Water & Culture, Adaptation & Integration

Integrated urban transformation for river flood resilience and sustainable leisure industry in the city of Maastricht

Danyi Xiang 5465036, P5 Report

Water & Culture, Adaptation & Integration

MSc Graduation Thesis P5 Report

MSc 4 Track Urbanism

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TU Delft BK Bouwkunde

Urbanism

ACKNOWLEDGEMENT

I would like to express my heartfelt gratitude and appreciation to the individuals who have played a significant role in the successful completion of my graduation project. Their guidance, support, and encouragement have been invaluable throughout this journey.

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I would also like to express my sincere appreciation to my second mentor, Diego. His insights and expertise have been invaluable in expanding the depth of my project and bringing it closer to reality. Diego's guidance and mentorship allowed me to gain a deeper understanding of my project's content. He introduced me to various useful networks and provided invaluable assistance in assessing the feasibility of my project from multiple perspectives. I am truly grateful for his valuable contributions and the profound impact he had on my professional growth.

Finally, I would like to extend my gratitude to all my colleagues and friends who accompanied me throughout this demanding year. Their effective feedback, encouragement, and constant support have been priceless. They have become my pillars of strength, providing guidance and motivation during challenging times. Their presence has been akin to that of a third mentor, and I am grateful for their unwavering support and belief in my abilities.

To all those who have contributed to my graduation project, whether as supervisors, mentors, colleagues, or friends, please accept my deepest gratitude. Without your guidance, assistance, and encouragement, this accomplishment would not have been possible. Thank you for being an integral part of my journey and for making this experience truly remarkable.

ABSTRACT

The survival and development of the city of Maastricht are facing enormous threats from the increasingly frequent and severe fluvial floods, while the leisure industry is the most vulnerable to flood damage as a crucial segment of the economy, accounting for about 50% of the total economic damage. However, flooding is essentially just a natural process with numerous ecological benefits, and can even stimulate diverse recreational activities under certain conditions.

Therefore, this report aims to explore integrated transformation from an urban design perspective for the city of Maastricht to adapt to river flooding and to promote sustainable leisure industry. It implies a transformed urban fabric that prevents the damage caused by river flooding and converts floods into a resource for sustainable leisure industry development through a series of spatial interventions and programs that cross three scales (regional scale, city scale, and neighborhood scale).

CONTENTS

00 PERSONAL MOTIVATION

I have always believed that all natural disasters as we think of them are simply ecological cyclical processes, and that to stop them is to disrupt natural circulation. Is it possible for us to find an urban form that allows "natural disasters" to coexist with mankind and we can even benefit from them? In this way, we may finally find our place in nature and live longer and better on the planet.

According to 2020 Global Natural Disaster Assessment Report, floods are the most frequent natural disaster in the world, accounting for 61.66%. Therefore, I would like to investigate the relationship between floods and urban fabric in order to understand the possibility of their coexistence and to explore whether floods can be utilized through urban design.

In a country like the Netherlands, which has extensive experience in water management and is a world leader in flood protection infrastructure, the province of Limburg, located in the highlands of the Netherlands, was not spared from a severe flood in 2021. I am deeply curious about the causes of this flooding and regard it as a good opportunity to explore the urban fabric of living with floods. Therefore, this report will focus on Maastricht, the largest city in the province of Limburg with circa 120.000 inhabitants, and explore the possibilities of its adaptation to flooding.

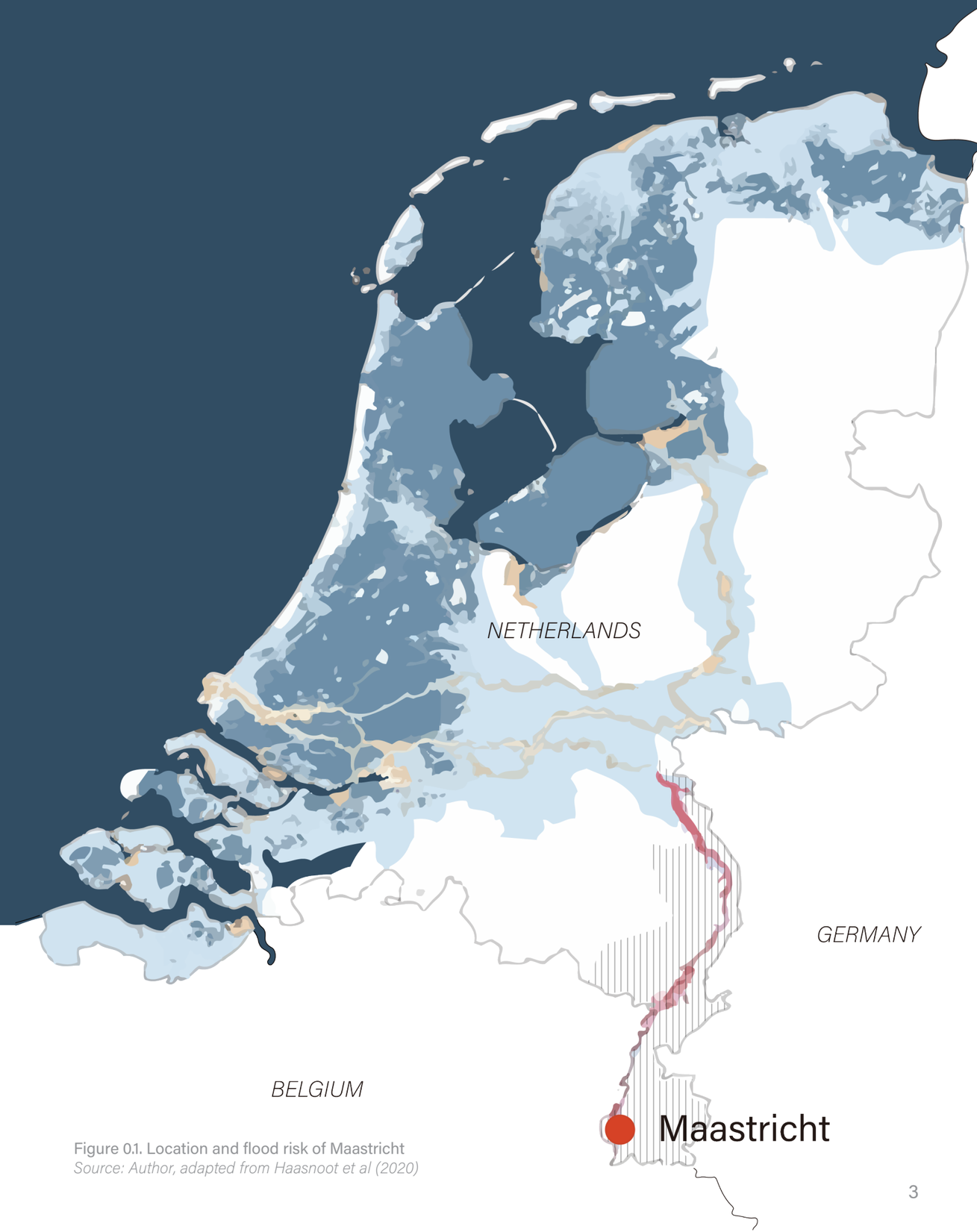


Figure 0.1. Location and flood risk of Maastricht
Source: Author, adapted from Haasnoot et al (2020)

01 CONTEXT

1.1 Historical Changes in the Maas River Basin

MAAS RIVER BASIN OVERVIEW

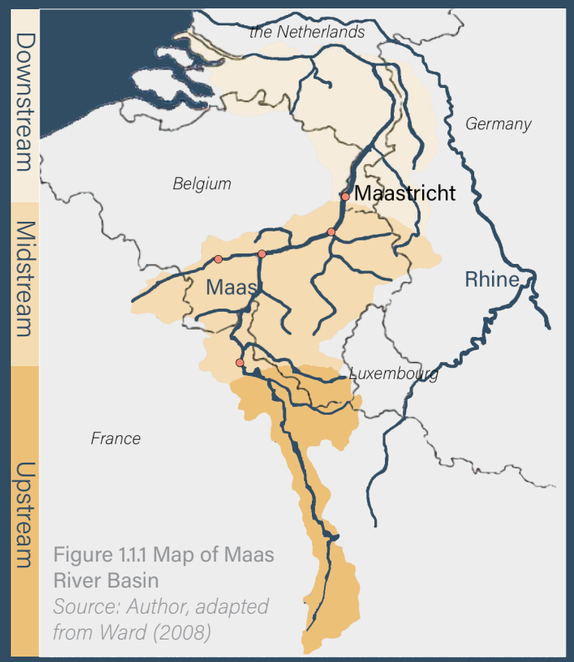


Figure 1.1.1 Map of Maas River Basin
Source: Author, adapted from Ward (2008)

The Maas River is an important river in Western Europe, originating from the Langres Plateau in France, flowing through the industrial areas of the Netherlands, Germany, Belgium, and France and other Western European countries, and finally joining the Rhine estuary in the Netherlands to form a delta and injecting into the North Sea, with a total length of 925 km (Figure 1.1.1). It has a variety of socio-economic functions such as navigation, drinking water supply, flood safety, ecology and recreation (de Rooij, 2020).

The Maas is a rain-fed river, which causes dramatic fluctuations in river flow, with low flows in summer and high flows in winter(de Rooij, 2020).

Maastricht is located **at the junction of its middle and lower reaches** and is **a densely populated** and **important city** in the Maas river basin.

CHANGES IN LAND USE AND RIVER PERFORMANCE

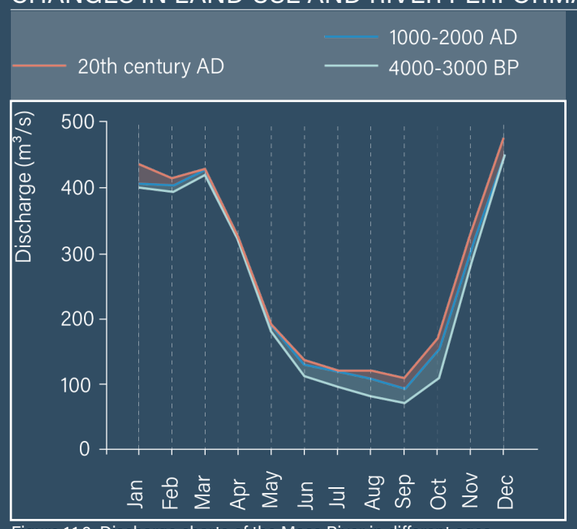


Figure 1.1.2. Discharge charts of the Maas River in different ages
Source: Author, adapted from Ward (2008)

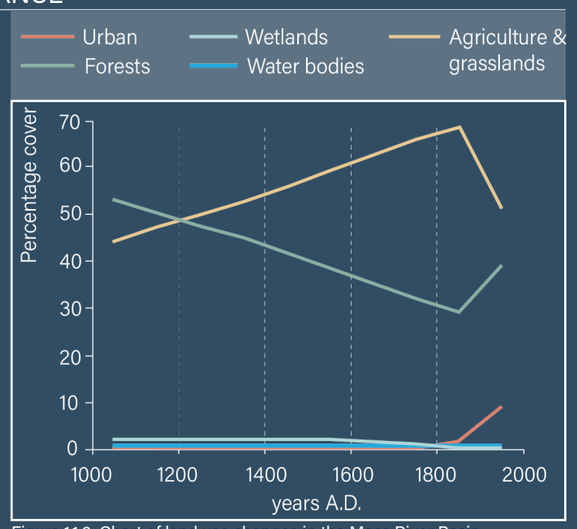


Figure 1.1.3. Chart of land use changes in the Maas River Basin
Source: Author, adapted from Ward (2008)

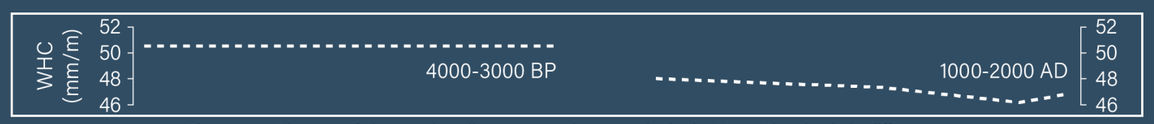


Figure 1.1.4. Diagram of changes in soil water retention capacity in the Maas River basin in different eras
Source: Author, adapted from Ward (2008)

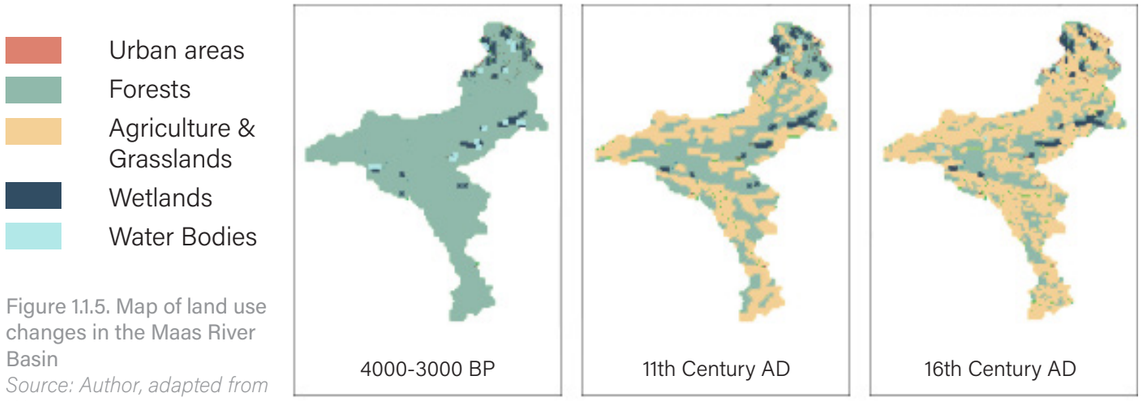


Figure 1.1.5. Map of land use changes in the Maas River Basin
Source: Author, adapted from Ward (2008)

4000-3000 BP (natural conditions):

- The average annual river discharge is 244.8 m3/s.
- The basin is considered to be almost completely covered by forest.
- The average soil water retention capacity is 50.5mm/m.

1000-2000 AD (subject to human influence):

- The average annual river discharge is 260.9 m3/s, with a higher frequency of high flow events (flow > 3000 m3/s) (recurrence time reduced from 77 to 65 years).
- Significant reduction in forest area and exploitation of large amounts of agricultural areas
- The average soil water retention capacity is 47mm/m.

20th century (human influences and climate change):

- The average annual river discharge (270.0 m3/s) is about 2.5% higher than in the 19th century (despite the increase in evapotranspiration). And recurrence time of high flow events is almost twice as long as under natural conditions (recurrence time reduced from 77 to 40 years).
- Regional reforestation, rapid urbanization
- The average soil water retention capacity is 46.5mm/m.

Between 4000-3000 BP and 1000-2000 AD, forest area declines dramatically, wetlands gradually disappear, and cropland and grassland grow extremely rapidly, while river discharge increase significantly (Figure 1.1.2, 1.1.3, 1.1.5). On millennial time scales, almost all of the **increase in river flow river flood frequency can be accounted for by land use change (especially deforestation)**; the effect of climate change is negligible (Ward, 2008).

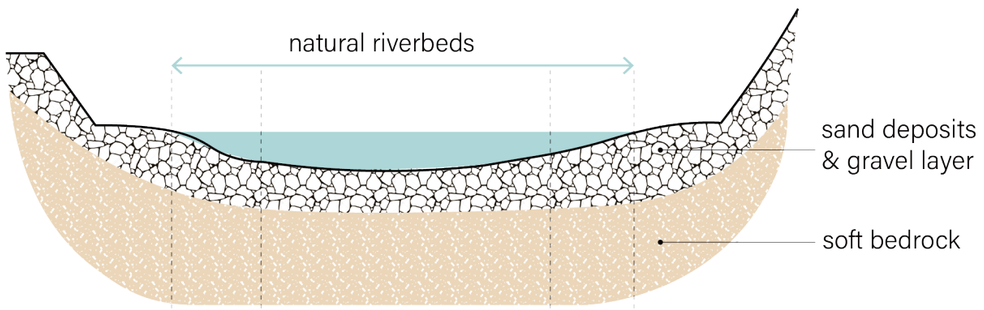
Some reforestation, and urban expansion occurred **in the 20th century,** but the discharge still go up markedly (Figure 1.1.2, 1.1.3, 1.1.5). At the centennial scale, **climate change** (large increases in annual precipitation, especially in winter) overwhelms land use change **as the main river discharge increase contributor and flood trigger mechanism** (Ward, 2008).

On the other hand, **Soil water holding capacity declined sharply from 1000-2000AD** and rebounded slightly in the 20th century, indicating a strong correlation with land use change (forest area)(Figure 1.1.2, 1.1.3, 1.1.4). However, with population growth, the Maas River basin has limited space and extensive afforestation is less feasible, thus alternative methods are required to restore the water retention capacity of the basin.

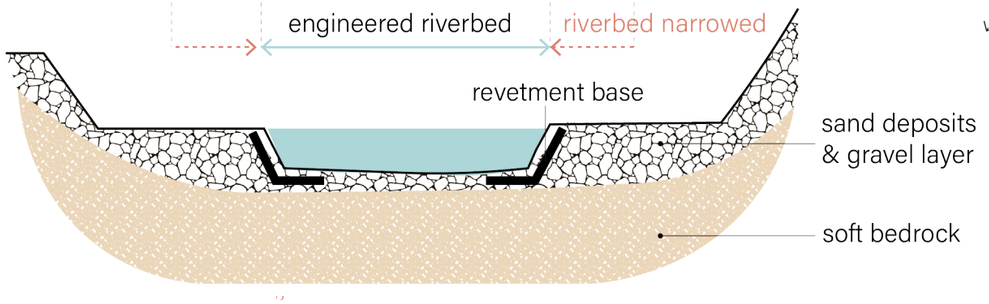
1.1 Historical Changes in the Maas River Basin

RIVERBED CHANGES DUE TO NATURAL FORCES AND HUMAN INTERVENTIONS

- Ancient Era



- Industial Era



- Information Era

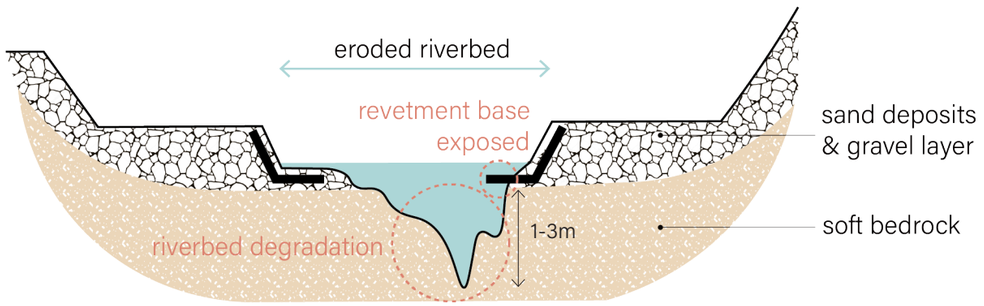


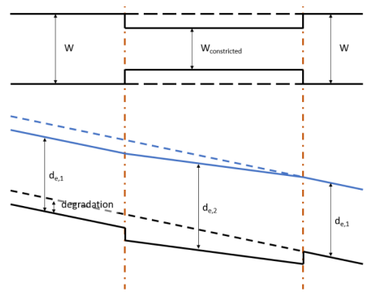
Figure 1.1.6. Section of riverbed changes in the Maas River Basin
Source: Author

Over the past century, riverbed degradation in the Dutch section of the Meuse River has been ubiquitous. **The hard sand deposits and gravel layer breaks up due to increased river discharge, resulting in degradation of the riverbed**.

The construction of dams and weirs, as well as intensive dredging, river normalization works and river bend cut-offs have led to bed degradation of the river Meuse in the last 100 years. This has resulted in a bed degradation of about one to three meters, depending on the length of the river. And after the 21st century, peaks in discharge will be more frequent and more severe due to global warming, while annual low tides will be longer and discharge will be less, which exacerbates the degradation of the riverbed, and **the degradation is expected to continue for decades.**

- Engneering interventions

Changes in river width — in the second half of the 19th century



navigation → multiple dynamic braided, river channels and islands

↓

one channel:Smaller and deeper river widths

↓

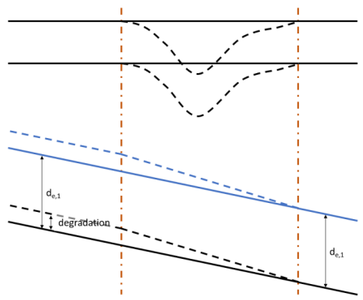
faster water flow rates

↓

a continuously higher sediment carrying capacity results in a milder river slope over time

widen project: away smaller scale than the normalisation works.
can't be at incision of the river bed

Cutting off river bends — the 20th century



discharge flood waves downstream faster → the river slope is steeper than the equilibrium slope, leading to increasing flow speeds

↓

a higher sediment carrying capacity

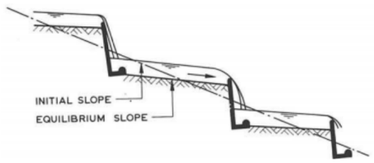
↓

riverbed erosion

↓

This erosion will migrate upstream and lead to riverbed incision upstream from the river bend cut off

Regulation of the river flow by weirs and dams — in the first half of the 20th century

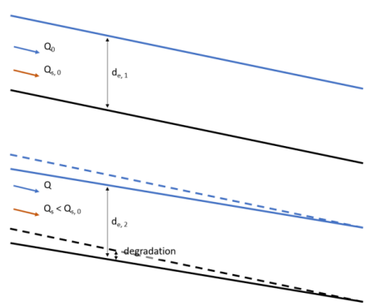


They were constructed to control the water level upstream from the weir . In this way , the water levels during low flows would increase in order to allow navigation throughout the full year → a sediment trap

↓

not fixed weirs, won't cause erosion/effect the morphology

Excavation of the riverbed — Since the 1940's



improve the navigable depth and/ or the flood safety → Widening of the river leads to a slower flow and a reduction in river capacity

If the excavation is not maintained, the sediment trap has a temporal influence on the downstream river morphology.

In case the excavation is maintained and the excavated sediments are put back in the river downstream, the effects are only local. maintenance dredged sediments are sometimes withdrawn from the river system

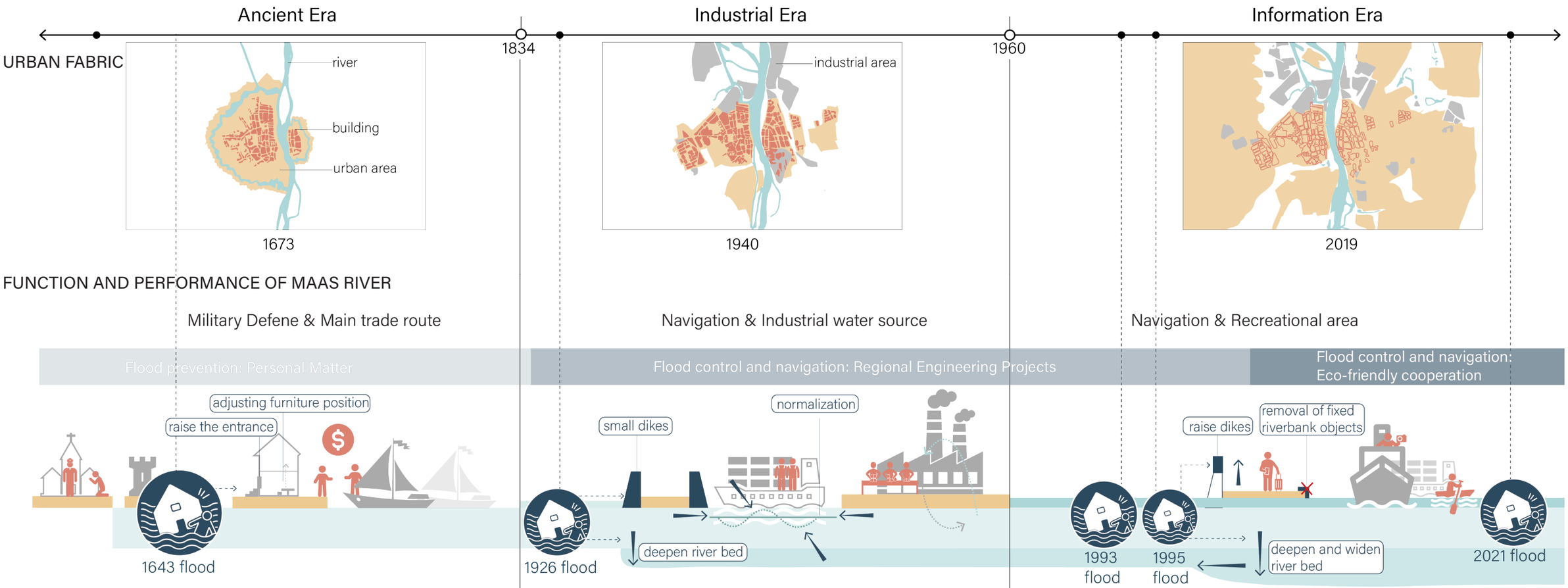
↓

The sediment load downstream of the sediment trap is artifically reduced, leading to a certain sediment load capacity that is not fed from upstream. This 'hungry' flow causes the river reach below the sediment trap to incise in the landscape.

↓

Excavations in the floodplains → an overall smaller equilibrium slope

1.2 Historical Development of Maastricht



Maastricht is a city rich in history and culture, and the river Maas played an important role in its development. In ancient times, the river's military defense and navigation enabled the city to become a religious center and a trading town. Later, in the industrial era, Maastricht became the first industrial city in the Netherlands thanks to the navigation and water provided by the Maas River. With the transition to a knowledge-based economy, the river has now become a recreational area contributing to the city's new identity as a cultural center and university town.

Maastricht has always **lived by water, but has also suffered from floods from several times**, but since the higher-lying west bank has always been the core of the settlement, flood damage has been manageable. In recent times, however, the **urban area has continued to expand into the floodplain on the east bank**, and in 2019, slightly more than half of the inhabitants lived on the east bank of the Meuse (61,100; compared to 60,445 on the west bank), and coupled with **extensive engineering measures** from the industrial era that led to degradation of the riverbed, and climate change, **significant fluvial flooding has become very frequent in recent years**. Although attempts have been made to prevent flooding from entering the city by raising dikes and deepening and widening the riverbed in some areas, the city of Maastricht has not been spared from disaster due to the uncertainty of flooding.

02 PROBLEMATIZATION

2.1.1 Problem Field & Analysis: Flood Risk

PROBABILITY OF FLUVIAL FLOODING

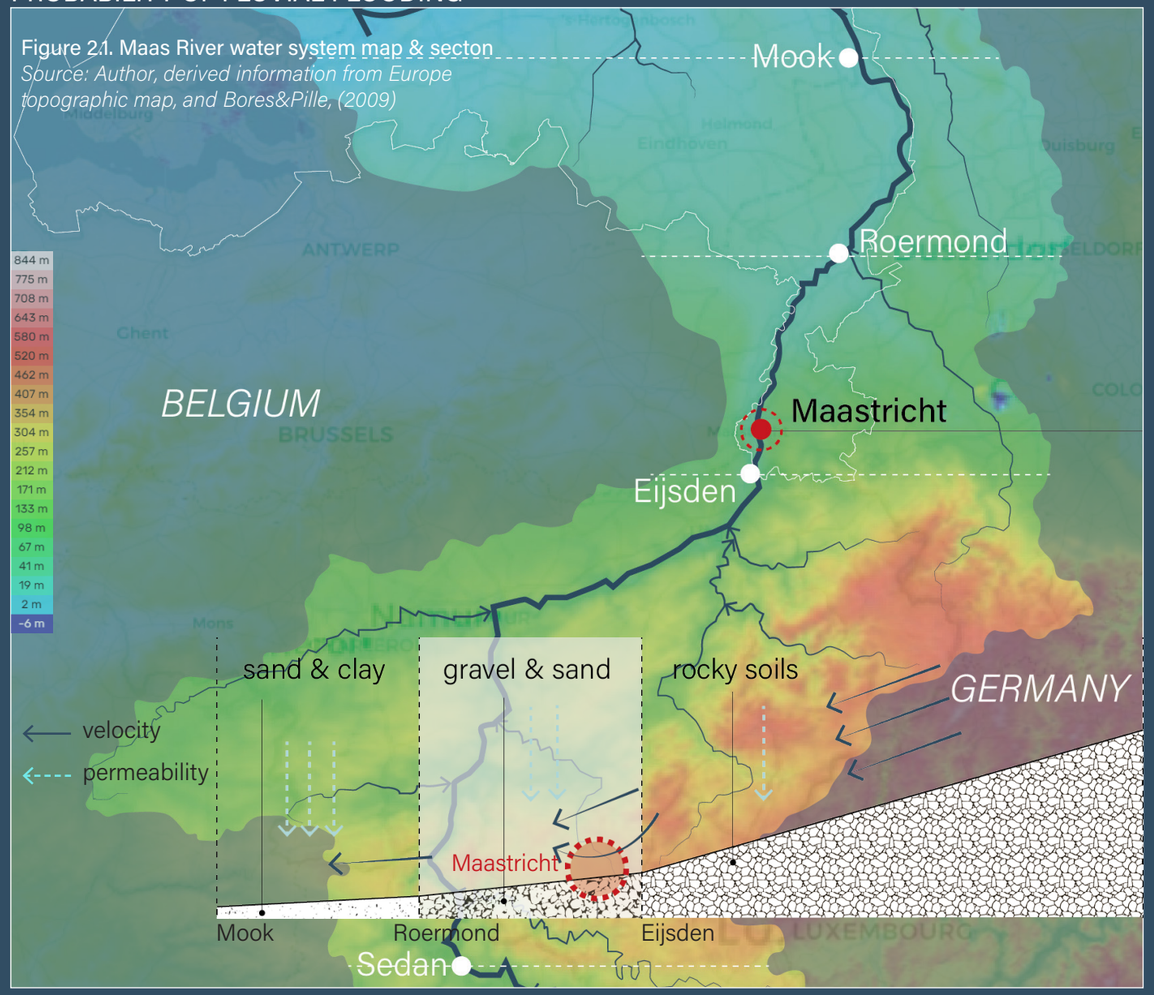


Figure 2.1. Maas River water system map & secton
Source: Author, derived information from Europe topographic map, and Bores&Pille, (2009)

Maastricht is located at the junction of the middle and lower Maas River basin. The high slope of the upper Eijsden area and the poor soil permeability make it difficult for water to be retained in the riparian area, which, when combined with the degradation of the upper Maas river bed (de Rooij, 2020), leads to a rapid discharge of most of the river water downstream carrying large amounts of sediment. In contrast, the sudden decrease in topographic gradient after Eijsden slows down the river flow, and water and partial sand tend to be retained in this section, while the water retention capacity of local rivers and soils decreases with urbanization(Bores & Pille, 2009), and when the water trapped during high flow periods exceeds the retention capacity of the riparian area, the neighboring cites are subject to river flooding (Figure 2.1.1).

Therefore, the security of Maastricht located at the Netherlands border would be directly threatened if Belgium and France upstream fails in flood management, leading to a surge of water in the Maas tributaries (Figure 2.1.2, 2.1.4, 2.1.5, 2.1.6). On the other hand, there are numerous cities located in the lowlands downstream of Maastricht, and if Maastricht fails to take on enough water in extreme weather, it will pose a huge security risk to the cities downstream.

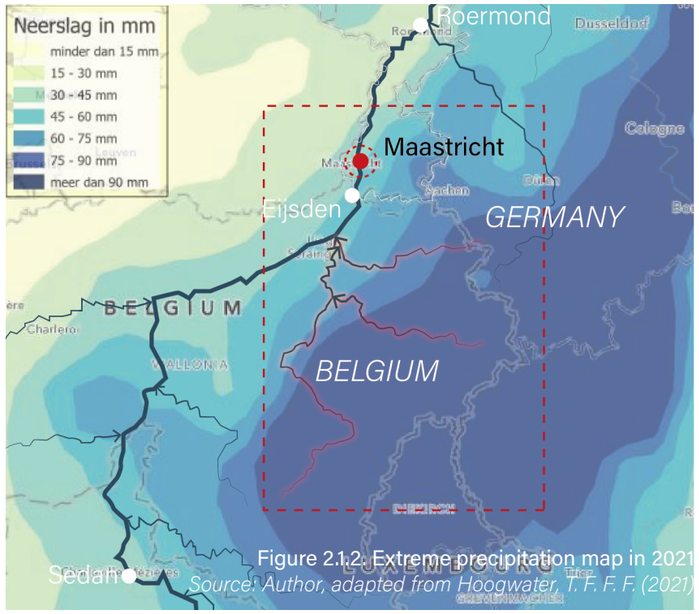


Figure 2.1.2. Extreme precipitation map in 2021
Source: Author, adapted from Hoogwater, T. F. F. F. (2021)

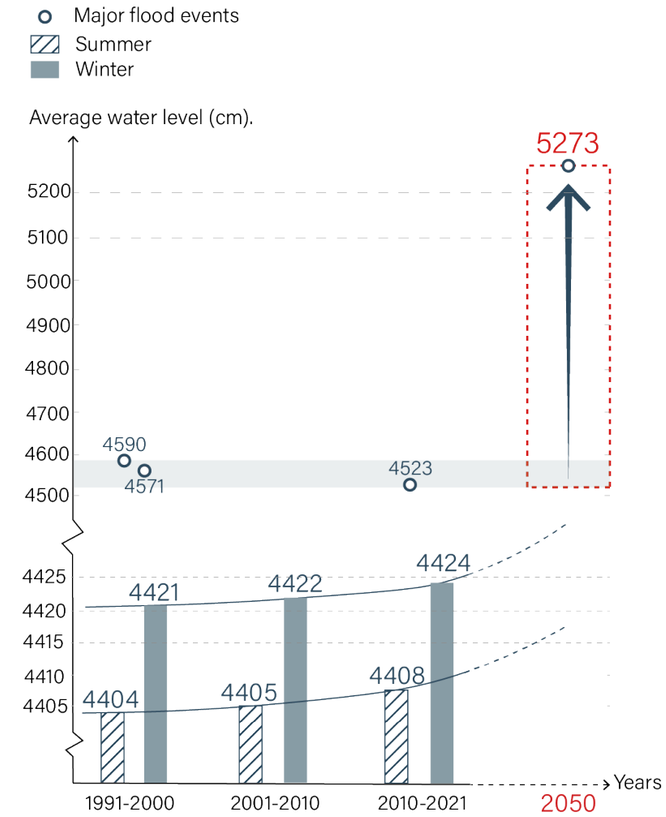


Figure 2.1.3. Changes in water levels in the Maastricht main channel
Source: Author, derived information from Hoogwater, T. F. F. F. (2021), Reuber et al (2005)

Figure 2.1.4. Photo of the Maastricht floods in 2021
Source: Google image

Figure 2.1.5. Photo of the Maastricht floods in 2021
Source: Google image

Figure 2.1.6. Photo of the Maastricht floods in 2021
Source: Google image

In addition to this, the Maas, being a seasonal river, precipitation has a great influence on its water level, and more frequent extreme precipitation due to future climate change will lead to a surge of water in the Maas River and its tributaries, exacerbating the rise of the main river level and expanding the floodplain along the Maas River (Hoogwater, 2021). Reuber et al (2005) concluded that in the worst case scenario, **the flood level of the Maas River will increase by an average of 0.75 m in 2050** (Figure 2.1.3).

