

THE IMPACT OF A RIVER ISLAND

*Regenerating the middle stream of the Danube river system
in Novi Sad, Vojvodina*



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Msc thesis Landscape Architecture

*the impact of a river island: regenerating the middle stream of the Danube river system in
Novi sad, Vojvodina*

Keywords

landscape architecture, resilience, Danube River Basin, Novi Sad, regenerative design

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Landscape Architecture: Flowscapes

Resilient Coastal Landscapes

1st mentor: prof. dr. Steffen Nijhuis

2nd mentor: dr. Claudiu Forgaci

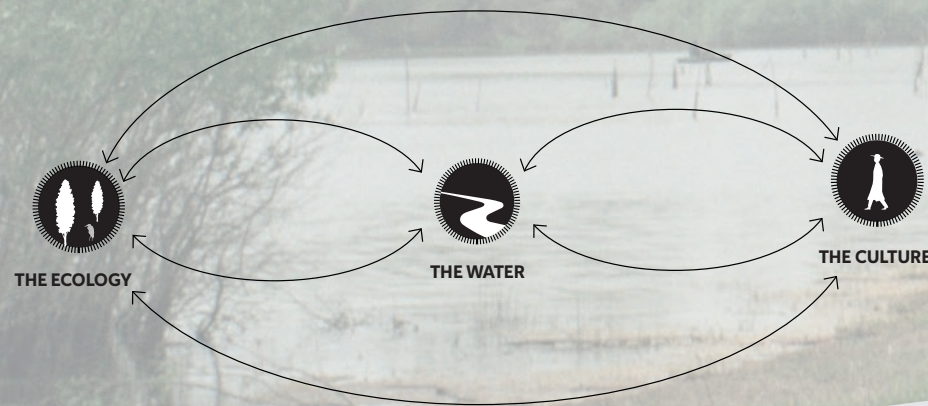
June 2024

FASCINATION

My personal fascination for this thesis project comes from a poem by J. Harrison, who writes about the shaping power of water to land, the gift of water to give land life and meaning. Since the birth of mankind, we have been attracted to water and dependent on it for survival. We have always settled near rivers, build our cities and flourished on the rivers connections through trade. In this way, we have created a beautiful and complex socio-ecological system that we are all part of, and dependent on. Because of our enormous population growth and our growing knowledge on the complexity of these systems we all have the responsibility to take care of our rivers and all life that comes with it. (Harrison, 1989)

“
*to speak it clearly,
how the water goes
is how the earth is
shaped*

J. Harrison





ABSTRACT

The Danube river is Europe's second largest and flows east from Germany to the Black sea through diverse foothills and plains. On the bank of the middle stream of the river, in the Vojvodina region and focus area of this thesis, the city of Novi Sad lies. Vojvodina is part of the fertile Pannonian plain and is known for its agricultural character. As a result of agricultural practice and the urban settlements in the former floodplain, the Danube river became constrained. On the left bank of the Danube at Novi Sad, a relic of the dynamic mid stream river processes lies, called Kamenička ada.

In the context of Novi Sad, the human impact on the river landscape is evident and has led to a polluted and partly chopped up system with cut-off floodplains. Less space is left for the riparian zone and room for the river, which means ecological degradation and increase of flood risk. The degraded connection between the river and the inland furthermore results in fresh water scarcity. Important dynamic river processes in the middle stream, such as erosion, sedimentation and occasional floodings are undermined in these areas, resulting in deteriorating ecological quality and a static environment. The former characteristic braided river with multiple channels and braid bars have become a rare sight.

Focus lies on tackling three main issues related to the water, the ecology and the culture: the components that create the layered landscape together. The first issue is related to the unbalanced amount of fresh water, which causes an increased risk of flood and drought due to climate change and restrictions in the river's floodplain.

The second focus is the loss of the typical middle stream braided system with the riparian ecological zone. This is due to a process of terrestrialisation and habitat fragmentation and becomes clear by the absence of dynamic habitat and the decline in pioneer vegetation.

At last, the relationship between the people of Novi Sad and its public space is highlighted: the disconnection between the locals and the river floodplain. Due to the complexity of ownership of public space in the Yugoslavia period, the relationship with the public space is neglected, which results in no ownership at all or appropriation of public space.

Kamenička ada, a former river island, has the potential to mitigate these issues and become a project example for spatial development based on an approach from the landscape. Therefore, the aim of this thesis is to develop a landscape-based regeneration strategy for the Danube at Novi Sad and to demonstrate the potential of a landscape approach for designing a social-ecological inclusive and flood proof island, Kamenička Ada.

The issues are tackled by using a landscape approach, which takes the landscape structure and processes as foundation for spatial development. From this approach the importance of nature based solutions are understood and applied, together with an understanding of urban and ecological resilience and the interconnections in the river system. The layers of the landscape, the water, the ecology and culture are guiding principles throughout the research.

Based on a literature review and precedent studies, four strategies are formed for the spatial development of Kamenička ada. All strategies relate in different ways to the three issues and guiding principles of water, ecology and culture. The first is related to the river cycle, and uses cyclic river design for flood prevention and development of ecological valuable areas. The second strategy is to create mutually beneficial design layers for water, nature and culture. The third is to create intermediate space for future ecological and urban resilience. And the last strategy is to identify and connect Kamenička ada in the bigger context to Novi Sad and the middle stream of the Danube.

The result of this research is an analysis and understanding of the challenges and potentials for the spatial development of Novi Sad and the translation of four spatial strategies to design principles. Secondly an application in the form of a strategic vision for the river island Kamenička ada and a reflection on the meaning and connection of the river island to the bigger context. Kamenička ada becomes an example for landscape based and resilient spatial development in the urban context of the river for the middle stream of the Danube. Finally, the results are discussed. Their significance for the wider field of landscape architecture and other applications is considered.



ACKNOWLEDGEMENTS

The full year of moving through all the phases of the graduation process and working on one project has been quite a journey. At first, I would like to name my gratitude towards prof. dr. Steffen Nijhuis for the guidance in the numerous sessions in group and individual form. To have such an experienced professor as a guide has been very meaningful to the whole process of research and design and everything in between, but it has also been meaningful on a personal level. I would as well like to say thank you for the involvement in the professional field and connecting me to the municipality of Novi Sad.

I would also like to thank my second mentor dr. Claudiu Forgaci for the guidance and deepening the knowledge on the river processes, urban context and the context of eastern Europe. Further I would like to thank the municipality of Novi Sad for the warm welcome and inside knowledge.

Next, I would like to name my family and close friends for the support and sometimes the needed distraction throughout the year.

And at last a special thanks to all the landschappers, which I experienced through multiple study years. You keep me inspired, and with you as talented designers I am hopeful for the future of landscape architecture field.

PART I

INTRODUCTION

RESEARCH FRAMEWORK



1. INTRODUCTION

1.1 LOCATION

1.1.1 *The Danube basin*

1.1.2 *The Danube rivercourse*

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1.3 RESEARCH OBJECTIVE + QUESTIONS

1.3.1 *Research objective*

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1.3.3 *Methodology*

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1.3.4 *Expected outcomes*

1.4 RESEARCH APPROACH

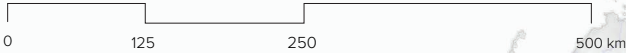
1.1 LOCATION

The Danube basin

Covering approximately 10 percent of the Continental Europe, the Danube basin is home to 80 million people from nineteen countries in the east of Europe. The Danube finds its origin in multiple small springs in Germany and flows east through diverse foothills and plains before reaching the Black Sea. Based on its slope gradients, the basin can be divided into three sub-regions, namely the Upper, Middle and Lower basin with the Delta.

The thesis location, the city of Novi Sad lies on the bank of the Danube in Serbia which is part of the Middle basin of the riversystem (ICPDR, 2009).

- ① The upper basin
- ② The middle basin
- ③ The lower basin and delta

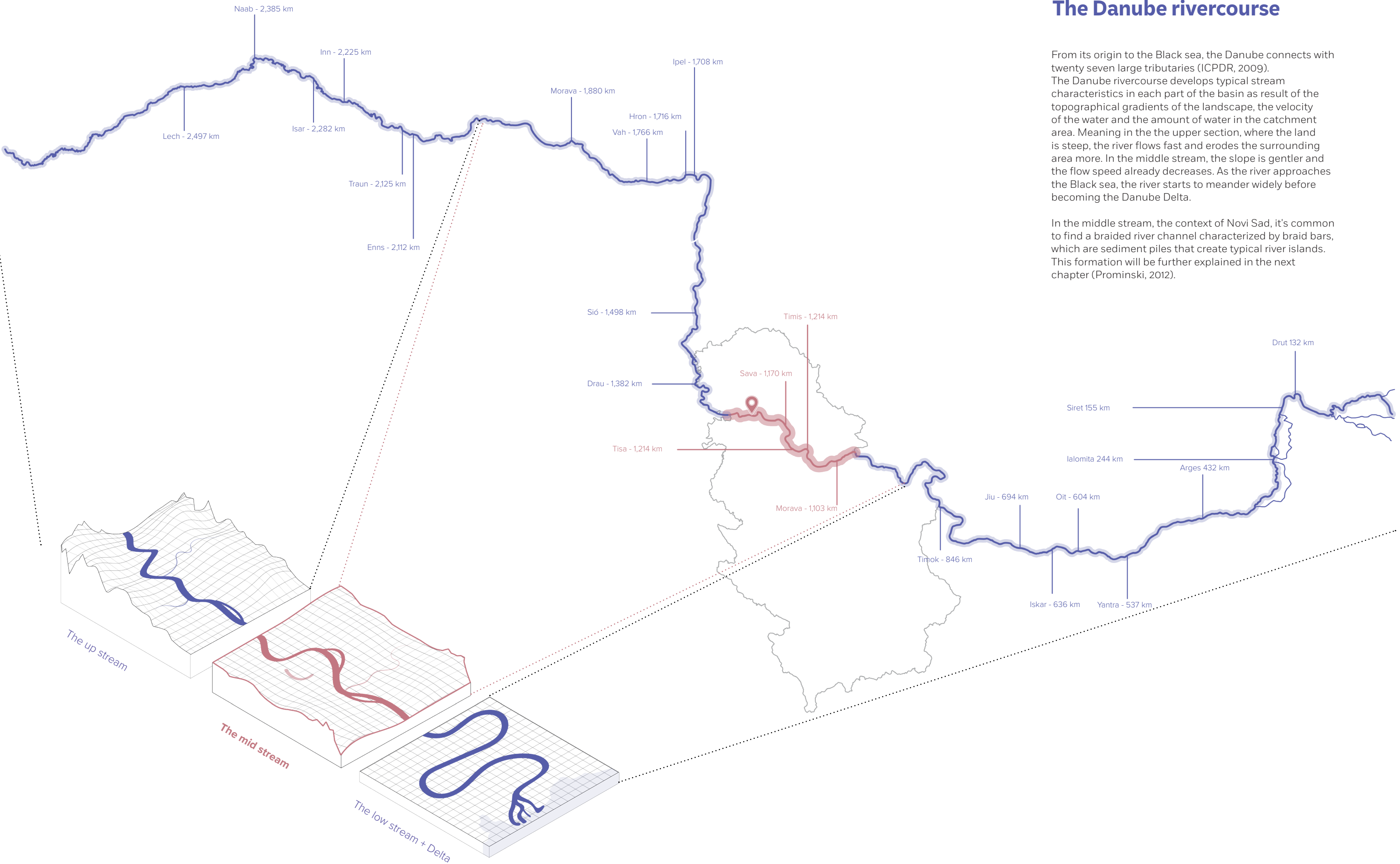


The Black Sea

The Danube rivercourse

From its origin to the Black sea, the Danube connects with twenty seven large tributaries (ICPDR, 2009). The Danube rivercourse develops typical stream characteristics in each part of the basin as result of the topographical gradients of the landscape, the velocity of the water and the amount of water in the catchment area. Meaning in the the upper section, where the land is steep, the river flows fast and erodes the surrounding area more. In the middle stream, the slope is gentler and the flow speed already decreases. As the river approaches the Black sea, the river starts to meander widely before becoming the Danube Delta.

In the middle stream, the context of Novi Sad, it's common to find a braided river channel characterized by braid bars, which are sediment piles that create typical river islands. This formation will be further explained in the next chapter (Prominski, 2012).

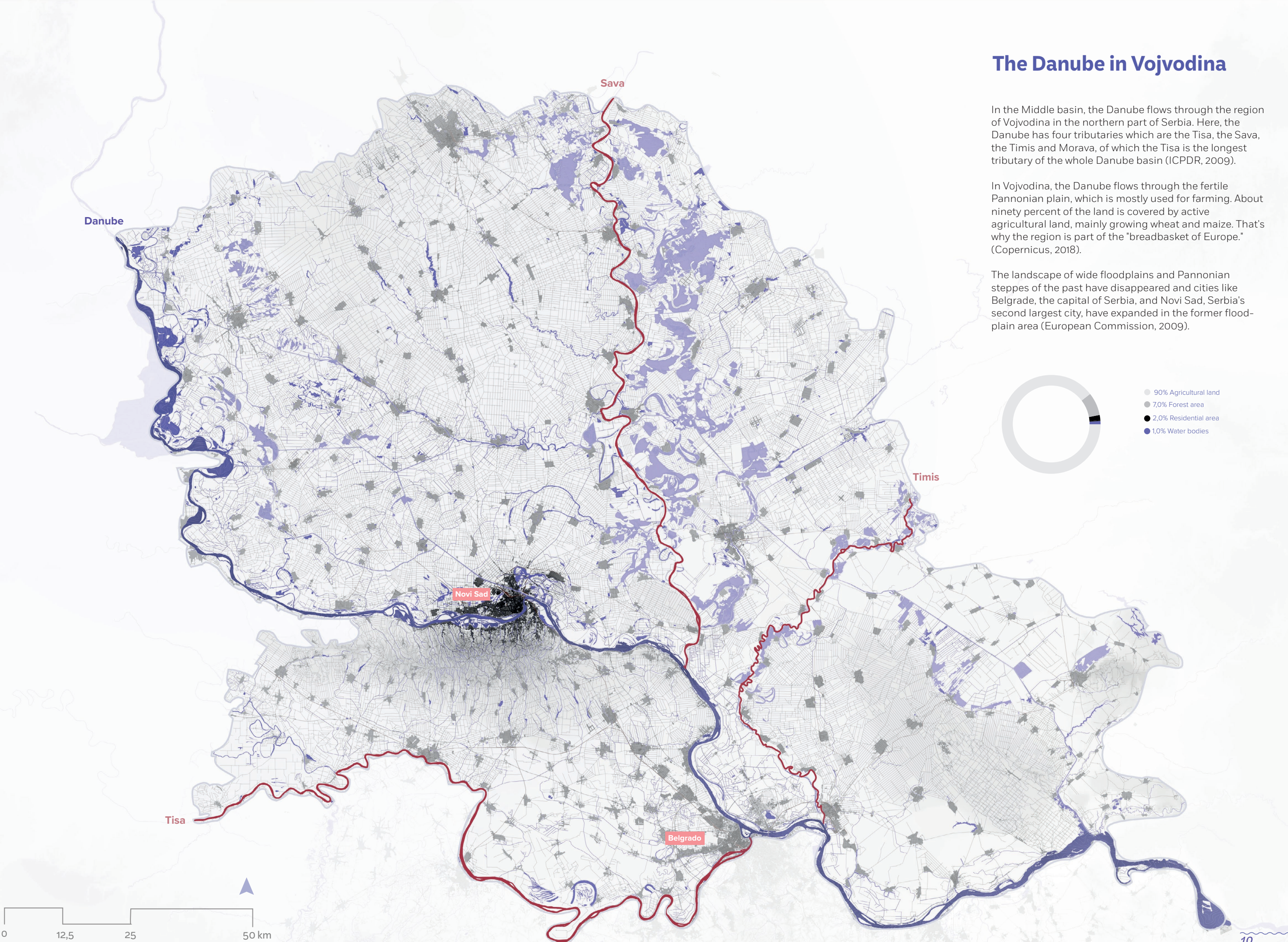


The Danube in Vojvodina

In the Middle basin, the Danube flows through the region of Vojvodina in the northern part of Serbia. Here, the Danube has four tributaries which are the Tisa, the Sava, the Timis and Morava, of which the Tisa is the longest tributary of the whole Danube basin (ICPDR, 2009).

In Vojvodina, the Danube flows through the fertile Pannonian plain, which is mostly used for farming. About ninety percent of the land is covered by active agricultural land, mainly growing wheat and maize. That's why the region is part of the "breadbasket of Europe." (Copernicus, 2018).

The landscape of wide floodplains and Pannonian steppes of the past have disappeared and cities like Belgrade, the capital of Serbia, and Novi Sad, Serbia's second largest city, have expanded in the former flood-plain area (European Commission, 2009).





The Danube at Novi Sad with the Varadin bridge.



The Danube park entry in Novi Sad.

Novi Sad: A case study

The city of Novi Sad, situated in the floodplain of the Danube, offers a valuable case study of urban development close to the river in its middle stream context. Novi Sad was founded on the river's left bank in the seventeenth century, during the Habsburg monarchy, shortly after the construction of Austria's Petrovaradin fortress. The city's historical development and its relationship to the river landscape is delved in further in Chapter 3.

The relationship between the Danube and Novi Sad has been both beneficial and challenging. While the river provided the city with water and trade opportunities, fostering cultural growth, its fluctuating water levels have also caused occasional damaging floods throughout the centuries (Savin, 2009).

In the 1990s, another significant historical event took place which is worth to mention, namely the NATO bombing of the city's bridges during the Yugoslav conflict.

With the dissolution of Yugoslavia, Serbia emerged as one of the seven countries from the former communist state in the early twenty-first century. Understanding this background is important for grasping the roots of Novi Sad's current culture and the perspective of its residents on public space and the city's well-being (Calcic, 2022).

Due to the city's growth through the centuries in the river's floodplain, urban development has altered the natural river course, channeling it and increasing flood risk. To protect against floods, dikes have been strategically built, yet at the same time they limit access to the river's public spaces and its ecological value. With climate change and extreme weather events in mind, Novi Sad must adopt a new approach to the river in order to ensure long-term ecological and urban resilience.

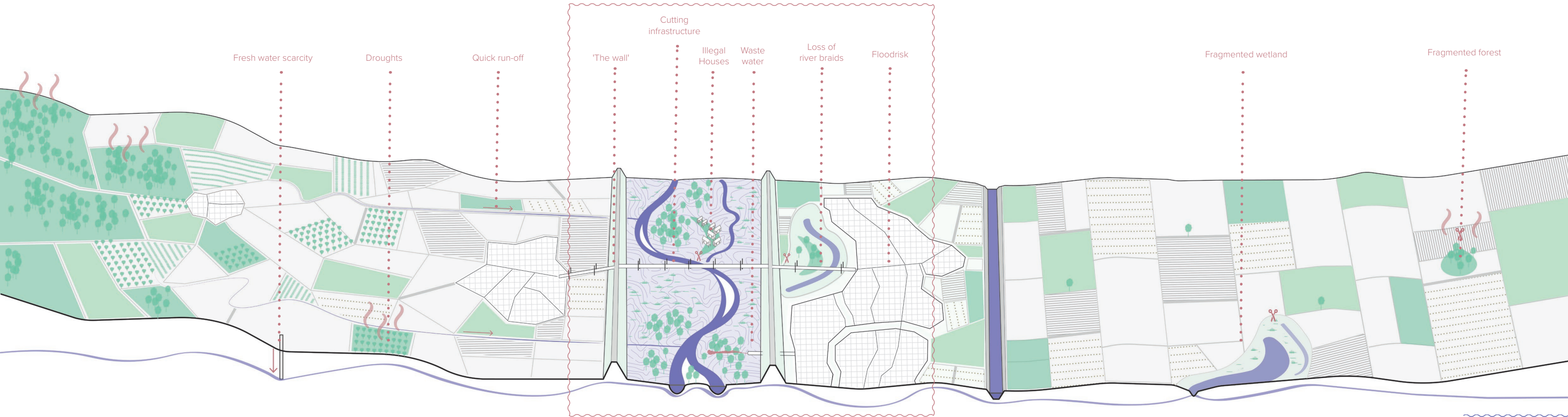
1.2 PROBLEM FIELD

In the region of Vojvodina and the agricultural landscape around the city of Novi Sad, the agricultural transformation of the original Pannonian steppe landscape and urban settlements in former floodplains have resulted in a constrained Danube riversystem (EC, 2009). Less room for the river means a degraded ecological riparian zone and an increase in floodrisk. The degraded connection between the river and the inland furthermore results in fresh water scarcity (SEPA, n.d.). This scarcity is worsened by the (illegal) pumping of fresh groundwater for irrigation purpose and climate change resulting in long droughts and soil degradation (EC Green paper, 2007). In the inland natural creeks are canalised, resulting in quick run-off and even more drought related issues. Only fragments of old river bends or braids and former wetlands can be found, slowly drying out in the inland (Gruijc, 2022).

The chopped mid stream river

In the context of Novi Sad, the human impact on the river landscape is evident and has led to a polluted and partly chopped up system with cut-off floodplains (Harries, 2020). Important dynamic river processes in the middle stream, such as erosion, sedimentation and occasional floodings are undermined in these areas, resulting in deteriorating ecological quality and a static environment. The former characteristic braided river with multiple channels and braid bars have become a rare sight. The city's expansion along the river led to the building of dikes, disrupting infrastructure and pollution of the river with urban wastewater. Illegal housing in the floodplain highlights the need for public housing and reflects a lack of concern for public space in Novi Sad.

This thesis focuses on the floodplain next to the river and the urban development within it, including its infrastructure components.



History of river extremes in Novi Sad

1876

Recorded flooding in the Danube street, heart of the city of Novi Sad.



1926

Danube floods throughout whole former Yugoslavia.



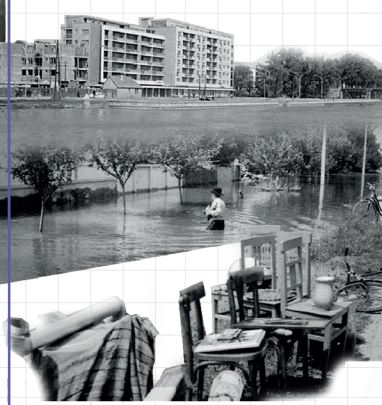
1940

April flood, the highest level of 704 cm, thousands of people left without their homes.



1965

Catatrophic flood of 778 cm, almost no flood defence. Lasted for 106 days in total.



2006

Flood of 100 year return period, highest water level in 25 years.



2012

Extreme droughts in the inland causing crop damage.



2014

Heavy May rainfall causes catastrophic flooding throughout whole Serbia. Mayor damage to houses.



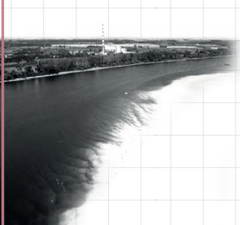
2019

Flash flooding by rainfall in June. Over 100 mm rain fall in 2 hours.



2022

Summer drought, low waterlevel exposes river bed.



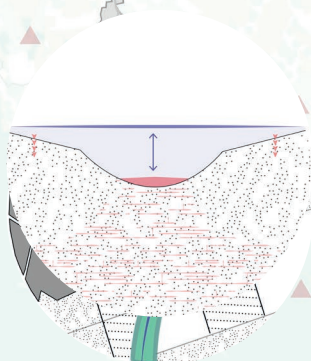
(László Takács, no date; Prodger, 2006; UN Serbia, 2014; Floodlist Europe, 2019; Novković, Dragičević and Djurović, 2022; Reuters, 2022)

Challenges and opportunities for Novi Sad

As indicated in the timeline on the previous page, over the past centuries, Novi Sad has experienced frequent floods. To mitigate these events, the city has implemented strategically positioned dikes. However, these dikes constrict the river floodplains, riparian ecological growth, and become an obstacle between the city and the floodplain. The Serbian government's traditional approach to flood prevention, centered on civil engineering and standard solutions further constricts the river and its surroundings. This traditional approach eventually results in higher flood risks, since it restricts the natural processes in the river system in an ongoing cycle of disaster. Consequently, Novi Sad's current river policy has sparked environmental protest and discontent among citizens, which highlights the urgent need for a new perspective and solutions to address the structural challenges of the Danube landscape (N1 Belgrade, 2022).

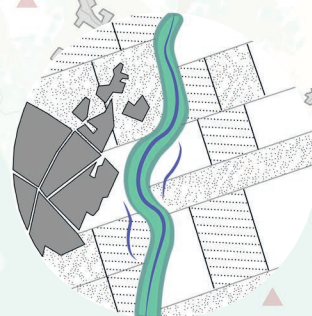
Three main issues have been identified related to the water, the ecology and the culture, all of which shape the landscape together. The first issue related to water, is the unbalanced freshwater availability, leading to flood risks and droughts. The second concern is the deterioration of the valuable ecological braided system and riparian zone. Lastly, there's a mental and physical disconnection between the inhabitants of Novi Sad and the river floodplain, calling for reconnection. Novi Sad has the spatial opportunity to mitigate these issues by redeveloping a relic of the braided river system, a former river island. This former island, called Kamenička ada, is situated on the left bank of the Danube in between the river and Novi Sad. Its position creates the unique opportunity to become once again part of the city and the river.

I. Water



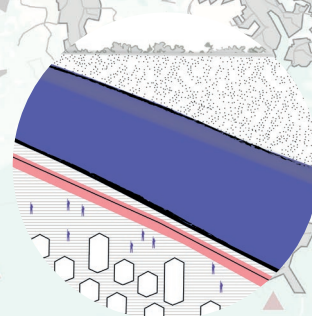
Unbalanced fresh water availability

II. Ecology



Loss of river braids with riparian buffer

III. Culture



Segregation between the city and the river

Kamenička ada

0 2 4 km

1.3 RESEARCH OBJECTIVE + QUESTIONS

Research objective

This research explores the potential of a new landscape-based approach for Novi Sad to mitigate the issues related to water, ecology and culture by designing a strategy for spatial development of Kamenička ada, former river island. Therefore the following research objective is formulated:

To develop a landscape-based regeneration strategy for the Danube at Novi Sad and to demonstrate the potential of a landscape approach for designing a social-ecological inclusive and flood proof island, Kamenička Ada.

Aim of this research is to conduct research through design, a special research method in the landscape architecture field, which is highlighted in the methodology chapter.

Research questions

To answer to the main research objective, three sub-questions have been formulated. The first question is related to understanding the components of this research and their interrelation, challenges and potentials. The second question is related to the research of spatial strategies and principles suitable for application. The third question relates to the translation of the strategies and principles to local design strategy. At last, a reflective question of the main lessons is posed.

RQ 1 } Understanding the Danube and Novi Sad

How did the Danube River landscape and Novi Sad develop over time and affect each other, and what are the challenges and potentials for Kamenička Ada as part of the river and the city?

RQ 2 } Finding solutions

What landscape architecture design strategies and principles are suitable for regenerating the Danube river landscape and facilitating inclusive spatial development of Kamenička Ada?

RQ 3 } Design application Kamenička ada

How can these design strategies and principles be applied to protect and develop the Danube River landscape at Novi Sad and Kamenička Ada therein?

RQ 4 } Reflecting of lessons for Novi Sad

What are the lessons taken from a landscape approach in general for Novi Sad and the Vojvodina area?

Methodology

A variety of research methods will be used to answer to the objective and formerly stated sub questions. These methods range from spatial analysis techniques, such as GIS data collection and mapping, to literature reviews of insightful theoretical approaches, strategies and similar precedent studies.

Research structure

The research is divided into three parts: research for design, research about design, and research by design. They together form the interative research through design cylce (RTD), a research method in which spatial design takes the lead (Nijhuis & de Vries, 2020). Research for design involves understanding the context of Novi Sad and Kamenička ada, as well as exploring theories about landscape dynamics and river systems. Research about design focuses on finding suitable spatial strategies and design principles in Novi Sad context. The last, research by design entails testing and applying these strategies and principles on site. The design is used to give context to the research topic within the local scale.

RQ 1 } Understanding the Danube and Novi Sad

The first research question focuses on understanding the Danube river landscape in the middle stream and the urban development of Novi Sad, particularly how they have influenced each other over time. This will involve a literature review and mapping of the Vojvodina region and Novi Sad using GIS data. Possible data gaps will be filled through analysis of governmental and historical documents containing spatial information, as well as satellite imagery from Google Earth.

RQ 2 } Finding solutions

The second research question aims to identify possible strategies and design principles for the regeneration of the Danube at Novi Sad and creating a flood-proof, socio-ecologically inclusive Kamenička Ada. This will involve studying literature on landscape-based approaches and resilience thinking. Additionally, precedent studies of similar sites will be examined to address this question.

RQ 3 } Design for Kamenička ada

The third research question focuses on the implementation of the knowledge gathered by research question one and two. Novi Sad and Kamenička ada are analysed more deeply with the same method described for research question one, based on the theoretical foundation previously established. To gather even more detailed knowledge of Kamenička ada, a site visit is organised by prof. dr. Steffen Nijhuis, the municipality of Novi Sad and the author. Details of this visit will be explained on the next page. Once a complete overview of the local context is gathered, the implementation of the strategic vision in the form of landscape architectural design is done through research by design.

Site visit

At the end of March 2024, the author had the opportunity to visit the municipality of Novi Sad and meet the local designers and project developers of the municipality. It was an insightful week of visit and very helpful to walk in the city of Novi Sad, and understand its landscape in a deeper way by experiencing it firsthand.

Meeting the municipality

On friday 29th of March, a meeting was held with the municipality of Novi Sad in which the current plans for the greening of the city of Novi Sad were presented, such as the development of a green connection from the city towards Kamenička ada. It was very enlightening to see the current plans and visions that the municipality is working on.

However, it also became clear how the development of Novi Sad is constrained by the Serbian government's spatial planning regulations. The Serbian government uses many standard solutions and civil engineered based approaches when dealing with landscape issues. This counts as well for the future of Kamenička ada. The municipality wants to embank the whole area for flood protection, which will stop all river dynamics.

Prof. Dr. Steffen Nijhuis delivered an inspiring presentation on three landscape-based concepts for the spatial development of Kamenička Ada, offering a fresh perspective for the municipality of Novi Sad. These concepts will be further explored in the design chapter.

Additionally, the author had the chance to present the midterm findings of this research to the municipality, which found it valuable in comprehending the broader context of Novi Sad and its complex relationship with the Danube river.



Site visit Kamenička ada with the municipality.



Presentation of mid-term results to the municipality of Novi Sad.

Visiting Kamenička ada

After the meeting, a short site visit by car was organised by the municipality to understand the current accessibility and status of Kamenička ada. It was interesting to see the relics of the riparian ecology on site and current usage of the old river arm as a spot for fishing and recreation.

On a different day, an individual bike excursion took place visiting Kamenička ada once more to spend more time to study the ecology and current functions. Analog photography was used to capture the current status of Kamencika ada, which are found throughout this book.

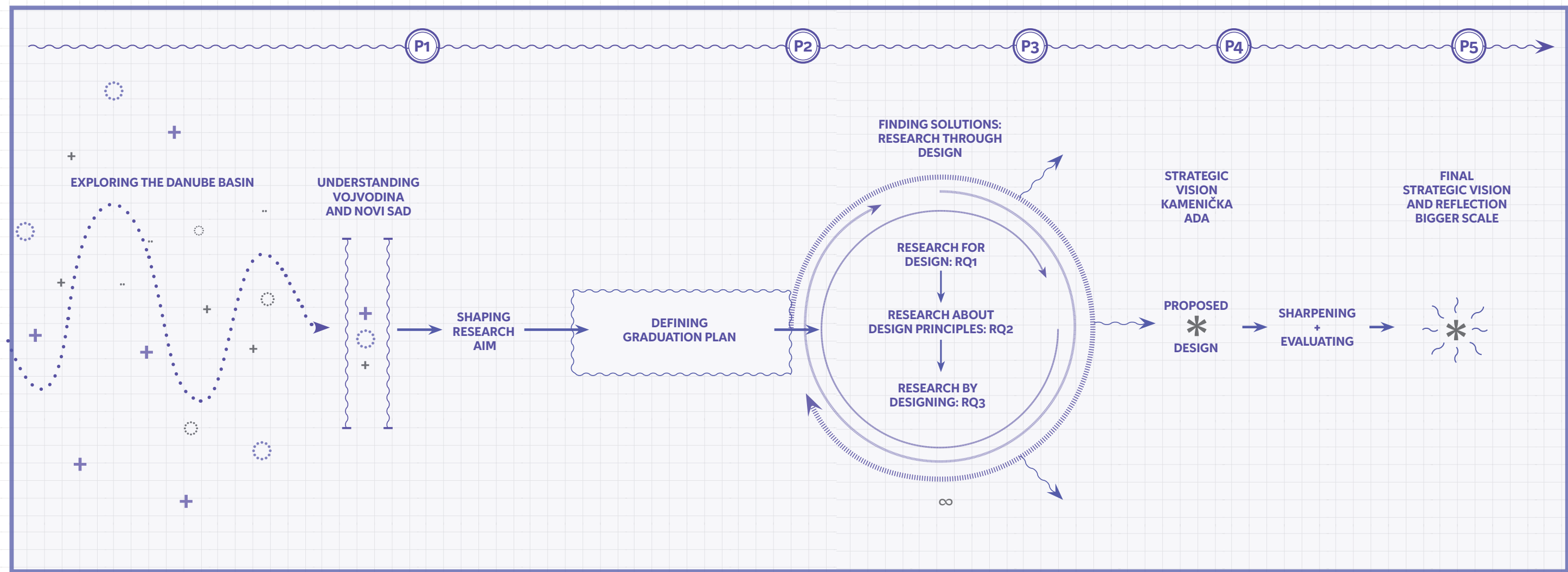


The current entry of Kamenička ada, next to the dike.



Status of the current harbour of Kamenička ada.

Research structure through time



Expected outcomes

Each of the four research questions have a specific expected outcome and expectation of knowledge gain to meet the objective of the research.

RQ 1 } Understanding

The expected outcome of the first research question is a textual and graphic in-depth understanding of the river formation of the Danube and it's relationship with the surrounding landscape developments and urban development of Novi Sad. It aims to understand the layers of the landscape: the water, the ecology and the cultural developments over time and what challenges and potentials lie in it.

RQ 2 } Finding solutions

The second research question aims to generate a textual and graphic overview of suitable spatial strategies and principles for the regeneration of Novi Sad and a flood-proof, socio-ecologically inclusive Kamenička ada. The result will contain a translation of theories into site-specific strategies and suitable principles, derived from theory and precedent studies.

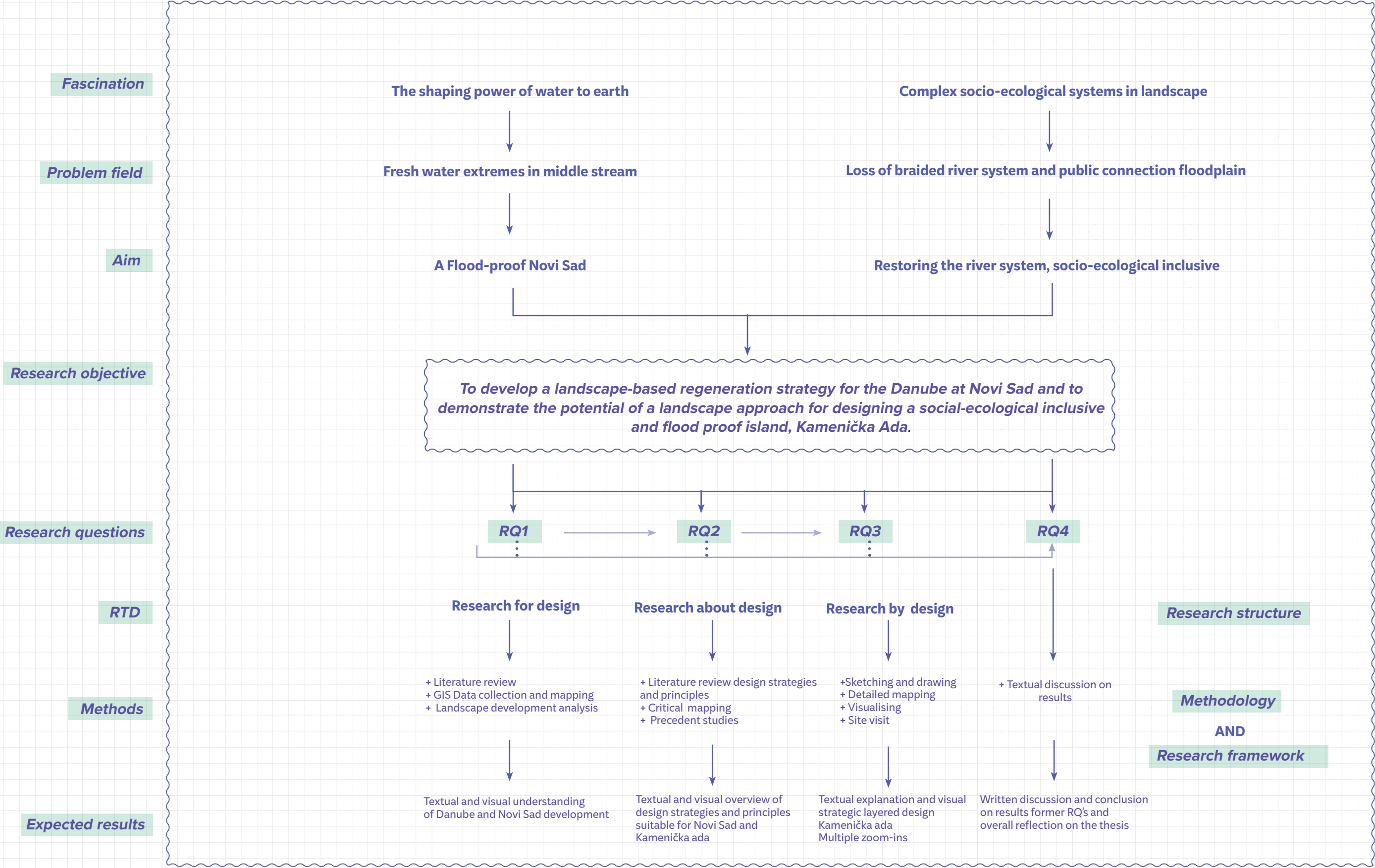
RQ 3 } Design

The findings of the former two research questions will feed the expected application result of the third research question. More in-depth textual and graphic analysis of the current site Kamenička ada will be produced, in order to be able to apply the principles to the local context in the form of a strategic vision for the river island. The design will be explained in text and graphics containing three layers of water, ecology and culture, building up to the complete strategic vision. Furthermore the design will be supported with multiple strategic zoom-ins, sections and visualisations.

RQ 4 } Reflecting

The result of the last research question will be a textual and partly graphic discussion and conclusion on the developed results of the former three sub questions, relating it to lessons learned for Novi Sad and the meaning of a landscape approach in the bigger context. Additional to that, the relevance of the results of this project in field of landscape architecture is reflected upon.

1.4 RESEARCH APPROACH



1.5 RELEVANCE

Relevance for Novi Sad

In this thesis, a new perspective of taking the landscape as a basis for spatial development is introduced and applied to the municipality of Novi Sad. The results of this research, the site-specific strategies and design are a relevant source of inspiration for Novi Sad to develop a flood-proof, socio-ecological inclusive future vision for the city and Kamenička ada therein. The current river policy is undermining the development towards a resilient Novi Sad and Kamenička ada, and the application of the landscape approach could steer in the right direction. On site visit, it became very clear the municipality of Novi Sad is open to change and has motivations to work towards a more resilient future.

Professional relevance

The thesis is related to the professional field of landscape architecture, since it is based on leading, important approaches and solutions found in the field of landscape architecture. The strategic vision is based on specific research on a landscape-based approach and suitable strategies, which result in argued design choices fitted to the local context.

Relevance for scientific field

The meaning of this research for the scientific field lies in the contribution of knowledge on the middle stream of the Danube river system in Serbia, and the documentation of important landscape processes for the municipality of Novi Sad. Many data sources have been combined and gathered, and have become a collection of relevant sources for future research about Novi Sad and the Danube. Furthermore, it serves as an example of research-based spatial development of the landscape approach. The results of the four strategies and principles could be applied to other similar cases.

1.6 READING GUIDE

This booklet is divided into three parts, of which part I is now almost at an end, with only the research framework following up.

Research framework

The last chapter of part I is the introduction of the research framework, which consists of the main theories used in this research. They can be found in the theoretical foundation chapter, which is followed by the research strategy and the explanation of the three guiding principles of water, ecology and culture as a division for the rest of the design strategies, principles and application of design layers.

Part II / Understanding, strategies and principles

Part II consists of chapter 3 Understanding the Danube and Novi Sad which contains the understanding of the Danube, Novi Sad and their interrelation. The following chapter 4 contains the design strategies and principles suitable for Novi Sad and Kamenička ada, with precedent studies included.

Part III / Deep analysis, design, reflection

Part III of this booklet consists of chapter 5 Novi Sad and Kamenička ada analysis with more detailed information of the current context of the design site. It also includes the formation of natural river island in the Danube, important for the application of the design. Chapter 6 contains the strategic vision which is first introduced with a chapter on three landscape approach concepts, followed by the vision itself for Kamenička ada and strategic zoom ins. Chapter 7, the last chapter, contains the discussion and conclusion of this work, and reflects upon the process.



2. RESEARCH FRAMEWORK

2.1 THEORETICAL FOUNDATION

2.1.1 Landscape approach: landscape-based urbanism

2.1.1 a Longue durée

2.1.1 b Nature based solutions

2.1.1 c Landscape ecology

2.1.2 Resilience approach

2.1.2 a Ecological resilience

2.1.2 b Urban resilience

2.1.3 The watershed approach

2.2 RESEARCH STRATEGY

2.2.1 Moving through scale

2.2.2 Water, Ecology, Culture

2.3 GUIDING PRINCIPLES

2.3.1 Water

2.3.2 Ecology

2.3.3 Culture

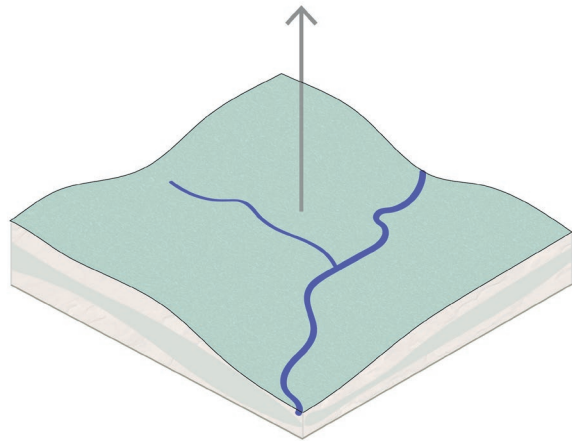
2.1 THEORETICAL FOUNDATION

In this subchapter of the research framework, three main theories are highlighted to conduct this research. Landscape-based urbanism, resilience theory and the watershed approach help to structure the research, analysis of Novi Sad and design strategies and principles.

Landscape-based urbanism

Landscape-based urbanism is a landscape approach which takes the regional landscape structure and processes that take place in it as foundation for spatial development. The goal of this multi-scaled and area-specific approach is to generate a system inclusive of water sensitivity, biodiversity and cultural history. Crucial to this particular approach is thinking about the landscape in the long-term perspective. Therefore, this approach in regard with spatial development, can provide a strong landscape structure or 'a resilient landscape framework' as a starting point for a development strategy. Next to that, the approach identifies crucial points in the landscape structure to become local projects as short-term interventions (Nijhuis, 2022).

In order to get a grip on the landscape approach, it is important to understand the landscape as a layered, living system. In order to understand these layers of the landscape, the layer approach is discussed on the next page, in which the term *longue durée*, or geological time is used.



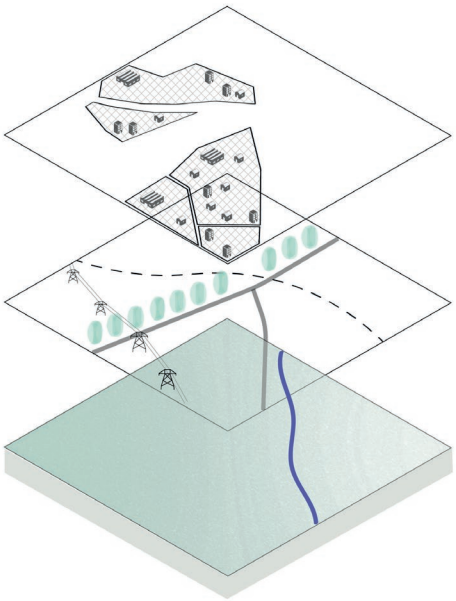
The landscape as a base for spatial development, made by author.

Longue durée

The concept of *longue durée*, or the layered landscape sees the landscape as a long term system in which different processes interact and have different dynamics of change. The first layer is associated with the natural environment, the geological layers and climate, layers that change slowly. The dynamics of this level is a slow, almost imperceptible process of change, and slow environmental cycles.

The second layer is the network layer, containing the infrastructural networks for (water) transport, management and energy networks. It is the layer of long term social, economic and cultural dynamics. The conditions of this layers are able to change more rapidly than the environmental conditions.

The final short-term layer contains the short-term events, occupation, evolving cities and policy. Together with the second layer, conditions are formed for spatial development, such as urban development and agricultural practices (Hoog et al., 1998).



The environmental layer, the network layer and the occupation layer, adapted by author from (Hoog et al., 1998).

