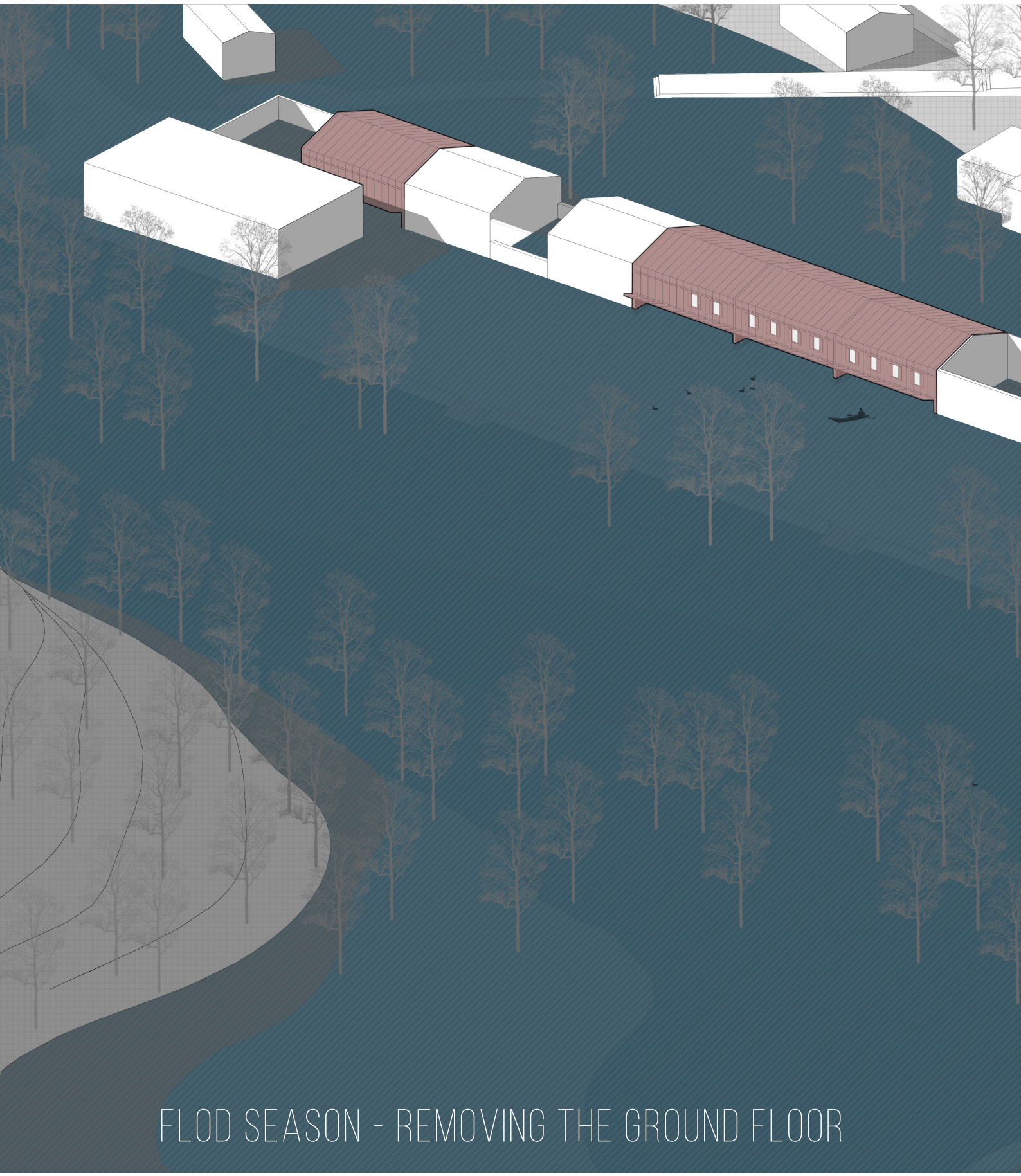


Figure 91: Winter season - rare occasion with houses all closed.



FLOD SEASON - REMOVING THE GROUND FLOOR

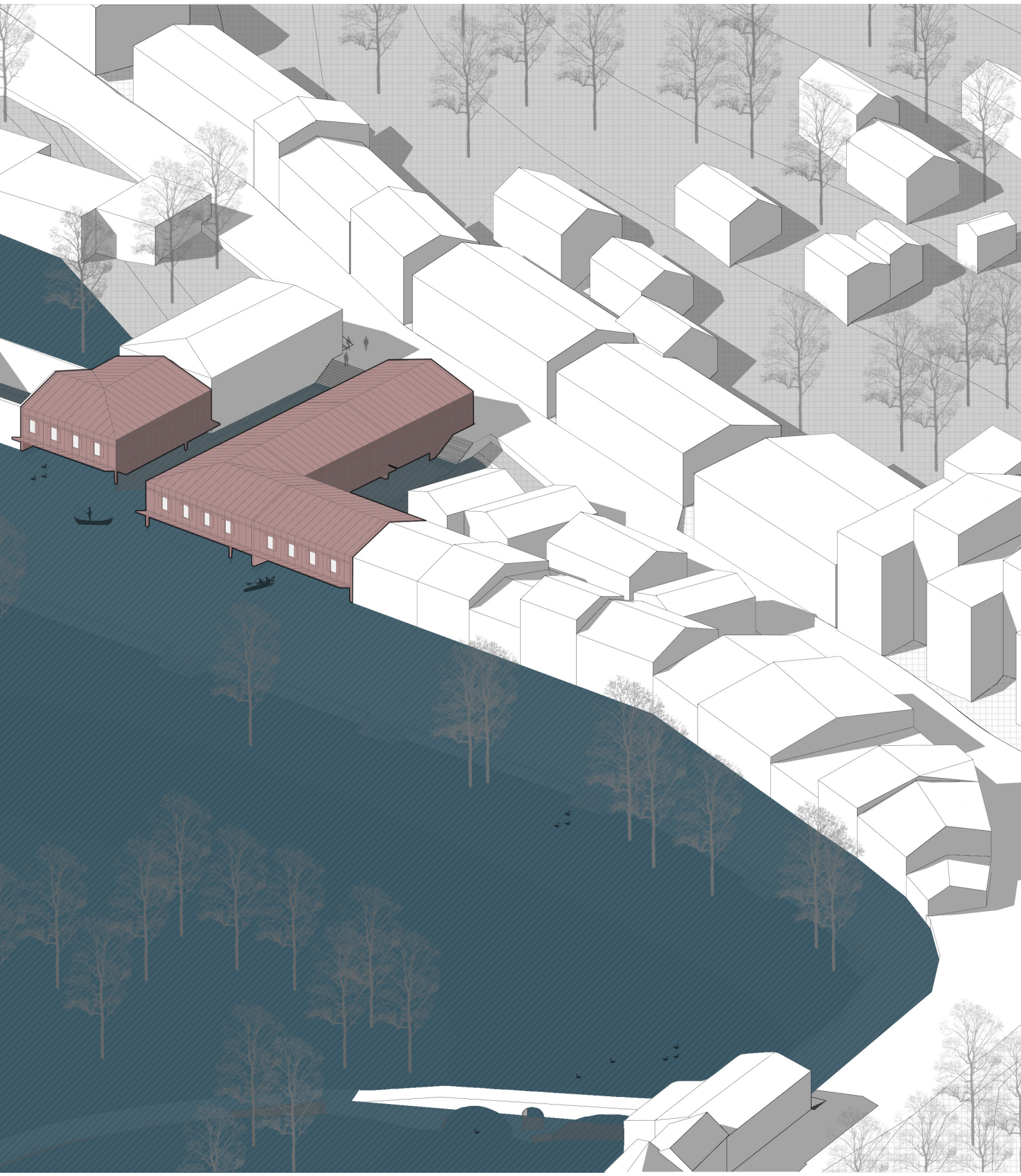


Figure 92: Annual flood season - ground floor open to let the water trough.

Price comparison - initial
PARTITION WALLS

Traditional system				Flexibile system			
CONSTRUCTION							
Partition wall 12cm				Movable wall 10cm			
Material		**Price €/m²**		**Material**		**Price €/m²**	
Full brick		33.25		Wood		90	
Overall cost							
Price €/m²	Height **m**	Surface area **m²**	€/m²	**Price €/m²**	Height **m**	Surface area **m²**	€/m²
33.5	2.6	61	5313.1	90	2.6	61	14274
DEMOLITION							
Partition wall 12cm				Movable wall 10cm			
Material		**Price €/m²**		**Material**		**Price €/m²**	
Full brick		21.3		Wood		0	
Overall cost							
Price €/m²	Height **m**	Surface area **m²**	€/m²	**Price €/m²**	Height **m**	Surface area **m²**	€/m²
21.3	2.8	61	3638.04	0	2.8	61	0

FACADE

Traditional system					Flexibile system			
CONSTRUCTION								
Exterior wall 25cm					Folding facade horizontal			
Material		**Price €/m³**			**Material**		**Price €/m**	
Full brick		159.56			Wood		1,000.00	
					Folding facade vertical			
					Material		**Price €/m**	
					Wood		1,900.00	
Standard facade carpentry					Folding windows horizontal			
Material		**Price €/m²**			**Material**		**Price €/m**	
Wood		208.13			Wood		103.00	
					Folding windows vertical			
					Material		**Price €/m³**	
					Wood		90.00	
Overall cost								
Price €/m²	**Height m**	**Length m**	**Ticknes**	**€/m²**	**Price €/m²**	**Length**		**€/m²**
159.56	2.8	28	0.25	3127.376	1,000.00	28		28,000.00
Price €/m²	**Surface area m²**			**€/m²**	**Price €/m²**	**Length**		**€/m²**
280	78.4			21952	1900	28		53,200.00
DEMOLITION								
Partition wall 12cm					Movable wall 10cm			
Material		**Price €/m³**			**Material**		**Price €/m²**	
Full brick		21.3			Wood		0	
Overall cost								
Price €/m²	Height **m**	Surface area **m²**	€/m²		**Price €/m²**	Height **m**	Surface area **m²**	€/m²
21.3	2.8	61	3638.04		0	0	0	0

Figure 93: Table of price comparison between static and flexible systems.

4.10. Economic viability

Cost comparison between flexible system and static system

Main idea is that the initial investment will be higher but the longer overall cost would be lower then the standard one, thus much more economically viable.
In table on the previous page (Image 51) price comparison between traditional static system and flexible system.
Average price of the standard partition wall, thickness 12cm is 33.25eur/m^2 for the full brick.
[1]By calculating the price of the full brick 33,35eruos/m^2 times 61m we are getting the price of 5313.1euro/m^2.

We must also include the price of highly possible rearrangements of space and demolitions.
For the full brick walls 12cm thickness are 21.30 euro/m^2 times 61m the result is 3638 euro.[2]
Added to that we take the price of disassembling of carpentry 25.26 euro/m^2 times 61m we get the price of 3081euro. In total we have additional long term cost of 5578 euro.

For comparison, the average price of proposed movable wall system thickness 10cm is 90euros[3] times 61m we get the number of 14274 euro, which is 3 and 4 times more expensive then the typical price.

Clearly there is no need for demolition of the flexible wall system if we want to rearrange the space.

If we take the span of 20 years, there would be at least one renovation or change of the interior layout, we get the next estimated numbers[4]:
5313.04 euro (initial price of the static system) + 5578euros(price of one demolition – during the 20 years period) = 11274,18euro if we count the additional costs of installations (electrical, water, ventilation system) and paint work the number in total exceeds 25 000 euro.

For the flexible wall system the initial price of 14274 euro, even with regular maintenance and change of broken parts does not exceed 20 000 euro in 20 years of life span. Also the possibility of changing installations is much lower because there is nothing to be demolished.

The greatest difference is made in the economic benefits that can be collected from renting the more elastic space that gives opportunities for better timing of space management compared to the standard model. Space arranges according to the real time needs, not vice versa.
Even though the initial price of the investment is higher, the flexible design compensates the initial investment with the greater opportunities for landlord to adapt to the real-time tourist number, needs and to maximize the profit which in the standard case would be the average amount.

14 https://www.troskovnik.net/cijena-zidarskih-radova/
15 https://www.troskovnik.net/cijena-zidarskih-radova/
16 https://www.alibaba.com/product-detail/
17 Stanislas Chaillou, Metabolisms - Flexibility in 21st Century, Harvard Graduate School of Design, 2018.

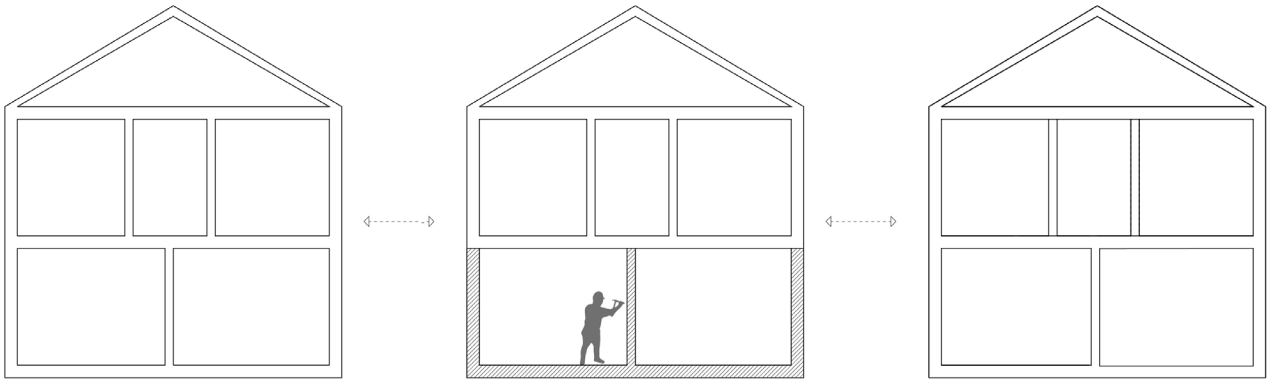


Figure 94: Upgrading and renovation of static system requires demolitions in most of the cases.

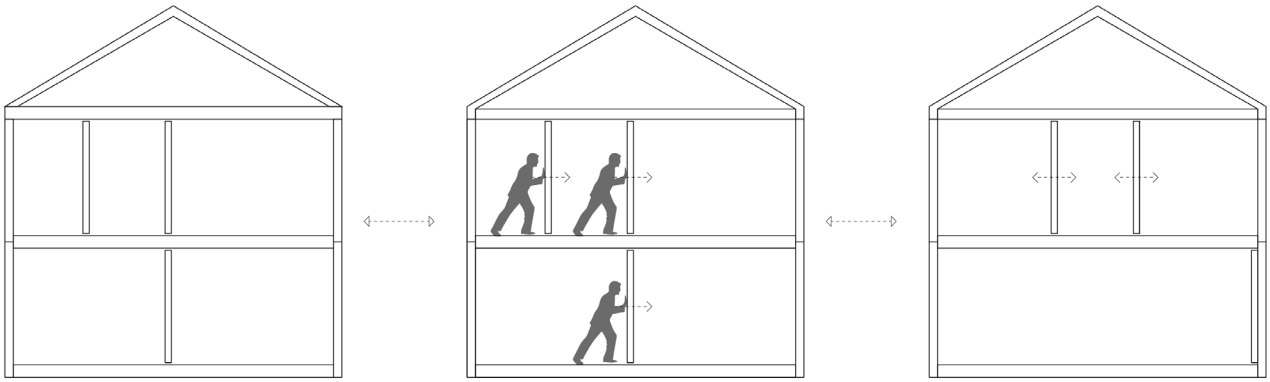


Figure 95: Upgrading and renovation of static flexible system does not require demolitions because it is made with changing function in mind.

Following the changes of interior, facade openings must adapt to the changing layout of the inside.

Taking into account the standard price of facade carpentry in Montenegro is 280eur/m^2 multiplied with the total area of 78.4m^2 we get the 21952euro as total price[5].

Price of the horizontal folding panels is around 1000euro per unit [6](in this case 1 meter in length) and multiplied with the given number of 28 units the price is 2800euro. Price of the vertical folding panels per unit is 1900euro[7], multiplied with 28 panels the price is 53200euro. The total price of the whole dynamic facade system is 81200euro.
The price exceeds standard one with up to almost 4 times.

But taking into account the larger picture and constant floods, we must include the price of repair and maintenance into the calculation. Added to the standard price are the constant maintenances during the year and repair after the flood season which goes 1500euro on average every year. Multiplied by 20 years period we get 30000euros of added costs to standard one, while the dynamic ones the maintenance cost in 20 years period does not exceed 3000 euro maximum, around 10 lower than static one.

In 20 year period prices are comparable:

Standard facade price total - 21952euros + 30000euro= 51952euro
Dynamic facade price total - 81200euro + 3000euro = 84300euro

Now the price of the dynamic system exceeds about 1.6 times price of the static one, and it is comparable in total.
The most likable reason for higher price is that this type of facade systems is not yet used enough and it is not industrially produced on large scales compared to the standard options. But the benefits of flexible facades, especially in the regions with "natural hardships" (floods in our case) are definitely worth of the greater investment.

18 https://www.emajstor.hr/cijene/prozori
19 https://www.soltec.si/sliding-folding-lifting-panels/
20 https://www.soltec.si/new-dynamic-facade-paris-playful-sunny/

5. Restoration – renovation of abandoned buildings

Figure 96: Promenade 1950ies.

Figure 97: Promenade 2020.

5.1. Preserving the authenticity

Decline of population in Rijeka Crnojevica had brought to gradual disappearance of the authentic architecture from the end of the 19th and first half of the 20th century for which it was known for. Together with architecture the atmosphere of life in the small urban settlement vanished.
Main promenade lost its look and with that its function of the marketplace and that of public space.

Traditional architecture, that one which did not collapse due to the lack of maintenance had been replaced with the newer one, that has changed the essence of the space.

Beside adding the new building on the empty spaces, that respect the morphology and essence of the place, there is need to treat the buildings that are in deteriorated state but have the ability ti be renovated.

Renovation would be done to preserve the memory of the space and to give it essence of continuity.

In the Figure 99 , it is shown image of promenade from 1950ies. Housing line with typical facades from 20th century.

In the figure it is shown the same promenade from the another angle, but with deteriorated houses that are left with walls only.
Renovation would be done with having in mind preserving the outer look of the buildings but also bringing back the functional aspect.
Inner layout would follow flexible principles arranged in the previous chapter.

Figure 98: Diagram of renovation classification.

Figure 99: First case.

Figure 100: Second case.

Figure 101: Third case.

5.2. Classification of intervention – first, second, third case

As the all abandoned objects are not in the same level of deterioration, the aproach to renovation should be different to different situations.
More concrete classification of deterioration is needed.

There are 3 cases of deterioration, shown in Figure 101:

1. First case, or the case where the building has deteriorated to the part where only what is left standing are walls along all the floors.
Approach to this case would be that exterior - facade would be left and inside would be renovated with similar flexibility in the layout as shown in Chapter 4. It would consist of housing on the upper floor and the economic or storage space in the ground floor, according to already established typology in the place. Ratio of flexibility would be 25% static and 75% flexible.

2. Second case is the one where only the wall is left on the ground floor. There would be no construction of the new building but it would serve as the green space - garden, restaurant, etc..
Walls would be renovated together with the green space. It would serve as the open - green interpolation in between buildings. Flexibility ratio in this case is not considered because it would be treated as the open space.

3. Third case is the abandoned hotel. Hotel is in better state then the previous mentioned cases. Extensive renovation would be made together with adding the new floor in the rooftop. Rtio of flexibility in this case would be - static 75% and flexible 25%.

According to established flexibility principal in previous chapter, buildings would be classified also by ability in employing the flexible design. It would make project continuous in its effort to revitalize the place with flexible solutions.

Figure 102: Front facade, present state.

Figure 103: Back facade, present state.

5.3. First case – Both floors left

Two buildings next to each other in the row are left with only walls that are standing.

Buildings are deteriorated to the level where it can not be use for any purpose and inside is structurally unstable and it is dangerous for the surrounding.
Roof has fallen together with the floors. All carpentry has fallen from the windows. Only wide openings are left.

Facade is deteriorated to the level that it must be fully renovated.

Buildings are of typical typology. Two floors, on the first floor housing and in the ground floor the economic area.

Exterior walls are left and would be renovated into the authentic look.
Renovation of interior would be done according to the flexibility principals stated in Chapter 4 and would be continuation of "flexibility as a solution" concept.

It would follow already existing typology that consists of housing on the upper floor and the economic or storage space in the ground floor.

Flexible layout would have 25% static and 75% flexible ratio.

Figure 104: Facade South, renovated.

Figure 105: Facade North, renovated.

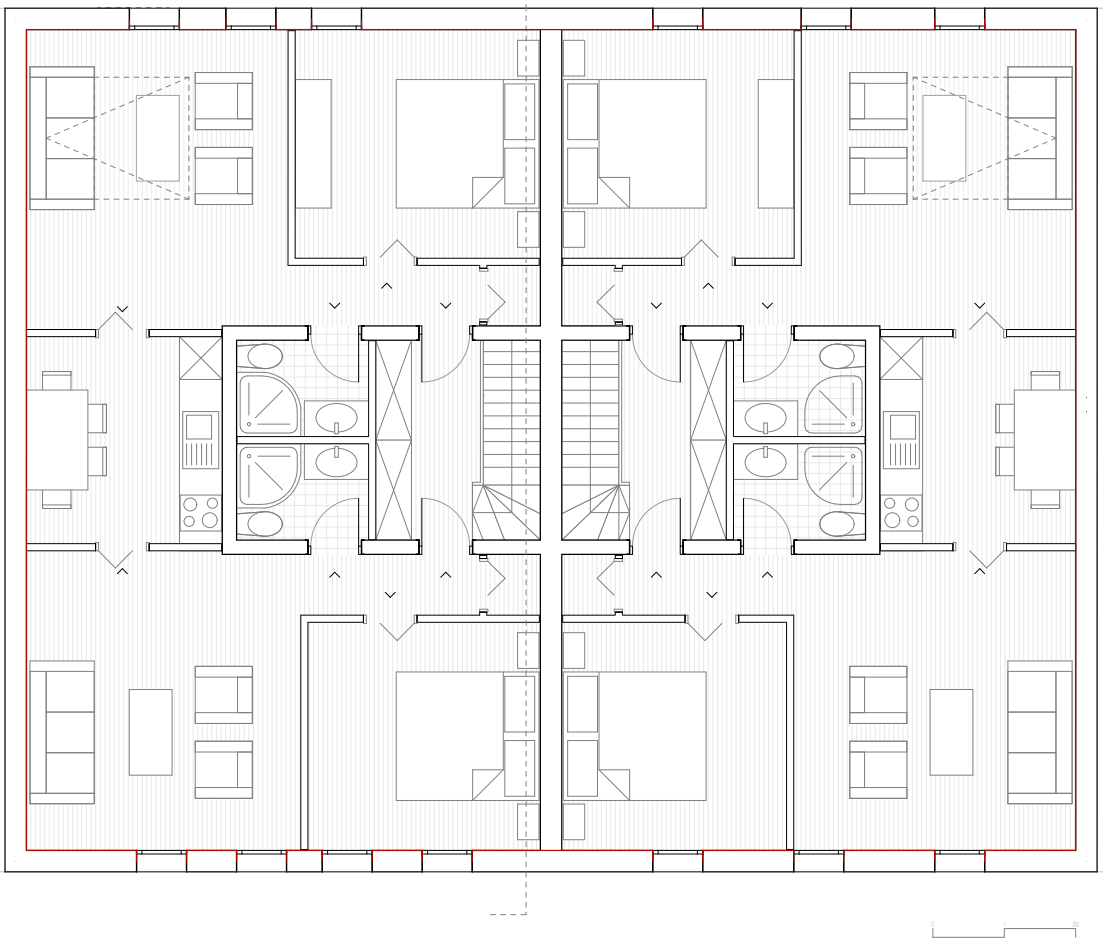


Figure 106: First floor layout, renovated.