In conclusion, Maastricht is extremely prone to river flooding and it will become more frequent and severe in the future.

VULNERABILITY OF FLUVIAL FLOODING

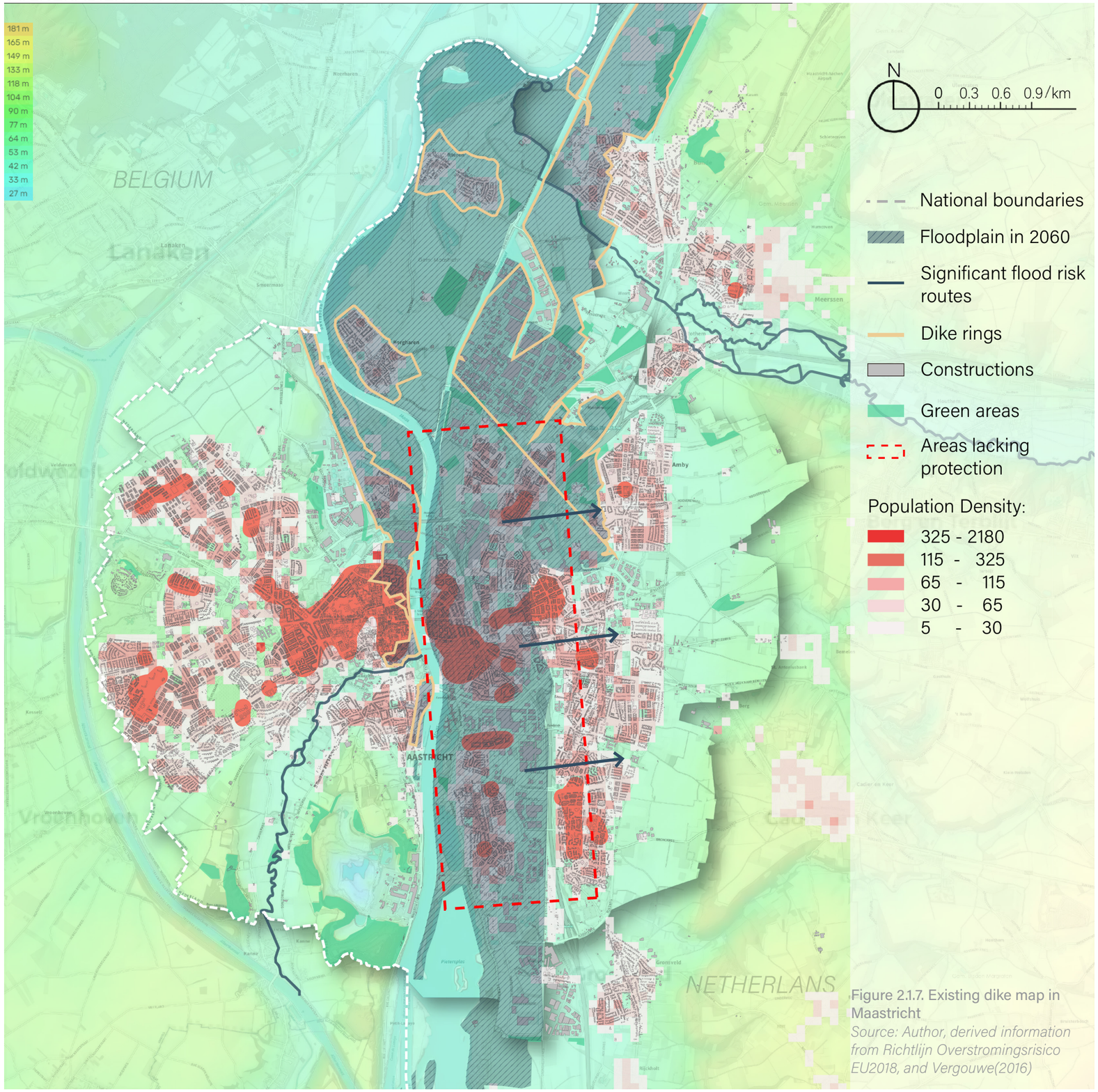


Figure 2.1.7. Existing dike map in Maastricht
Source: Author, derived information from Richtlijn Overstromingsrisico EU2018, and Vergouwe(2016)

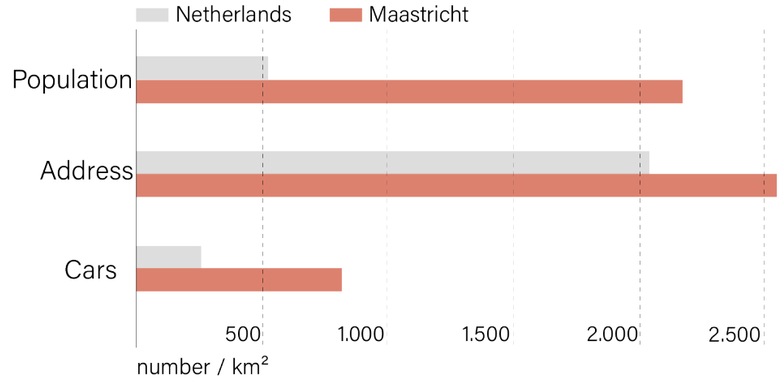


Figure 2.1.8. Chart of density of Netherlands and Maastricht respectively
Source: Adapted from Gemeente Maastricht (2021)

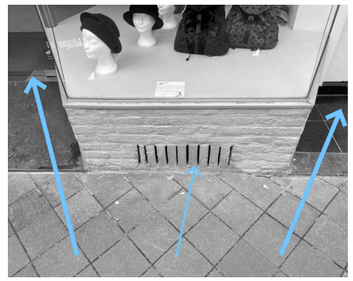


Figure 2.1.9. Photo of the drainage measures in the historic city buildings of Maastricht
Source: Author

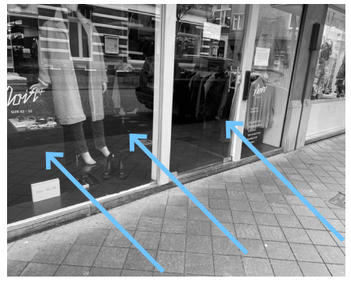


Figure 2.1.10. Photos of a store in the floodplain of Maastricht
Source: Author

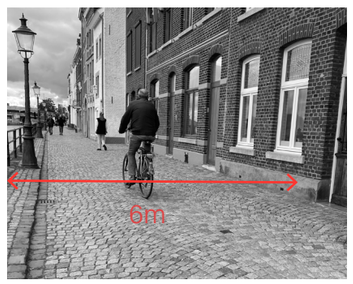


Figure 2.1.11. Maastricht Waterfront Photo
Source: Author

The eastern bank of the Maas River is a low-lying floodplain that will cover about one-third of Maastricht's built-up area by 2060 (Figure 2.1.7). Maastricht has a very **high population density**, almost four times the Dutch average (Figure 2.1.8), and this part of the city is densely populated. However, it **lacks protection from existing dikes** and has **limited green spaces** (Figure 2.1.7). **The buildings in the area are vulnerable to flooding** (Figure 2.1.9, 2.1.10), and there is not enough space to build new dikes between the river and the city (Figure 2.1.11). Additionally, rising river levels each year reduce the effectiveness of existing dikes, increasing the risk of flooding in the urban area.

Moreover, as the floodplain expands to the east where the land is low, more urban areas will face the threat of flooding (Figure 2.1.7). In summary, **Maastricht's floodplain is currently at high risk of river flooding and will face even greater danger in the future.**

2.1 Problem Field & Analysis: Flood Risk + Leisure Industry

FLOOD DAMAGE

Figure 2.1.12. Photo of flood damage to buildings in Maastricht
Source: Google Images (1926)

Figure 2.1.13. Photo of flood damage to railway in Maastricht
Source: Google Images (1993)

Figure 2.1.14. Photo of Social disruption in Maastricht
Source: Google Images (1993)

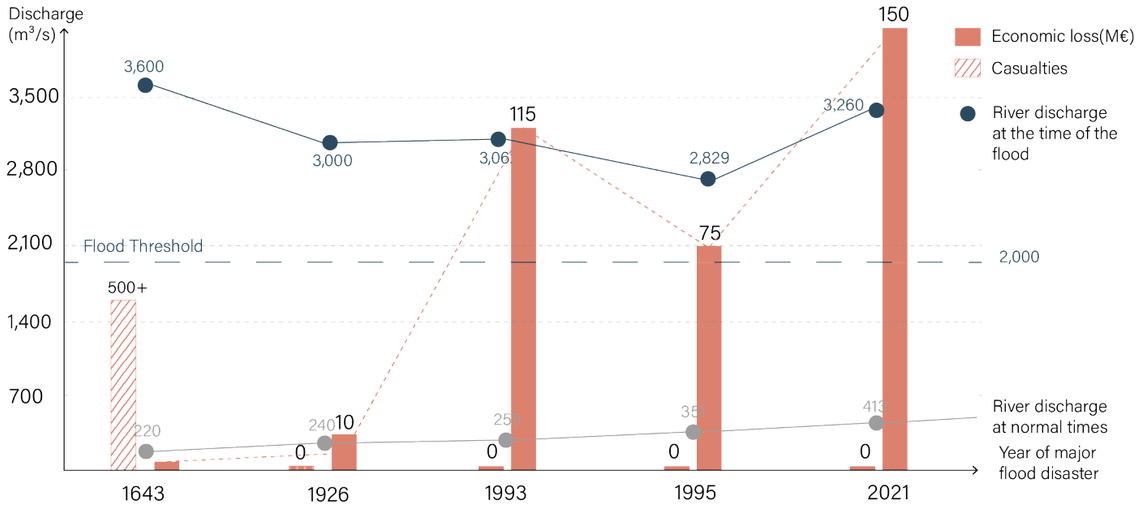


Figure 2.1.15. River discharge and damage at the time of major floods in the history of Limburg
Source: Author, derived information from Hoogwater (2021), De Bruijn (2005)

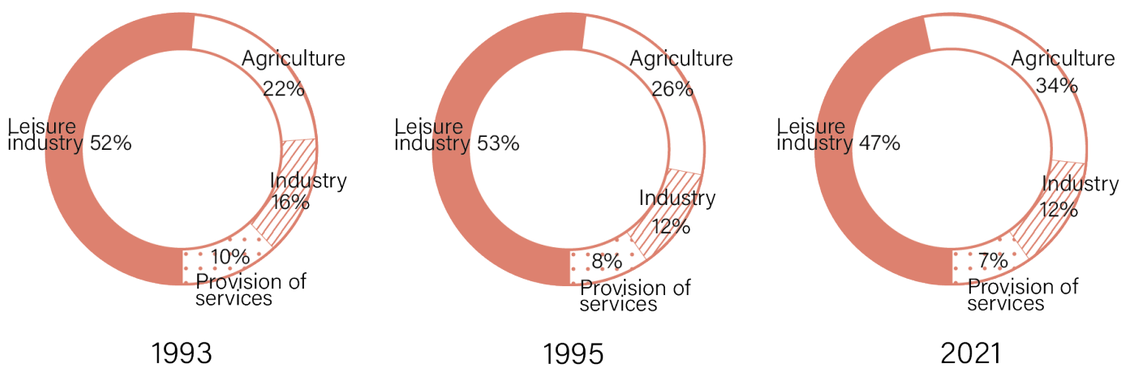


Figure 2.1.16. Economic share of losses due to fluvial floods in different sectors in Limburg in 1993, 1995, and 2021
Source: Author, derived information from Hoogwater (2021), De Bruijn (2005)

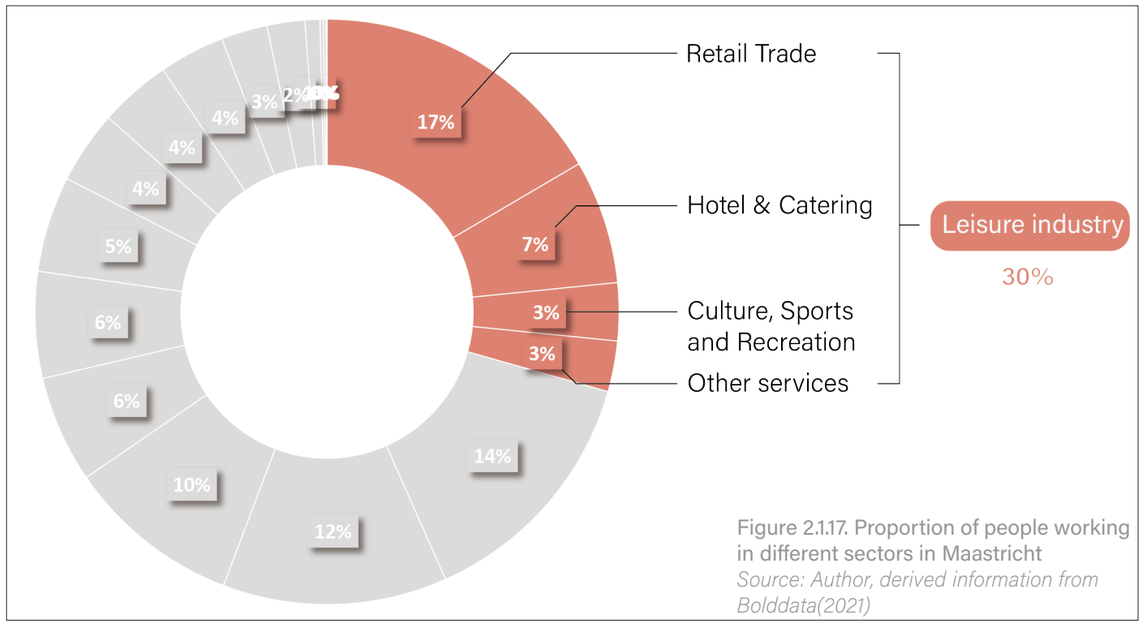


Figure 2.1.17. Proportion of people working in different sectors in Maastricht
Source: Author, derived information from Bolddata(2021)

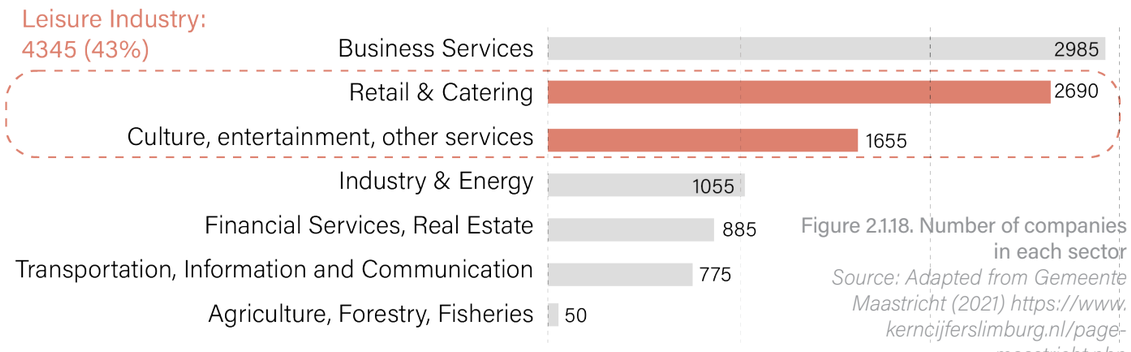


Figure 2.1.18. Number of companies in each sector
Source: Adapted from Gemeente Maastricht (2021) https://www.kerncijferslimburg.nl/page-maastricht.php

In recent years, Maastricht has witnessed a notable escalation in economic consequences with the absence of any reported human casualties(Wind et al., 1999, Figure 2.1.15).

The leisure industry, a significant component of Maastricht's economic landscape, assumes a pivotal role in the city's socio-economic fabric, employing approximately 30% of its resident workforce (Figure 2.1.17, 2.1.18). Consequently, the detrimental effects of the economic downturn have disproportionately affected this sector, rendering it the most severely impacted. In fact, the leisure industry alone accounts for an estimated 50% of the overall business losses incurred by Maastricht (Figure 2.1.16). This finding underscores the leisure industry's vulnerability and the urgent need for targeted interventions to mitigate its profound economic setbacks.

2.1 Problem Field & Analysis: Flood Risk + Leisure Industry

VULNERABILITY OF LEISURE INDUSTRY TO FLOODING

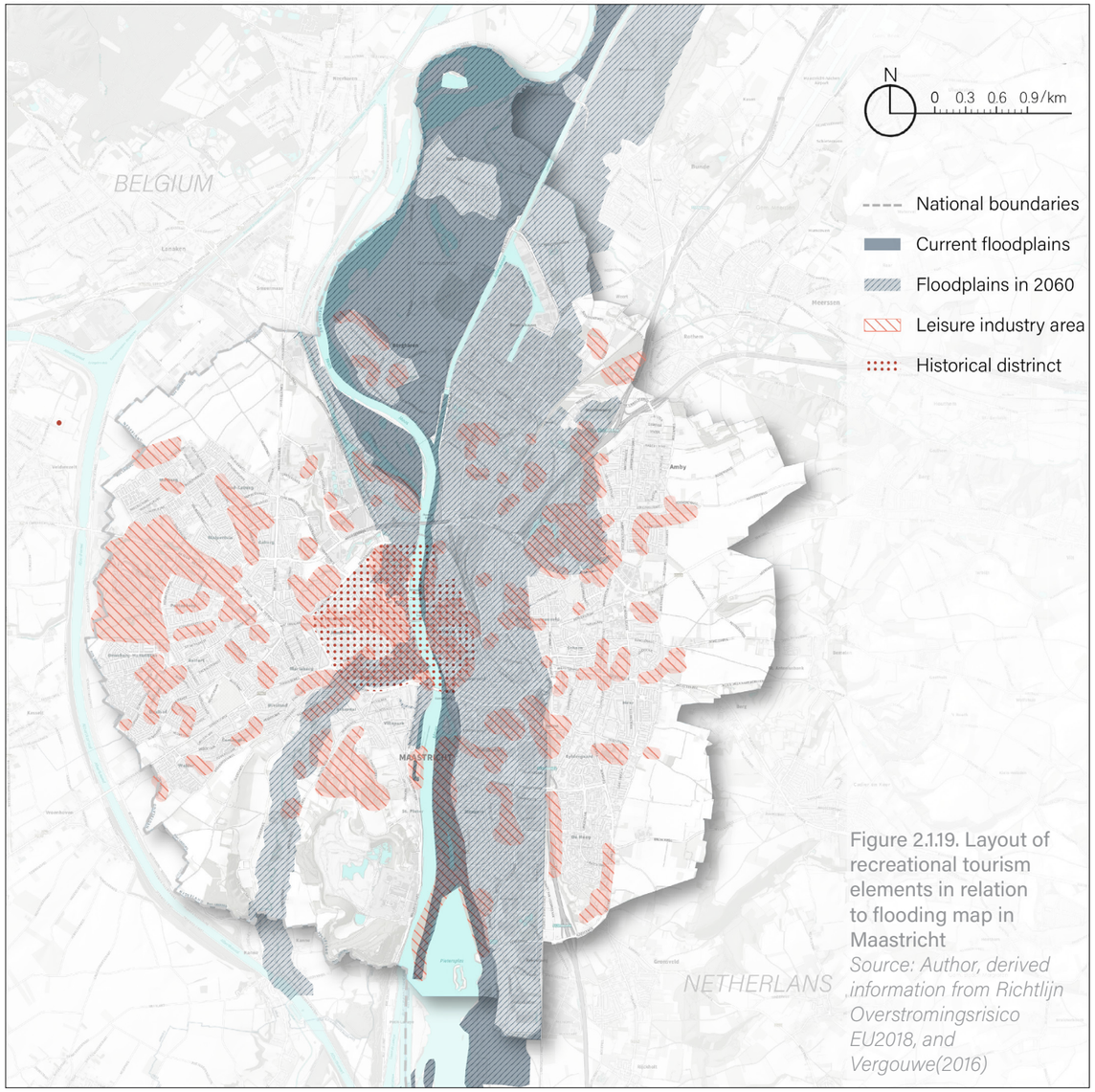


Figure 2.1.19. Layout of recreational tourism elements in relation to flooding map in Maastricht
Source: Author, derived information from Richtlijn Overstromingsrisico EU2018, and Vergouwe(2016)

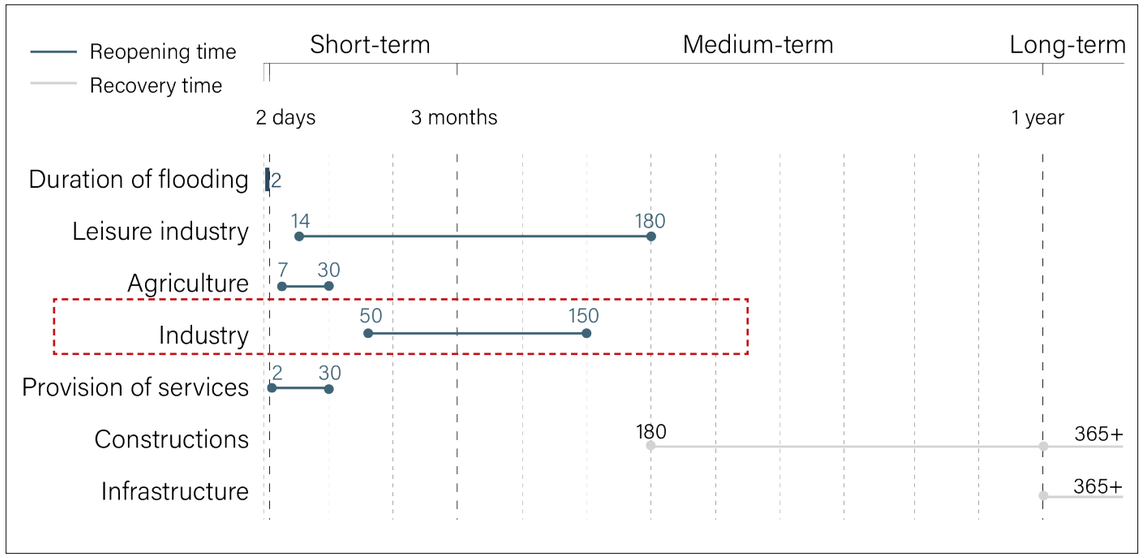
Figure 2.1.20. Photo of the restaurant during the flood in Maastricht
Source: Google Images (2021)

Figure 2.1.21. Photo of the highway during the flood in Maastricht
Source: Google Images (2021)

Figure 2.1.22. Photo of cleaning up after the floods in Maastricht
Source: Google Images (2021)

Table 2.1.1. Map of current flood protection measures in Maastricht
Source: Author, adapted information from Hoogwater (2021)

	Monetary value	Non-monetary value
Physical damage	▪ Capital losses (homes, contents, crops, cars, plants, buildings, inventory) ▪ Cleaning costs	Casualties, stress, ecosystems, pollution, monuments, cultural loss
Business interruption	▪ Loss from production downtime ▪ Loss of income ▪ Interruption of infrastructure	Social disruption, emotional harm and inconvenience due to interruption of infrastructure



▪ Note: Leisure industry: Retail, Catering, Culture, entertainment, other services

Figure 2.1.23. Chart of damage of floods on recreation industry in Maastricht
Source: Author, derived information from Hoogwater (2021)

Flooding in Maastricht inflicts significant harm encompassing both physical damage and disruptions to business operations (Table 2.1.1). An alarming scenario unfolds wherein nearly half of the city's leisure industry faces the risk of river flooding by 2060 (Figure 2.1.19). This inundation poses dire consequences for establishments such as restaurants, retail stores, entertainment venues, hotels, and other entities within the leisure sector, compelling them to cease operations and incur additional costs for repair and cleanup (Figure 2.1.20, 2.1.21, 2.1.22). Moreover, **these enterprises encounter prolonged recovery periods following flood events, with some even succumbing to permanent closure** (Figure 2.1.23).

To mitigate the detrimental impact of flooding in Maastricht, it is imperative to prioritize measures aimed at minimizing flood-related damage specifically targeting the leisure industry.

2.1 Problem Field & Analysis: Leisure Industry

CURRENT SITUATION OF THE LEISURE INDUSTRY

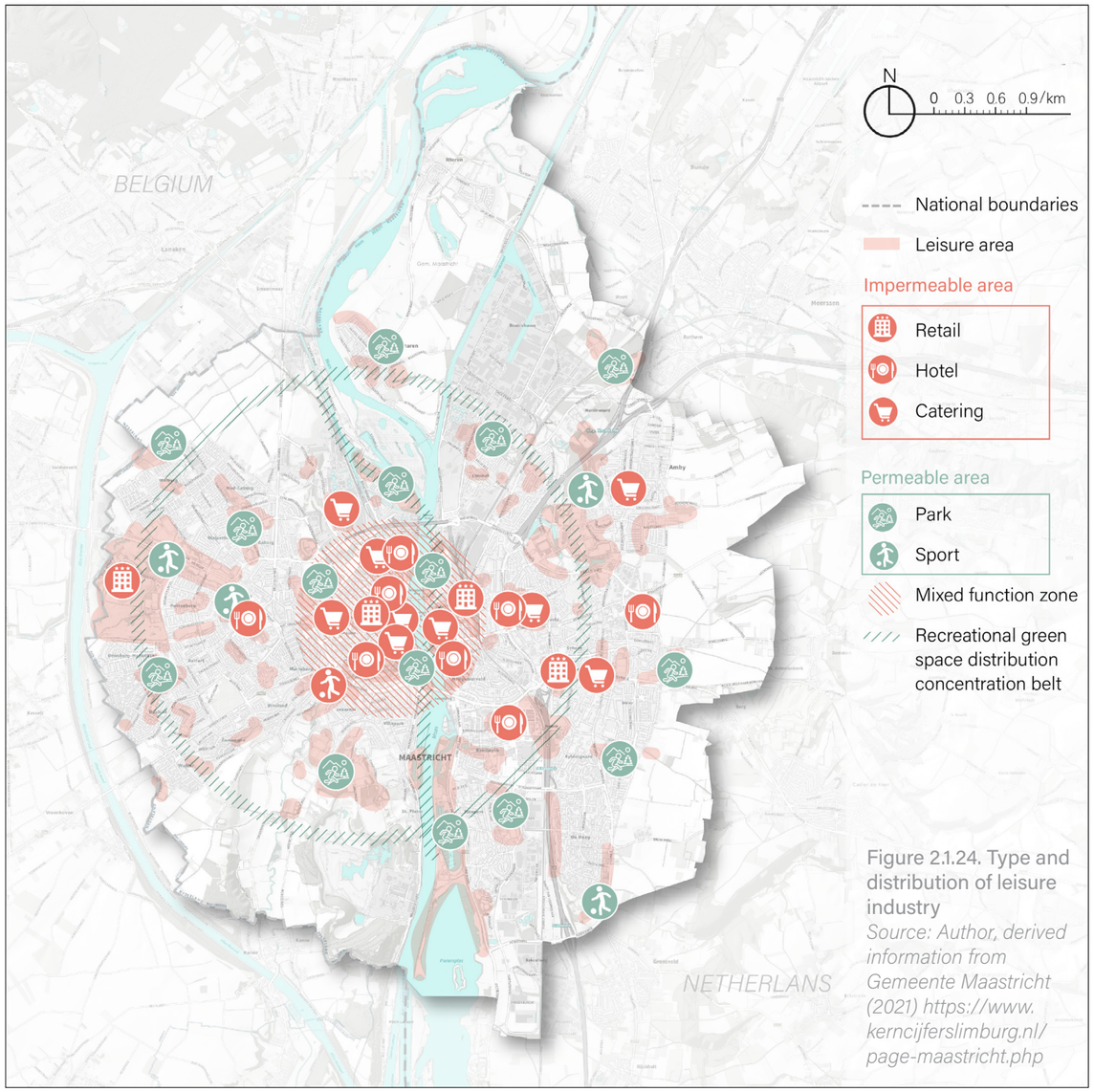


Figure 2.1.24. Type and distribution of leisure industry
Source: Author, derived information from Gemeente Maastricht (2021) https://www.kerncijferslimburg.nl/page-maastricht.php

Leisure resources in Maastricht are unevenly distributed, primarily concentrated in the central historic district, limiting access and benefits for many residents (Figure 2.1.24). Traditional retail and restaurant establishments dominate, lacking a strong representation of local history and culture (Figure 2.1.24). Sports areas and parks are mostly found along the riverbanks and outskirts, making them less accessible to inland residents (Figure 2.1.24). The proximity of daily leisure facilities is insufficient, with limited options reachable within a five-minute walk and a scarcity of culture-related facilities (Figure 2.1.25). This layout promotes car dependency in the dense city and hampers cultural dissemination.

It is imperative to prioritize equitable distribution, enhance walkability, and explore flood treatment opportunities in suburban areas to foster a vibrant and sustainable leisure environment in Maastricht.

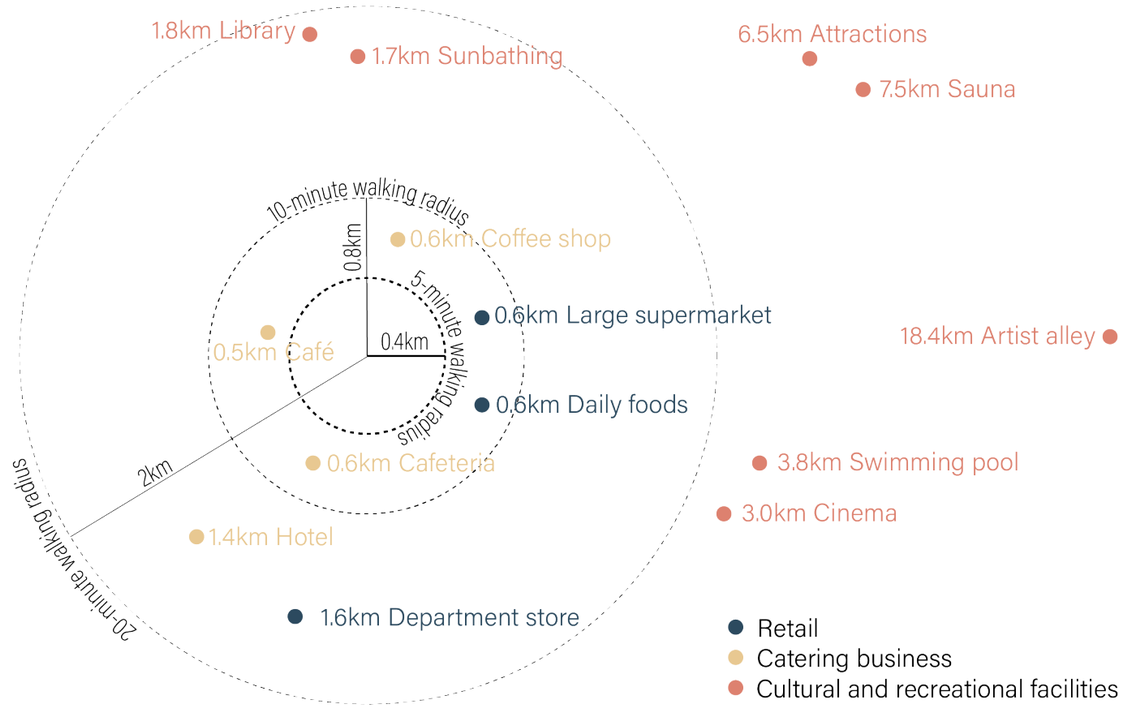


Figure 2.1.25. Proximity map of leisure industry facilities
Source: Author, derived information from https://morphocode.com/the-5-minute-walk/, Gemeente Maastricht (2021) https://www.kerncijferslimburg.nl/page-maastricht.php

Figure 2.1.26 Catering & retail
Source: Author

Figure 2.1.27 Cutural facilities
Source: Author

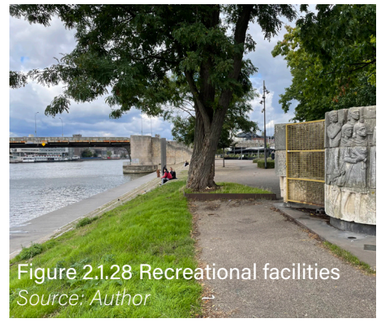


Figure 2.1.28 Recreational facilities
Source: Author

By ensuring fair access to leisure resources, promoting pedestrian-friendly infrastructure, and addressing flood risk, Maastricht can create an inclusive and resilient leisure landscape that enhances the city's overall vitality and long-term sustainability.