Nature based solutions

From landscape-based urbanism, the importance of nature-based solutions is understood and applied in this thesis. Nature-based solutions are spatial solutions that use nature and natural processes as a basis for development to meet the growing challenge of resilience. Their application requires an understanding of the local ecology, climate, soils and stakeholders. Solutions are linked to the layered landscape explained on the former page, the physical, ecological and social systems in the landscape.

Another important feature of NBS are their innovative, multifunctional nature, creating space for water, ecology and culture

Examples of relevant NBS approaches for Novi Sad include restoring river corridors, creating buffer zones, enabling ecosystem processes and connecting people to water (van Eekelen & Bouw, 2021).



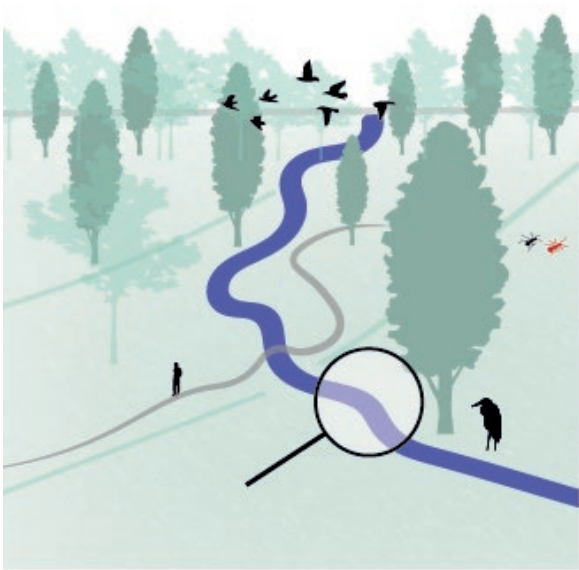
Nature-based solutions, made by author.

Landscape ecology

In this thesis, knowledge of a landscape ecology handbook which explores principles and concepts of landscape ecology is adopted in order to apply holistic thinking to tie water, ecology and people together. The aim of doing so is to develop an integrative strategic vision.

Ecology is the study of the interactions among organisms and their environment. The landscape is a layered mosaic of patterns of local ecosystems and land uses. Landscape ecology is the field of understanding the relation between spatial patterns in the landscape and the ecological processes or values behind it.

Examples of landscape ecology principles are habitat diversity and buffer or intermediate spaces around nature areas (Dramstad, W.E.).



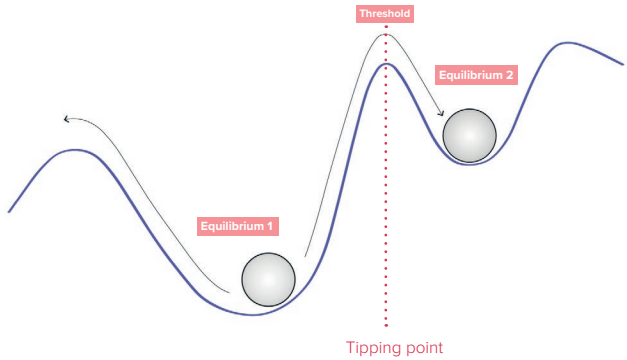
Landscape ecology study, made by author.

Resilience theory

Resilience theory is related to the ability of a certain landscape to sustain with desired ecological functions, important landscape processes over time and to maintain a strong landscape structure under stressful, changing conditions and uncertainty.

Ecological change of a system is not continuous or gradual, but in balance between stability and instability, which is a character of a healthy ecosystem. Ecosystems have various tipping points and ecological resilience is characterised as the ability of a system to flip back to original state, or to another equilibrium after disturbance without changing its basic state (Holling, 1973), (Holling, 1996).

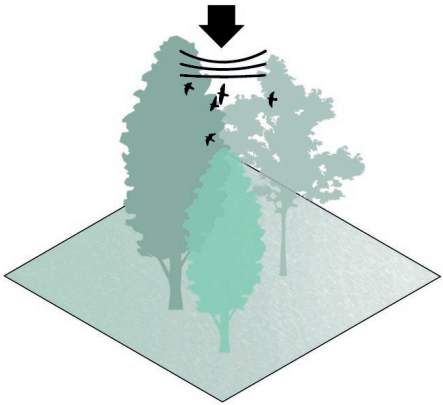
Building resilience capacity in landscape architecture means to identify the socio- and natural processes, their disturbances and frequency and intensity of disturbance (Ahern, 2011).



The tipping point and equilibirum in resilience thinking, made by author, adapted from (Holling, 1973).

Ecological resilience

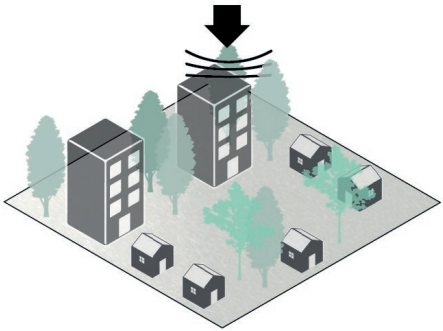
In order to maintain ecological resilience, it is important to steer a landscape into a strong framework that can carry the disturbances and maintain stable. There are important factors playing a role in building ecological resilience in a landscape. The first is the amount of flexibility and adaptability of the landscape. The second is the amount of attention paid to the local ecology as a starting point for spatial development. The third is heterogeneity and redundancy in landscape ecology, meaning multiple species or ecological components within an ecosystem that can perform similar functions or roles. At last, allowing intermediate space for future interpretation or a safe-to-fail mentality is important. With enough space in a system to absorb disturbances, it is safe for a landscape to 'fail' (Masoud and Holland, 2021), (Dhar and Khirfan, 2023) and (Ahern, 2011).



Ecological resilience, made by author.

Urban resilience

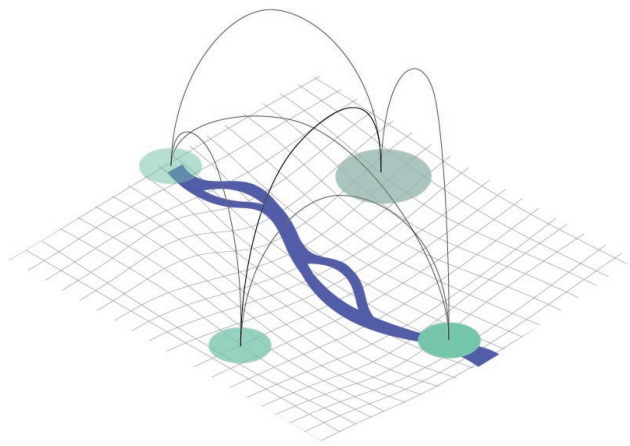
Building urban resilience is similar to ecological resilience, but it is important to understand the for this thesis, in order to restore the relationship of the people of Novi Sad and it's public space. Building urban resiliency capacity can be established in multiple ways. The first is to intertwine and combine functions, to switch functions through time to gain multifunctionality of the space. The second is redundancy and modularization of elements, such as infrastructure connections to provide backup systems. The third is to develop bio- and social diversity and at last to establish multi-scale networks to support functions by connectivity (Masoud and Holland, 2021), (Dhar and Khirfan, 2023) and (Ahern, 2011).



Urban resilience, made by author.

Watershed theory

In the watershed theory, the interconnection within a watershed or basin is recognised, which means action taken place at one scale or place within the watershed has consequences on another scale or place in the landscape. This is important to understand and reflect on the effect of a landscape approach for the city of Novi Sad and Kamenička ada therein (Hooimeijer, F.L., et. al., 2021). The context of this thesis is the middle stream of the Danube at Novi Sad, but this river landscape is as well connected to the whole Danube basin, and under influence of the upper stream. On the other hand, the river landscape of Novi Sad itself is influencing the river landscape of the lower stream and the Danube delta.



Interconnection in the watershed, made by author.

Main take away

The overall takeaway from this summary of the landscape approach, resilience theory and watershed theory is, firstly, that we now have an understanding of how the landscape system works. It has also become clear which specific approach we can use to achieve socially and environmentally resilient and flood-proof spatial development in the future.

The landscape approach provides tools to consider landscape structure as a basis for spatial development and to support the multifunctional purpose of this thesis.

To understand the structure of the landscape, the concept of *longue durée* was discussed, where the different dynamics and associated layers of the landscape became clear. It is important to understand that interventions can be made in the network layer and the occupation layer of the landscape.

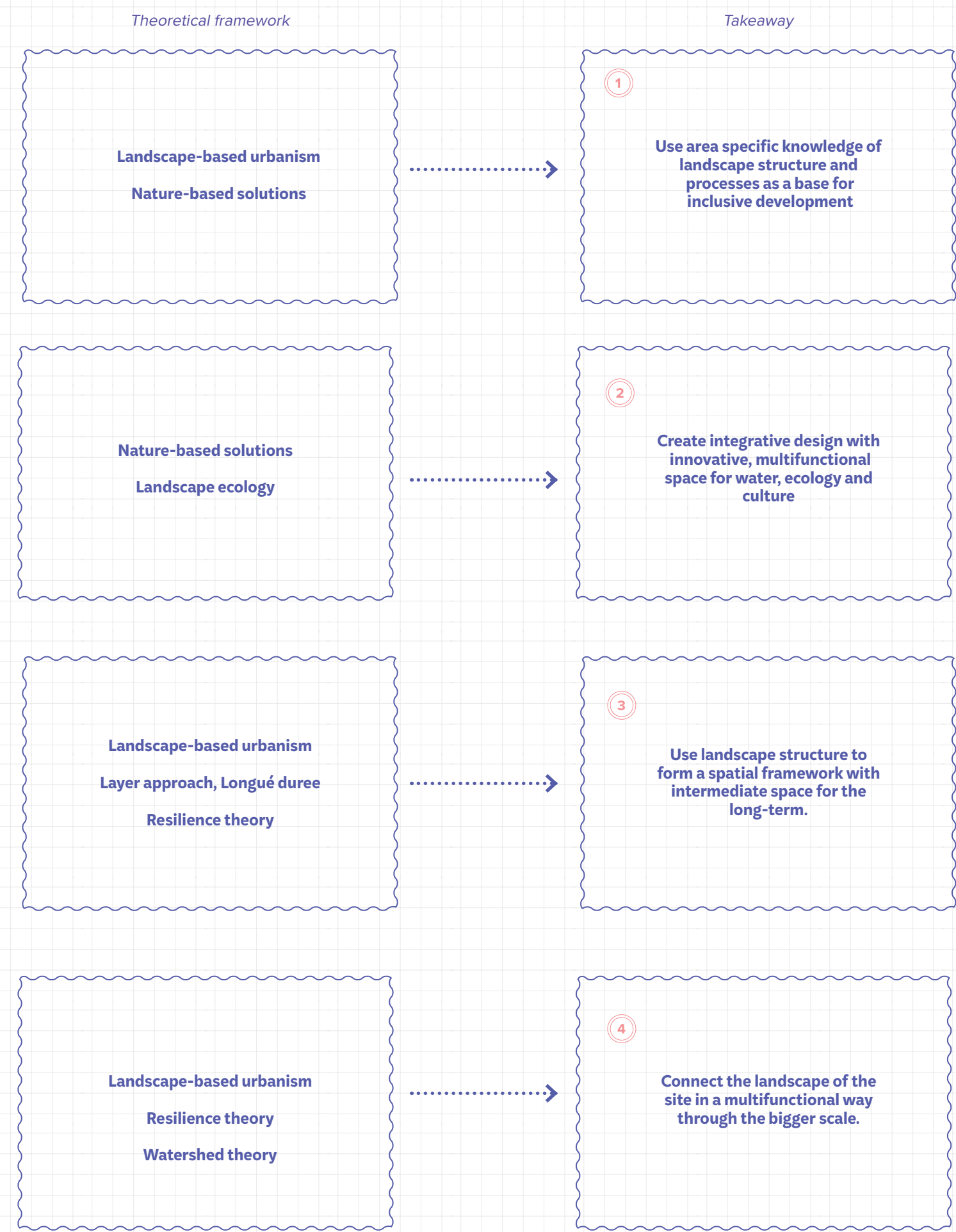
The landscape approach also highlighted the importance of nature-based solutions, which innovative multifunctional character offers valuable opportunities to be developed in the context of Novi Sad and its river landscape.

In order to apply NBS locally in the correct way, the study of landscape ecology has highlighted the importance of local ecological knowledge and landscape structures. Furthermore, the integral nature of landscape ecology lent itself to the development of integral design principles, which are in line with the aim of this thesis.

From studying resilience theory, it became clear that a strong landscape frame with intermediate space is crucial in times of changing conditions and unclear disturbances. We also understand now, what ecological resilience and urban resilience is, and what aspects we can apply to achieve this in the context of Novi Sad's river landscape. These handles provide knowledge for forming specific local strategies and later design principles applicable to Kamenička Ada.

From watershed theory, it became clear that the larger scale of the middle stream should be considered, and that the effect of the design on the midstream must be reflected upon.

The diagram on the opposite page shows the combinations of the different theories and what the specific takeaway is for shaping spatial strategies. The first takeaway is the importance of area-specific knowledge of landscape structures and to take these processes as the basis for inclusive development. The second takeaway is to create an integrated design with innovative, multifunctional space for water, ecology and culture. The third takeaway is to use the landscape structure to create a spatial framework with intermediate space for the long term. Finally, the last concluding takeaway from this study is to connect Novi Sad and Kamenička Ada in a multifunctional way across scales.

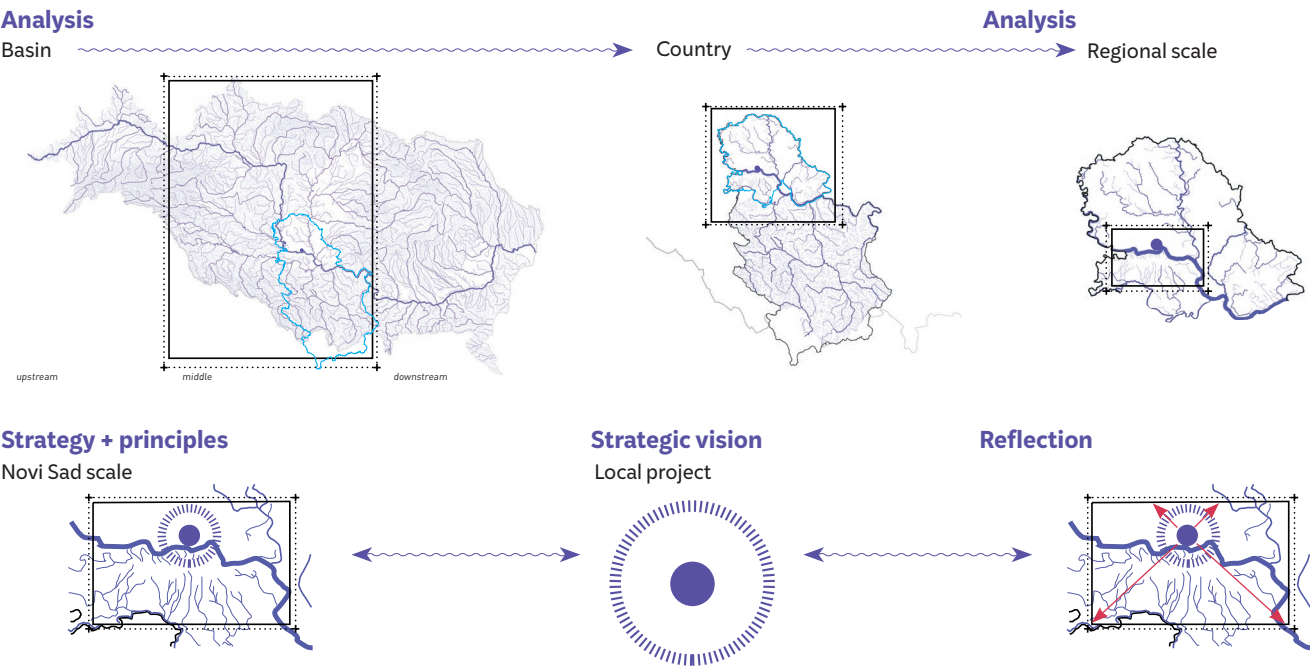


2.2 RESEARCH STRATEGY

The strategy of this research contains two components: moving through the scale and the guiding pillars of water, ecology and culture through analysis and design.

Moving through scale

Analysis at the level of the Danube basin provides understanding of the context of the country of Serbia and the region of Vojvodina in the middle stream of the river. On the regional scale of Novi Sad, appropriate strategies and principles are identified that can be applied to the local river island of Kamenička ada in order to develop a strategic vision for the regeneration of the Danube in Novi Sad. In order to connect the new findings, a reflection on the meaning of the strategic vision for Novi Sad is carried out.



Water, Ecology, Culture

As identified in the theoretical foundation, the water, ecology and culture are the components that together form the long-term landscape structure of the river landscape of Novi Sad. Because of this, these three elements are used as guiding elements or layers to analyse the landscape as a whole and to work out the strategic vision for Kamenička ada. In order to clarify the meaning of these pillars, guiding principles are formulated to conclude the research framework.

2.3 GUIDING PRINCIPLES

In this chapter, the guiding principles for the pillars water, ecology and culture are formulated. These principles stand at the basis of the spatial strategies and implementation of design principles.

Water

The first pillar, the water, has the guiding principle of allowing river dynamics, which implies a relational alignment between the natural flow of water and the landscape.

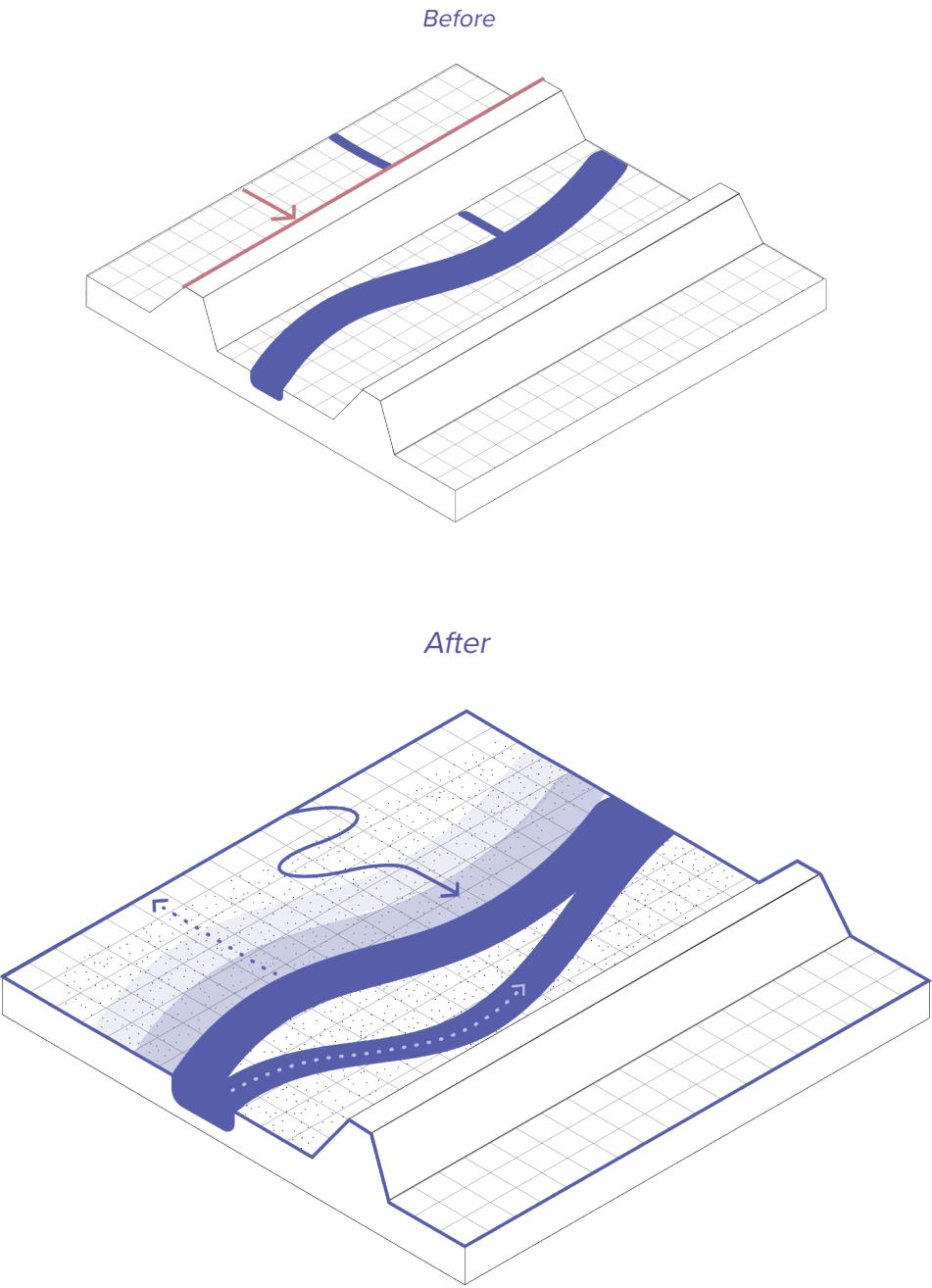
This principle is rooted in the landscape approach principle of using landscape structure as the basis for spatial development and working with natural processes rather than against them, an important principle of the NBS.

It also relates to building resilience and making space for the river and natural disturbances such as fluctuating river levels and occasional flooding. Allowing and making space for these river dynamics creates a sustainable landscape and reduces the risk of flooding in the city.

Allowing dynamic river processes is also important for restoring riparian ecology, and is important to make residents aware of the natural fluctuations of the system.

Allow river dynamics

Relational alignment water flow - landscape



Ecology

In relation to the second pillar, ecology, it's essential to assess the existing landscape structure and comprehend the connectivity within the system for spatial development.

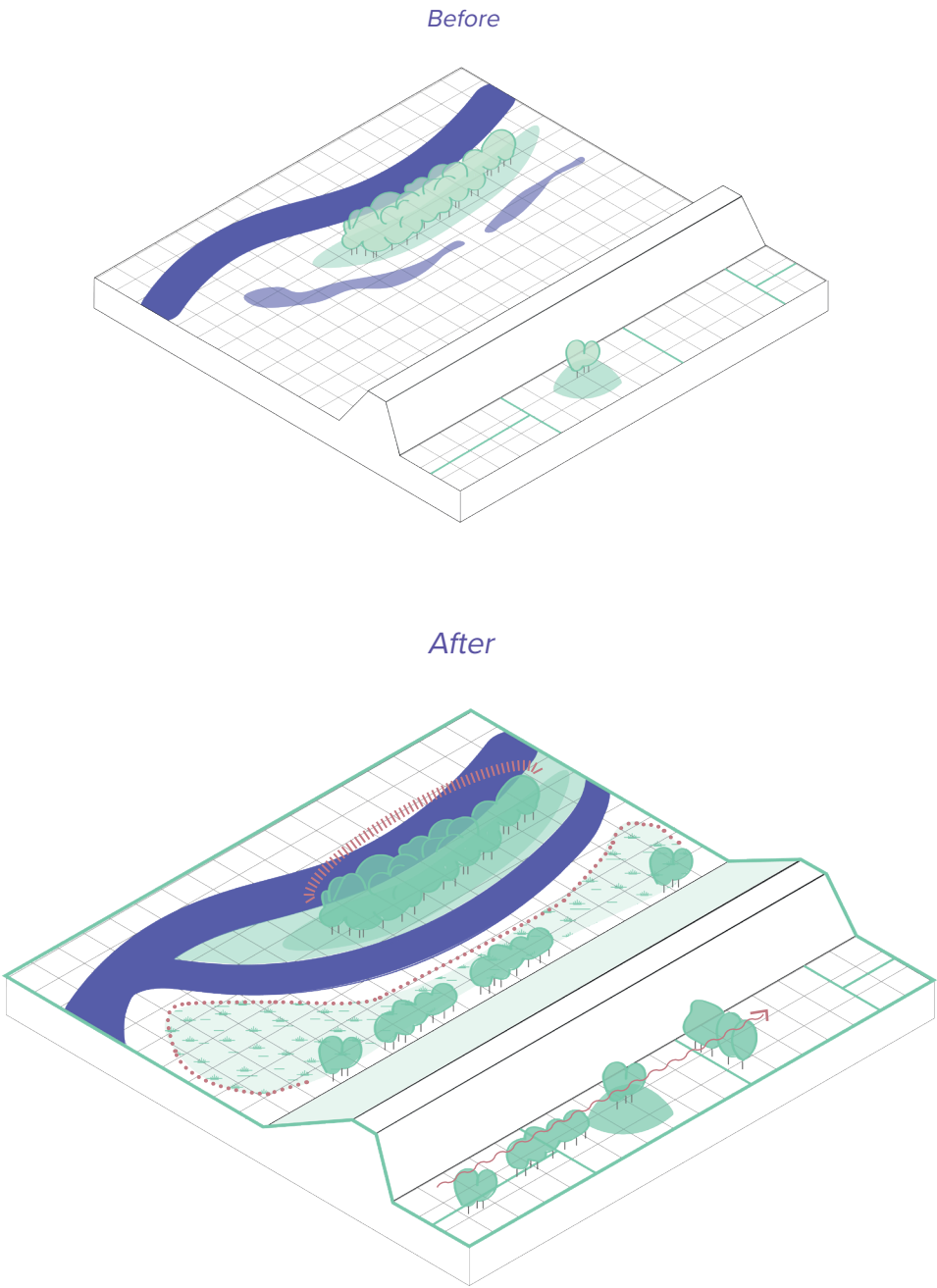
The principle of 'restore, create, and connect' is grounded in identifying ecologically valuable areas that have been degraded and fragmented. These areas should undergo restoration and be linked through the development of new ecologically significant areas, in this way enhancing connections within the landscape structure.

Also, this guiding principle aligns with the landscape approach and the principles of earlier mentioned principles of NBS and landscape ecology.

Moreover, within the context of ecological resilience, this principle serves as a strategy for establishing a resilient landscape framework capable of withstanding external disturbances.

Restore, Create, Connect

Reading the landscape + systems connectivity



Culture

The fundamental principle guiding the third pillar, culture, is to understand the current relationship with the river landscape and public spaces. This understanding enables the engagement of residents in spatial development, shaping public spaces positively.

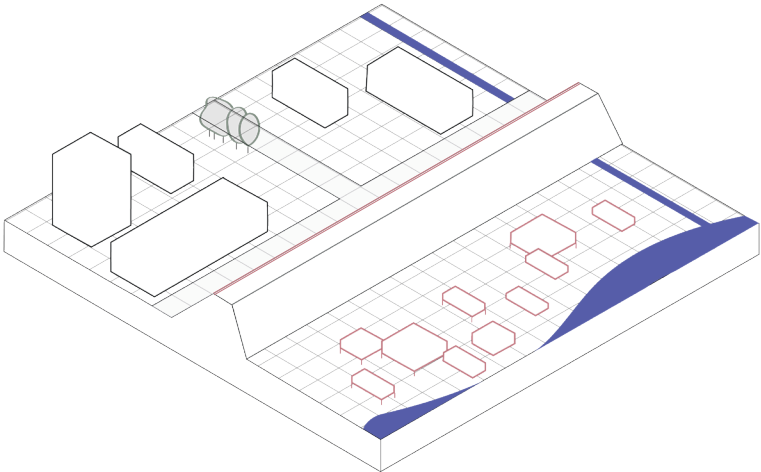
Emphasizing adaptability, it's essential to approach public spaces in a multifunctional manner to enhance urban resilience and strong social networks through accessible public space and housing.

Integrating culture into the principles mentioned earlier is crucial for fostering experiences and connections with the landscape, water, and ecology. Therefore, it's vital to emphasize the integration of these three principles to ensure mutually beneficial outcomes are achieved in an innovative manner.

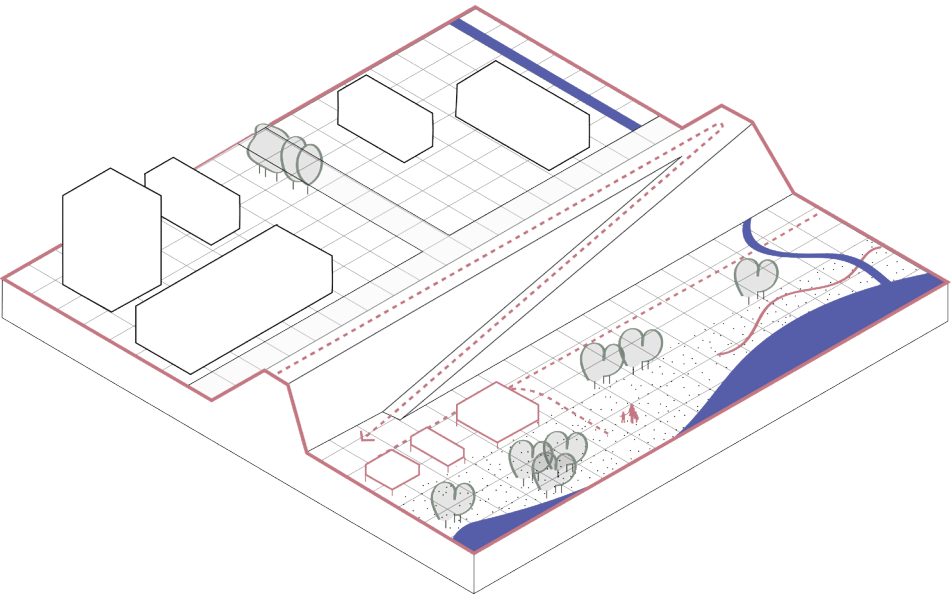
Understand, Involve, Adapt

Public health & Public good

Before



After



PART II

UNDERSTANDING THE DANUBE IN NOVI SAD

STRATEGIES AND PRINCIPLES



3. UNDERSTANDING THE DANUBE IN NOVI SAD

3.1 INTRODUCTION

3.2 THE RIVER

3.2.1 *Dynamic river processes*

3.2.2 *The middle stream river*

3.2.3 *The riparian landscapes*

3.3 THE DANUBE IN NOVI SAD

3.3.1 *Physiography of Vojvodina*

3.3.2 *The past: landscape development*

3.3.3 *Contemporary challenges*

3.4 CONCLUSION



3.1 INTRODUCTION

This chapter focuses on understanding the Danube river and the surrounding landscape, including the development of Novi Sad. First, a general picture of the important dynamic processes in a river and its formation is presented. This is followed by a more specific discussion of the processes in the middle stream of the river and the resulting morphological features. These processes influence the surrounding landscape through sedimentation and erosion and, together with the local soils, form the basis for the development of the riparian zone. After this general picture of the Danube river, the focus is on the specific development of the river in Novi Sad, with a brief introduction to the physiography of Vojvodina, followed by an analysis of landscape development in three time periods. Finally, the current challenges of the river landscape in Novi Sad and the opportunities for resilient and inclusive spatial development are discussed, followed by an overall conclusion.

3.2 THE RIVER

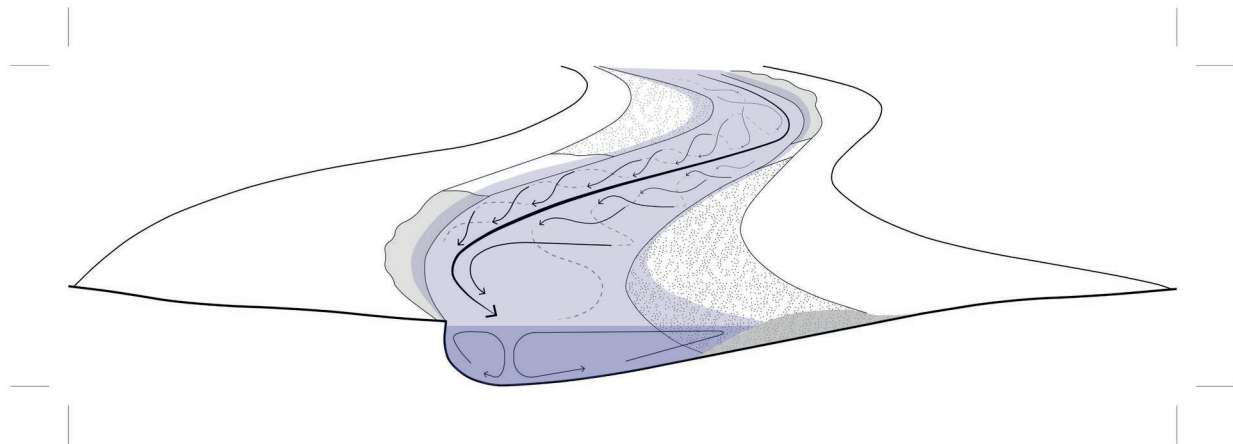
Rivers are dynamic and living entities that change their course over time, influencing the formation of entire landscapes. As water falls and flows downhill, it contains energy that can be released. The steeper the slope, the more energy is released. In this process, water can erode material, shaping the landscape. The water then carries the materials downstream, where it can sediment in slow-flowing areas (Prominski, 2012).

Dynamic river processes

The appearance of a river in the landscape is a result of complex morphodynamic development. The driving force is the primary river current, which carries the water downstream. Along is the secondary current, which is the rotation of water around the main flow. Two contrary spiral flows are formed, of which the outer flow accelerates in bends causing erosion. The inside flow is slowed down and sediments can deposit, seen in the image below.

The watel level of a river fluctuates in daily and even yearly cycles under influence of the local climate and seasons. The discharge rate, the volume of water expressed in m^3 / s can be linked to the water level of the river.

High water levels can cause flooding in the inland, which spread nutrient-rich river water and sediments (Prominski, 2012).



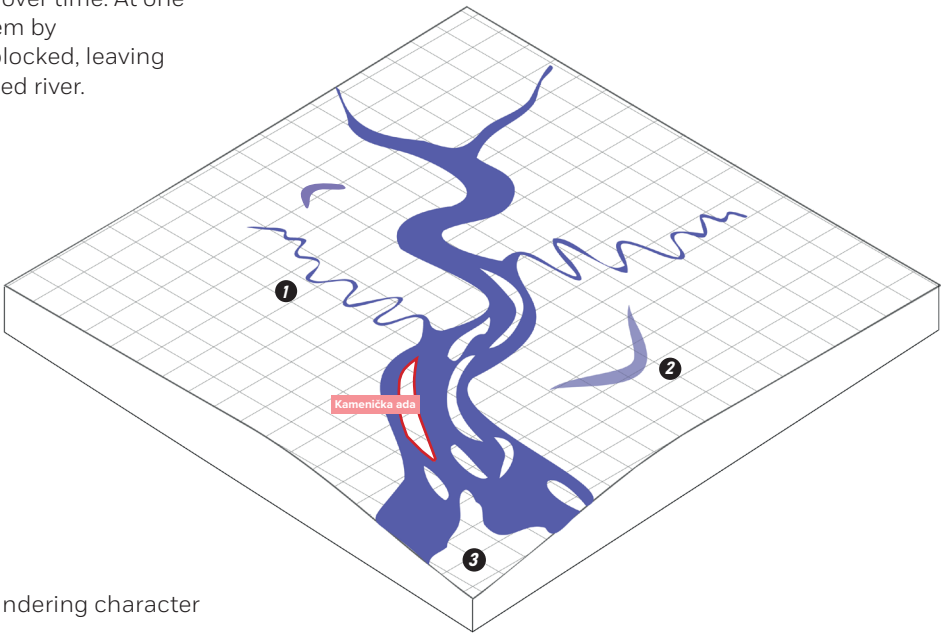
The dynamic river processes in a river bend, adapted from (Prominski, 2012).

The middle stream

In the context of this thesis, the Danube river channel is identified with characteristics typical of a braided river channel. Braided rivers represent one of three primary channel types, with approximately one third of the total river length in Northern Eurasia showing this pattern. The patterns observed in braided channels represent specific hydrological and ecological conditions.

In the section of the Danube at Novi Sad, sediment primarily consists of a mixture of gravel and sand. When water flow lacks force to carry these materials downstream, sediment accumulates, leading to the formation of gravel braid bars. Over time, vegetation takes root on these bars, strengthening their structure and developing them into fully vegetated forested river islands. This type of island-braided channel is typically situated in the mid-channel of rivers. The length of these island-braided patterns is directly related to the meandering of the channel and its width (Sergey et al., 2015), (Leopold et al, 1970).

Kamenička ada, the former river island at Novi Sad used to be a braid bar in an island-braided channel, which developed into a forested river island over time. At one point, due to change in the river system by human impact, the side channel got blocked, leaving Kamenička ada as a relic of this braided river.



- 1 Sidearms of the Danube have a meandering character
- 2 Slow meandering channel with cut/off loops
- 3 Braided riverchannel with floodplain islands

The riparian landscapes of the middle stream

In the natural environment, specific vegetation types develop along the riverbanks of the middle Danube. These vegetation patterns result in the formation of different types of riparian landscapes. The riparian habitat types can also be described as the potential natural vegetation type (PNV), which in this case encompasses a range of habitats, from gravel and sand to pioneer vegetation, willow scrub, alder, ash-alder forest, and oak forest (Egger et al., 2007). A more detailed overview of the specific plant communities and habitat conditions (flood duration, depth to groundwater) is provided in chapter 5.

It is crucial to recognise that the riparian landscapes are defined by the annual flooding duration and the soil conditions. The riverine forest landscapes that can be observed today are predominantly composed of softwood and hardwood species. Furthermore, more open wetland forest and scrub are an important landscape type (Dragan et al., 2023).

The riparian landscapes of the Danube are currently undergoing a process of terrestrialisation and habitat fragmentation. This is clear by the absence of dynamic habitat and the decline in pioneer vegetation (Egger et al., 2007).



Riparian landscape of Kamenička ada, in Novi Sad.

3.3 THE DANUBE IN NOVI SAD

In conclusion, the Danube in Novi Sad is characterised by a dynamic water level, exhibiting a daily and yearly cycle of fluctuations. The processes of erosion and sedimentation, coupled with the specific hydrological and ecological characteristics of the site, have resulted in the formation of an island-braided channel, which is typical of the middle stream of the river. The riparian landscape is predominantly characterised by well-developed softwood and hardwood forest, with a notable absence of dynamic habitats and pioneer vegetation. The former river island of Kamenička Ada is an example of the loss of this dynamic habitat in the landscape.



Boat along the river bank of Kamenička ada.



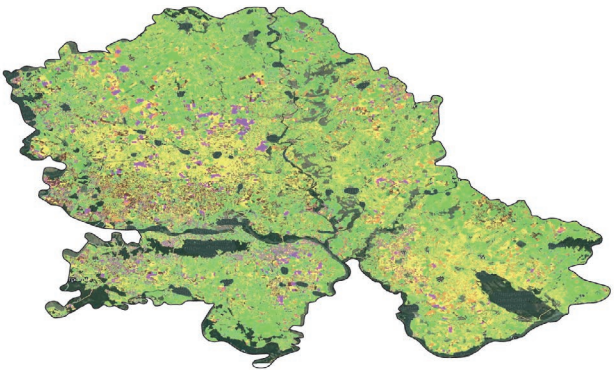
Petrovaradin fortress in Novi Sad with riparian forest patches.

Physiography of Vojvodina

To gain understanding of the development of the river landscape in Novi Sad, the physiological characteristics of the landscape are researched. Given the lack of specific information on the context of Novi Sad, an analysis was conducted for the broader Vojvodina region.

The reconstruction of landscape development involved examining the layers of the current landscape and the identification of fragments that offer insights into its historical evolution. This approach aligns with the layered approach and *longué duree* discussed earlier (chapter 2).

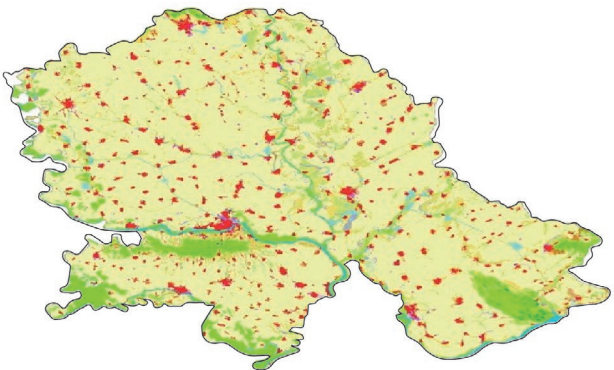
Exploring the subsurface of Novi Sad involved studying its geomorphology, soil composition, and water system. The water system is furthermore significant for understanding the network layer, alongside current land use patterns. Given that agriculture covers nearly ninety percent of the region, an examination of the various agricultural practices undertaken was also conducted.



Agricultural types

- Weath
- Maize
- Soybean
- Sunflower
- Sugar beat

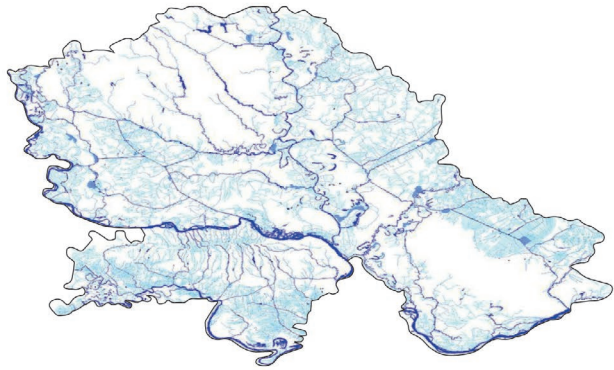
(Copernicus, 2012)



Land use

- Agriculture
- Urban, industrial areas
- Forests
- Waterbodies

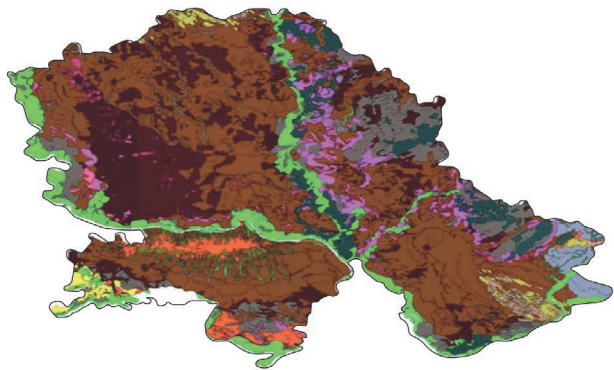
(Copernicus, 2012)



Watersystem

- Main waterways
- Second waterways

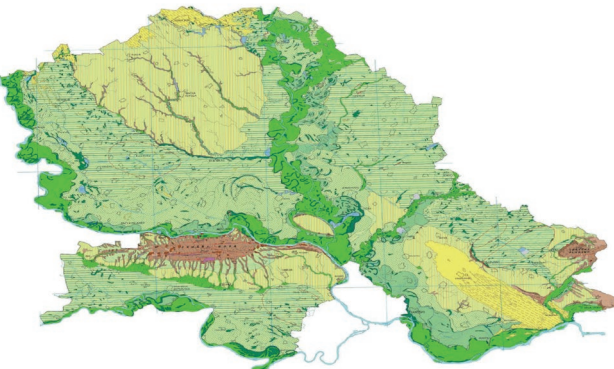
(Geofabrik, 2024)



Soils

- Chernozem
- Fluvisol
- Cambisol
- Vertisol
- Solonchak and solonetz

(Mrvic et al, 2013)



Geomorphology

- River-terrace sediment and flood area
- Alluvial sediments floodplain
- Metamorphic rocks
- Loss, clay and sand
- Sandstone, calcium stone

(Koscal, 2005)

5000 BC: The wild river landscape and early cultures

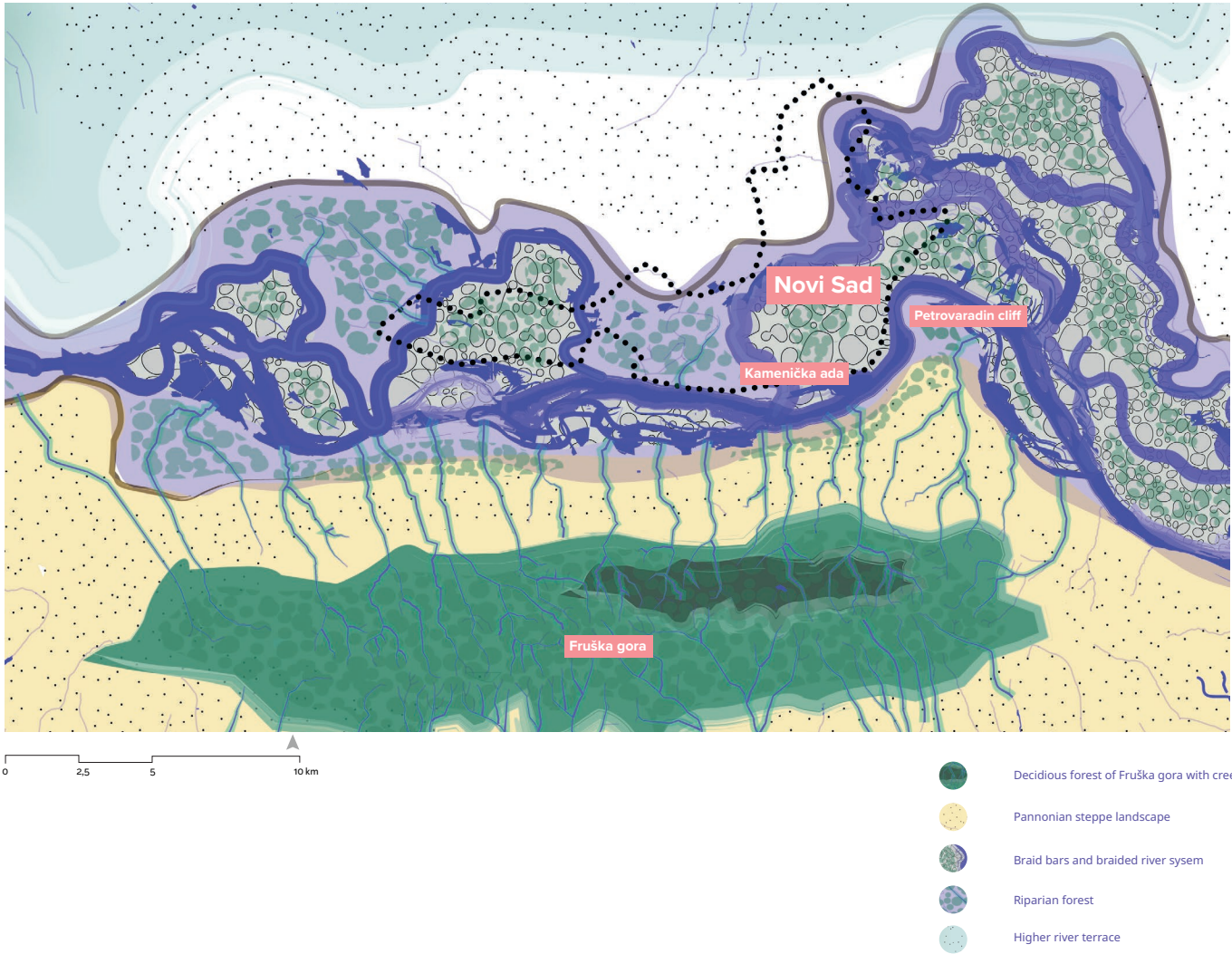
In ancient times, the Danube river at Novi Sad was a braided river system comprising multiple channels and gravel braid bars and river islands. The river channel had the opportunity to shape the surrounding landscape, resulting in the formation of different river terraces through time. Riparian forest and pioneer vegetation were abundant, with Pannonian steppe on loss soils and the mountain ridge of Fruška gora in the inland (Maric, 2014).