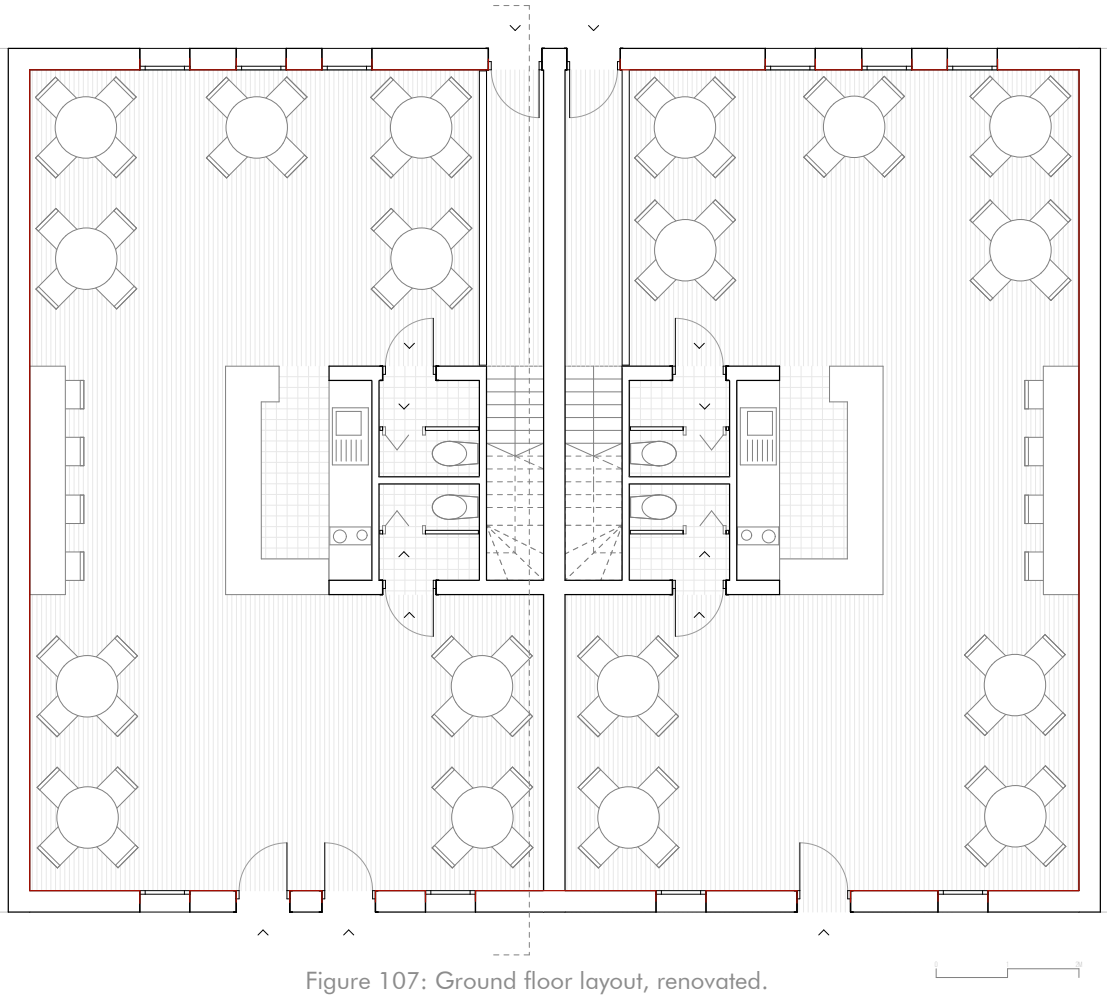


Figure 107: Ground floor layout, renovated.

Figure 108: South facade, present state.

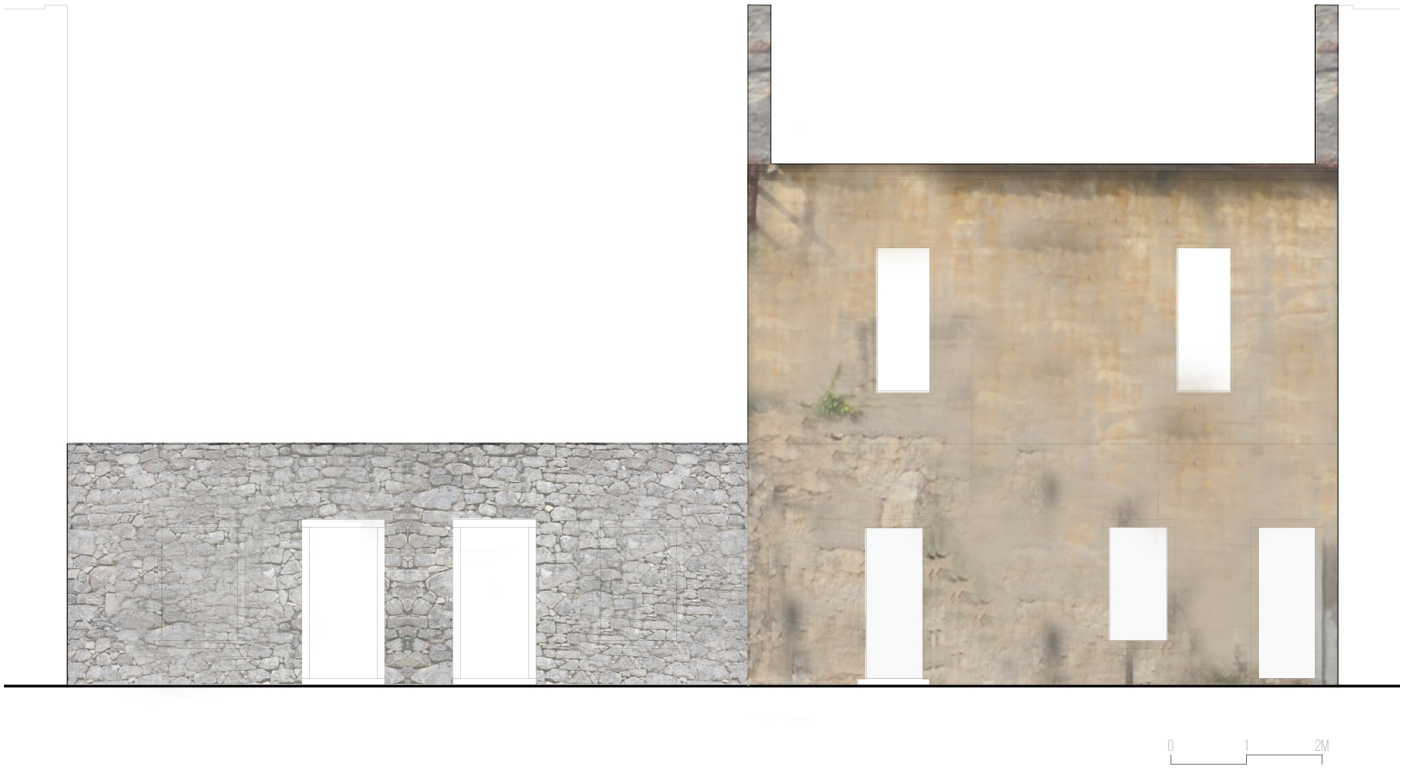


Figure 109: Facade North, present state.

5.4. Second case – ground floor left

Second case is the building which has only one floor left. In this case there is a first case building next to it.

Structurally is unstable and it is dangerous for the surrounding.
Roof, floors and walls have fallen. All carpentry has fallen from the windows. Only wide openings are left.

Facade is completely deteriorated but it would be partially renovated, because it is consider as an exterior space.

Ground floor would become a green area, that would be use for the economic area - restaurant, etc..

This open space would serve as the green interpolation and serve as the buffer zone.

It would follow already existing typology that consists of housing on the upper floor and the economic or storage space in the ground floor.

Flexibility ratio for the open part would be 100% and closed space as the 25% to 75%.

Figure 110: Facade South, renovated.

Figure 111: Facade North, renovated.

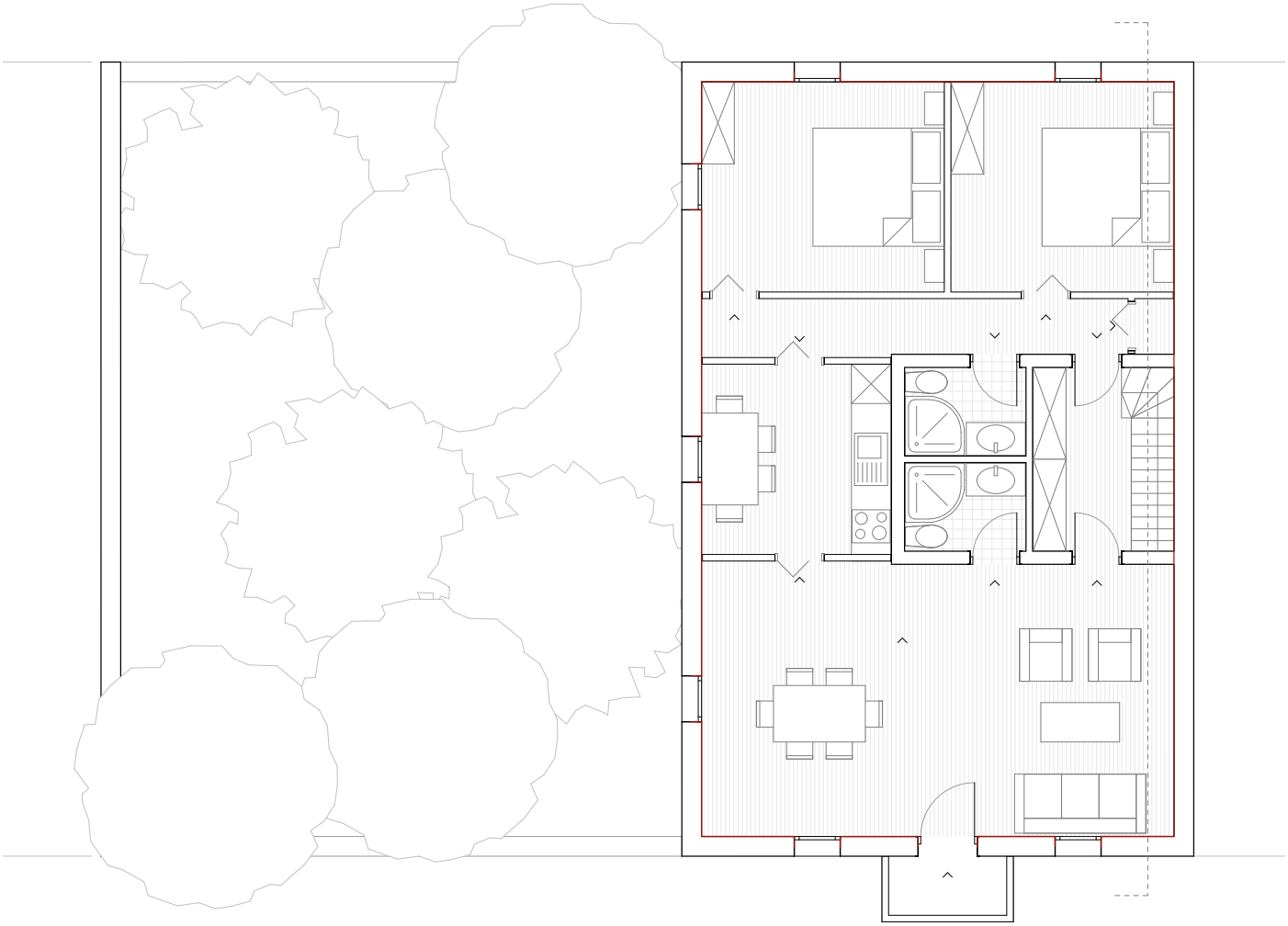


Figure 112: First floor layout, renovated.

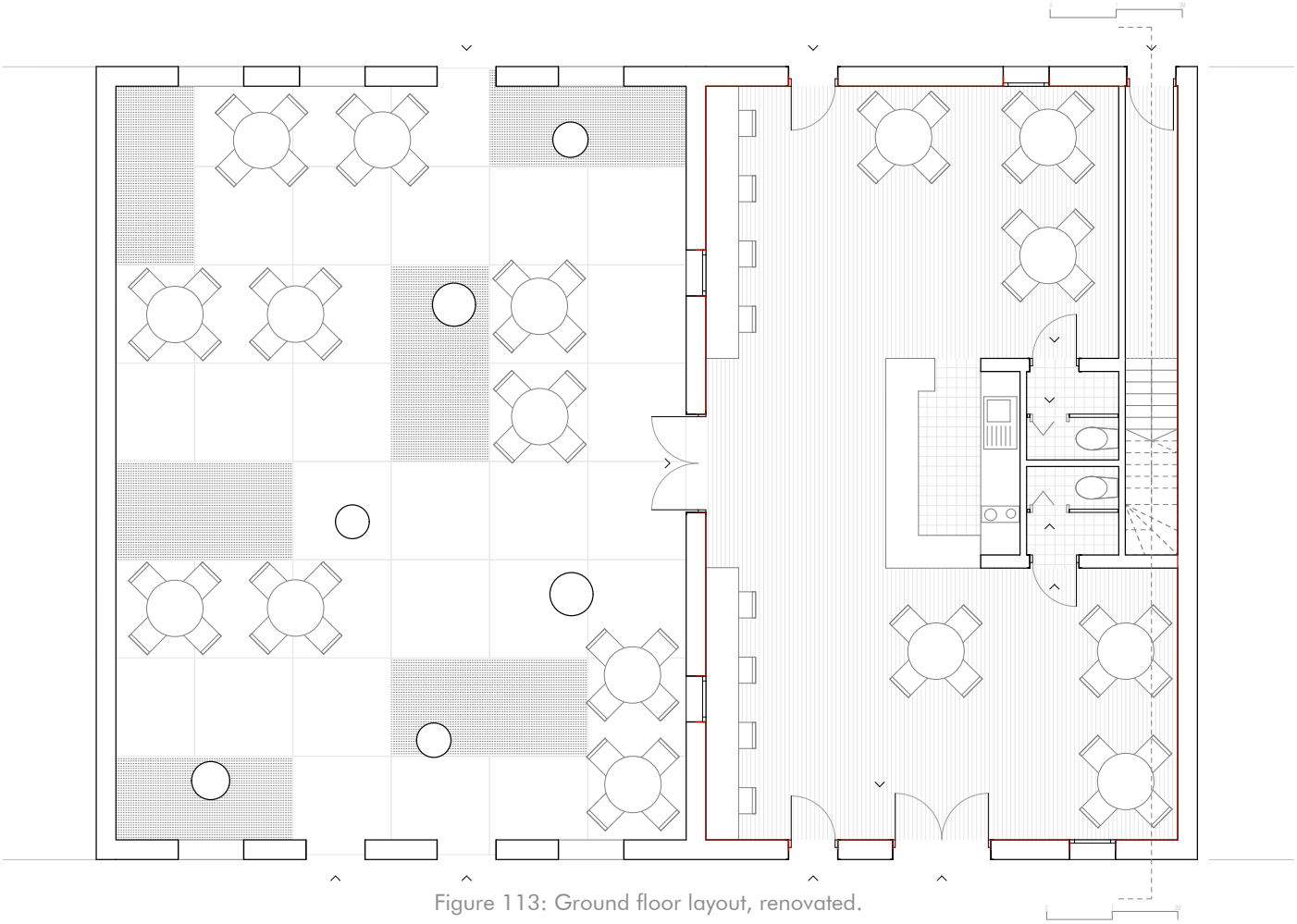


Figure 113: Ground floor layout, renovated.

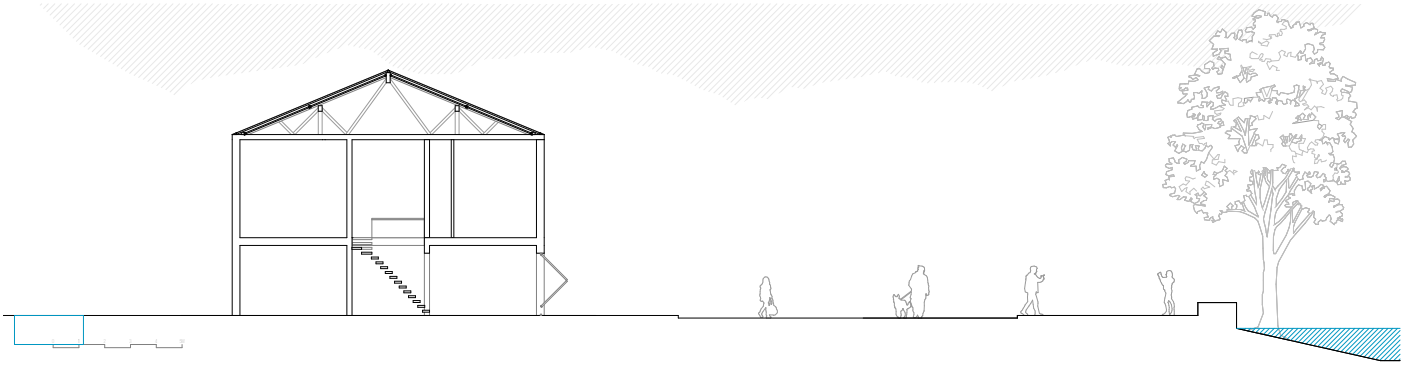


Figure 114: Case 1, section.

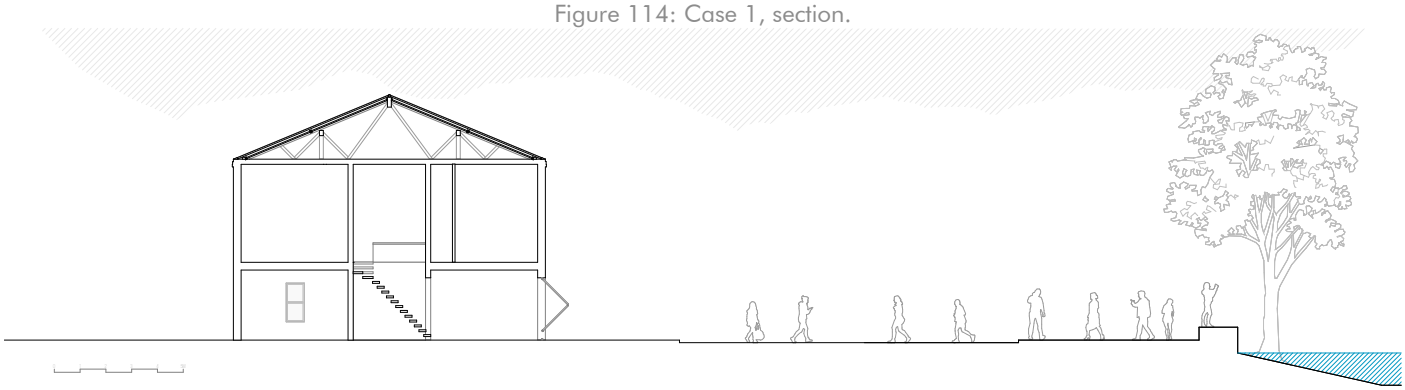


Figure 115: Case 1, section.

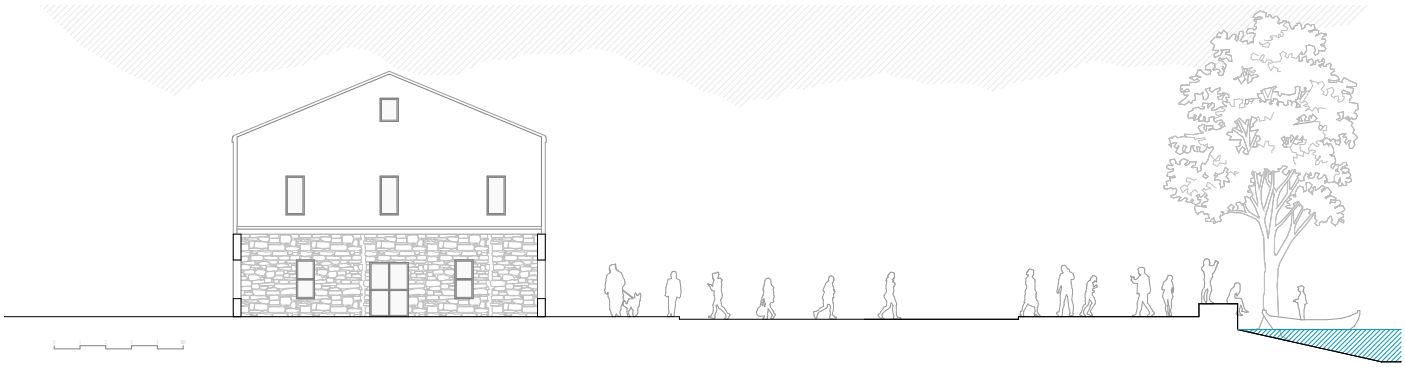


Figure 116: Case 2, section.

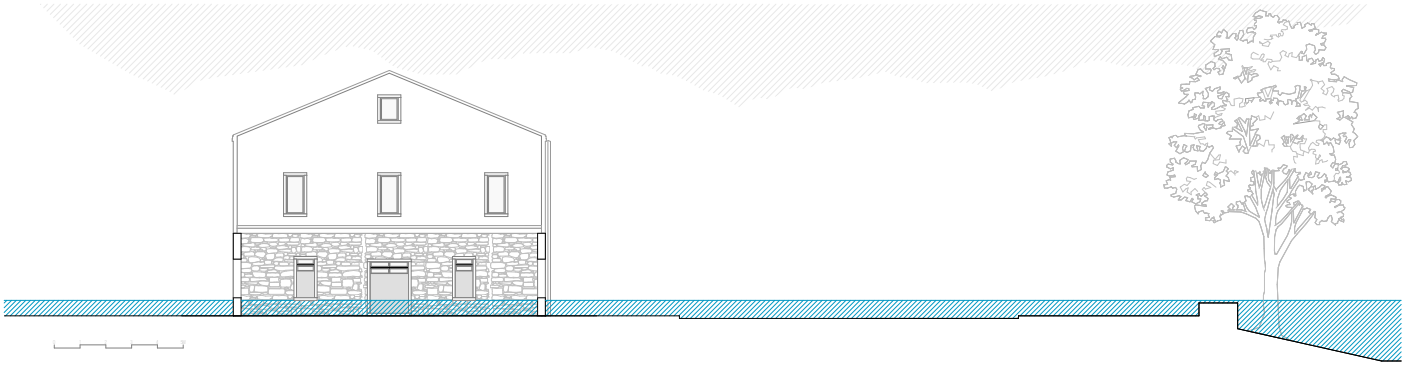


Figure 117: Case 2, section.

Flexibility ratio for the closed part is 25% static and 75% mobile.

Ground floor is equipped with the openings that can be moved vertically to prevent the flood from damaging the carpentry.
Principal is the same as one described in the Chapter 4.

Exterior part would serve as a green open area ,
It would be covered with water during the annual flood, same as the closed part.

Figure 118: Hotel, East facade, present state.

Figure 119: Hotel, West facade, present state.

5.5. Third case – Hotel

Hotel is the third case. It is the most preserved part that should be renovated. Structurally it is in the good shape and it needs minor repairs.

While interior and facade needs extensive repair and redesign.

Hotel would be resigned, new content would be added.
Instead of already existing two floors, ground and first floor, the extension on the roof floor would be added, thus extending the capacity of the hotel than previous.

Layout will follow ratio that will consist of 75% static and 25% mobile. Second floor will be floor with the flexible layout, consisting of rooms that could be merged into bigger apartment spaces.

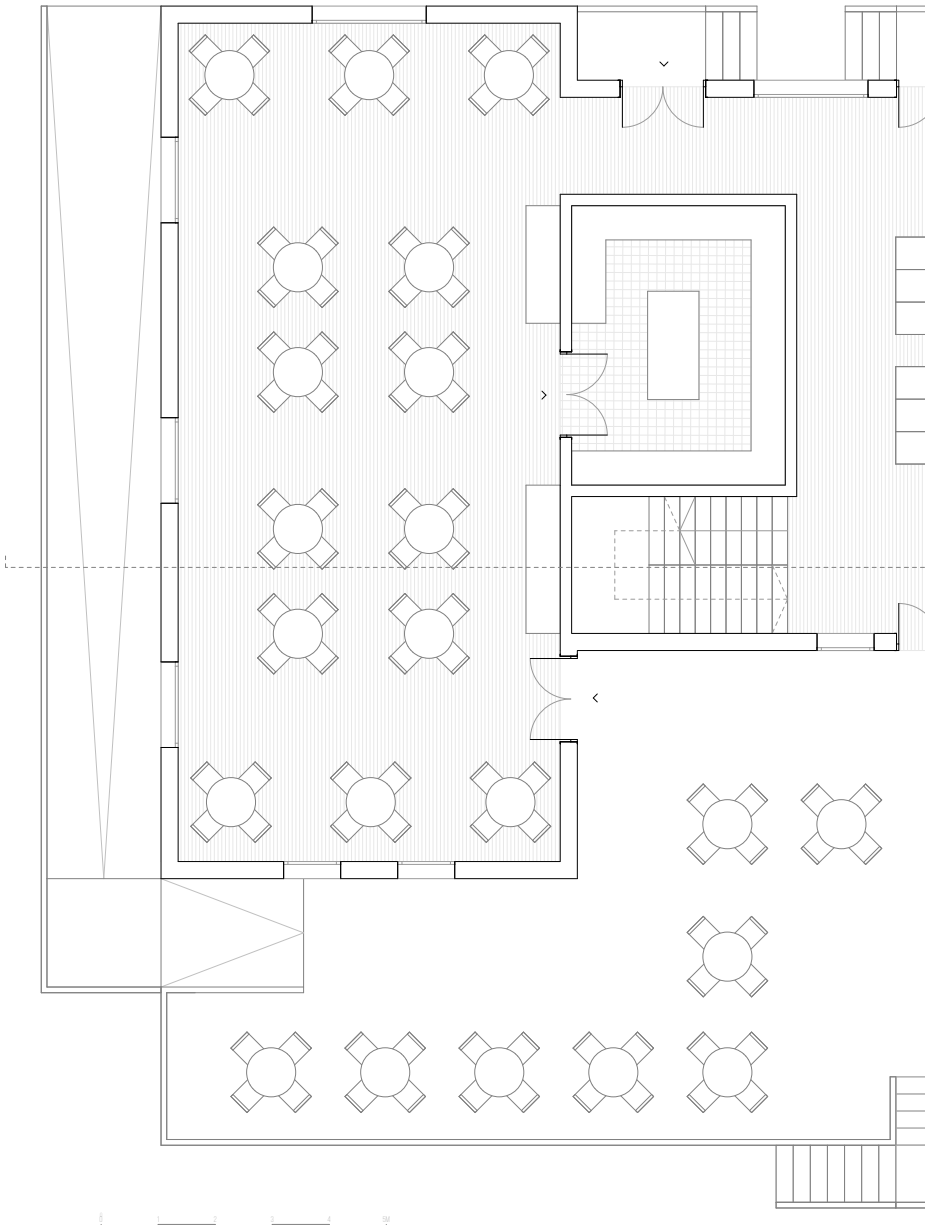
Also the roof would have mobile facade that would be able to adapt to the changes of the interior layout.