POTENTIAL OF THE LEISURE INDUSTRY

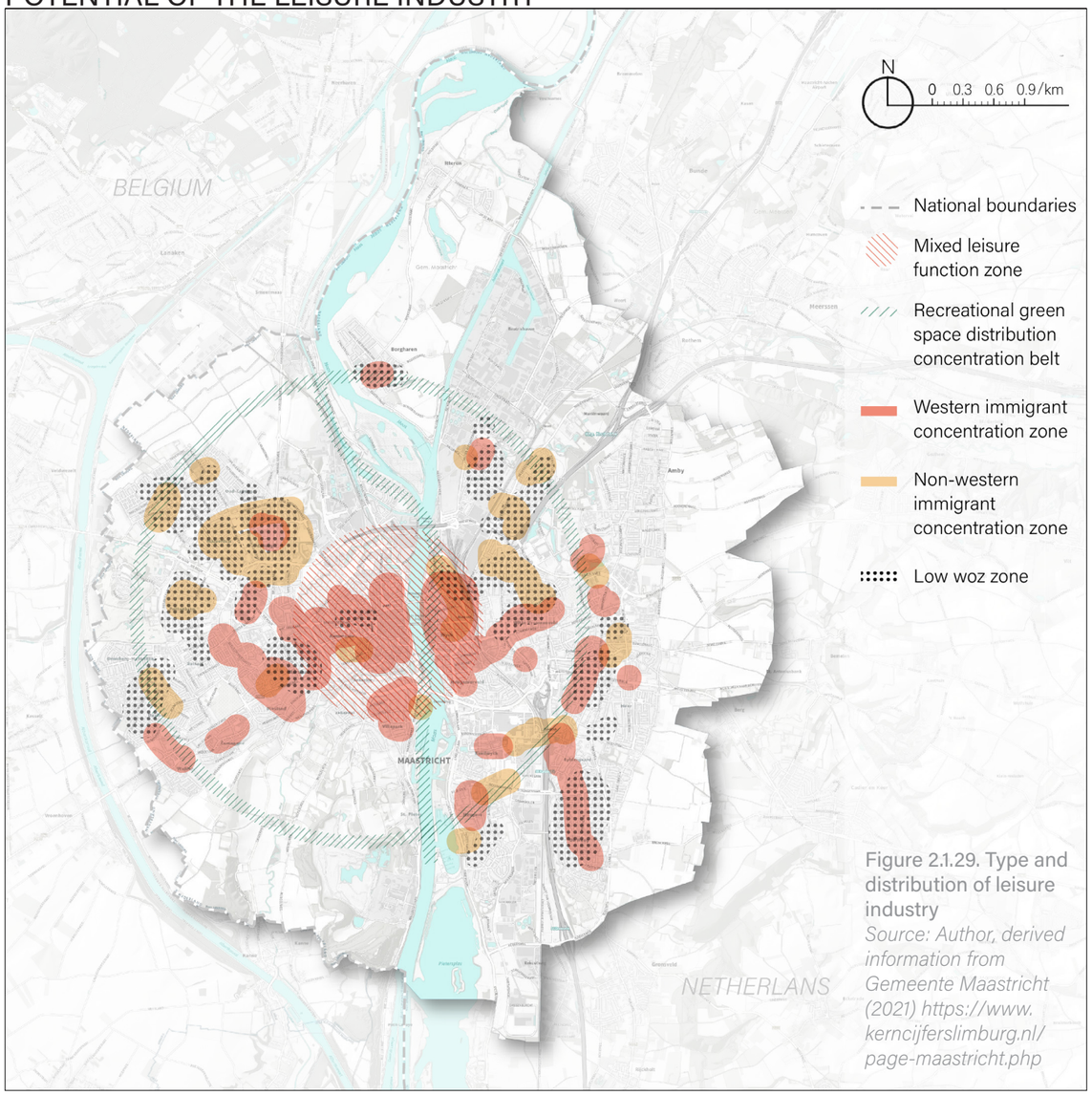


Figure 2.1.29. Type and distribution of leisure industry
Source: Author, derived information from Gemeente Maastricht (2021) https://www.kerncijferslimburg.nl/page-maastricht.php

The suburban leisure industry belt in Maastricht aligns closely with areas characterized by high concentrations of migrants and low land prices (Figure 2.1.29). This spatial coincidence presents a promising opportunity to integrate flood management measures with the development of the leisure industry in the region. Additionally, recent years have witnessed a slight population decline in Maastricht, primarily due to the outmigration of local residents (Figure 2.1.30). Paradoxically, this decline has been accompanied by an increase in unemployment rates (Figure 2.1.31), highlighting the urgent need to create more job opportunities within the city. Implementing integrated projects that combine flood management and leisure industry development can serve as a viable solution. Not only will these projects generate a significant number of jobs, but they will also contribute comprehensively to the overall advancement and growth of Maastricht in various aspects.

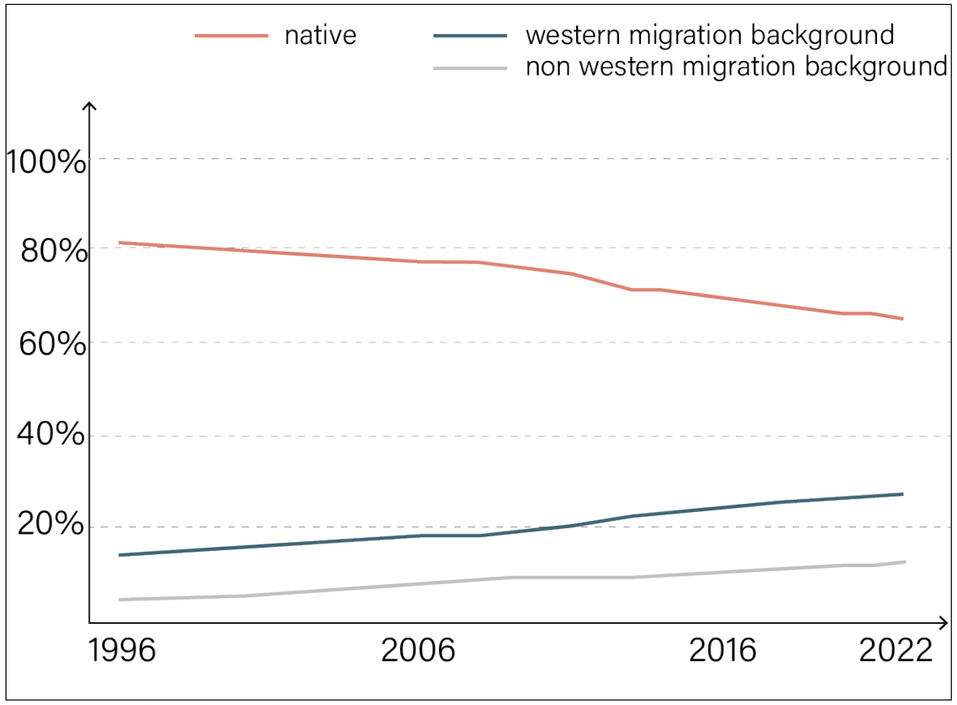


Figure 2.1.30. Chart of migration trend of Maastricht
Source: Author, derived information from CBS (2022)

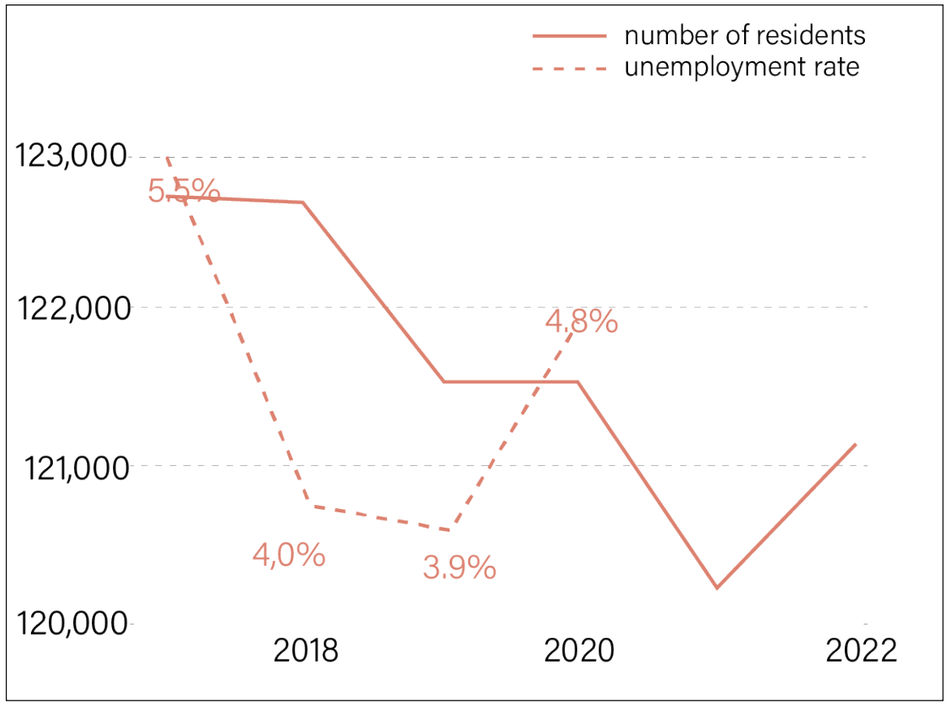


Figure 2.1.31. Chart of migration trend of Maastricht
Source: Author, derived information from CBS (2022)

RECREATIONAL VALUE OF FLOOD

Street Boating & Water Games

Figure 2.1.32. Photo of children playing in the water after the 1926 flood in Maastricht
Source: Google Images (1926)

Backyard Fishing

Figure 2.1.34. Photo of a man fishing in his backyard after the 2021 flood in Maastricht
Source: Google Images (2021)

Waterfront Resting

Figure 2.1.33. Photo of teenagers seating at the ponding's edge after the 2021 flood in Maastricht
Source: Google Images (1995)

Road Picnic

Figure 2.1.35. Photo of people gathering and eating on a flooded road after the 2021 flood in Maastricht
Source: Google Images (2021)

Despite its tremendous destructive effects, flooding also has the potential to **stimulate specific recreational activities** and **enhance multifunctionality** for various types of urban spaces.

During several major historical flood events, local residents have spontaneously engaged in various recreational activities such as boating, fishing, water play, and picnicking in different spaces (Figure 2.1.32, 2.1.33, 2.1.34, 2.1.35).

The arrival of the floods has transformed many of Maastricht's originally dry, hard urban spaces into open water, small ponds and waterfront spaces. This has undoubtedly increased the possibilities and accessibility of water related activities, such as (hiring) canoes, rowboats, motorboats, sailboats and surfboards etc.

From this perspective, **the flood connected these spaces and gave them new functions, thus increasing their leisure value and improving the urban fabric on a recreational level**. It is implied that floods have the potential to have a facilitating effect on the leisure industry.

The survival and development of the city of Maastricht is facing enormous threat from the increasingly frequent and severe **fluvial floods**, while the **leisure industry** is the most vulnerable to flood damage as a crucial segment of the economy, accounting for about 50% of the total economic damage.

Therefore, it is necessary to strengthen the **integration** of flood management and leisure industry development in Maastricht.

Susceptibility to fluvial flooding

Maastricht has long suffered from river flooding since the city was founded in the Middle Ages. **The poor flood management in Belgium and Germany** located upstream of it promotes river flooding, while the increasing frequency and intensity of extreme precipitation due to **climate change** will undoubtedly increase the frequency and intensity of floods, with the mega-floods of this century shortening from 77 to 40 years, exacerbating the threat to the survival and development of the urban area in an expanding floodplain, for which the city must be prepared for **possible floods in 2060**.

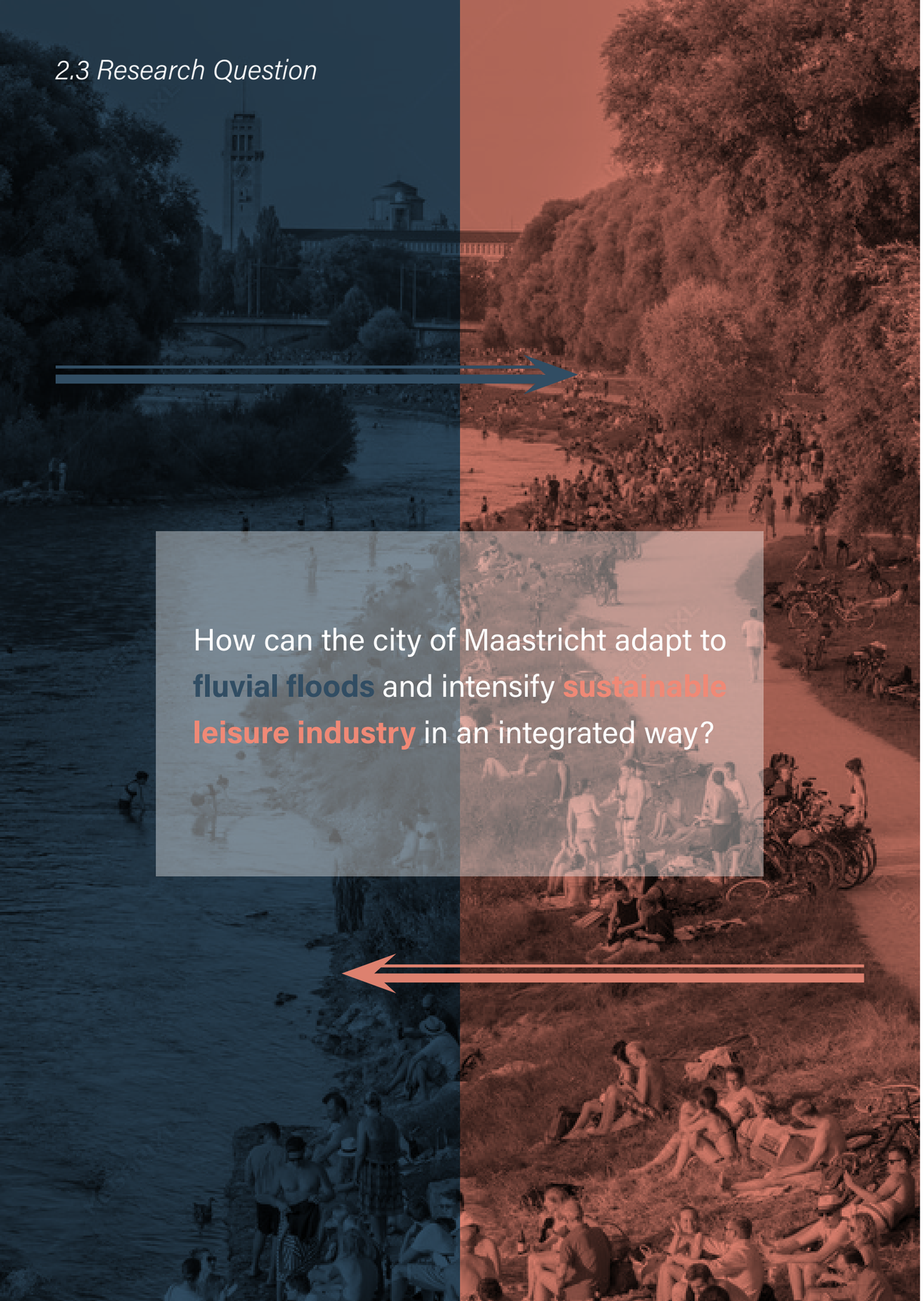
Vulnerability of the leisure industry to fluvial flooding

On the other hand, the **city's high density** and the fact that 1/3 of the city is located on the **floodplain without adequate flood protection measures** have caused **millions of euros of economic damage** to the city in recent years. Among them, due to the non proximity and non-proofing of amenity and infrastructure, floods are very likely to cause **physical damage** and **business interruptions** in the **leisure industry**, making it difficult or taking a long time to reopen, which is an important aspect of flood losses in Maastricht.

The recreational value of fluvial flooding

Although flooding can be destructive and highly uncertain, it is essentially just a **natural process with plenty of ecological benefits**, and has even **stimulated recreational activities** such as boating and fishing in the city of Maastricht, which implies that floods have a great potential to be transformed from a disaster into a resource in Leisure industry. As a major host of recreational activities, the city of Maastricht is called upon to be able to **embrace and even prosper from river flooding,** for reconciling urban development and ecological preservation. Therefore, this report explores the **integrated transformation** of Maastricht to a city living in symbiosis with river floods and led by sustainable leisure industry from an **urban design** perspective (including at the organizational level) across different scales.

2.3 Research Question



How can the city of Maastricht adapt to **fluvial floods** and intensify **sustainable leisure industry** in an integrated way?

2.4 Research Aim

This report aims to explore **integrated transformation** from an **urban design** perspective for the city of Maastricht to **adapt to river flooding** and to **promote sustainable leisure industry**. It implies a transformed urban fabric that prevents the damage caused by river flooding and converts floods into a resource for sustainable leisure industry development through a series of **spatial interventions** and **programs** that **cross three scales** (regional scale, city scale, and neighborhood scale).

In order to achieve this goal, the study will explore:

Spatial and social opportunities for **urban transformation** applicable to flood management and sustainable leisure industry development in Maastricht and Maas basin

A Pattern language for integrated flood control adaptation and leisure industry sustainability

A city-scale flood adaptation and sustainable leisure industry **synergistic design proposal** of Maastricht

A scheme for integrated cooperation and implementation of flood adaptation and sustainable leisure industry **across regional, city and neighborhood scales**

03 RESEARCH STRUCTURE

3.1 Theoretical Background

NATURE BASED SOLUTION

According to IUCN (2016), nature-based solutions (NbS) encompass actions aimed at protecting, sustainably managing, and restoring natural and modified ecosystems. These actions are designed to effectively address societal challenges while simultaneously benefiting both human well-being and biodiversity (Figure 3.1.1).

Recognizing the critical importance of integrating nature conservation into key economic sectors, governments and businesses are increasingly acknowledging NbS as not just a useful tool, but a necessary approach to combat the dual global crises of biodiversity loss and climate change. IUCN (2020) emphasizes that NbS can effectively mitigate the impacts and long-term risks associated with climate change, which stands as the greatest threat to biodiversity. By embracing approaches that work in harmony with ecosystems instead of relying solely on conventional engineering solutions, communities can better adapt to the consequences of climate change.

Nevertheless, the practical application of NbS as a general concept poses challenges for governments and businesses. Without fully realizing its potential, NbS may only make a marginal contribution to pressing sustainability needs. In response, the IUCN has developed a global standard for NbS. This standard not only provides guidance for on-the-ground implementation but also fosters the formation of a global community of users, expediting policy development and facilitating advancements in conservation science pertaining to NbS (Figure 3.1.2). Through the establishment of this standard, NbS can be rooted in a shared understanding of its interpretation and a common vision of fostering a just and sustainable world.

Figure 3.1.1 Definition of nature-based solutions
Source: IUCN (2016)

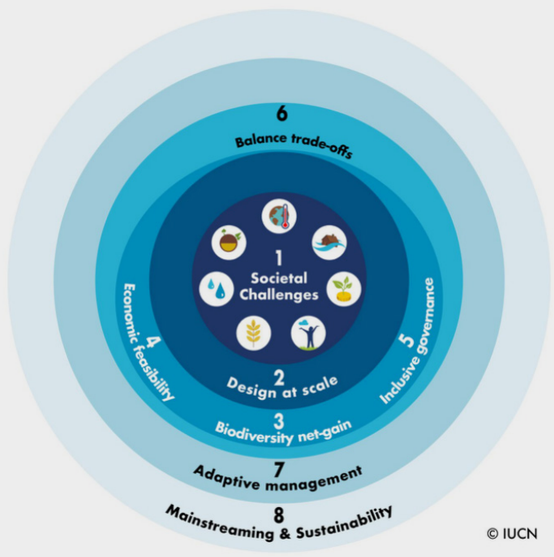


Figure 3.1.2. IUCN Global Standard for Nature-based Solutions
Source: IUCN (2020)

CULTURAL LANDSCAPE RESTORATION

Cultural landscape restoration, which embraces a landscape perspective, has gained attention in recent years as a means to enhance the effectiveness of nature conservation and management (Moreira et al., 2006). This approach recognizes the importance of incorporating cultural and scenic values, which may be less prominent in traditional ecosystem restoration efforts, while acknowledging that ecosystem restoration takes place within the broader landscape context (Moreira et al., 2006). By integrating ecological conservation with the sustainable use of natural resources and human development, cultural landscape restoration offers a valuable framework to address the challenges presented by our rapidly changing world.

The challenges associated with cultural landscape restoration extend beyond the natural sciences, requiring an interdisciplinary approach that integrates social sciences, humanities, and local knowledge (Tress & Tress, 2001). As argued by Winterhalder, Clewell, and Aronson (2004), the future of ecological restoration lies in adopting a more interdisciplinary and integrated approach that encompasses both scientific and value-based components.

To effectively carry out cultural landscape restoration, four distinct operational components can be considered (Moreira et al., 2006). **Landscape composition and configuration** encompass the spatial patterns of the landscape, including individual elements such as landforms, ecosystems, and land uses. **Traditional land management techniques**, which have shaped landscapes over time, encompass practices like animal traction, livestock grazing, cultivation techniques, and work organization. **Linear and point features**, resulting from landscape composition and traditional techniques, can form independent parts of landscape restoration efforts, including structures like stone walls, terraces, and hedgerows. Lastly, cultural landscape restoration also addresses **other heritage features** such as ethnography, architecture, dialects, music, oral traditions, and specific forms of social organization associated with the landscape.

By recognizing and addressing these operational components, cultural landscape restoration can effectively integrate ecological conservation and cultural heritage preservation. This comprehensive approach fosters a deeper understanding of the complex interplay between natural and cultural dimensions, enabling the development of strategies that promote the sustainable management and revitalization of landscapes.

3.2 Theoretical Framework

RESEARCH TOPIC

FLOOD RESILIENCE

Flood resilience lacks a clear definition at present, but scholars like Liao (2012) and Rodina (2019) strongly advocate for the adoption of ecological resilience as a foundation for flood resilience applications due to its enhanced suitability for a dynamic world. Kresge (2015) defines urban ecological resilience as the community's capacity to anticipate, plan for, and mitigate the risks associated with environmental and social changes, while also seizing the opportunities they present. This definition emphasizes concepts such as "**coping**," "**transformation**," and "**bouncing forward**," highlighting the absence of equilibrium states and emphasizing the continuous nature of change (Rodina, 2019).

Coping | Transformation | Bouncing Forward

LEISURE INDUSTRY SUSTAINABILITY

At present, a specific definition of sustainable leisure industry is yet to be established. However, we can refer to the definition of sustainable tourism put forth by the United Nations Environment Programme and the United Nations World Tourism Organization. According to this definition, sustainable leisure industry refers to an industry that fulfills the needs of the sector, the environment, and the resident community, while considering its present and future economic, social, and environmental impacts.

Sustainable leisure industry encompasses the following key elements:

- **Optimal utilization of environmental resources** to support industry development, while preserving ecological processes, natural heritage, and biodiversity.
- Respect for **socio-cultural authenticity**, including the preservation of indigenous communities' architectural and cultural heritage, traditional values, and promotion of intercultural understanding.
- Ensuring economically viable and **long-term operations** that provide **equitable socio-economic benefits**, such as stable employment, income opportunities, social services for local communities, and contributing to poverty alleviation.

Ecological Service Potential Maximization | Socio-cultural Authenticity | Equitable Distribution Economy

IMPLEMENTATION MEDIUM

Blue-Green Infrastructure

Blue-green infrastructure refers to an interconnected system comprising **natural and designed landscape elements**. It encompasses water bodies, green spaces, and open areas that serve multiple purposes and enhance ecological services. These include functions such as water storage for irrigation, regulation of urban microclimates, flood control, creation of wetlands for wildlife habitat, and water purification (Ghofrani, 2017).

Nature Based Solution

Nature-based solutions are actions that harness the power of nature and healthy ecosystems to address societal challenges, optimize infrastructure, sustain human well-being, and increase biodiversity in an effective and adaptive manner (IUCN, 2020).

Dynamic Cultural Landscape

Cultural landscape is the result of interaction between human and space in a dynamic transaction process, the intersection of nature and culture, tangible heritage and intangible heritage, biodiversity and cultural diversity (Schaich et al., 2010 & Plieninger et al., 2014). It mainly consists of landscape composition and configuration, traditional technology of land management, landscape point and line feature elements, cultural heritage (tangible and intangible) (Moreira & Aronson, 2006).

DESIGN GOALS

Environmental aspects:

Ecological Integrity

The ecosystem has the expected **biotic and abiotic components** in its natural area, while **its processes** (e.g., fire, flooding, predation) occur with the frequency and intensity expected in its natural area. In other words, the ecosystem of the Maastricht city has integrity when the primary components of the system are intact (Moreira et al., 2006).

Economic aspects:

Equality of Opportunity

Equality of opportunity aims to ensure that everyone has the same access to the resources and services of the city and nature (Roemer, 2002), which means creating more benefits in Maastricht (spatial multifunctionality, job opportunities) and making them more inclusive (facility accessibility, flood proofing).

Socio-cultural aspects:

Cultural Identity Consolidation

Cultural identity is established through acknowledging shared origins or characteristics within a group. The construction of this collective identity draws upon diverse cultural elements such as history, geography, religion, and sexuality. These materials are utilized to highlight the distinctiveness of group identity (Neill, 2003). To underscore this distinctiveness, it is essential to safeguard the shared historical heritage of the group and harness its complete socio-spatial potential.

3.3 Conceptual Framework

RESEARCH FOCUS

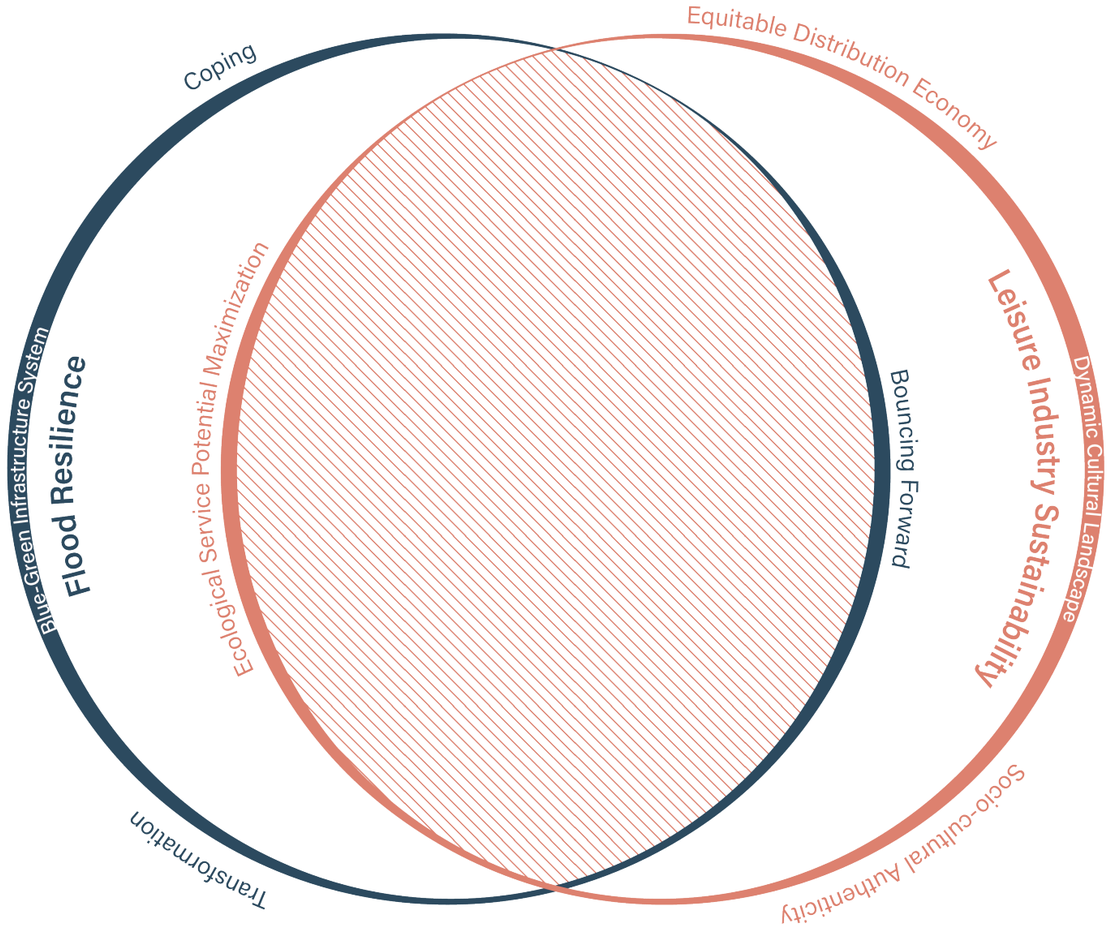


Figure 3.1.3. Research fields
Source: Author

DESIGN GOALS

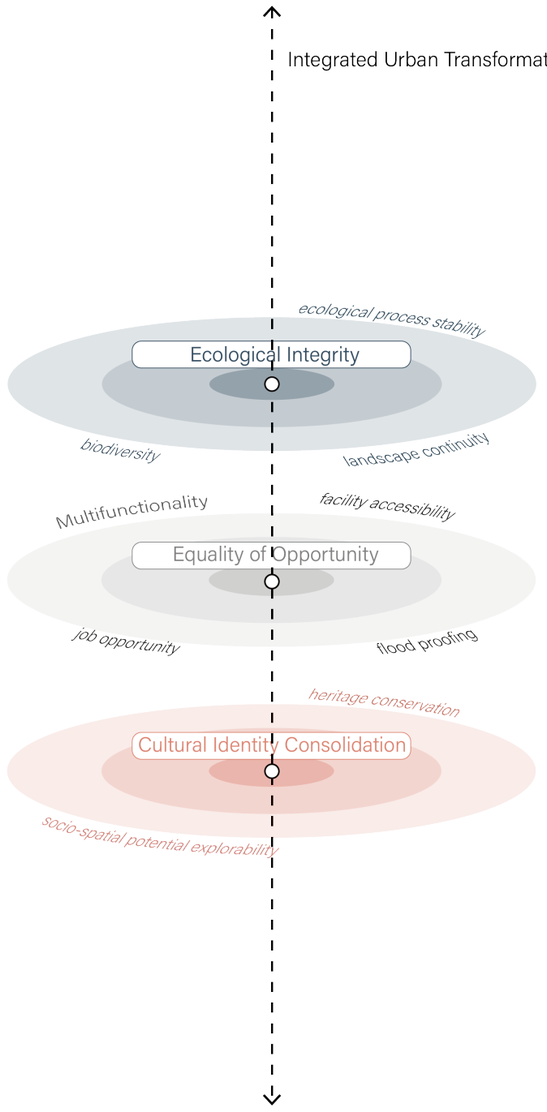


Figure 3.1.4. Design goals
Source: Author

This study aims to explore the intersection of flood resilience and the sustainable leisure industry, focusing on the relationship and potential synergies between these two areas (Figure 3.1.3). It seeks to investigate how flood resilience measures can be effectively integrated into the design, planning, and operation of leisure facilities and activities. Additionally, the study aims to understand the role of the sustainable leisure industry in enhancing flood resilience, particularly through aspects such as infrastructure design, public awareness, and community engagement. By examining these aspects, the research intends to provide insights and recommendations for improving the resilience of leisure spaces and their contribution to overall flood resilience strategies.

This study explores the integration of flood resilience and sustainable leisure industries within an integrated urban transformation program. It aims to achieve ecological integrity, equal opportunity, and cultural identity consolidation (Figure 3.1.4). The research investigates how these objectives can be met through strategies such as incorporating ecological considerations in leisure facility design, promoting equal access and benefits in the sustainable leisure sector, and aligning leisure spaces with local cultural traditions. The findings will inform policymakers and urban planners, contributing to the development of integrated approaches for resilient and sustainable urban environments.