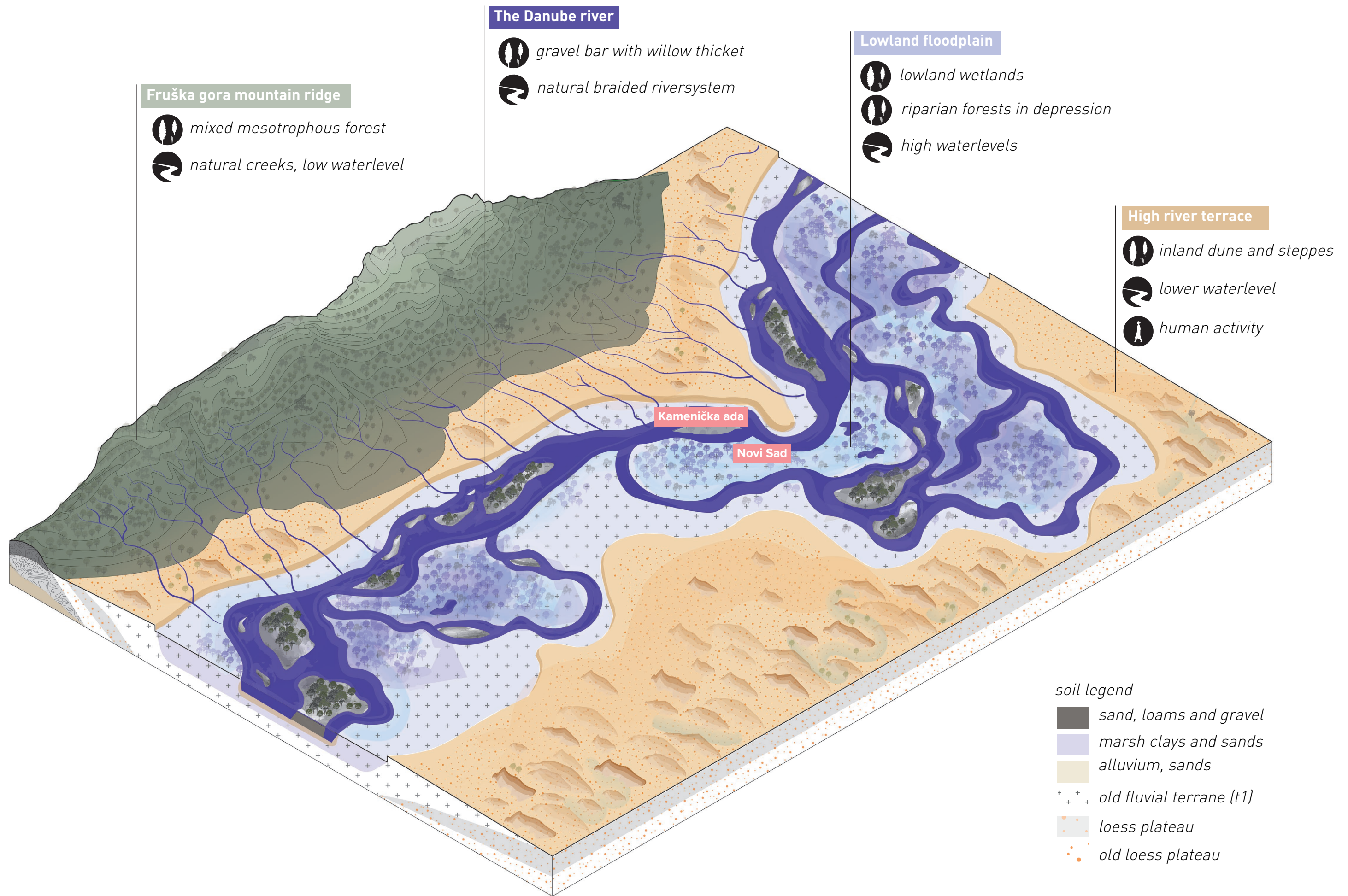
The oldest evidence of Neanderthals in South-eastern Europe has been preserved in the loess deposits accumulated on the Petrovaradin cliff at Novi Sad, which date back to 40,000 years ago (City museum NS, 2024).

The timeframe of circa 5000 BC, the late Neolithic and early Copper Age is marked by the Vinca and Starcevo cultures in the Danube region of Serbia. Important settlements, such as Gomolava, were located on higher-lying areas of the riverbanks of the Danube River in Novi Sad. Additionally, settlements of the Vinca culture were discovered on the Petrovaradin cliff.

The areas of settlements were situated close to wetlands, creeks, and rivers, ensuring access to fresh water. However, they were situated at a sufficient distance from these water sources to provide flood safety. The dense forests of Fruška gora provided wood from which small rectangular houses were constructed (City museum NS, 2024).

The river island of Kamenička ada was a wild braid bar or island, lying inbetween active channels of the Danube.





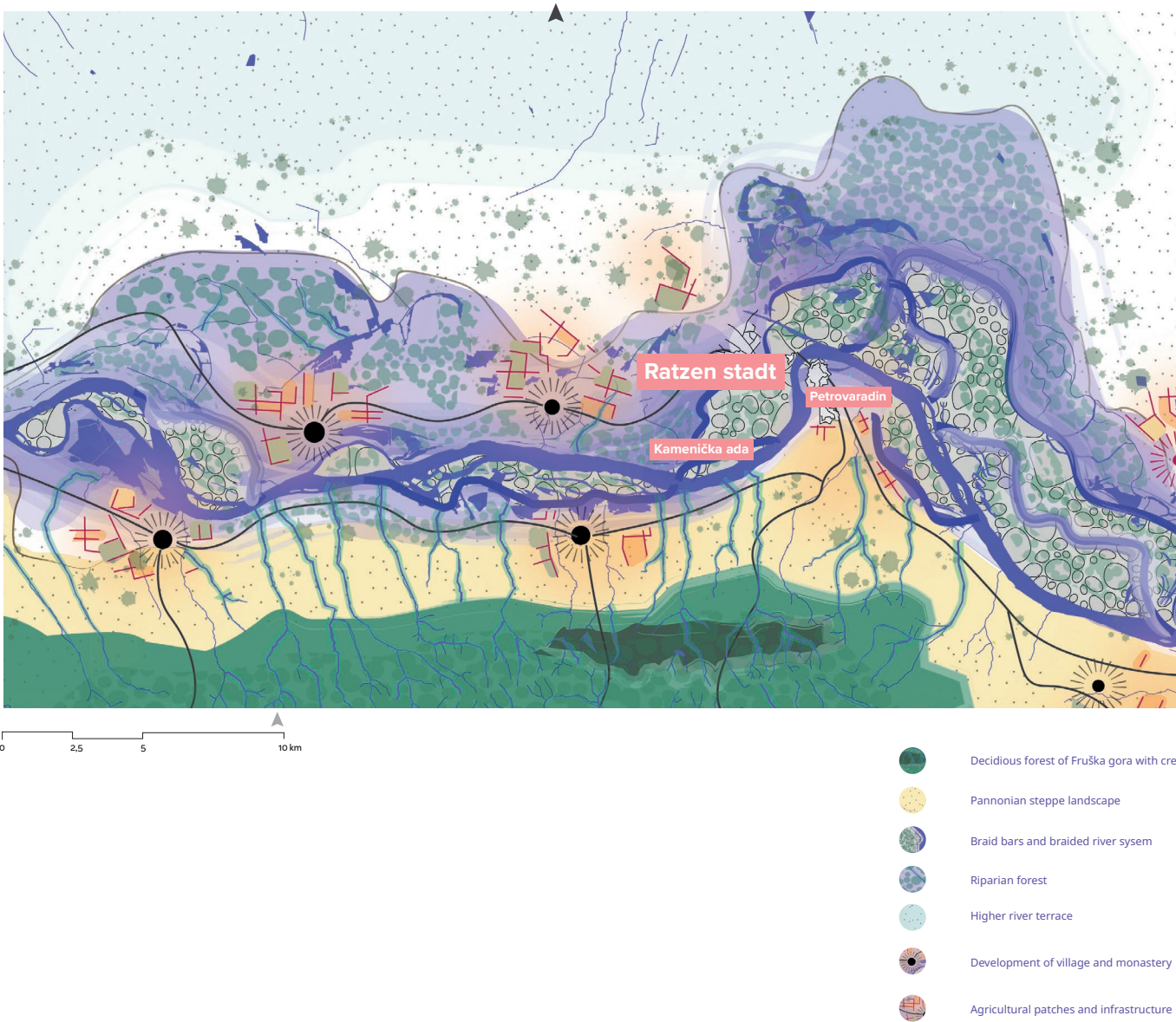
1700/1800: The subdued river landscape and 'Ratzen stadt'

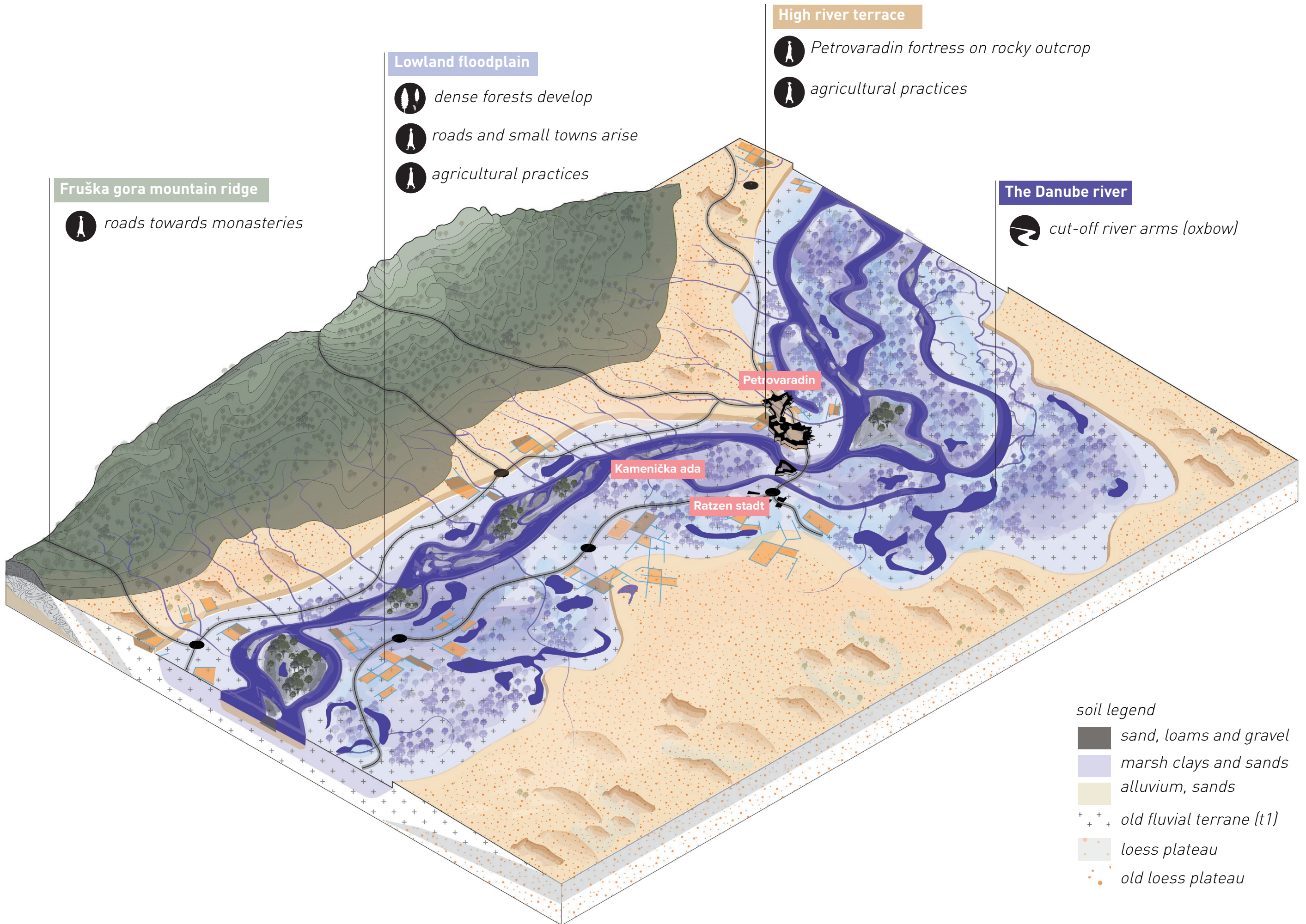
The Habsburg monarchy settled in the area in the 17th and 18th centuries and developed the Petrovaradin fortress on a medieval structure on the Petrovaradin cliff, a rocky flood-proof outcrop that offers a strategic view of the Danube. During the construction of the Habsburg fortress, particular attention was paid to the establishment of a system for the delivery of fresh water to the fortress. Consequently, a well, designated the Great War Well, was excavated with an underground network that connects to the Danube River (City Museum of NS, 2024).

The Serbs were compelled to settle in a city that had been established by the Habsburg monarchy and was known as Ratzenstadt, which translates to 'Serb city' in the local language. The new city was situated in the middle of the floodplain, in the lower lying left bank of the Danube. The city's core was established on a higher ridge within the wetland, yet it remained sensitive to flooding (Ravnoplov, 2024).

Similarly, small towns began to emerge, as did monasteries, and both began to cultivate crops in the fertile lowland areas and floodplain. The infrastructure between the villages, monasteries and cities began to develop, cutting into the active floodplain of the river. As a result of the fluctuating water levels, small dikes were constructed as a form of protection (City of Novi Sad, 2011).

During this period, the Kamenička Ada river island was still part of the active braided river system. However, as the urban context developed, the river's morphology began to change.





Fruška gora mountain ridge

- roads towards monasteries

Lowland floodplain

- dense forests develop
- roads and small towns arise
- agricultural practices

High river terrace

- Petrovaradin fortress on rocky outcrop
- agricultural practices

The Danube river

- cut-off river arms (oxbow)

soil legend

- sand, loams and gravel
- marsh clays and sands
- alluvium, sands
- old fluvial terrane (t1)
- loess plateau
- old loess plateau

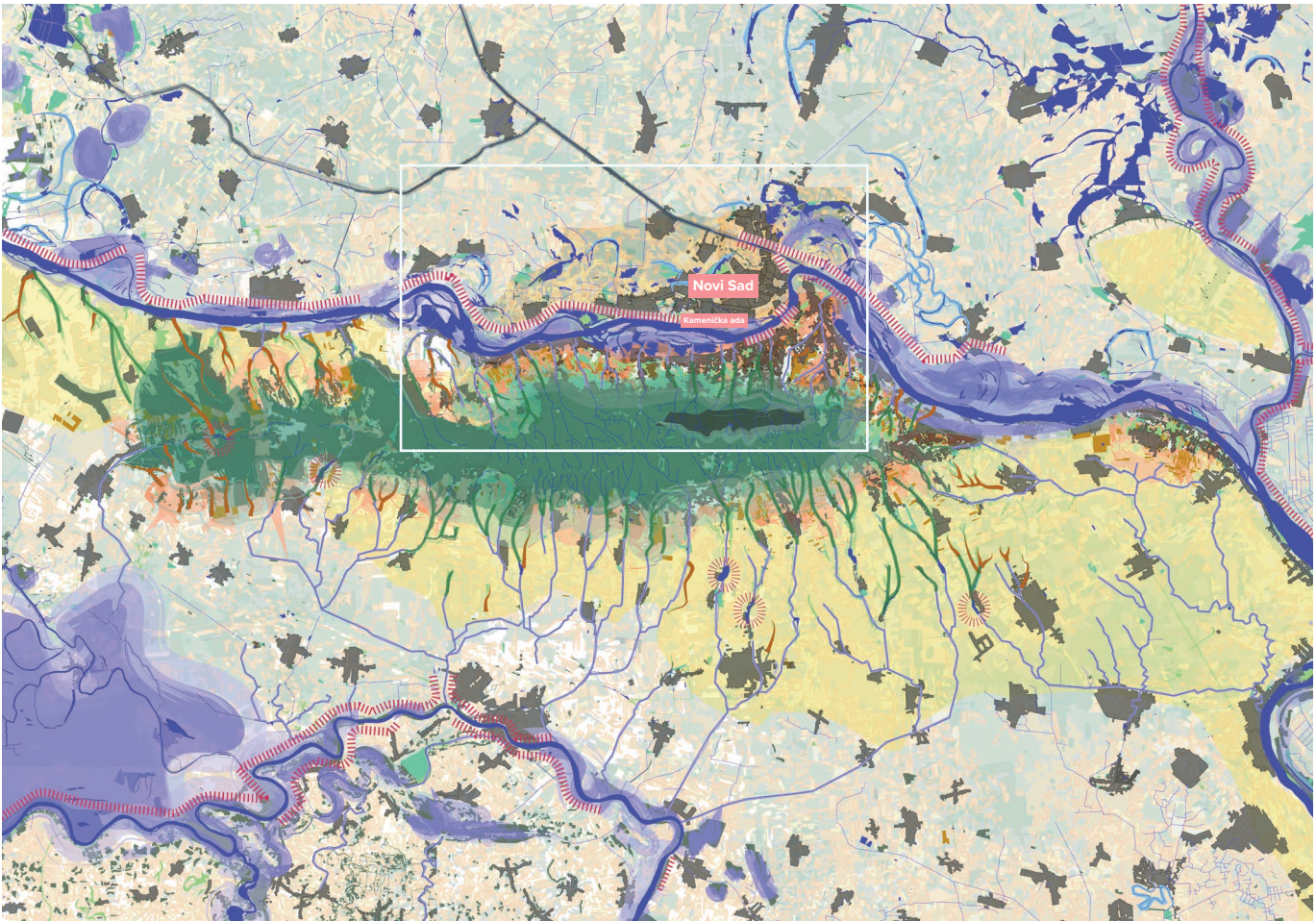
2000s: The constrained river landscape and Novi Sad

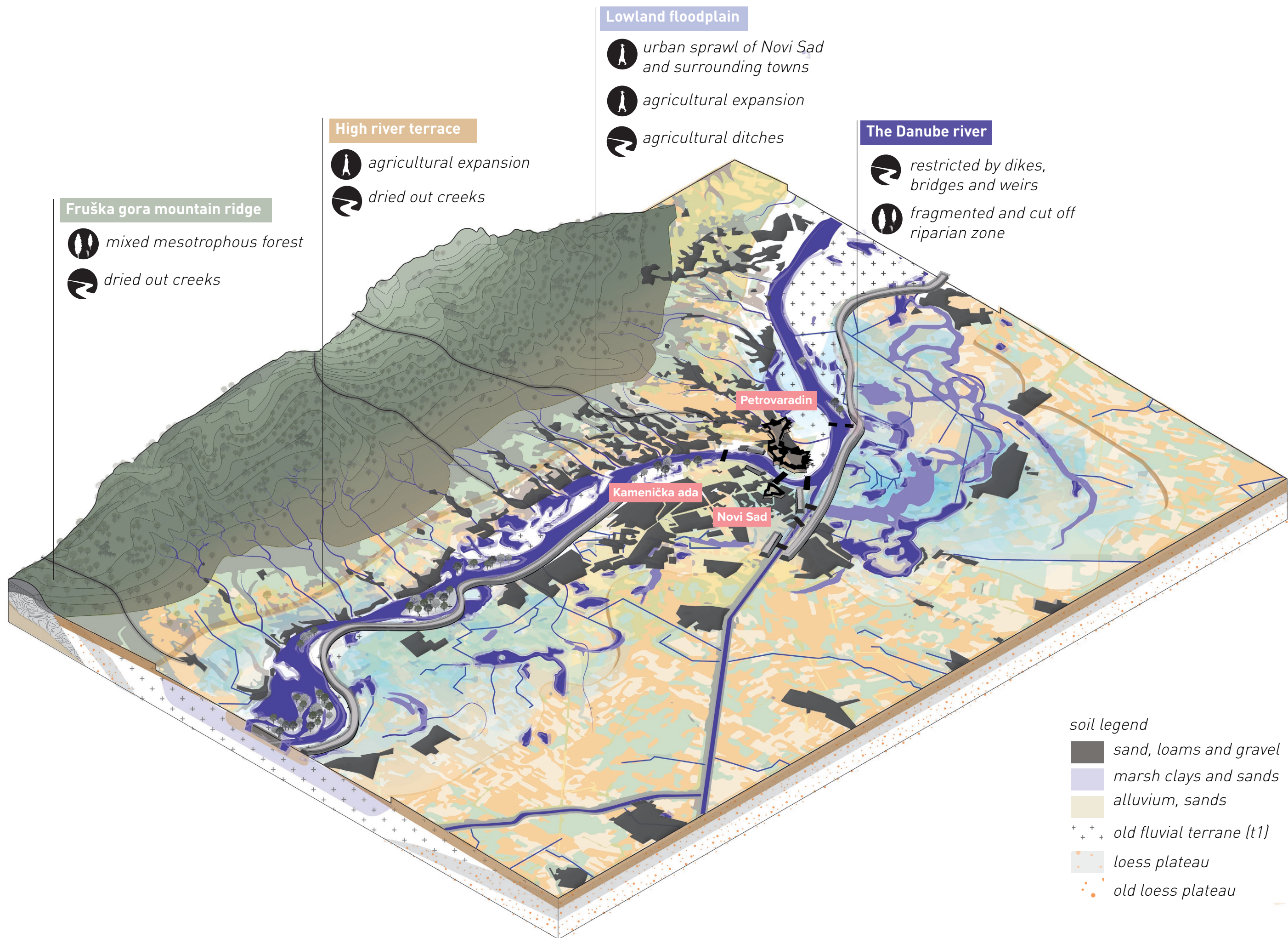
In the 21st century, the city of Novi Sad has developed into a meeting place of different cultures and civilisations, and a city of European value. It is situated at the intersection of waterways, land routes and newly developed commercial channels (Dragovic, 2005). Novi Sad became the capital of the autonomous province of Vojvodina and is currently home to approximately 350,000 citizens (City of Novi Sad, 2011).

In parallel with the advancement of civilization, the steppe landscapes have been transformed into active agricultural fields, primarily dedicated to the cultivation of wheat and maize.

Furthermore, the expansion of agriculture into the former floodplain has resulted in a reduction in the available space for the river to flow. In order to protect the city of Novi Sad, which urban areas and infrastructure have expanded into the former floodplain, strategically placed dikes were developed for flood protection, further constraining the river's space. This has resulted in the river being limited to a single channel, with the image of a constrained river.

The strategically placed dikes limit the access and relationship between the people of Novi Sad and the floodplain, Kamenička ada. In this time period, Kamenička ada is cut off from the active river system and no longer a river island in a braided channel.





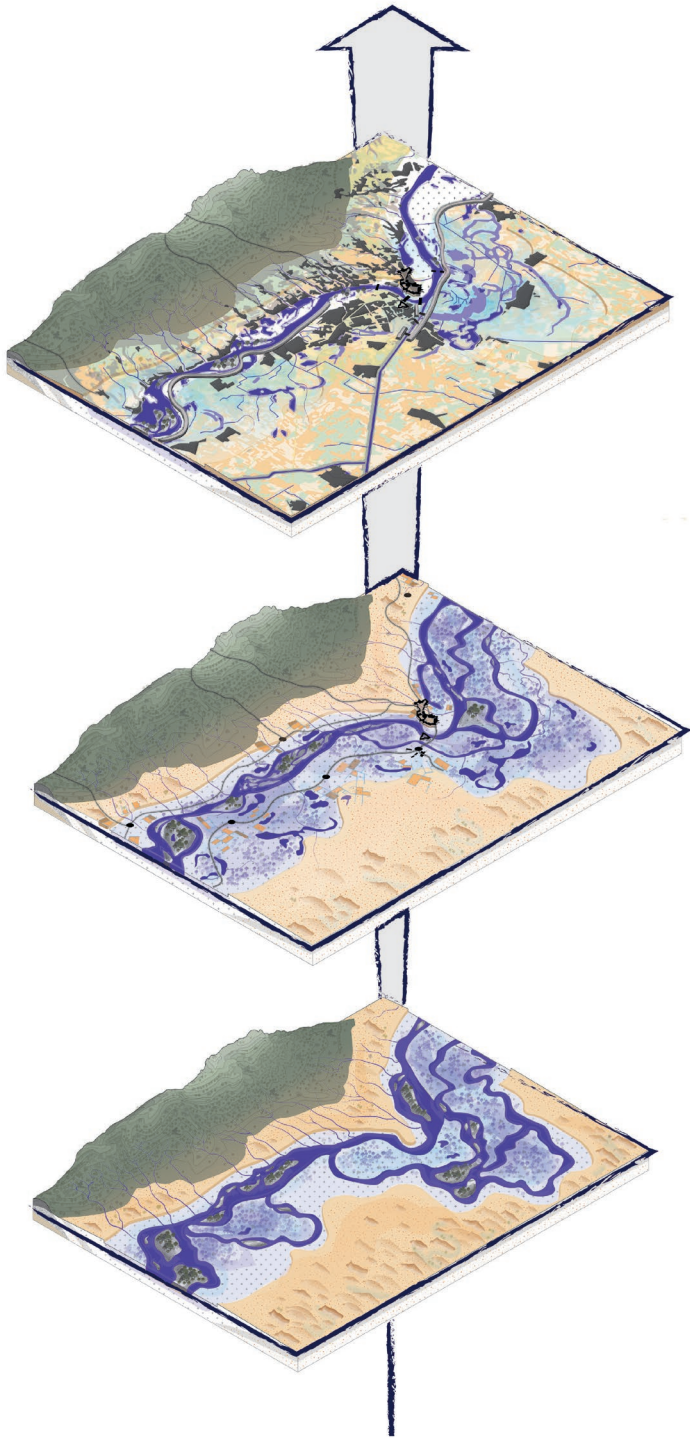
Conclusion landscape development

The landscape development of the surroundings of Novi Sad, shaped by the Danube river, reflects significant landscape changes over time. Originally, the Danube flowed as a braided river system, forming diverse riparian ecosystems and shaping the landscapes over time. Human settlements like Gomolava and the Vinca culture emerged in harmony with this wild landscape.

As civilisations developed, strategic fortifications such as the Petrovaradin fortress were built, emphasizing the area's importance. The landscape was in balance and the river subdued, however, settlements faced challenges due to their vulnerability to flooding.

With urbanisation and agricultural expansion, the natural landscape underwent significant alteration. Steppe landscapes transformed into agricultural fields, and floodplains were used for human settlement and cultivation. In response to floods, protective measures like dikes were implemented to mitigate flood risks.

Today, Novi Sad stands as a cultural icon, but its landscape bears the marks of human intervention, illustrating the constrained river system and its natural dynamics.



The constrained landscape



The subdued landscape

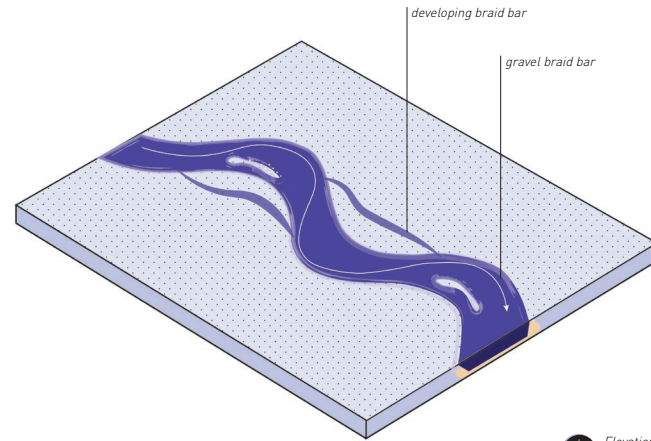
River dynamics



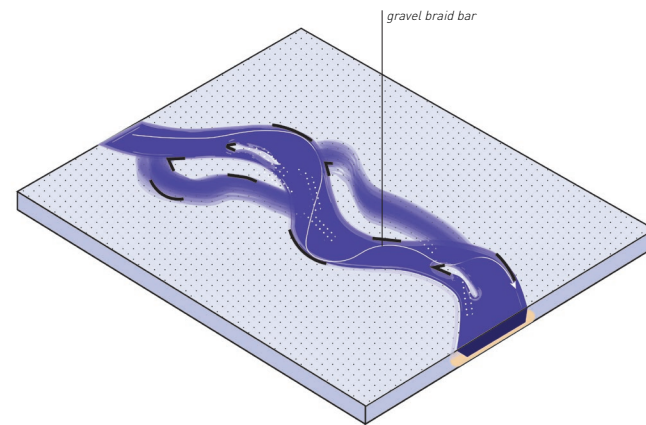
The wild landscape

Source (Municipality of Novi Sad, n.d.)

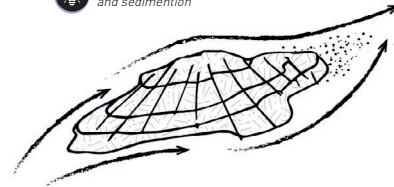
1 single wandering channel flowing through floodplain



2 braided channel with bars

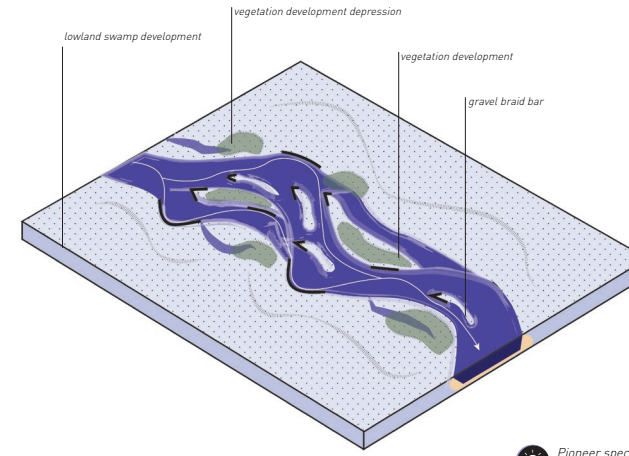


Elevation, erosion and sedimentation

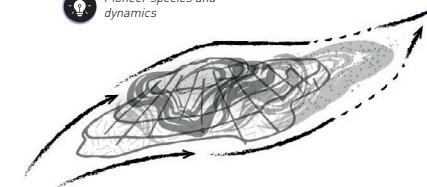


- erosion sand bank
- dominant flow river
- sediment deposit
- active floodplain
- marsh clays and sands
- alluvium, sands

3 braided channel with vegetation development

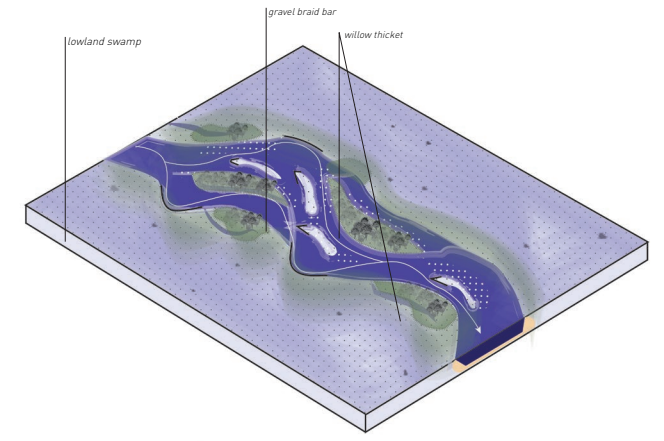


Pioneer species and dynamics

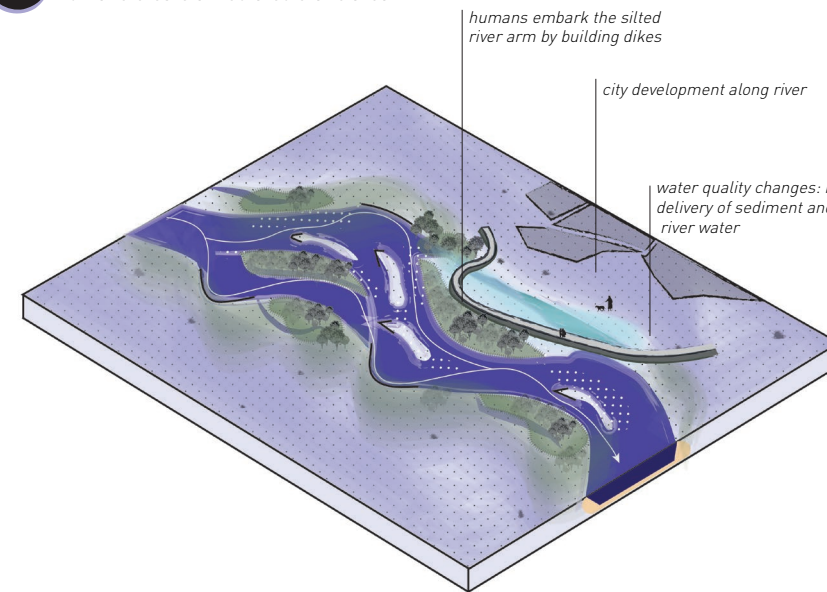


- erosion sand bank
- dominant flow river
- sediment deposit
- active floodplain
- marsh clays and sands
- alluvium, sands

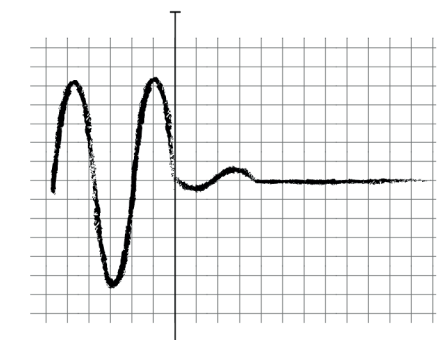
4 vegetation slows the flow



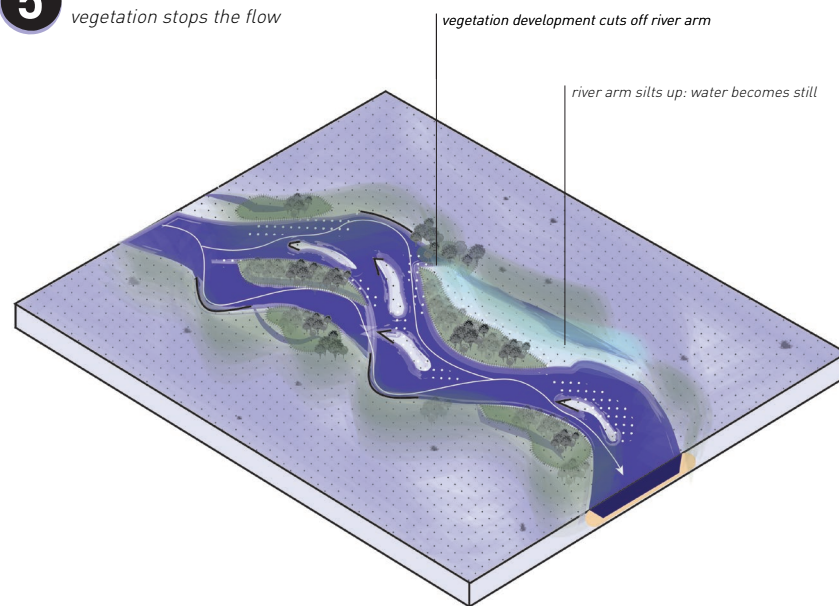
6 humans create an isolated static area



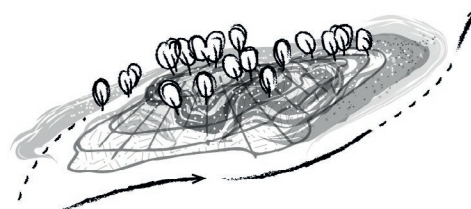
ending the floodplain stops the water and succession dynamics, slowly clugs the system



5 vegetation stops the flow



Sub and climax stages of succession



A landscape of succession

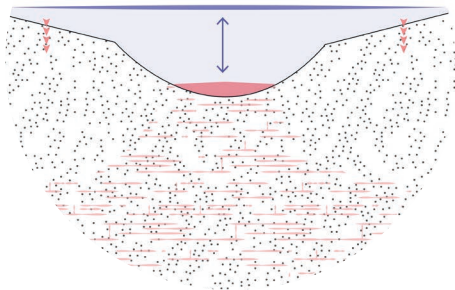
The analysis of the evolution of the landscape showed that the river landscape is in fact a landscape of succession, in which the different stages of the formation of the river and the natural succession are linked. When human activity enters the floodplain, the natural succession processes are abruptly stopped, resulting in the static natural river processes that we observe today, for example, in Kamenická ada. In the illustrations above, the steps of the succession can be found, with the last step related to the impact of human activity on the system.

Contemporary challenges

The contemporary challenges Novi Sad is facing is related to the sensitive position in the river landscape the city still has, which explains the occurrence of multiple floodings over the last decades. The implemented dikes constrict the former floodplains, the original braided river channel and riparian ecological growth. Furthermore the dike has become an obstacle between the city and the floodplain, limiting the river island of Kamenička ada.

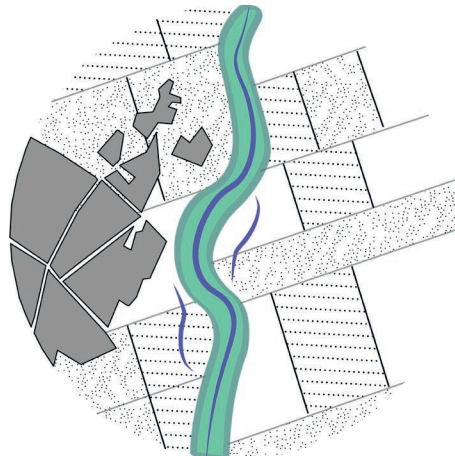
As mentioned before in the introduction, three main issues have been identified related to important elements constraining the river landscape over time, which became clear in the landscape development analysis. The first issue in the unbalanced freshwater availability, leading to flood risks and droughts. The second concern is the deterioration of the braided system and riparian zone. Lastly, there's the disconnection between the people of Novi Sad and the river floodplain, Kamenička ada.

I. Water



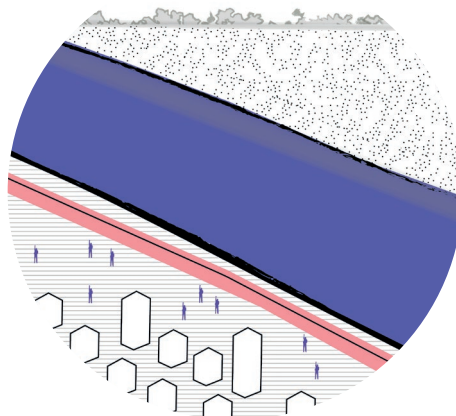
Unbalanced fresh water availability

II. Ecology



Loss of river braids with riparian buffer

III. Culture



Segregation between the city and the river

3.4 CONCLUSION

In conclusion, we now have a clear understanding of the main components of this thesis. Firstly, we have a clear understanding of the morphological processes of the Danube river at Novi Sad, including its formation over time and the specific character of the mid-stream island-braided channel.

Furthermore, we have examined the physiography of Vojvodina and the landscape development behind it in three time frames. This landscape development has demonstrated how the natural landscape has undergone significant alteration as a result of the development of Novi Sad and the surrounding towns. This has resulted in a river landscape which bears the marks of human intervention.

The three main focus issues related to the constrained river landscape have been linked to this landscape development and the concept of landscape succession.



4. STRATEGIES AND PRINCIPLES FOR NOVI SAD

4.1 INTRODUCTION

4.2 STRATEGIES FOR KAMENIČKA ADA IN CONTEXT

PRECEDENT STUDIES

Spiegelwaal, Nijmegen

Bosbaan, Amsterdam

River forest island, Changsha

Rowing club, Shanghai

4.3 DESIGN PRINCIPLES

4.3.1 *Water*

4.3.2 *Ecology*

4.3.3 *Culture*

4.3.4 *Synergies between principles*

4.4 LESSONS LEARNED

4.1 INTRODUCTION

This chapter begins with a definition of a strategy, followed by an overview of suitable strategies for the spatial development of Kamenička Ada and its context. The suitable strategies are then explained and linked to the theoretical foundation and earlier takeaways.

Subsequently, the definition of a principle is provided, followed by the suitable principles for Kamenička Ada, which are categorised into the three pillars: water, ecology and culture. These principles are based on the theoretical foundation, strategies and precedent studies.

4.2 STRATEGIES

In this thesis, a strategy has the definition of specific physical interventions made in the landscape. Based on the theoretical foundation and precedent studies, four spatial strategies are developed, suitable for the local context of the river landscape of Novi Sad and Kamenička ada. Each strategy is linked to the guiding principles of water, ecology and culture. The character of these strategies is in line with the aim of this thesis, the development of a flood-proof, socio-ecologically inclusive Novi Sad.

The next page provides an overview of the theoretical foundations and the spatial strategies to which they are linked. The following page gives an overview and explanation of the four strategies.

Landscape-based urbanism

Nature-based solutions

Use area specific knowledge of landscape structure and processes as a base for inclusive development

Landscape-based urbanism

Layer approach, Longué duree

Resilience theory

Use landscape structure to form a spatial framework with intermediate space for the long-term.

Create integrative design with innovative, multifunctional space for water, ecology and culture

Connect the landscape of the site in a multifunctional way through the bigger scale.

Nature-based solutions

Landscape ecology

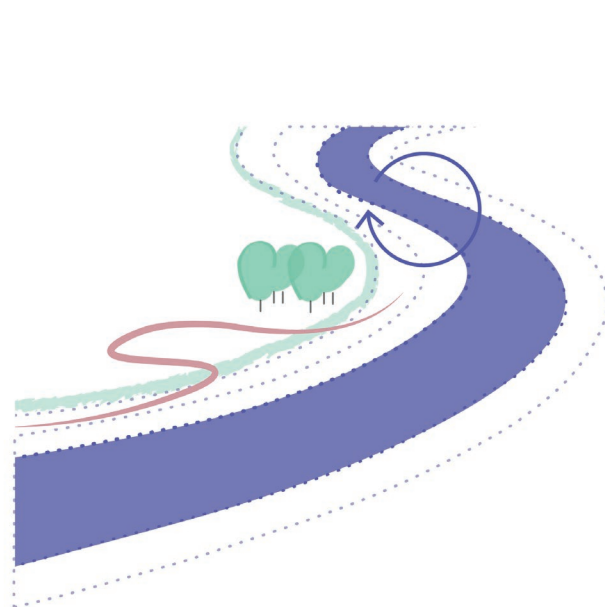
Landscape-based urbanism

Resilience theory

Watershed theory

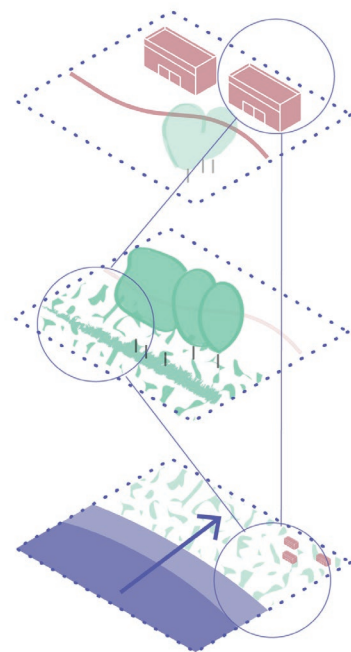
Four leading strategies

The first strategy is linked to the takeaway from Landscape-based urbanism and NBS to use specific knowledge of landscape structure and processes as a base for inclusive development. Cyclic river design requires specific knowledge on the river fluctuations and ecological processes, through which a strong socio-ecological structure can be developed for Novi Sad. The strategy gives room for the river and allows natural dynamics for flood mitigation, restores ecology and gives opportunity for recreation.