Figure 120: Hotel, North facade, present state.

Figure 121: Hotel, South facade, present state.


0 1 2 3 4 5M


0 1 2 3 4 5M



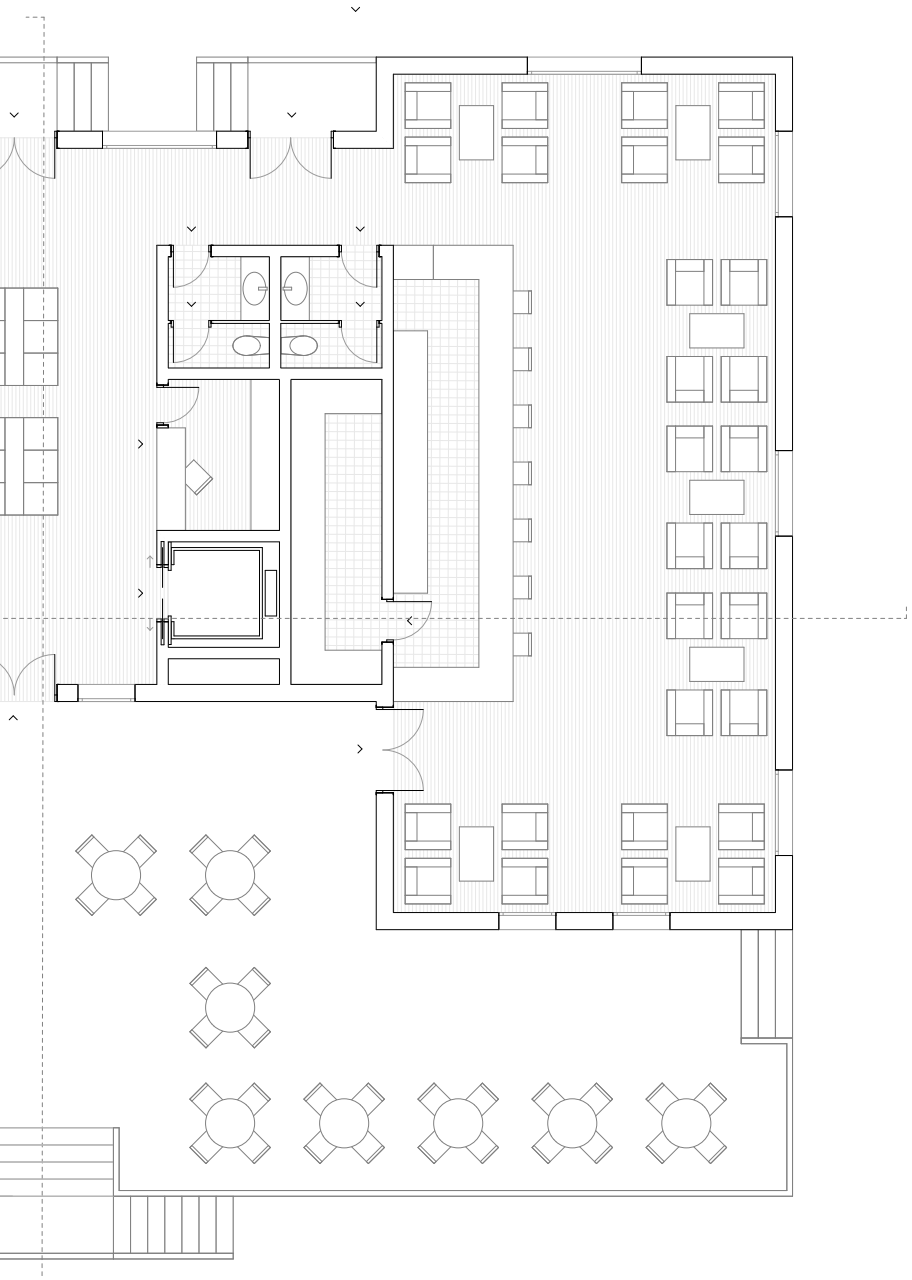
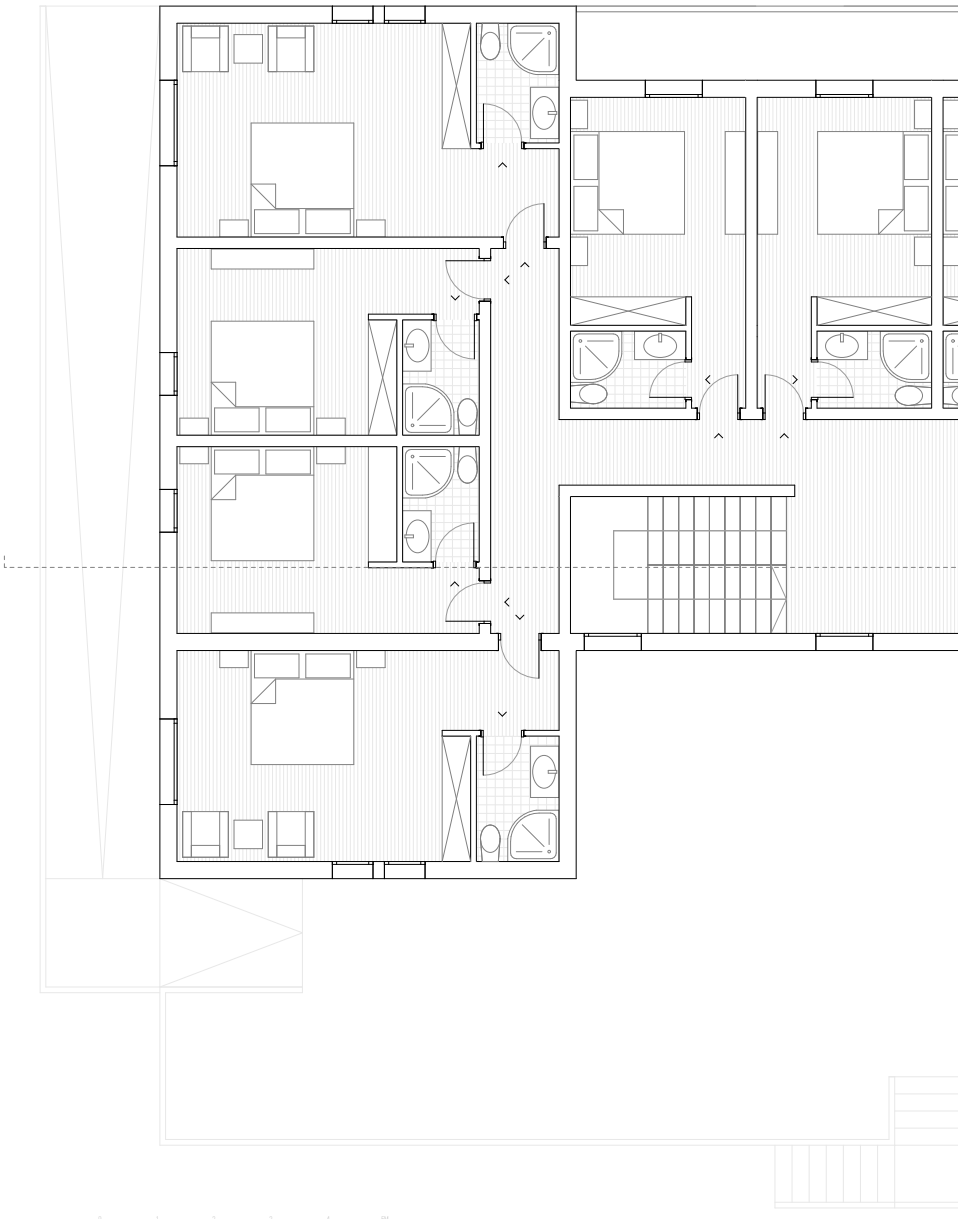


Figure 122: Ground floor layout, renovated.



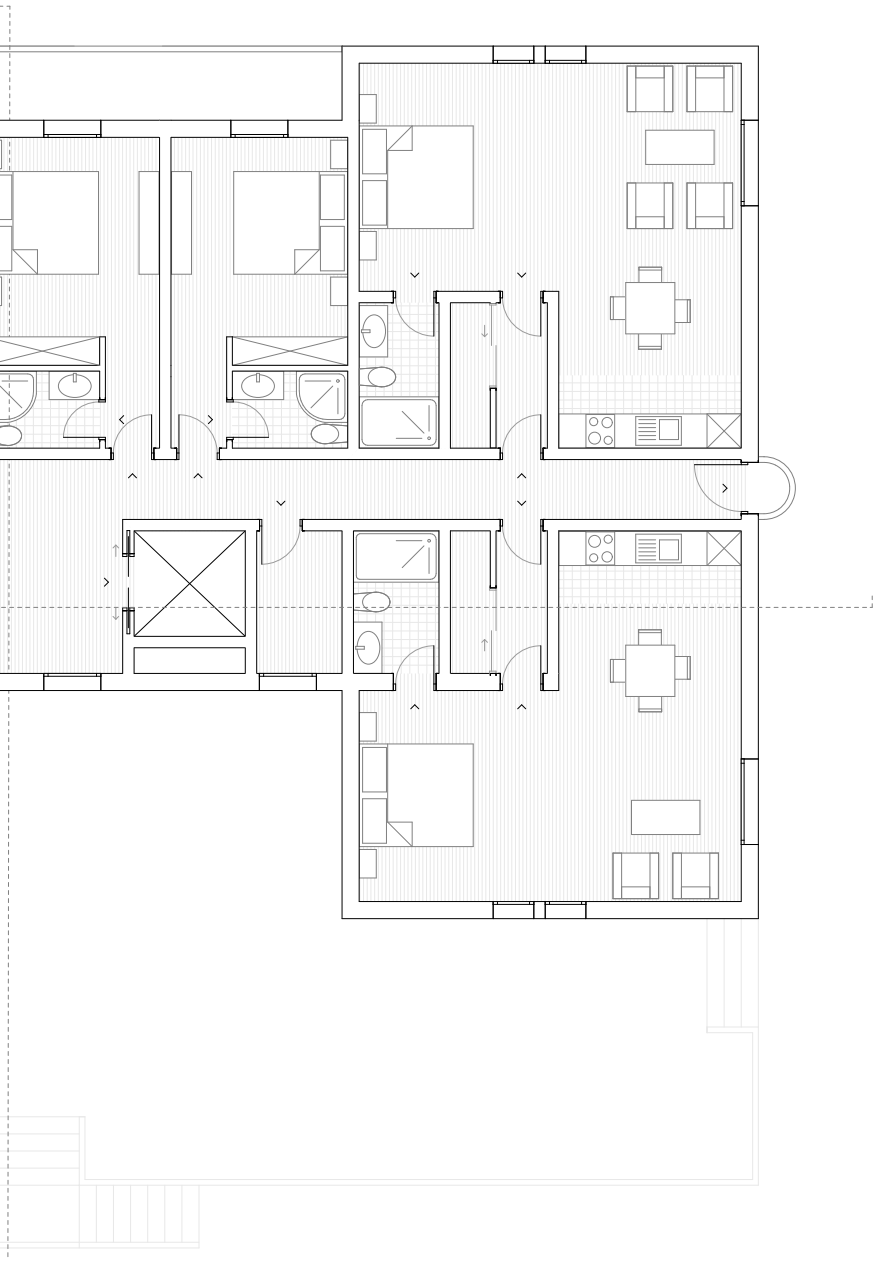
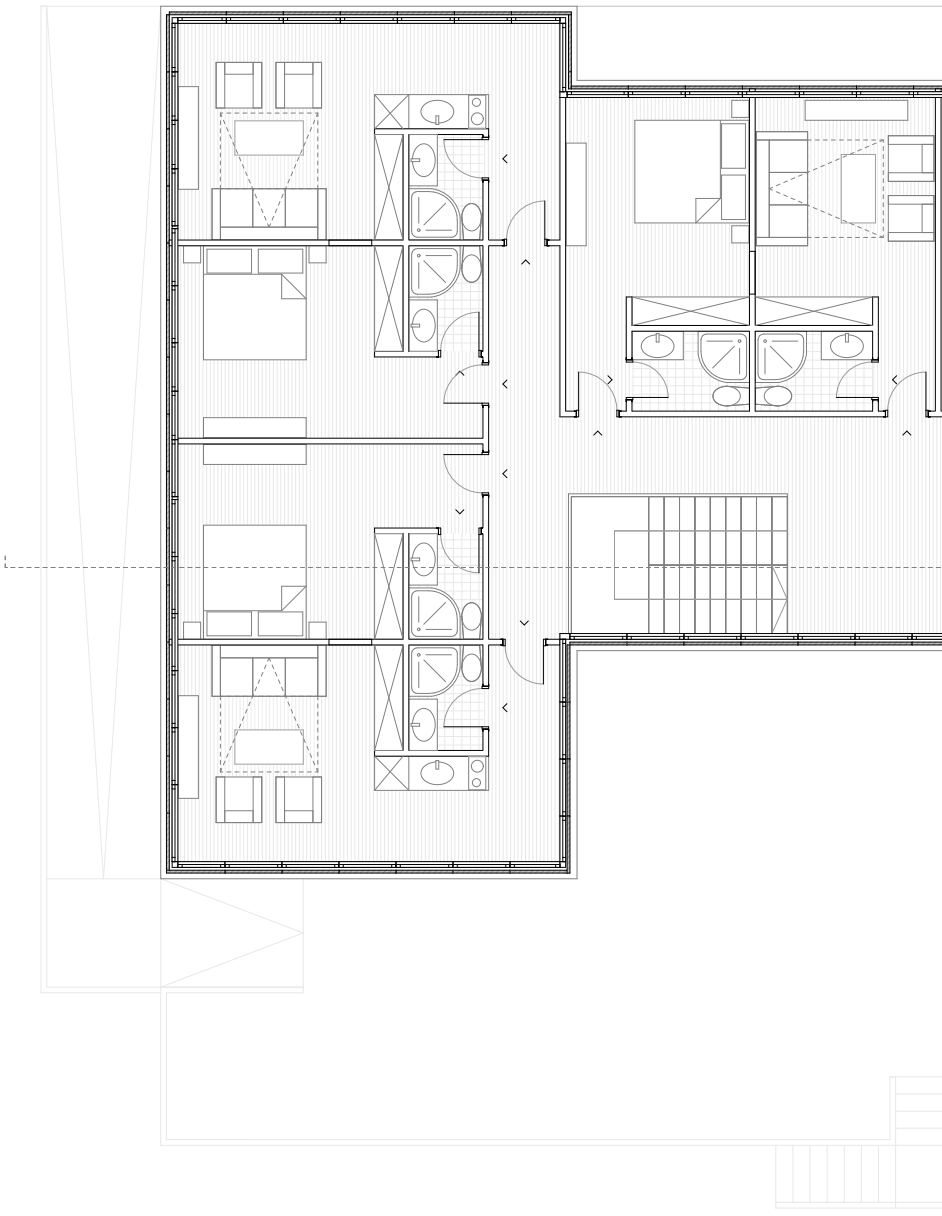


Figure 123: First floor layout, renovated.



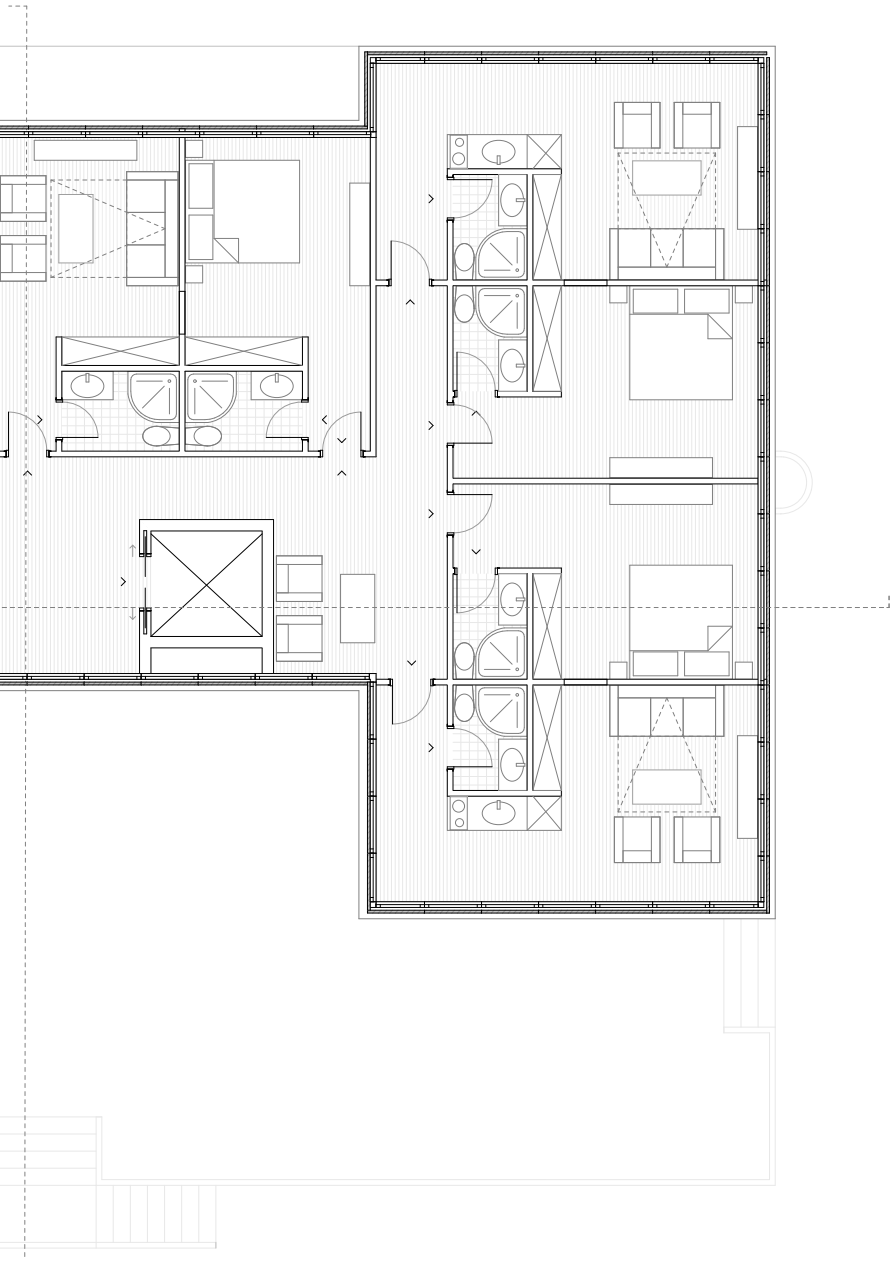
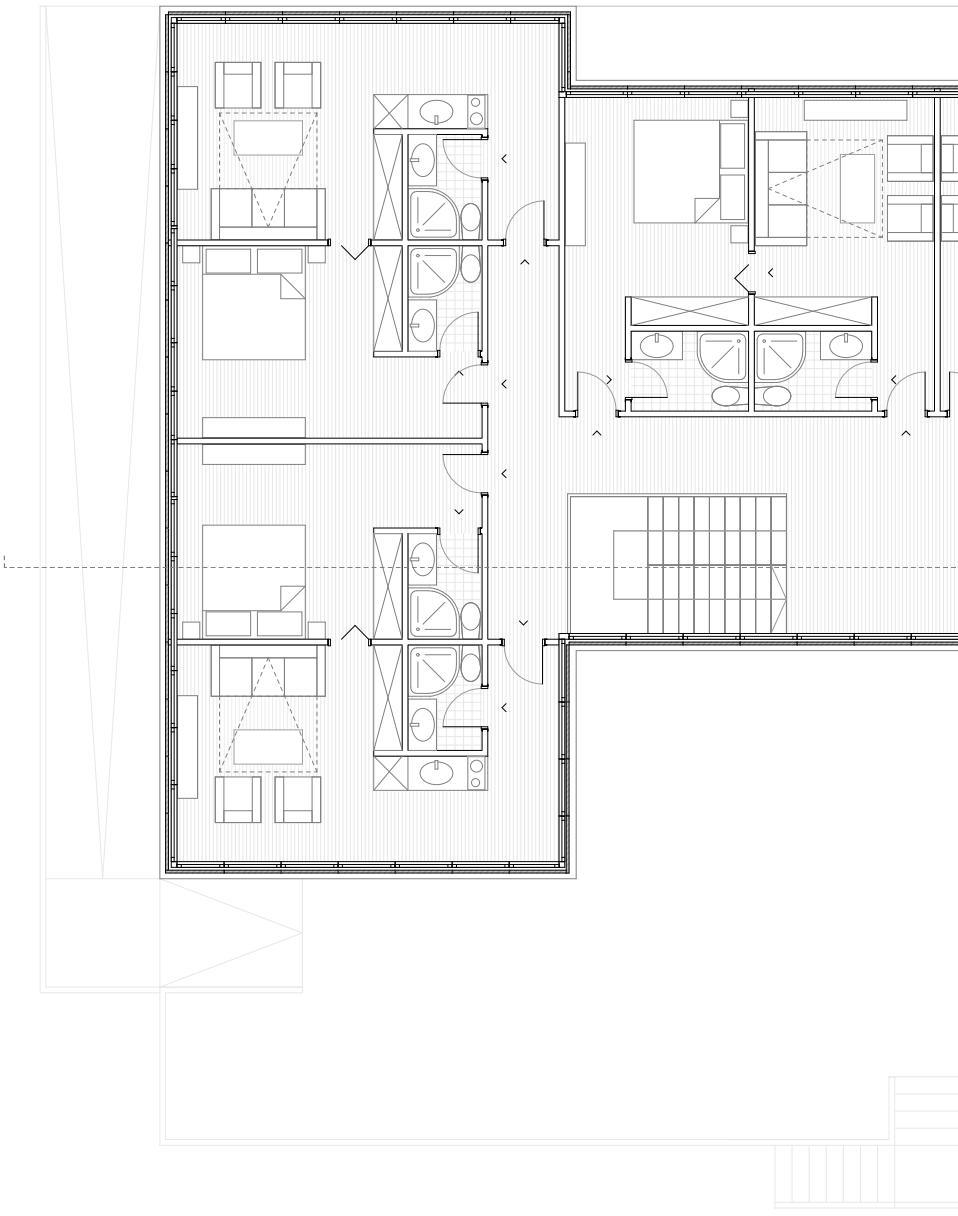


Figure 124: Second floor layout, renovated, scenario 1.



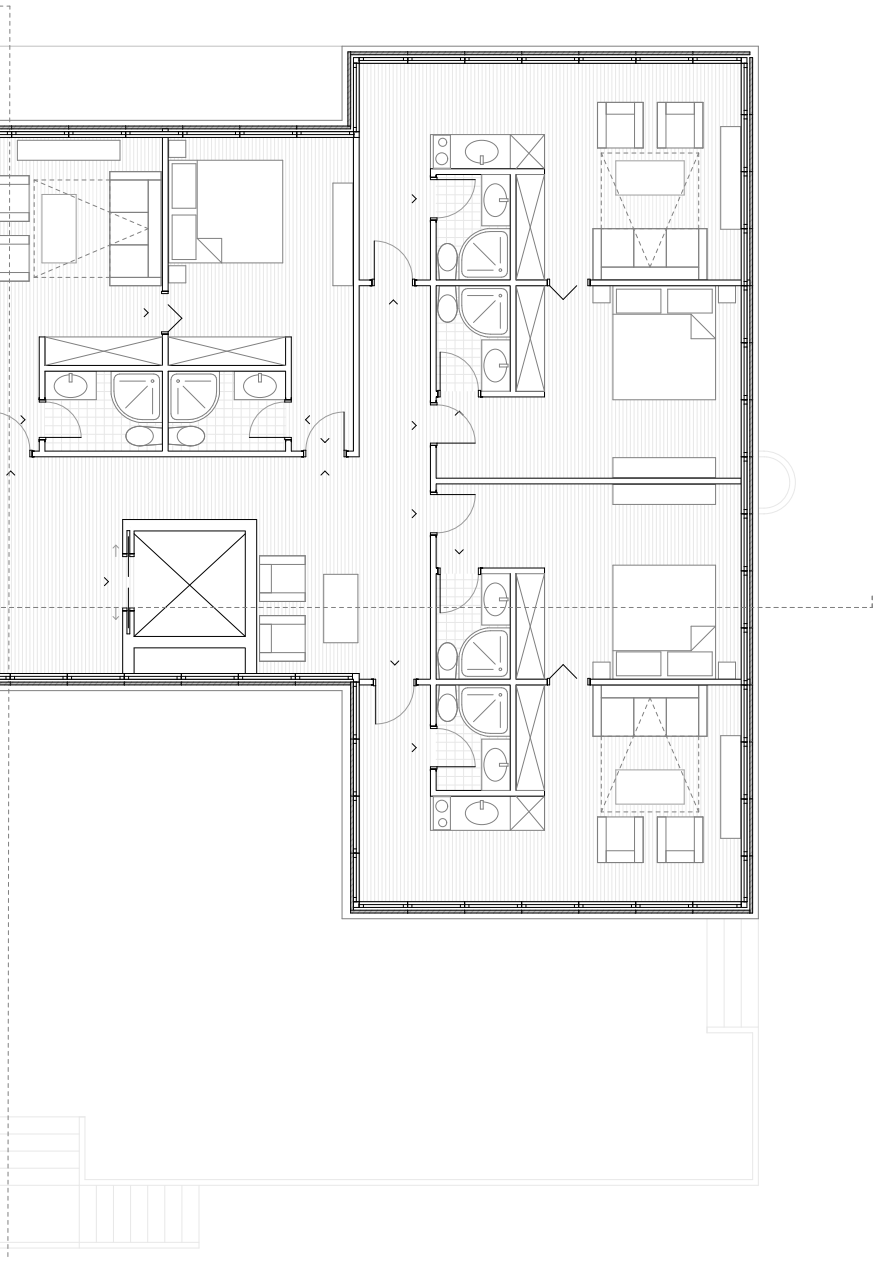


Figure 125: Second floor layout, renovated, scenario 2.