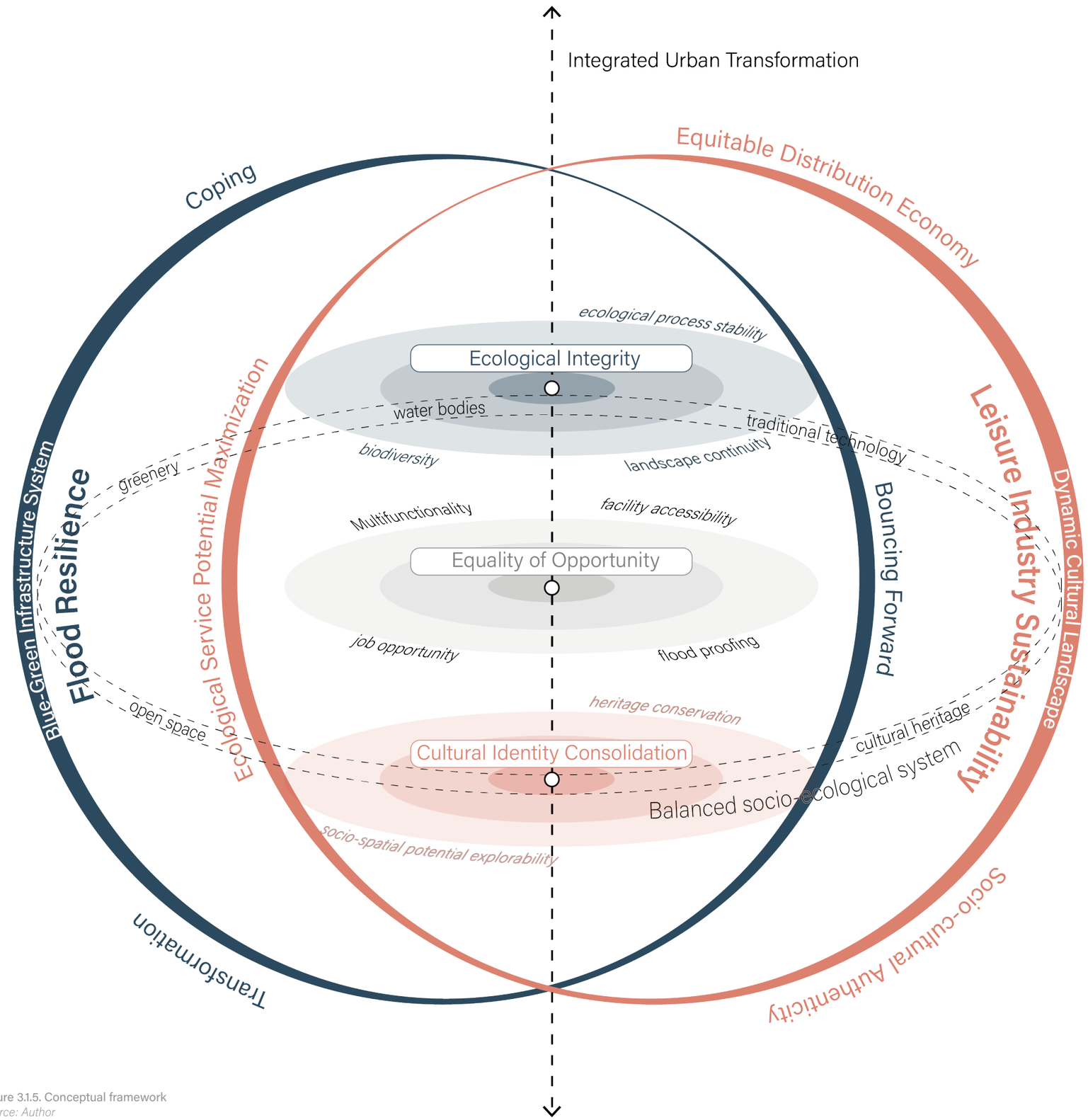


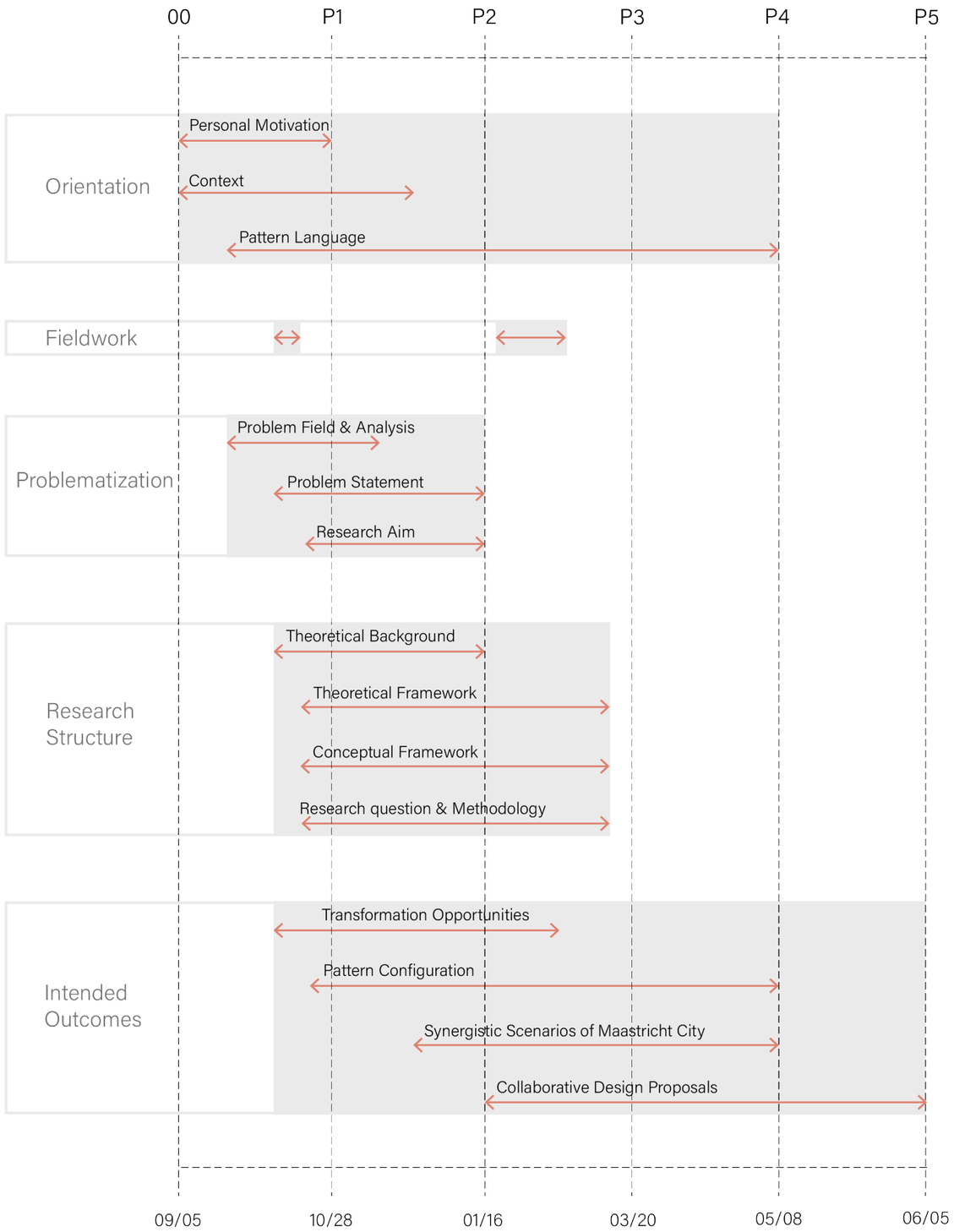
Figure 3.1.5. Conceptual framework
Source: Author

The study will focus on the integration of flood resilience and sustainable leisure industries, utilizing the essential components of Maastricht's blue-green infrastructure and cultural landscape. These elements include open spaces, greenery, water bodies, traditional technologies, and cultural heritage. The objective is to facilitate an integrated urban transformation that aligns with three primary design goals: ecological integrity, equality of opportunity, and cultural identity consolidation. Through this approach, the study aims to restore a balanced social-ecological system in Maastricht while extending the benefits to the broader Maas Basin region.

How can the city of Maastricht adapt to **fluvial floods** and intensify **sustainable leisure industry** in an integrated way?

SUB QUESTIONS	METHODS		INTENDED OUTCOMES
How did the **flood** in Maastricht occur and what are its future trends?	Spatial Analysis	▪ **Data Analysis & Literature Review: :** Analysis of the water system of the Maas River and the characteristics of its different reaches ▪ **Data Analysis & Literature Review: :** Projection of future flood trends and flooding areas in Maastricht ▪ **Spatial Analysis:** Wasted space and porosity with potential for flood management	**Spatial and social opportunities** for **urban transformation** applicable to flood management and sustainable leisure industry development in Maastricht and Maas basin
What are the **leisure values** of Maastricht?	Data Analysis	▪ **Spatial Analysis:** Mapping of existing leisure facilities and sites ▪ **Literature Review:** Mapping of the cultural values and identity of Maastricht in different periods ▪ **Spatial Analysis:** Wasted space and porosity with potential for leisure industry ▪ **Surveys and Interviews:** Residents' expectations of cultural and leisure places	
What are the **approaches** that enable urban areas across different scales in Maastricht to live with **fluvial floods**?	Literature Review	▪ **Spatial Analysis:** Mapping of the existing flood protection facilities in Maastricht ▪ **Literature Review:** Traditional methods of flood protection in Maastricht ▪ **Pattern Language:** Applicable measures related to flood protection ▪ **Maximization Scenario:** Flood retention maximization scenario for the city of Maastricht	**A Pattern language** for integrated flood control adaptation and leisure industry sustainability **A city-scale** flood adaptation and sustainable leisure industry **synergistic design proposal** of Maastricht
	Pattern Language		
What are the **sustainable leisure industry development models** applicable to Maastricht?	Surveys and Interviews	▪ **Spatial Analysis:** Mapping of socio-spatial problems of the city and neighborhoods ▪ **Literature Review:** Mapping of traditional leisure activities in Maastricht ▪ **Pattern Language:** Measures related to the sustainable leisure industry ▪ **Maximization scenario:** A developed sustainable leisure industry scenario in the city of Maastricht	
How can **the integration** of **flood adaptation projects** and **sustainable recreational activities** help rebuild a **balanced social-ecological system** in Maastricht?	Maximization Scenario	▪ **Pattern Language:** Areas of conflict and synergy of measures related to flood control and sustainable recreation industries ▪ **Literature Review & Surveys and Interviews:** Stakeholder demands and power changes ▪ **Literature Review & Maximization scenario:**Increased water retention capacity and economic and social benefits of design solutions	**A scheme for integrated cooperation and implementation** of flood adaptation and sustainable leisure industry **across regional, city and neighborhood scales**

3.5 Timeline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P1
P2
P3
P4
P5
Orientation
Personal Motivation
Context
Pattern Language
Fieldwork
Problematization
Problem Field & Analysis
Problem Statement
Research Aim
Research Structure
Theoretical Background
Theoretical Framework
Conceptual Framework
Research question & Methodology
Intended Outcomes
Transformation Opportunities
Pattern Configuration
Synergistic Scenarios of Maastricht City
Collaborative Design Proposals
09/05
10/28
01/16
03/20
05/08
06/05

04 INTENDED OUTCOMES

4.1 Transformation Opportunities

4.1.1 Transformation opportunities at Maas basin scale

TRANSFORMATION OPPORTUNITIES IN THE MAAS RIVER BASIN

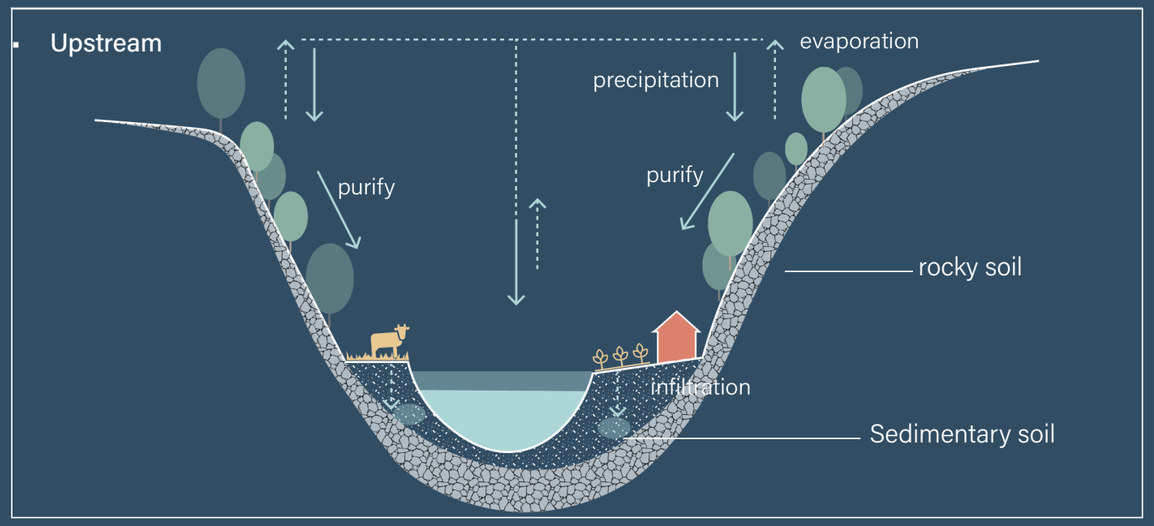


Figure 4.1.1.1. Section of the upper Maas basin
Source: Author，derived information from De Wit et al.(2001)

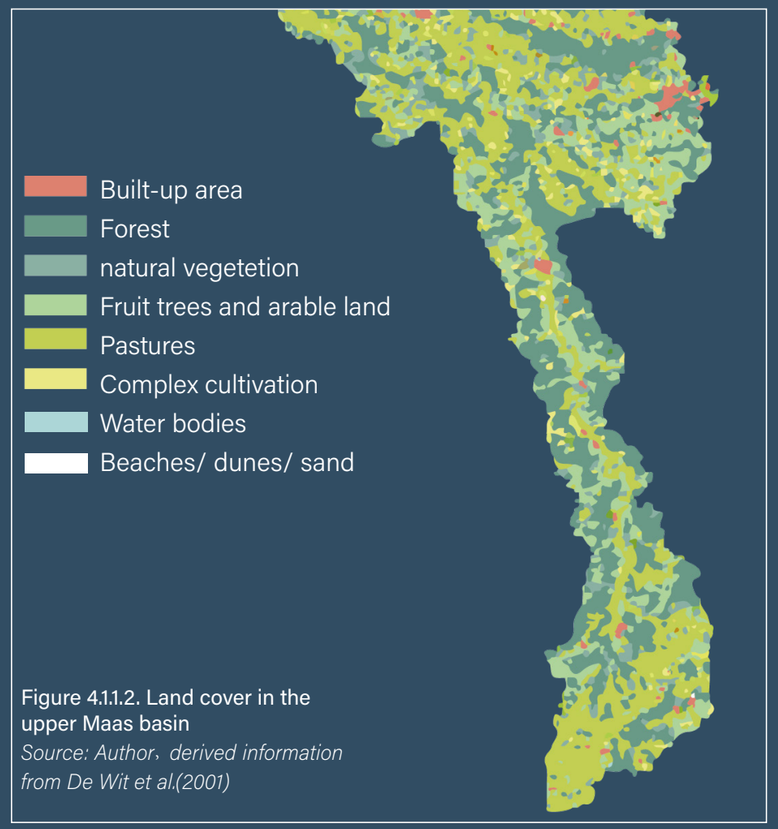


Figure 4.1.1.2. Land cover in the upper Maas basin
Source: Author，derived information from De Wit et al.(2001)

- Retention capacity: **low**
- Flood control system: **weak**
- Public awareness & motivation: **weak**

The current transformation potential of the upper Maas River basin is low due to natural conditions (poor soil permeability, high slope) and social aspects (limited flood control technology and poor public awareness).

Figure 4.1.1.3. Photo of the upper Maas basin
Source: Google image (2021)

The basin is narrow and has a wide river bed in winter. The French part of the river basin is a sloping landscape with wide valleys and narrow ridges(Figure 4.1.1.1). The slopes are usually forested and the valleys are used for agriculture and cattle breeding (Figure 4.1.1.1). Except for some larger towns such as Charlevile-Mézières, this part of the river basin is relatively sparsely populated(Figure 4.1.1.2).

The upper reaches are already in a more natural state (Figure 4.1.1.3) and are not suitable for arbitrary intervention, and their floodplains are so small (Figure 4.1.1.1) that **the possibility of increasing the retention capacity is relatively small**.

4.1.1 Transformation opportunities at Maas basin scale

- **Midstream**

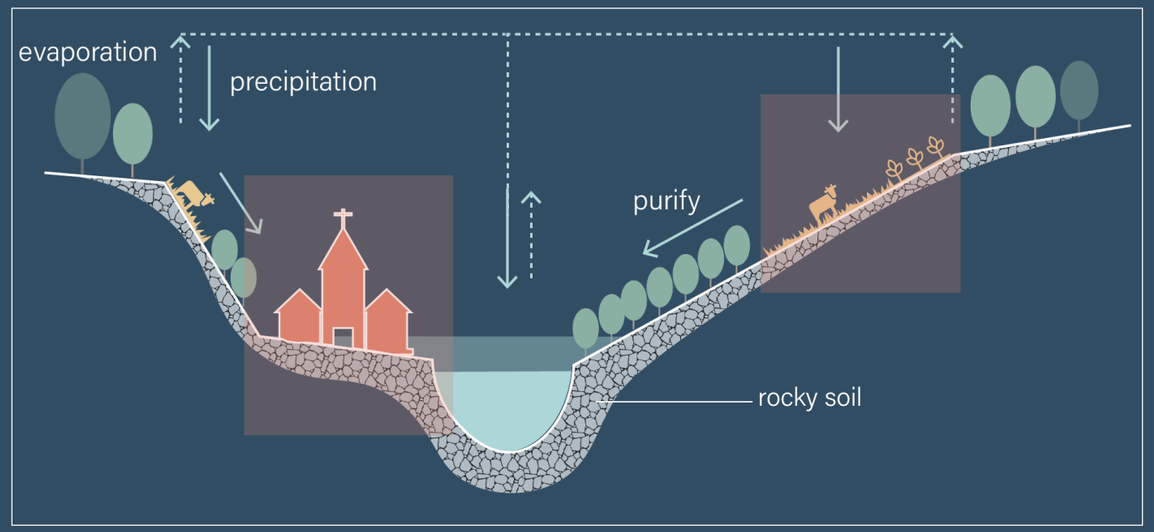


Figure 4.1.1.4, Section of the mid Maas basin
Source: Author，derived information from De Wit et al.(2001)

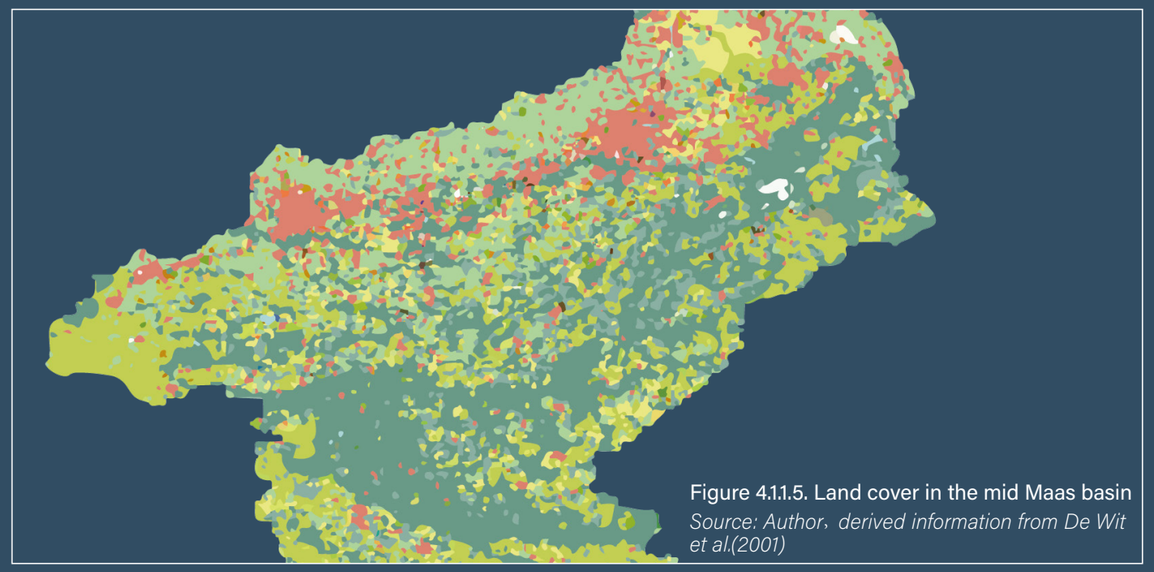


Figure 4.1.1.5. Land cover in the mid Maas basin
Source: Author，derived information from De Wit et al.(2001)

- Built-up area
- Forest
- natural vegetetion
- Fruit trees and arable land
- Pastures
- Complex cultivation
- Water bodies
- Beaches/ dunes/ sand

- Retention capacity: **low**
- Flood control system: **weak**
- Public awareness & motivation: **weak**

Built-up areas and **agricultural areas** have certain potential and motivation (high threat of flooding) for transformation.

Figure 4.1.1.6. Photo of the mid Maas basin
Source: Google image (2021)

This section of the river cuts through the hard rock of the Ardennes, and the Meuse has a narrow winter bed with a steep slope at the edge. Many areas of the Ardennes are forested for timber production. In addition, **agricultural areas** can be found **in the higher parts**, especially extensive cattle farms (Figure 4.1.1.4). Moreover, the area is relatively sparsely populated, except for the industrial axis along the Charleroi-Namur- Liège (Figure 4.1.1.5).

The direct flow of rainfall from the Ardennes into the Maas due to **impermeable rocky soils** (Figure 4.1.1.4), combined with the **reduction of the floodplain** of the Maas by humans through **canalization, damming and urbanization** (Figure 4.1.1.6), has allowed the Belgian part to make **a significant contribution to the high water level of the Maas**.

4.1.1 Transformation opportunities at Maas basin scale

- **Downstream**

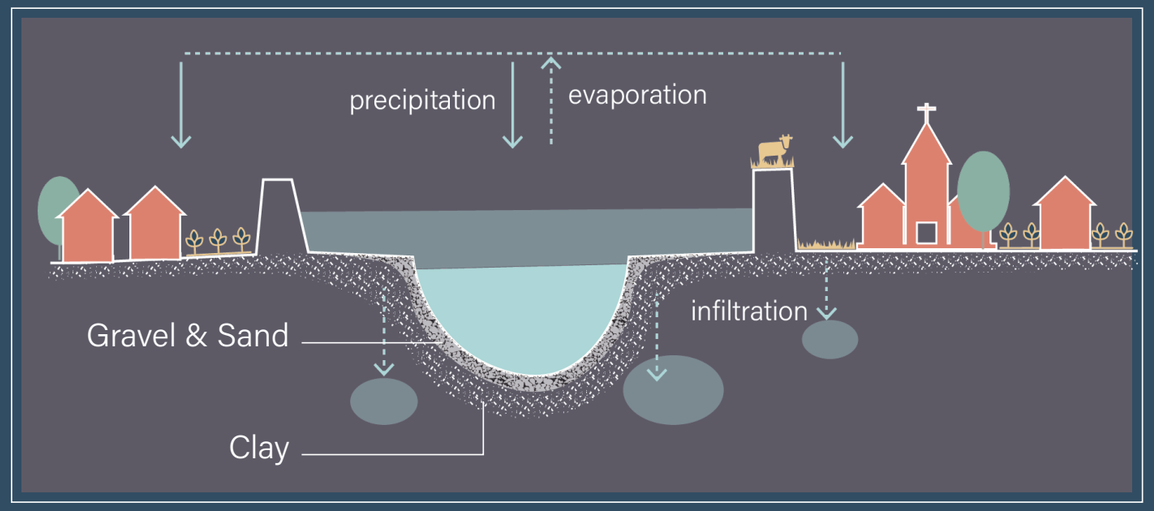


Figure 4.1.1.7. Section of the down Maas basin
Source: Author，derived information from De Wit et al.(2001)

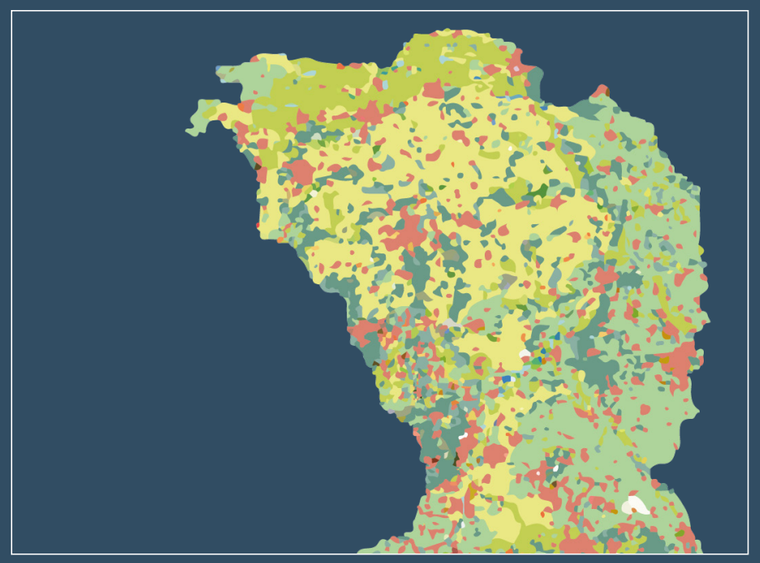


Figure 4.1.1.8. Land cover in the down Maas basin
Source: Author，derived information from De Wit et al.(2001)

- Retention capacity: **high**
- Flood control system: **advanced**
- Public awareness & motivation: **strong**

Overall, **the lower Mas River has the highest potential** to promote integrated design projects for flood adaptation and sustainable leisure industry.

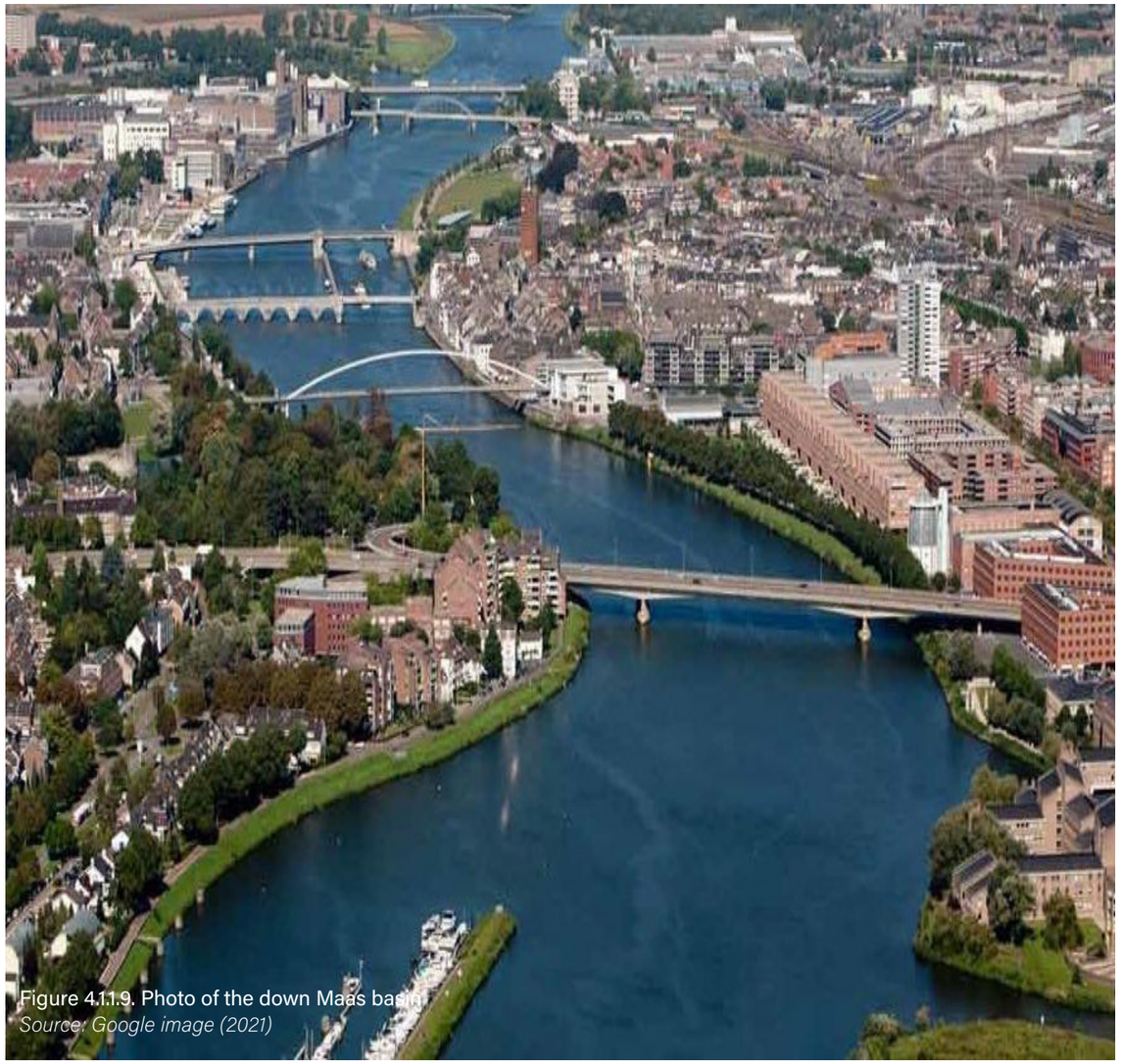


Figure 4.1.1.9. Photo of the down Maas basin
Source: Google image (2021)

The permeability of the soil is the strongest and the flow rate is the slowest in this section of the river, making the lower Mas River the most likely basin to retain flood water from the point of view of natural conditions (Figure 4.1.1.7). On the other hand, the flood protection system in the Netherlands is very well developed, and public awareness in this area is high, and the and cooperation of residents in flood protection is high, which makes the social context favorable for flood adaptation projects. At the same time, there is a high urban and population density along the river and a great demand for urban development (Figure 4.1.1.8, 4.1.1.9).

SCOPE OF COOPERATION OPPORTUNITIES AT MAAS BASIN SCALE

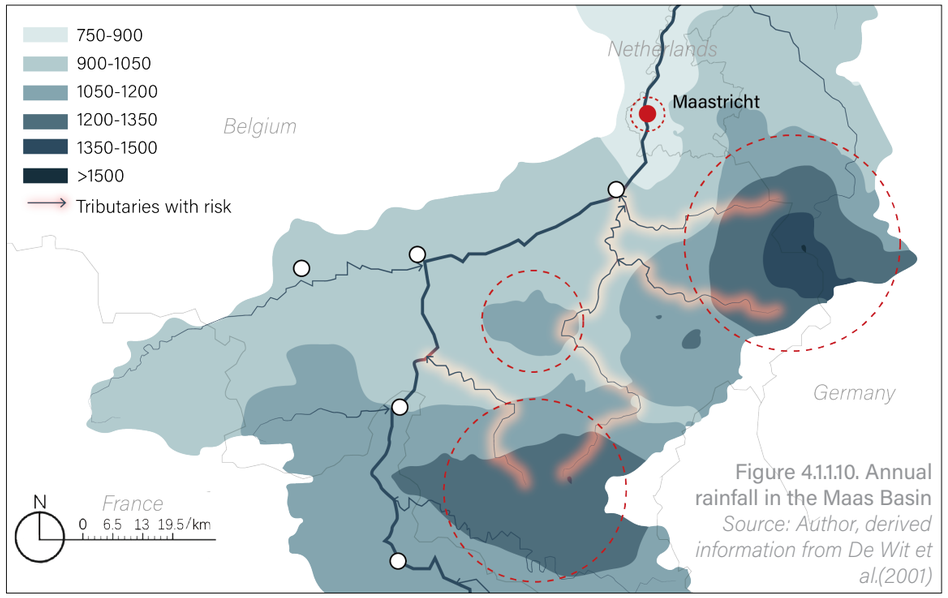


Figure 4.1.1.10. Annual rainfall in the Maas Basin
Source: Author, derived information from De Wit et al.(2001)

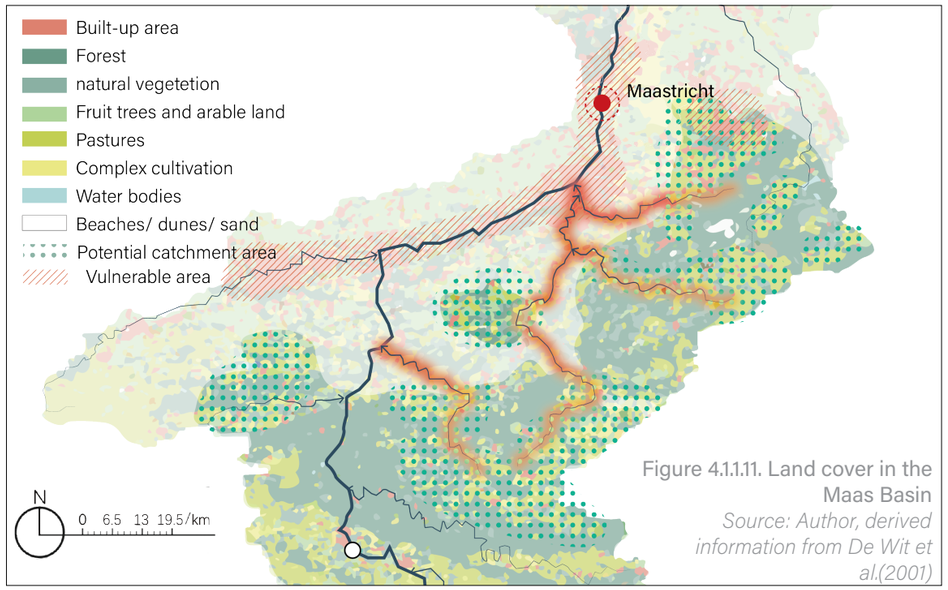


Figure 4.1.1.11. Land cover in the Maas Basin
Source: Author, derived information from De Wit et al.(2001)

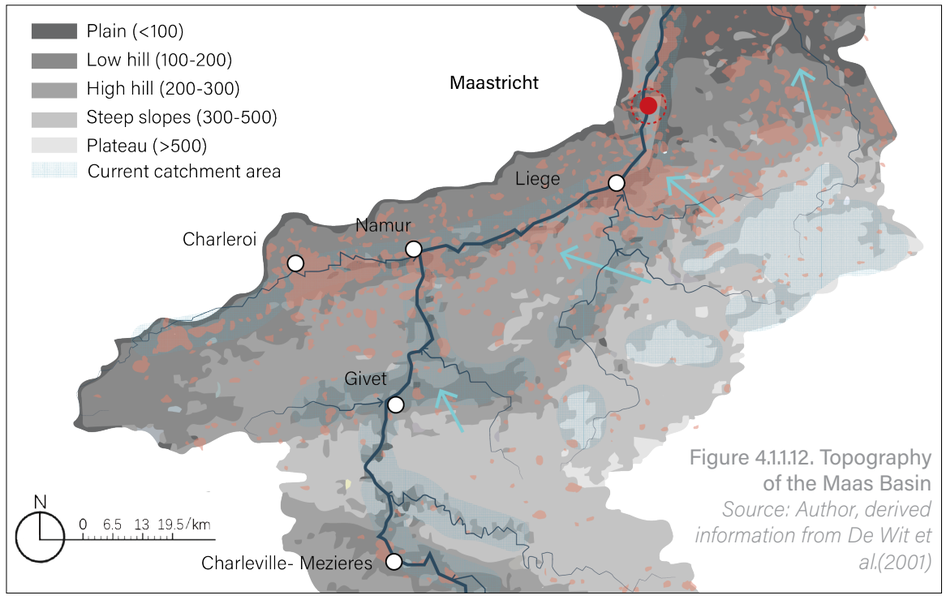


Figure 4.1.1.12. Topography of the Maas Basin
Source: Author, derived information from De Wit et al.(2001)

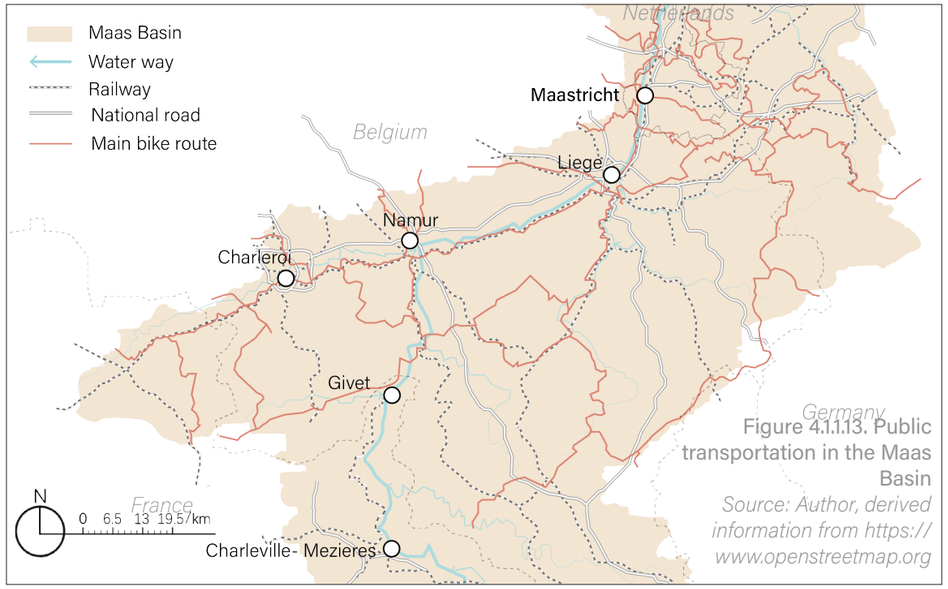


Figure 4.1.1.13. Public transportation in the Maas Basin
Source: Author, derived information from https://www.openstreetmap.org

The areas most significantly impacted by flooding in the Maas River basin are concentrated along the border of Belgium and Germany (Figure 4.1.1.10). Implementing buffer zones in this region can effectively mitigate river floods by effectively retaining excessive rainfall. Besides, the geographical characteristics of this area play a significant role in determining its suitability for water harvesting. While certain portions of the region have sloping terrain, it is primarily the plateau that offers the most favorable conditions for effective water harvesting initiatives (Figure 4.1.1.12). It is important to acknowledge that the land cover in this area can be broadly categorized into agricultural and natural areas (Figure 4.1.1.11). However, due to complex ownership issues, the transformation of the buffer zone should prioritize the preservation of natural areas over agricultural ones.