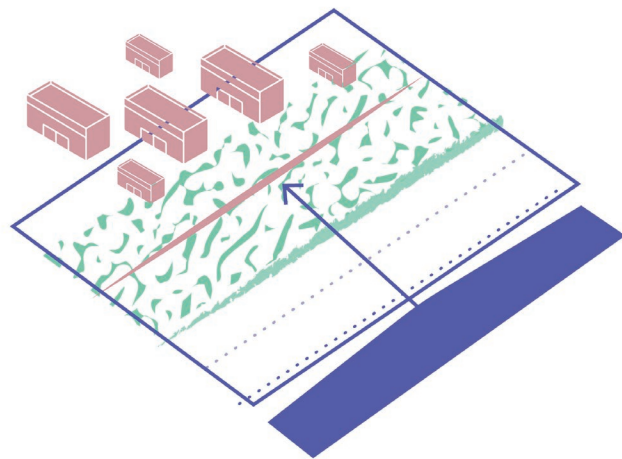
Cyclic river design with strong socio-ecological structure.

The second strategy is linked to the takeaway from NBS and Landscape ecology, which is to create integrative design with innovative, multifunctional space for water, ecology and culture. This leads to the strategy to create mutually beneficial design elements in the landscape, for water safety, ecological development and recreation and housing.



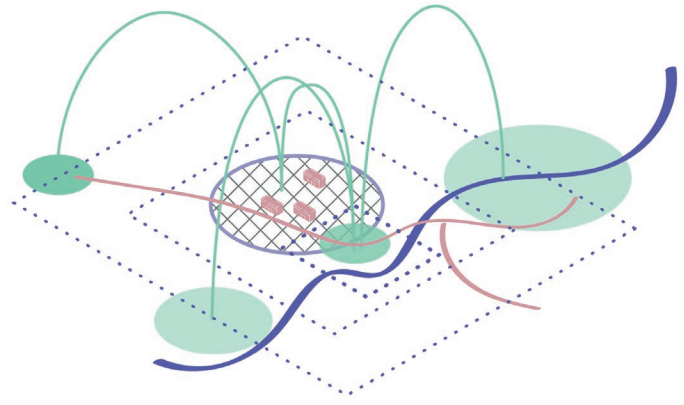
Create mutually beneficial design elements: water safety, ecological development, recreation and housing.

The third strategy is based on the findings of Landscape-based urbanism, longué duree and resilience theory. It suggests using the landscape structure to form a spatial framework with intermediate space for the long term. This leads to the strategy to design buffer zones of intermediate space for long-term adaptive capacity. This is related to intermediate space between the river and the city, to maintain a strong landscape framework under intense disturbances.



Design buffer zones of intermediate space for long-term adaptive capacity.

The last strategy is based on the takeaway from Landscape-based urbanism, resilience theory and the watershed theory to connect the landscape of the site in a multifunctional way through the scales. The strategy is to connect Kamenička ada to Novi Sad in its middle stream context with the water, ecological structure and social network.



Connect Kamenička ada to Novi Sad in its middle stream context with the water, ecological structure and social network.

PRECEDENT STUDIES

The study of precedent studies provides insight into the formation of design principles and the translation of spatial strategies into a strategic vision or design. In order to gain knowledge for the application of the vision to Kamenička ada, design examples of river islands in similar urban contexts were considered. The functions, the division of functions and the underlying processes of the landscape in the design are important sources of inspiration. The municipality of Novi Sad has the wish to create a rowing track for the city, which is considered by looking at rowing track designs in natural context.

Spiegelwaal, Nijmegen

Ruimte voor de Waal or 'Room for the River' is a notable project in the Room for the River programme, in which the Netherlands is redesigning its river floodplains throughout the country to improve flood protection. The Spiegelwaal project in Nijmegen is driven by the risk of flooding from the Waal and the need to improve the waterfront and the relationship between the city and its river. Key features of the project include the widening of the river, the development of a Spiegelwaal bypass, new bridges and infrastructure, and public green spaces. The development of the Spiegelwaal results in a new context in which a river island is created. The river island is a river park, beach and urban extension in one, with housing developments at a higher point on the island.

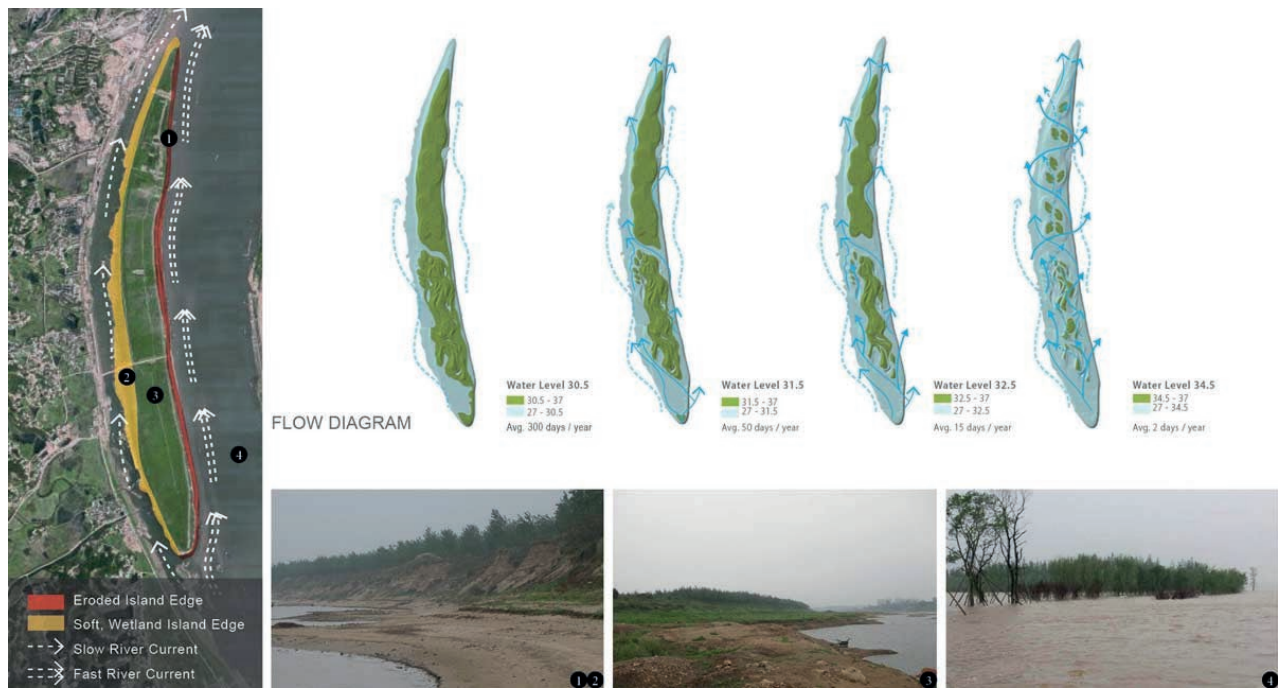
The inflow of water into the bypass is regulated by a threshold upstream which is connected to the dike. The culverts, placed at different water levels as part of the threshold design, ensure sufficient refreshment and flow of water in the canal. In times of high water, the threshold can be completely overflowed and in times of drought the water can be kept (HNS, 2015).



Overview of the Ruimte voor de Waal project, source (HNS, 2016)

River forest island, Changsha

River Forest Island is positioned in the Xiang River, right in the center of Changsha, a city in southern China. Although the river is lined with concrete walls to manage flooding during different seasons, this project uses a landscape approach. It works with the natural flow of the river and the surrounding local landscape. The island's shape is designed to handle flooding in different areas depending on the time of year. The island utilized natural wetland terraces and native forest planting to provide a journey of discovery for the people of Changsha, with recreational spaces throughout the island. (SWA group, 2014)



Flow diagram of yearly flood periods and river processes, source (SWA GROUP, 2014)

Bosbaan, Amstelveen

The Bosbaan in Amstelveen is the most important rowing track of the Netherlands, build in 1937 for the KNRB. The name 'Bosbaan' translates to forest track, relating to the natural context of the track in the Amsterdam forest park (Korteknie, 2014).

The edges of the rowing track have slow slopes, in order for animals and bank vegetation to establish. This waterway serves as inspiration for the design of a multifunctional bypass, which could serve for flood mitigation and sporting activities at the same time. Also the edge profiles of the bank serves as inspiration for nature friendly design.



View from rowing platform towards the track, the rowing club situated on the right bank (Korteknie Stuhlmacher Architekten, 2014).

Rowing club, Shanghai Century Park

Century park is the largest wetland park open to the public in downtown Shanghai. The Zhangjia-bang River, which crosses the park, is an urban river. Located on this river in Shangai Century park is an important rowing club which is interwoven with the nature of the park by a network of dynamic paths. Narrow piers are made to carry the boats into the water and to impact the environment least as possible (Schran studio, 2018). This project serves as an example of the development of a rowing sports area on a dynamic river and in forest context. The current of the river is an extra element for water sport enthusiasts.



Rowing club with its piers, situated on the natural river in the accessible wetland park of Shanghai (Schran Studio, 2018).

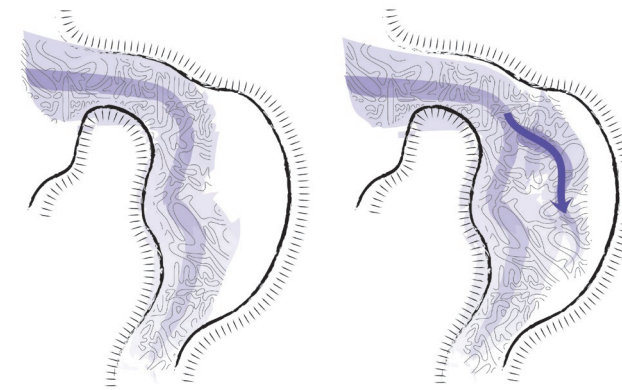
4.3 DESIGN PRINCIPLES

In this thesis, the design principles are used as tools to give the previously mentioned strategies their physical form and to be able to apply them to the local context of Kamenička ada. The principles serve as an organising element to make the design choices clear and to fulfil the goal of multifunctional, flood-proof and socio-ecologically inclusive development. They are based on the theoretical foundation and earlier mentioned precedent studies.

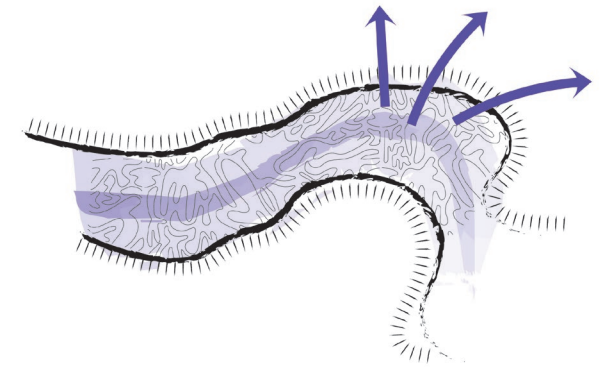
In this chapter an overview of the design principles is depicted, organised by the guiding principles of the water, ecology and culture. At the end of this chapter, examples of synergies between the principles are given.

Water

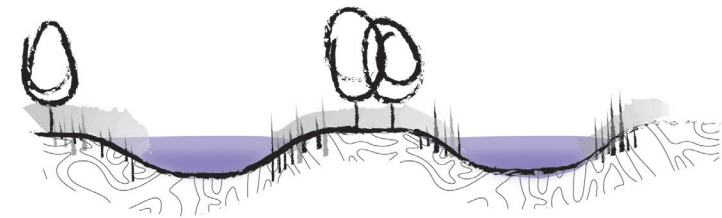
The design principles for the water layer are to make space for the river channel in the form of a bypass, in order to release the pressure on the constrained river channel. Furthermore, to increase the overall space of the floodplain to be able to create a buffer between the city and the river, with flood resiliency in mind. Next to that, slow edges and terrain differences for cyclic river design are important tools to shape the base of the river island. Working with the local topography and river fluctuations is essential to use this tool. The last, reactivating of riparian wetlands is related to water retention and resiliency, but also creates ecological pioneer opportunities.



Make space for the river: bypass



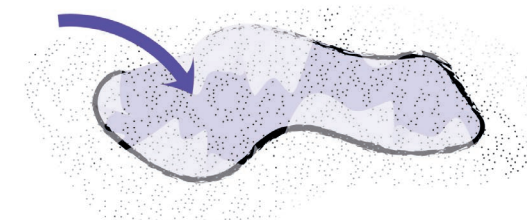
Increase floodplain



Slow edges for cyclic flooding



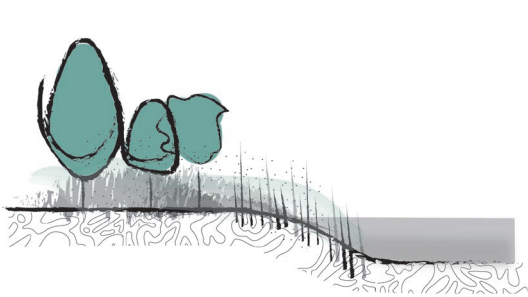
Terrain differences for cyclic design



Reactive riparian wetlands for water retention

Ecology

The design principles related to the inclusive ecological development of Kamenička ada, are to create slow edges on the river banks to be able to control the riparian succession and give pioneer species the change to develop. Secondly, to use an accessible river park as a buffer between protected habitat and the city of Novi Sad. Furthermore, to give the bypass edges heterogeneity by applying diverse edge habitats for different species of fish and freshwater birds. Next to that, a principle is to connect Kamenička ada to the green network of Novi Sad by establishing green corridors. For the development of the river park, the principle of soft edges for ecological benefits is applied, in combination with the usage of smart infrastructure to prevent water edges to degrade in ecological quality.



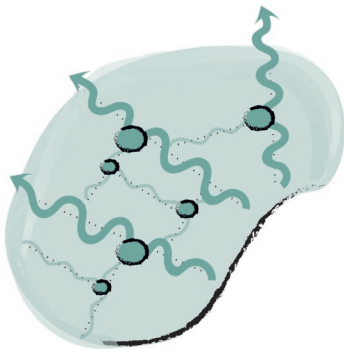
Controlled riparian succession, slow edges



River park as buffer between protected habitat and city



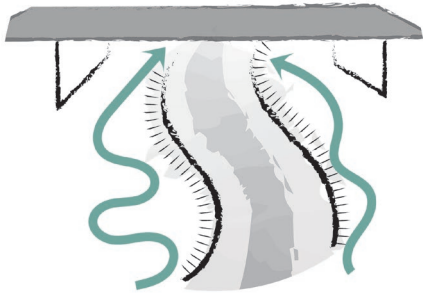
Diverse edge habitats bypass



Connecting river park and city



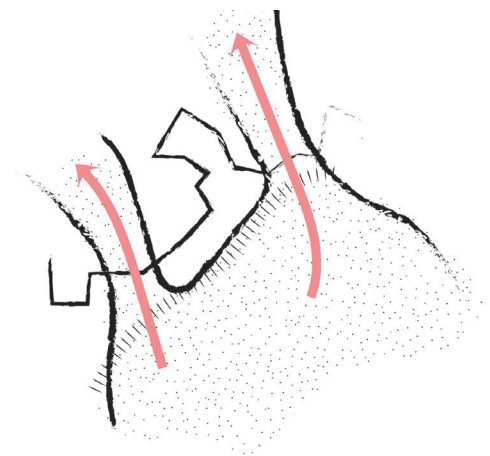
Soft edges



Smart infrastructure

Culture

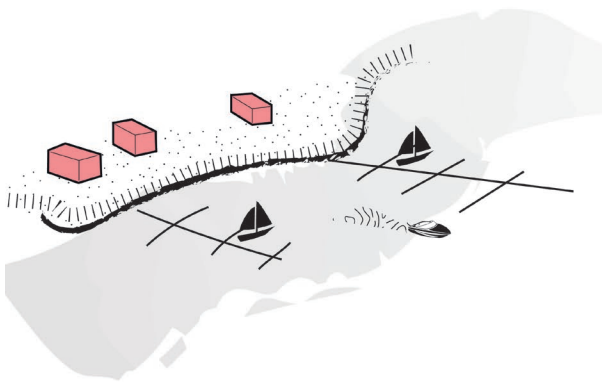
The design principles for culture are first to blend the borders between the city and the floodplain, by integrating green connections and infrastructure. This goes hand in hand with the principle to make an accessible river park and new public space in the floodplain. Furthermore, the development of new types of (multifunctional) housing on Kamenička ada is possible, in harmony with the river and the ecology. Next to that, a principle is to promote the interaction of humans and water and to make the river dynamics visible. At last, the new bypass creates opportunity for new sporting activities, such as rowing.



Blending the borders between the city and the floodplain



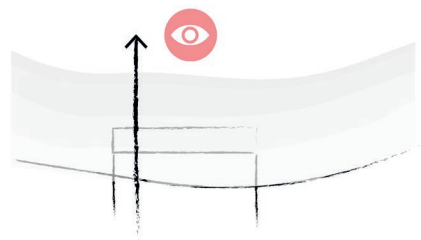
Accessible river park and new public space



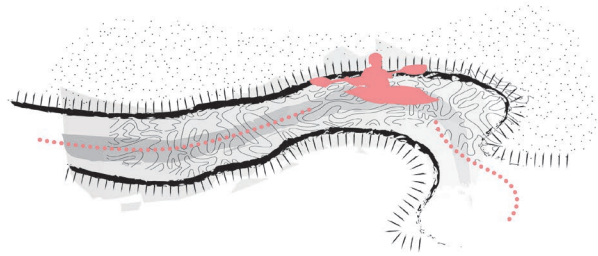
Development of living with water



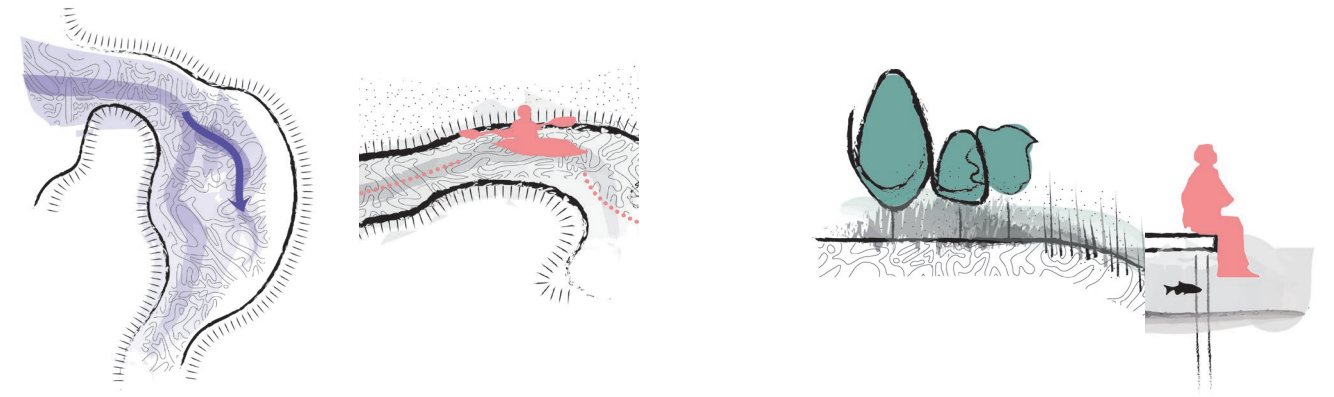
Interaction of human and water



Make river dynamics visible



Sporting activities



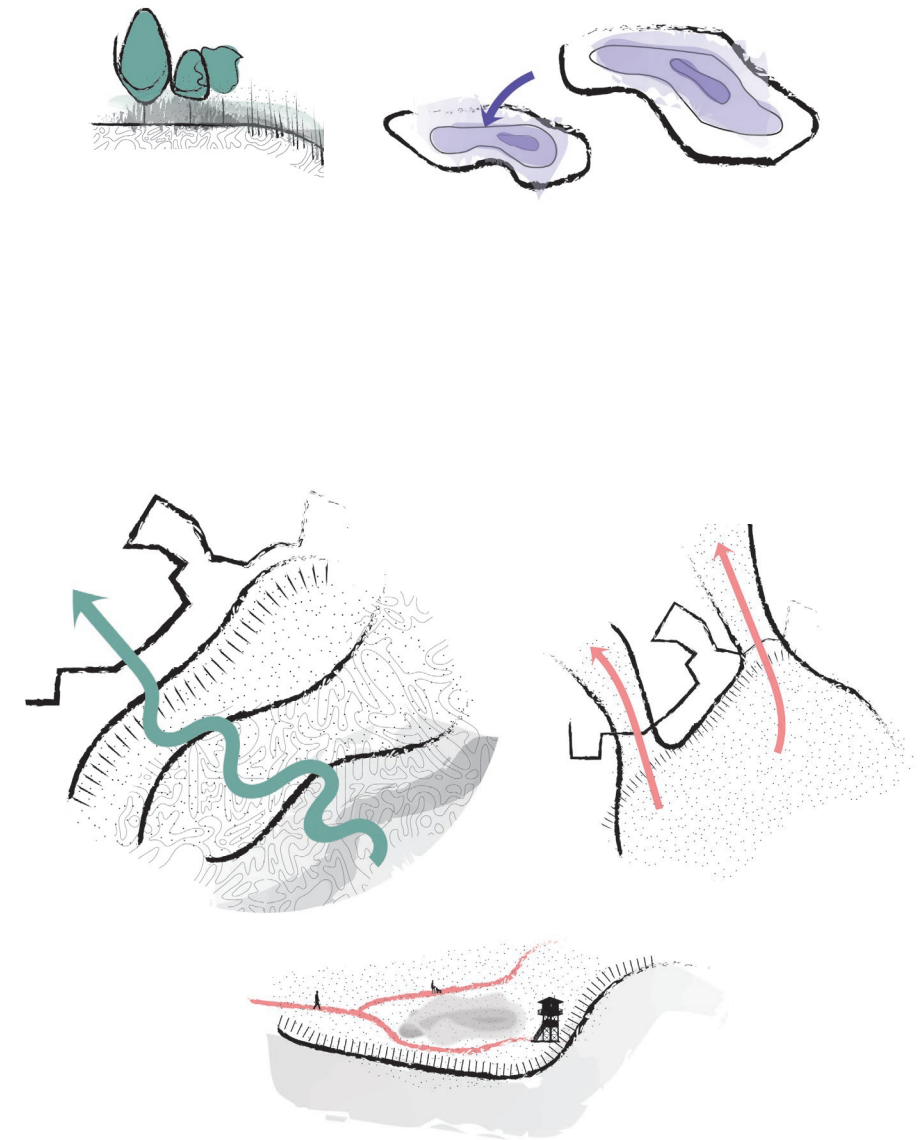
Synergies between principles

In order to get a grip on the previously mentioned second strategy, which aims to create mutually beneficial design elements for water safety, ecological development, recreation and housing, it is important to briefly discuss possible examples of synergies between the principles.

Firstly, as became clear from the selected case studies, the bypass can be given a multifunctional character by adding a water sports club, such as a rowing club. In this way, the bypass is not only realised for flood mitigation. This is line with the municipality's wishes for Kamenička ada, which are discussed in greater detail in the discussion of this thesis. Most importantly, the bypass will create a new space for water-based recreation, fostering interaction between individuals and the riparian environment.

The ecological edges can also be integrated with initiatives to enhance contact between people and water, or to shape the topography of the site to accommodate varying flood levels.

Furthermore, the intermediate space can simultaneously act as a buffer between the river and the city, in the form of an accessible and recreational river park, where at the same time the boundaries between the city and the flood-plain become more smooth.



4.4 LESSONS LEARNED

In this chapter, the definition of a strategy, specific physical interventions in the landscape is given. Then an overview of the four appropriate strategies for the spatial development of Kamenička ada are explained, and the theoretical principles to which they are linked. In order to give guidance to the strategies, the design principles for Kamenička ada are described in the structure of the water, the ecology and the culture. These design principles are derived from the theoretical framework and precedent studies presented in this chapter. Finally, examples of some possible synergies of the principles have been given to show how they can meet the multifunctional nature of the objective of this thesis. Now that we have this information, we can carry out a detailed analysis of Novi Sad and Kamenička ada in order to apply the principles to the local landscape.

PART III

NOVI SAD AND KAMENIČKA ADA ANALYSIS

KAMENIČKA ADA STRATEGIC VISION

CONCLUSION AND DISCUSSION



5. NOVI SAD AND KAMENIČKA ADA ANALYSIS

5.1 INTRODUCTION

5.4 ISLAND FORMATION IN THE DANUBE

5.2 NOVI SAD ANALYSIS

5.5 CONCLUSION KAMENIČKA ADA

5.2.1 Water

5.2.2 Ecology

5.2.3 Culture

5.2.4 Conclusion

5.3 KAMENIČKA ADA ANALYSIS

5.3.1 Water

5.3.2 Ecology

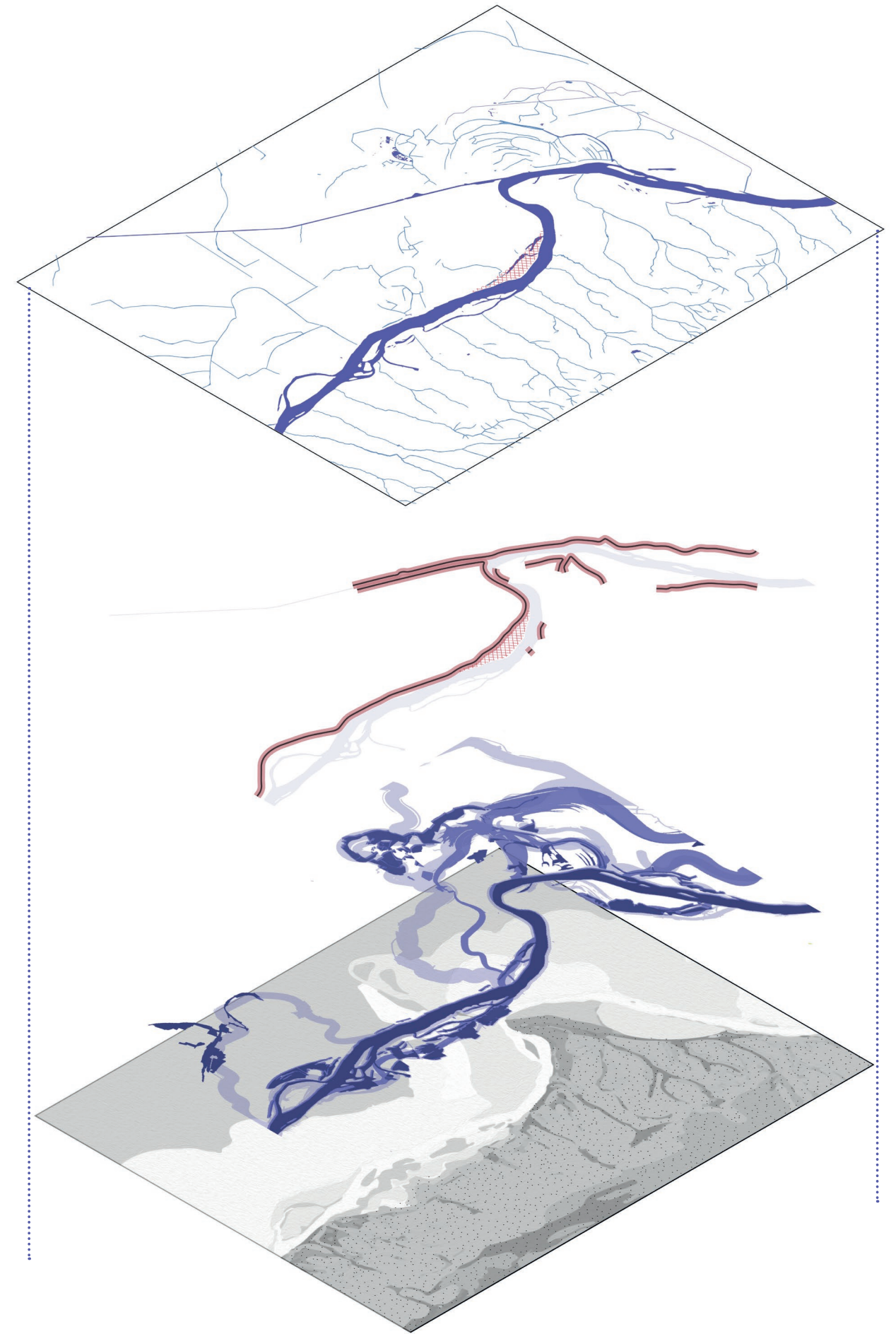
5.3.3 Culture

5.1 INTRODUCTION ANALYSIS

In order to better understand the specific characteristics of the landscape of Novi Sad, the city and the river island of Kamenička ada itself, a more detailed analysis of Novi Sad and Kamenička ada is presented in this chapter. This analysis is carried out in the structure layers of water, ecology, culture for both scales. Relevant photos from the site visit are also shown to give an idea of what the area looks like today. When needed, the maps and photos are supported with relevant graphs or other graphical representations of local knowledge on the workings of the river landscape.

5.2 NOVI SAD ANALYSIS

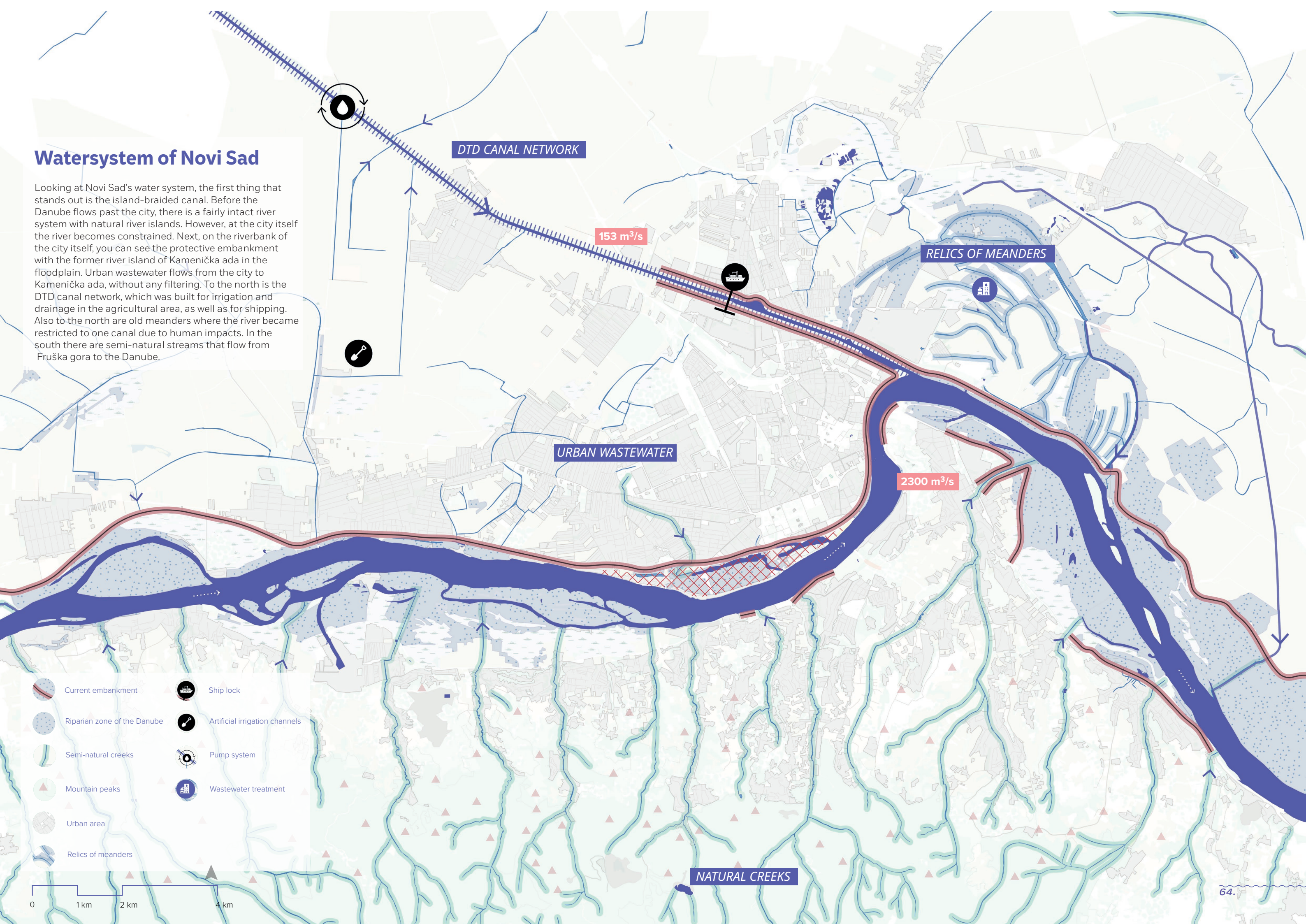
To begin the Novi Sad analysis, it is first important to briefly explain the different layers of the landscape and their speed of change. As mentioned in the theoretical foundation, the slow layers of the landscape, the geomorphology, the soil and the natural river channels have developed over the last centuries, mostly unperceivable to the human eye. Furthermore, in the network and occupation layer, humans have influenced the slow development of the Danube river channel and, with the construction of embankments, restricted the river's path, subjecting it to a single channel. This has resulted in the current river path and river system at Novi Sad, with artificial streams and a network channel designed for ship navigation purposes.



The slow environmental layers of geomorphology, natural braided system followed by human constraints and the network layers of Novi Sad.

Watersystem of Novi Sad

Looking at Novi Sad's water system, the first thing that stands out is the island-braided canal. Before the Danube flows past the city, there is a fairly intact river system with natural river islands. However, at the city itself the river becomes constrained. Next, on the riverbank of the city itself, you can see the protective embankment with the former river island of Kamenička ada in the floodplain. Urban wastewater flows from the city to Kamenička ada, without any filtering. To the north is the DTD canal network, which was built for irrigation and drainage in the agricultural area, as well as for shipping. Also to the north are old meanders where the river became restricted to one canal due to human impacts. In the south there are semi-natural streams that flow from Fruška gora to the Danube.



DTD CANAL NETWORK

153 m³/s

RELICS OF MEANDERS

URBAN WASTEWATER

2300 m³/s

NATURAL CREEKS

- Current embankment
- Riparian zone of the Danube
- Semi-natural creeks
- Mountain peaks
- Urban area
- Relics of meanders
- Ship lock
- Artificial irrigation channels
- Pump system
- Wastewater treatment

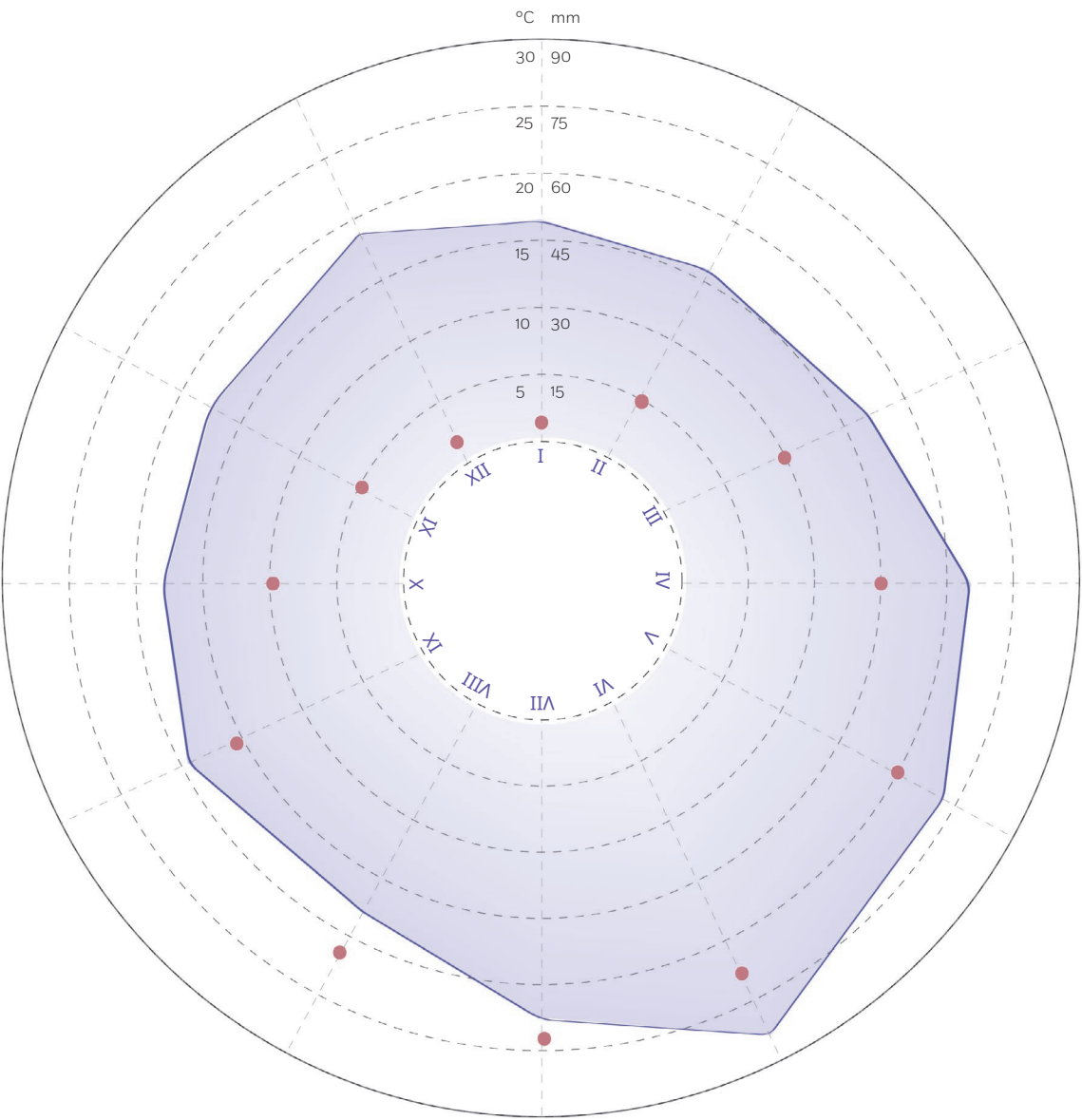
0 1 km 2 km 4 km

Climate Novi Sad

In order to understand the water level fluctuations of the Danube, we first have to understand the local climate. The climate in Novi Sad is warm and temperate, with significant rainfall throughout the year. According to the Köppen-Geiger classification, climate in this region can be categorized as Cfa. The mean yearly temperature observed in Novi Sad is recorded to be 12.7 °C and the rainfall is around 695 mm per year (EN climate data, 2024).

The Danube in Novi Sad contains the most water in the period of April-June, with the maximum in June and the least in the period October-November, with minimum in October. So, the high waterlevels occur in spring, and low waterlevels appear during summer due to the lack of precipitation and the increased evapotranspiration.

In Serbia, most floods occur at the end of spring and beginning of summer because of the large precipitation and the snow cover melting of the Alps. The most frequent floods occur after intensive rainfalls, accompanied by snow melting and high water coincidence (Urosev et al, 2022).

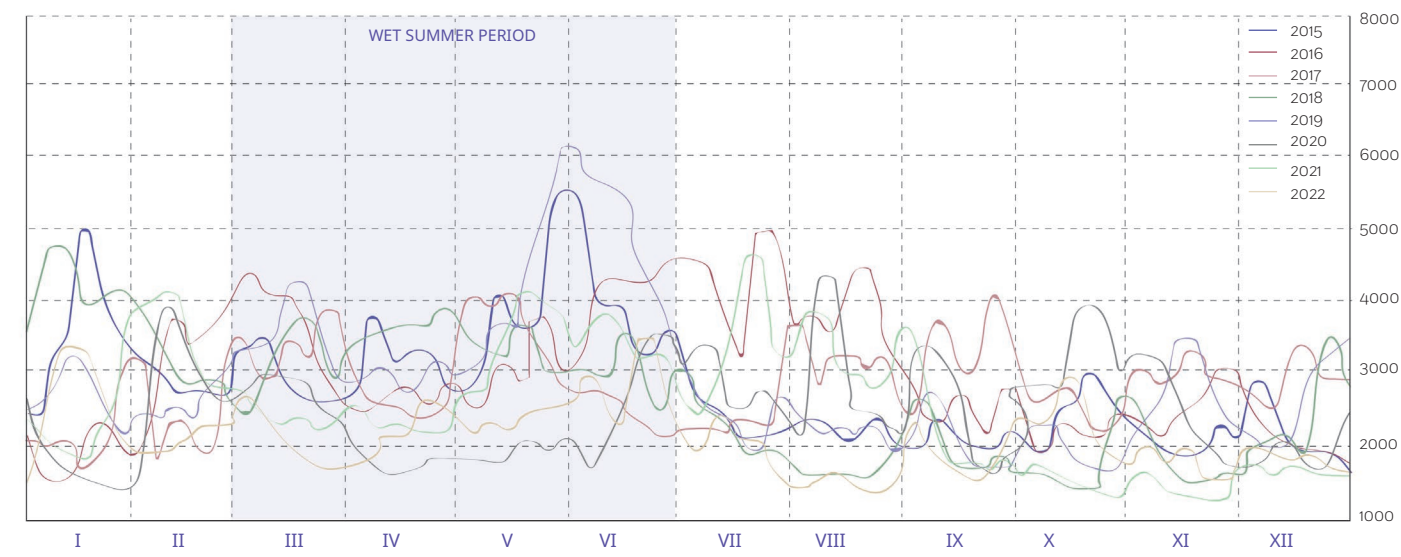


Climate graph of Novi Sad showing monthly temperature and rainfall (EN Climate, 2024).

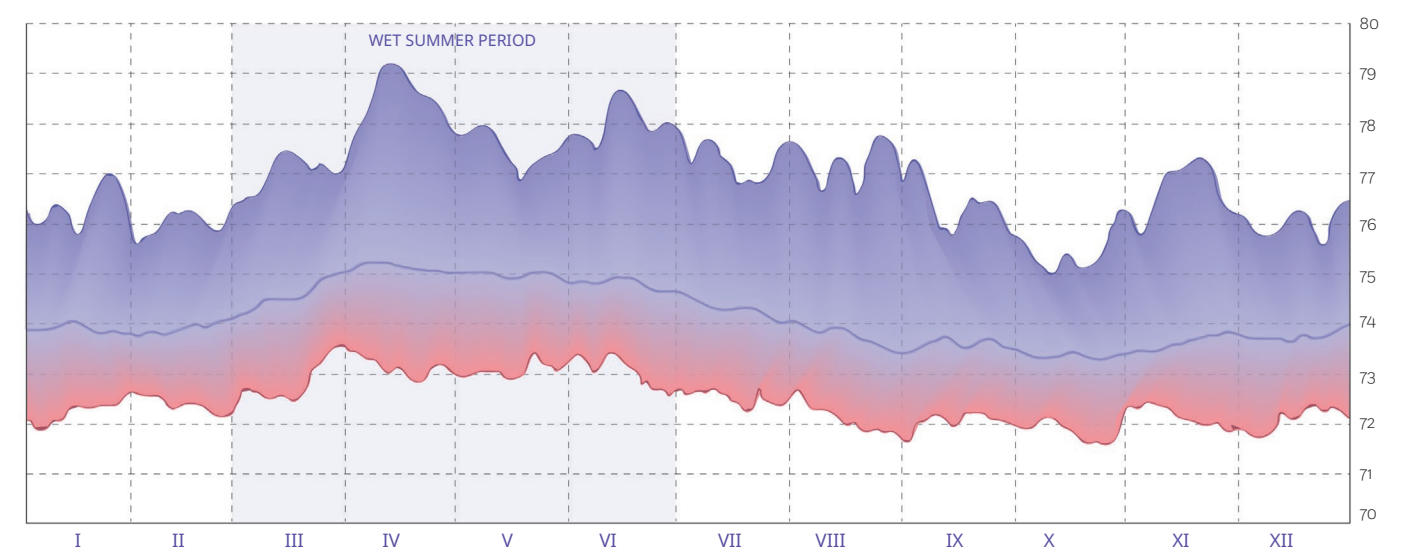
The Danube fluctuations

Now that we know the climate and rainfall patterns, we know that there is a wetter period in early summer and a drier period in winter. This pattern is also reflected in the discharge pattern of the Danube, which tells us something about the amount of water flowing through the river. This corresponds to the water level of the Danube, which is on average highest at the beginning of summer for the reasons mentioned above. The mean annual waterlevel of the Danube is 74,5 m.a.s.l. From this graph a calculation was made how many days per year the river is at a certain level in order to be able to shape the topography of the river landscape in the design. This will be explained later in chapter 6.

DANUBE DISCHARGE PATTERN AT Novi Sad (m3/s)



AVERAGE WATER LEVEL (m.a.s.l.) AT Novi Sad



Danube discharge pattern and average water level (m.a.s.l.) at Novi Sad (DanubeHIS, 2024).



A partly canalised creek on the foothill of the Fruška gora mountain ridge.