Figure 126: Hotel, North facade, renovated state.

Figure 127: Hotel, South facade, renovated state.

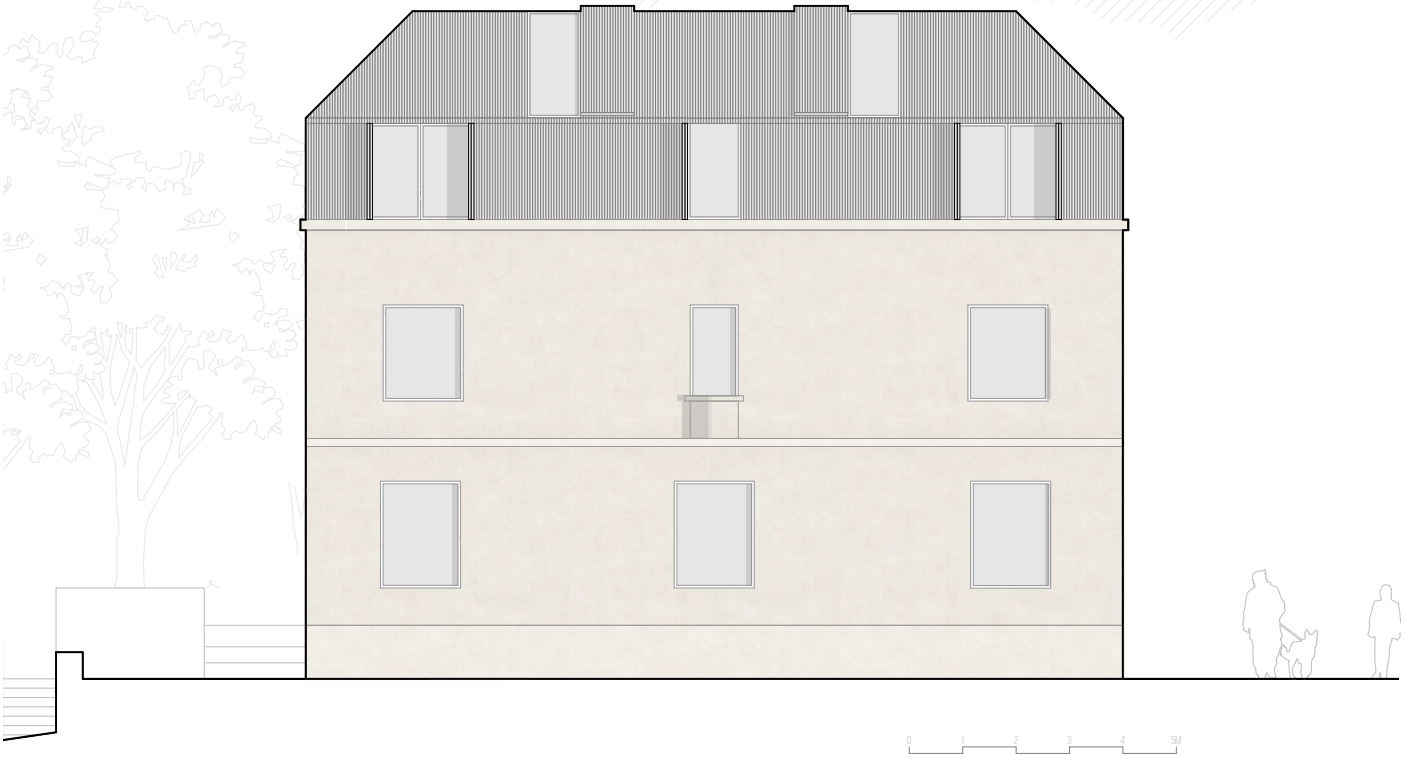


Figure 128: Hotel,
East facade, renovated state.

Figure 129: Hotel, West facade, renovated state.

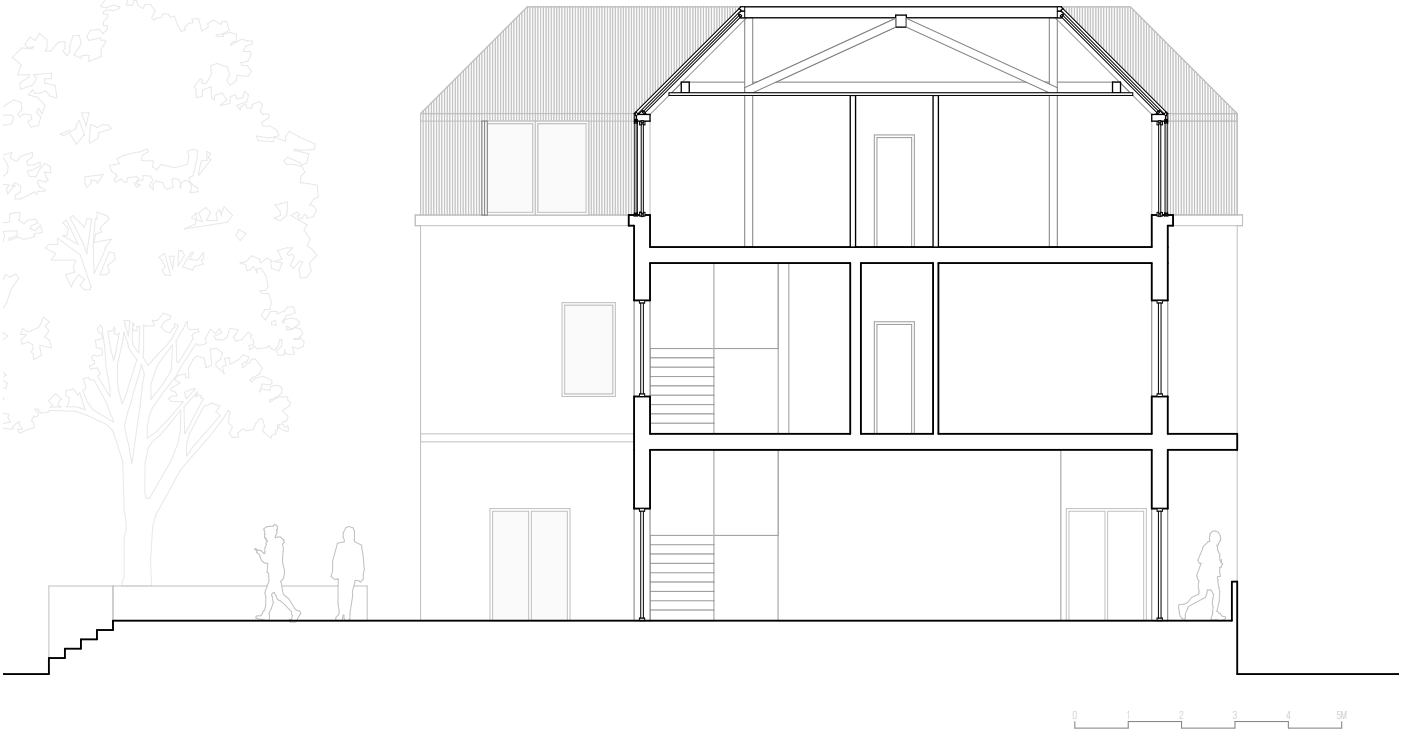
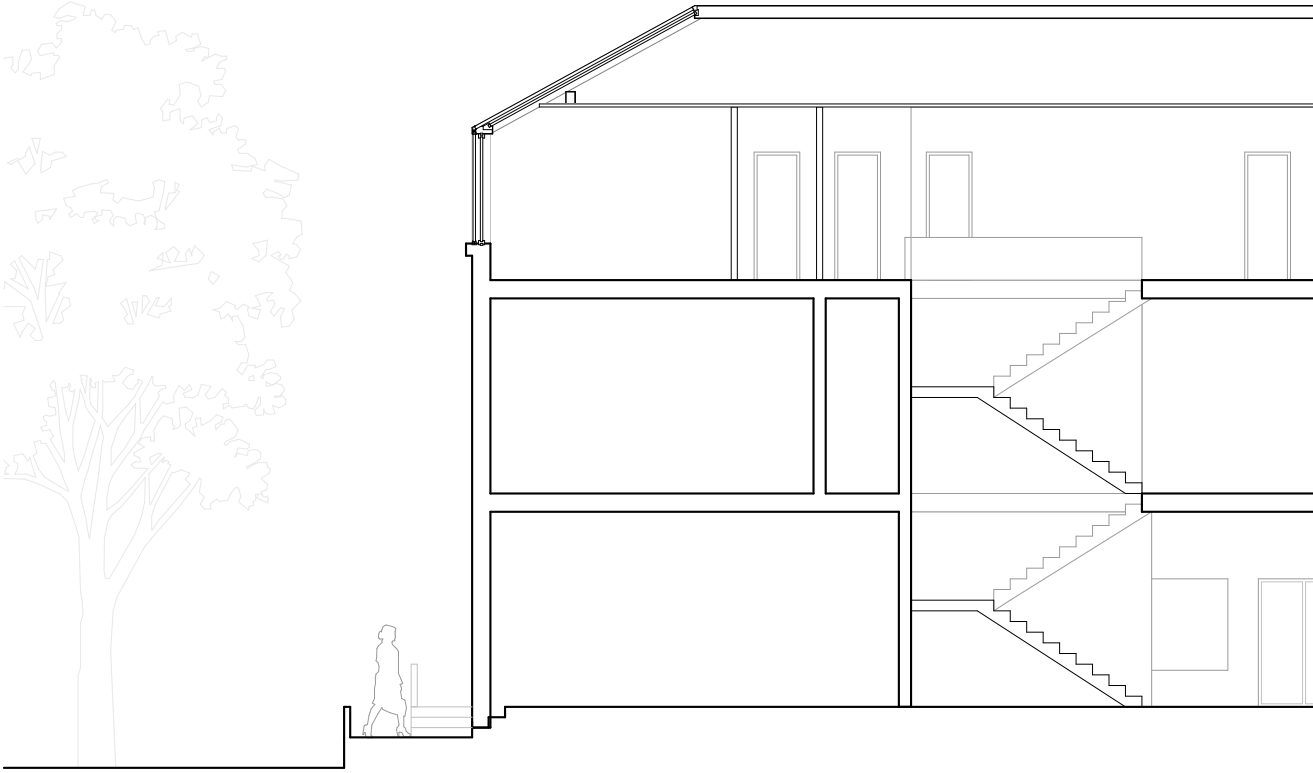


Figure 130: Hotel, Section, renovated state.

Figure 131: Hotel, West facade, flood event.




0
1
2
3
4
5M

Figure 132: Hotel, Section, renovated state.

Figure 133: Hotel, North facade, flood event.

5.6. Overall look – axonometric

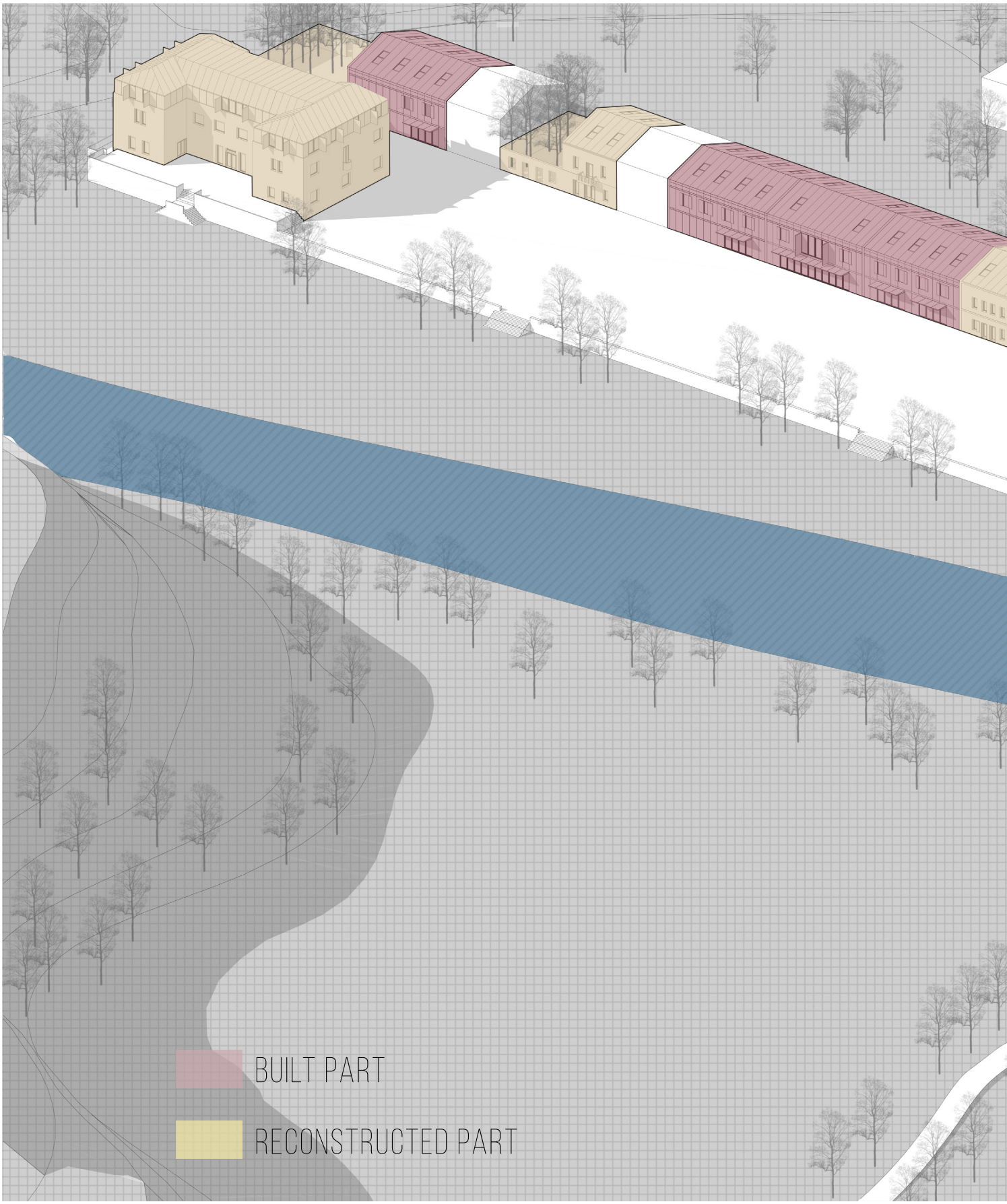


Figure 134: Axonometric view of phase 1 and phase 2, built and renovated parts.

6. Public space
- designing according to dynamics of public space

Figure 135: Market at the promenade in 1950ies.

Figure 136: Market in the beginning of 20th century.

Figure 137: Promenade in 1930ies.

Figure 138: Promenade, present.

6.1. Promenade - central point of town

Riverbank or the promenade along the river is the central part of the settlement.
It was the point from where the town had started and evolved. It was the meeting point of surrounding villages where they would gather, make market and make a commerce.
It started as the open market due to its favorable position on the river.

Soon the houses started appearing around the market, and the settlement had developed.
In the beginning riverbank had a function of the river-market. It was the place for the exchange of two kind of goods, fish from the lake and agricultural products from the inland.

With development of housing around Rijeka evolved into the real town. The function diversified from strict market to a more multi-functional public space that served as the main square of the town. Permanent stores were opened in the housing, restaurants, coffee shops, hotels, post offices could be found. Boat rides, ferries started going from the promenade, it got the function of medium scale transport hub.

With depopulation of the settlement, the promenade had lost its previous functions and now it only serves as the walking ground with some amount of restaurants and it is the occasional starting point for the tourist cruises around the lake.

Main goal of the third phase is to create space that can attract and gather people with its vibrancy and plethora of activities that can be made in it.

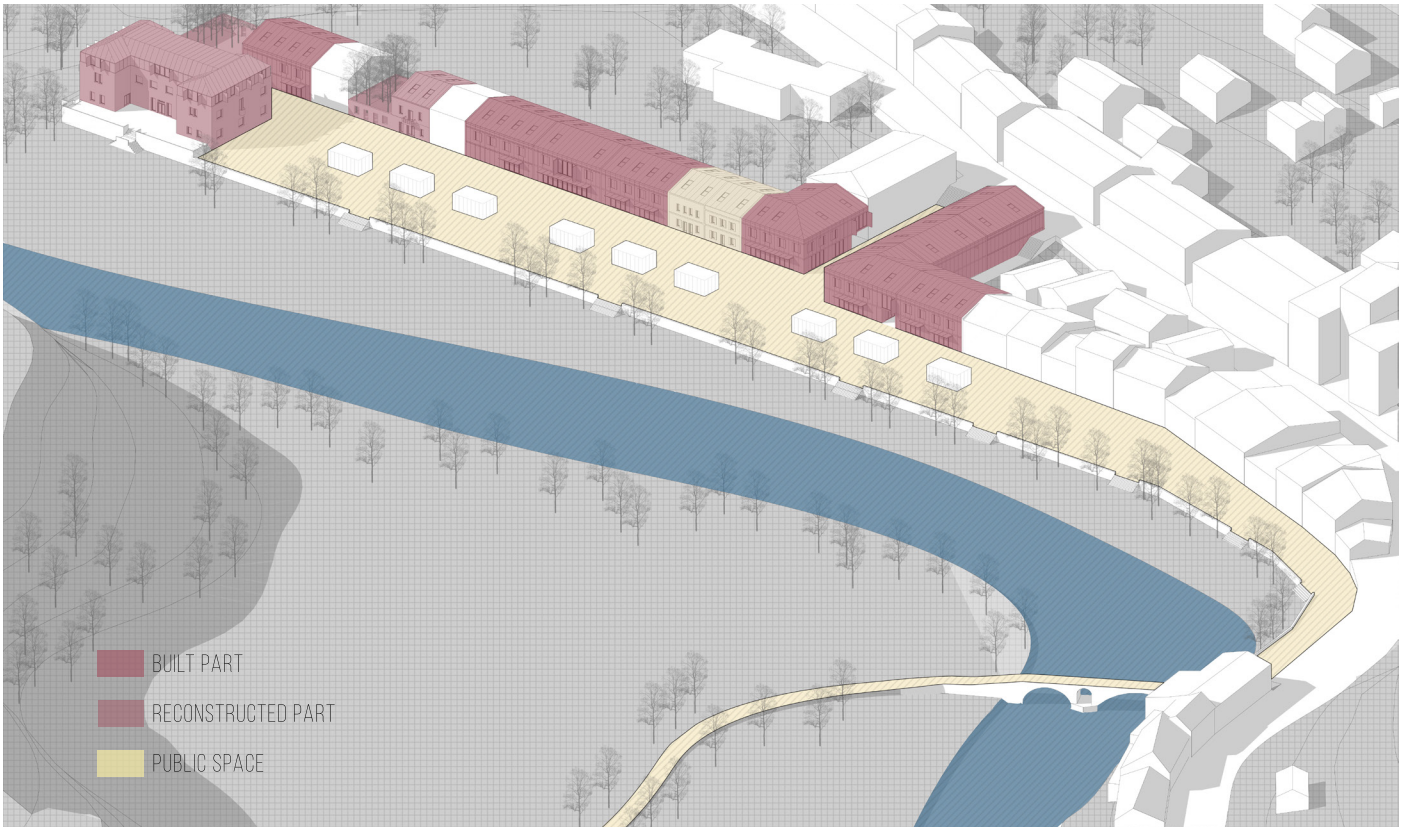


Figure 139: Public space, third phase.

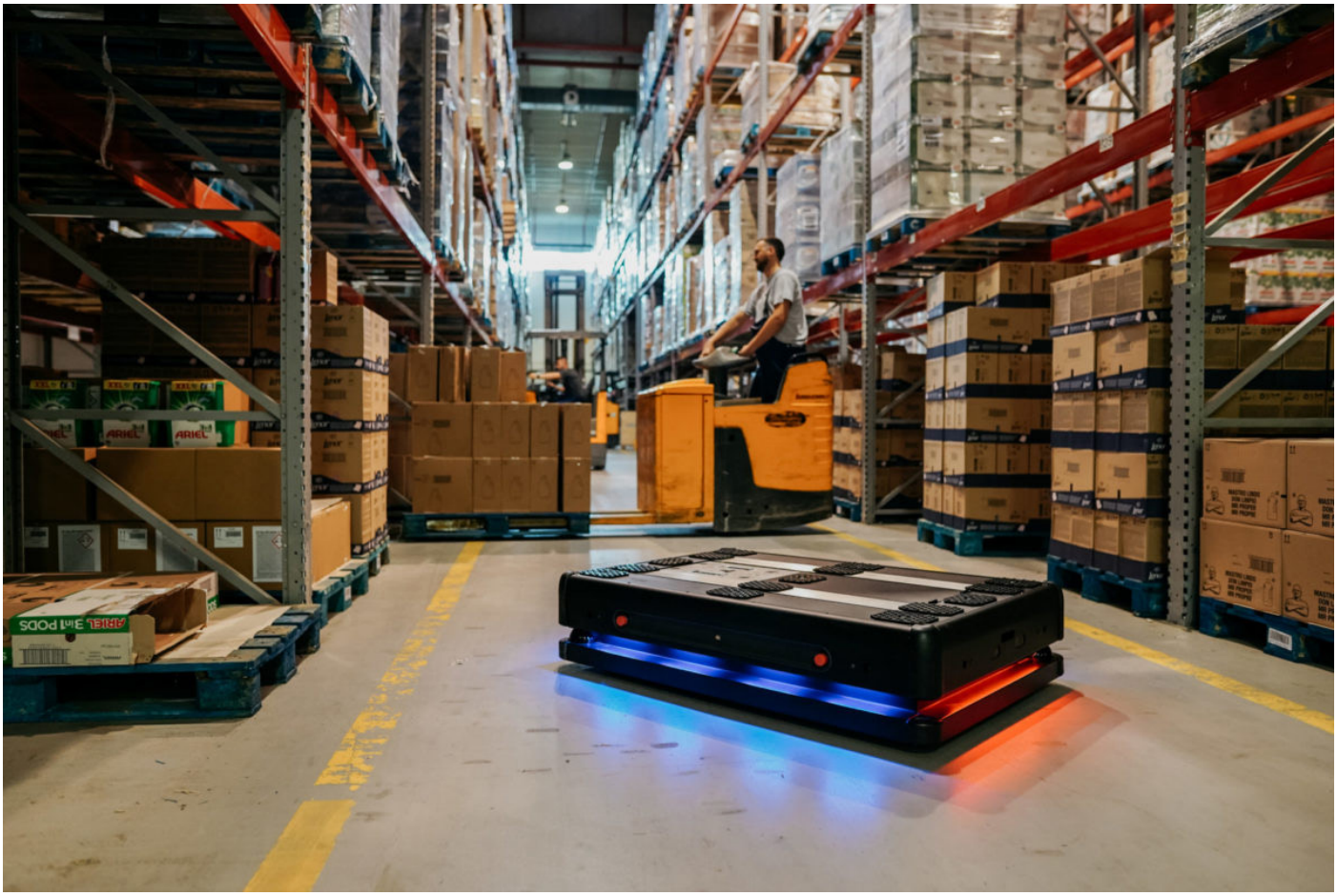


Figure 140: Robots for transporting heavy loads in the warehouses.

6.2. Different space needs

Changing of needs throughout time

Public spaces are the places large variety of happenings, from casual walking grounds to spots of exhibitions or mass gatherings. Success of the depends from its possibility to adapt to different activities that occurs.
Goal of the third phase is to create the vibrant space that can respond to the many different occasions during the year.
As it is already mentioned, number of visitors fluctuates greatly in Rijeka dependent from the time of the year. Expectedly greatest number of visitors is in the peak of the season in summer, and the lowest number is in the winter time. Most of the visitors in summer are the foreigners. Short increase of visitors happens during the autumn and spring festivities and in the weekends. In this case visitors are mainly domestic ones and these kind of visitations are short time, on daily basis.

There are two scales of occasions to which attention would be given. These are: Annual and Daily.

Annual ones are occasions that happens during the year and are happening during the span of several days. These are traditional festivities, markets, concerts, exhibitions, etc.. In these occasions is included also the flood season.

Daily scale are changes that are occurring during the day in public space. The activity varies from time of the day, different areas are used differently. To optimize the efficiency of the promenade as the vibrant space, there must be system that is set to respond to those changes.

Mobility systems

To respond to changing needs of the public space, the system of flexible and mobile modules will be introduced to ensure the easier and higher degree of mobility. The autonomous robotic system similar to those in the warehouses would be used to move the modules.