A critical aspect to consider is the presence of fragile built-up areas on both sides of the river. To safeguard these areas and mitigate potential risks, it becomes imperative to establish a buffer zone between the river and the built-up regions. This buffer zone would act as a protective barrier, minimizing the impact of flooding and other related hazards. Furthermore, it is worth noting that the main public transport routes within this area predominantly follow the course of the river (Figure 4.1.1.13), which underscores the urgent need to strengthen the transportation network along the river and enhance flood control measures.

SCOPE OF COOPERATION OPPORTUNITIES AT MAAS BASIN SCALE

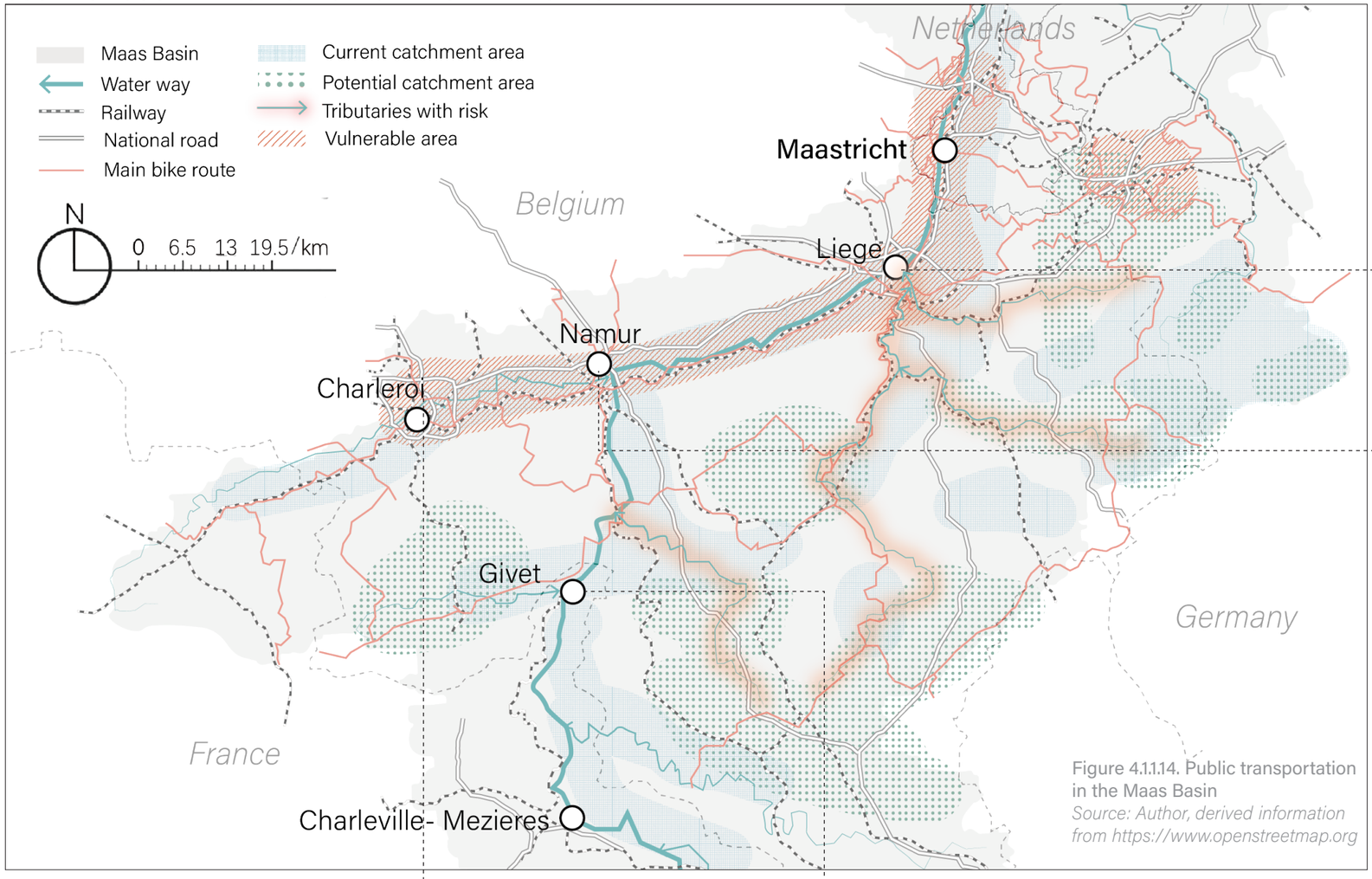


Figure 4.1.1.14. Public transportation in the Maas Basin
Source: Author, derived information from https://www.openstreetmap.org

Figure 4.1.1.15. Liege photo
Source: Google image (2016)

Figure 4.1.1.16. Namur photo
Source: Google image (2018)

Figure 4.1.1.18. Charleroi photo
Source: Google image (2020)

Figure 4.1.1.17. Givet photo
Source: Google image (2015)

The Middle and Lower Maas River Transition Zone is a tri-border region with **diverse cultures** but **cities are scattered and weakly connected to each other**, with the **river being their most important link** in physical space.

Using flood control as an opportunity to promote transnational cooperation projects in this region will not only make full use of wasted land for flood control, but also take advantage of the diverse cultures at the border to drive the economic and cultural development of the surrounding cities.

This approach can also raise awareness and willingness of local residents to participate in regional cooperation.

ELEMENTS OF THE CULTURAL LANDSCAPE OF MAASTRICHT IN DIFFERENT PERIODS

Religious Center & Commercial City

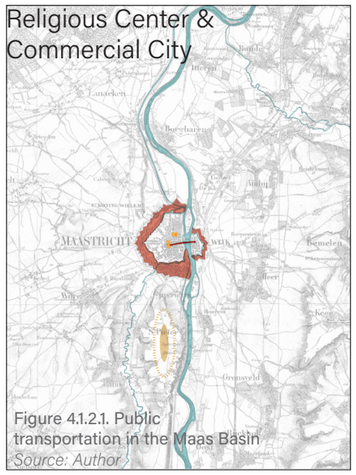


Figure 4.1.2.1. Public transportation in the Maas Basin
Source: Author

Industrial City

Figure 4.1.2.2. Public transportation in the Maas Basin
Source: Author

Cultural Center & University Town

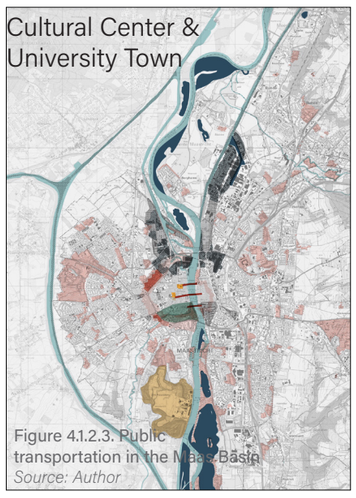


Figure 4.1.2.3. Public transportation in the Maas Basin
Source: Author

River

Bridge

Figure 4.1.2.4 Historical Maastricht city model
Source: Google image (2013)

Maastricht was built on a wide part of the floodplain on higher ground, and bridges were built where the river flow was low enough in the braided water system to cross, creating an **ideal market place.**

Figure 4.1.2.6. Maastricht city in 1964
Source: Google image (1964)

Due to the need for industrial development leading to increased traffic demand on both sides of the river, a new bridge was built over the main channel, slowing down the river flow resulting in **more sediment deposition**. At the same time, bank stabilization measures to ensure navigability by stabilizing the river level caused the **river banks to gradually harden**.

Figure 4.1.2.9 Current Maastricht city
Source: Author

As the city expanded to the east bank, a new bridge was built. Almost all of the river banks are now man-made hard banks, but the bank stabilization is being removed to restore the river to its natural state.

Canal

Figure 4.1.2.7. Maastricht canal in 1964
Source: Google image (1964)

Sluice gates and canals were built parallel to the main channel, allowing relatively **stable water levels** in most sections of the river,as well as **increased shipping routes**.

Figure 4.1.2.10. Maastricht cannal
Source: Google image (2016)

The boundary canals still serve to regulate water levels, but they are **no longer used for shipping** and no new functions have been added.

Recreation Area

Figure 4.1.2.11. Maastricht recreational area
Source: Google image (2016)

Many artificial wetlands with recreational functions have been placed on the banks of the Maas River, and many parks, ball fields and other recreational green spaces have been introduced within the city.

City walls & Moat

Figure 4.1.2.5 Historical Maastricht city drawing
Source: Google image (2013)

The walls and moat **created habitat for some rare mosses and plants**, and served as a **military defense as well as an area of early trade** for the inhabitants.

Figure 4.1.2.8. Maastricht city in 1964
Source: Google image (1964)

Most of the walls were demolished because they lost their military role, and the moat was filled in as a road. Most of the **original site was destroyed and replaced by wide carriageways and houses**.

Figure 4.1.2.11. Current Maastricht
Source: Author

The whole area is not very different from the industrial era, except for the part of the wall ruins that has been transformed into a park, providing **recreational opportunities** for the residents and contributing to the **restoration of the local ecosystem.**

ELEMENTS OF THE CULTURAL LANDSCAPE OF MAASTRICHT IN DIFFERENT PERIODS

Religious Center & Commercial City

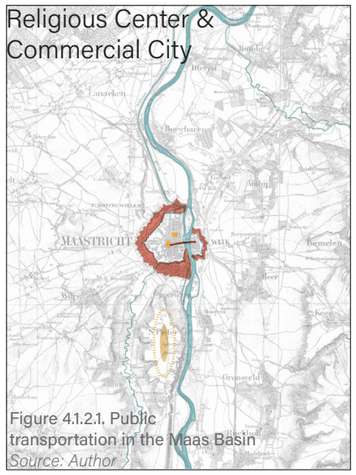


Figure 4.1.2.1. Public transportation in the Maas Basin
Source: Author

Industrial City

Figure 4.1.2.2. Public transportation in the Maas Basin
Source: Author

Cultural Center & University Town

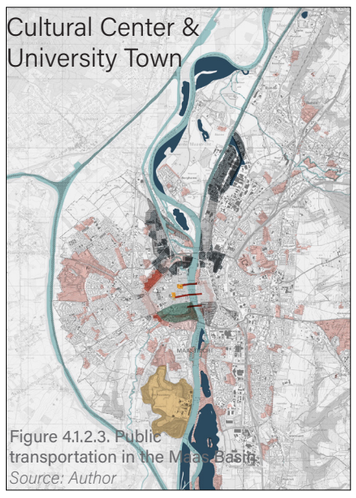


Figure 4.1.2.3. Public transportation in the Maas Basin
Source: Author

Quarry

Figure 4.1.2.12. Historical Maastricht quary drawing
Source: Google image (2002)

People started tunneling in the Sin Peter area around the 18th and 19th centuries for quarrying and building towns.

Figure 4.1.2.14. Maastricht quary
Source: Google image (1973)

Quarry expansion, large-scale extraction of limestone for urban construction to cope with explosive population growth.
With the rapid decline of limestone resources, the **balance of the tunnel is gradually disrupted.**

Figure 4.1.2.17. St. Peter
Source: Google image (2021)

People stop quarrying in 2018,ENCI quarry has been **restored in the form of a large suburban park**, with spaces reminiscent of water and vegetation. It meets the needs of both recreation and ecological restoration.

Industrial

Figure 4.1.2.15. Maastricht factory
Source: Google image (1978)

Large-scale production of glass, crystal, ceramics, etc., with a focus on light industry, has provided **a large number of jobs** for residents.

Figure 4.1.2.18. Maastricht square
Source: Author

In order to accommodate the population growth and the transformation of the knowledge-based economy, most of the industrial areas have been transformed into residential areas **with little job opportunities and limited industrial heritage.**

Education Area

Figure 4.1.2.19. Maastricht university
Source: Google image (2021)

Maastricht is a student city due to the presence of the largest educational institution in Limburg, the Maastricht University (UM), various art schools and university institutions are located in the Jekerkwartier concentration, so this part of the center has developed into the Maastricht Latin Quarter.

Monument square

Figure 4.1.2.13. Historical Maastricht city hall drawing
Source: Google image (2002)

It was the center of trade and gathering in ancient times.

Figure 4.1.2.16. Maastricht city hall in 1978
Source: Google image (1978)

The square has been turned into a parking lot due to the extensive use of private cars, and **its function and historical memory have been lost**.

Figure 4.1.2.20. City hall
Source: Google image (2021)

The square once again resumes its function as a bazaar and a meeting place.

VALUE DYNAMICS OF THE MAASTRICHT CULTURAL LANDSCAPE KEY AREAS

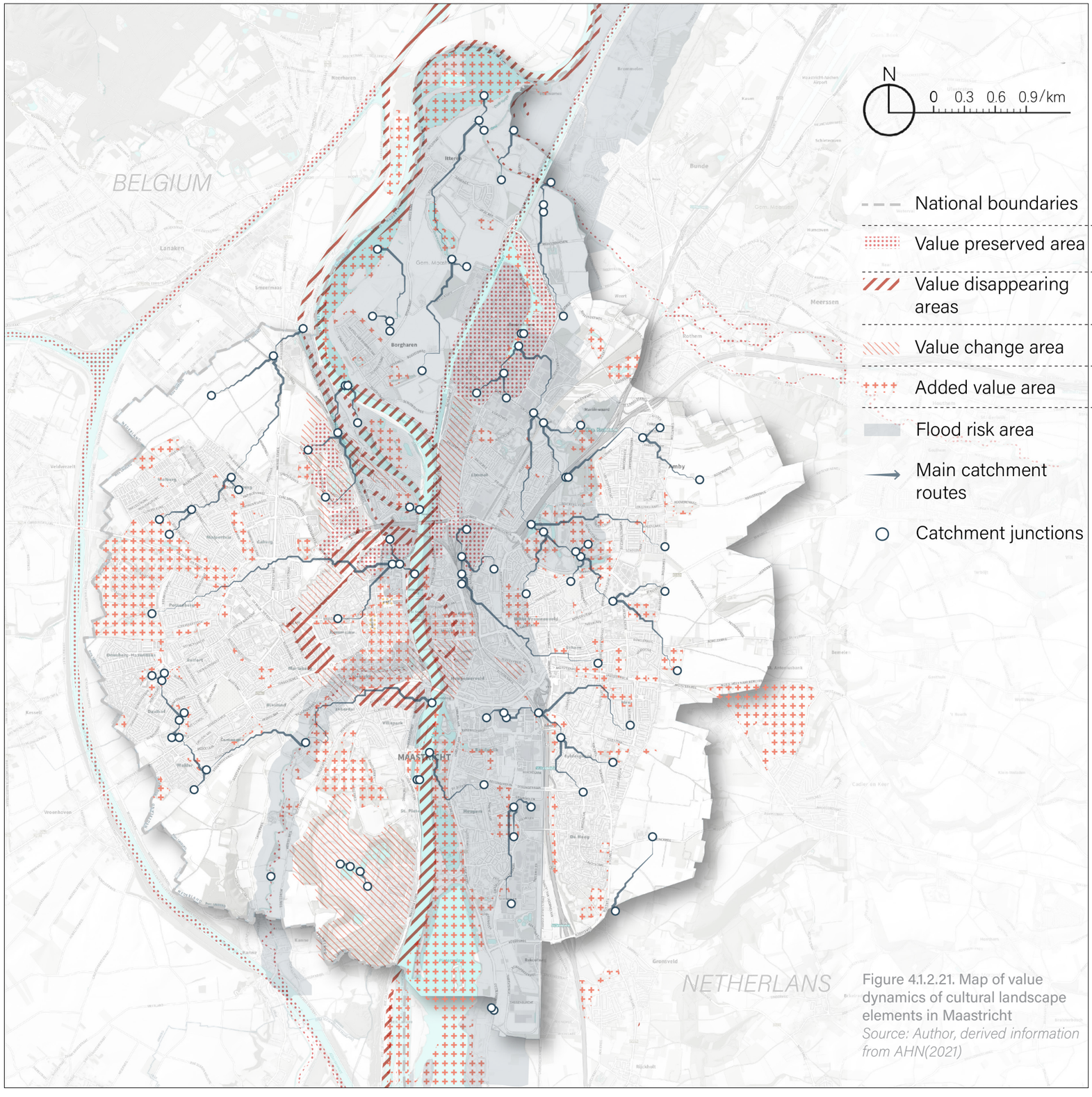


Figure 4.1.2.21. Map of value dynamics of cultural landscape elements in Maastricht
Source: Author, derived information from AHN(2021)

Value Assessment Framework

	Functionality	Historical memory	Ecological service
Value preserved area	preserve/ change	preserve	preserve/ increase
Value disappearing areas	lost	lost	lost
Value change area	change	preserve	preserve/ increase
Added value area	new	\	increase

\+ Flood proofing potential

Current urgent needs in Maastricht

This study classifies Maastricht's cultural landscape elements into four categories based on functionality, historical memory transmission, and ecological services (value preserve area, value disappear area, value change area, and added value area).

Due to possible climate change, the decisive flow of the Meuse River is expected to rise from 3,800 to 4,600 cubic meters per second in the coming winter, an increase of 20%. Floods will occur more frequently than in our time. Therefore, the value of flood protection is an urgent current and future need for Maastricht and should be an indispensable indicator for the assessment of the value of cultural landscape elements.

Furthermore, in addition to dealing with the overflow from the main channel of the Maas River, flood protection should also consider other sources of flooding - rainwater. In this study the catchment routes and catchment junctions of the Maastricht city were calculated using GIS based on DEM maps of the ahn. Finally, this study overlays the 2060 floodplain and stormwater sources, with maps of important areas of the cultural landscape in Maatricht, to re-evaluate the value of these areas.

POTENTIAL SPACE TO EXPAND THE VALUE OF MAASTRICHT

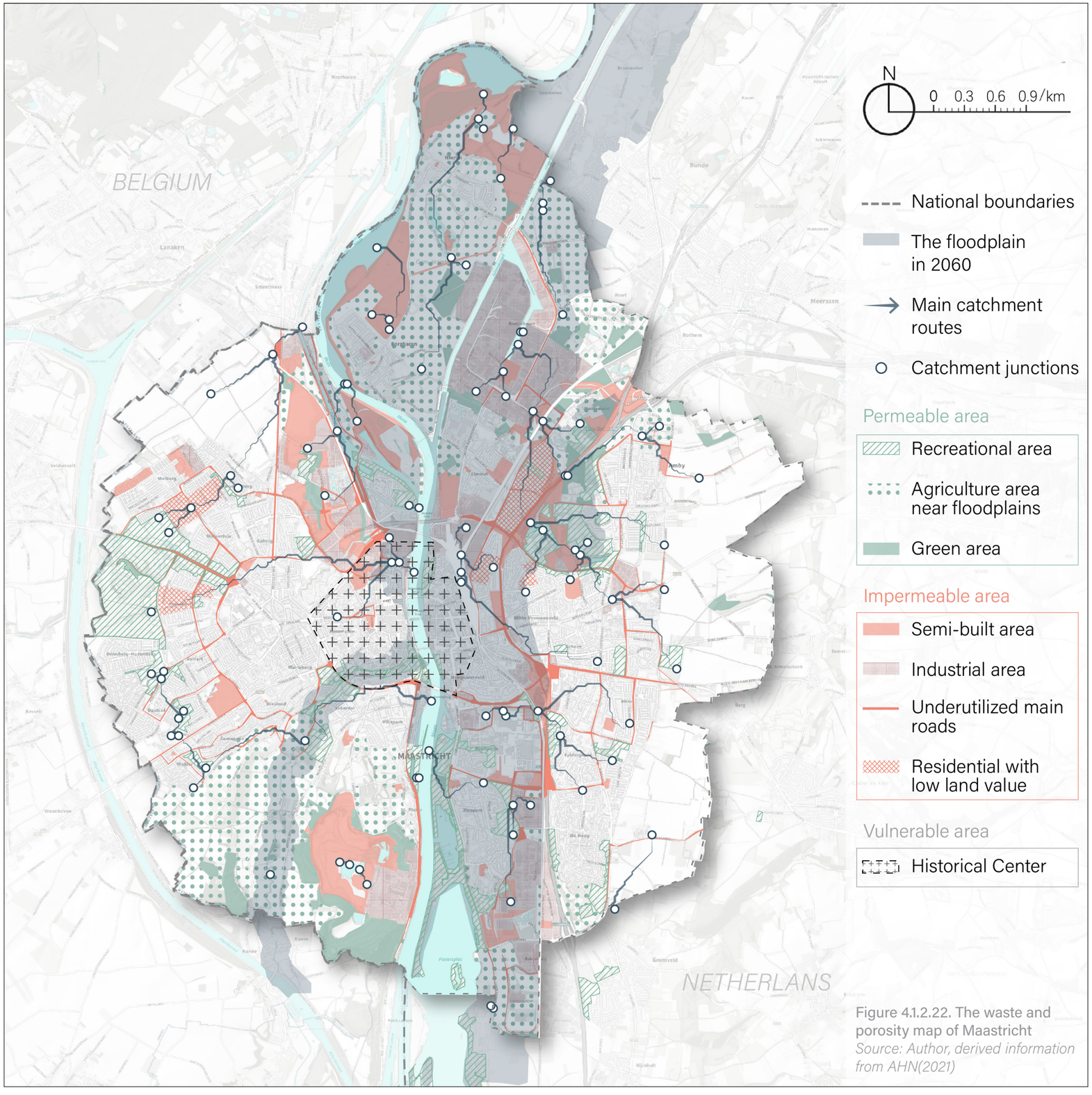


Figure 4.1.2.22. The waste and porosity map of Maastricht
Source: Author, derived information from AHN(2021)

Figure 4.1.2.23. Waste space of industrial area
Source: Author

Figure 4.1.2.25. Waste space of agriculture
Source: Author

Figure 4.1.2.24. Waste space of road
Source: Author

Figure 4.1.2.26. Waste space of recreational area
Source: Author

The study involved a comprehensive examination and evaluation of various land types within the study area, including industrial, agricultural, major roads, and recreational areas, etcs. Through rigorous field research, these land types were carefully scrutinized, and subsequently classified into two distinct categories based on their permeability characteristics: permeable and impermeable areas (Figure 4.1.2.23, 4.1.2.24, 4.1.2.25,4.1.2.26). This classification aimed to determine their respective capacities for flood retention and mitigation.

The permeable areas encompassed land types that allow water infiltration and absorption, thereby exhibiting a higher potential for flood retention. Conversely, the impermeable areas comprised land types that hinder or restrict water infiltration, thus demonstrating a relatively lower flood retention potential. This classification provided a valuable framework for understanding the flood-related characteristics and behavior of different land types within the study area.

In order to further assess and enhance the flood-proofing potential of the region, the waste and porosity map, derived from the permeability classification, was subsequently overlaid with the flood source and risk zone map (Figure 4.1.2.22). This overlay analysis enabled the identification of specific areas that held promise for extending Maastricht's flood-proofing capabilities. By combining these maps, areas with favorable characteristics in terms of both permeability and flood risk were identified as priority locations for implementing flood-proofing strategies and measures.

FLOOD WATER MANAGEMENT POTENTIAL ASSESSMENT

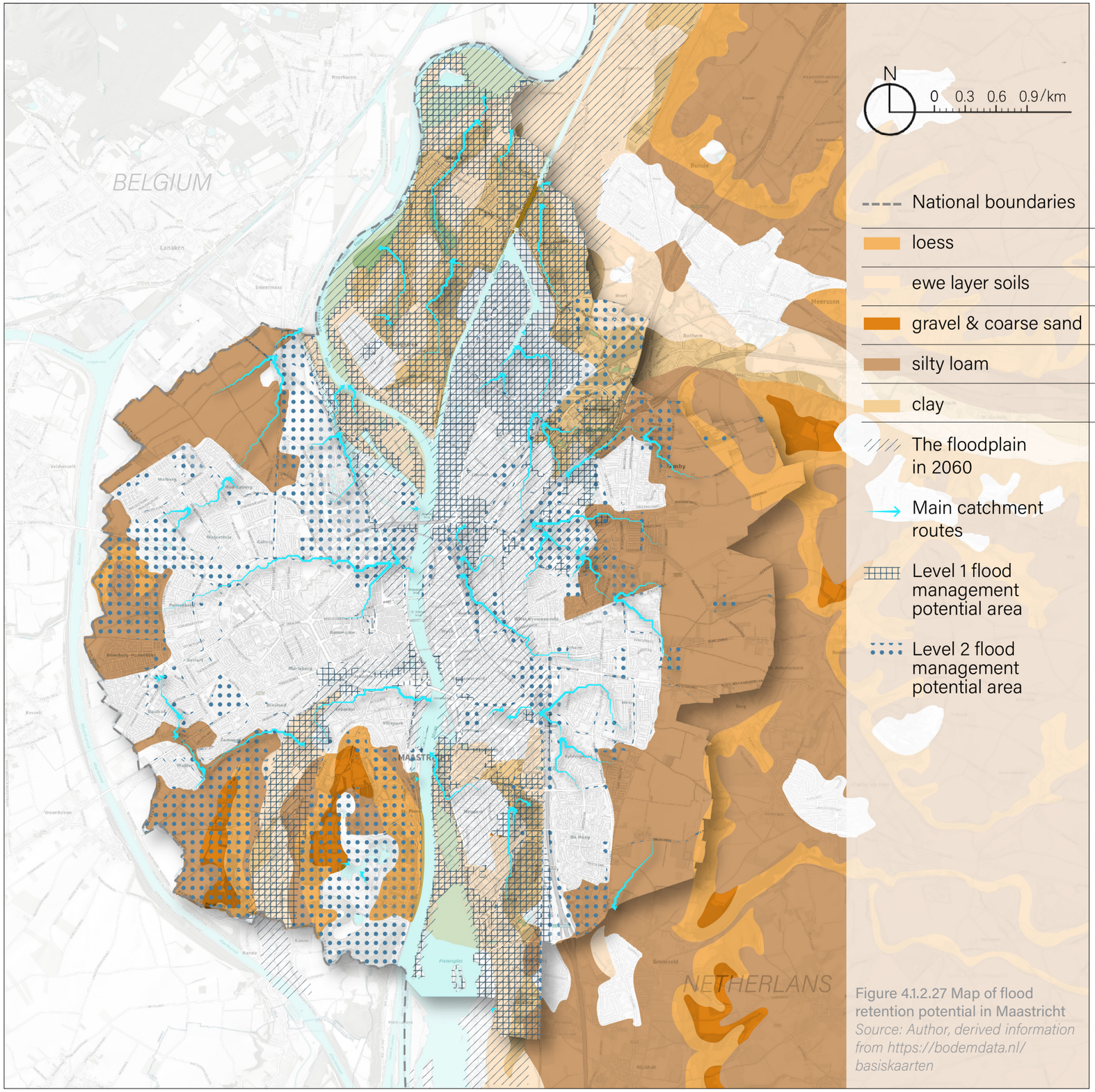


Figure 4.1.2.27 Map of flood retention potential in Maastricht
Source: Author, derived information from https://bodemdata.nl/basiskaarten

In this study, the flood management capacity of the identified flood-proofing potential areas was classified into two levels based on soil type (Figure 4.1.2.27, Table 4.1.2.1) and distribution location: directly affected areas and stormwater runoff areas (Figure 4.1.2.28, 4.1.2.29).

- Soil flood management potential assessment

Table 4.1.2.1 Soil flood management potential assessment
Source: Author

	Water holding capacity	*Drainage capacity*	*Permeability*
loess	● ● ●	● ● ●	● ● ●
ewe layer soils	● ● ●	● ●	● ●
gravel & coarse sand	●	● ● ●	● ● ●
silty loam	● ● ●	● ●	● ●
clay	● ● ●	●	●

- Level 1 flood management potential area--- deal with fluvial flood

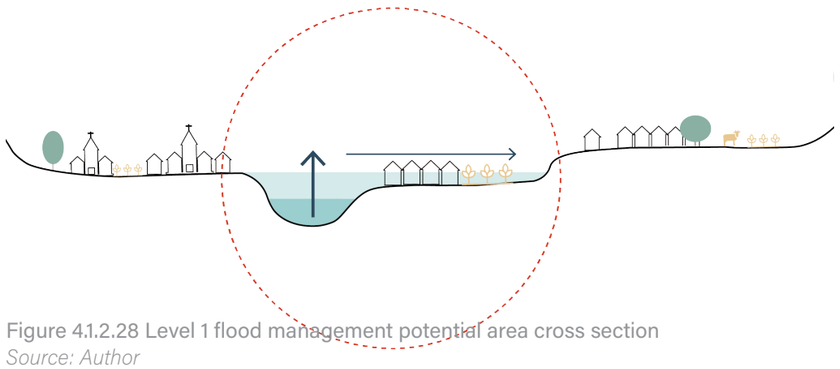


Figure 4.1.2.28 Level 1 flood management potential area cross section
Source: Author

- Level 2 flood management potential area--- deal with rain flood

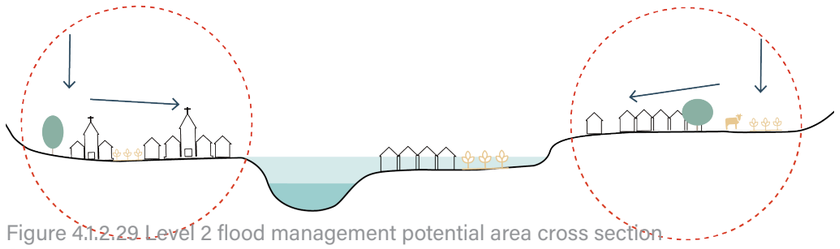


Figure 4.1.2.29 Level 2 flood management potential area cross section
Source: Author

ACCESSIBILITY POTENTIAL ASSESSMENT AT CITY SCALE

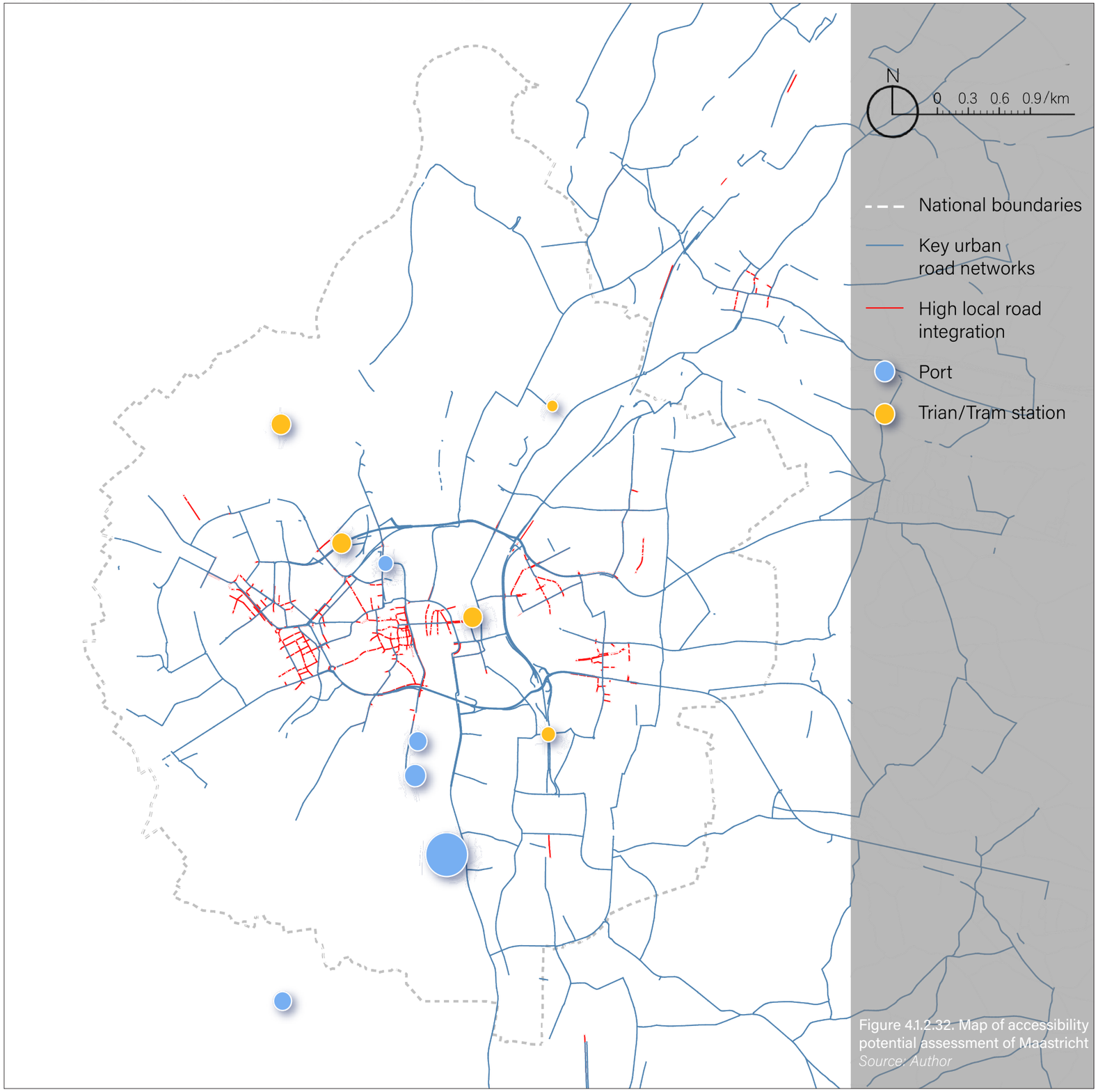


Figure 4.1.2.32. Map of accessibility potential assessment of Maastricht
Source: Author

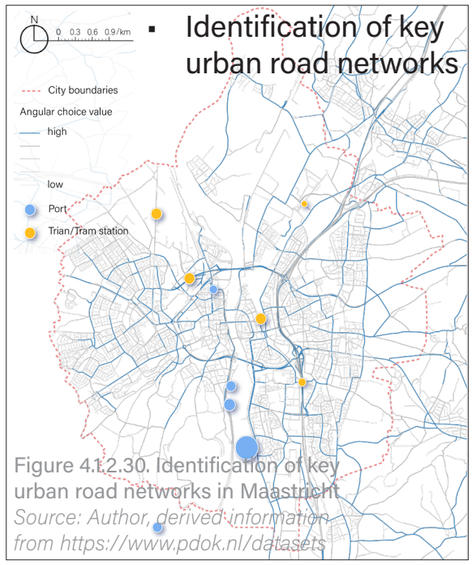


Figure 4.1.2.30. Identification of key urban road networks in Maastricht
Source: Author, derived information from https://www.pdok.nl/datasets

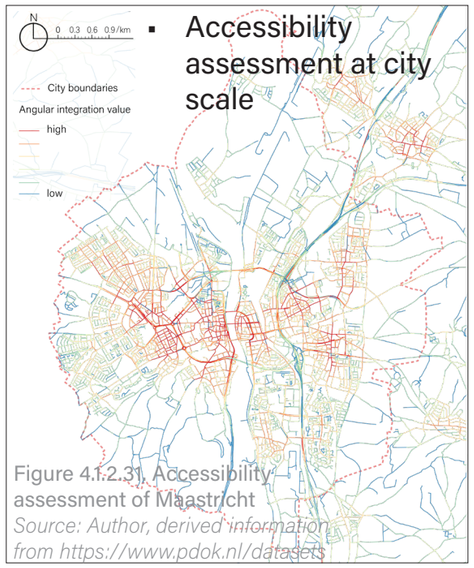


Figure 4.1.2.31. Accessibility assessment of Maastricht
Source: Author, derived information from https://www.pdok.nl/datasets

In this study, angular choice analysis and angular integration analysis within the spatial matrix method were employed to identify crucial urban road networks within a 5000m walking distance (Figure 4.1.2.30) and assess the accessibility of various neighborhoods within an 800m walking distance (Figure 4.1.2.31). The overlay of the highest values from both analyses helped the identification of areas with the greatest potential for enhancing accessibility (Figure 4.1.2.32, Table 4.1.2.2).