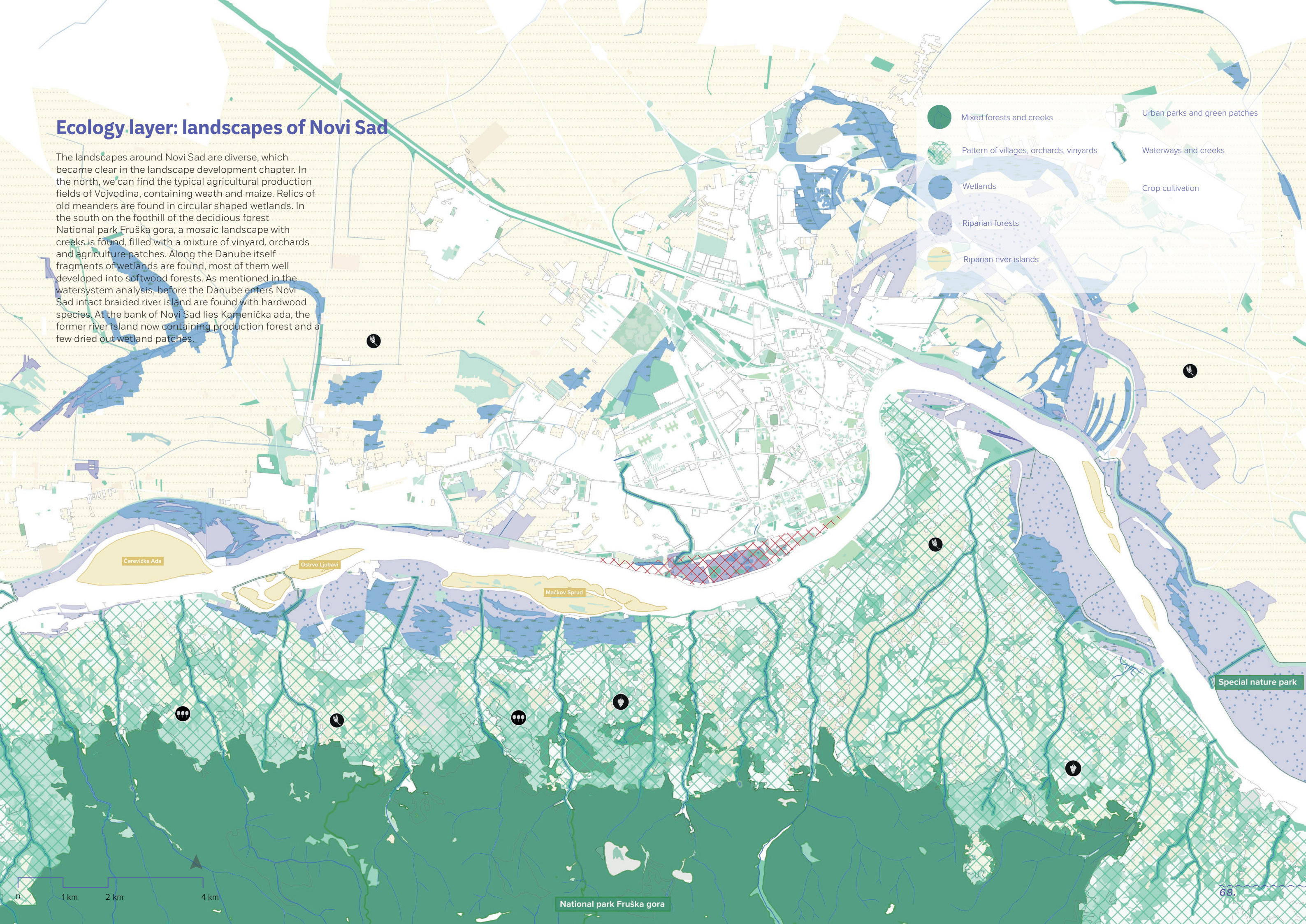


The protective embankment of Novi Sad along Kamenička ada, seen on the left of the image.

Ecology layer: landscapes of Novi Sad

The landscapes around Novi Sad are diverse, which became clear in the landscape development chapter. In the north, we can find the typical agricultural production fields of Vojvodina, containing weath and maize. Relics of old meanders are found in circular shaped wetlands. In the south on the foothill of the decidious forest National park Fruška gora, a mosaic landscape with creeks is found, filled with a mixture of vinyard, orchards and agriculture patches. Along the Danube itself fragments of wetlands are found, most of them well developed into softwood forests. As mentioned in the watersystem analysis, before the Danube enters Novi Sad intact braided river island are found with hardwood species. At the bank of Novi Sad lies Kamenička ada, the former river island now containing production forest and a few dried out wetland patches.

- Mixed forests and creeks
- Pattern of villages, orchards, vineyards
- Wetlands
- Riparian forests
- Riparian river islands
- Urban parks and green patches
- Waterways and creeks
- Crop cultivation





The mosaic landscape of agriculture, vineyards and orchards at the foothill of Fruška gora.



An orchard in bloom at the foothill of Fruška gora.



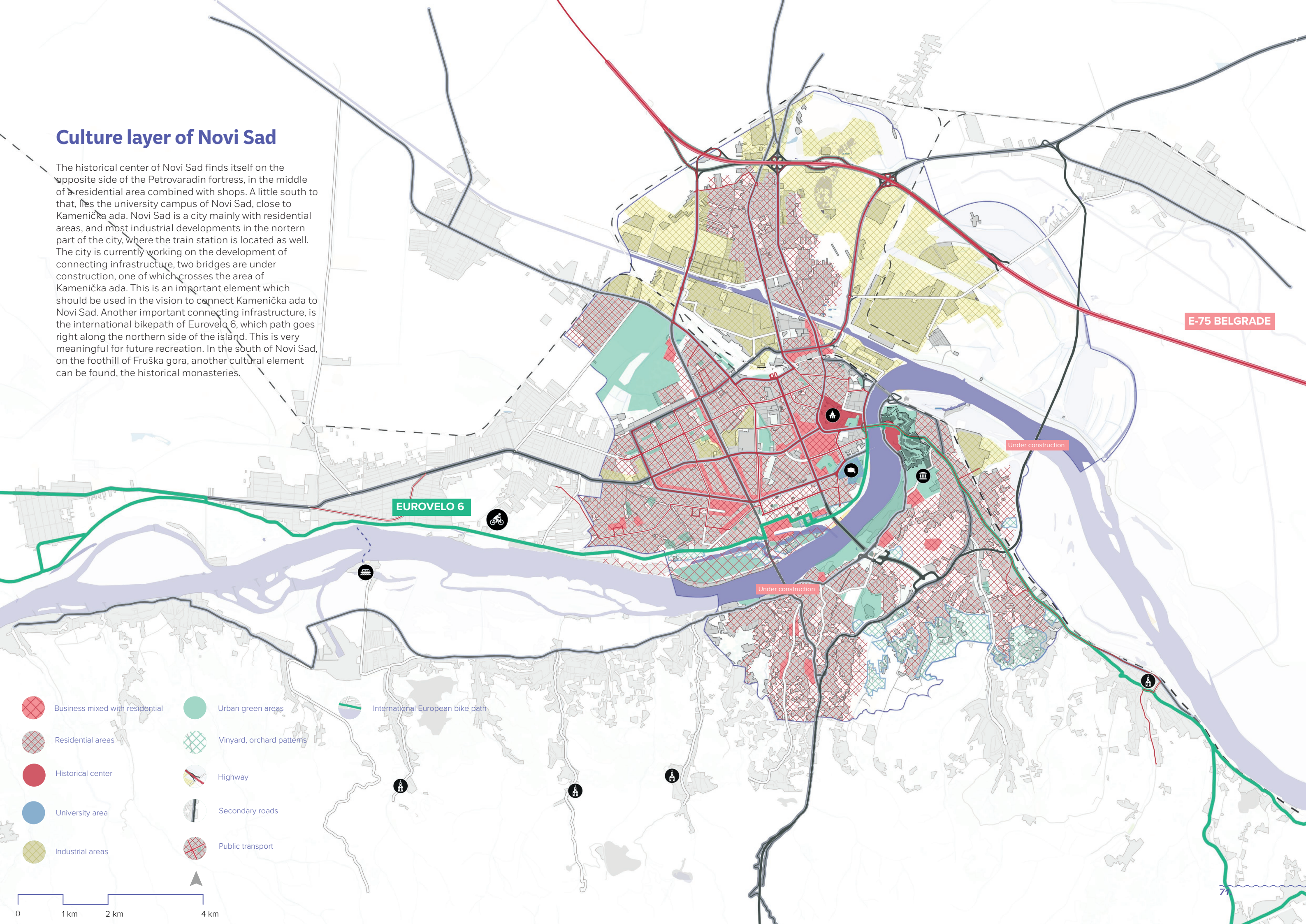
Relic of the river arm at Kamenička ada with a recreational fisher's boat.



A bare agricultural field near Novi Sad, Vojvodina.

Culture layer of Novi Sad

The historical center of Novi Sad finds itself on the opposite side of the Petrovaradin fortress, in the middle of a residential area combined with shops. A little south to that, lies the university campus of Novi Sad, close to Kamenička ada. Novi Sad is a city mainly with residential areas, and most industrial developments in the northern part of the city, where the train station is located as well. The city is currently working on the development of connecting infrastructure, two bridges are under construction, one of which crosses the area of Kamenička ada. This is an important element which should be used in the vision to connect Kamenička ada to Novi Sad. Another important connecting infrastructure, is the international bikepath of Eurovelo 6, which path goes right along the northern side of the island. This is very meaningful for future recreation. In the south of Novi Sad, on the foothill of Fruška gora, another cultural element can be found, the historical monasteries.



Business mixed with residential

Residential areas

Historical center

University area

Industrial areas

Urban green areas

Vinyard, orchard patterns

Highway

Secondary roads

Public transport

International European bike path

0

1 km

2 km

4 km



The central square, Liberty square of Novi Sad with view on the City hall.



The busy pond of the Danube park on a sunny spring day, Novi Sad.



The Beocin monastery and the Renaissance garden.



The nearby forest of the Beocin monastery, on Fruška gora.

Relationship with public space

Because of the history of Serbia, the people of Novi Sad have lived for a long time under the communist ideology, in which nor the government nor the inhabitants own land, space or buildings. This resulted in public space to develop a meaningless character, and non-attachment between the people and the public space. Because of this, for a long time, the space in the city, as well as the flood-plains were neglected. The shift from communism to the current liberal political situation has not been a smooth one. In many cases there is unclarity of ownership and lack of responsibility.

Therefore, there is lack of meaningful spaces in Novi Sad where people can get involved in culture, nature or sports without the interference of the government. On the right page some opinions of Novi Sad's citizens on public space are cited, illustrating their need for change (Van Rijswijk, 2013).

It is important to note that this view on public space is a generational issue, and younger generations are already willing to put more effort into maintaining the public spaces and creating meaning.

“

*We are standing in the park now, but there are **not many public spaces** in the city.*

*In the **culture** of living in this city we dont have places or spaces for exchange.*

*We are witness that Novi Sad is in a **crisis** when it comes to public space.*

*Notion of public space almost lost its **meaning**, citizens don't think about that at all.*



Citizen of Novi Sad expressing his need for public space (Source: Van Rijswijk, 2013).

Conclusion analysis Novi Sad

Understanding the climate and rainfall patterns of Novi Sad, particularly the wetter early summer and drier winter periods, is crucial to understanding the water level fluctuations of the Danube. This river experiences its highest water levels from April to June, with the highest levels in June, and its lowest levels from October to November. These fluctuations are largely influenced by precipitation and evapotranspiration rates. In Serbia, floods are most frequent in late spring and early summer due to heavy rainfall and snowmelt in the Alps. Understanding these patterns is important to designing the topography of the river landscape for cyclic floods.

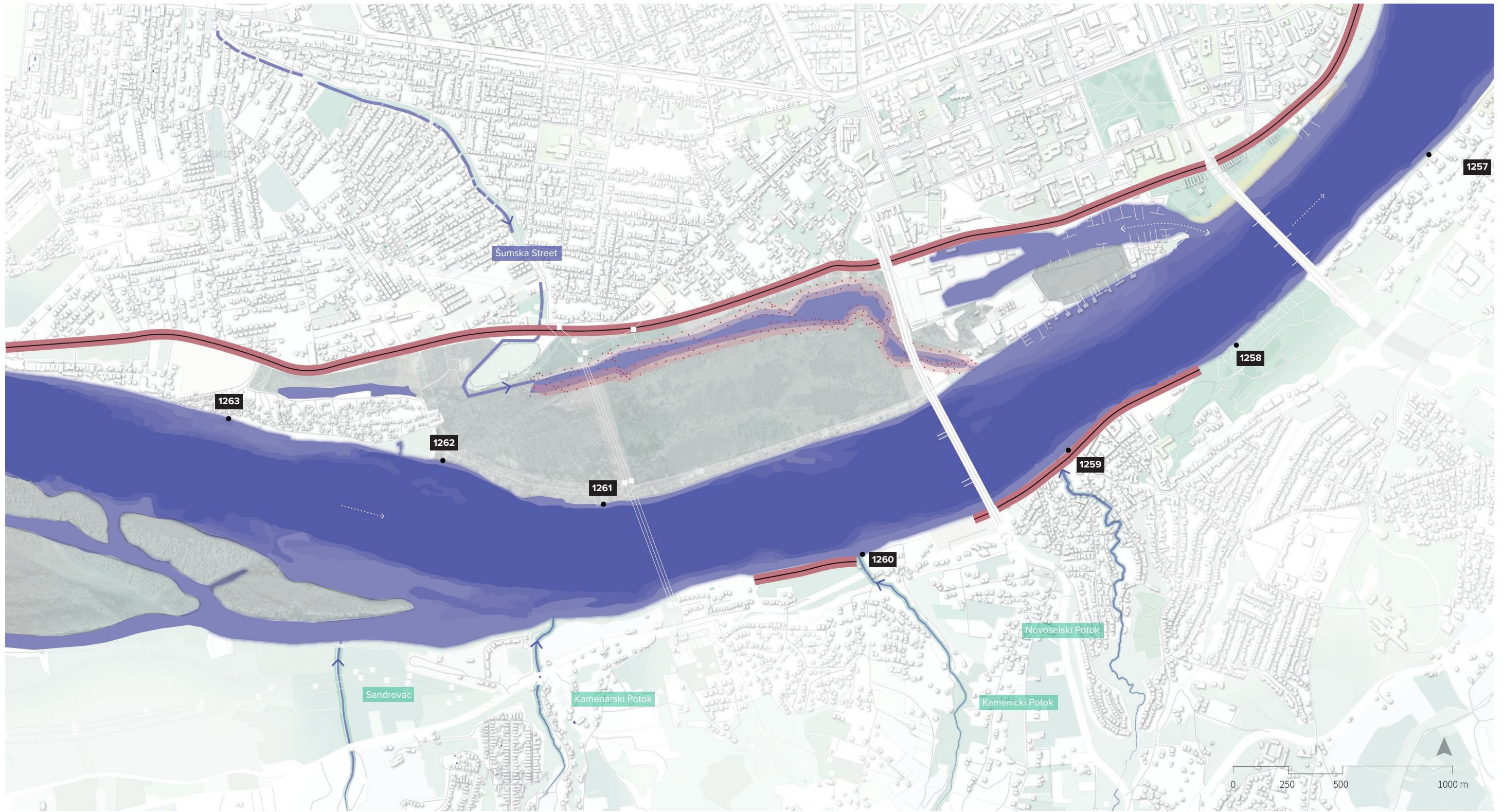
The landscape surrounding Novi Sad is diverse, ranging from agricultural fields in the north to forested areas in the south. The city itself is predominantly residential, with industrial areas in the northern part. The Eurovelo 6 cycle path is an important recreational connection. Efforts are underway to improve connectivity, including the construction of bridges. However, there has been a historical neglect of public spaces, due to the legacy of communist ideology. This has led to a lack of meaningful community spaces for cultural, recreational and social activities. While there is a generational divide in attitudes towards public space, younger generations show a willingness to invest in revitalising and maintaining these spaces for the benefit of the community.

5.3 KAMENIČKA ADA ANALYSIS

This section presents a detailed analysis of the current situation at Kamenička ada. This analysis consists of the three layers water, ecology and culture and is supported by relevant photographs from the site visit. For the ecology layer, the potential natural vegetation cover and associated plant communities are discussed in more detail. After the analysis of the three layers, the formation of natural river islands in the Danube and their differences in elevation are discussed, followed by a discussion of the current differences in elevation of Kamenička ada.



Elephant paths leading from the dike of Novi sad to Kamenička ada.



Water layer Kamenička ada

Observing the Danube at Kamenička ada reveals the main river flow in eastern direction, along with the inflow and outflow of water at the river arm near the eastern tip, where the harbor is located. Currently, the old river arm within Kamenička ada is sealed off from the main river due to sand accumulation, resulting in a constricted entrance that obstructs the Danube water from flowing into the area as backwater.

Consequently, the water surface on Kamenička ada remains stagnant, fostering algae growth and water evaporation, thereby diminishing the ecological value. Further degrading the ecological value is the urban watercourse flowing through Novi Sad, which channels its sewage into this stagnant water body. The map further shows the existing dikes, southern creeks, and river kilometres and river depths.

Elements

-  Danube's km
-  Embankment
-  Bridges
-  Creeks

River depth

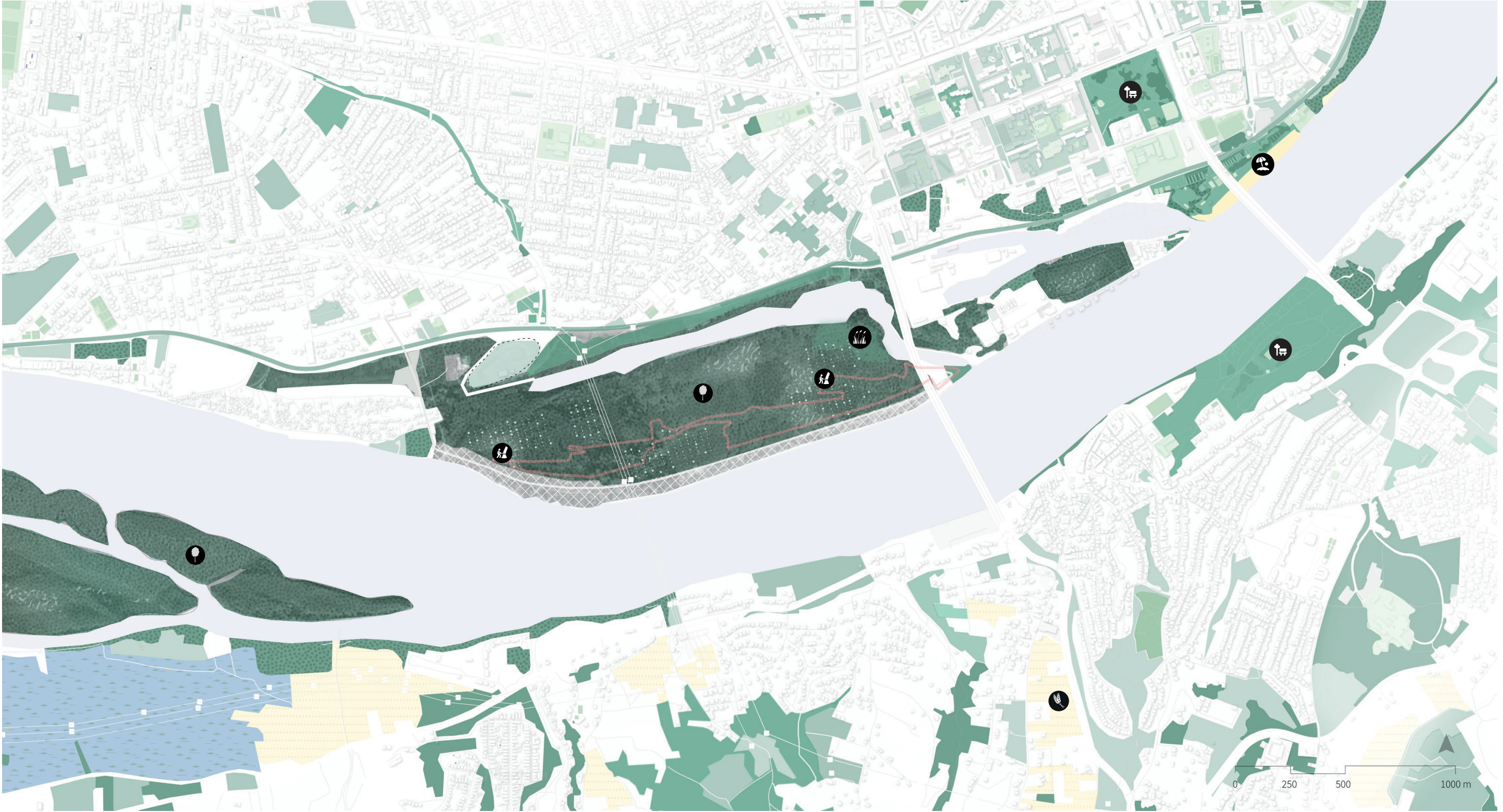
-  0 - 1,6 m
-  1,6 - 2,5 m
-  2,5 - 3,5 m
-  > 3,5 m



The former river arm at Kamenička ada, seen from the dike.



The city beach of Novi Sad with view on the liberty bridge.



Ecology layer Kamenička ada

Kamenička ada is currently a forested area, with some wetter areas along the river arm that have characteristics of the former wet riparian forest. In addition to the natural forest, about one third of the existing forest is production forest, which is important for timber harvesting. In the south of Kamenička ada, a protected area has been designated by the municipality to protect the condition of the riparian forest.

Parts of this area, however, are already production forest. In the north, the area is partly connected to the green area around the urban waterway. In addition, Novi Sad has an urban beach and two parks on the riverbank near the Liberty Bridge. In the southwest, we find natural river islands with mainly climax vegetation of developed riverine forest. On the right bank of the Danube is a large wetland in the south, along with several patches of agriculture, and orchards.

Elements

- | | |
|--|---|
|  Riparian forest |  Production forest |
|  Agricultural patches |  Protected habitat |
|  Wetlands |  Wetland patch |
|  Urban greenery |  Beach |
|  Public parks | |

Existing species

During the site visit some of the existing species were captured and collected, of which *Salix Alba*, *Ulmus leavis*, *Populus alba* and *Populus nigra* have been identified, all tree species which grow in wet riparian forests. The image on the right page shows the conditions these species grow in, next to the old river arm.

The planted production forest also consists of *Populus alba*, which is seen on the image below captured at Kamenička ada.



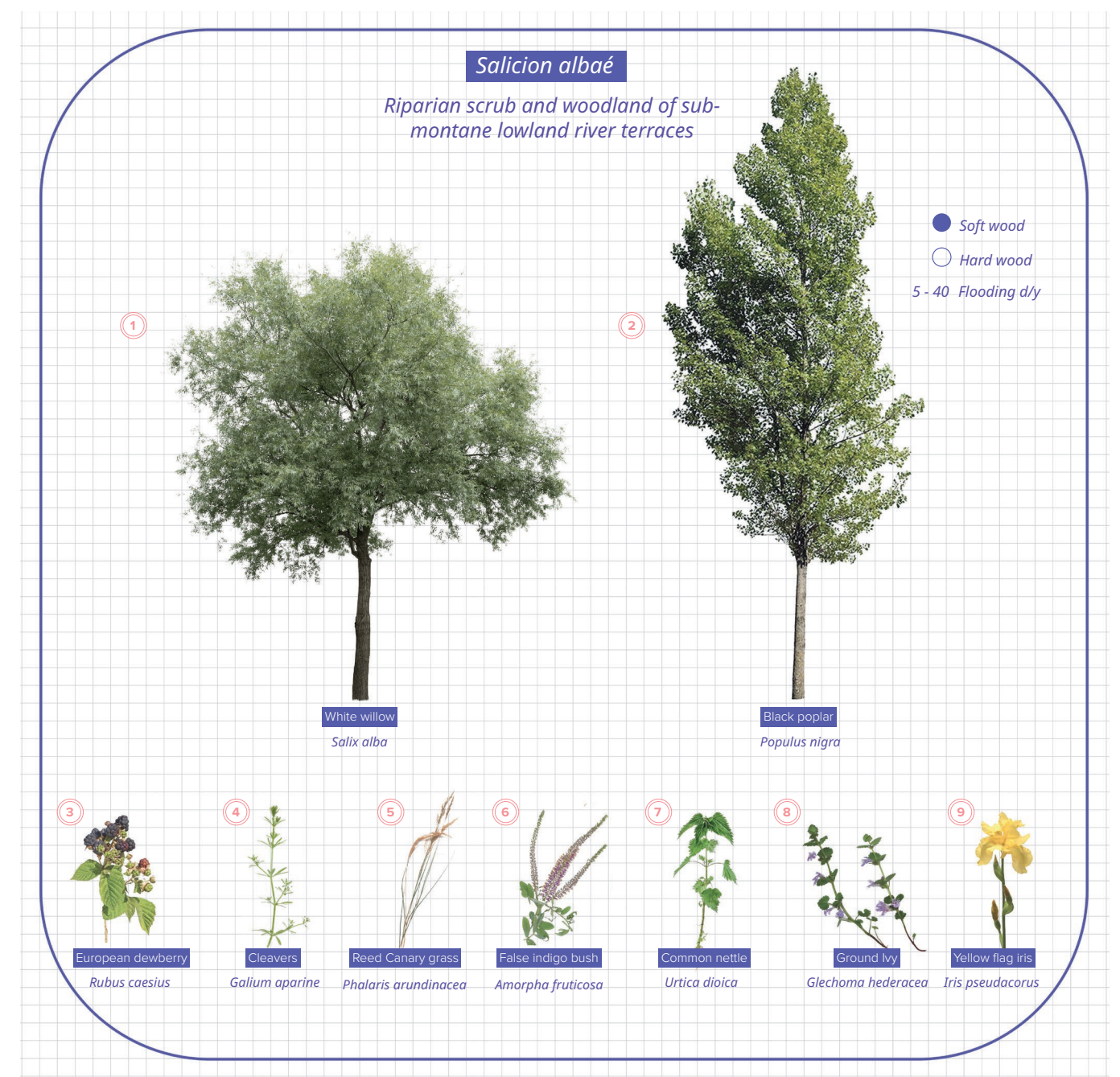
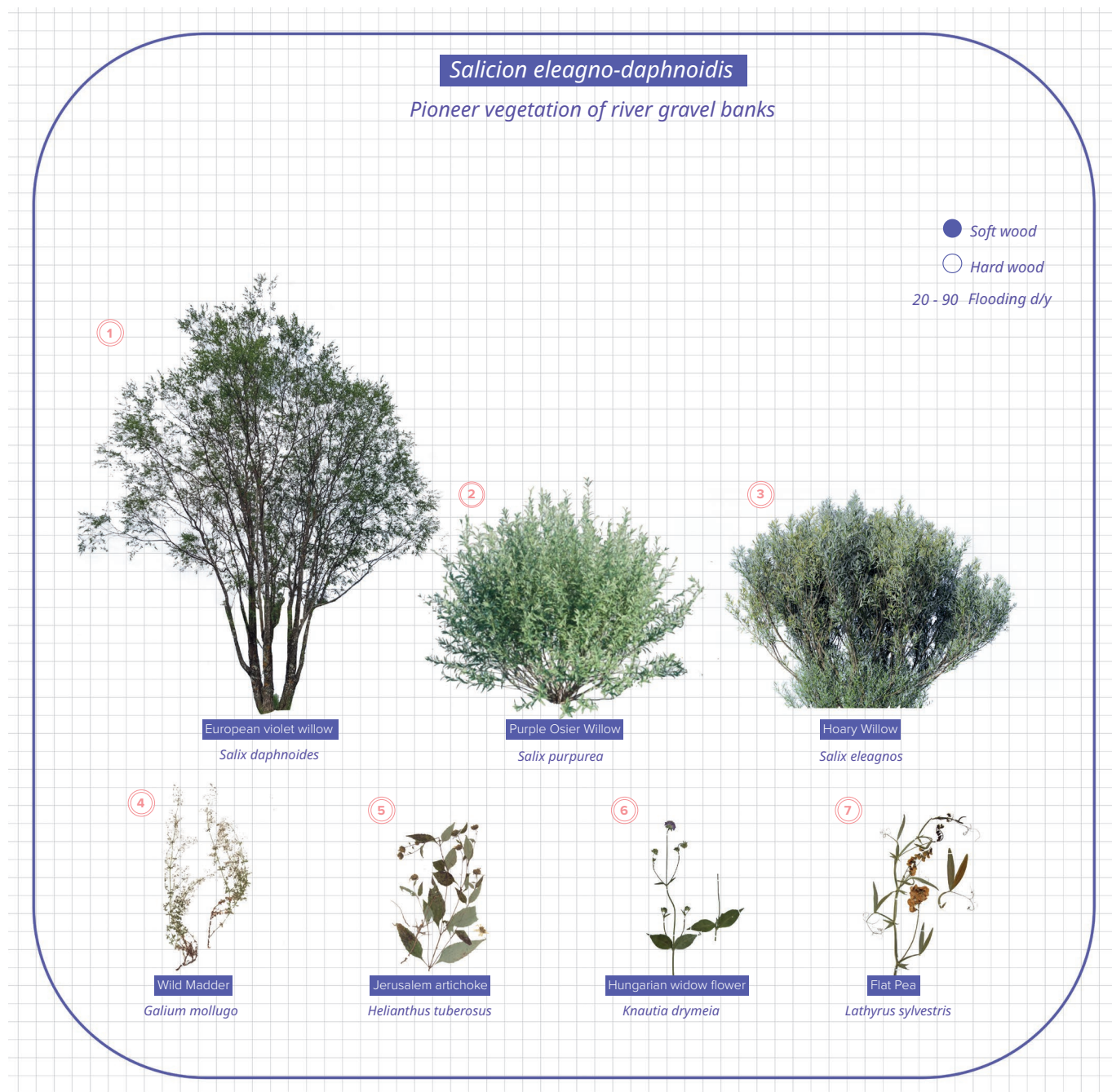
Production forest of *Populus alba*, captured on Kamenička ada.



Sample of existing plant and tree species at Kamenička ada.

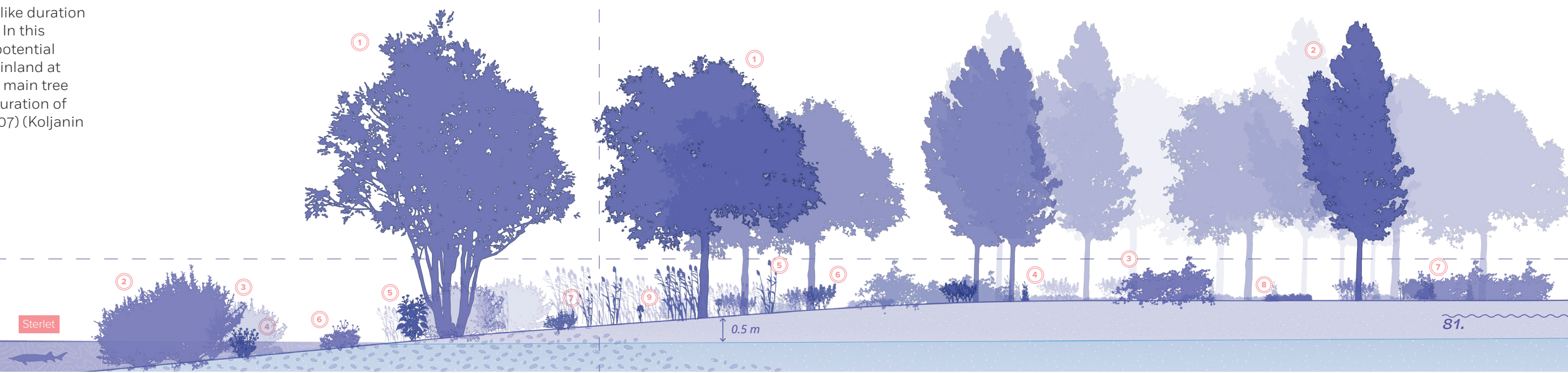


Willows standing at the bank of the former river arm on Kamenička ada.



Potential natural succession

The riparian wetland forests and scrubs are conditioned by the strong impact of water and consist of various vegetation types, depending on many factors like duration of flooding, the water table and soil substrate. In this section combined with vegetation cards, the potential natural succession of the riparian zone to the inland at Novi sad is illustrated. Each card contains the main tree species and main scrub or herb species, the duration of flooding and the type of wood (Egger et al, 2007) (Koljanin et al, 2023) (Mandzukovski, 2021).



Populion albae

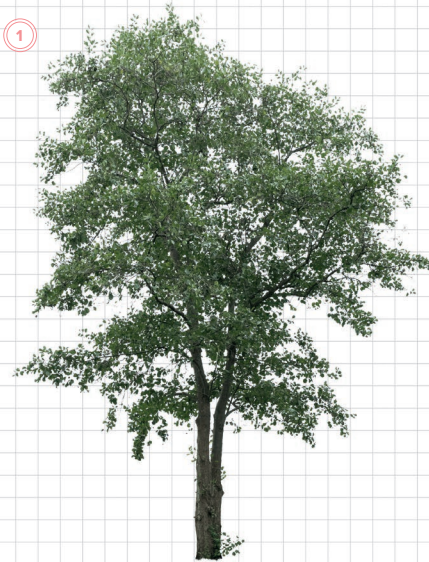
Riparian forest of submediterranean regions

● Soft wood

○ Hard wood

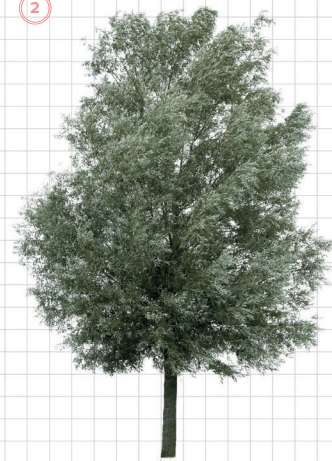
5 - 10 Flooding d/y

1



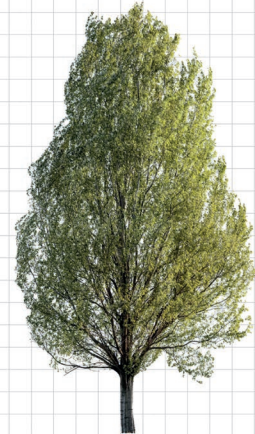
Common alder
Alnus glutinosa

2



White willow
Salix alba

3



White poplar
Populus alba

4



Italian arum
Arum italicum

5



Stinking iris
Chamaeiris foetidissima

6



Common hop
Humulus lupulus

7



Creeping bent
Agrostis stolonifera

Salicion cinerea

Scrub found in river alluviums, wet meadows and fens

● Soft wood

○ Hard wood

4 - 90 Flooding d/y

1



Grey willow
Salix cinerea

2



Black sedge
Carex nigra

3



Carnation sedge
Carex panicea

4



Meadowsweet
Filipendula ulmaria

5

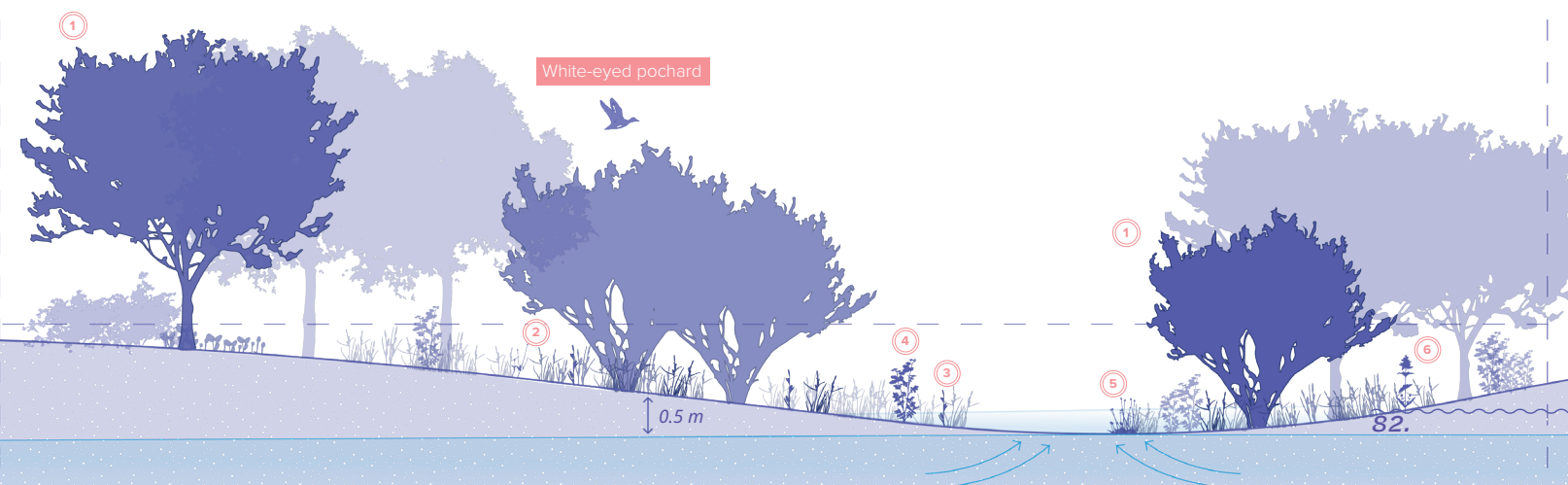


Frosted pearls
Succisa inflexa

6



Yellow Rattle
Rhinanthus rumelicus



The succession gradient goes from pioneer species on gravel banks, to riparian scrub containing willow and poplar, to alder and poplar on higher grounds. In depressions, willow scrub is found combined with different type of Sedge species. These wetlands are perfect habitat for many riparian birds, like the white-eyed pochard.

Alno-Quercion roboris

Riparian forest of higher terraces

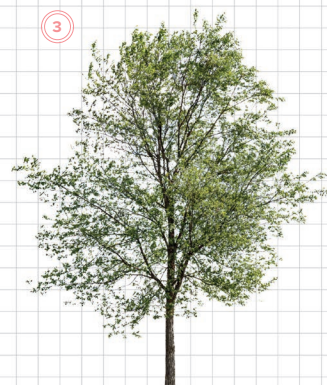
○ Soft wood
● Hard wood
0 - 5 Flooding d/y



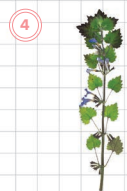
Common oak
Quercus robur



Narrow leaved ash
Fraxinus angustifolia



European field elm
Ulmus minor



Ground ivy
Glechoma hederacea



Moneywort
Lysimachia nummularia



Wood dock
Rumex sanguineus



Three-lobed beggar-ticks
Bidens tripartita

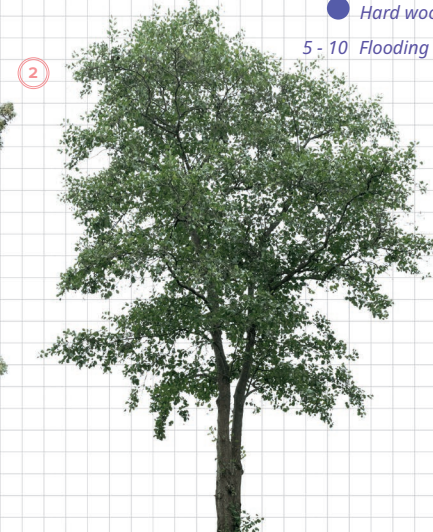
Alnion glutinosae

Forests of shallow waterlogged depressions (swamps)

○ Soft wood
● Hard wood
5 - 10 Flooding d/y



Narrow leaved ash
Fraxinus angustifolia



Common alder
Alnus glutinosa



Elongated sedge
Carex elongata



Lesser Pond-sedge
Carex acutiformis



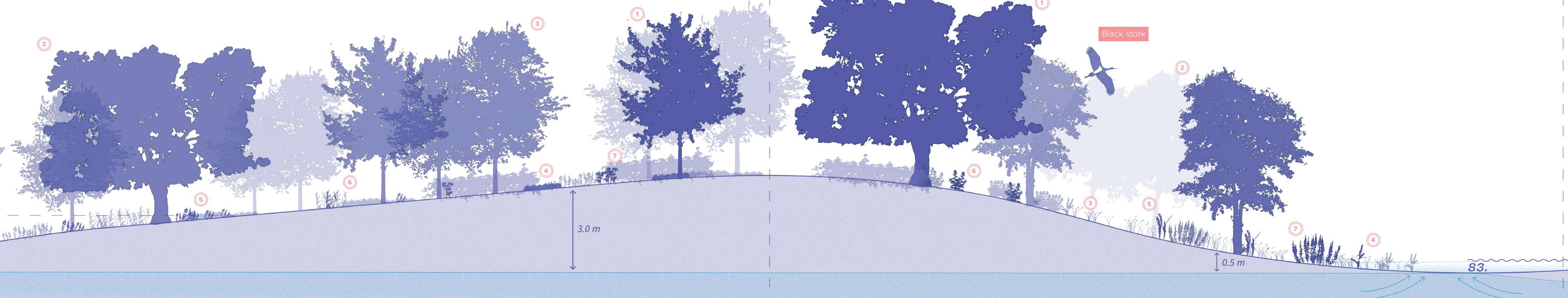
Greater Pond sedge
Carex riparia



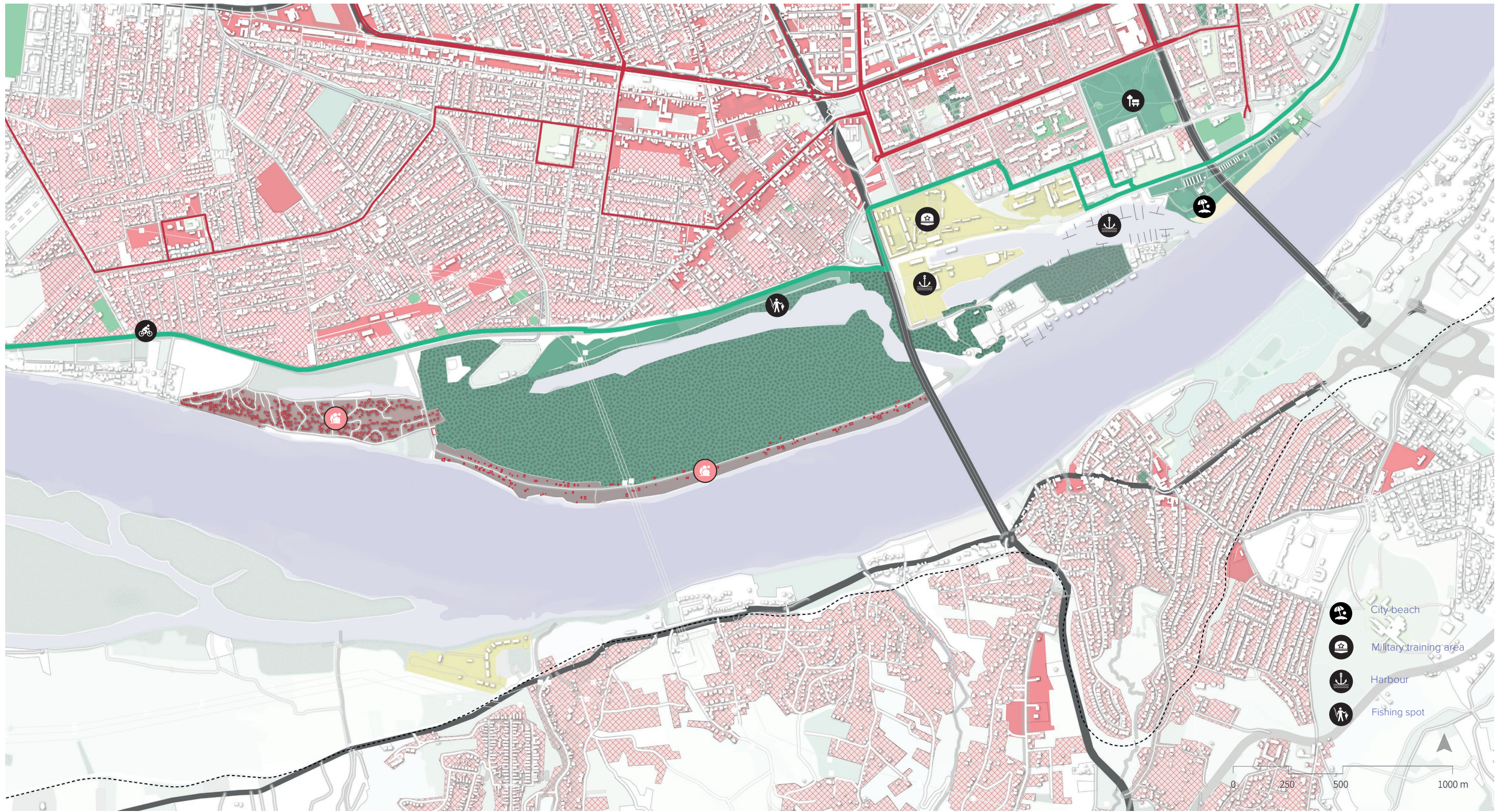
Bugleweed
Lycopus europaeus



Purple loosestrife
Lythrum salicaria



The riparian forests of the higher terraces contain tree species such as the Narrow leaved ash, European elm and Common oak. These higher terraces are nowadays mostly out of reach from the river. In the inland in shallow water depressions, ash and alder forest develops.