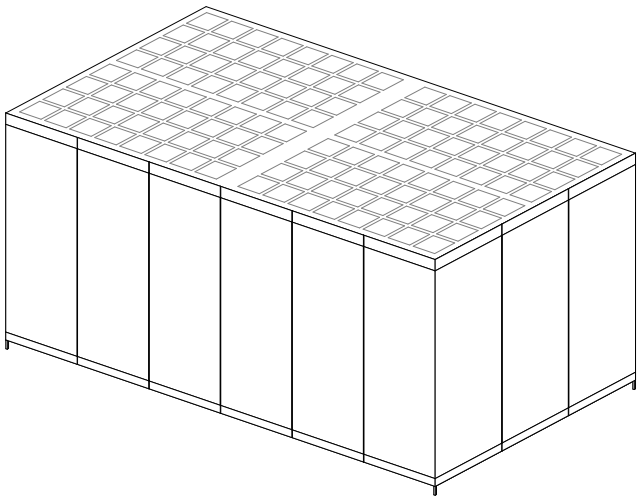


Figure 141: Module, closed.

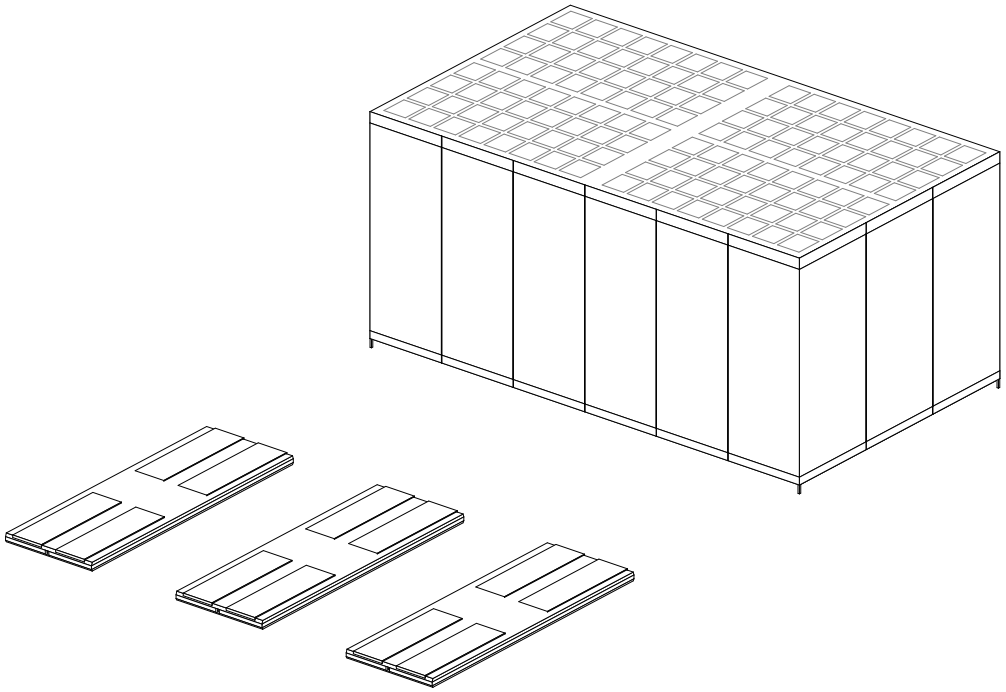


Figure 142: Robotic mobility system.

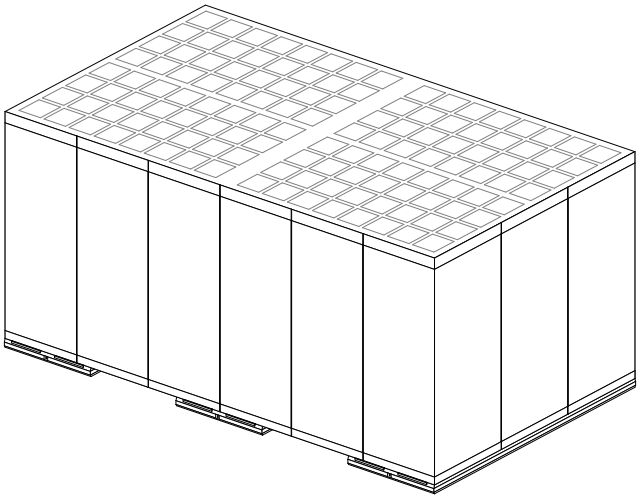


Figure 143: Module embarked on robotic mobility system, autonomous moving.

6.3. Module – movable/flexible, self sufficient

Main question by which means can flexibility be brought in the public space.
Idea is to put flexible modules that are in the same time movable. These modules would serve as the elements that can be used for many purposes like: news stand, shops, stores, market stand, information point for tourists, stand for selling tickets etc..

Multi functionality would give the ability to easily adapt to the new situations and needs.
Mobility would allow to use the space proportionately and more efficiently according to the real time needs.

As shown in Figure 142, the Module in closed state. Module is the flexible, multi-functional, rectangular element that has movable panels instead of the walls, similar to the facade used in Chapter 4. Walls are able to fully open on the sides by folding the panels, thus completely opening the interior to the exterior.
It is self sufficient in terms of the electric power, there are solar photocells installed on its roof trough which the electric energy for the internal consumption is generated.

It has protruding legs on the bottom, that go around 25cm to the floor. There is empty space separating the module and the floor.
The space is left that the robotic mobility system goes under the module and lifts the object and move it to the another position in space.

Movable walls give opportunity to the module to easily switch functions.
We can see in the pages ahead that the module can change functions from being totally empty in Figure 145 to host the function of the store in Figure 146.
It can also contain the function of small gallery in Figure 147 and serve as the market stand in figure 148.

The ability to move trough space which is provided with the robotic carrying system is one of the crucial steps in making 100% flexible public space. Robotic system is autonomous and it moves according two factors.

First factor is daily cycles of the activities in the promenade, where the system moves modules closer to the areas where the highest activity is taking place, and moving away the modules from the areas like restaurants inventory where people are enjoying the sun, etc..
It works according to time programing.
Second factor are annual occasions. During special occasions, festivities the system is arranging modules in the positions in which they can best serve the activities that range from markets to concerts.

Autonomy of the system is making public space more responsive to needs of the users and it can adapt to different situations much more easily.

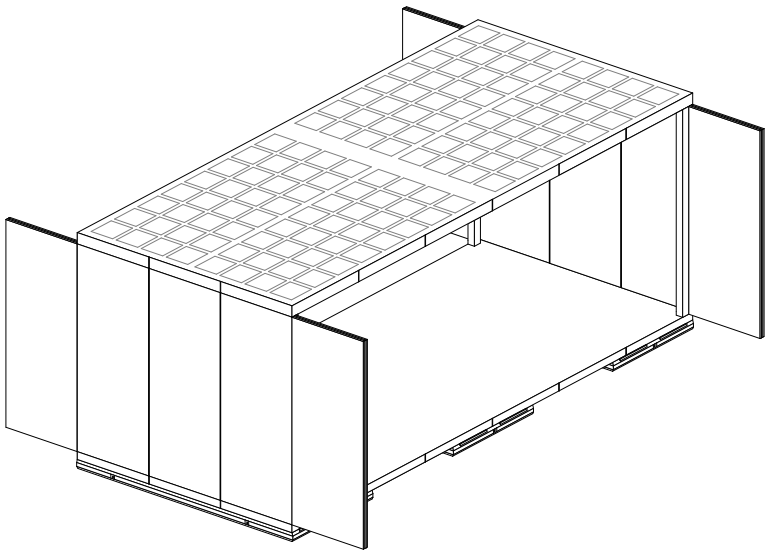


Figure 144: Module open.

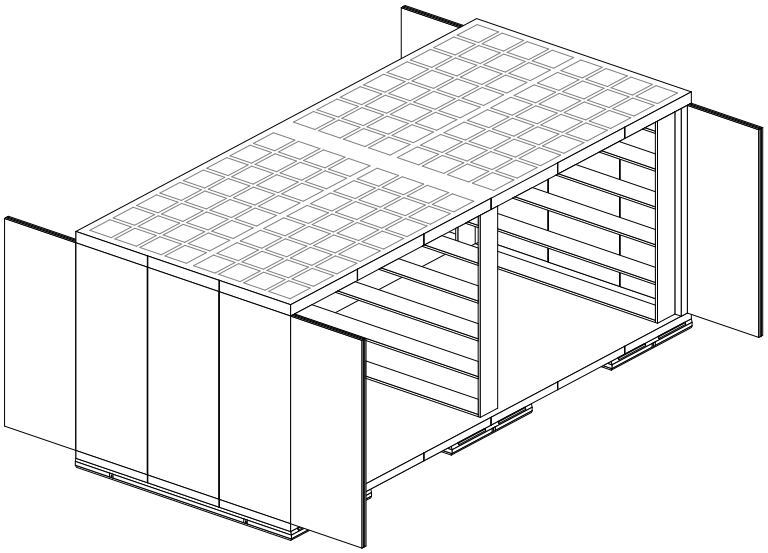


Figure 145: Module as a store.

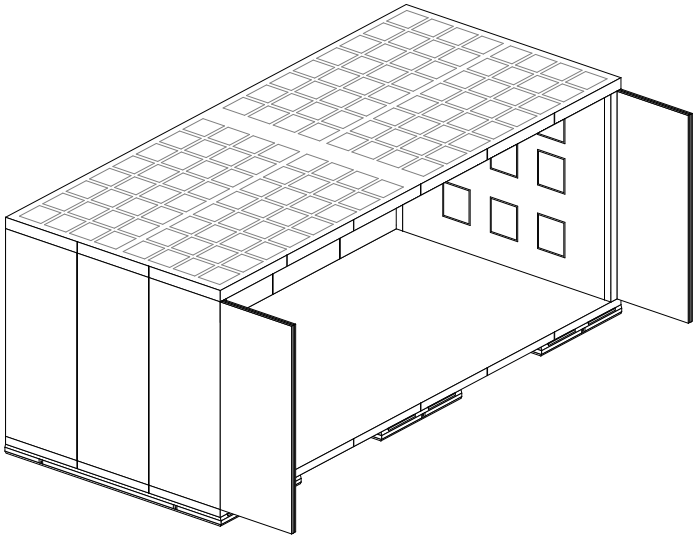


Figure 146: Module as a gallery spot.

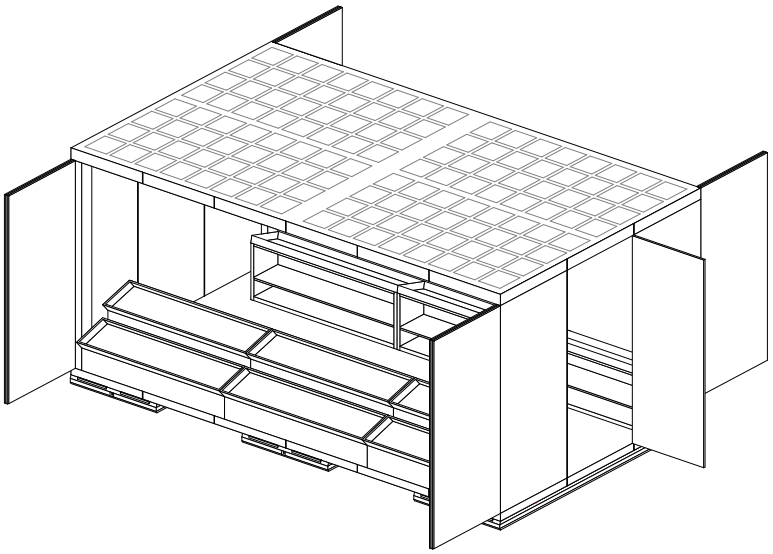


Figure 147: Module as a market stand.

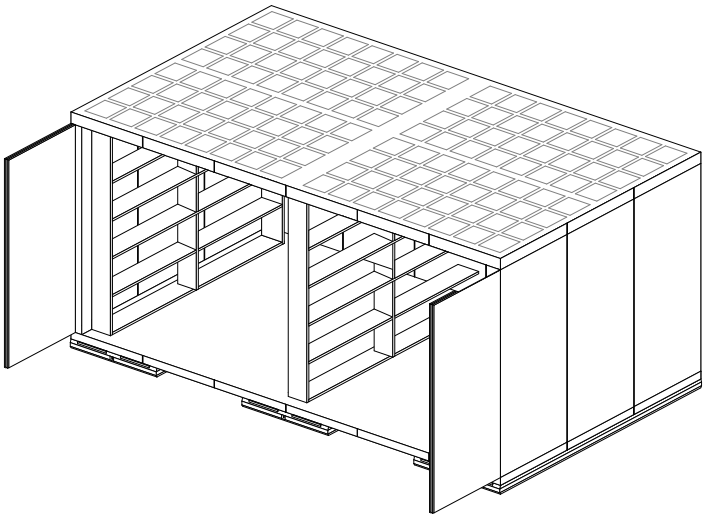


Figure 148: Module as store.

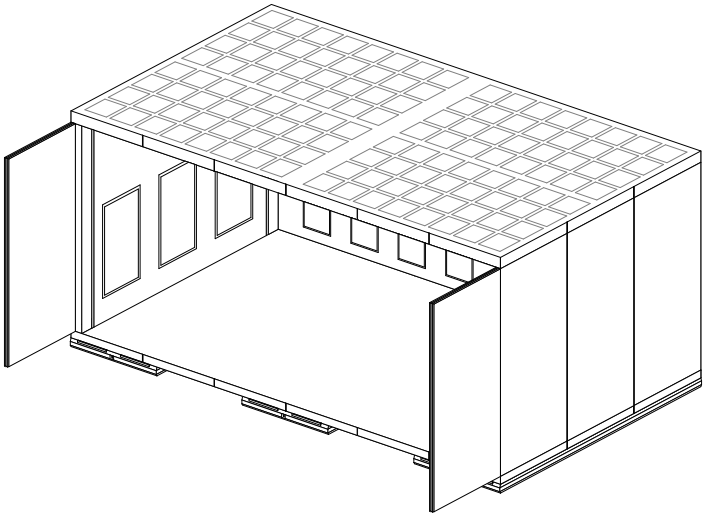


Figure 149: Module as a gallery spot.

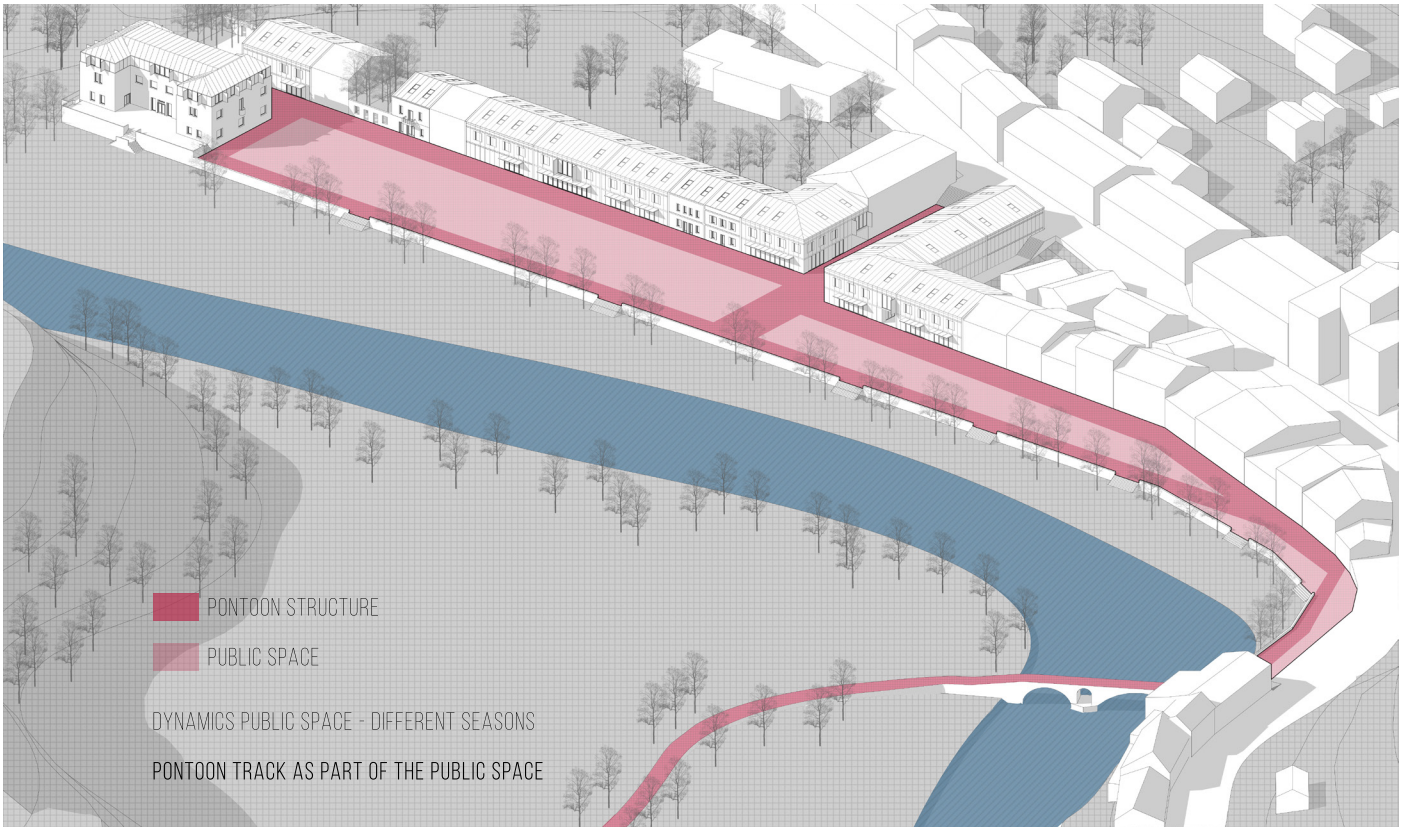


Figure 150: Promenade as a public space with integrated pontoon structure.

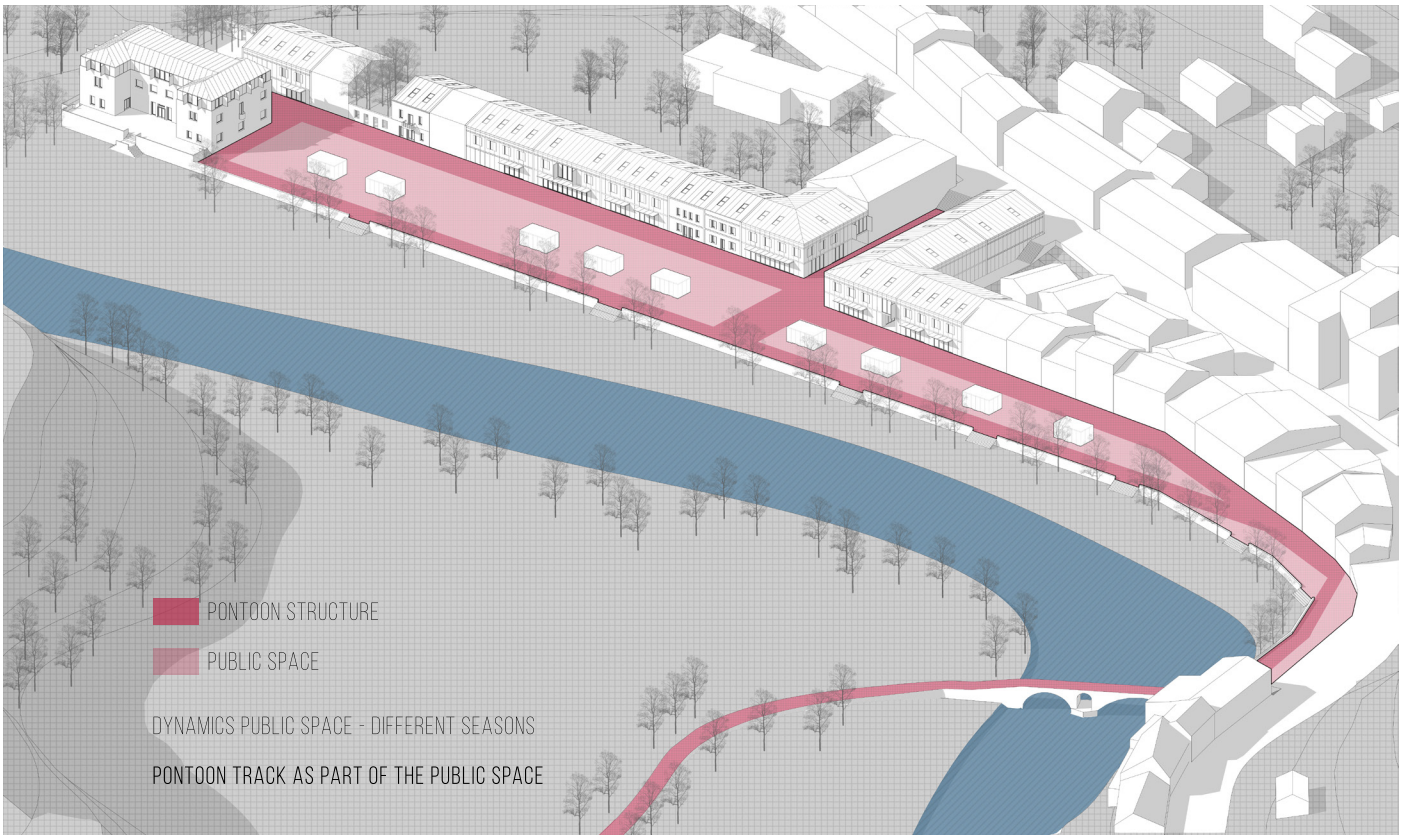


Figure 151: Promenade as a flexible public space with the autonomous modules stationed in it.

6.4. Public space - adapting to annual flooding

As the annual floods are posing continuous problem for the settlement and especially for the normal functioning of the promenade, the problem must be solved.

The goal is not just to solve the problem in the functional way, but also to give the settlement the new value for which the place would be known for and to be the additional reason to visit the place even during the flood season.

The public space would be separated into two parts as seen in Figure 151. Free space or public space and pontoon track that would be inseparable part of the public space/promenade.

In the free space the modules would be put, and would be able to move freely trough the space, visible in Figure 152.

Pontoon structure is cutting through the sides of the promenade. It has the function of connecting the building with the street inside of the town on the higher level, seen in Figure 153.

In this way all the housing are connected and during the flood season, it would serve as the street. During the flood the pontoon structure that is integrated part of the promenade lifts up together with high tide. Its height level to which it goes depends from the height of the tide, visible in Figure 154.

Pontoon structure is not connecting just the promenade but also goes by the bridge and it connects the other side of the coast, following the already existing elevated path.

As seen in Figures 155, 156, 157, 158, 159 the pontoon structure responds completely naturally to the annual floods and it makes space much more adaptable. The modules are moved on the pontoon structure during the flood, Figure 158.

Pontoon structure is made out of (material), similar to one that is used in Christo's and Jeanne-Claude's Floating Piers installation at Lake Iseo 2016.[1]
In this case the difference is that pontoon structure are installed permanently and serve as the inseparable part of the public space composition.

21 https://deep-dive-systems.com/the-floating-piers-lago-diseo/

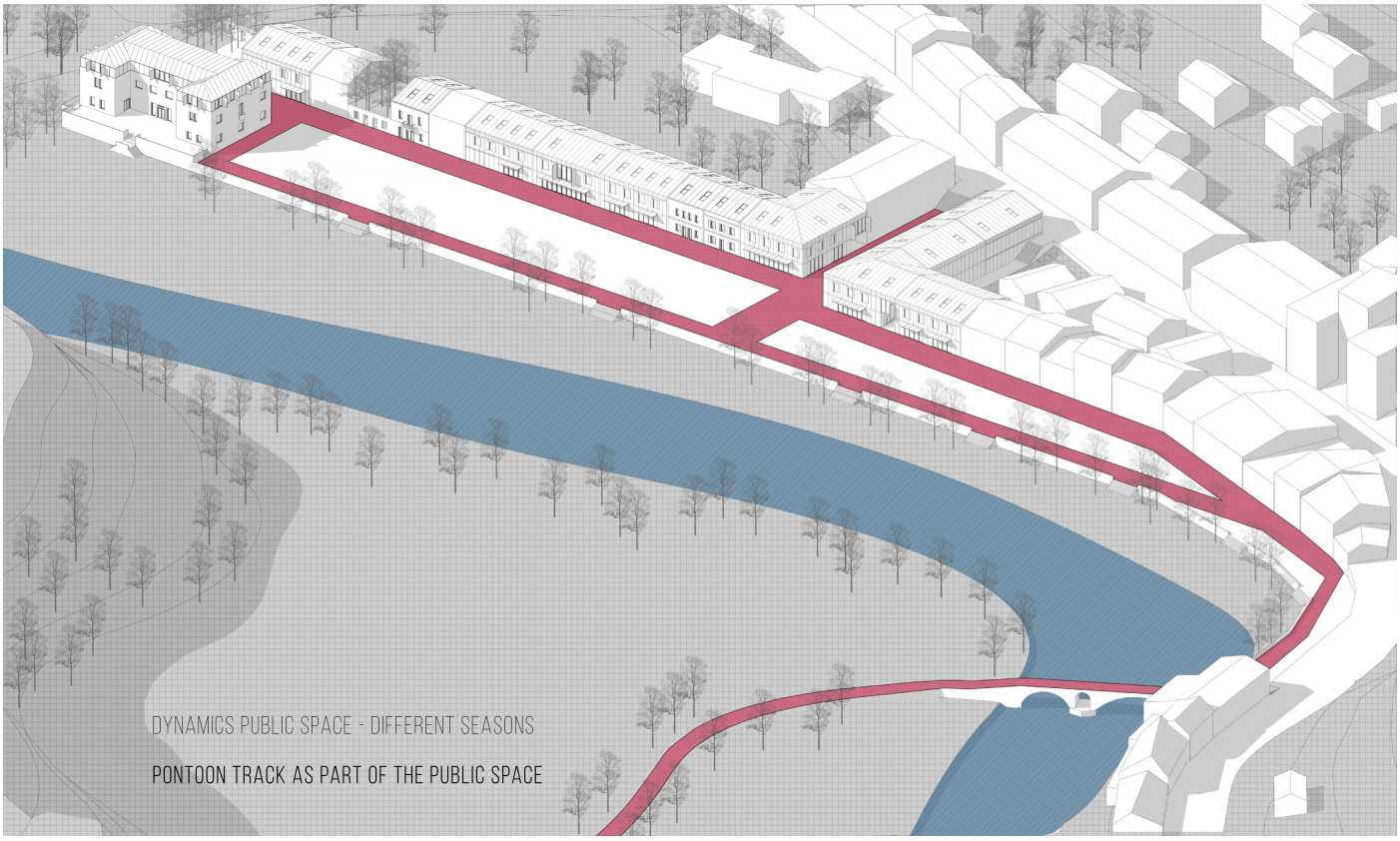


Figure 152: Pontoon structure as the indispensable part of public space that creates the walking track.