- Accessibility potential assessment framework

Table 4.1.2.2. Accessibility potential assessment framework
Source: Author

Key urban road networks	✗	✓	✗	✓
High local road integration	✗	✓	✓	✗
Potential for accessibility improvement	Low	Low	Medium-low	Medium-high
Near port/ stations	Bonus points (level +)			

OPPORTUNITIES AND POTENTIAL FOR TRANSFORMATION OF MAASTRICHT

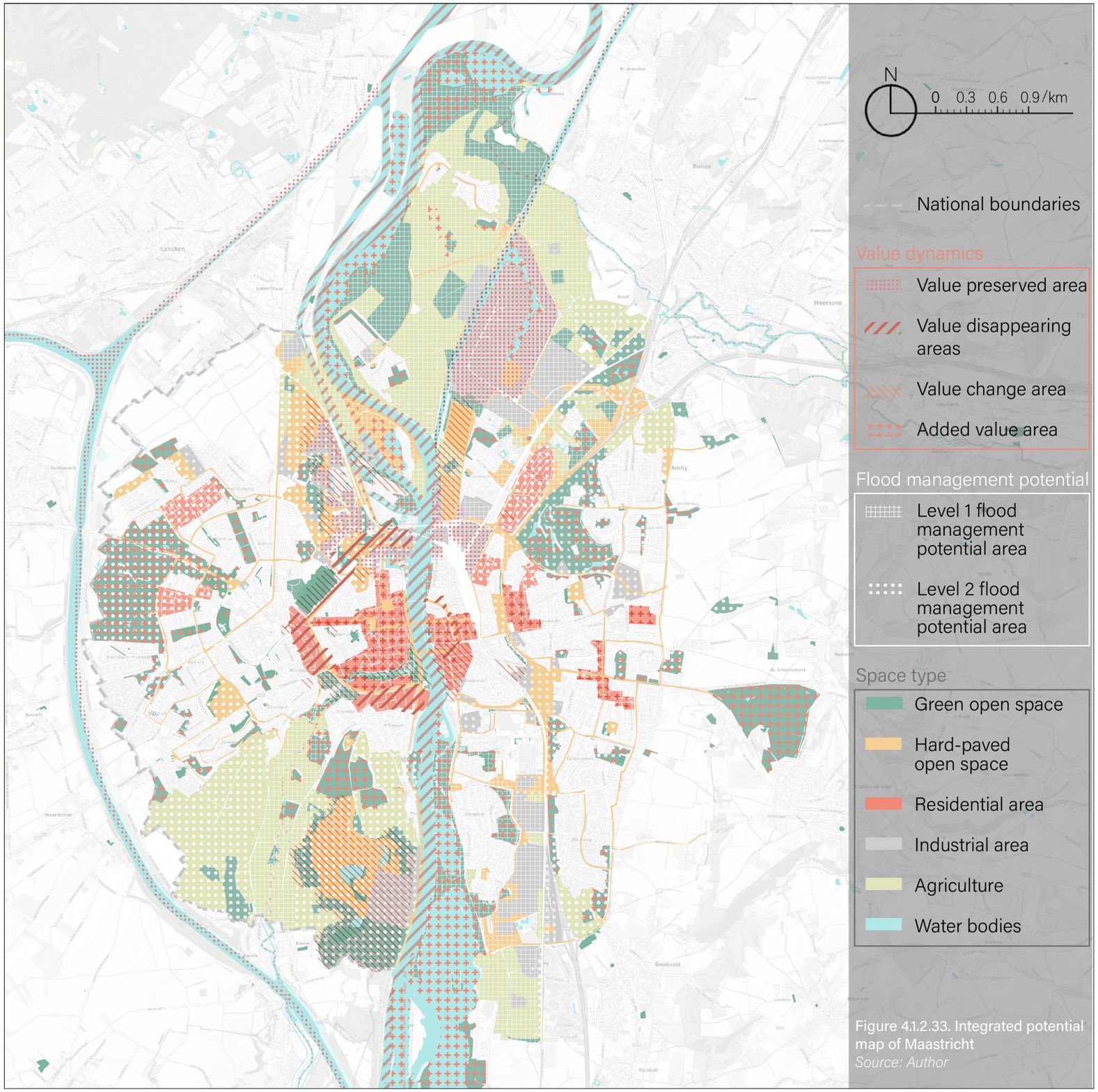
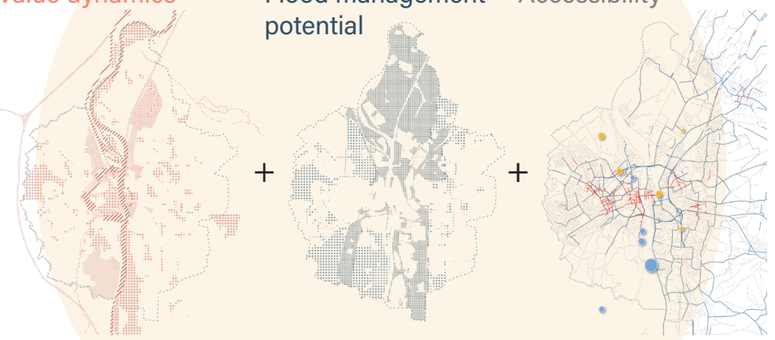


Figure 4.1.2.33. Integrated potential map of Maastricht
Source: Author

Potential for three design goals:

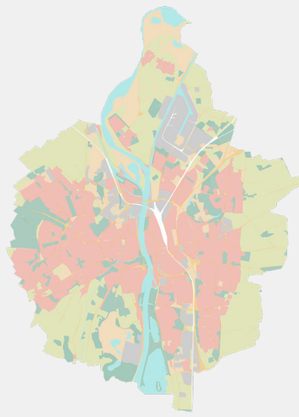
Cultural Identity Consolidation | Ecological Integrity | Equality of Opportunity

Value dynamics + Flood management potential + Accessibility



Current situation:

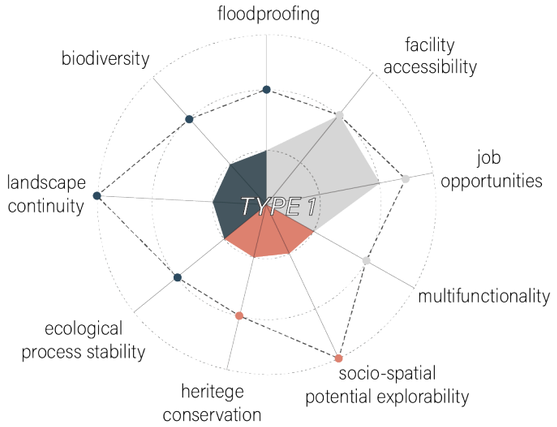
Land use



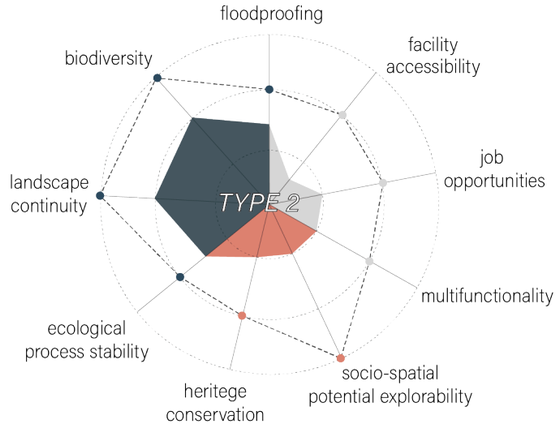
The preceding analysis pertaining to the three designated objectives provides the basis for deriving a holistic potential for Maastricht. This potential can subsequently be combined with Maastricht's existing land use patterns, thereby enabling a conclusive evaluation of the city's capacity for urban spatial transformation (Figure 4.1.2.33).

POTENTIAL ANALYSIS OF THE SPATIAL TYPES AT NEIGHBORHOOD SCALE

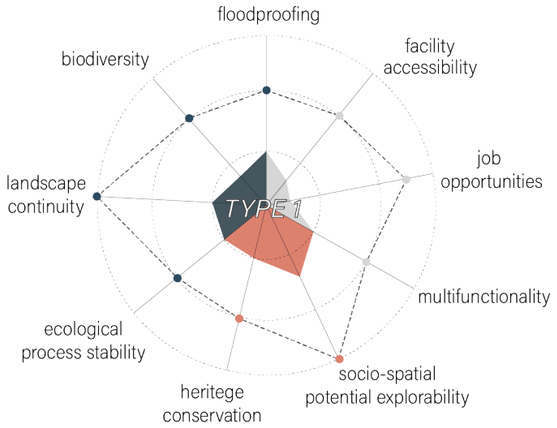
Value changed industrial area with level 2 flood management potential



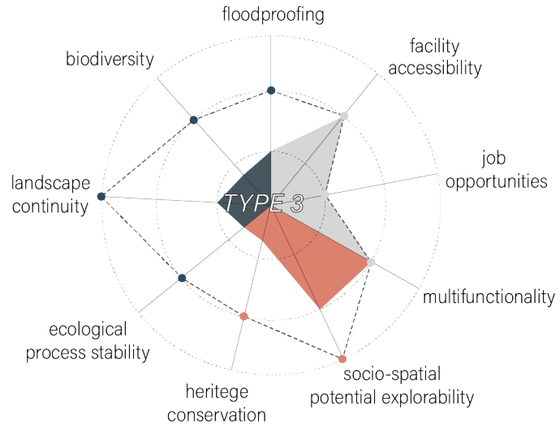
Agriculture with level 2 flood management potential



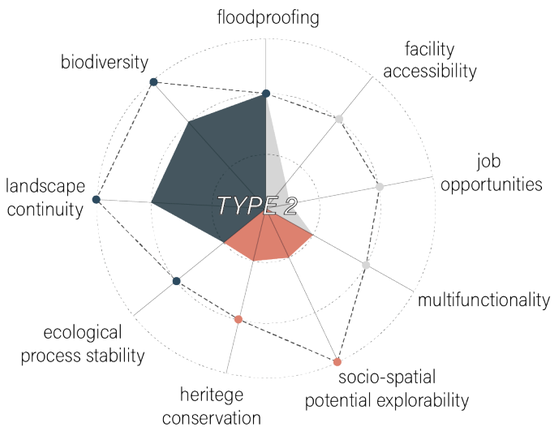
Residential area with level 1&2 flood management potential



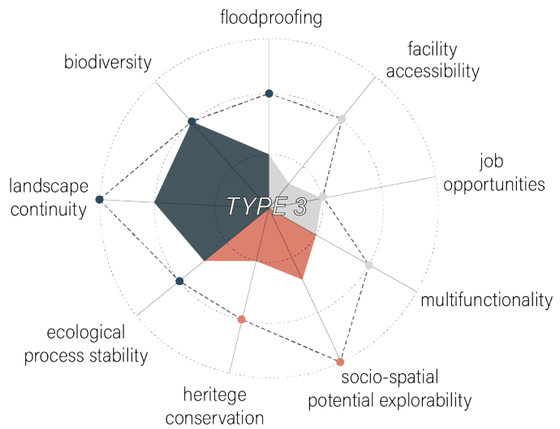
Hard-paved open space with level 2 flood management potential



Value added green open space with level 2 flood management potential

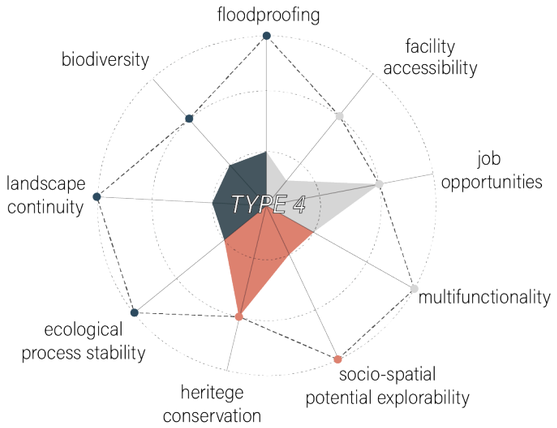


Value added green open space

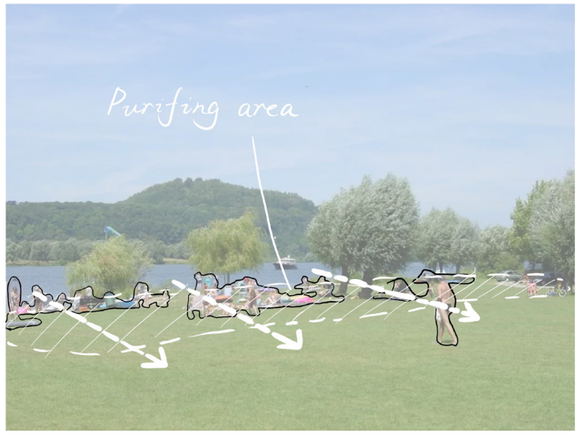


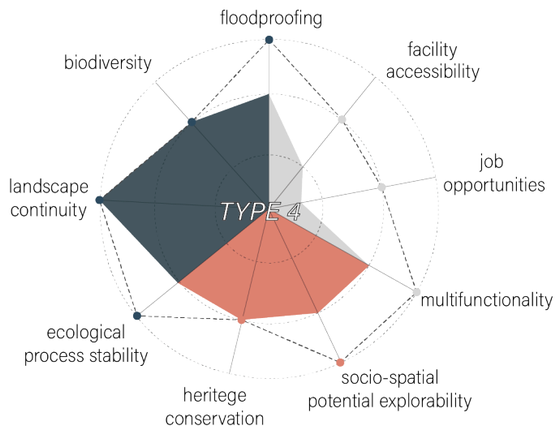
POTENTIAL ANALYSIS OF THE SPATIAL TYPES AT NEIGHBORHOOD SCALE

Value preserved industrial area with level 1 flood management potential

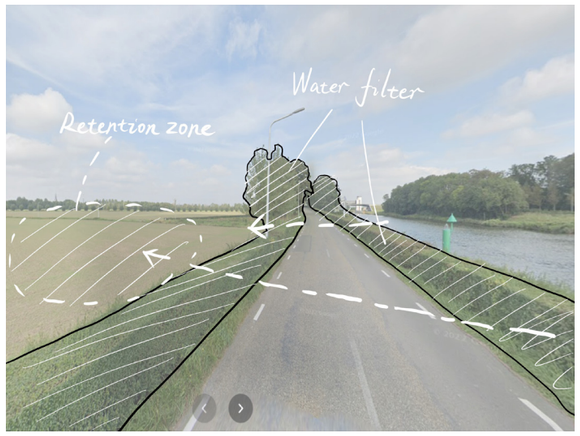


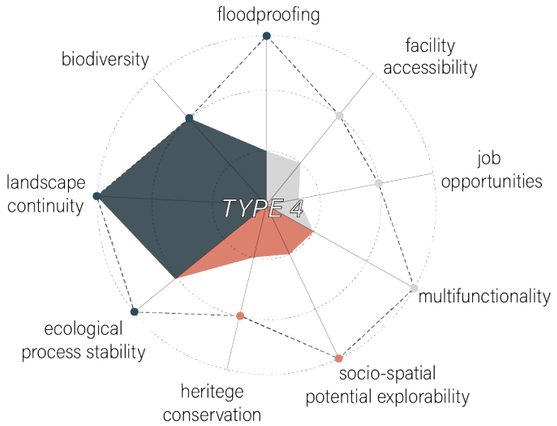
Value added green open space with level 1 flood management potential



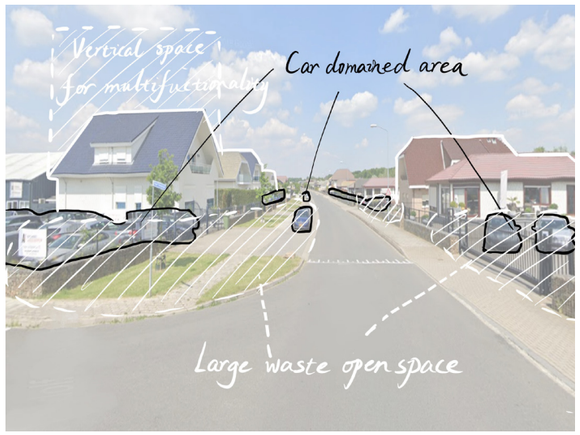


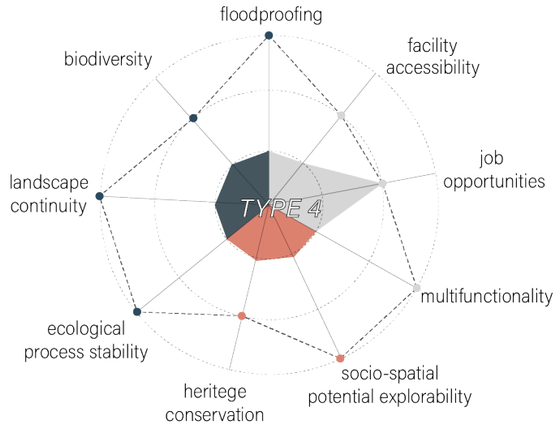
Agriculture with level 1 flood management potential



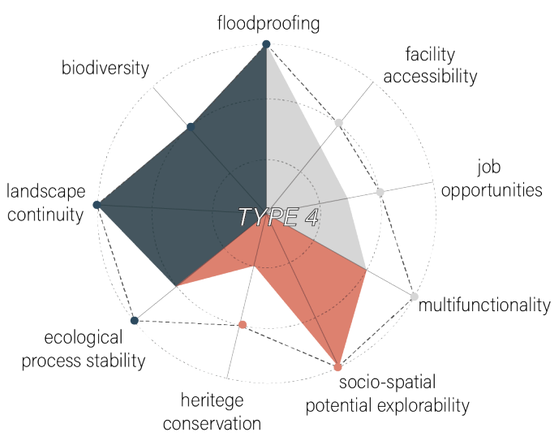


Industrial area with level 1 flood management potential

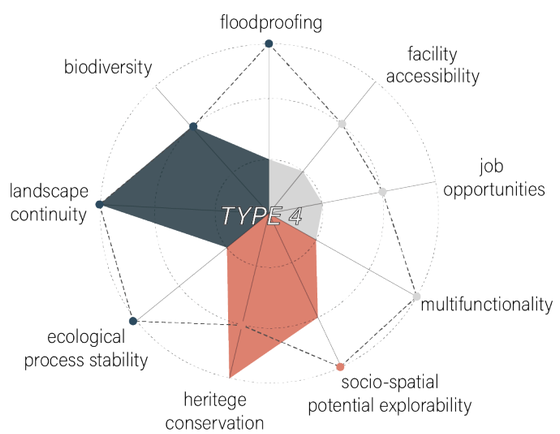




Value added water bodies

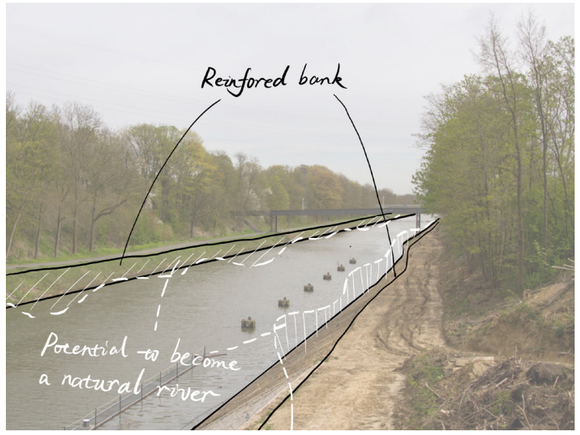


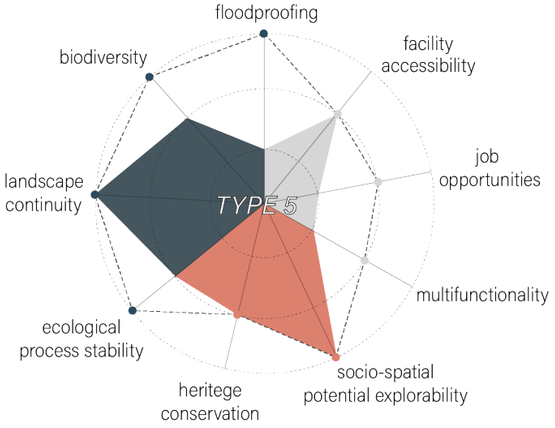
Value changed hard-paved open space with level 2 flood management potential



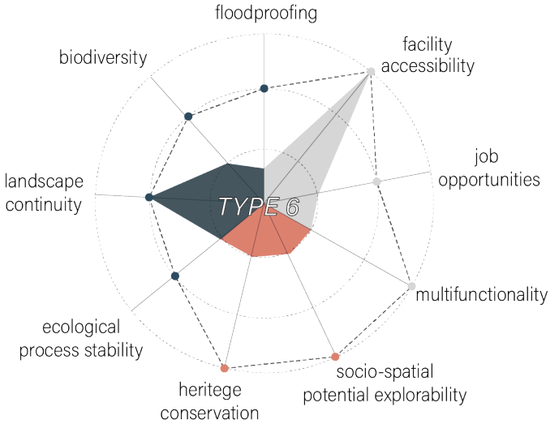
POTENTIAL ANALYSIS OF THE SPATIAL TYPES AT NEIGHBORHOOD SCALE

Value preserved water bodies

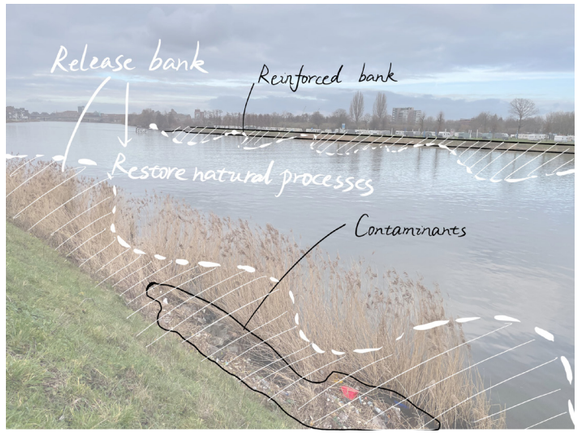


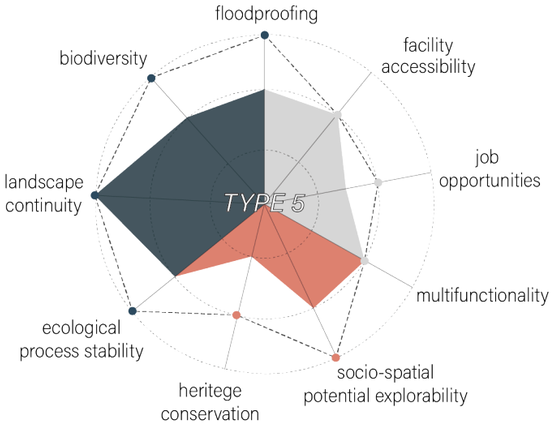


Value disappearing residential area

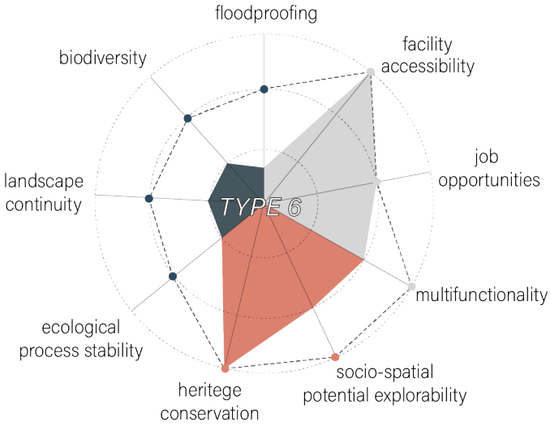


Value disappearing water bodies

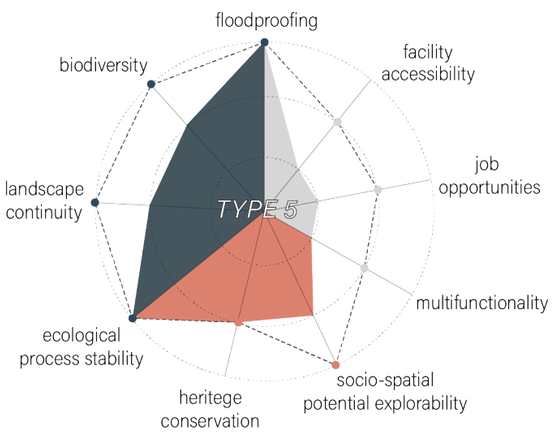




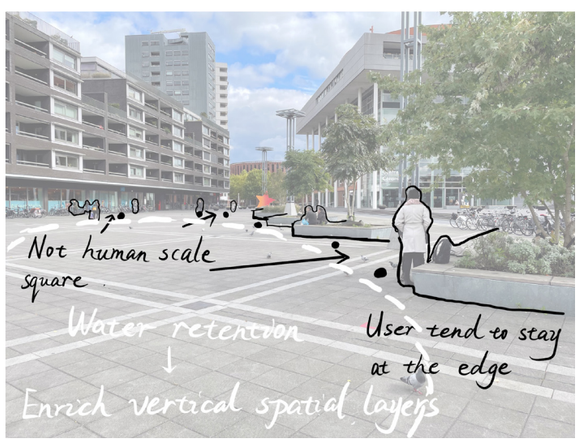
Value added residential area

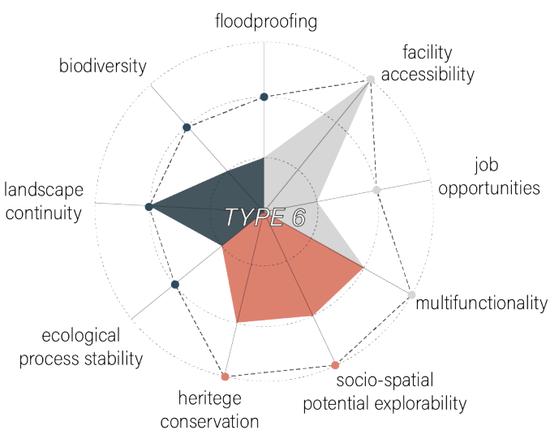


Value changed green open space level 1 flood management potential



Value changed residential area



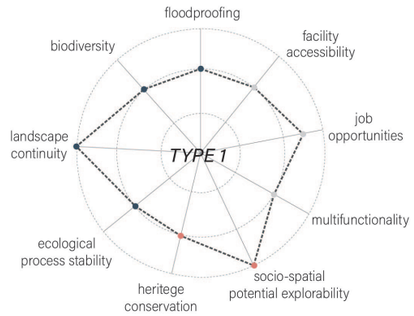


4.1.3 Transformation opportunities at neighborhood scale

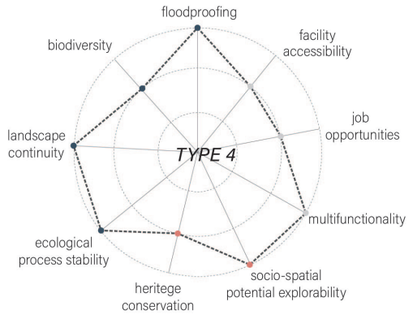
POTENTIAL ANALYSIS OF THE SPATIAL TYPES AT NEIGHBORHOOD SCALE

Figure 4.1.3.1. Potential space type map of Maastricht
Source: Author

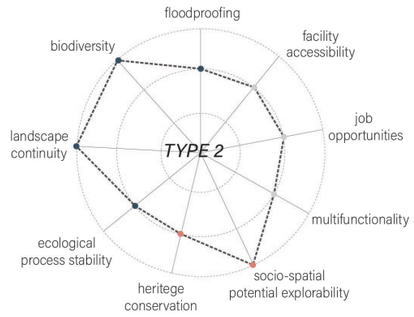
Type 1



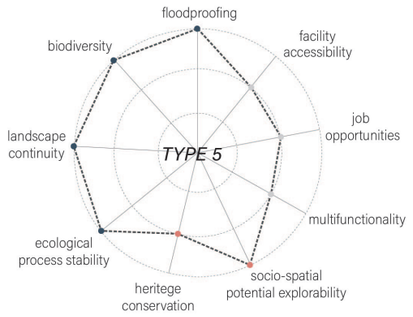
Type 4



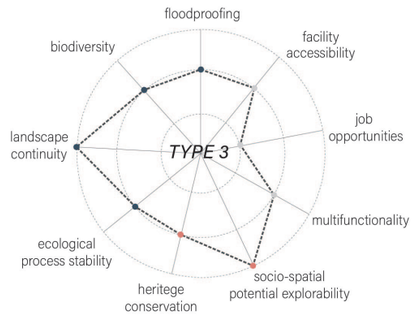
Type 2



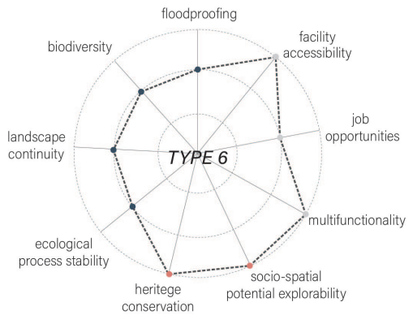
Type 5



Type 3



Type 6



The spatial potential map derived from the earlier analysis proves intricate for direct design orientation. Therefore, it becomes necessary to conduct a more detailed assessment of the potential at the neighborhood level. This assessment reveals that numerous neighborhoods, despite exhibiting different current conditions, share similar potential characteristics.

Consequently, the potential spaces in the city of Maastricht can be categorized into six main categories (Figure 4.1.3.1). It emphasizes the need for a systematic and informed approach to leverage Maastricht's spatial potential, address specific neighborhood characteristics, and foster sustainable urban transformation.

4.1.4 Transformation opportunities from residents' perception

MAASTRICHT RESIDENTS' PERCEPTIONS

To delve deeper into the design direction of the identified potential space types, an empirical investigation was conducted through on-site interviews and questionnaires administered to Maastricht residents. The primary objective was to gain insights into residents' perceptions of the city and their preferences for leisure activities. During a dedicated field trip, it was observed that Maastricht residents could be categorized into three main groups: locals, immigrants, and international students, with a small proportion of visitors from Germany. The data collection process yielded a total of 29 valid questionnaires, comprising 7 responses from local residents, 13 from international students, and 9 from immigrants.

During the survey, all participants exhibited a positive impression of Maastricht, with a notable emphasis on its aesthetic appeal and commendable walkability (Figure 4.1.4.1). However, discussions regarding Maastricht primarily revolved around the city center, with limited mention of other areas within the city. This observation aligns with the findings of the earlier analysis, which highlighted the challenges related to the accessibility of Maastricht beyond the city center and the lack of diverse leisure activities.

Consequently, there is an excessive concentration of individuals in the city center during leisure time, thereby exerting significant population pressure.