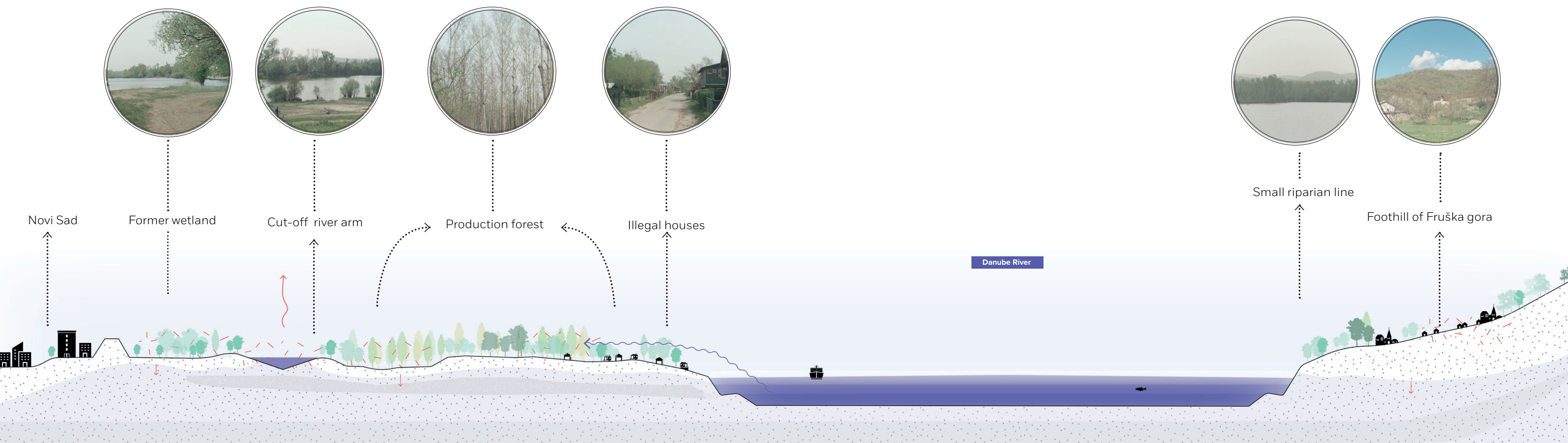
Culture layer Kamenička ada

Kamenička ada is located in the south of the Novi Sad, surrounded by residential areas, with a public park and the city beach. There is also a military training area adjacent to the island, which diverts the cycle path over the embankment and the Eurovelo 6 path. This is a point where access to the city centre could be improved. From this side, most people will head towards Kamenička ada. In addition, the harbour is located next to the shore, which is also currently difficult to access.

In addition, the large bridge connecting Novi Sad to the right bank of the Danube is currently under construction. On the island itself, illegal construction can be seen on the riverbank and to the west, where people are appropriating public space. This can be explained by the aforementioned description of the lack of attachment to public space due to the communist past. The appropriation of public space neglects its value for the city.

The island is now mainly used by recreational fishermen who fish in the former river arm. Other forms of recreation are almost impossible, as the only road is occupied by residents of illegal buildings.





Summary current conditions Kamenička ada.



The harbour of Kamenička ada, seen from the dike.



The main road of Kamenička ada, with fenced off illegal houses.



Adapatation to the fluctuation of water levels on one of Kamenička ada's illegal houses.



Another form of adaptation to the fluctuation of water levels with production forest in the background.

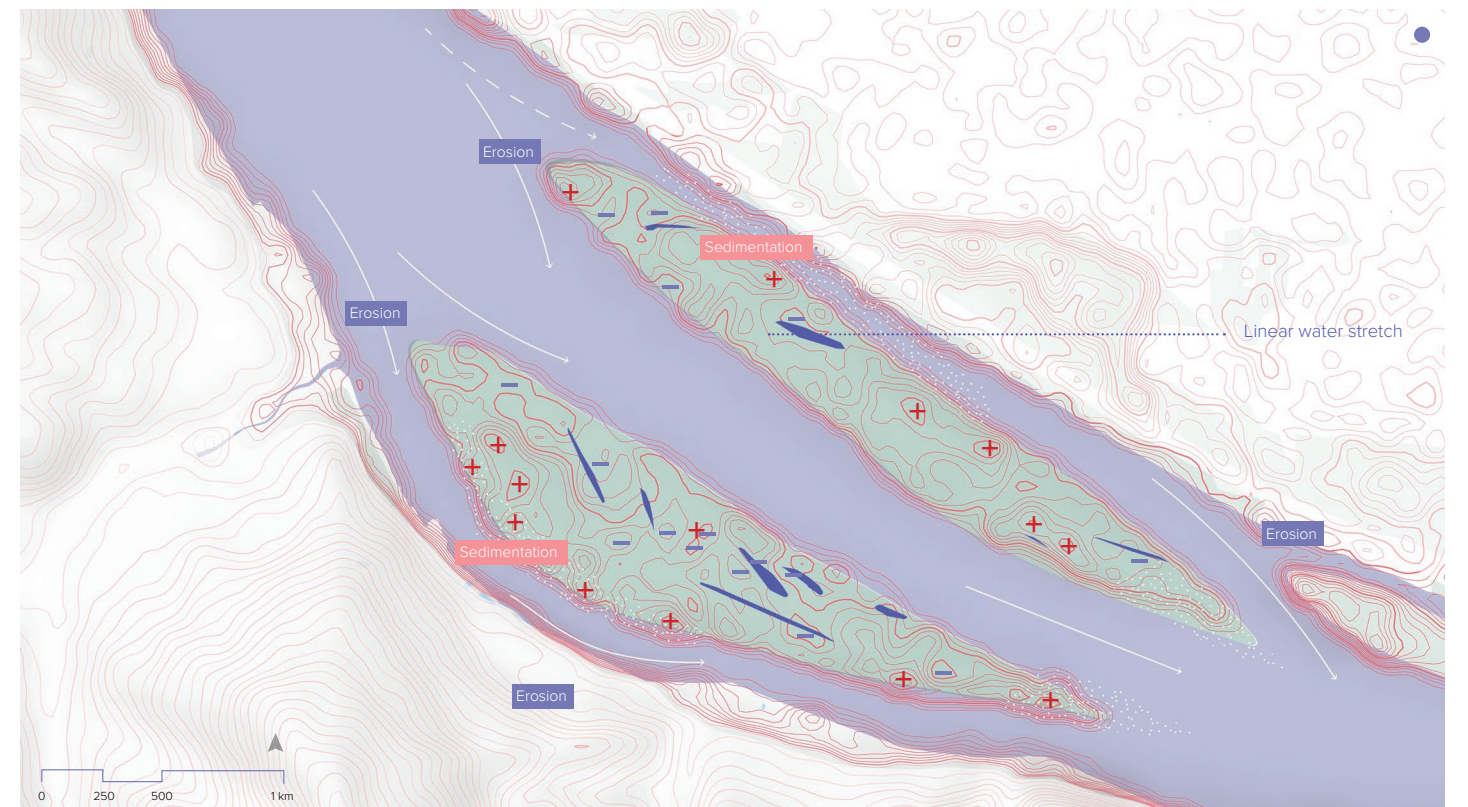
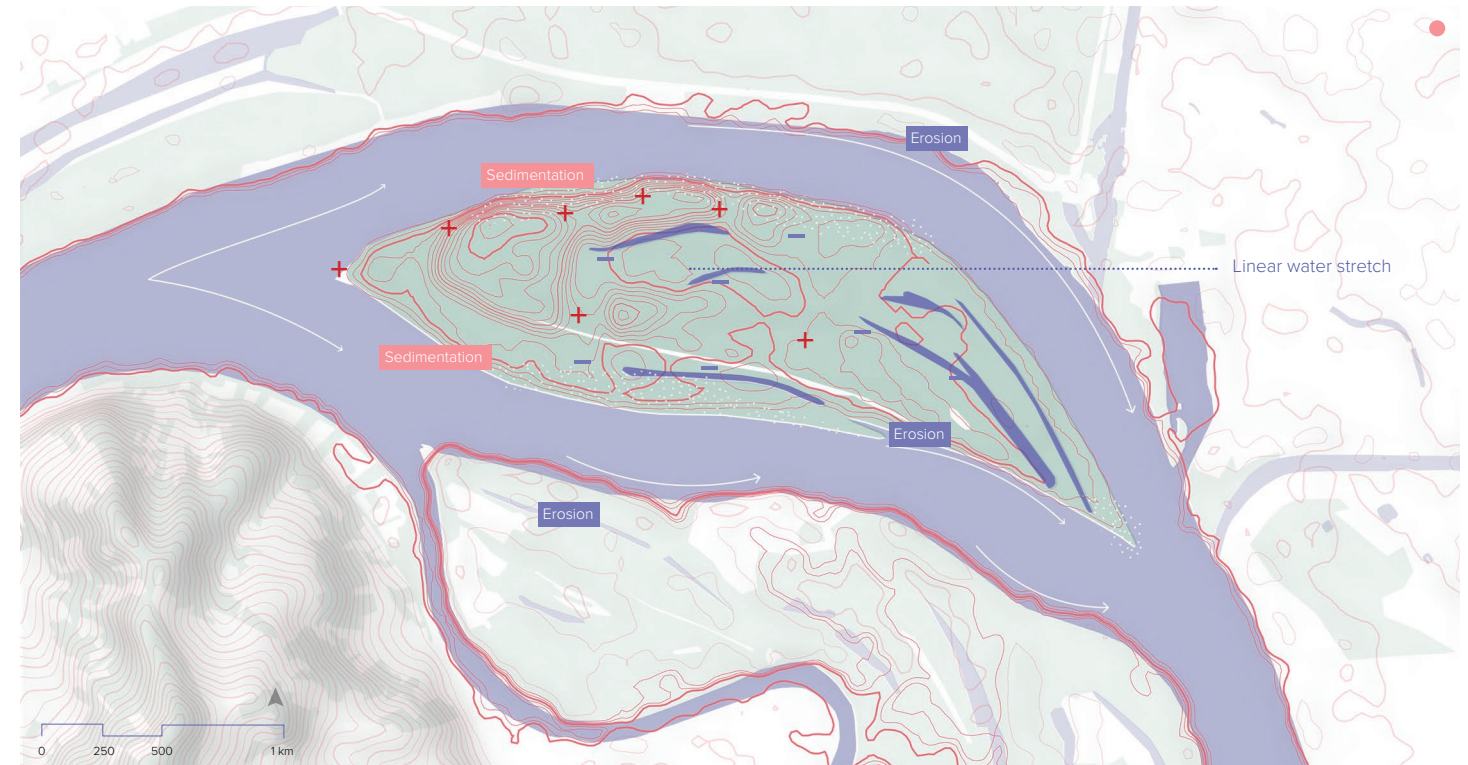
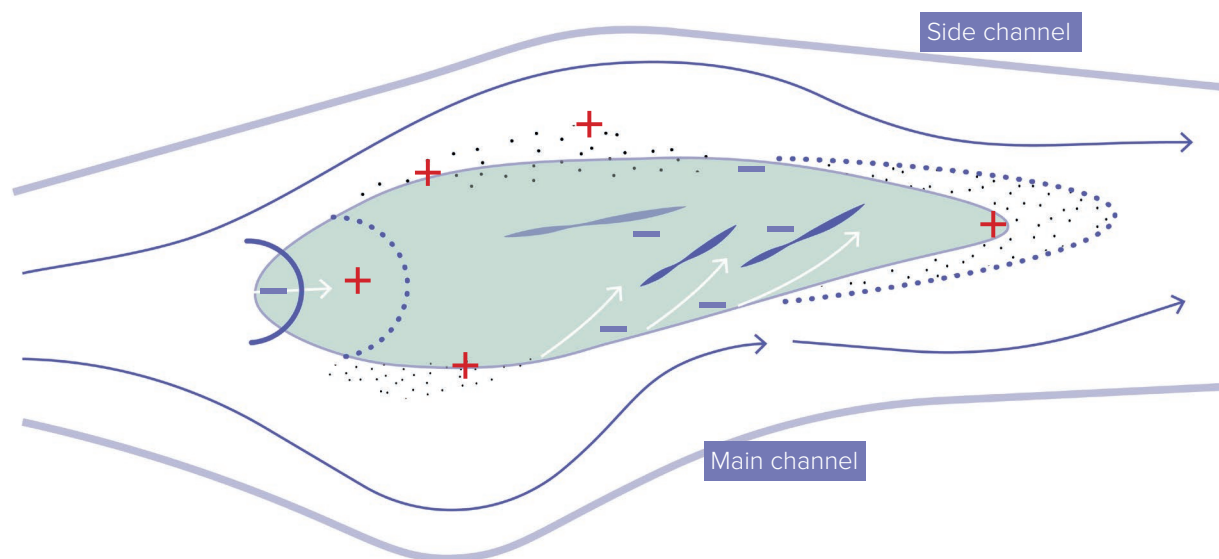


5.4 ISLAND FORMATION IN THE DANUBE

Two islands in the Danube, located downstream of Novi Sad in Vojvodina were studied in order to develop knowledge on the natural elevation patterns of Danube river islands. With the study of these river islands, it has become clear that the formation process is strongly influenced by sedimentation and erosion processes combined with the water velocity. In both river island cases, it can be seen that the tip of the headland is eroded by the water movement of the river currents. The movement of sediment creates an elevation behind this eroded headland.

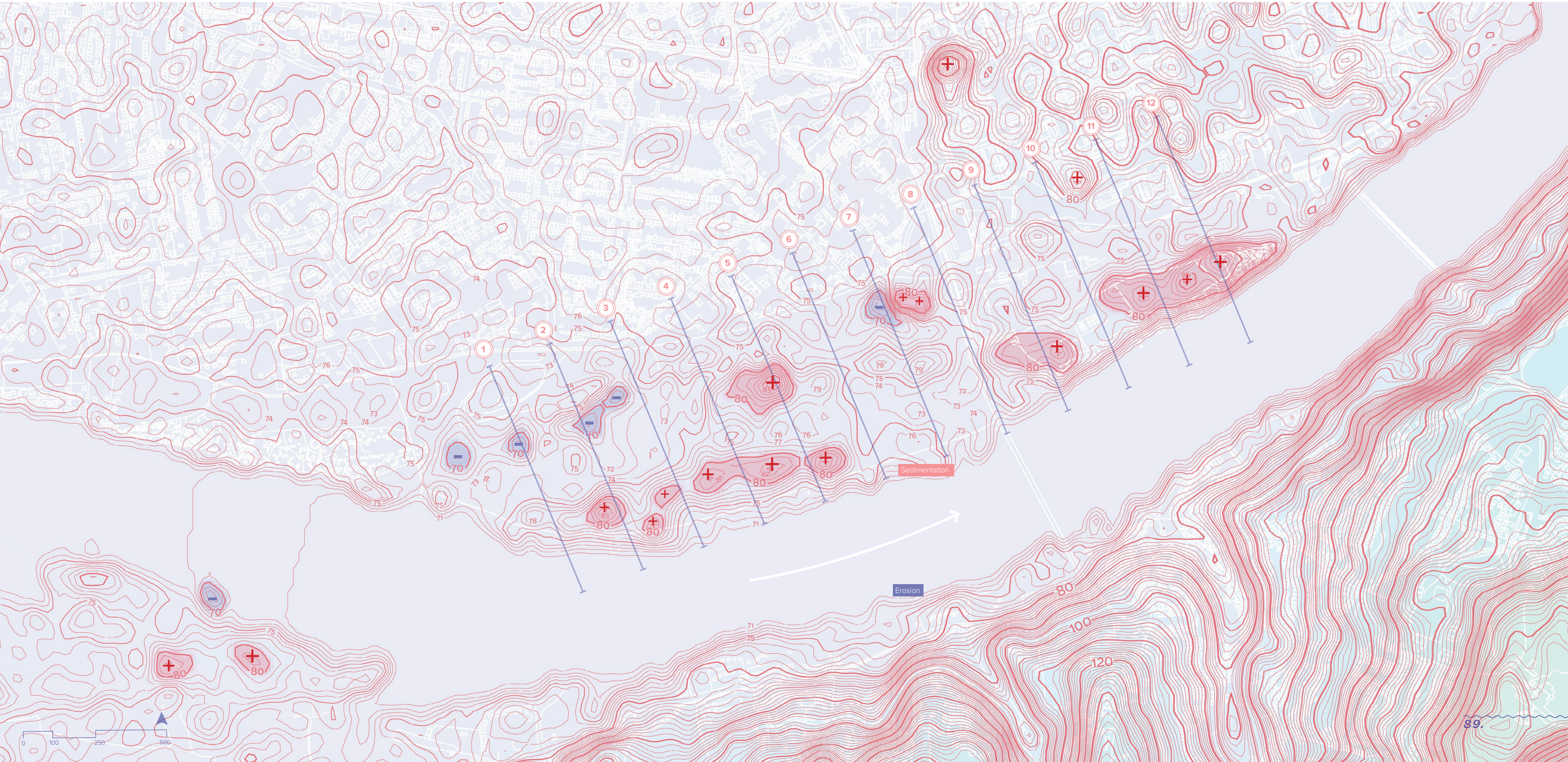
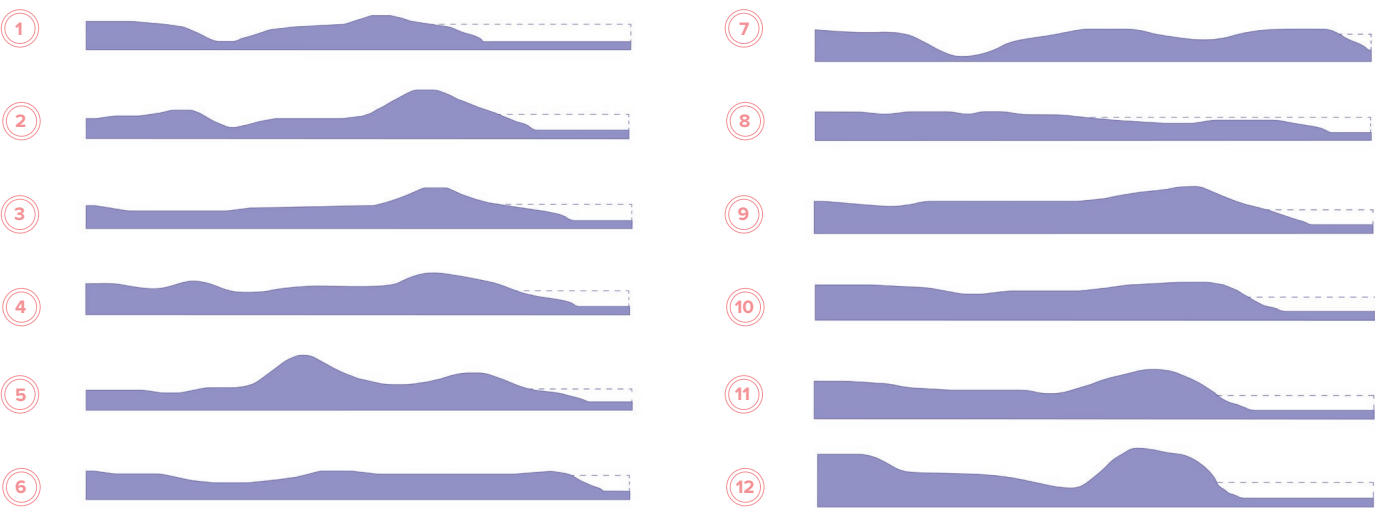
Further, sedimentation takes place in the inner bend of the channel, giving the river islands a higher edge. More sedimentation also takes place in smaller channels due to the slower flow of water. The force of the main flow erodes the island creating an open side, where a pattern of water intrusions develop. Linear water patterns develop in these eroded areas. The downstream tips of the river islands are stretched by the water flow and sedimentation takes place.

Below, a schematic summary of these formation processes is showcased.



Elevation patterns of Kamenička ada

The elevation patterns of Kamenička ada have some similarities with the natural river islands. On the left bank of the Danube, the inner bend, sedimentation has taken place where Kamenička ada has a higher edge. However, this higher edge has been artificially raised in some places at the harbour and where the sand cuts off the river arm at Kamenička ada. There are also a number of depressions more to the inland where the former arm of the river used to flow. Partly due to the illegal constructions and moving around of sand, many of the island's original elevations have been lost, creating a pattern with many bumps.



Conclusion analysis Kamenička ada

In conclusion, the analysis of Kamenička ada highlights several important lessons. Firstly, the blockage of the old river arm from the main Danube flow had resulted in stagnant water. An urban watercourse from Novi Sad discharges its sewage into the stagnant water, further reducing the ecological value. Secondly, the forest of Kamenička ada has characteristics of a natural riparian ecosystem, but the production forest and changes in the natural elevation pattern dominate the former river island. Finally, the impact of human activities, such as the illegal construction of houses, underlines the need for integrated development of the island's ecological value and public spaces.



6. KAMENIČKA ADA DESIGN

6.1 INTRODUCTION

6.2 LANDSCAPE APPROACH KAMENIČKA ADA

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6.2.2 Branches I

6.2.3 Branches II

6.2.4 Conclusion

6.2.5 Research by design

6.3 VISION KAMENIČKA ADA

6.3.1 The water layer

6.3.2 The ecology layer

6.3.3 The culture layer

6.3.4 The strategic vision

6.4 STRATEGIC ZOOM IN RIVER PARK

6.4.1 The water principles

6.4.2 The ecology principles

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6.4.4 The river park

6.5 STRATEGIC ZOOM IN THRESHOLD

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6.5.3 The culture principles

6.5.4 The threshold and bypass

6.6 RIPARIAN RESTORATION AND MANAGEMENT

6.7 CONCLUSION DESIGN

6.1 INTRODUCTION KAMENIČKA ADA DESIGN

This chapter presents the design for Kamenička Ada in the form of a strategic vision. Before the strategic vision is shown, three concepts for the island developed by Prof. Dr. Steffen Nijhuis are explained. These concepts are based on a landscape approach, and form the basis the strategic vision is built upon.

After that, the vision for Kamenička Ada will be built up in relation to the three structural layers: water, ecology and culture. The strategic vision is then presented as a whole, with some relevant maps of the river cycle through the year. A few zoom-ins on the design then provides maps with more detailed sections showing more clearly the different design layers in relation to the design principles mentioned in chapter 4. Eye level perspectives also give meaning to the new spatial qualities of the vision. Finally, a conclusion is drawn about the design.

6.2 LANDSCAPE APPROACH KAMENIČKA ADA

Commissioned by the municipality of Novi Sad, Prof. dr. Steffen Nijhuis has developed three concepts for the spatial and urban development of Kamenička ada, based on a landscape approach. This chapter briefly describes the three concepts and explains their significance for the strategic vision for Kamenička ada.

The bypass concept

The first concept is the bypass concept, where a full connection to the Danube is created in the form of a bypass or secondary channel. The municipality of Novi Sad wants to build a rowing course, that can be integrated into the bypass of this concept. A continuous inflow of water is possible through the threshold which was explained in the case study of the Spiegelwaal in Nijmegen. At the edge of the dike surrounding the river island, new innovative forms of legal housing can take place. This could be a place where people want to live with the knowledge that their homes could flood at certain times in the year. In the interior of the island, the influx of river water from the bypass will give a new chance to the wet riparian forests to develop. A new beach at the edge or front of the city can be developed due to the presence of abundant sand. Low boardwalks can be built across the island for suitable recreation in the wet nature. The harbour in the east of the island and the tip of Kamenička ada can be connected to the new motorway and become new urban developments.



The bypass concept for Kamenička ada, made by author (Source: Nijhuis, 2024).

Branches I

The second concept, called Branches I, has a one-way connection with the Danube river in the form of a backwater inflow. This backwater inflow is very favourable for the development of fish spawning habitat due to the slow flowing of water. The wetland nature is also given a chance to develop in this concept. The embankment continues in the same place around the edge of the river island and ends at the point where urban development can take place in this concept. Urban development can further take place in the harbour and a little further to the west than in the bypass concept. There is also space for an urban beach and wet walkways in the natural core.



The Branches I concept for Kamenička ada, made by author (Nijhuis, 2024).

Branches II

The third concept, Branches II, also has a one-way connection to the Danube, but in a different form up-stream, increasing the speed of the river water inflow. In this concept, the water can flow back into the river and is constantly refreshed by the open connection in the threshold. The embankment runs straight up the island, allowing wetlands to develop on the inside. To the east of Kamenička ada, this will allow for the development of a large urban enclave and a large harbour area. Wet footpaths also run through the nature area, and there is space for an urban beach on the edge of the city.



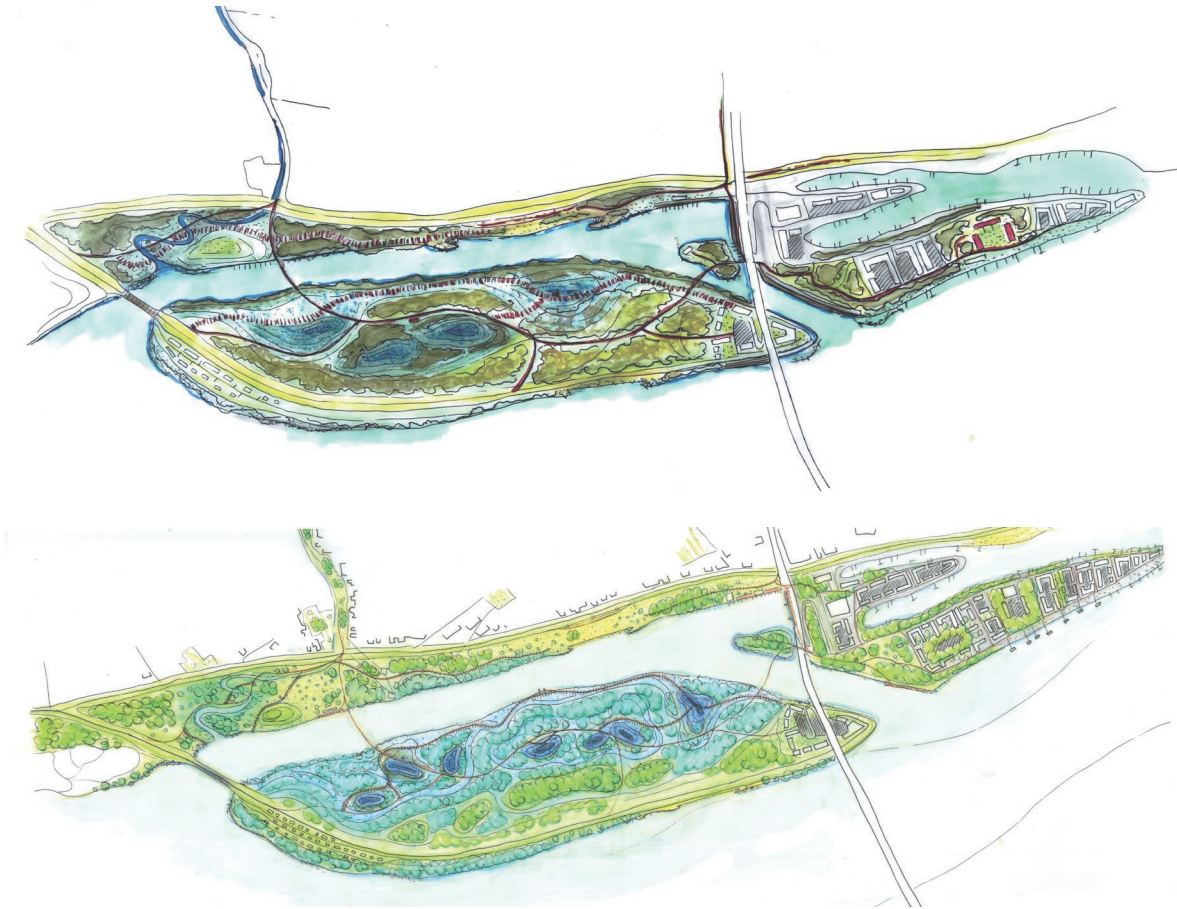
The Branches II concept for Kamenička ada, made by author (Nijhuis, 2024).

Conclusion landscape approach concepts

The three concepts, developed from a landscape perspective, provide a basis for the strategic vision of Kamenička ada. In order answer to the objective of this thesis, it is important to focus on the flood-proof, socio-ecologically inclusive spatial development for Kamenička Ada and Novi Sad. In principle, all three concepts do so, as they are developed from a landscape approach. However, the bypass concept is the most effective in terms of flood-proofing, as it allows the most space for the Danube to flow in the bypass by providing two-way connectivity to the main channel. Furthermore, it still allows enough room for the development of ecological and social spaces. Therefore, it was decided to set up the strategic vision from this bypass concept.

Research by design

To achieve the strategic vision, research by design was applied as part of the iterative research through design cycle. In several sketching sessions, the underlying topography of the island was developed and refined in conjunction with different spatial forms of river water intrusion. The final design shape was derived from these tests and the study of natural patterns on active river islands in the Danube. After taking a step back from the design sketches to study natural river islands, the conclusion was made that, through intrusion channels, deeper open water in the island can be naturally filled with fresh river water. Over time, this will have a significant impact on the ecological value and natural succession of the riparian nature. The different design layers of the final strategic vision will be discussed next.



Explorations of the bypass concept.

6.3 STRATEGIC VISION KAMENIČKA ADA

This chapter discusses the different layers of the strategic vision for Kamenička ada and shows the full vision map. The water layer of the vision relates to the underlying topography of the river island and the Danube's flood regime. Using the Novi Sad hydrographic station, the number of days per year when certain water levels occur was calculated to understand the annual flood regime of the river. The table opposite shows a summary of these figures.

It was also necessary to understand the extremes of the river, the so-called return periods of the floods. For Novi Sad, the return periods are also shown in the adjacent table. A return period of 10 years means that the type of flood in question occurs once every 10 years. The river extremes have been taken into account for the accessibility of the island and the safety of living near the river. The first layer, the water layer, shows how this knowledge is reflected in the design.

The second layer, the ecology layer, deals with the natural succession that can take place in the different areas of the river island, which is strongly related to the flood regime, as clearly described in the analysis chapter of Kamenička ada. The planned vegetation growth was predicted using this knowledge in order to paint a picture of the target vegetation of the vision. Also, some local species are linked to the target habitats, such as the Black Stork and Sterlet.

In the third design layer, the cultural layer, various new connections with the city, the Eurovelo bicycle path, and the highway are discussed. Specifically, there are pathways accessible only to pedestrians, situated at a lower elevation, making them unreachable at a water level of 75.5 meters above sea level. Higher pathways, accommodating both cyclists and pedestrians, remain accessible throughout the year and are only prone to flooding during rare occurrences.

Additionally, the design showcases the new development of urban clusters, notably a high-urban development in the harbor area, urban development at the eastern tip of the river island itself, and dike houses along the dike's edge.

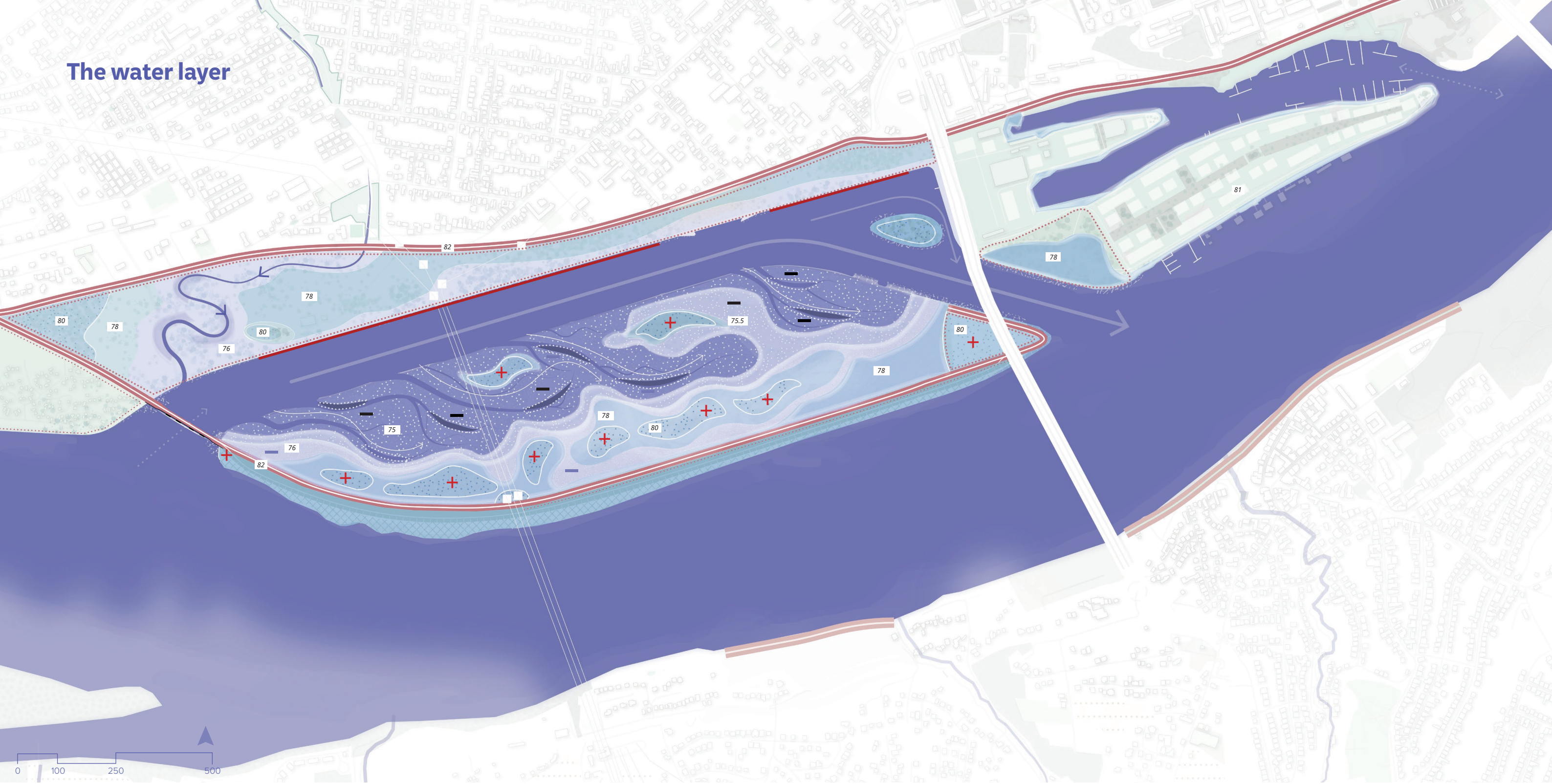
Perhaps most importantly in the cultural layer, the design includes the addition of new public, accessible space for Novi Sad. The first in the form of a fully accessible park north of the bypass. This park features multiple viewpoints overlooking the bypass, a beach, and a potential location for a rowing club. Furthermore, the river island itself, along the pathways, is transformed into an accessible nature river park, featuring two bird-watching towers and several recreational routes. The southern part of the island, designated as protected habitat, remains largely undisturbed. Within the urban cluster, there is also space allocated for the creation of meeting squares and gathering spots with views over the Danube.

<i>Amount of days per year</i>	<i>Water level of the Danube m.a.s.l.</i>
circa 150 days	73 m.a.s.l.
circa 120 days	74,5 m.a.s.l
max. 90 days	75 m.a.s.l
max. 40 days	75,5 m.a.s.l
max. 10 days	76 m.a.s.l

<i>Return period</i>	<i>Water level of the Danube m.a.s.l.</i>
1x in 10 years	78 m.a.s.l.
1x in 100 years	80 m.a.s.l

Two tables on the river cycle per year and return periods. Source: (DanubeHIS, 2024) and (Sakulski, 2011).

The water layer



Flood cycle

- max 90 days per year flood
- 10 year return floodable area
- max 40 days per year flood
- 100 year return floodable area
- max 10 days per year flood

Elements

- Intrusion channel
- Wetland lake
- Meander
- Intermediate buffer
- Threshold
- Dike
- Erosion prevention measure

On this map the water layer of the design is showcased. The threshold, through which constant influx of fresh river water is possible is seen on the upstream side of the bypass, connected to the dike. The left bank of the bypass is prone to erosion, for which rocks can be placed alongside the banks. The right side of the bank is open to create water influx in designed intrusion channels, with deeper inner bends for the water to slow down and to create wetland areas. Over time, these channels can get clogged with sediments, which can be removed in order to maintain the influx of fresh river water deep inside the island.

In the urban front, the north side of the bypass, an urban waterway from Novi sad is expanded and given a meandering character, in which wetland plants could be placed to filtrate the water before entering the bypass. Furthermore, in the red dotted areas, the north of the bypass, the housing development on the eastern edge, and the park near the harbour development the intermediate space of the design is seen. These spaces could be adapted in the future in cases of more heavy floods than predicted.

The ecology layer



Nature types and elements

- Riparian wetland
- Pioneer Willow scrub and Willow-Poplar forest
- Willow-Poplar forest
- Poplar-Alder forest
- Ash-Elm forest
- Oak-Ash-Elm forest

Elements urban front

- Sediments deposit
- Erosion
- Park meander
- Urban green
- City beach
- Dike
- Green corridor

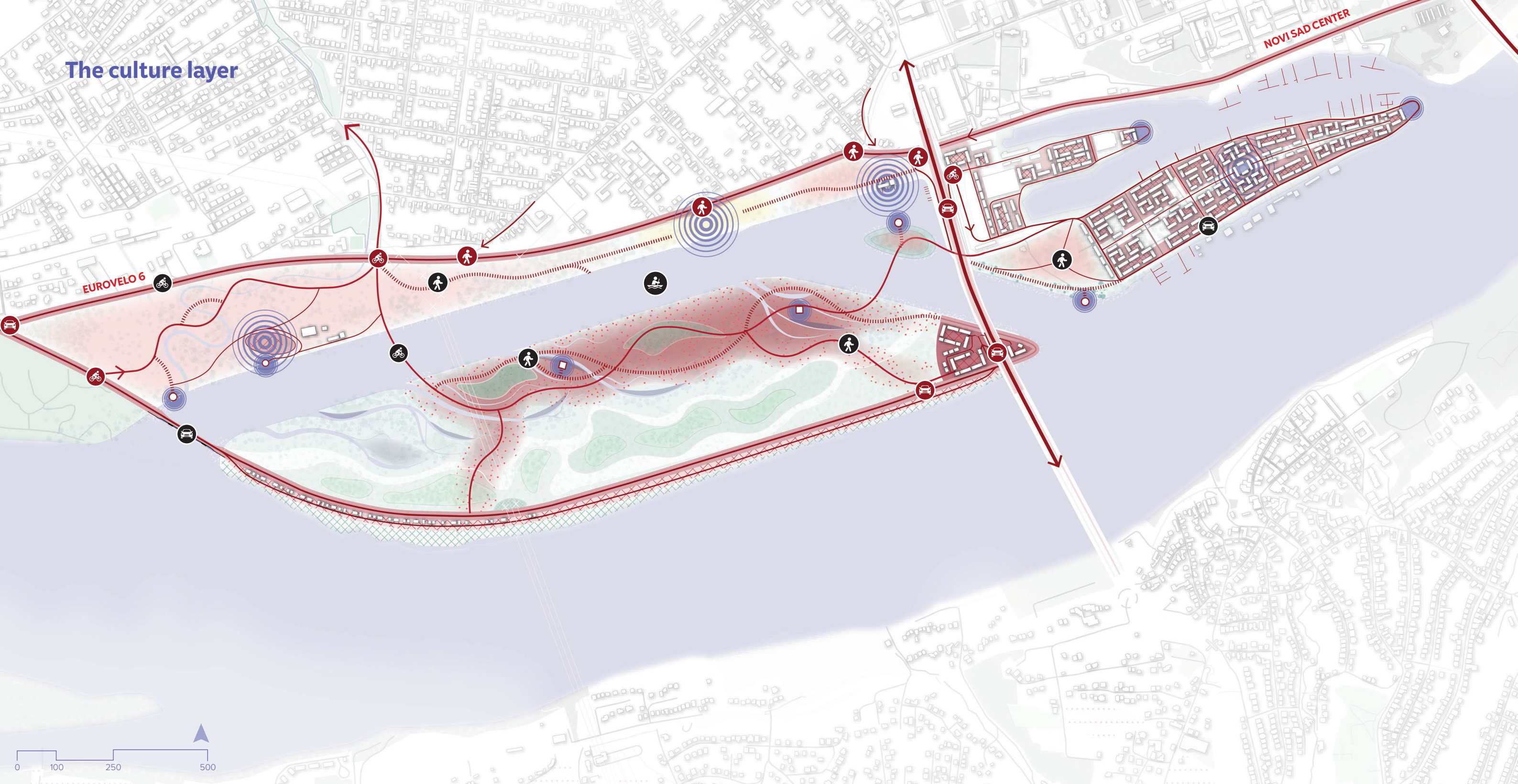
Animals

- Riparian birds
- European pond turtle
- Amphibians
- Danube fish

The second map shows the ecology layer of the design, in which the different wetland and riparian forest types are shown. Also, the different edge typologies for the bypass are visible on the map. The most low lying areas of the river island will develop into wetlands, with surrounding pioneer Willow scrub and Willow-Poplar forest, habitat for the Black Stork. Furthermore, in the intrusion channels, the Sterlet and other Danube fish could lay its eggs between rocks. At higher elevations, the Poplar-Alder forest and the Ash-Elm forest can be found. At the highest points, even Oaks could settle in time.

At the urban front the meander in the park becomes habitat for species such as the European pond turtle. The connection to the urban waterway itself could be valuable for the migration of amphibians. The river island itself becomes a new bird sanctuary, in which it becomes an important stepping stone with the river islands in the west of Kamenická ada.

The culture layer



Functions

- River island nature recreational area
- Recreational park urban front
- Urban development island
- Dike pole houses
- Walking path with look out dock
- Bird watching tower

- Sand stairs
- Urban development harbour
- Public cultural square
- Public places for long stay
- Public elements for views

Infrastructure

- Car road along dike
- Elevated cycling and pedestrian path
- Pedestrian path
- Car entry way
- Cyclist entry way
- Pedestrian entry way

The third layer shows the culture layer of the strategic vision. With the red symbols, the new entryways for pedestrians, cyclists and vehicles is seen. In this way, the river island becomes an accessible public space. Furthermore, in the northern part of the bypass new meeting spaces are developed for the city, in the form of a lookout hill in the west, a second city beach accessed through sand stairs from the dike, and a rowing facility with docks along the bypass. Also look out spots are developed along this edge. In the river park, the recreational network is showcased, with two bird watching towers connected to different paths. Also, the urban developments along the dike, in the form of dike houses and the development on the eastern point of the island and the harbour are showcased.