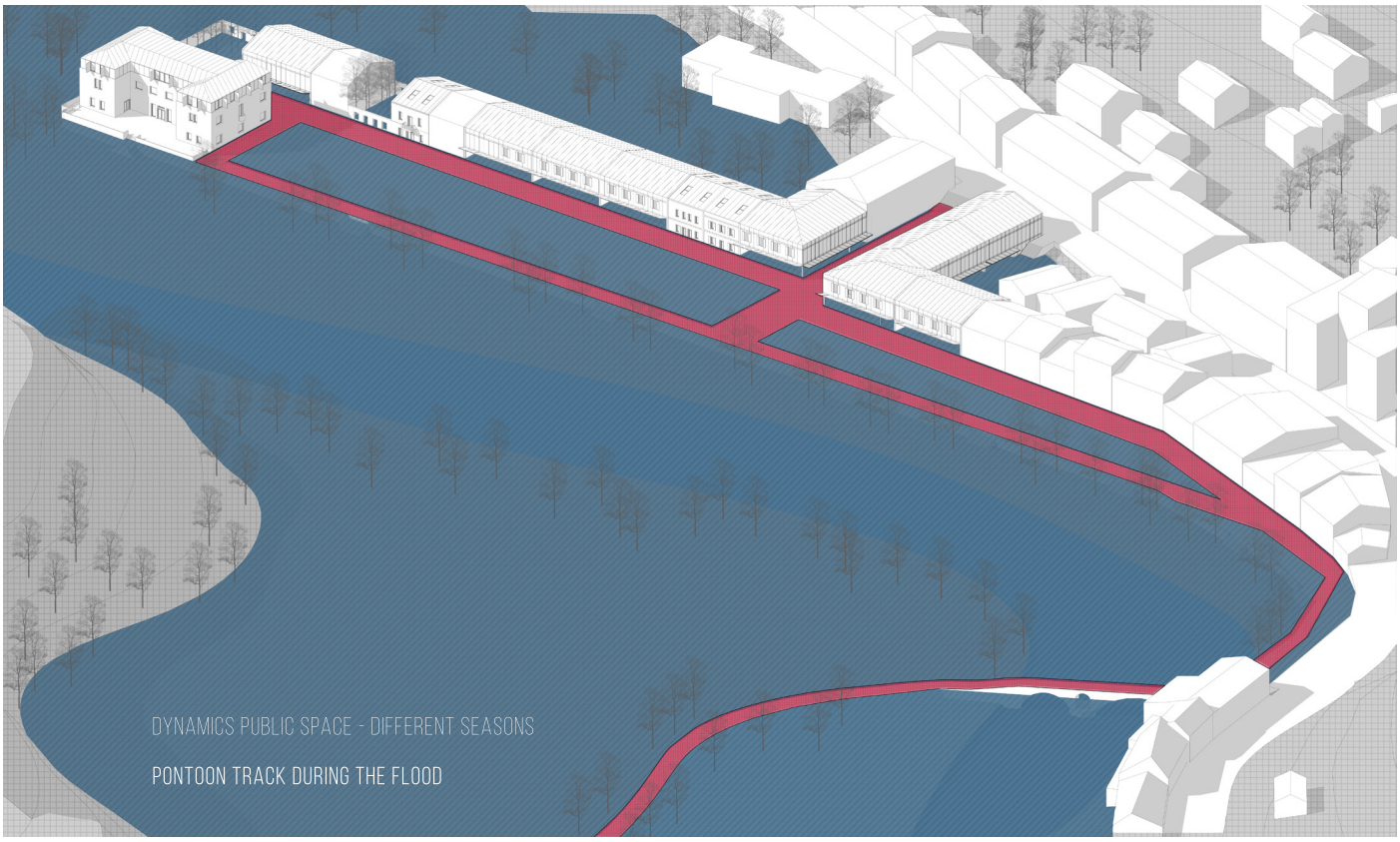


Figure 153: Pontoon structure in action.

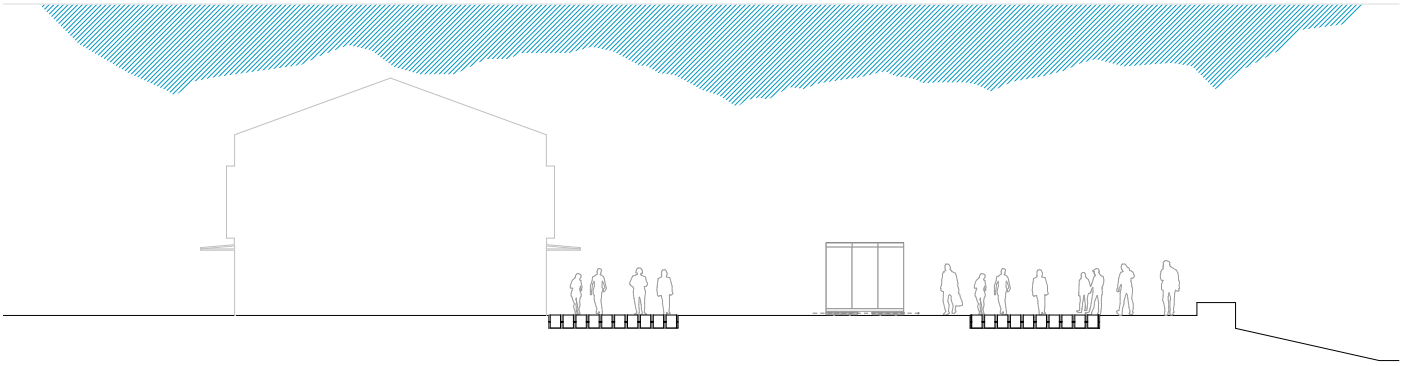


Figure 154: Promenade with integrated pontoon track and movable modules.

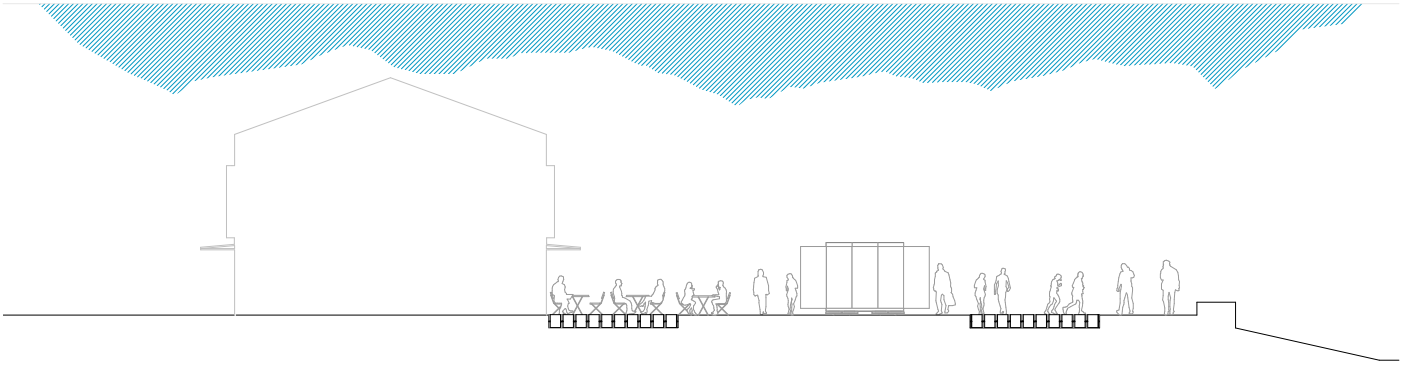


Figure 155: Promenade with modules in action.

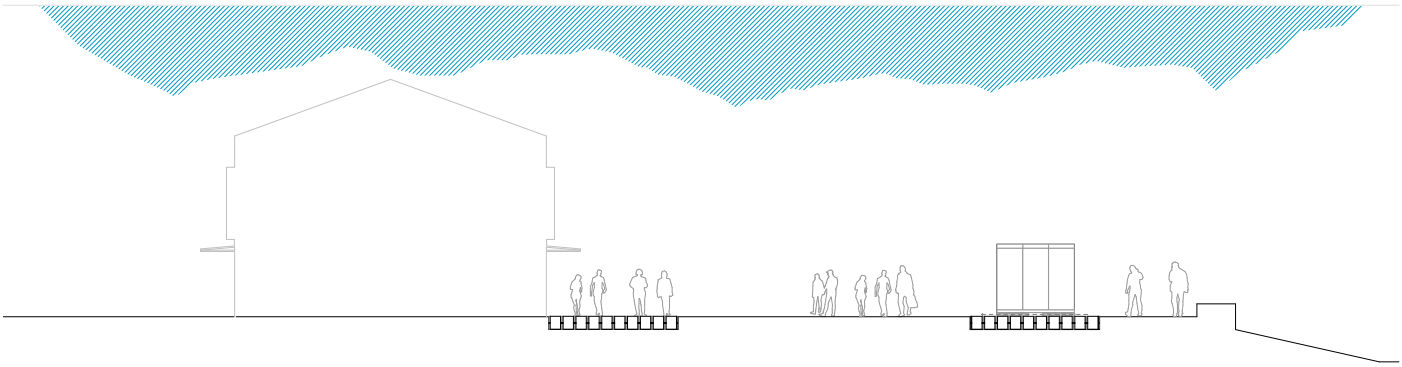


Figure 156: Promenade, module is stationed at the pontoon structure.

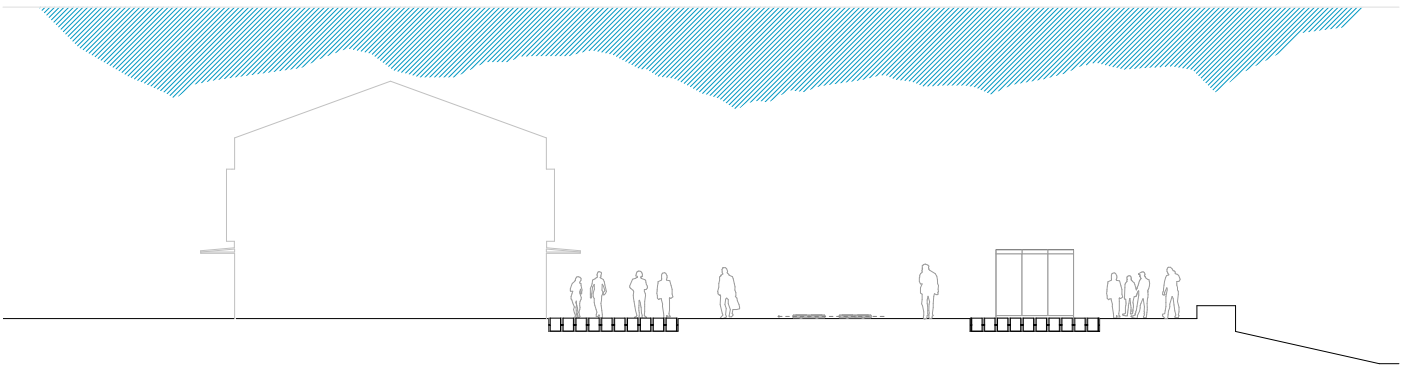


Figure 157: Kiwa mobility system is put in the storage space.

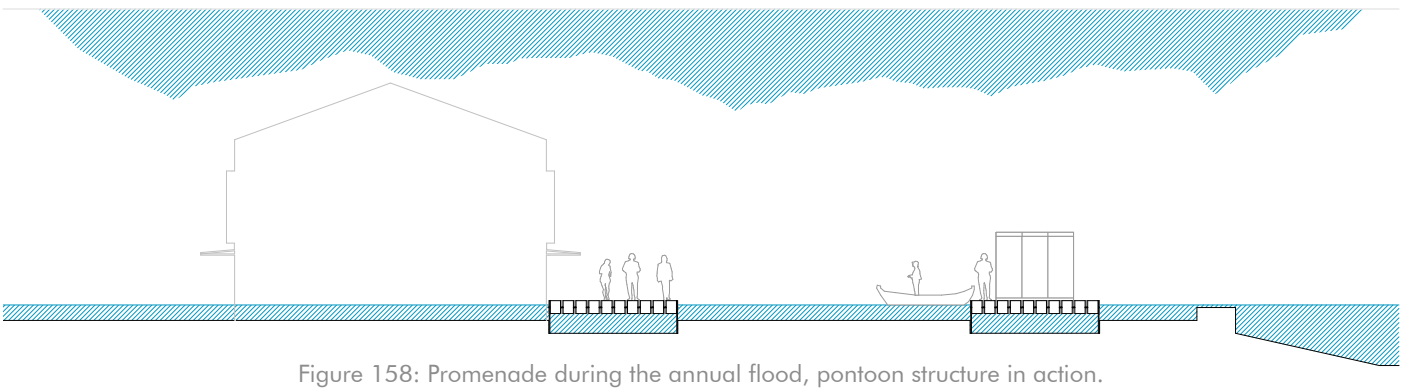
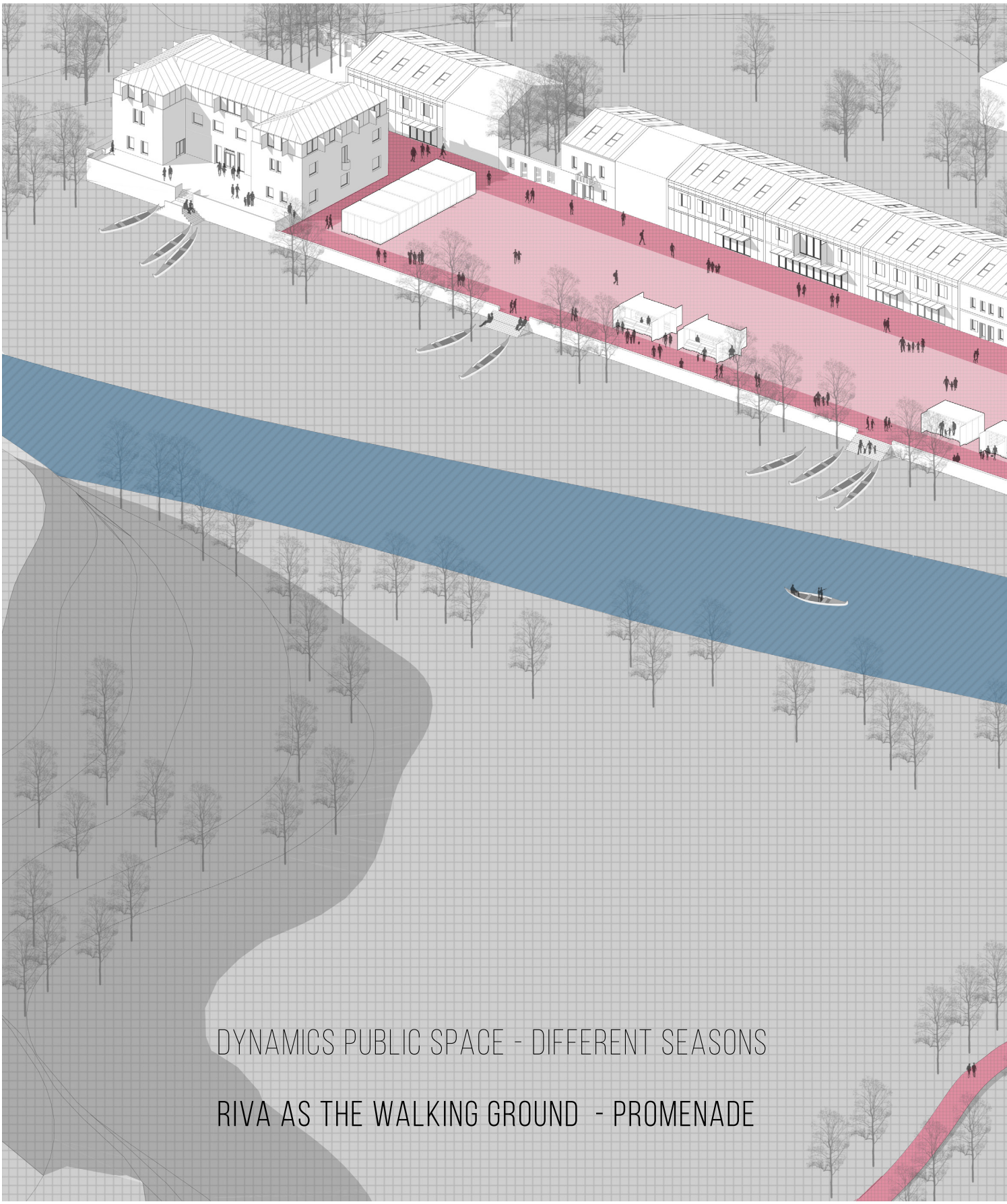


Figure 158: Promenade during the annual flood, pontoon structure in action.

6.5. Different scenarios - Annual

Different activities on the annual basis, shown trough the axnomoetrics.



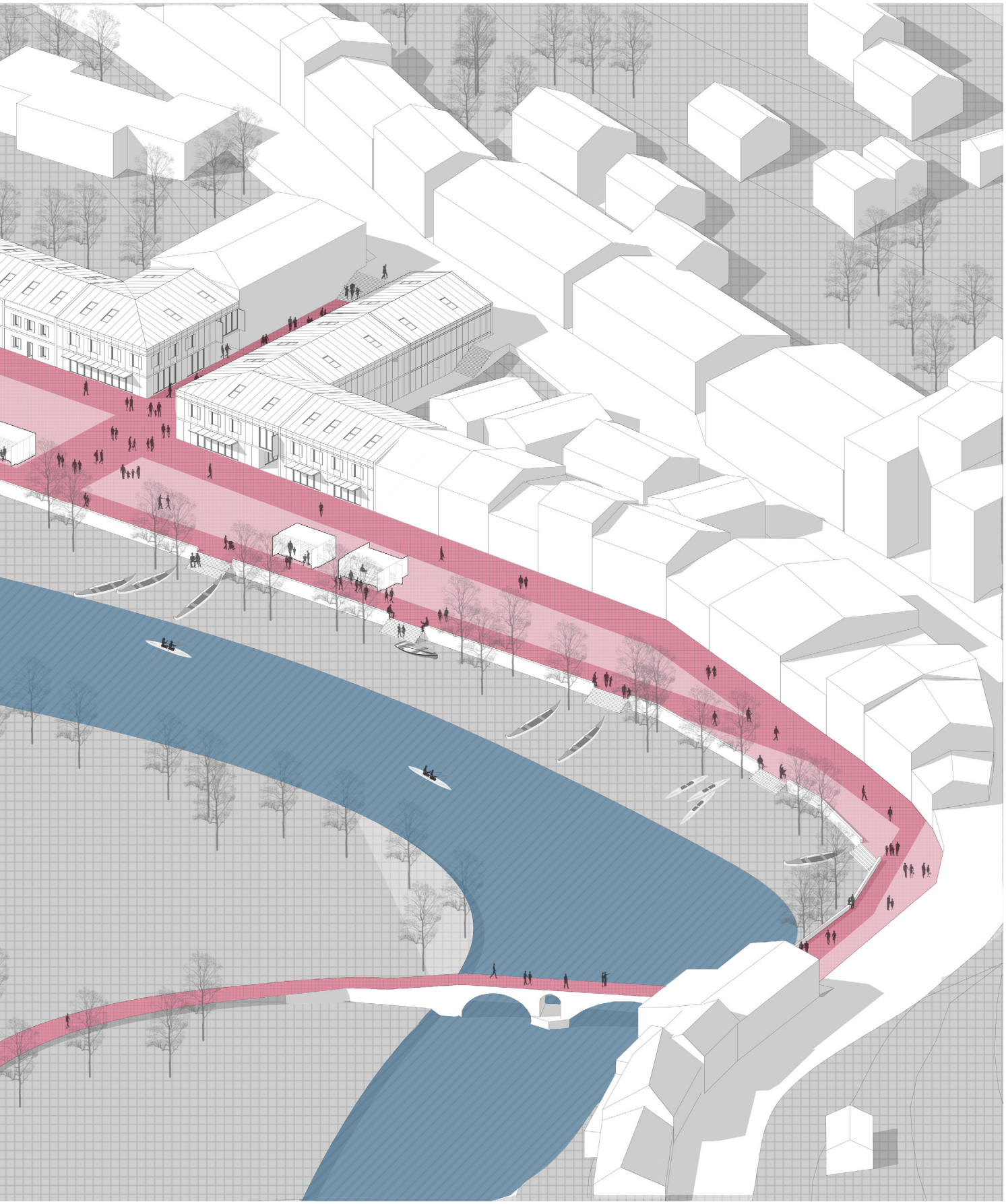
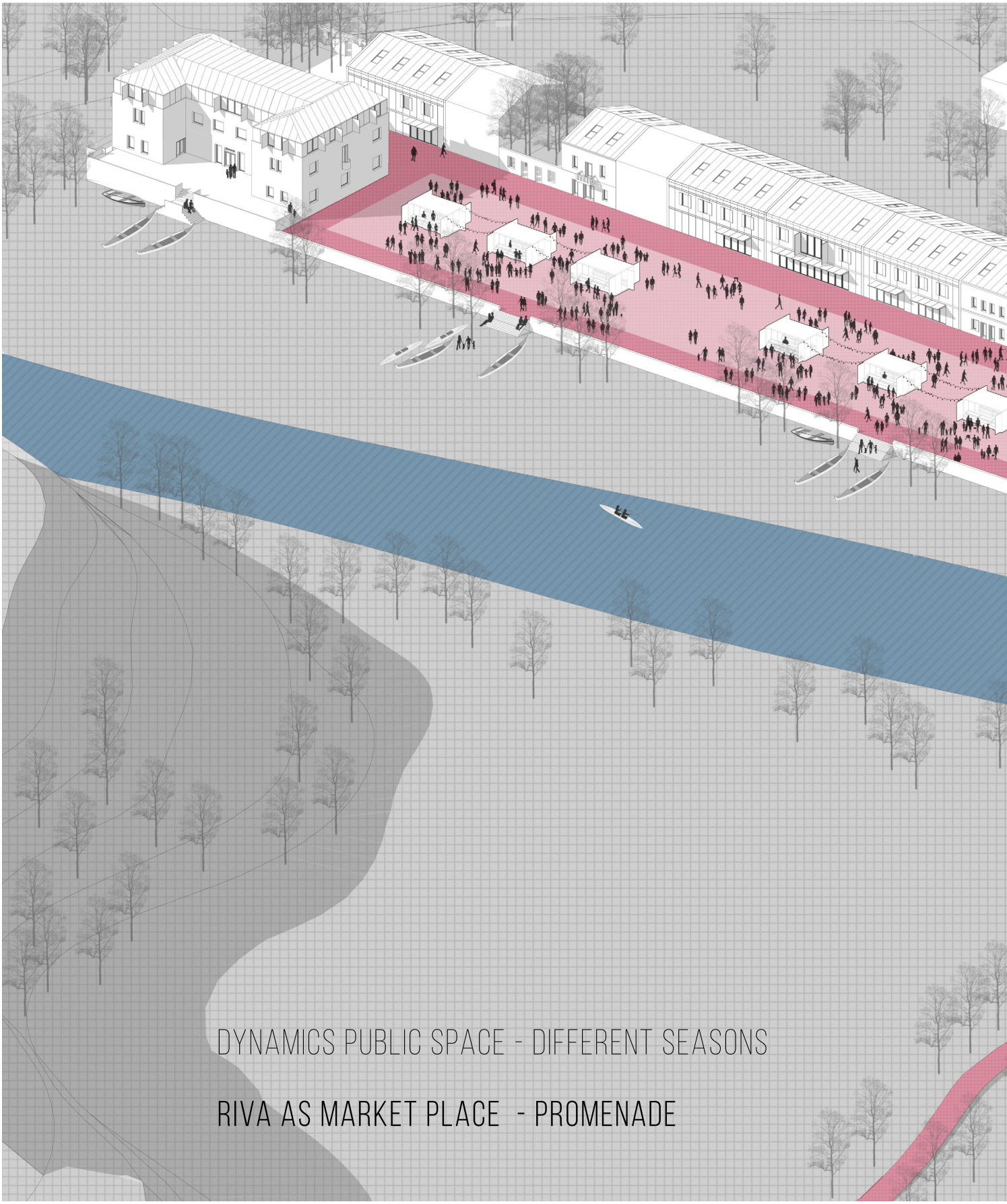