Moreover, the most popular leisure activities among local residents predominantly centered around socializing through dining with friends and partaking in walking and drinking activities (Figure 4.1.4.2). These activities also predominantly occur within the city center. This further reinforces the earlier analysis's conclusions regarding the city's walkability and highlights the dearth of alternative leisure options outside the city center. Furthermore, when residents expressed their general demands concerning the city, the majority emphasized the need for improved public transportation connectivity and affordable housing, with international students consistently mentioned the desire for a greater abundance of recreational facilities (Figure 4.1.4.3).

These survey findings provide valuable insights into the residents' perspectives and demands. They underscore the importance of addressing issues related to accessibility, diversifying leisure options, enhancing public transport connectivity, and ensuring affordable housing in Maastricht's urban development planning.

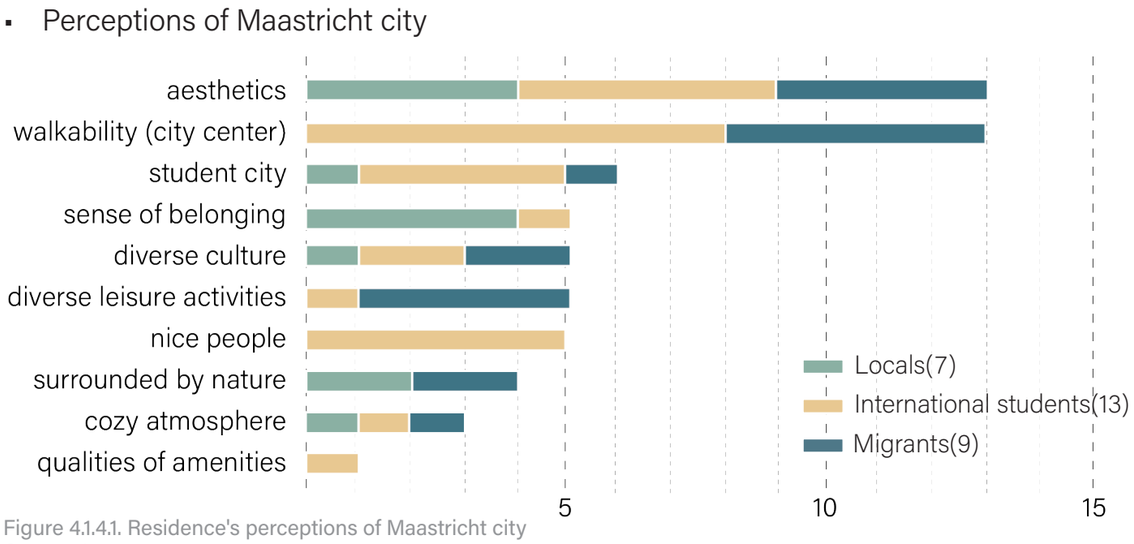


Figure 4.1.4.1. Residence's perceptions of Maastricht city
Source: Author

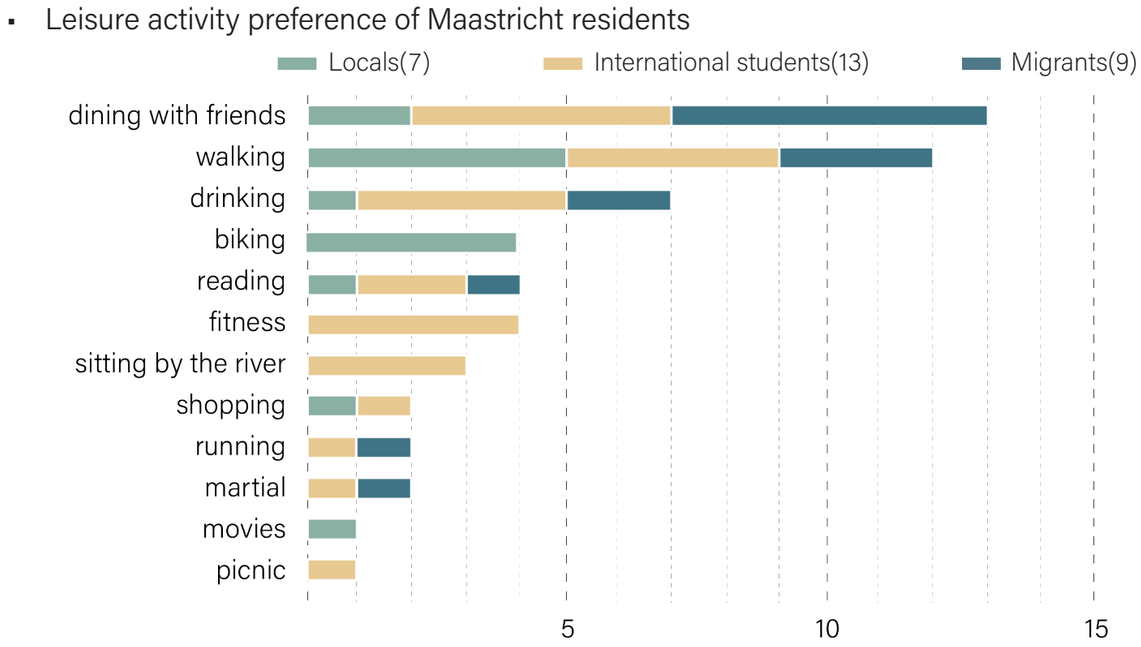


Figure 4.1.4.2. Leisure activity preference of Maastricht residents
Source: Author

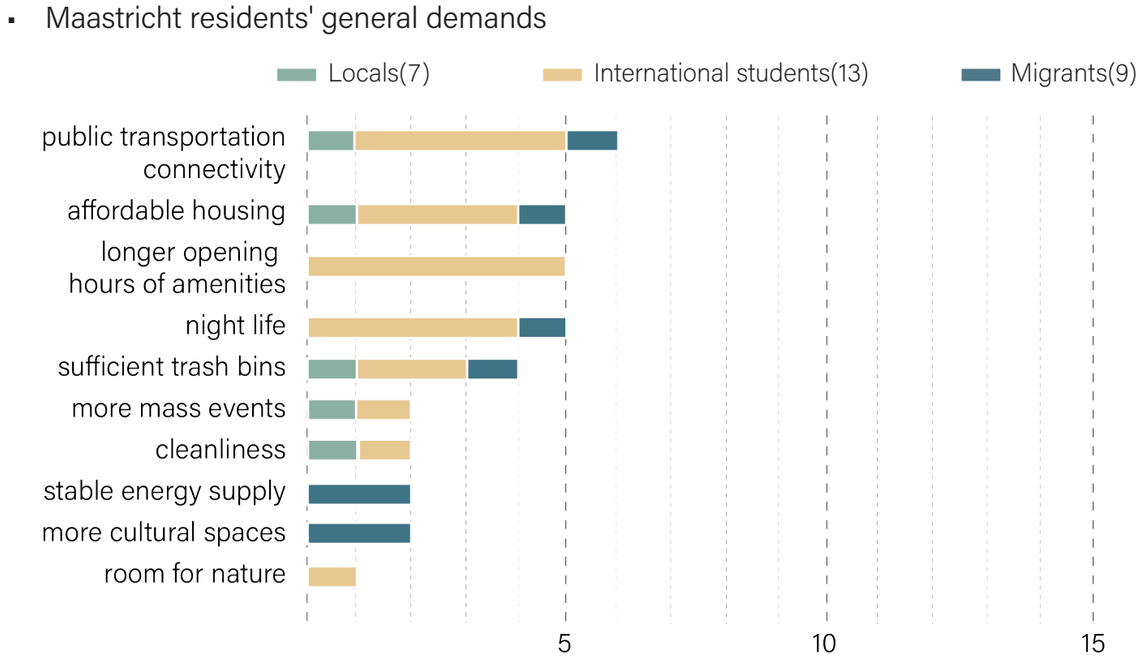


Figure 4.1.4.3. Maastricht residents' general demands
Source: Author

MAASTRICHT RESIDENTS' DEMANDS

Migrants

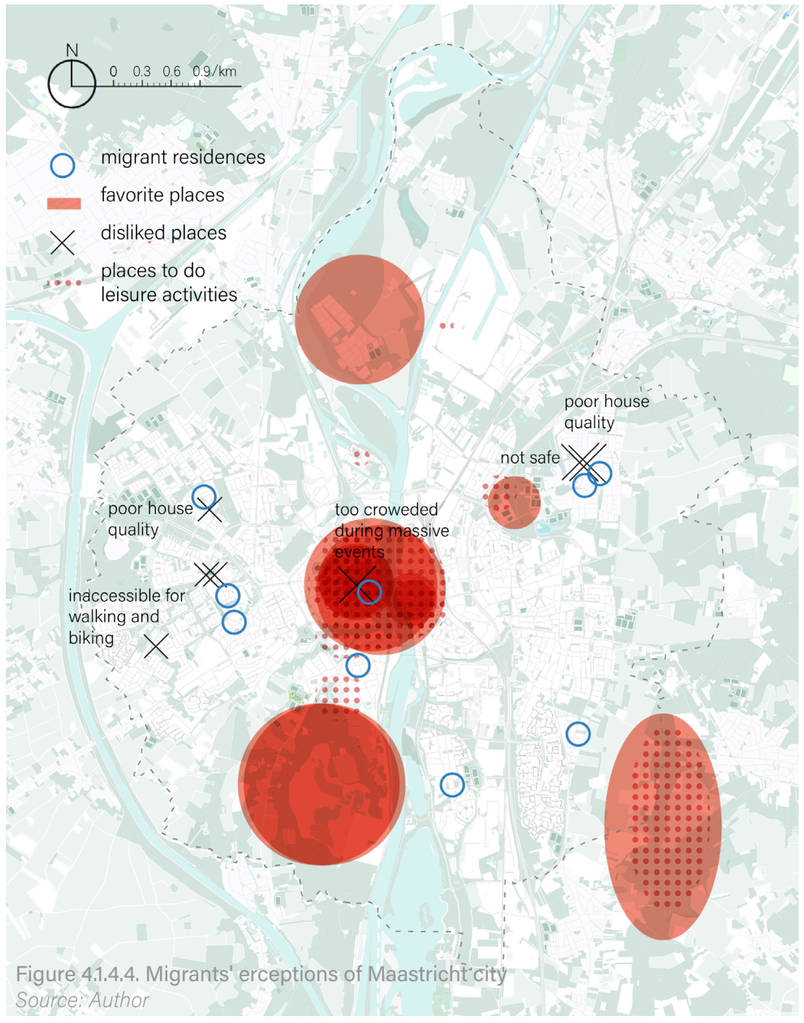


Figure 4.1.4.4. Migrants' erceptions of Maastricht city
Source: Author

Migrants often live in low-value areas and are not very satisfied with the neighborhoods they live in, preferring city centers and specific recreational locations (Figure 4.1.4.4).

↓

Improving the quality of suburban neighborhoods (accessibility and mixed use)

International students

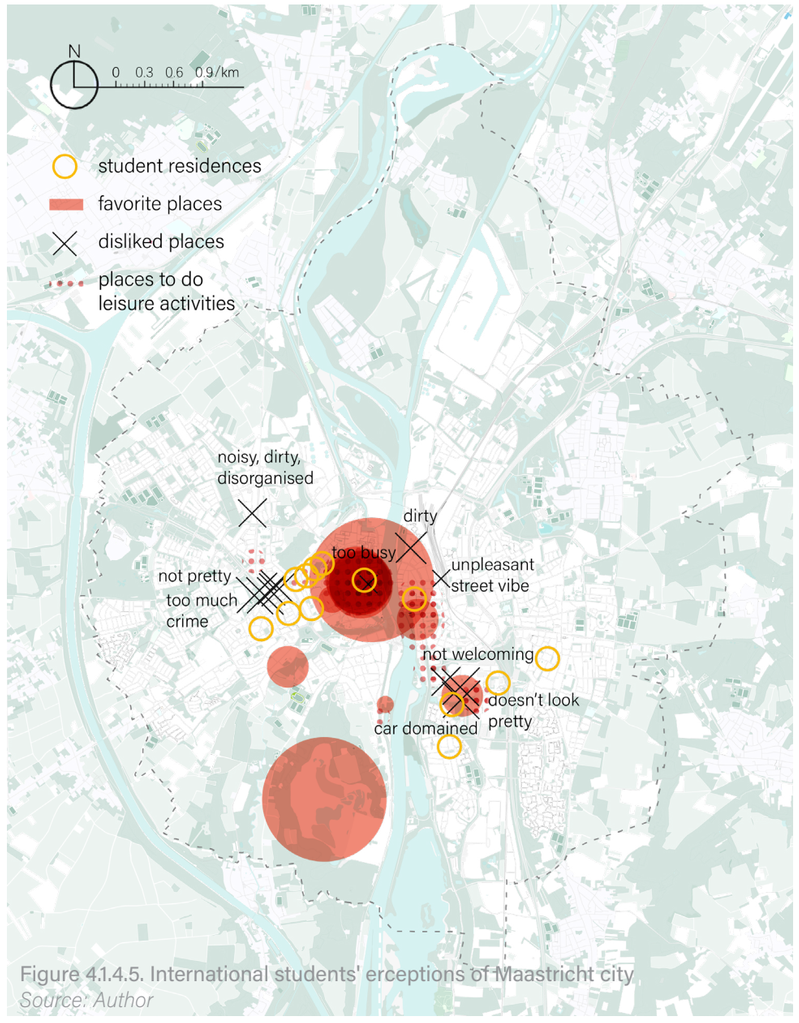


Figure 4.1.4.5. International students' erceptions of Maastricht city
Source: Author

Students usually live in the city center and like where they live very much, often do leisure activities in places that overlap highly with their living area and favorite places, have a small range of activities, pay close attention to the community atmosphere, and have a low appreciation for neighborhoods that lack amenity (Figure 4.1.4.5).

↓

Distribute the population pressure in the city center and reduce its perceived density

Locals

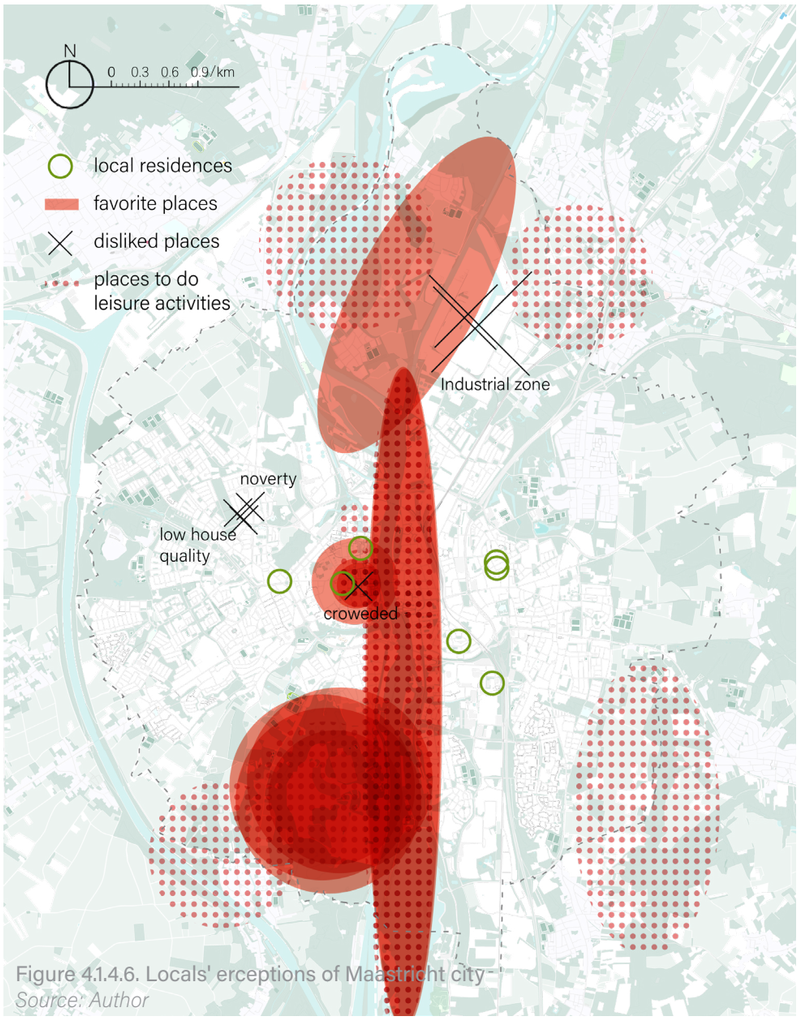


Figure 4.1.4.6. Locals' erceptions of Maastricht city
Source: Author

Local residents prefer outdoor sports and pay more attention to the natural part of the city, with a wider range of activities and a lower evaluation of industrial areas near natureand poor neighborhoods (Figure 4.1.4.6).

↓

Improving accessibility to natural areas and enhancing natural systems

THE MAASTRICHT LANDSCAPE STRUCTURE AS PERCEIVED BY THE RESIDENTS

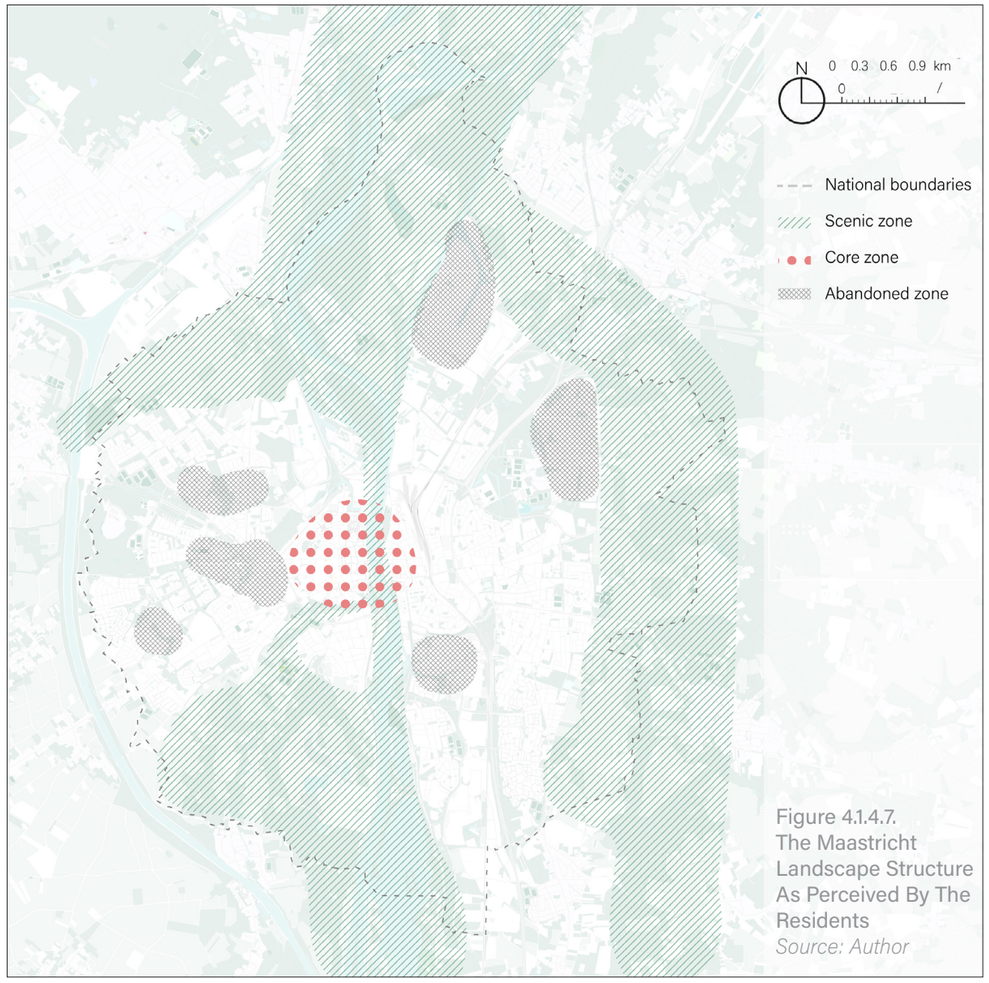


Figure 4.1.4.7.
The Maastricht Landscape Structure As Perceived By The Residents
Source: Author

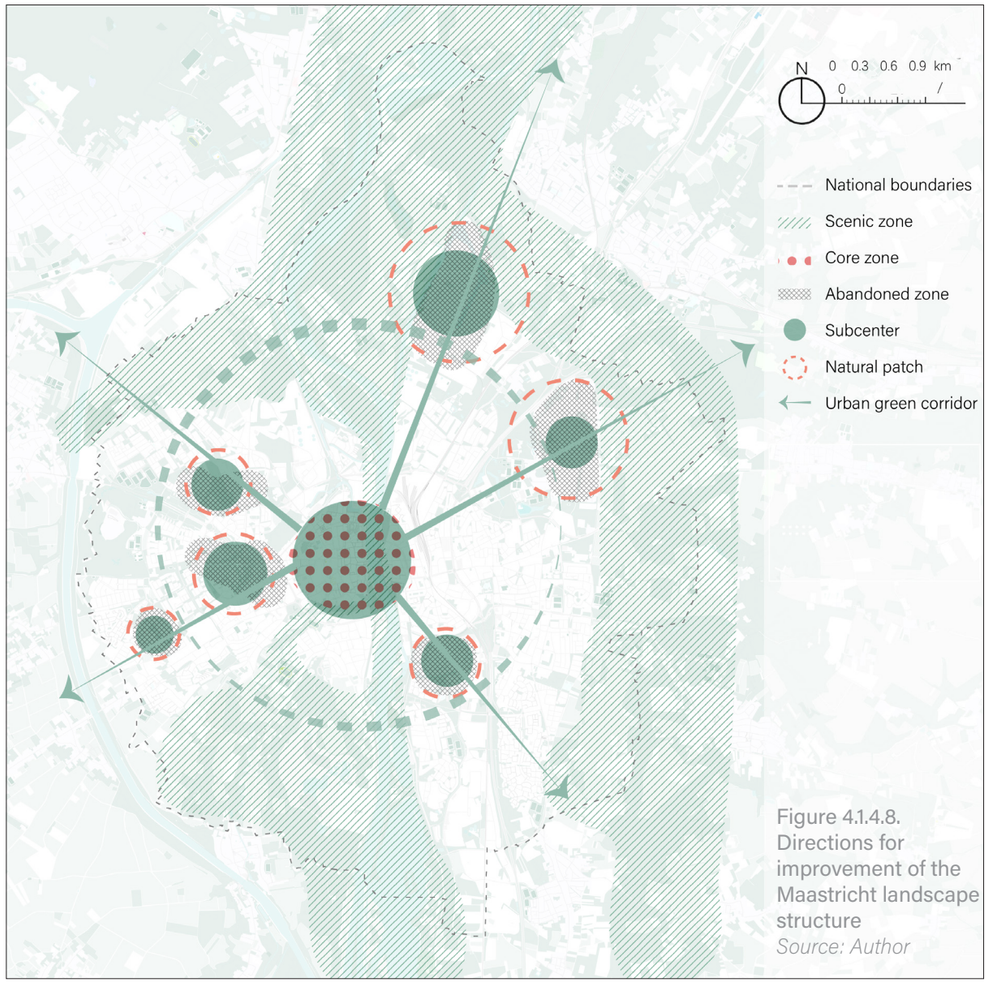


Figure 4.1.4.8.
Directions for improvement of the Maastricht landscape structure
Source: Author

According to the perceptions of Maastricht residents, the city can be broadly categorized into three zones: the city center as the vibrant core, the natural areas surrounding the city as the scenic zone, and the other neighborhoods as neglected places lacking identity or interest (Figure 4.1.4.7).

Based on these perceptions and the identified needs of residents, including walkability, increased leisure activities, improved public transportation connectivity, affordable housing, and reduced overcrowding in the city center, this study proposes preliminary design directions. These directions aim to address the identified challenges and capitalize on the city's potential :

- **Greening individual neighborhoods and enhancing accessibility and leisure activities** (Figure 4.1.4.8): By focusing on the abandoned neighborhoods lacking identity and interest, the design should prioritize greening initiatives to transform these areas into vibrant and attractive spaces. This can involve introducing green spaces, such as parks and gardens, as well as enhancing accessibility through improved pedestrian and cycling infrastructure. Additionally, the provision of diverse leisure activities within these neighborhoods will help distribute recreational opportunities more evenly throughout the city.

- **Stitching together Maastricht's natural landscape fabric with green public transportation corridors** (Figure 4.1.4.8): To better integrate the natural areas surrounding Maastricht with the urban fabric, the design should emphasize the creation of green public transportation corridors. These corridors would not only enhance connectivity but also serve as greenways that preserve and showcase the city's natural beauty. By intertwining the transportation network with green elements, such as linear parks or tree-lined paths, a seamless connection between urban and natural spaces can be achieved.

These preliminary design directions align with the residents' desires for improved livability, accessibility, and a sense of place in different areas of Maastricht. However, further research, consultation, and collaboration with stakeholders, urban planners, and experts will be essential to refine and implement these design strategies effectively.

VISIONING TYPOLOGY MAP AT CITY SCALE

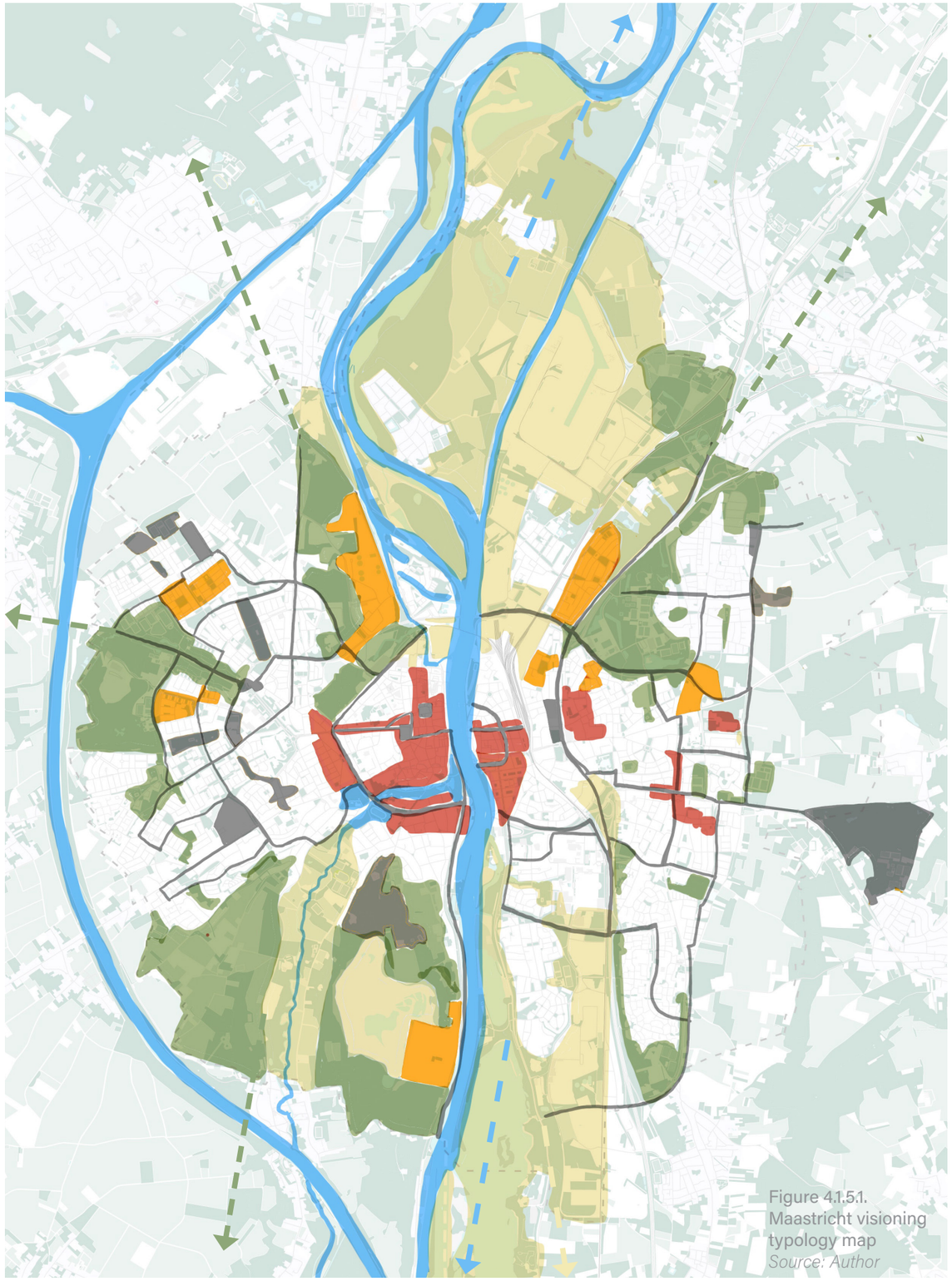
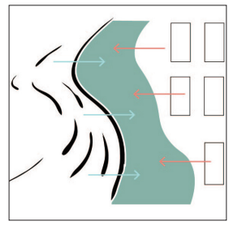


Figure 4.1.5.1.
Maastricht visioning typology map
Source: Author

Type 1: Benefit densification

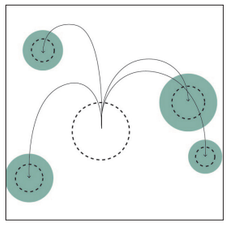
Densification projects stimulate human and ecological flows in abandoned areas, promoting local self-circulation.

Type 4: Buffer



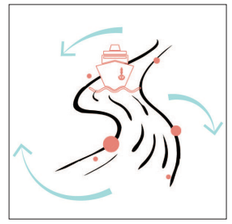
Keeping the buffer zone between the city and the river natural controls the damage of river floods and reduces the disturbance of river dynamics by urban development.

Type 2: Nature hub



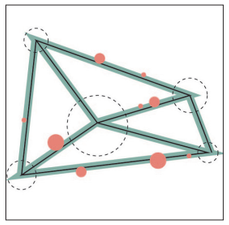
Nature hubs dissipate the pressure of intensive leisure activities in urban centers and enhance their participation in the natural circulation.

Type 5: Dynamic water bodies



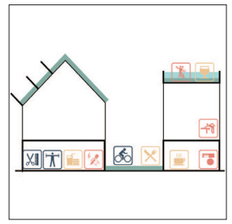
Restoring the river to its natural state increases a variety of ecological services for urban development, such as navigation and recreation.

Type 3: City skeleton



Emphasis on the vitality and eco-friendliness of the city's key road network allows the city to integrate with nature.

Type 6: Multi-chance neighborhoods



Maximizing the multifunctionality and cultural diversity of neighborhood common spaces reduces the perception of density in the area and stimulates multiple economic and environmental benefits.

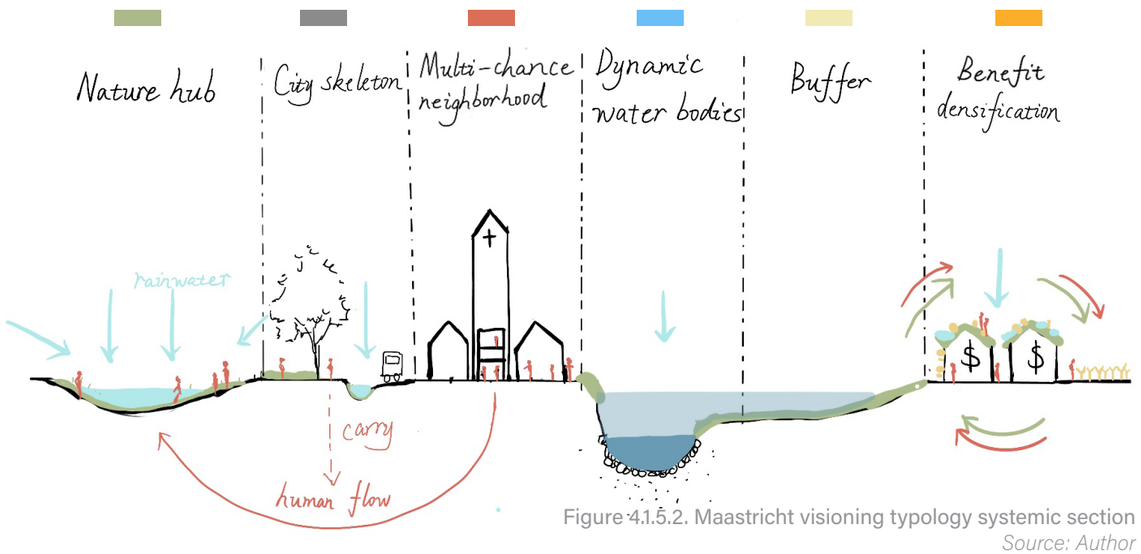


Figure 4.1.5.2. Maastricht visioning typology systemic section
Source: Author

VISIONING COOPERATION AT REGIONAL SCALE

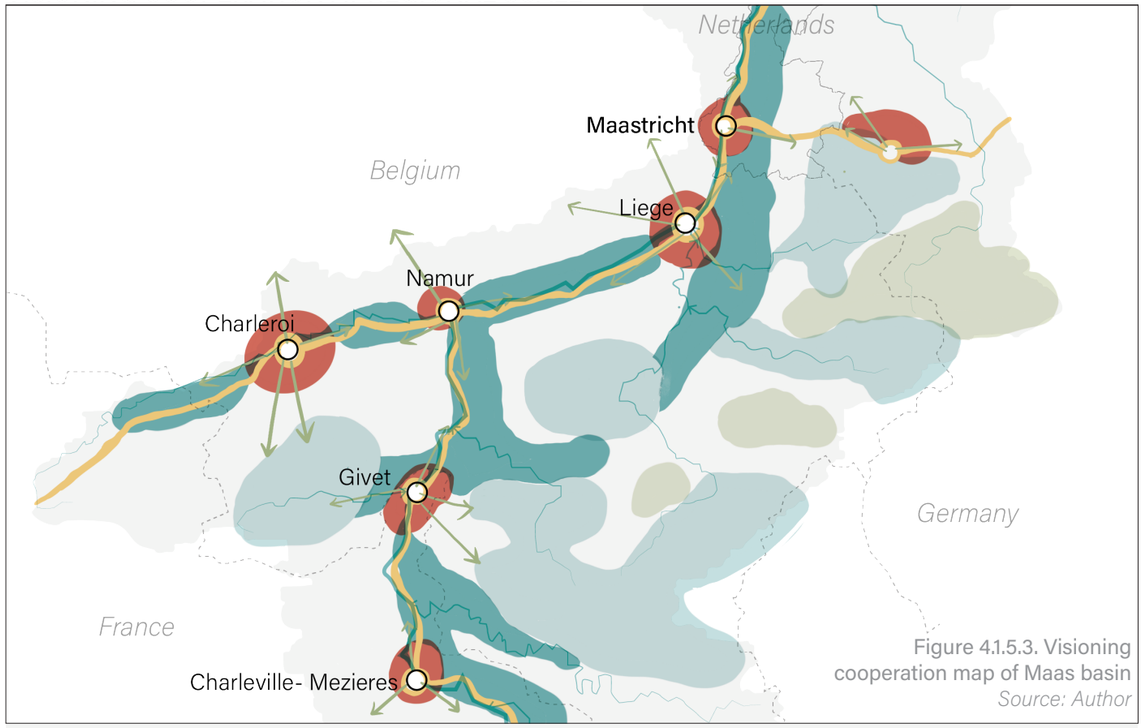


Figure 4.1.5.3. Visioning cooperation map of Maas basin
Source: Author

- Main fields of cooperation:

City's cultural potential:

Exploitation of the potential for water-related leisure activities and increased urban flood resilience in major cities along the Maas River

Transportation connectivity:

Enhancing transportation connectivity along the Maas River corridor (Ensuring water levels to meet navigation requirement + Diversified transportation options)

Natural structure:

Stitching of natural structures in the Maas Basin

- Existing International Cooperation:

The river basin

France:
- Delaying of the excess rainfall-runoff

Belgium:
- Rapid transport of the excess rainfall-runoff
- Important contribution during periods of flood

The Netherlands:
- The Common Meuse: low sloping landscape
- Important tributary: the Rur River

International policy (1)

Intern. Com. for the protection the Meuse (ICPM):
- Water Quality,
- Emissions
- Cross border Waterways Cooperation

Important projects:
- Monitoring water quality from source to outlet
- A Warning and Alarm System for water supply
- A breakdown of the affluents is presented

International policy (2)

Action Plan against Meuse River Flooding
Important measures:

- Augmentation of flow capacity
- Installation of retention basins
- Greater community awareness of flooding
- A reliable flood warning system

Figure 4.1.5.4. Existing International Cooperation of Maas river
Source: https://unece.org/fileadmin/DAM/env/water/meetings/conf2/3b-meuseriverbasin_bastings.pdf

- International Cooperation history:

Previous successful cooperation among the countries of the Maas River basin has been about **ensuring the navigation of the river**, indicating that the control of the stability of the water level of the Maas River has been the focus of international cooperation.