Strategic vision Kamenička ada



- 1 Sand steps to city beach
- 2 Recreational park with old farm
- 3 Rock beach
- 4 Bird watching tower
- 5 Protected habitat
- 6 Rowing/ Water sport facility
- 7 Spectator island
- 8 Connection to bridge
- 9 Cultural public square
- 10 Look out point

River island nature park

- Riparian wetland
- Pioneer Willow scrub and Willow-Poplar forest
- Willow-Poplar forest
- Poplar-Alder forest
- Ash-Elm forest
- Oak-Ash-Elm forest
- Dike with houses
- Cycle and walking path
- Low walking path
- Urban point river island

Urban front Novi Sad

- Accessible park with meander
- Spectator hill
- City beach
- Threshold bypass
- Urban development harbour
- Harbour
- Green connections towards Novi Sad

150 days per year

120 days per year

max. 90 days per year

max. 40 days per year

max. 10 days per year

return period 10 years

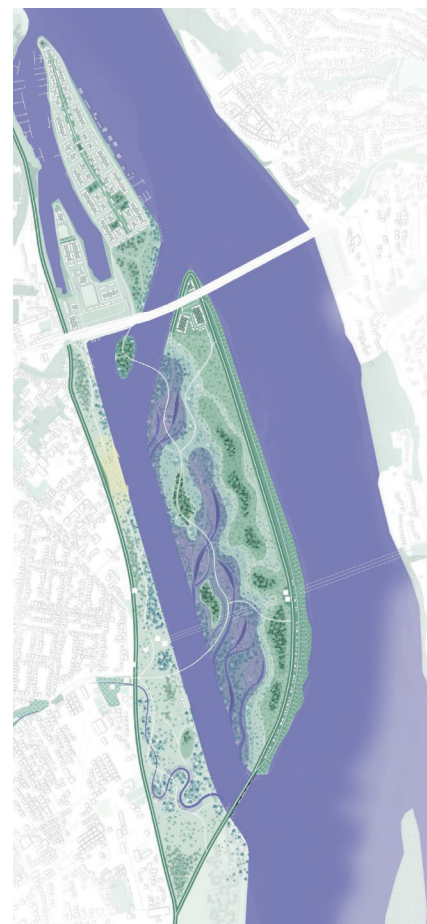
return period 100 years



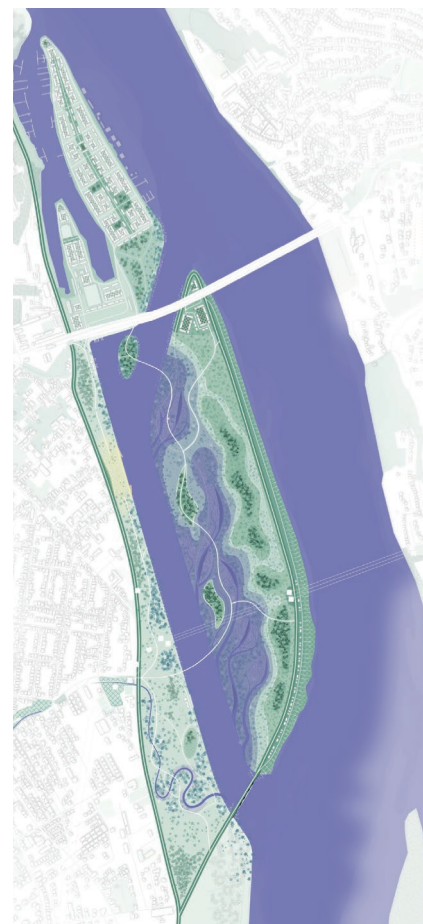
73 m.a.s.l



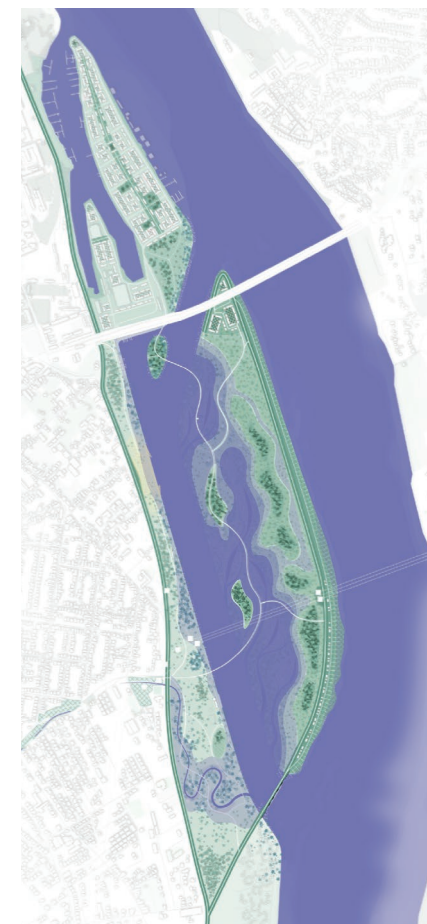
74.5 m.a.s.l



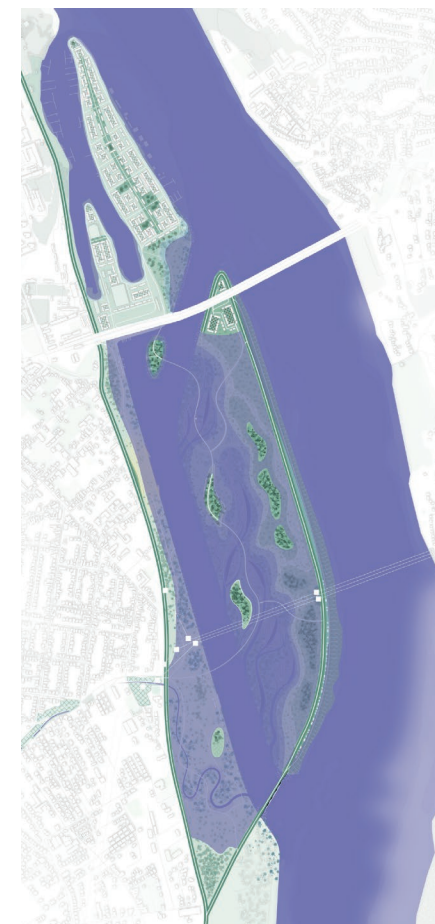
75 m.a.s.l



75.5 m.a.s.l



76 m.a.s.l



78 m.a.s.l



80 m.a.s.l

Low water level

High water level

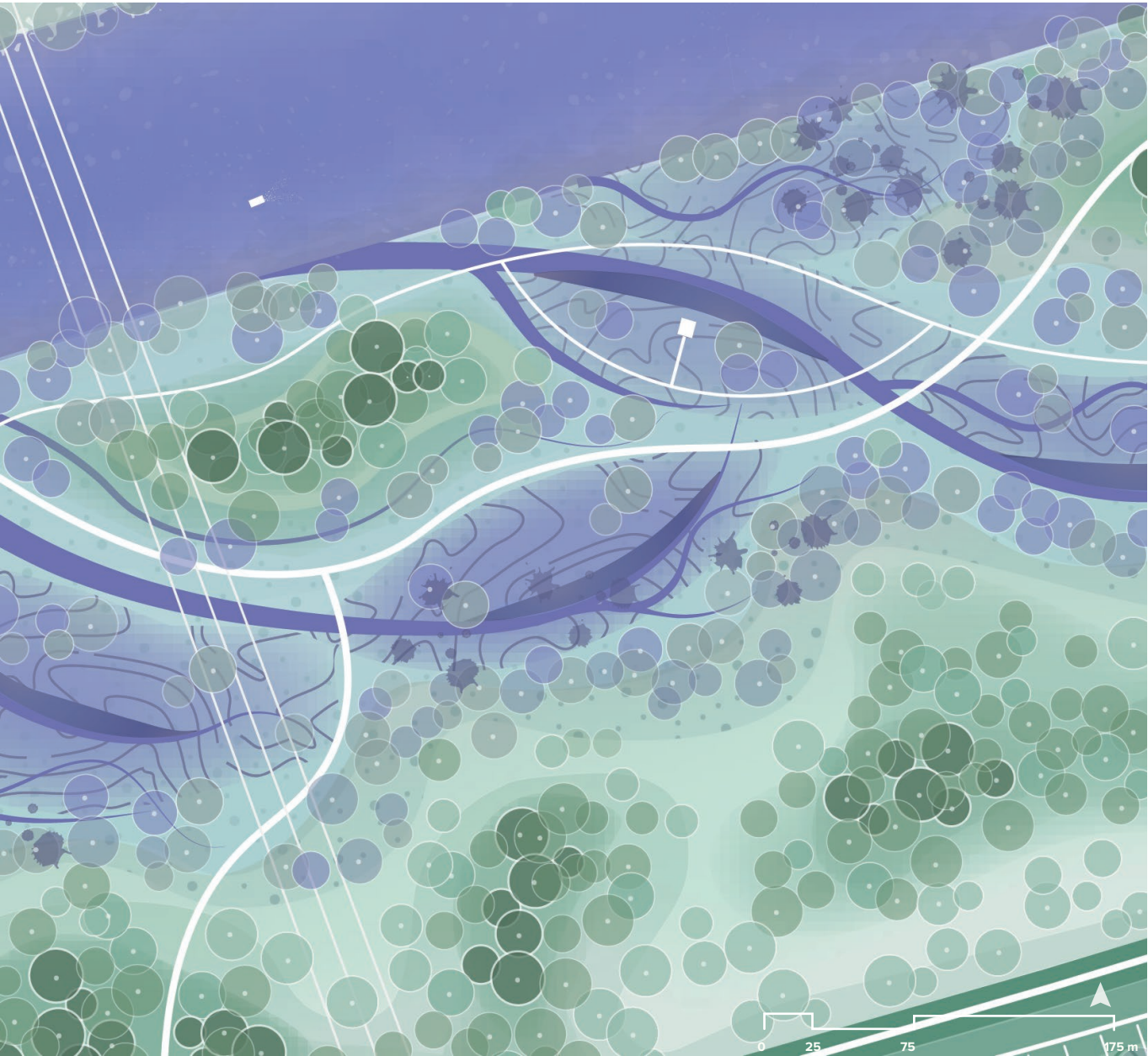
The flood cycle of the river island is an important element for the functioning of the whole strategic vision. In this map series, the different stages of flooding, the duration and the associated Danube water level is seen. From 75 m.a.s.l, which is the water level for a maximum of 90 days per year, the first small flood of the river island occurs. The wet walking paths will be still accessible, however the rest of the nature area will be flooded with a layer of water.

From 75.5 m.a.s.l. onwards, the wet walking paths will overflow, making the river park accessible through the higher pedestrian and cycling bridge, which stand at 78 m.a.s.l. At the water level of 76 m.a.s.l, which occurs a maximum of 10 days per year, most of the lower lying parts of the river island will be flooded. Only at the return period of ten years, the higher pedestrian and cycling bridge will risk flooding.

Also the dike houses standing at the left bank of the Danube will be partly flooded once in ten years. The island will remain accessible for the housing development at the most eastern point through the infrastructure on the dike and threshold. However, at the return period of 100 years, the threshold will overflow, same goes for the housing development at the point. This is part of the choice of living on this dynamic river island.

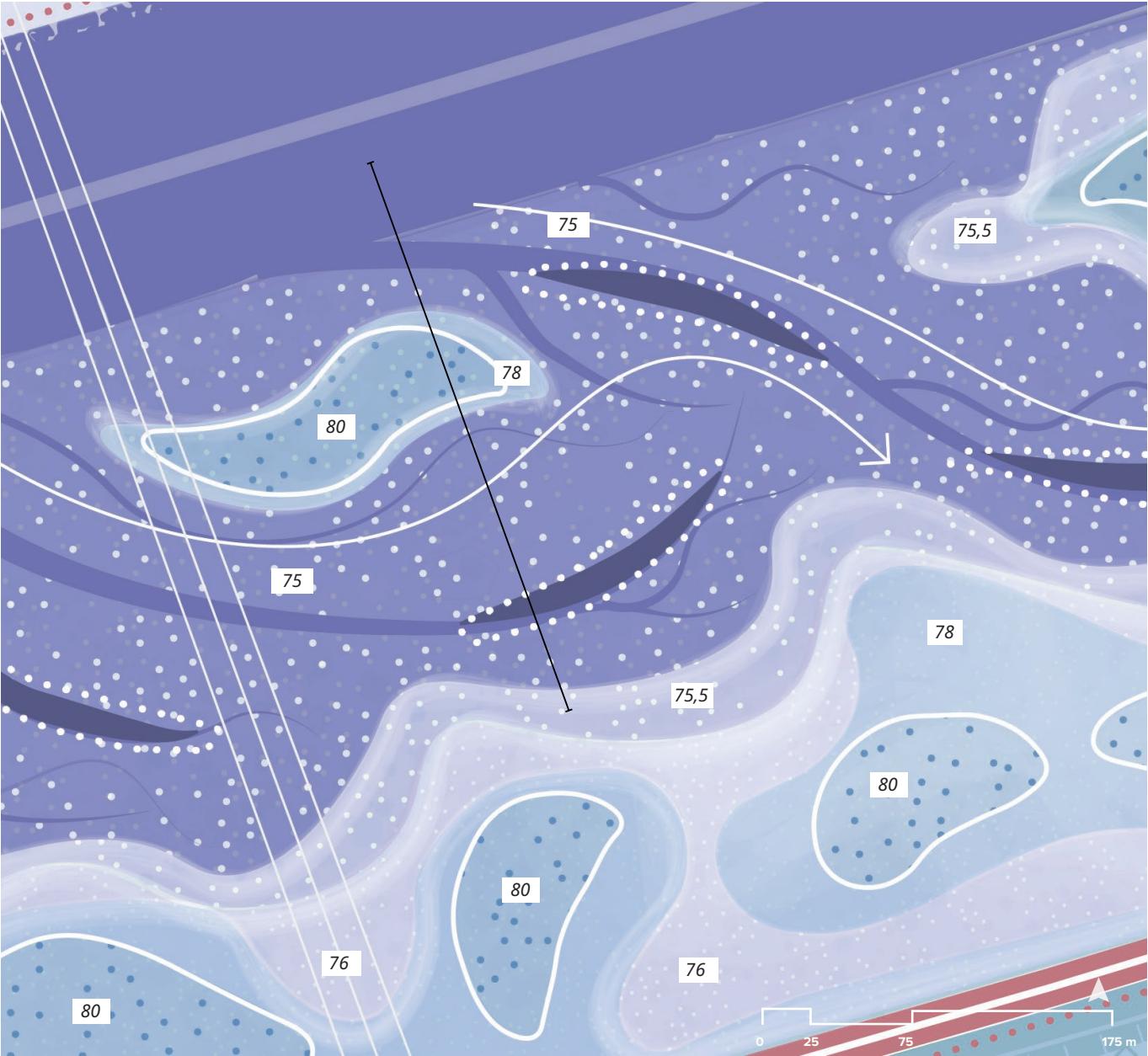
6.4 STRATEGIC ZOOM IN RIVER PARK

In this chapter, a zoom in is provided of a strategic point in the river island nature park, where the different recreational paths come together, a bird watching house is developed and most elevation differences related to the yearly flood cycle come back. First, the different design layers are explained again through the three layers of water, ecology and culture, with a series of sections. To these sections, the earlier mentioned principles are linked to make the translation of principles to strategic vision clear. The chapter ends with a visualisation of the different components of this strategic zoom in, in order to give a complete image of which spatial qualities are added through the design.



- | | | |
|---|---|--|
|  Riparian wetland |  Poplar-Alder forest |  Bird watching tower |
|  Pioneer Willow scrub and Willow-Poplar forest |  Ash-Elm forest |  Cycle and walking path |
|  Willow-Poplar forest |  Oak-Ash-Elm forest |  Low walking path |

The water layer



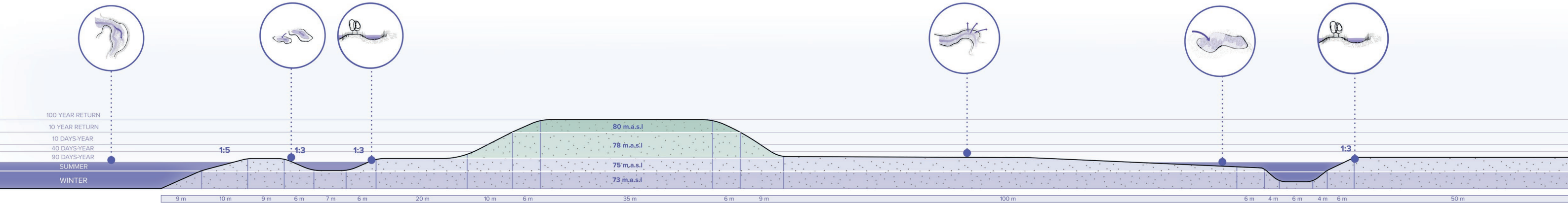
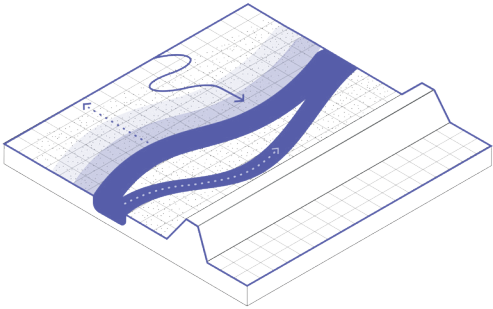
In the section below, the gradients of the elevation patterns become clear. From the bypass to its right bank, a 1:5 talud is used in order to foster the development of an ecological edge. The intrusion channels, forming the fertile connection between the bypass and the river island have a slow talud of 1:3. Because of the deeper inner bends of the channels, the channels have assymetrical profiles, with one very slow edge to provide water to flow into the developing wetlands.

In the sections, the different lines indicate the water levels related to the earlier mentioned yearly flood cycle and return periods.

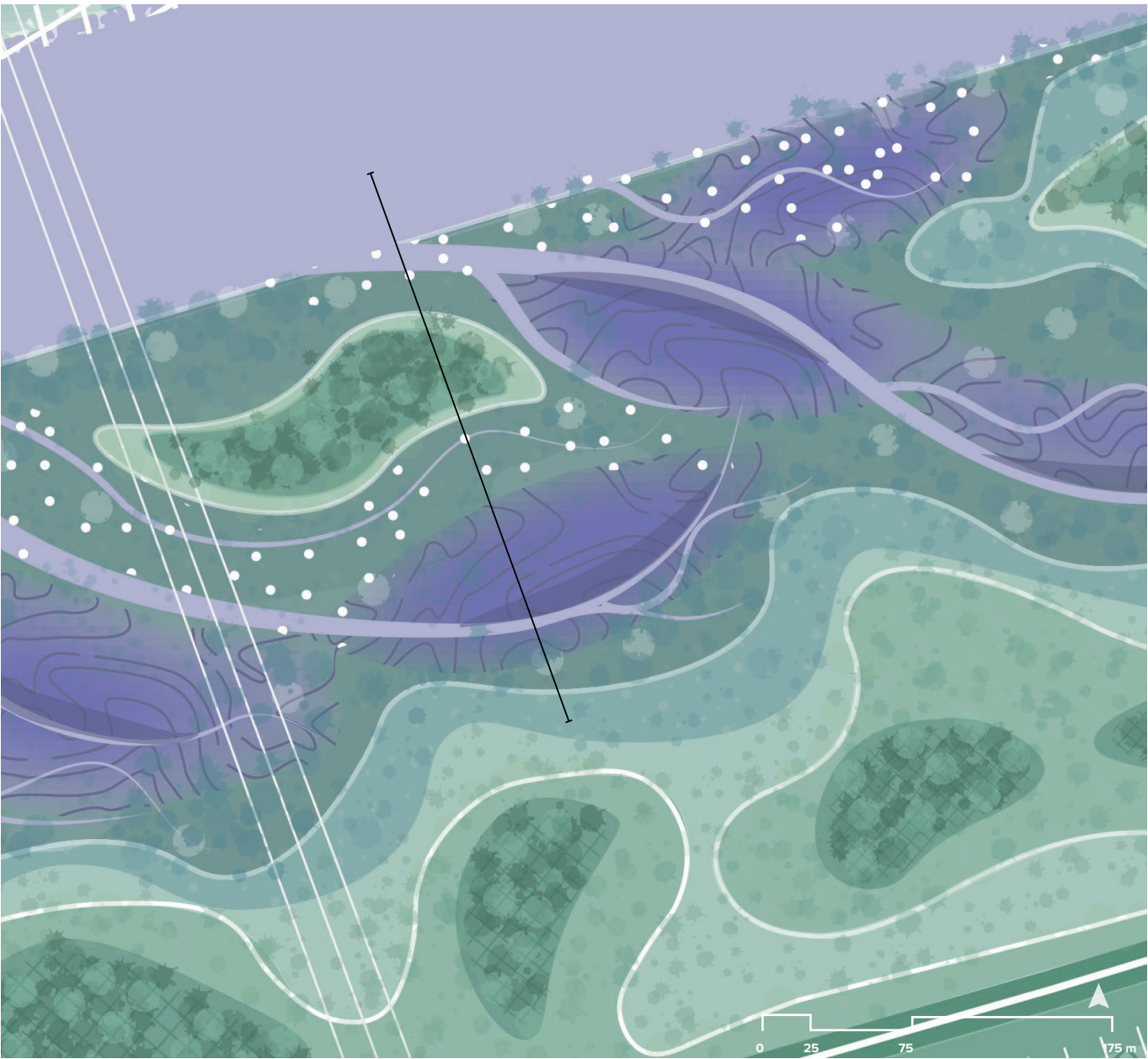
It is visible how the principles have been applied to the river island, in the form of the bypass, the intrusion channels and newly activated wetlands, the slow edges and the newly developed expansion of the floodplain.

- max 90 days per year flood
- max 40 days per year flood
- max 10 days per year flood
- 10 year return floodable area
- 100 year return floodable area
- Intrusion channel
- Wetland lake
- Dike
- Flow direction
- XX** Meters above sea level

Allow river dynamics



The ecology layer



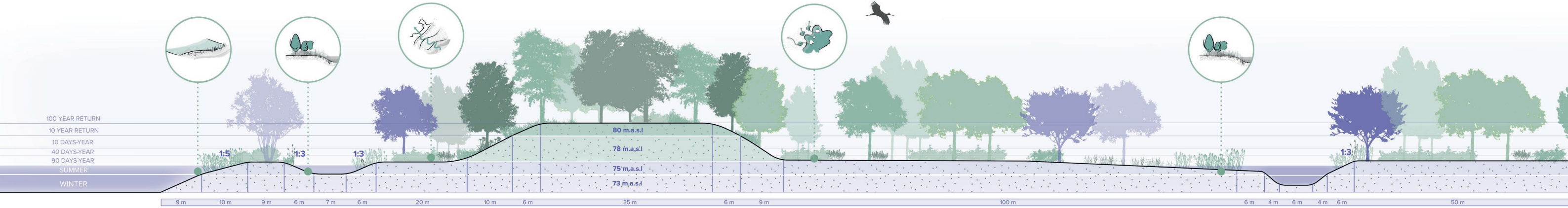
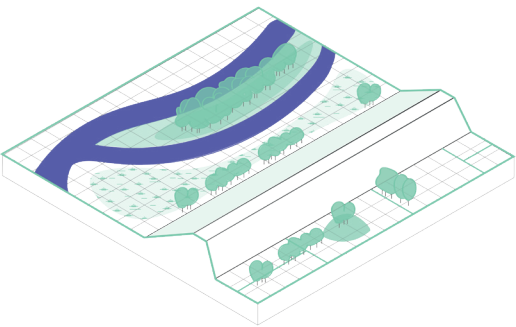
For the ecology layer of the zoom in, the gradients between the different ecological developments become clear. Near the river bank, pioneer vegetation such as Willow scrub can develop, as well as along the edges of the intrusion channels. Further, Willow-Poplar forest can develop around the intrusion channels, and in the wetlands more lower, wetland vegetation can grow with few Willow trees. Moving to the higher topography of the river island, Poplar-Alder forest, then Ash-Elm forest can develop with on the highest topography of 80 m.a.s.l. some Oaks.

The slow slopes of the bypass edge and the intrusion channels promote the development of species such as the earlier mentioned Sedge to thrive.

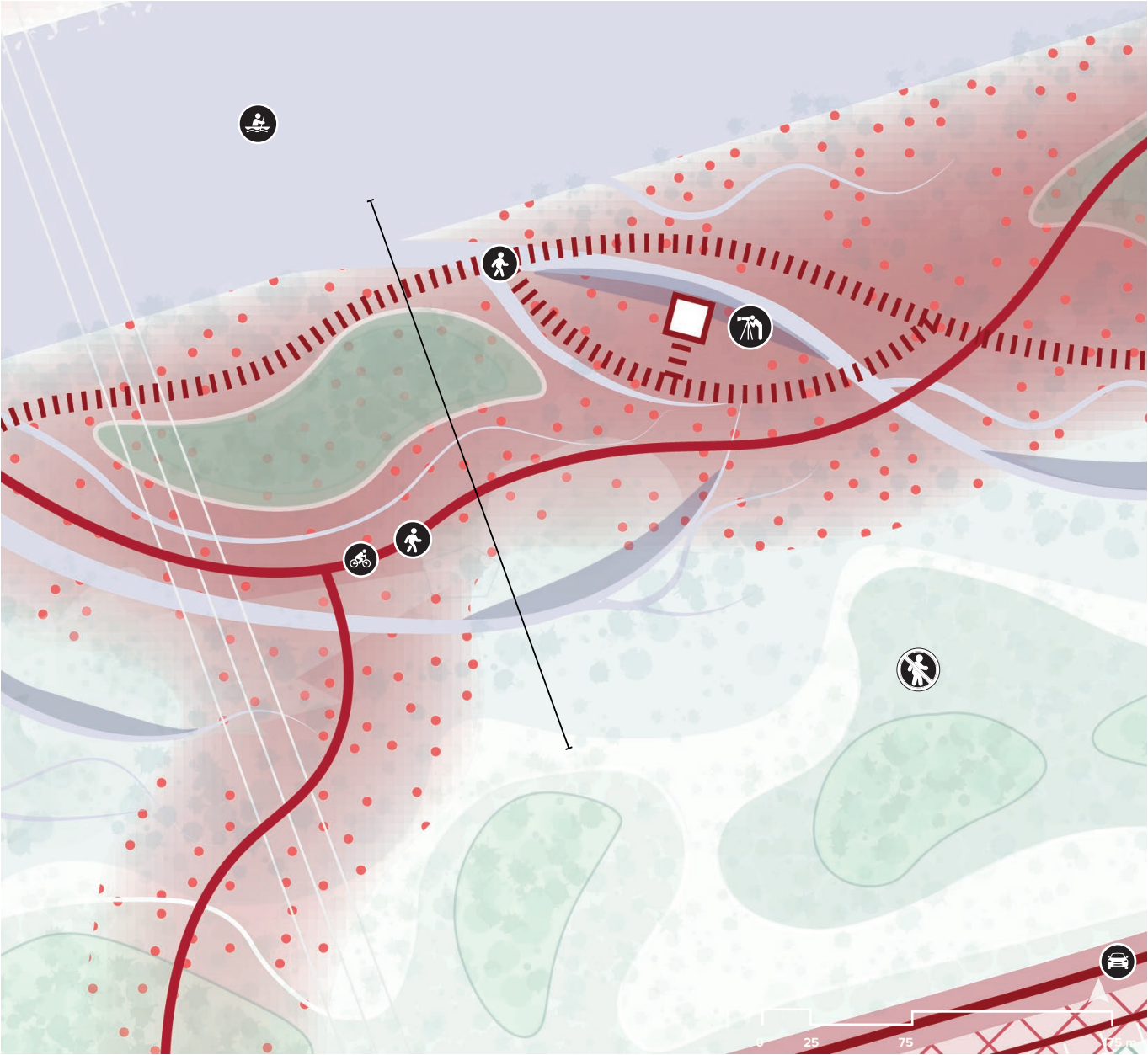
In the section it is visible how the principles have been related to the design, namely the slow edges, the river park as a buffer between the city and the protected habitat and soft edges.

- Riparian wetland
- Pioneer Willow scrub and Willow-Poplar forest
- Willow-Poplar forest
- Poplar-Alder forest
- Ash-Elm forest
- Oak-Ash-Elm forest
- Sedimentation

Restore, Create, Connect



The culture layer

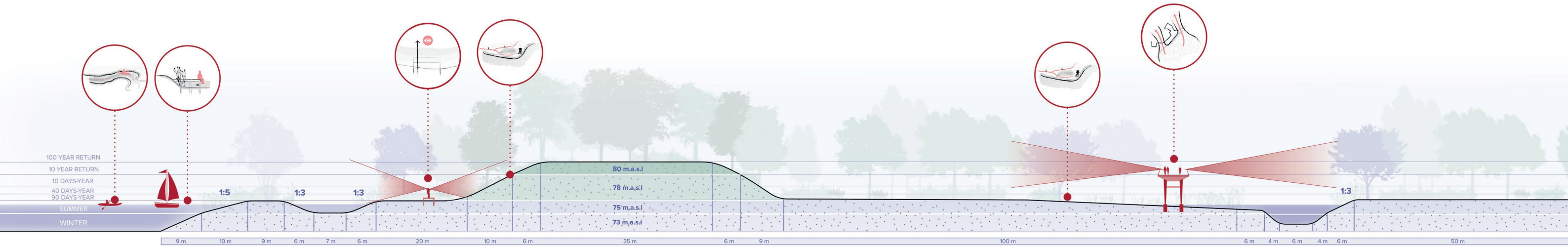
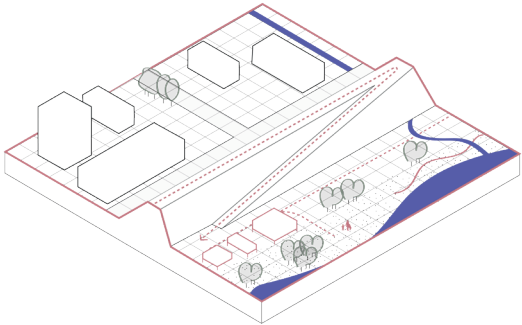


The section of the culture layer shows the different recreational paths and accessibility of the island. As mentioned before the wet walking path overflows yearly, through which an experience with the river dynamics is provided visually, as well as reconnection between humans and the river. The higher pedestrian and cycling connection provides a special higher overview over the river island, and floods only during the ten year return period.

In the bypass different types of sporting activities, such as rowing or sailing can take place. In the section the different applied culture principles are visible, namely the principle of sporting activities, human interaction with water, accessible river park and blending the borders between the city and the river.

-  River island nature recreational area
-  Low lying pedestrian paths
-  Elevated cycling and pedestrian path
-  Bird watching house
-  Car route along dike
-  Protected habitat

Understand, Involve, Adapt



The Kamenická ada River park

In this collage perspective, the vision for the Kamenická ada river nature park is showcased. A low lying wooden walking path leads to one of the bird watching towers of the nature area. From there, visitors have view over a wetland patch and intrusion channel, which is an attractive area for riparian birds.

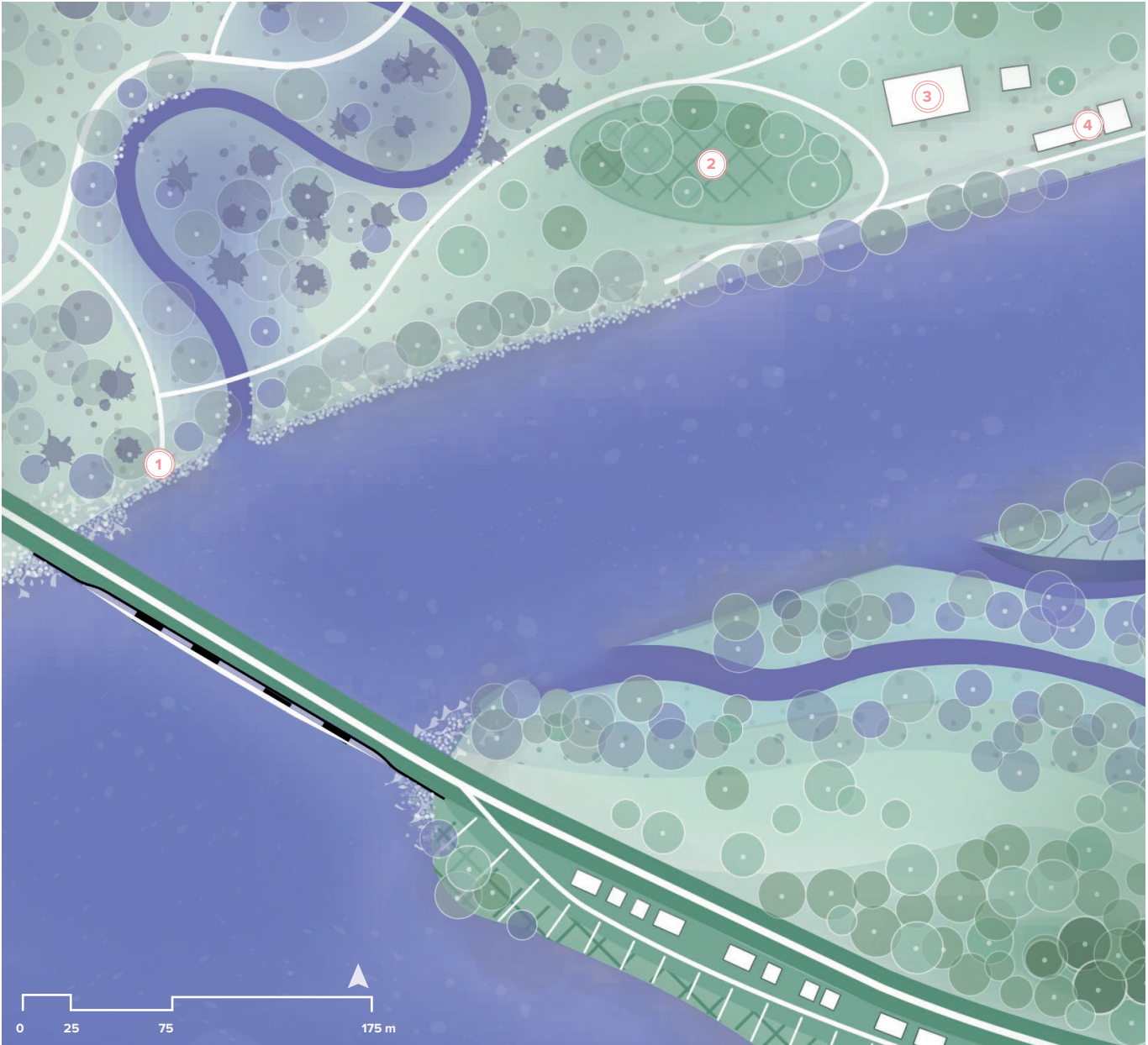




This collage perspective shows how the elevated cycling and walking route runs through the nature reserve. From this elevated path, one has extensive views of the nature area and the various intrusion channels. It offers a different nature experience from the lower paths. Along these channels, the development of riparian wetlands can be seen along with willows, poplars and riparian birds.

6.5 STRATEGIC ZOOM IN THRESHOLD

In this chapter, a zoom in is provided of the threshold and bypass, with the infrastructural connection of the dike and legal dike houses. Again, the different design layers are explained through the three layers of water, ecology and culture, and a series of sections. To these sections, the earlier mentioned principles are linked to make the translation of principles to strategic vision clear. The chapter ends with a visualisation of different components of this strategic zoom in, in order to give a complete image of which spatial qualities are added through the design.



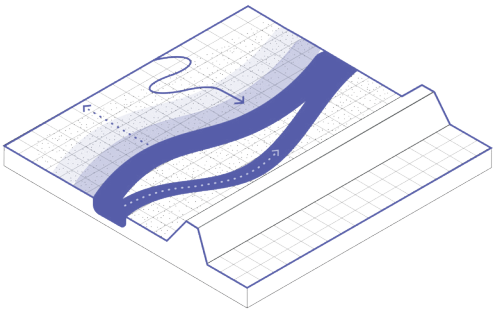
- | | | | |
|---|--------------------------|----------------------|--------------------|
| Pioneer Willow scrub and Willow-Poplar forest | Oak-Ash-Elm forest | Dike and dike houses | 1 Rock beach |
| Willow-Poplar forest | Cycle and walking paths | Threshold bypass | 2 Spectator hill |
| Poplar-Alder forest | Intrusion channel | | 3 Old farm |
| Ash-Elm forest | Meander water filtration | | 4 Tourist function |

The water layer



- max 40 days per year flood
- 10 year return floodable area
- Intrusion channel
- Threshold and dike
- Intermediate buffer
- max 10 days per year flood
- 100 year return floodable area
- Wetland lake
- Meander
- xx Meters above sea level

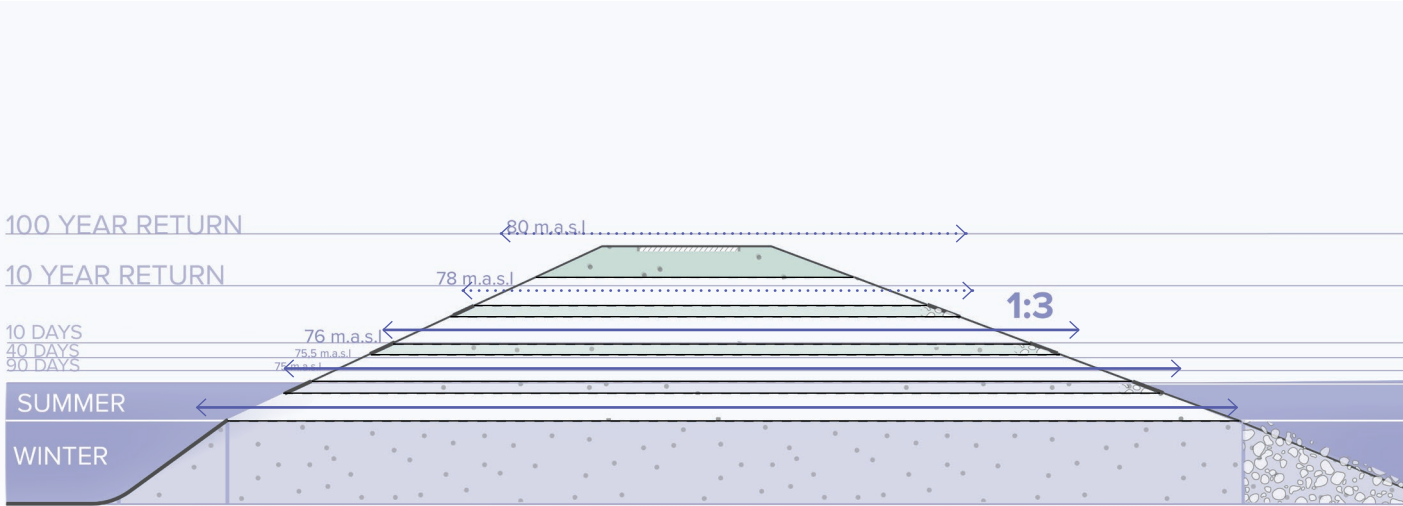
Allow river dynamics



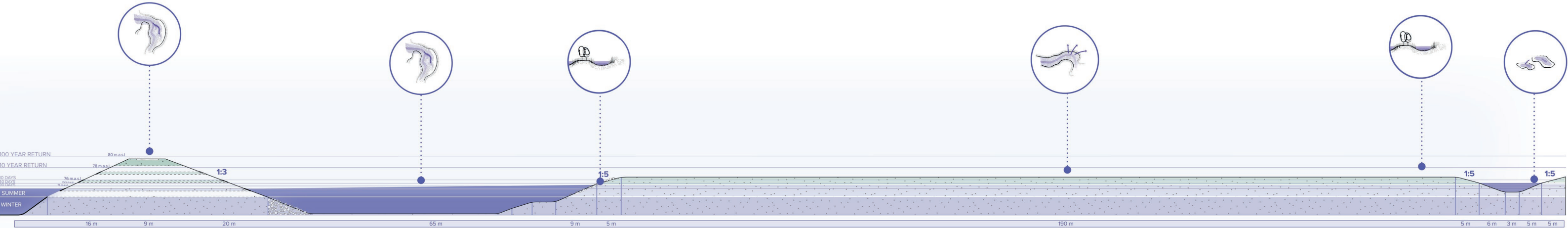
In the water layer of this zoom-in, the main water safety object, the threshold is showcased. It is inspired by the threshold at the Spiegelwaal in Nijmegen, but has been adapted to the fluctuations of the Danube, which can be extremely different in dry and wet periods during the year. The threshold is part of the embankment or dike, one of the main connections to the river island for cars from mainland Novi Sad.

The threshold is surrounded by stones to prevent erosion and maintain its shape. These stones extend into a rock beach where people can enjoy the water at the end of the urban waterway and meander. This area is part of the earlier mentioned intermediate space.

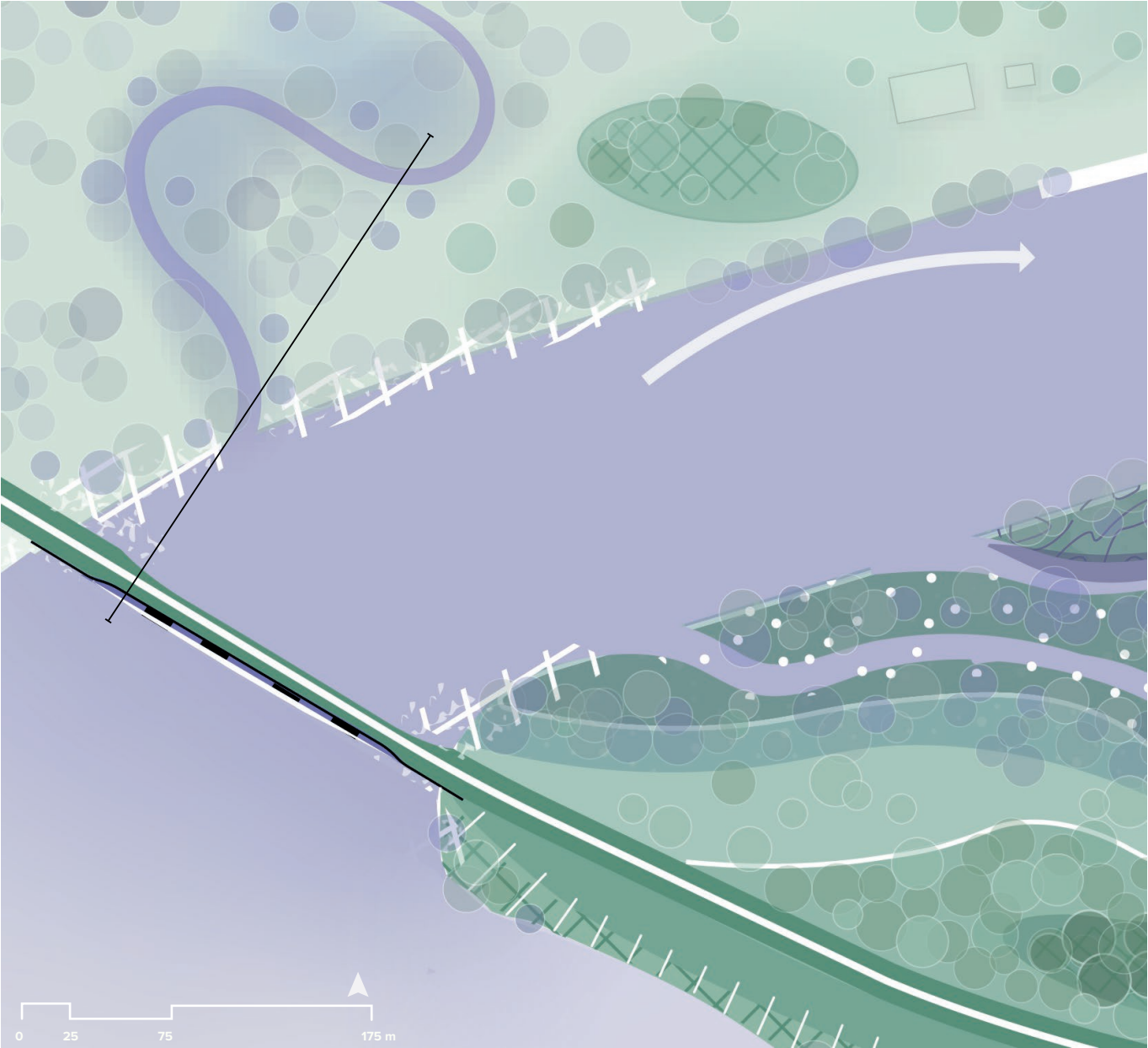
The cross-section below shows which principles were applied where for the water layer at this specific location.



Concept threshold bypass.



The ecology layer



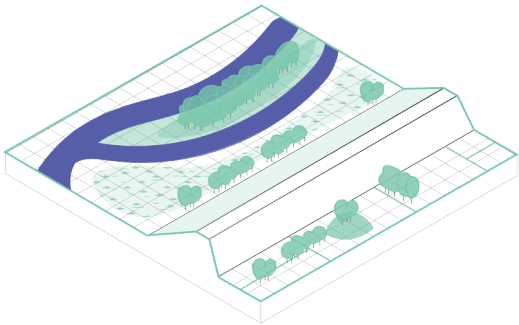
In the threshold and bypass zoom for the ecological layer, erosion and sedimentation processes play a major role. To prevent erosion, a stone edge is applied close to the threshold to reinforce the bank. Further along, a soft edge with a slow slope is applied where erosion can take place and willows can keep the bank strong. The different edges of the bypass create habitat types for fish species and birds.

We can also see how the meander in the park along the urban edge of Novi Sad provides opportunities for wetter nature to develop here too. Willows and Poplars will also be able to grow here.

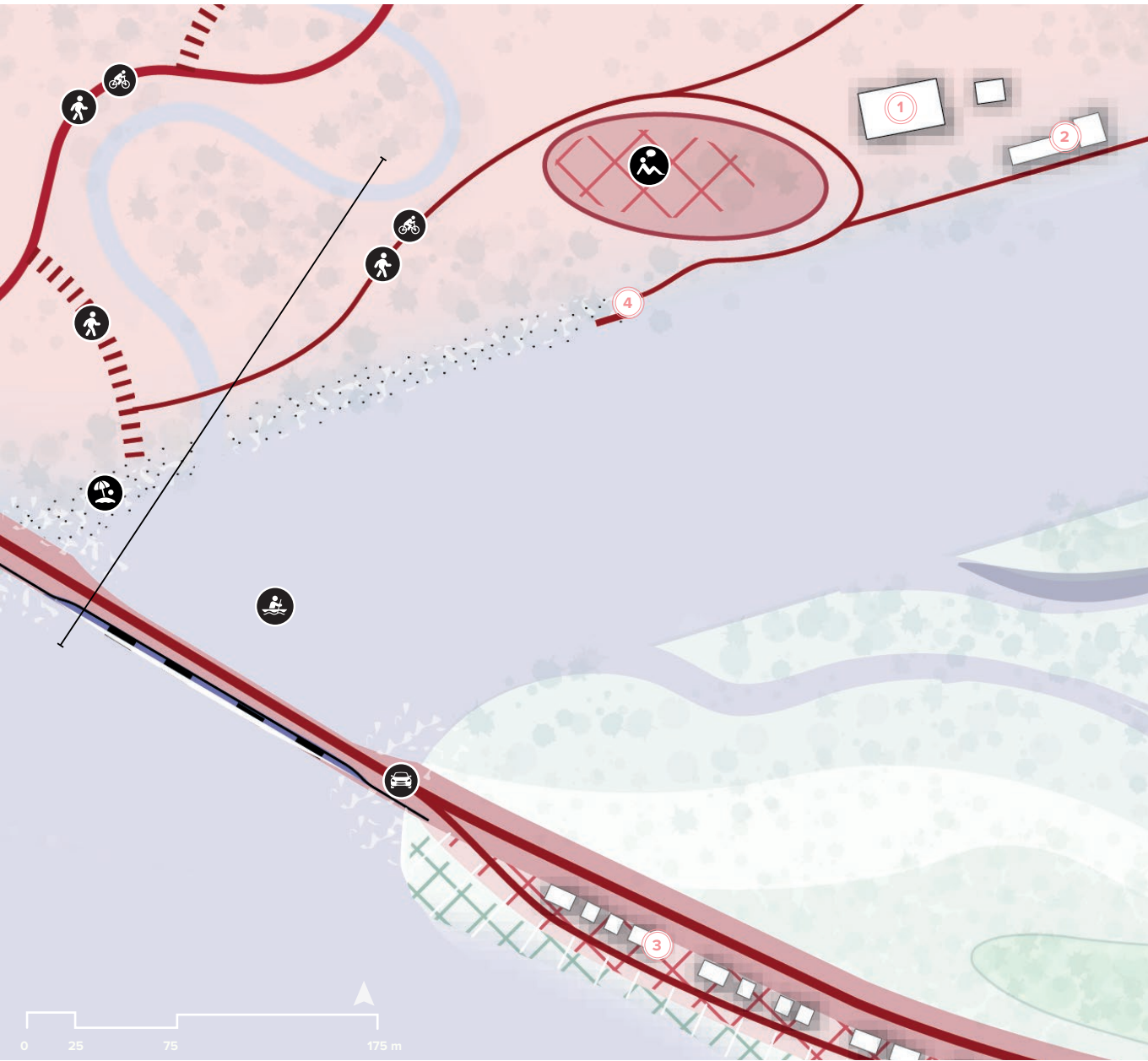
The cross section below shows which ecological principles have been applied to this site.