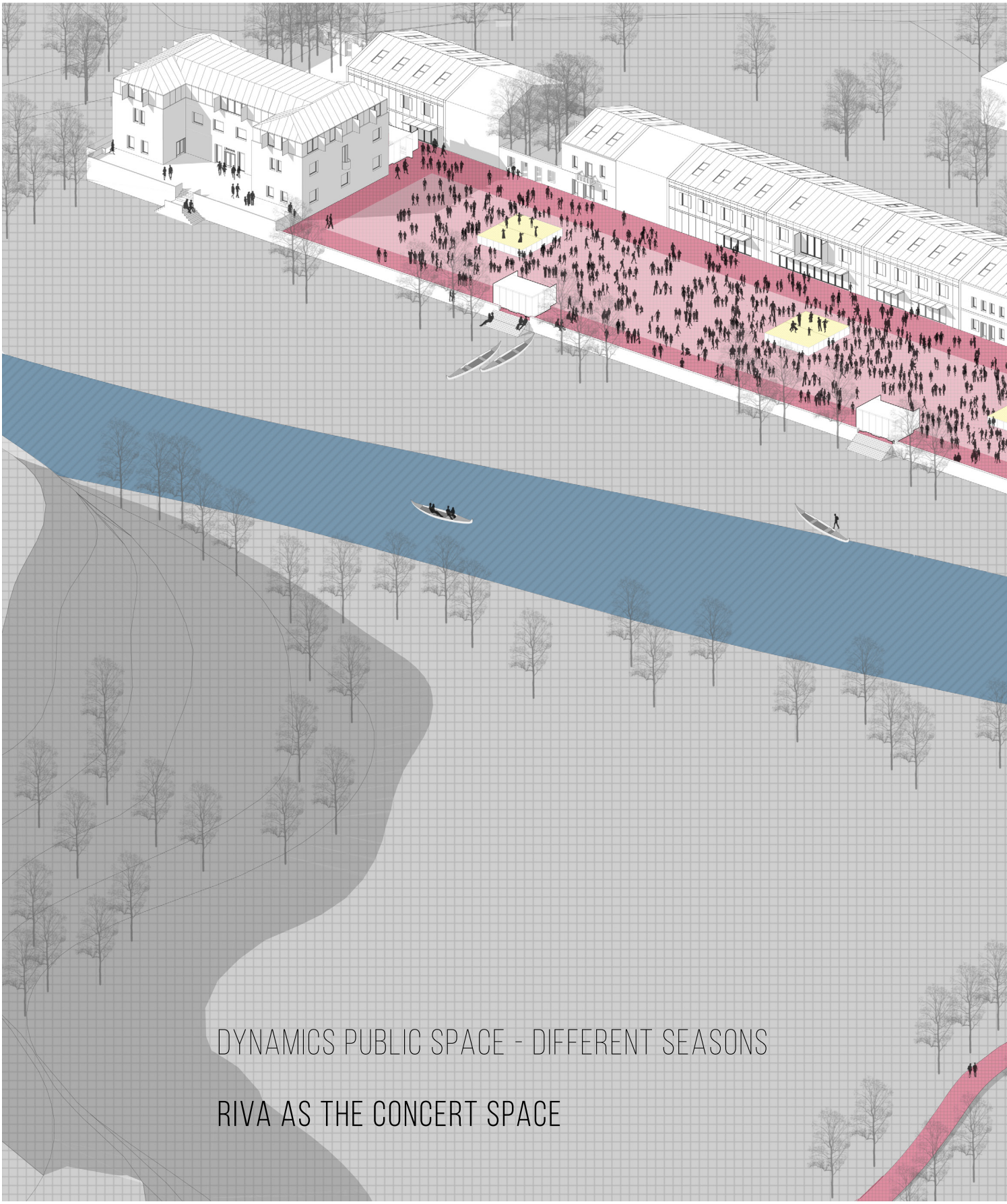
Figure 159: Riva as the walking ground.



DYNAMICS PUBLIC SPACE - DIFFERENT SEASONS

RIVA AS MARKET PLACE - PROMENADE

Figure 160: Riva as the market place.



DYNAMICS PUBLIC SPACE - DIFFERENT SEASONS

RIVA AS THE CONCERT SPACE

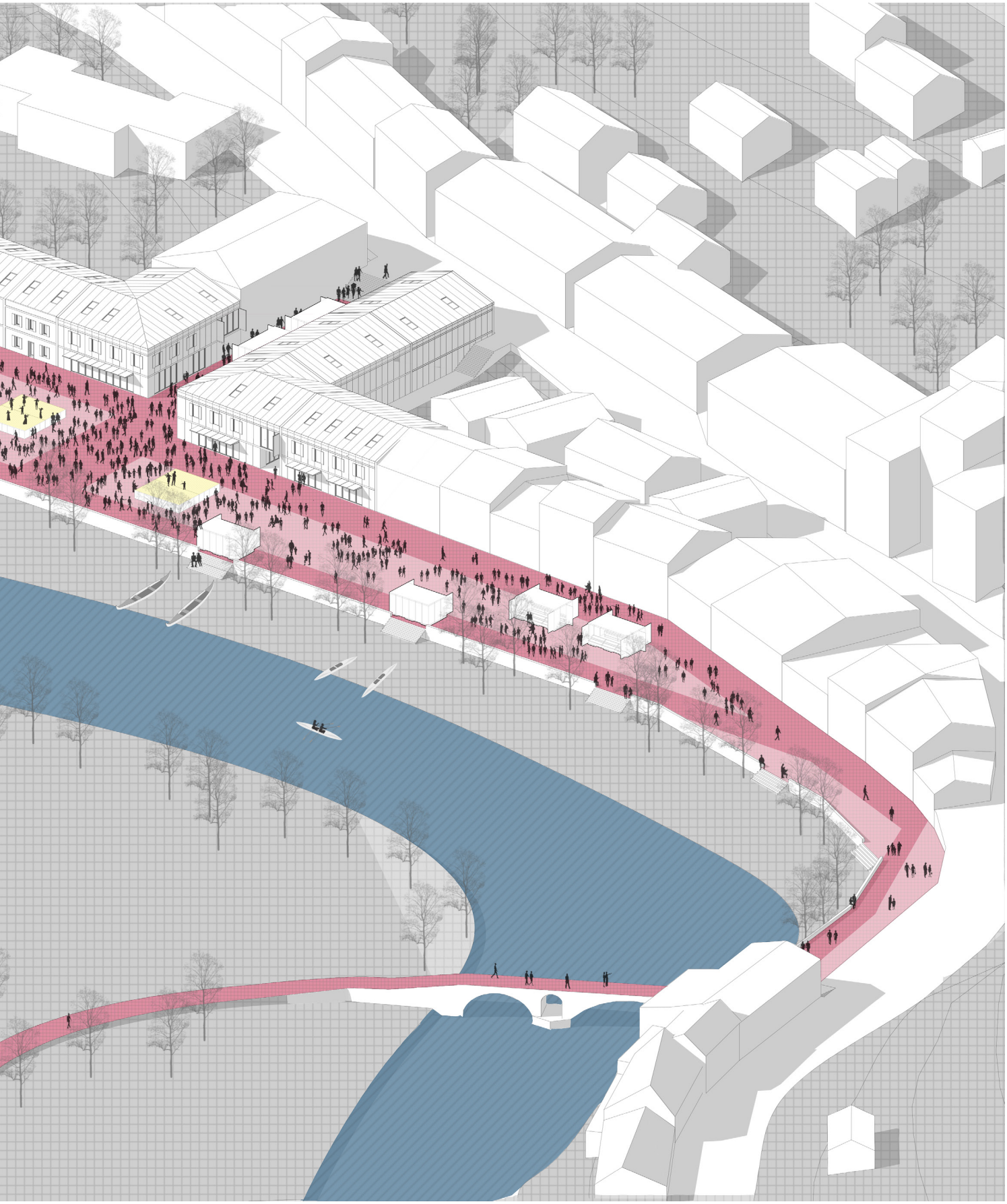
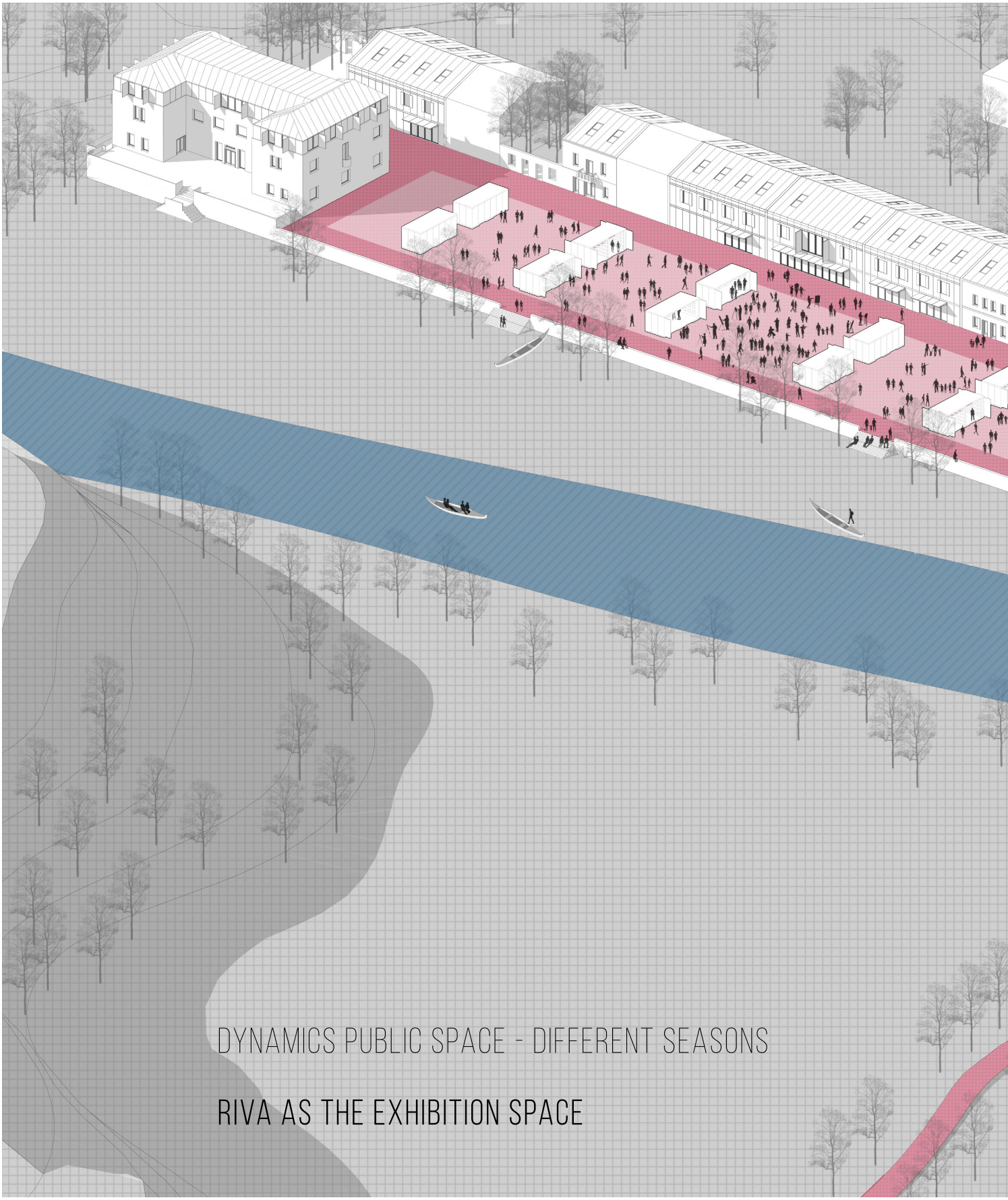


Figure 161: Riva as the concert podium.



DYNAMICS PUBLIC SPACE - DIFFERENT SEASONS

RIVA AS THE EXHIBITION SPACE

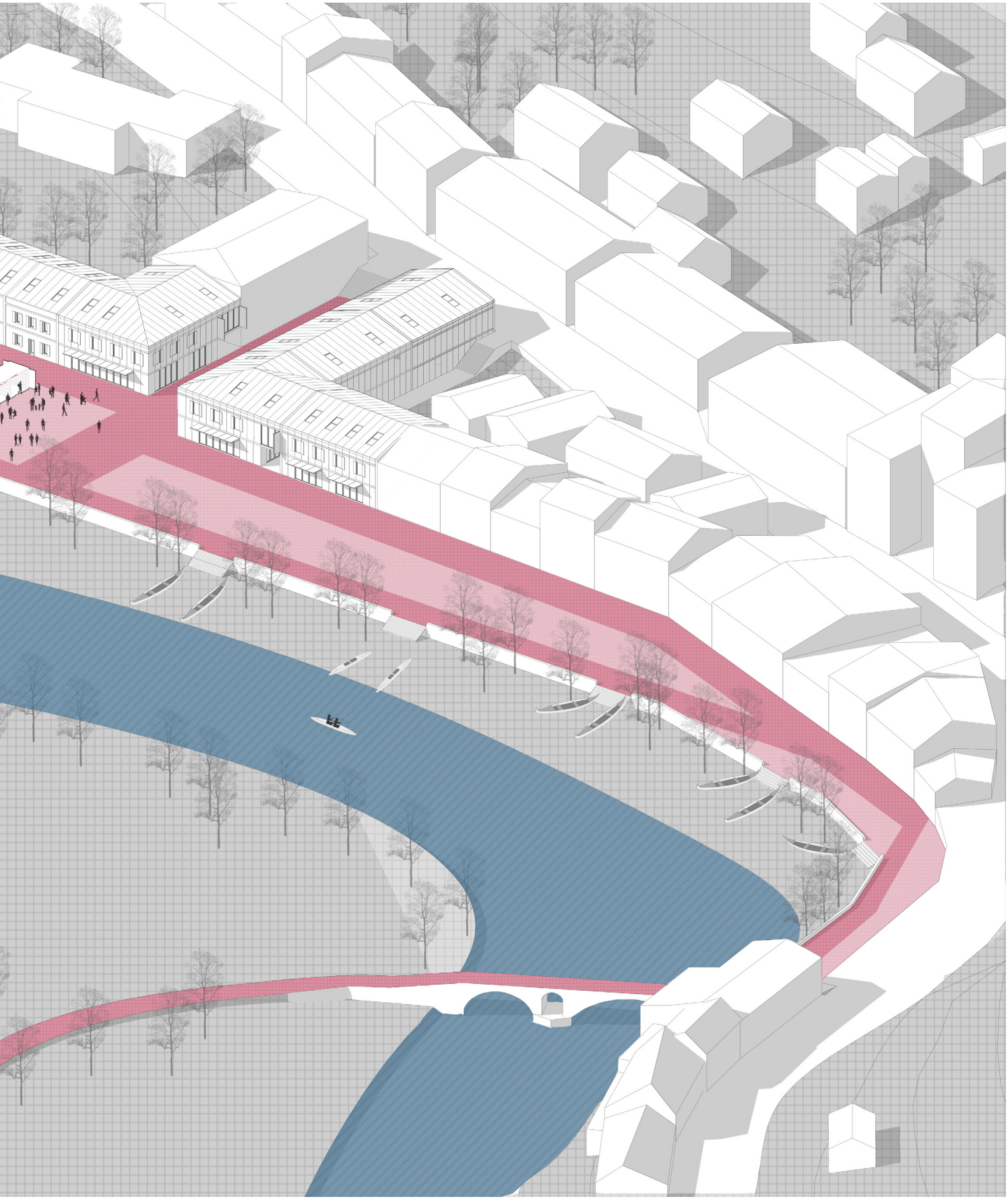
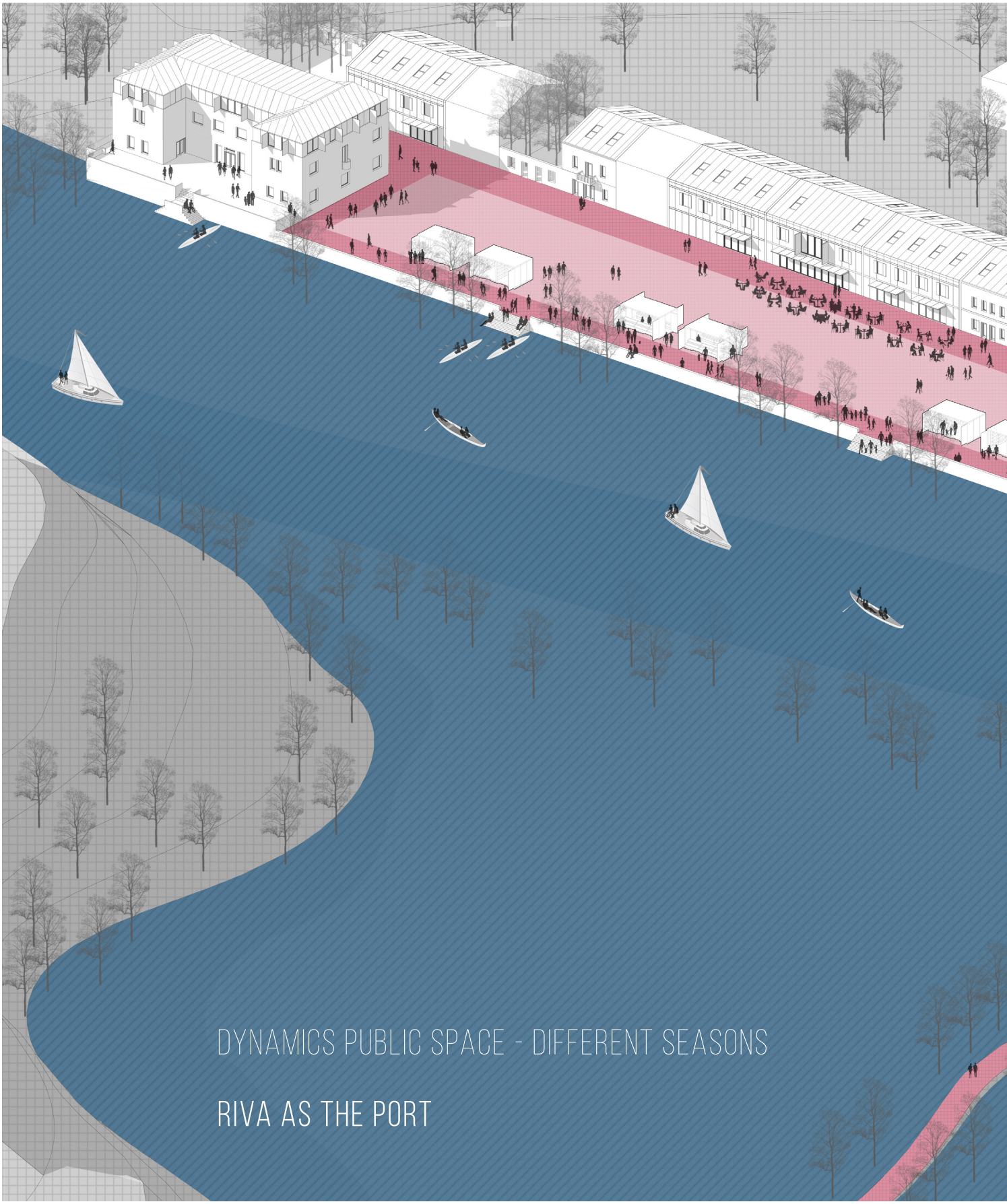


Figure 162: Riva as the exhibition space.


DYNAMICS PUBLIC SPACE - DIFFERENT SEASONS
RIVA AS THE PORT

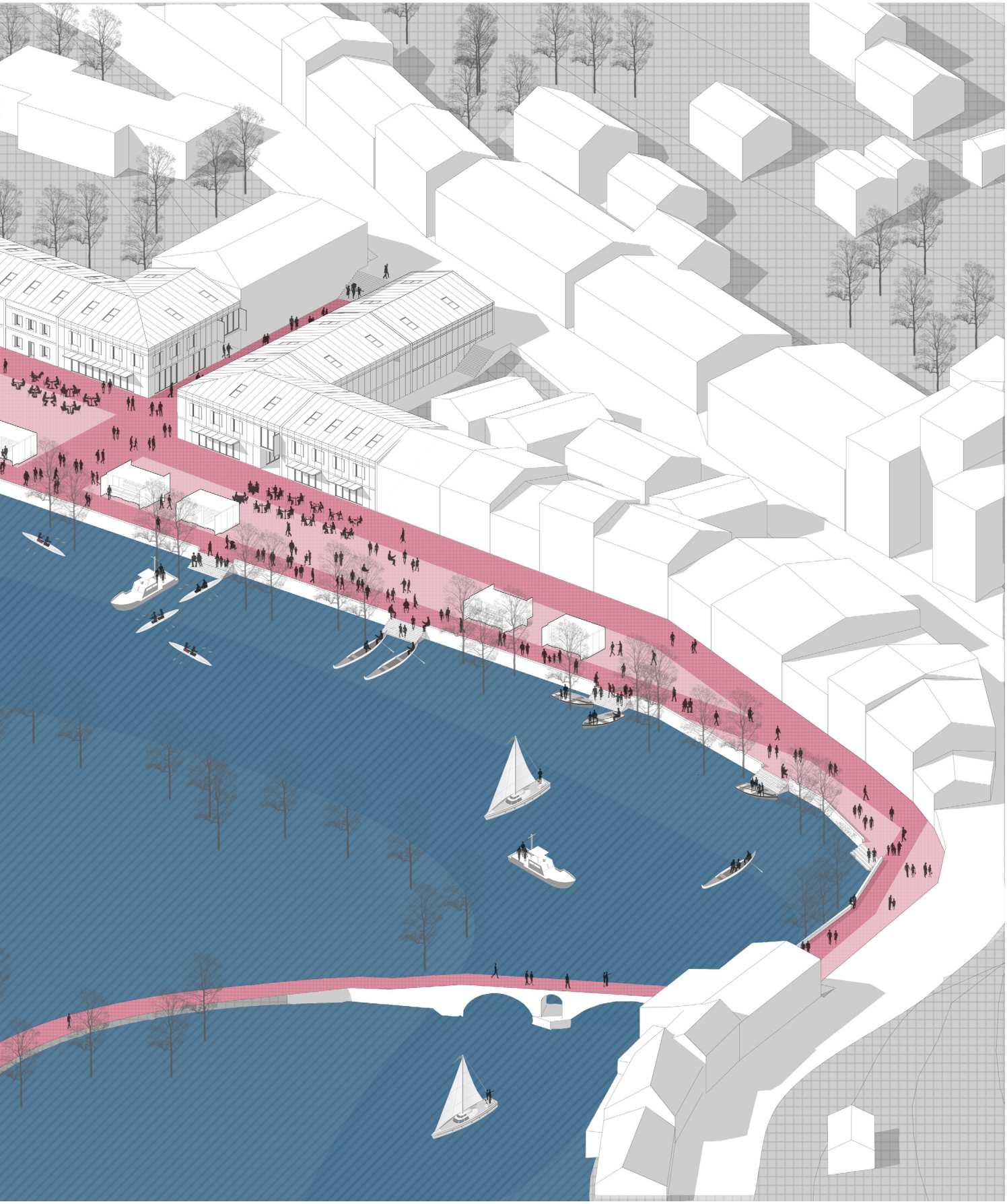


Figure 163: Riva as the port for lake traffic.