- Riparian wetland
- Pioneer Willow scrub and Willow-Poplar forest
- Willow-Poplar forest
- Poplar-Alder forest
- Ash-Elm forest
- Oak-Ash-Elm forest
- Sedimentation
- Rock edge bypass
- Erosion

Restore, Create, Connect



The culture layer



The cultural layer of the threshold reveals the diverse functions of the park north of the bypass, seamlessly integrating the legal dike houses along the new dike. The park features distinct routes for cyclists and walkers, offering both higher and lower paths. Additionally, similar to the nature area, several wooden lower walking paths are present. However, visitors are free to walk off the paths in the park, and can explore own routings.

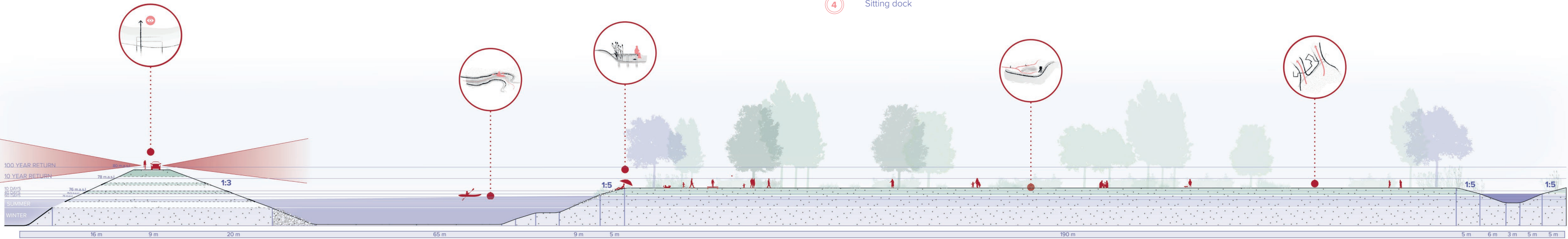
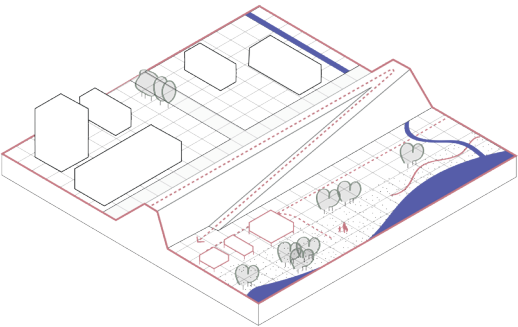
Along the edge of the bypass, a rock beach is situated, where a wet forest may also develop. A lookout hill provides a meeting point with panoramic views over the bypass. Another spot for relaxation is a wooden dock along the water's edge. An old farmhouse has been pre-served, and there's a potential location for a restaurant or tourist point nearby.

- Meander and wet nature
- Rock city beach
- Threshold bypass
- Spectator hill
- Dike
- Elevated cycle and pedestrian path
- Cycle and pedestrian path
- Pedestrian path
- 1 Old farm
- 2 Tourist function (restaurant, information)
- 3 Dike houses (permanent and rent)
- 4 Sitting dock

The dike houses serve as legal replacements for previous illegal structures on Kamenička ada, allowing original residents to return. This arrangement gives structure to public spaces while offering opportunities for all Novi Sad residents. Some of these houses could be rented out as holiday homes or used flexibly for cultural purposes throughout the year.

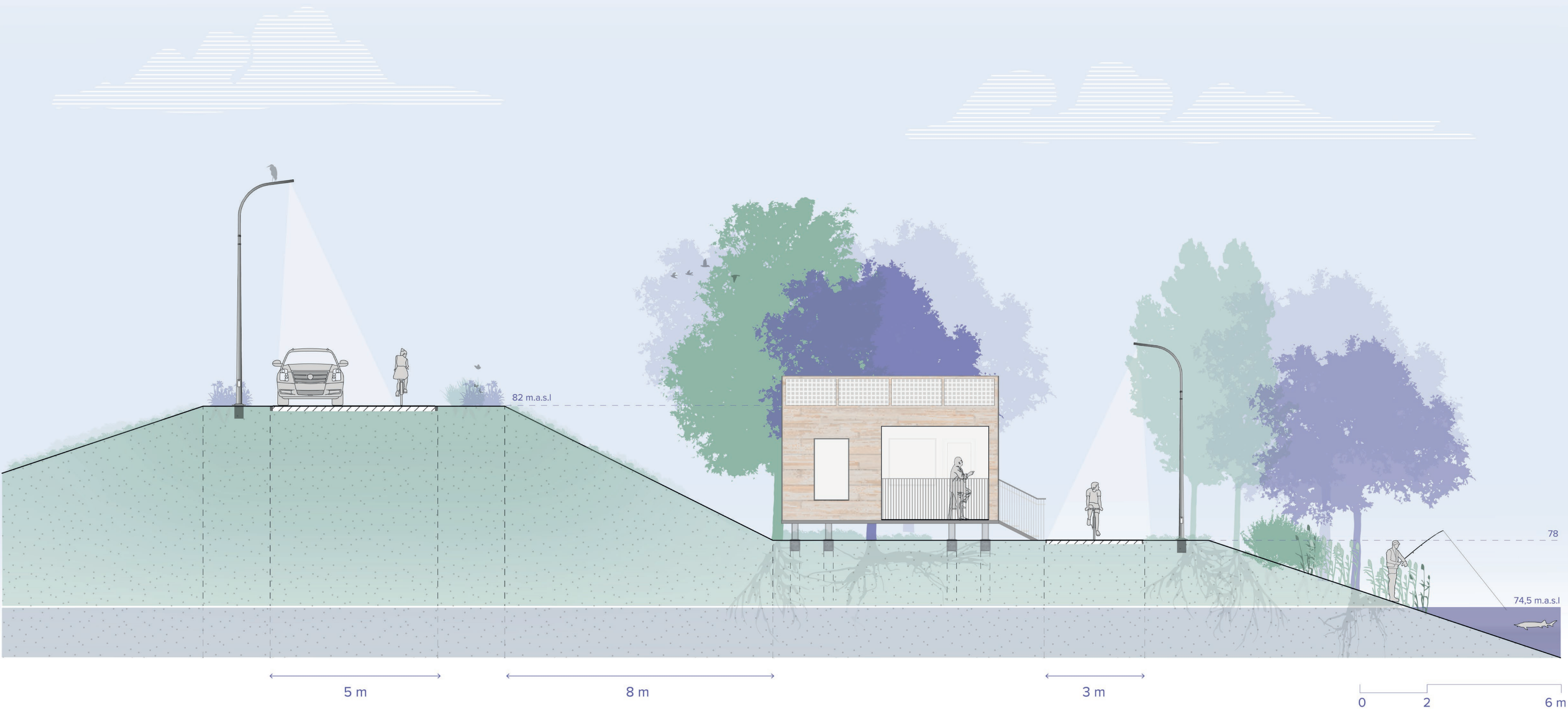
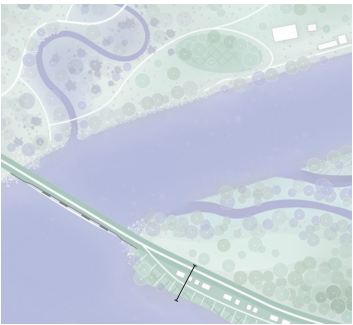
In the section below, the principles adapted for the culture layer of this location are showcased.

Understand, Involve, Adapt



This detail of the embankment profile highlights its two-step layout. At the highest point of the embankment, the main road leads to the urban tip of Kamenička ada. This road is illuminated with street lights facing the Danube, minimizing light pollution into the nature river park. On the lower part of the embankment are the legal dike houses, designed in various ways to withstand fluctuating water levels, such as using poles. A narrower road, primarily for bicycle traffic, runs alongside these houses or cottages.

Given the proximity to the river, it is crucial to be aware of the flood risks when occupying these houses permanently, with flooding expected approximately once every 10 years. This riverside density also attracts hobbyists, including recreational fishermen who can easily fish in the Danube from this location.



The threshold and bypass

This collage perspective visualises the threshold, with a high water level where some culverts are completely submerged. The inflow of water creates currents in the bypass, where water sports enthusiasts can canoe against. The threshold itself is made out of hard material, however some Willows and grass species can develop on it or between the rocks near the water edge. The threshold is one of the connections to mainland Novi Sad for car traffic, but it is also part of the routing for cyclists.



This collage visualises Novi Sad's new rock beach, with the bypass in the background, where rowing and other water sports take place. On the other side of the bypass is the Kamenička ada nature river island. The rock city beach is a place where families can meet, swim, rest and enjoy the surrounding wet nature. In the background the elevated pedestrian and cyclist bridge is seen, that runs through the nature area of Kamenička ada.



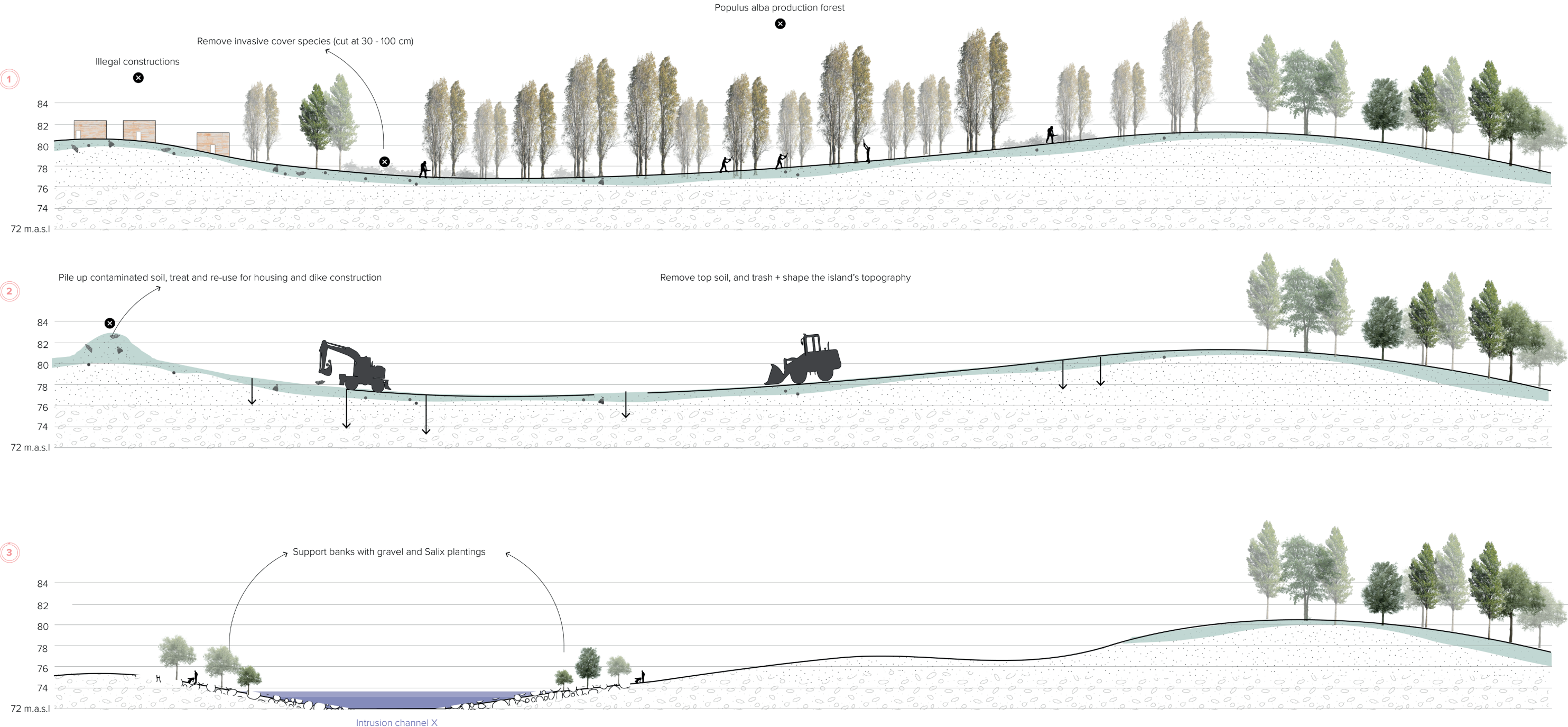
6.6 RIPARIAN RESTORATION AND MANAGEMENT

To guide the ecological development of the Kamenička ada river island, a riparian restoration and management plan is needed. This chapter explains the steps of active and passive restoring, with management steps in normal conditions and in the case of extreme flooding. In the case of Kamenička ada, the first step of active restoring is by means of afforestation.

The illegal constructions, invasive cover species and the production forest need to be removed. Because of the illegal activities, the soil is contaminated in certain places, so the top layer of soil needs to be excavated and accumulated. After treating the sand, it can be reused for dike construction and urban harbour development.

The base layer of the island is shaped according to the heights studied for planned flooding and riparian development. Existing valuable nature remains. The third step is to reinforce the constructed banks of the intrusion channels with gravel and Willow plantings. (Dimitrov et al, 2018)

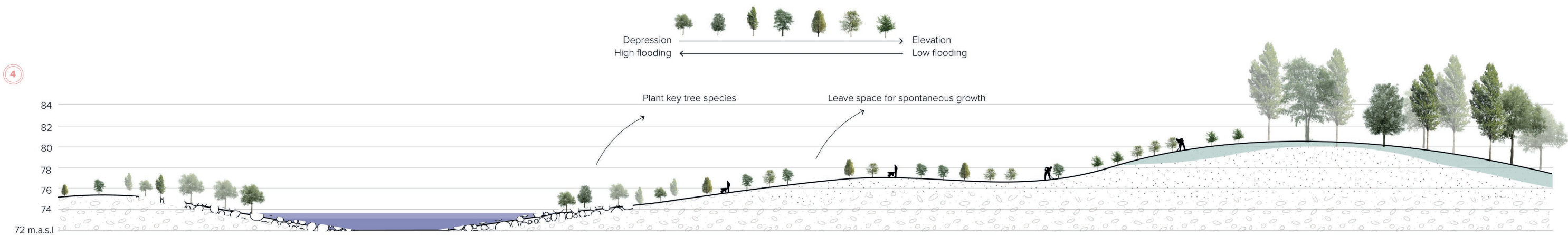
Year 1 Active restoration



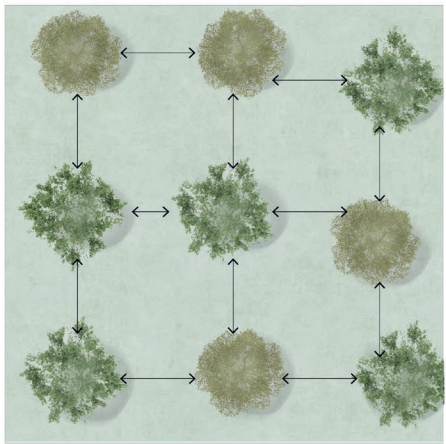
The final stage of active restoration is the replanting of Kamenička ada through key tree species, previously named in the strategic vision. According to the elevation, softwoods with Willow-Poplar are planted in a gradient towards hardwoods of Ash, Elm and Oak. For the each forest type, it is recommended to plant in a certain density and mosaic pattern, which can be found at the bottom of this page.

Where the condition of the river island is good, a lower density of trees can be applied and in bare areas a higher one. It is also important to leave space for spontaneous growth, where pioneer vegetation could settle (Dimitrov et al, 2018).

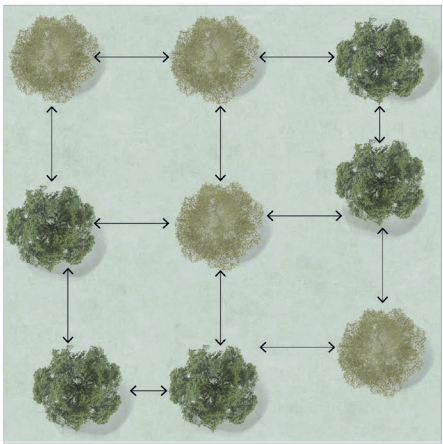
Year 1 Active restoration



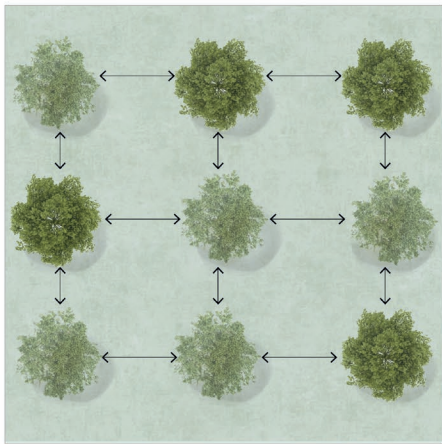
Mosaic planting pattern 1:2



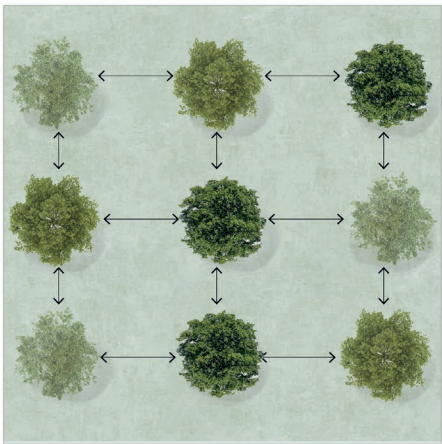
Willow-Poplar
Willow 2 x 1 m
Poplar 2 x 2 m



Poplar-Alder
Alder 2 x 1 m
Poplar 2 x 2 m

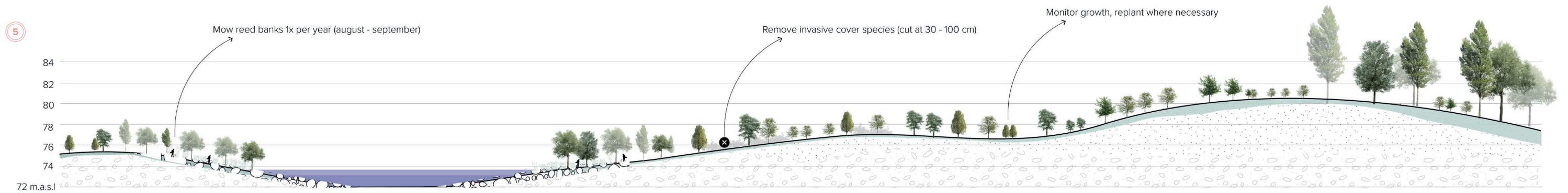


Ash-Elm
Ash 2 x 1 m
Elm 2 x 1 m



Ash-Elm and Oak
Ash 2 x 1 m
Elm 2 x 1 m
Oak 2 x 1 m

Year 2 - 10 *Passive restoration and management*



Year 11 - 20 *Growth monitoring and management*



Year 21 - 50 *Growth monitoring and management*



The first year of active restoration is followed by a period of passive restoration and management. In the years following the construction of the island, it is important to keep the open wetlands open through annual mowing of the vegetation, including the reed beds. This is done in August and September. It is also important to keep an eye on whether invasive species are taking over the island again. If this is the case, the cover species should be removed.

In addition, if the growth of the planted species is failing, patches can be replanted in some places. After 10 to 20 years, the differences in growth rates between the softwood species and hardwood species become apparent. The Willows and Poplars grow faster, and so will be the tallest trees on the island after 20 years. The slow-growing hardwood species only get their peak later. During this period, the aforementioned management continues.

After 50 years, the first softwood species will decay and the difference in height becomes smaller with the hardwood species that continue to grow. The climax state of these hardwood forests is after 100 years of growth. The older forest that remained during the restorations has also regenerated at this point. A new topsoil of nutrient-rich forest soil has developed throughout the island, fed yearly by the cyclic floods (Dimitrov et al, 2018).

Management after extreme flooding event

As mentioned earlier, there are certain return periods that predict the return of severe floods. Therefore, it is important to have a recovery plan for Kamenička ada in case of extreme flooding. In a severe flood of 78 or 80 m.a.s.l, groups of trees may fall down and be damaged by the force of the water. In case of large patches of dead trees, the trees are removed and key species can be replanted. If there are many loose single dead trees, they can be left to promote biodiversity through the dead wood.

Flooding can leave a large amount of sediment, which can cause congestion in places along the intrusion channels. In these places, the remaining silt should be removed. Further, paths on the island should also be repaired in case of damage, or cleaned so that they become accessible again.



6.7 CONCLUSION KAMENIČKA ADA DESIGN

The strategic vision for Kamenička ada

The developed strategic vision for Kamenička ada aims to regenerate the Danube at Novi Sad, and to create a flood-proof socio-ecologically inclusive river island. The four strategies, cyclic river design, mutually-beneficial design elements, intermediate space and connection to bigger social and ecological networks have been applied to Kamenička ada by the design principles for the water, the ecology and the culture layer of the landscape. The result is a three-layered strategic vision for Kamenička ada.

The water layer

The water layer of the strategic vision encompasses the river island's topography and the flood patterns of the Danube. Utilizing data from the Novi Sad hydrographic station, the frequency of various water levels throughout the year was analyzed to understand the annual flood regime and shape Kamenička ada's topography. Additionally, the return periods of floods were considered. This information was crucial for assessing Kamenička ada's accessibility and ensuring flood safety for the people of Novi sad.

The design map illustrates key features, such as the threshold facilitating the influx of fresh river water to the bypass, erosion prevention measures, and the creation of wetland areas. The expansion of the urban waterway with meandering characteristics aims to enhance water filtration before entering the bypass. Intermediate spaces within the design provide flexibility for resilient adaptation capacity for the future.

A series of maps depict the island's flood cycle, detailing the stages of flooding, duration, and associated water levels. At lower water levels, certain areas remain accessible, while higher water levels necessitate the use of higher bridges. Flood risks for housing developments and infrastructure are assessed based on the return periods, informing the new residents' understanding of living on a dynamic river island.

Overall, the water layer plays a vital role in shaping the strategic vision by integrating knowledge of flood patterns and implementing adaptive measures to ensure both safety and accessibility within the designed environment.

The ecology layer

The ecology layer, the second component of the strategic vision, focuses on the natural succession processes within distinct areas of the river island, closely tied to its flood regime. The succession riparian vegetation growth was forecasted with the knowledge on local species communities. Additionally, specific local species, such as the Black Stork and Sterlet are associated with target habitats. The design map illustrates the ecology layer, showing various wetland and riparian forest zones, as well as different edge typologies along the bypass. Goal of this is to reach diverse habitats throughout the whole island, for ecological resilience.

The lowest lying areas of the river island are designed to evolve into wetlands, characterized by pioneer Willow scrub and Willow-Poplar forest. Moving slightly higher, areas are anticipated to support Alder-Poplar and Ash-Elm forests, with the potential for Oaks to grow over time in the most elevated regions. The meandering feature in the park north of the bypass presents an appealing habitat for the European pond turtle, while the connection to the urban waterway facilitates the dispersal of for example amphibians.

The river island itself is envisioned as a new nature river park and bird sanctuary, serving as a crucial stepping stone within the broader network of river islands to the west of Kamenička ada. Overall, the ecology layer plays a fital role in fostering diverse riparian ecosystems, enhancing habitat connectivity, and promoting biodiversity conservation within the strategic vision.

The culture layer

In the cultural layer, the third layer of the strategic vision, the central focus is to create new meaningful public accessible spaces for the people of Novi sad. This is done by the transformation of Kamenička ada into an accessible river nature park, featuring bird-watching towers and recreational trails, while preserving the island's southern protected habitat. Further, the design of an accessible park situated north of the bypass, offers panoramic viewpoints over the bypass, a beach area and potential facilities for a rowing club and tourist information points.

The integration with the social network of the city is discussed by the connection to the Eurovelo bike path and the highway. Also in the design area itself, pathways designated only for pedestrians are envisioned, positioned at lower elevations, which become inaccessible when water levels reach 75.5 meters above sea level. Higher pathways, for cyclists and pedestrians, remain accessible year-round and are only subject to floods during rare events.

Furthermore, the culture layer emphasizes the development of urban clusters, notably a high-density urban expansion within the harbor area and further urbanization at the eastern end of the river island itself as well as the incorporation of flexible dike houses along the dike's edge.

The bypass area facilitates diverse sporting activities, including rowing and sailing, reflecting the commitment to multifunctional design elements. This aspect of the culture layer embodies key cultural principles, such as fostering human interaction with water, creating an accessible river park, and blurring the boundaries between the city and the river.

The River nature park zoom in

In the river park zoom in, the accessible recreational area of Kamenička ada's nature park is visualised in more detail. The slow edges of the bypass and different water intrusion channels are explained, which foster the riparian ecology to thrive and pioneer species in the wetland to develop.

Further, the different types of wet riparian forest and wetland is shown, in line with the flood duration and topography of the river island.

Also, with perspective collages, the spatial quality of the river island nature park is visible, with newly created recreational area, the different slopes, vegetation types and recreational network. The bird watching tower over one of the wetlands is envisioned, as well as the water intrusion channel's overall ambience, showing the new Kamenička ada nature park.

The threshold zoom in

With the threshold zoom in, the detailed connection of the threshold and bypass with the dike and legal dike houses is visualised. The design layers of water, ecology, and culture are explained, linking earlier principles to the strategic vision, concluding with visualisations of added spatial qualities of the rock beach and threshold.

The threshold, inspired by the Spiegelwaal in Nijmegen and adapted for the Danube, ensures water safety and connects the dike to the river island from Novi Sad. Stones prevent erosion and create a recreational rock beach. The bypass edges support fish and bird habitats. The meander fosters wet nature with Willows and Poplars. A detail of the dike profile explains the position of the legal dike houses to the Danube and attracts water enthusiasts.

Riparian restoration and management

In this chapter the restoration and management plan for Kamenička ada is discussed. Active restoration involves afforestation, removal of illegal constructions and invasive species and soil remediation. Willow and gravel are used to fortify intrusion channel banks, with key tree species replanted in varying densities. Passive management includes annual wetland mowing and invasive species control, ensuring sustained growth and biodiversity. A recovery plan addresses extreme flooding impacts and related management, for long-term ecological resilience.



7. CONCLUSION AND DISCUSSION

RQ1: How did the Danube River landscape and Novi Sad develop over time and affect each other, and what are the challenges and potentials for Kamenička Ada as part of the river and the city?

The Danube river finds its origin in Germany and flows east through diverse foothills and plains before reaching the delta in the Black Sea. Based on its slope gradients, the basin can be divided into three sub-regions, namely the Upper, Middle and Lower basin. The city of Novi Sad lies on the left bank of the Danube in Vojvodina, Serbia, which is part of the Middle basin of the river system. The region of Vojvodina is part of the fertile Pannonian plain, and its land use characterizes itself as highly agricultural.

Novi Sad was founded in the 17th century during the Habsburg monarchy and its relationship with the Danube has been both beneficial and challenging. The river provided the city with water and trade opportunities, but its fluctuating water levels have also caused damaging floods throughout the centuries.

These occurring floods are proof of the dynamic character of the Danube and the basic trait of all rivers to fluctuate in water levels, vertically and horizontally. Rivers are dynamic living entities that change their course over time, influencing the formation of entire landscapes. The appearance of a river in the landscape is a result of complex morphological developments, in which the process of sedimentation and erosion takes the lead.

The Danube river channel in the middle stream context of Novi Sad can be characterized as a typical braided river, one of the three primary river channel types. At Novi Sad, sediments primarily consist of gravel and sand. When the water current lacks the ability to carry these materials downstream, sediment accumulates leading to the formation of gravel braid bars. Over time, vegetation takes root on these bars, developing into forested river islands. This type of island-braided channel is found at Novi Sad.

However, due to the human impact on the river, the Danube river at Novi Sad is constrained to one channel, leading to an increase in flood risk and loss of the riparian zone and river braids. To protect the city, strategically placed dikes have cut off the space for the river to flow, and resulted in a degraded system. This becomes especially clear when looking at the history of Kamenička Ada, a former river island located at the bank of Novi Sad.

In ancient times, around 5000 BC the Danube at Novi Sad flowed as a wild braided river channel with many river islands, one of which was the island of Kamenička Ada. Human settlements of different cultures lived in harmony with this wild landscape.

As civilisations developed, strategic fortifications around the Danube, like the Petrovaradin fortress at Novi Sad, were built. People started to practice agriculture in the floodplains or on higher river terraces and the river was partly subdued, with Kamenička Ada still being an active river island in the braided system.

With urbanisation and agricultural expansion, the natural landscape underwent significant alteration in which the landscape fully transformed into agricultural fields and floodplains were used for human settlements and cultivation. In response to floods, protective measures like dikes were implemented. Because of this human impact, the river arm around Kamenička Ada was restrained and cut off from the active river system, resulting in the current situation in which Kamenička Ada is left as a relic of the former braided river island.

Three main issues have been identified in the current river landscape of Novi Sad. The city, despite its embankments, still experiences frequent flooding due to extreme weather events and climate change, also causing droughts in the river landscape and its inland. The Serbian government has a traditional engineered-based approach to flood prevention, which will only constrain the river system more. Consequently, this approach has sparked environmental protests among citizens, who are in the current situation not connected to the flood plains at all.

The specific three issues are defined as the following: The first issue is the unbalanced freshwater availability, leading to flood risks and droughts. The second concern is the deterioration of the braided system and riparian zone. Lastly, there is the disconnection between the people of Novi Sad and the river floodplain, calling for reconnection.

The city has the spatial opportunity to mitigate these problems by developing a flood-proof socio-ecologically inclusive Kamenička Ada, situated on the left bank of the Danube in between the river and the city. Its position creates the unique opportunity to become part of the city and once again of the river.

RQ2: What landscape architecture design strategies and principles are suitable for regenerating the Danube river landscape and facilitating inclusive spatial development of Kamenička Ada?

Learning from the theoretical foundation, river formation processes and landscape development of Novi Sad, four strategies have been developed as suitable for the regeneration of the Danube at Novi Sad and capable of the inclusive spatial development of Kamenička Ada. In this thesis, a strategy has the definition of specific physical interventions made in the landscape. The first strategy, cyclic river design with a strong socio-ecological structure is based on the take away to use area specific knowledge of the landscape structure and processes as a base for inclusive development. Goal of this strategy is to give room for the river and to allow the natural river dynamics for flood mitigation, to restore ecology and give opportunity for recreation to experience the river fluctuations.

The second strategy is to create mutually beneficial design elements in the landscape for water safety, ecological development and recreation and housing. It is based upon the take away to create an innovative design with multifunctional space for water, ecology and culture. Goal of the strategy is to create as much opportunities for synergies in the design interventions.

The third strategy is based on the takeaway to use the landscape structure to form a spatial framework with intermediate space for the long-term. The strategy is to design buffer zones of intermediate space for long-term adaptive capacity, and achieve resilience.

The last strategy is to connect Kamenička ada to Novi Sad in its middle stream context with the bigger water and ecological structure, and social network. This is based on the importance of landscape connectivity in a multifunctional way through the scales. Goal is to make Kamenička ada part of the city of Novi Sad and its networks, and part of the water and ecological structure of the Danube.

Furthermore, learning from the theoretical foundation, the research strategy of water, ecology and culture was developed, the components that together form the landscape. This research strategy served as an organizational tool for analysis and design principles. In this thesis, the design principles are used as tools to give the earlier mentioned strategies their physical form and to be able to apply the strategies to the local context of Kamenička ada. The design principles themselves are based on theoretical foundation and precedent studies.

RQ3: How can these design strategies and principles be applied to protect and develop the Danube River landscape at Novi Sad and Kamenička Ada therein?

In order to apply the strategies and design principles, a deeper understanding of the context of Novi Sad related to the water, ecology and cultural layer is necessary. This means understanding the climate and water level fluctuations of Novi Sad, in order to understand the flood patterns. The Danube experiences its highest levels in early summer and lowest levels from October to November. Understanding these patterns is important to design the topography of the river island for ‘controlled’ cyclic floods.

It also means understanding the surrounding landscape of Novi sad, and broader ecological connections to the river island. Further an understanding of the local culture and relationship with public place needs to be understood. Because of the legacy of communist ideology, there has been an historical neglect of public space. A lack of meaningful community spaces for the city is a direct result. The younger generations show willingness to invest into maintaining new public spaces for the community.

Furthermore, a deeper understanding of the local conditions of Kamenička ada is needed to apply the strategies and design principles. This is done by a site visit and deeper analysis of the water, ecology and culture layer of Kamenička ada. It became clear that the water and ecological conditions of the island have degraded throughout the years, because of changes in land use through illegal housing, production forest, wastewater and topography manipulations. The illegal housing shows again the lack of care for meaningful public space, since the inhabitants claim space as their own.

Also, a study of the formation of natural river islands in the Danube is necessary to understand natural topography of a river island and ecological patterns.

After the deeper understanding of the different contexts, a strategic vision could be applied to Kamenička ada, based on a landscape approach concept developed by Prof. Dr. Steffen Nijhuis. In the bypass concept for Kamenička ada, most space is allowed for the Danube to flow by providing a two-way connection to the main channel of the Danube. Furthermore, it allows enough room for the development of inclusive socio-ecological spaces.

The developed design for Kamenička ada results in a three-layered strategic vision for the river island. The water layer encompasses the river island’s topography and the cyclic flood patterns of the Danube and its influence on the accessibility of the river island.

The design map illustrates key features, such as the bypass and threshold, erosion prevention measures and the creation of intrusion channels and wetlands. Intermediate spaces provide flexibility for adaptive capacity in the future.

The ecology layer focuses on the natural succession processes related to the new cyclic flood pattern of the river island, illustrating different types of riparian wet forests and the development of diverse habitats for local species. It also shows the bigger ecological connection to Novi Sad and the Danube.

In the culture layer, the central focus is to create meaningful public accessible spaces for the people of Novi Sad. Kamenička ada itself becomes an accessible river island park, with new connections to the city for pedestrians, cyclists and cars. A recreational network leads to two bird watching towers and creates an interesting experience through the river island. Meaningful spaces along the bypass have also been developed, such as a new park in the north with a beach, lookout hill and rowing facility. The bypass itself is multifunctional and does not only serve for flood mitigation, but also for sporting activities. Furthermore, the developments of urban areas are possible in the harbour area east of Kamenička ada, and in the most eastern point of the island, with opportunity for meaning public squares to develop.

A zoom in on the river island park of Kamenička ada and the threshold and bypass shows the new spatial qualities and provides more detail of the application of the specific principles and the ambience of the strategic vision.

A restoration and management plan gives insight into the realisation of the riparian nature and management over the years in normal and extreme conditions.

RQ4: What are the lessons taken from a landscape approach in general for Novi Sad and the Vojvodina area?

Through a landscape approach, the city of Novi Sad can become a flood-proof, socio-ecologically inclusive city, with a connected Kamenička ada to the fabric of the city as well as the dynamics of the Danube, ensuring a resilient future. Allowing more space for the river in the form of a bypass presents greater opportunities for flood resiliency compared to the current river policy of Novi Sad.

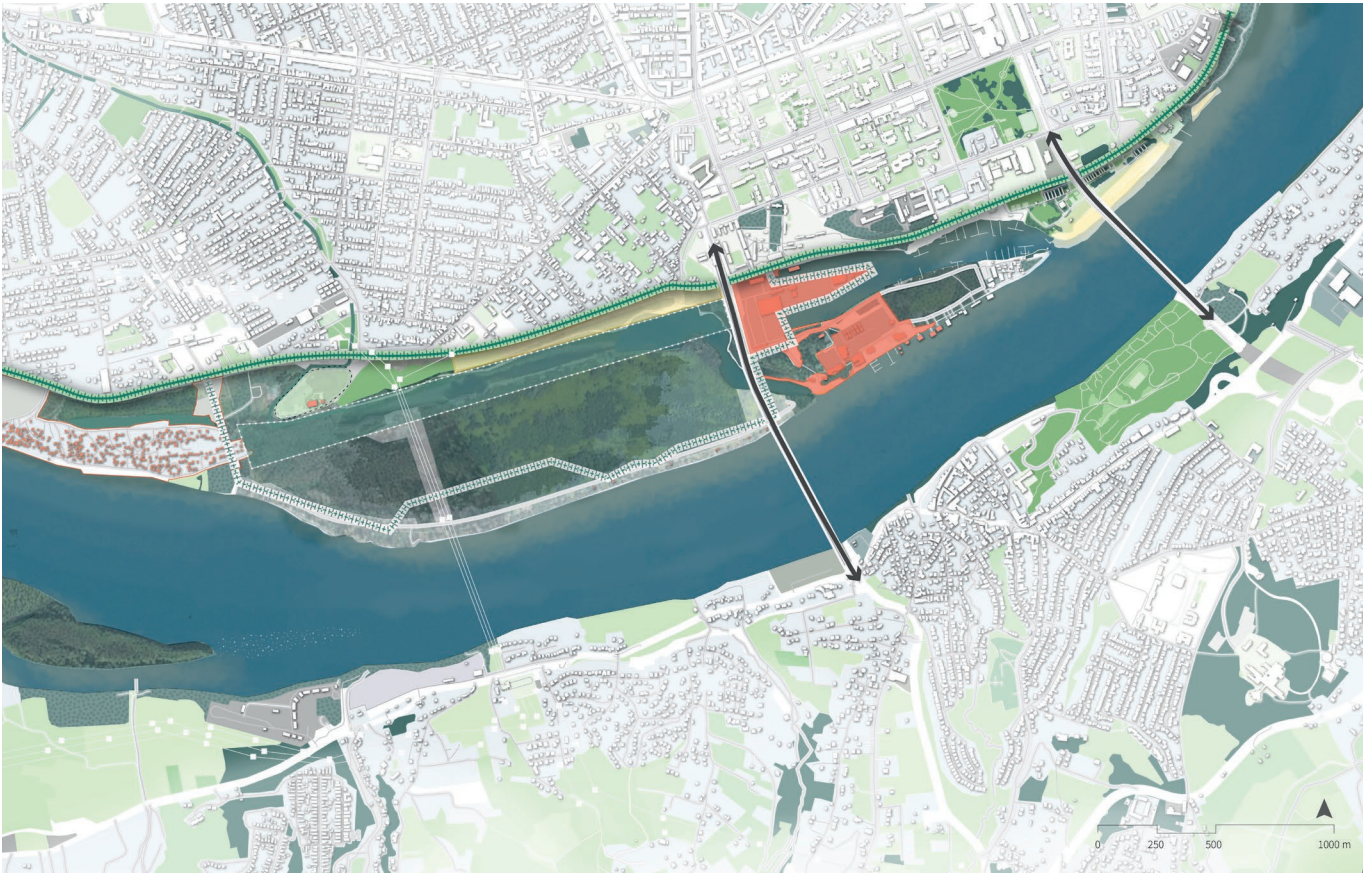
The current plans of the municipality of Novi Sad for Kamenička ada are developed from a traditional engineering perspective, which is working against nature instead of with nature. In the plan of the municipality, the whole forested area of Kamenička ada is embanked and cut off from the Danube river's dynamics. This embankment will only cause further ecological degradation of the relics of the riparian forest. Further, the city wants to create a rowing canal with pumps connected to the Danube to regulate the water level, a plan which is in contrast to working in harmony with the landscape to build a resilient future.

With the landscape approach, more opportunities are provided for the ecological development of the river island and restore valuable riparian wet forest habitats, including the disappearing pioneer habitats of the Danube. Also more diverse habitats for local species to thrive are developed.

Furthermore, the landscape approach prioritizes a place for local culture, recognizing the need for valuable public spaces and fostering identification with nature and connection to the river. It also facilitates connection with the broader social and ecological network, which fosters ecological value of the Danube river and enhances social cohesion within Novi Sad.

For the region, the landscape approach which is applied to Novi Sad may identify opportunities for other local projects along the Danube river, where the developed strategies in this thesis can be applied for more flood-proof, social and ecological developments. For application, deeper analysis of the local contexts can be done, shaping design principles that are applicable elsewhere.

Most principles developed in this thesis are applicable to similar cases, but it is still important to take the local context in consideration for more specific, meaningful spatial development. In this way, the strategies and results of this thesis serve as an example for similar cases and its research strategy can be applicable along the broader scale of the Danube river. Moreover, the same research strategy could potentially be applicable for transforming the agricultural inland areas with adjustments to the spatial strategies.



The current plans of the municipality for Kamenička ada, based on traditional river policy. Source: (Municipality of NS, 2024) and (Nijhuis, 2024).

Discussion

Theoretical assumptions

1. Unpredictablity of the river system

The strategic vision is based on theoretical assumptions about the annual river cycle and flood return periods. In order to make the vision more precise, it is necessary to have a specialist, a river engineer, who can provide data on the specifics of river dynamics. For example, the flow of the Danube at Novi Sad, the amount of sedimentation and the rate of erosion. Even with the knowledge of a specialist, there is uncertainty about the effects of climate change. Questions arise about the development of precipitation and evaporation patterns in relation to the return periods of floods. This could become even more extreme in the future.

2. Natural succession

Overall, the riparian landscapes and plant communities of the Danube in Serbia are not well studied. In the absence of local sources, assumptions are made based on theories and data available for a wider context. There is also a lack of knowledge about the specific soil types of Kamenička ada and the possible contamination of the soil by the illegal housing developments.

Governmental issues

During the field visit, it became clear that the traditional view of the Serbian government on how to deal with flood issues will not change quickly. It is a process of changing mindsets that could take years. With the current laws of the Serbian government, the development of the strategic vision for Kamenička ada is simply not possible, and change may come very slowly. However, the Municipality of Novi Sad is motivated to change and is very open to new ideas and spatial opportunities, which is hopeful for the future of Kamenička ada. Nevertheless, it's a very difficult and slow political process, with results coming from the top down.

Reflection on methodology

The research framework, with its theoretical foundation and strategy, was very helpful in structuring my research. The landscape approach was most helpful in several ways. First, through the organisational components of water, ecology and culture layers. Secondly, by identifying many theories relevant to my research, such as the longué duree, the importance of nature-based solutions and landscape ecology. During the process, it was quite difficult to structure the research and provide a personal understanding of all the components. However, after formulating the main takeaway of the theoretical foundation and the four spatial strategies of Kamenička ada, it made sense to me how to work through this research. It was also very helpful to distinguish the differences in the research through design cycle and to link the different stages of the cycle to the different research questions and results.

There were a number of difficulties that arose during the course of this thesis. In the beginning, the amount of environmental problems around the Danube struck me and made me want to analyse everything and solve all the problems in one design. At a certain point, it was important to accept that this is not possible in one academic year. Furthermore, a difficult aspect was the availability of data. Sometimes valuable data was not available because Serbia is not part of the European Union and many databases are developed through the European Union. This resulted in spending quite some time to find relevant sources and searching in the Serbian language, which was very difficult to understand and perhaps took up valuable time that could have been spent more productively. In retrospect, it might have been easier to choose a thesis topic in the Netherlands or more Western Europe, but it would not have contributed as much to my analytical skills, which I have now developed to find relevant sources.

Reflection on design

The four central themes of the Master of Landscape Architecture at TU Delft all play a role in this thesis. The first, process, stands for the complexity of processes and dynamics of a system within the landscape, which, in this thesis, forms the whole basis of the strategic vision for Kamenička ada. The second, perception or experience of space, is present in the cultural layer of this thesis, which aims to reconnect the people of Novi Sad with their historically neglected public space. This is also done by offering new recreational experiences of space and by adding spatial quality to Kamenička ada. The third, landscape as palimpsest or layered biography, is present in the landscape development analysis, identifying the relics of the river system in Novi Sad and using their potential. The last theme, the scale continuum, is defined as the influences or connections and relationships that link the scales within a landscape. The scale continuum is present throughout the analysis, from the basin scale to the scale of Kamenička ada, and by incorporating the watershed approach and reflecting on the connections of the strategic vision of Kamenička ada, Novi Sad and the wider region.

Personal role as a designer and researcher

Looking back on the academic year, I have developed myself as a student and as a landscape architect, now almost standing in the professional field. It was a huge learning process to work for a whole academic year on one topic individually and keep yourself on the main track, focused to reach the thesis objective. Because of my personal interest in history, the river processes and ecology I sometimes got lost in all the interesting details, losing the main focus. During the process, I slowly learned more to focus on the objective and how to get there instead of knowing all the details, which is simply not possible in the timespan we have. And that is perhaps the most challenging of the whole process, knowing what you want to do, but having to limit yourself because of the time you have. It was very helpful to feel the time pressure, in order to keep yourself on track.

The same goes for the uncertainty that was sometimes felt during the process. It was simply not possible sometimes to fully understand all the details of the local context. This is why I was very pleased to be able to visit Serbia and experience the Danube landscape for the first time. It was very meaningful and helpful to meet the municipality of Novi sad and actually visit the design site, which gave many helpful insights to the culture layer of this thesis.

The most important lesson learned is that, in order to achieve water sensitive, socio-ecologically inclusive development of any place, the landscape approach is crucial. To fully understand a place, is to understand the history of the landscape, the different layers and all the connected systems and landscape processes.

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