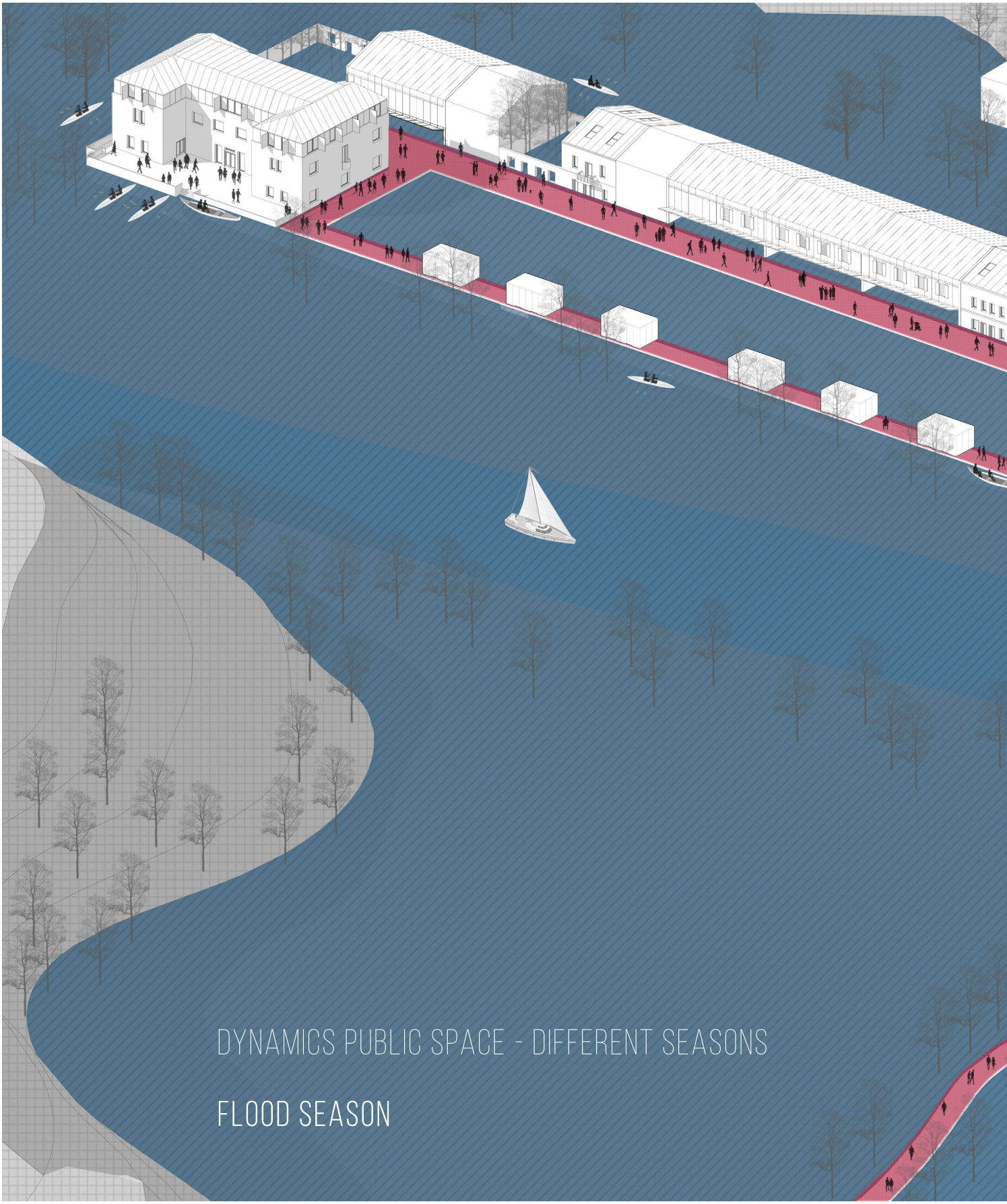

DYNAMICS PUBLIC SPACE - DIFFERENT SEASONS
FLOOD SEASON

Figure 164: Riva during the annual flood.

6.6. Different scenarios - Daily

Changing of the positions of modules on the daily basis. It is integrated part of the dynamics of the public space. It changes position according to different activities happening in different time of the day.

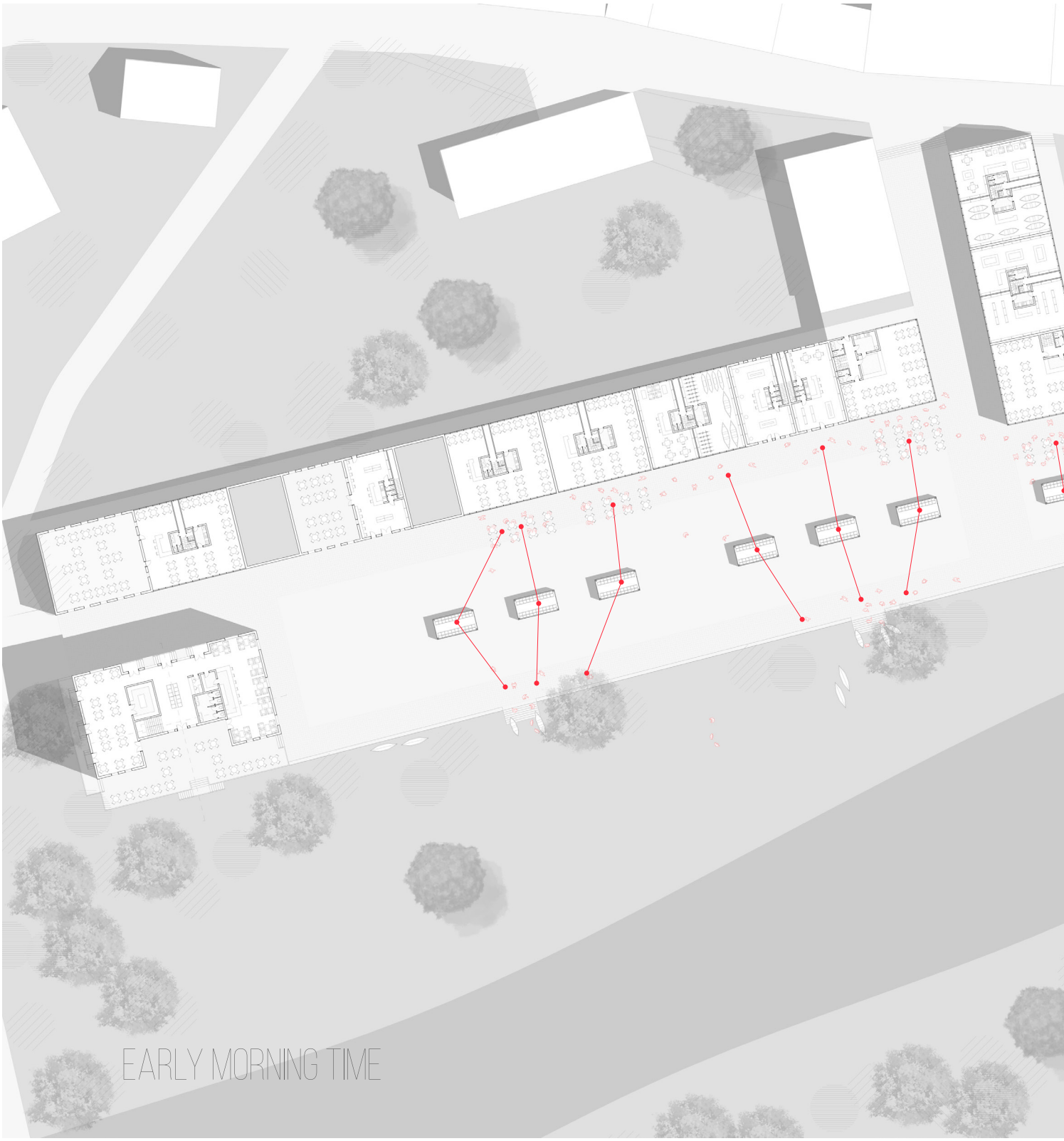


Figure 165: Morning position of the modules.

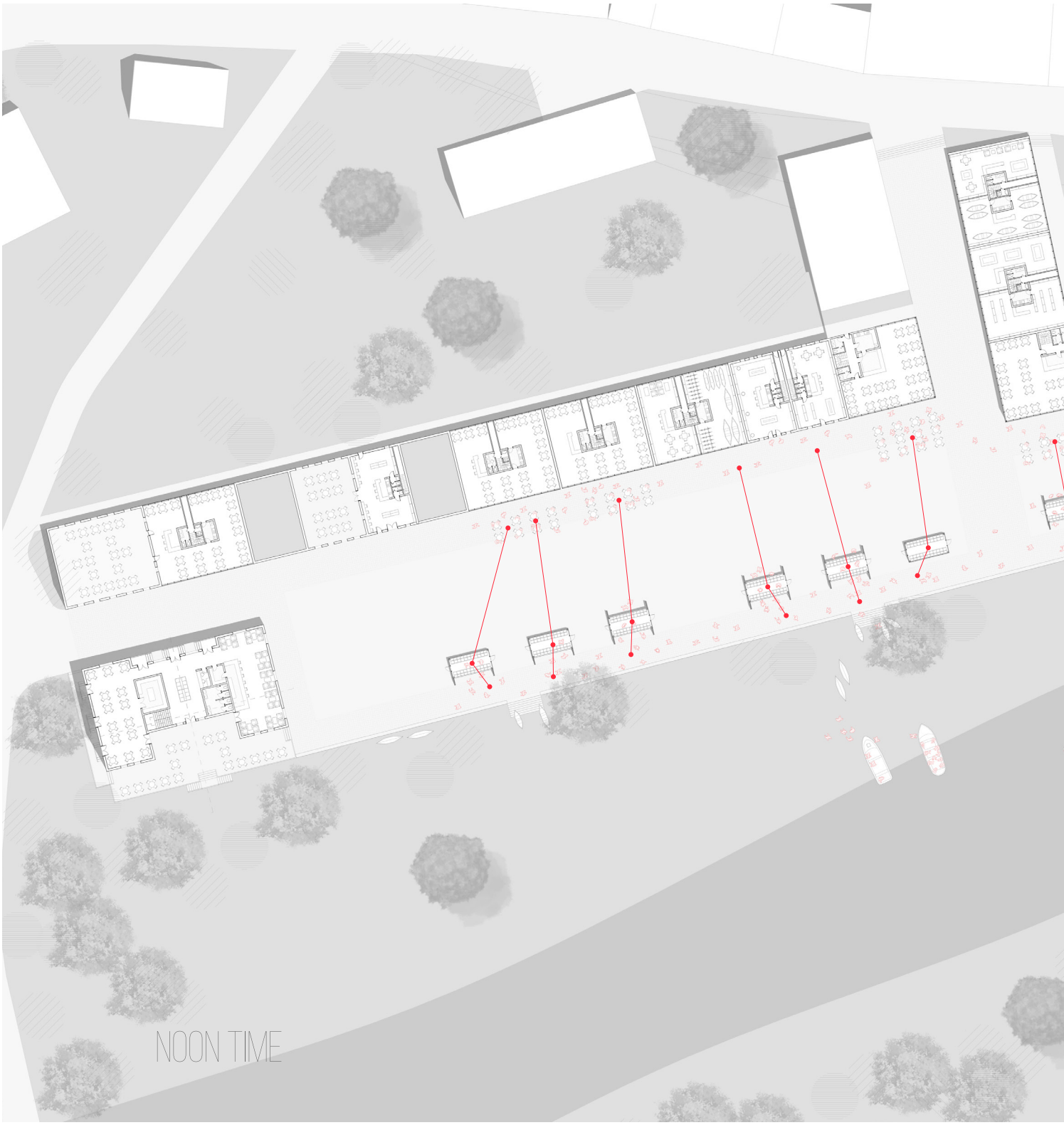
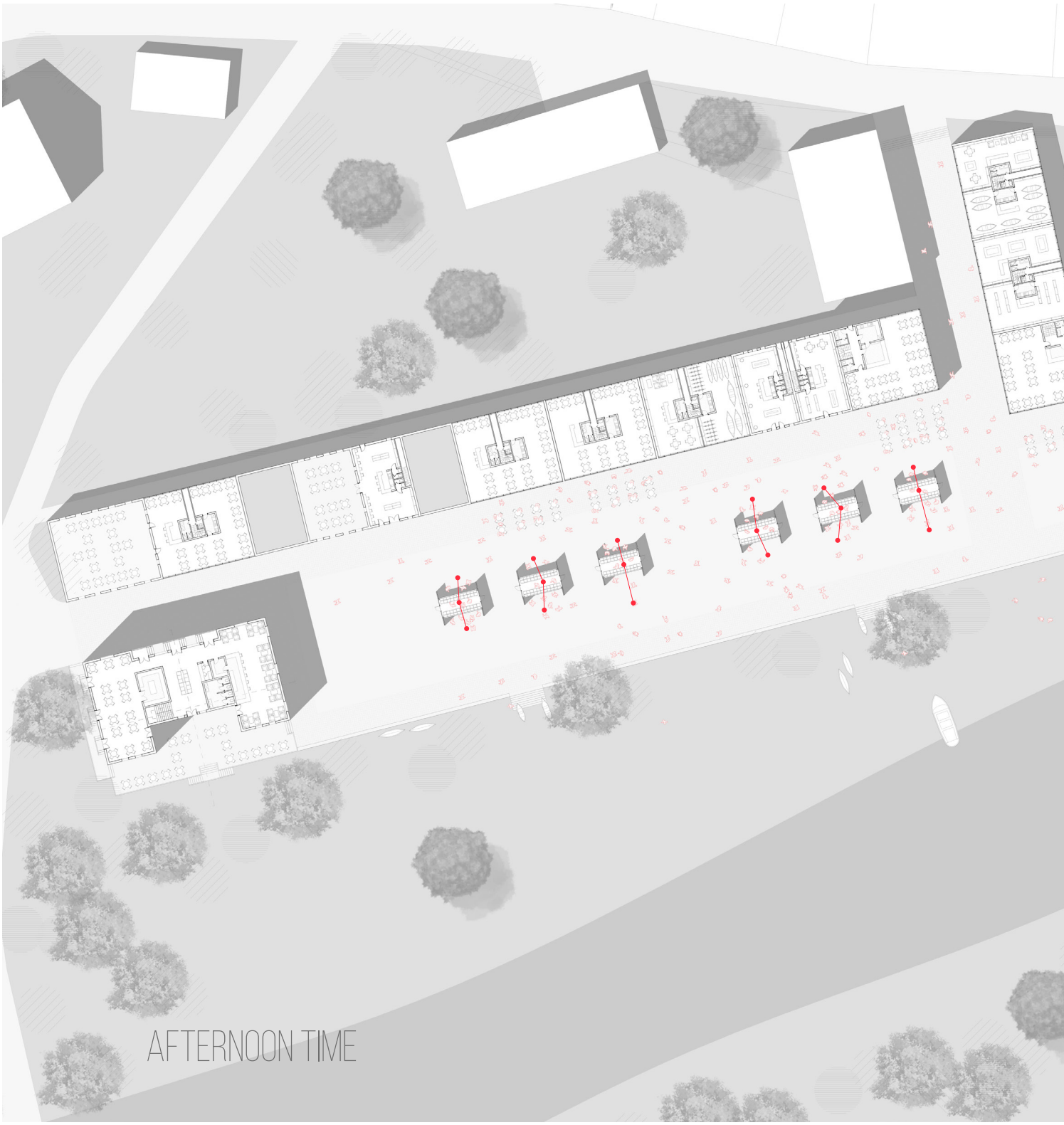

NOON TIME

Figure 166: Midday position of the modules.


AFTERNOON TIME

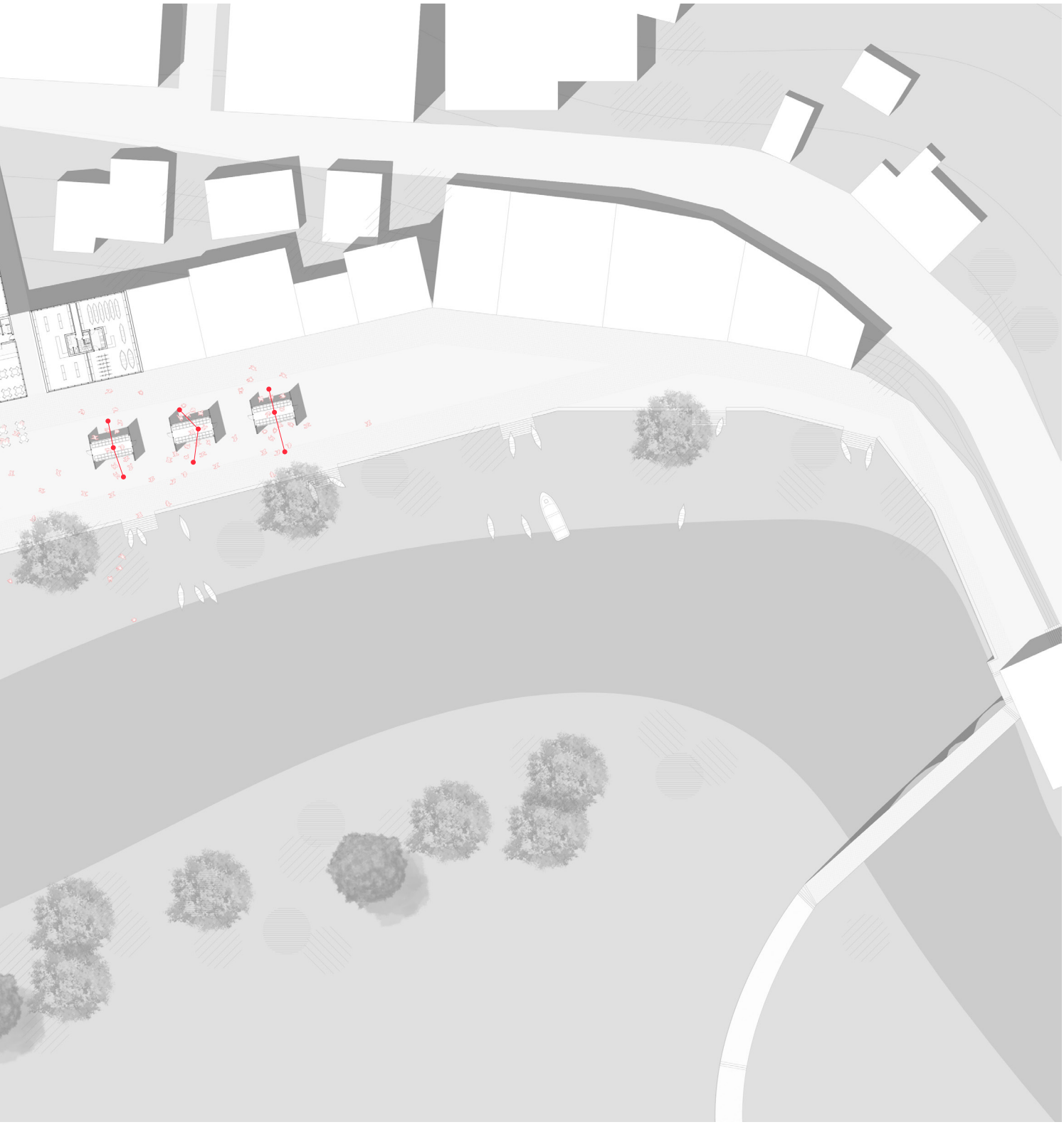


Figure 167: Afternoon position of the modules.

7. Conclusion

7.1. Architecture as Choreography.

Goal of the research and of the proposal is to rethink the architecture not just as a discipline of creating and modifying the space, but more as a discipline of choreographing the space throughout time.
In physics space can not be contemplated without time, they both create inseparable structure called space-time.
Architecture's preoccupation only with space leads to many flaws in building's functionality over certain amount of time. From designing the apartments with rigid layout that can not be easily adapted to the new situations, with obvious changes of family structure, or the public spaces that were made with the only few purposes in mind, and that must be renovated every decade or less.
To prevent such a flaws the architects should design with having time in mind much more often, and with greater awareness to the contemplating the future processes.

Flexibility is the key to ensure the long term functionality of design.

Design flexibility in the project proposal does not just ensure the long term functionality but it also gives much more economic possibilities of space usage, thus it provides the settlement with increased opportunities in different sectors of development.

Flexibility of design is one of the main factors that drive the economic revitalization of the place.

The 3 phases of the project are touching the 3 important parts of the architectural profession in today's world.

First one is construction of new buildings, but construction of buildings in manner of enabling higher opportunities of space usage. The layout is sett in that way that with the highly flexible design, the owner can be provided with greater amount of freedom and possibilities in planning the smarter usage of the space, according to real time needs. Here the flexibility is in the greatest percentage.

Second one is the restoration of the built fabric that is in the state of deterioration and abandonment. Goal is the preservation of authenticity of settlement. Preservation and partial renovation of the exterior boundaries and total renovation of the interior. The amount of flexibility in this case is lower than in the first case.

Third case is creating the flexible public space that can respond to the constant changes of the activities by which it would attract the greater number of visitors. The smart automated system of flexible modules is used to ensure the high degree of design efficiency.

On top of the all intervention there is a environmental problem of high tides that was also solved with the functional solution, but which with its look and attractiveness can become new touristic attraction of the place, and by which, some amount of "Bilbao effect" can be ensured.

Conclusion is that thinking of architecture as a spatial choreography more than just building is the necessary for the future which is demanding ever more flexibility.

7.2. 3D visualization

Figure 168: Public space during the evening.

RIVA - PROMENADE

Figure 169: Public space as the vibrant place full of activities.


FLOOD SEASON - ENTRANCE STREET

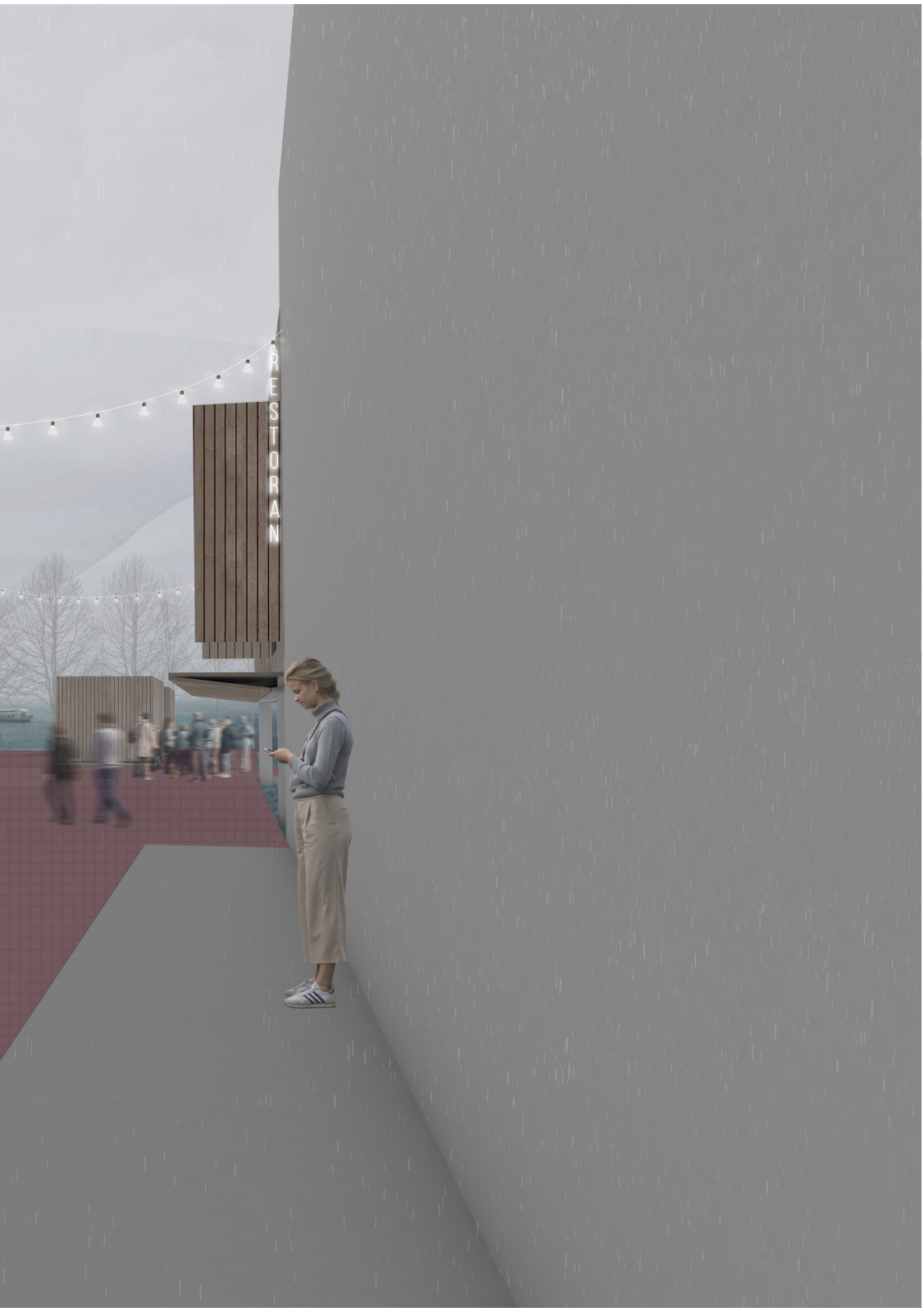


Figure 170: Entrance street during the annual flood.


FLOOD SEASON - PROMENADE

Figure 171: Riva during the annual flood.


FLOOD SEASON - HOTEL

Figure 172: Hotel during the annual flood.

8. Bibliography

(1) World Urbanization Prospects The 2018 Revision - New York 2018.

(2) Urban Europe Statistics on cities, towns and suburbs 2016 edition - Luxembourg 2017.

(3) Statistics Explained (http://ec.europa.eu/eurostat/statisticsexplained/) - 27/06/2018.

(4) Metabolism(S)-Space Flexibility in the 21st Century Stanislas Chaillou, , Harvard Graduate School of Design 2018.

(5) Towards a New Architecture, Le Corbusier 1923.

(6) Metabolism 1960: the proposals for a new urbanism, Kawazoe N Tokyo, 1960.

(7) Metabolism 1960: the proposals for a new urbanism, Kawazoe N Tokyo, 1960.

(8) Nell Greenfildboyce, Morning Post, 2010.

(9) Edward Barsley, Retrofitting for Flood Resilience, 2019.

(10) Bureau of Statistics of Montenegro, Podgorica, 2018. 11 Internal migration in Montenegro in 2018, Podgorica 2018.

(12) Economic Chamber of Montenegro, Podgorica 2012.

(13) Stanislas Chaillou, Metabolisms - Flexibility in 21st Century, Harvard Graduate School of Design, 2018.

(14) https://www.troskovnik.net/cijena-zidarskih-radova/

(15) https://www.troskovnik.net/cijena-zidarskih-radova/

(16) https://www.alibaba.com/product-detail/

(17) Stanislas Chaillou, Metabolisms - Flexibility in 21st Century, Harvard Graduate School of Design, 2018.

(18) https://www.emajstor.hr/cijene/prozori

(19) https://www.soltec.si/sliding-folding-lifting-panels/

(20) https://www.soltec.si/new-dynamic-facade-paris-playful-sunny/

(21) https://deep-dive-systems.com/the-floating-piers-lago-diseo/