The failure to reach consensus on the 1975 treaty was mainly due to the fact that the proposed flood control measures at that time could not bring direct socio-economic benefits to the countries and that there was insufficient incentive to cooperate, confirming that **flood control projects must be integrated with urban development** to ensure their feasibility.

STAKEHOLDER ANALYSIS AT CITY SCALE

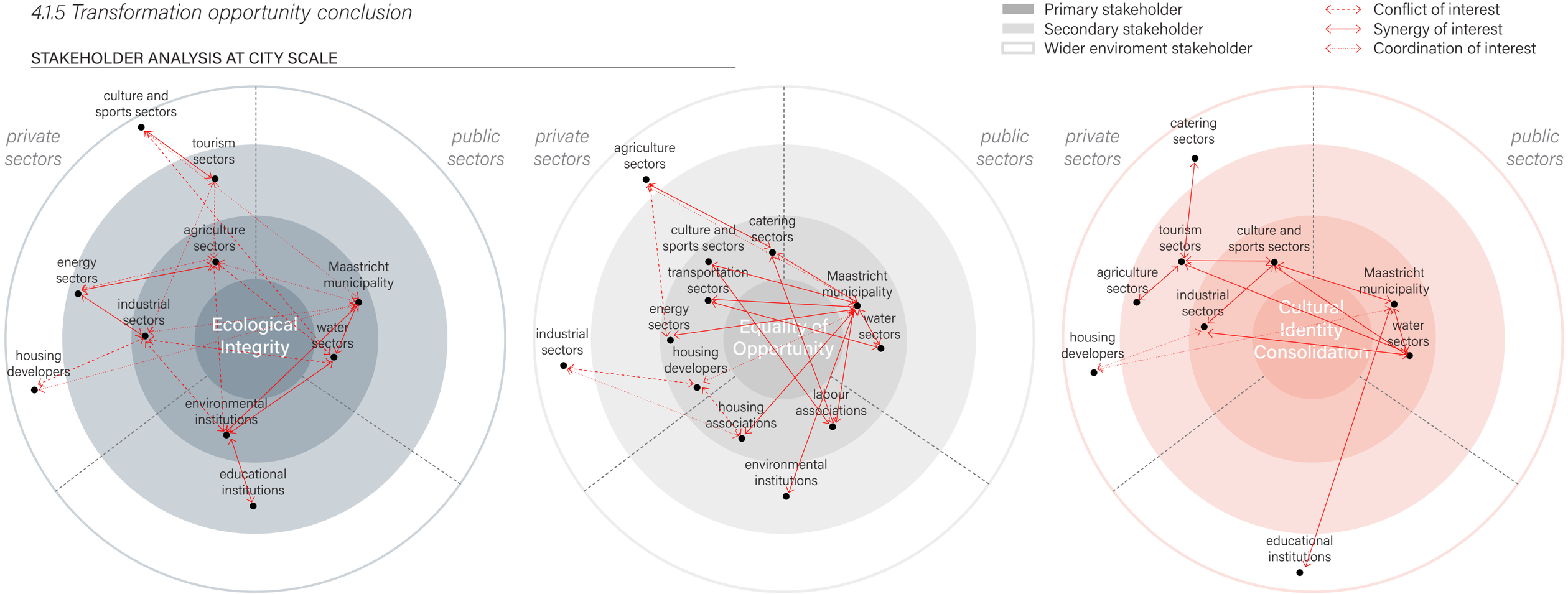


Figure 4.1.5.5. Stakeholder analysis towards three goals
Source: Author

programe:

The municipality provides subsidies for agriculture, industry and other sectors involved in ecological conservation.

plan:

Creating retention areas along the Maas River balances effective flood management with the preservation of original land functions.

The chart indicates that the interests between the public sector and civil society are aligned, but they are more in conflict with the private sector, which has high internal consistency of interests. Also, there is little collaboration between the private and public sectors, which is detrimental to the long-term development of the city.

programe:

Municipality offers subsidies to residents and businesses for installing new energy equipment.

project:

Establish a densification model of cooperation between factories and real estate developers to promote the use of construction waste materials and limit the price of housing.

plan:

Stabilizing the water level of the Maas River in different seasons to ensure navigation.

The linkages between the public sectors and other stakeholders are strong, but the connection between different private sectors and civil society needs to be strengthened and will require programs to advance their cooperation.

project:

Establish an information sharing platform for residents to become tour guides and leisure business operators through simple registration.

plan:

Establish a regional leisure chain to expand the advantages and involve more stakeholders in the pursuit of more leisure opportunities and related benefits.

In term of cultural identity consolidation, it is difficult for civil society to participate in this process. There is a need for programs to include more participation from civil society stakeholders.

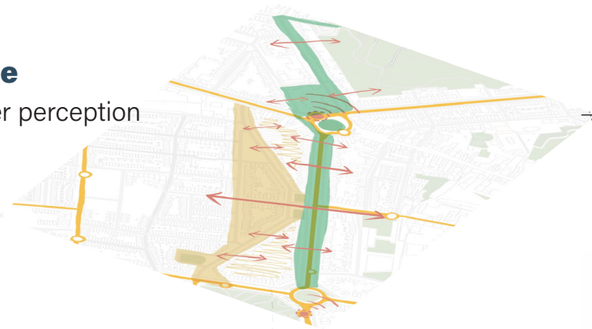
4.1.5 Transformation opportunity conclusion

TRANSSCALAR FRAMEWORK

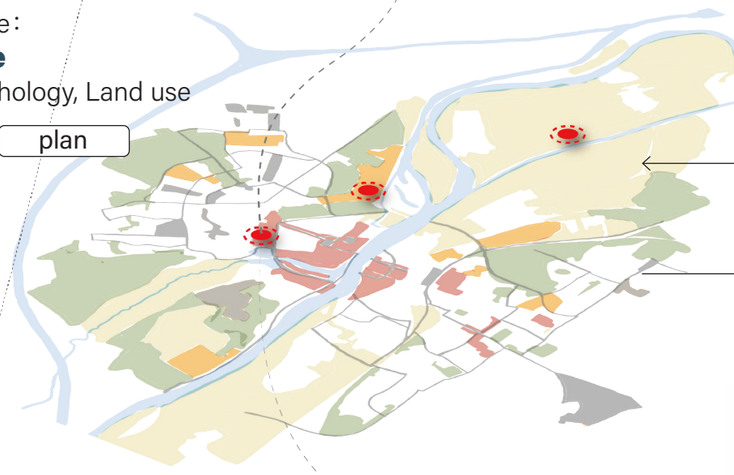
public sectors
private sectors
civil society

	Location	Size	Main mission	Stakeholders
Implementation Scale: **Neighborhood scale** Space atmosphere，User perception project	▪ Benefit densification ▪ Buffer ▪ City skeleton	10ha	Optimization of the quality of **daily life** and restoration of the cultural landscape from **a human perspective** under flood and normal conditions respectively	Maastricht municipality leisure business transportation companies energy companies contractors factories locals international students migrants tourists
Design Scale: **City scale** Spaial morphology, Land use programe plan	Composition and configuration of Maastricht's potential urban landscape	60km²	Maximizing the **city's potential** for sustainable leisure development and enhancing Maastricht's water retention capacity	Maastricht municipality water sectors tourism sectors catering sectors transportation sectors agriculture sectors industrial sectors energy sectors culture and sports sectors housing developers educational institutions environmental institutions housing associations labour associations
Strategic Scale: **Regional Scale** River ecosystem, Leisure industry chain plan policy & strategy	Transitional areas in the middle and downstream of the Maas Basin	1000km²	Establish an integrated cross-border flood adaptation and sustainable leisure industry **cooperation zone** to distribute floodwater that exceeds Maastricht's detention capacity to other regions and to unite surrounding cities to jointly **expand** leisure industry markets and flood treatment **effectiveness.**	international governments Province of Limburg Rijkswaterstaat & Water boards international transportation companies non-government organizations

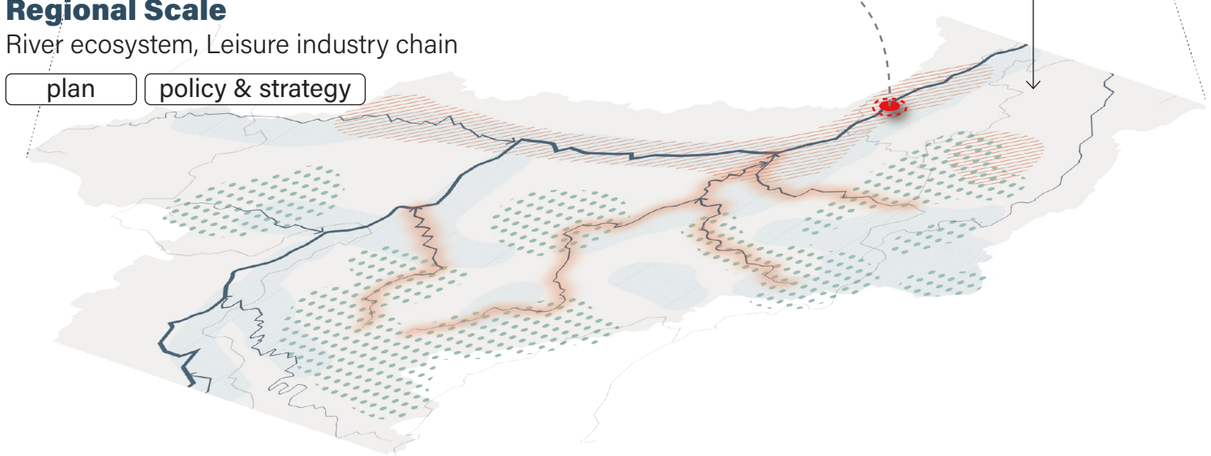
Key scale



Improve the ecological and cultural connectivity of different typologies in the city and increase the willingness of residents to participate in the transformation



Connecting the ecosystems of the vunurable areas of the Maas Basin and highlighting the local cultural landscape features



4.2 Scenario Experiments of Maastricht City

DESIGN FRAMEWORK

The design framework adopted in this study builds upon the conceptual framework of a previous study. It aims to achieve three key objectives: ecological integrity, equality of opportunity, and cultural identity consolidation, within the context of both flood resilience and sustainability of the leisure industry (Figure 4.2.1).

However, this framework further enhances the scope of spatial implementation at the urban scale, providing specific design directions for six distinct spatial types. Moreover, it demonstrates the application of each spatial typology at the neighborhood scale, while also extending the benefits of urban design to the regional scale, thereby maximizing its impact.

This approach ensures that the benefits of the urban design intervention are not limited to a single area but can be realized on a broader scale, bringing about significant advantages.

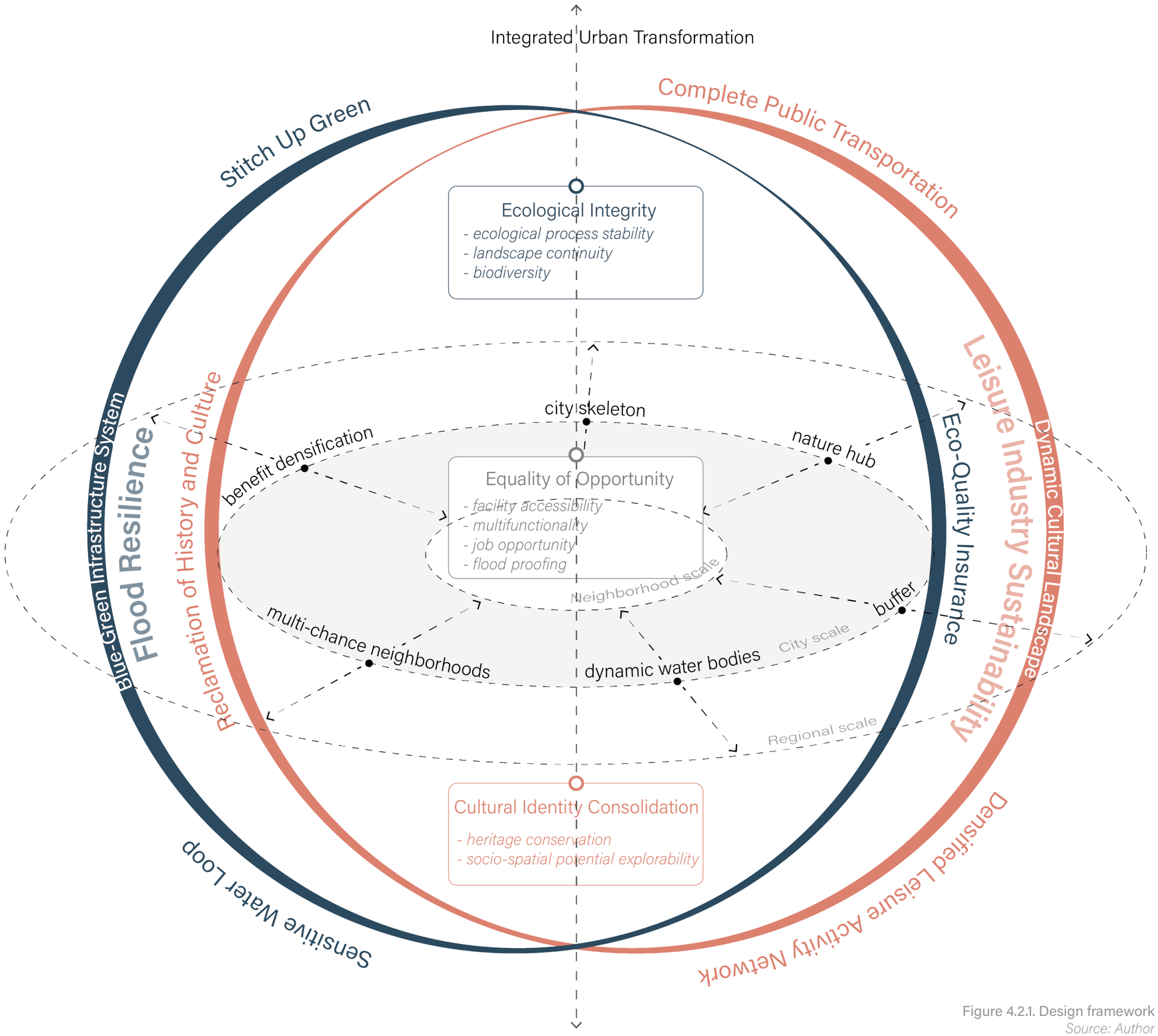


Figure 4.2.1. Design framework
Source: Author

DESIGN METHODOLOGY

Pattern Language

Transferability: Integrated Design Models

Maximization Scenario

Regional effects

Life Spin | *Guidelines* | *Strategies & Programs* | *Visioning Typology* | *Integrated Design Proposals*

In 30 years

Complete public transportation by diverse transportation options and shared mobility systems.

Create densified leisure activity networks by vibrant pedestrian areas and accessible natural landscapes.

Reviving history and culture value by reconnection of cultural landscape and inspiring past behaviors.

Pattern box

Leisure Culture City

Benefit densification

Multi-chance neighborhoods

City skeleton

Test in neighborhood scale

Buffer Implementation

Benefit densification Implementation

City skeleton & Multi-chance neighborhoods Implementation

Synergies & Conflicts

Flowing culture city

In 80 years

Stitch up green by urban ecological corridors and natural patches.

Close sensitive water loop by highly water-sensitive public spaces with connected water systems.

Insurance on eco-quality by purification and isolation systems at the urban interfaces

Eco-Water City

Buffer

Dynamic water bodies

Narure hub

Test in neighborhood scale

Integrated strategies for the Maas Basin

Literature Review

Spatial Analysis

neighborhood scale

city scale

regional scale

4.2.1 Pattern language

INTRODUCTION

Christopher Alexander defined a pattern language as a way to communicate and document successful design solutions for the built environment. It consists of individual design patterns that address specific problems and offer contextually relevant and adaptable solutions (Alexander, 1977). Patterns are structured and reusable, including a name, problem statement, context description, proposed solution, and consequences. Patterns are organized hierarchically, allowing for flexible combination and application. A pattern language is an evolving collection of interconnected patterns that encourages continuous refinement based on designers' and users' insights and experiences (Alexander, 1977).

Pattern language is a useful tool for realizing an integrated urban transformation of flood resilience and leisure industry sustainability.

Firstly, a pattern language provides a systematic approach to understanding complex urban systems and their interdependencies. It allows urban planners, designers, and policymakers to identify recurring problems, solutions, and relationships within the urban context. By employing a pattern language, it becomes possible to analyze the patterns of flooding and the leisure industry, their causes, and their impacts on the urban environment.

Secondly, a pattern language enables the communication and exchange of knowledge among stakeholders involved in urban transformation. It provides a common language and framework for discussing flood resilience and leisure industry sustainability, facilitating collaboration between different disciplines and sectors. This interdisciplinary approach is crucial for addressing the multifaceted challenges associated with urban transformation.

Moreover, a pattern language assists in the development of effective strategies and design interventions. By examining successful patterns from different contexts and adapting them to specific urban conditions, decision-makers can learn from past experiences and implement proven solutions. This approach enhances the efficiency and effectiveness of urban transformation initiatives, allowing for the integration of flood resilience measures and sustainable leisure industry practices.

Furthermore, a pattern language promotes the scalability and replicability of solutions across different urban areas. It enables the identification of generic patterns that can be applied in various contexts, while also accounting for the unique characteristics of each specific location. This flexibility allows for the transfer of knowledge and best practices, facilitating the dissemination of successful approaches to flood resilience and leisure industry sustainability.

Overall, the utilization of a pattern language as a tool for integrated urban transformation of flood resilience and leisure industry sustainability offers a structured and comprehensive framework for understanding, communicating, and implementing effective strategies and design interventions. It supports collaboration, knowledge exchange, and scalability, ultimately contributing to the creation of resilient and sustainable urban environments (Alexander, 1977).

Pattern as

A Learning Tool

Patterns can be used as a learning tool to study and understand successful design solutions. By examining and analyzing patterns, designers can gain insights into effective approaches, problem-solving strategies, and underlying design principles.

A Design Tool

Patterns provide designers with a catalog of proven solutions that can be applied to address specific design problems. Designers can leverage patterns as building blocks, adapting and combining them to create new and contextually relevant designs while maintaining a level of consistency and coherence.

A Communication Tool

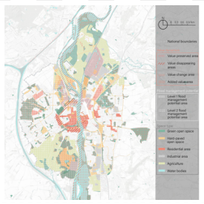
Patterns facilitate effective communication among designers, stakeholders, and users. They provide a shared language and vocabulary to describe design problems, proposed solutions, and their implications. By using patterns, design ideas can be communicated more efficiently, enhancing collaboration and understanding between different parties involved in the design process.

A Assessment Tool

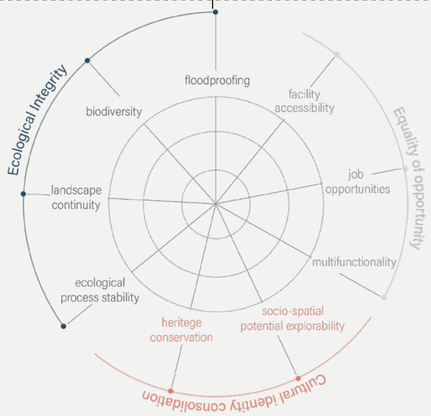
Patterns can be used as a framework for evaluating and assessing the quality of designs. By comparing a design solution to relevant patterns, designers can identify strengths, weaknesses, and areas for improvement. Patterns can serve as criteria for evaluating design choices, ensuring that the final design aligns with established best practices and principles.

PATTERN FRAMEWORK

Potential of each space type



Types of physical elements with transformative potential in Maastricht

A Learning Tool	TOPICS	GUIDELINE	STRATEGY	IMPLEMENTATION
Extensive investigation of urban design case studies and scholarly literature pertaining to flood management and the leisure industry is undertaken to discern relevant patterns that foster comprehensive comprehension and guide practical approaches.	FLOOD RESILIENCE	G1 Stitch Up Green G2 Sensitive Water Loop G3 Eco-Quality Insurance	Spatial Strategy	Open space Agriculture Technology Water bodies Construction
	+			
	LEISURE INDUSTRY SUSTAINABILITY	G4 Complete Public Transportation G5 Densified Leisure Activity Network G6 Reclamation Of History And Culture	Program	
A Assessment Tool *Systematically evaluate each individual pattern in accordance with the design goals to ascertain the intrinsic value and overall effectiveness of designs implemented through the utilization of these patterns.*		Based on the average of the strategy scores	Based on the average of the implementation scores	

Regional Scale *City Scale* *Neighborhood Scale*

A Design Tool + A Communication Tool

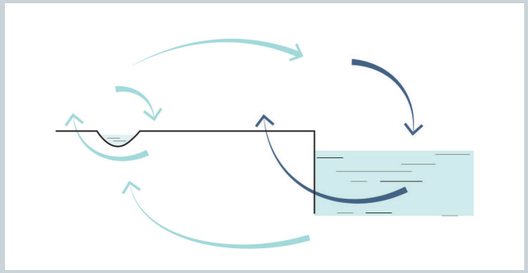
Stakeholders at each scale are involved in pattern choice decisions

EXAMPLE PATTERN

G2 SENSITIVE WATER LOOP

Hypothesis

Reserving enough space for water and massively closing the local water loop in rivers and inland, respectively, accommodates excessive rain and river water during extreme weather.



Included patterns

S4 ROOM FOR RIVERS
S5 RIVER DYNAMICS STIMULATION
S6 RELEASE CHANNEL
S7 FLOOD-ADAPTED AGRICULTURE
S8 FLOATING ISLANDS
S9 STORMWATER BUFFER
S10 SURFACE DRAINAGE
S11 MULTIFUNCTIONAL FLOODPLAIN

Reference

Prominski, M., Stokman, A., Stimberg, D., Voermanek, H., & Zeller, S. (2012). *River. Space. Design.* In River. Space. Design. Birkhäuser.

Guideline

Strategy

Specific implementation of the strategy

Applicable physical object: Construction

This study adopts a pattern language approach, organized into three distinct levels: guideline, strategy/program, and implementation. This hierarchical structure allows for a logical progression from abstract concepts to concrete actions.

At the guideline level, the study establishes overarching principles and objectives for the integrated urban transformation of flood resilience and leisure industry sustainability. These guidelines serve as a foundation for the subsequent development of strategies and programs.

Moving to the strategy/program level, the study explores various spatial and social strategies that align with the established guidelines. These strategies encompass a range of approaches and interventions aimed at addressing the specific challenges associated with flood resilience and leisure industry sustainability. Each strategy is tailored to the unique characteristics and requirements of the urban context under consideration.

Finally, at the implementation level, the study delves into the practical realization of the identified strategies and programs. This involves the application of the developed strategies in specific spaces within the urban environment. The implementation approaches may vary depending on the type of site, taking into account its specific conditions, constraints, and opportunities.

It is worth noting that the diverse strategies and implementation approaches contribute differently to the three design goals of the study, namely ecological Integrity, equality of opportunity, cultural Identity. The varying contributions of these strategies are carefully evaluated and considered, ensuring that the overall urban transformation objectives are effectively addressed.

In this study, 22 spatial strategies and 2 programs were created based on six guideline, they include 75 implementation methods, see Appendix 5: pattern box for details.

flood resilience — leisure industry sustainability

S9 STORMWATER BUFFER

Hypothesis

Enough urban retention spaces allow the rainwater to stay during extreme flood events.

Theoretical back-up & Practical implication

Various forms of retention space, such as retention ponds, natural ditches, urban canals, floodable wetlands, amphibious parks, rainwater squares/ sports fields, retention roofs, and storage below buildings, serve as valuable tools for managing rainwater and enhancing flood resilience in cities. These spaces provide permanent or temporary water storage capacity, allowing them to store excess rainwater during floods and also be utilized for future consumption, maximizing space utilization and improving urban flood resilience (NWRM, 2015).

Reference

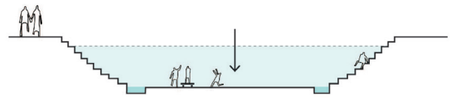
Magdaleno Mas, F., & Dalacamara Andres, G. (2015). *Natural Water Retention Measures (NWRM): from Design to Implementation through European Projects.* Ingenieria Civil (Madrid), 179, 131-138.
Mairs, J. (12 July, 2016). *Chains of pools proposed to ease flooding in Copenhagen.* Retrieved from https://www.dezeen.com/2016/07/12/hans-tavsens-park-korsgade-sla-copenhagen-denmark-flooding-urban-planning/

Applicable physical object: Open space

S9.1 WATER SQUARE

Hypothesis

The sunken square acts as a sports field in dry weather, but forms a storm water retention area during heavy rainfall.



Contribution to Goals

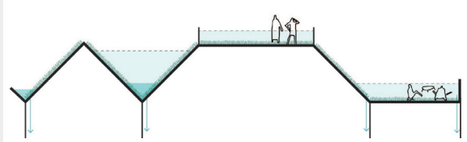
Stakeholders

Maastricht municipality
leisure business
contractors
locals
international students
migrants
tourists

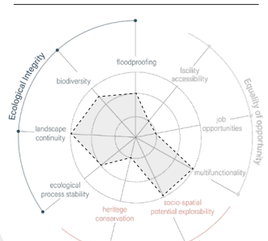
S9.3 CATCHMENT ROOF

Hypothesis

A certain amount of rain-collecting roofs expands water retention areas and promotes urban biodiversity.



Contribution to Goals



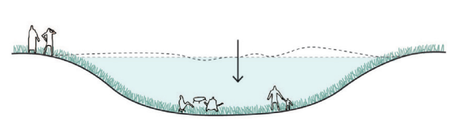
Stakeholders

Maastricht municipality
leisure business
contractors
locals
international students
migrants
tourists

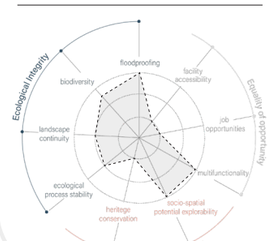
S9.2 SINKING GREEN SPACE

Hypothesis

The sunken green space stores and purifies rainwater while improving the urban microclimate.



Contribution to Goals



Stakeholders

Maastricht municipality
leisure business
contractors
locals
international students
migrants
tourists

PATTERN NETWORK

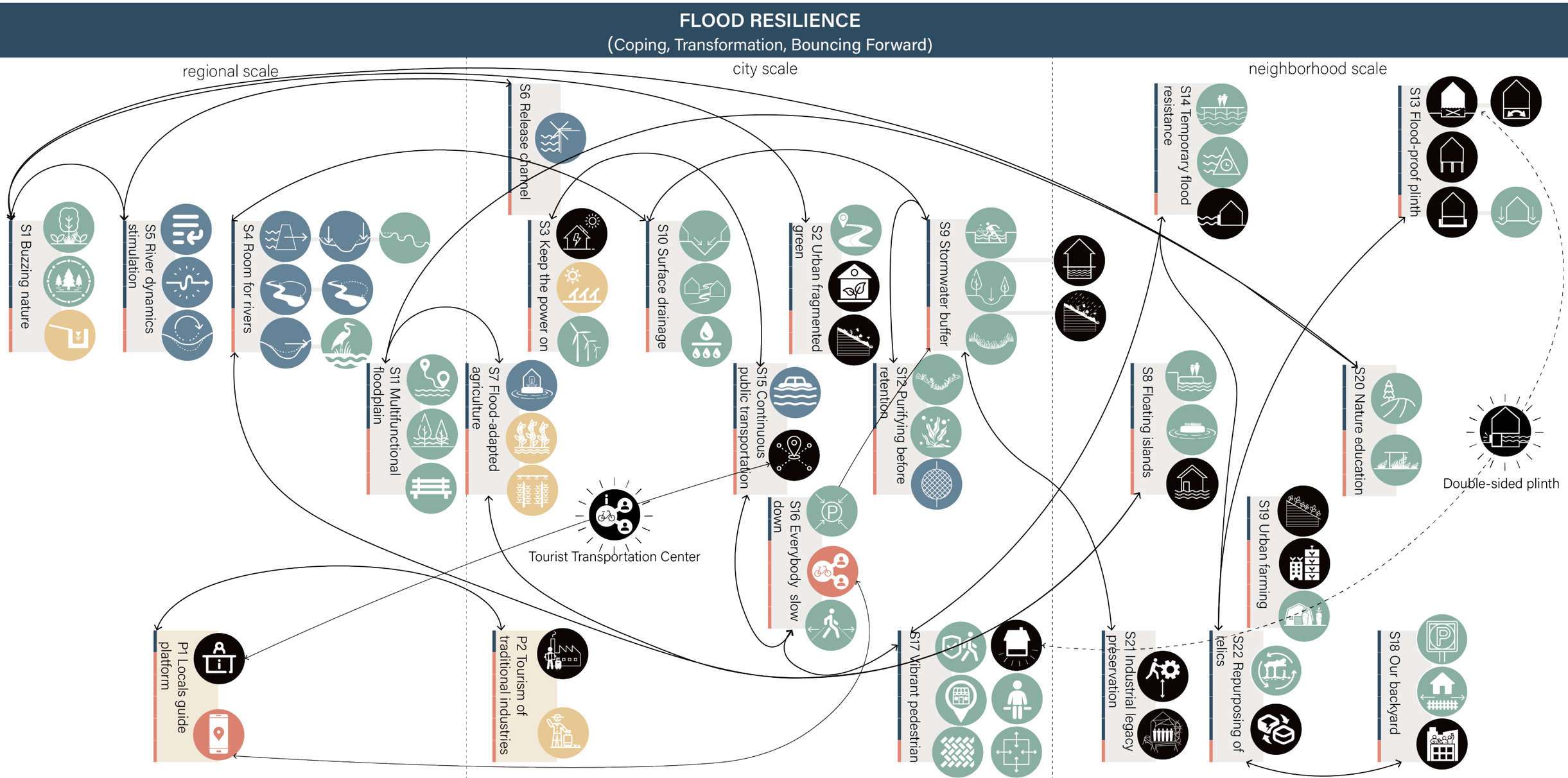
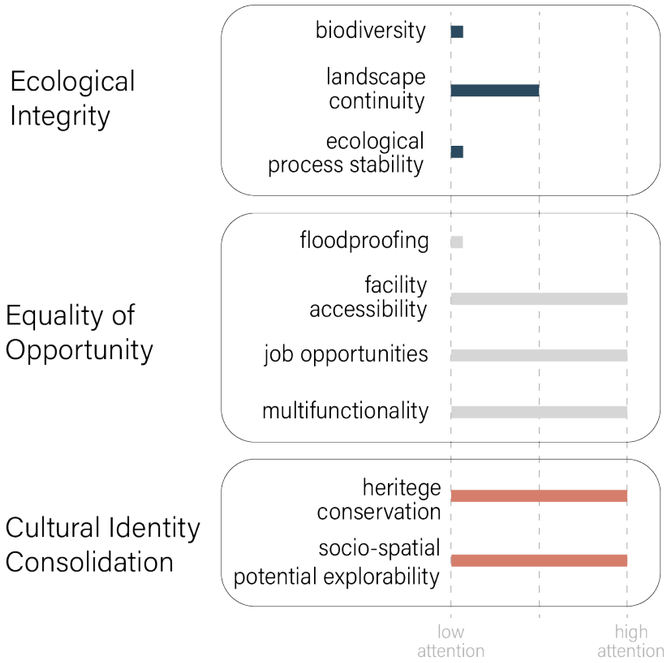


Figure 4.2.1.1 Relation between the patterns
Source: Author

4.2.2 Maximization scenario: leisure culture city

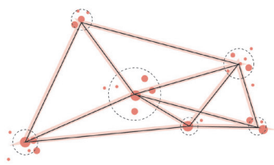
LAYERS OF LEISURE CULTURE CITY

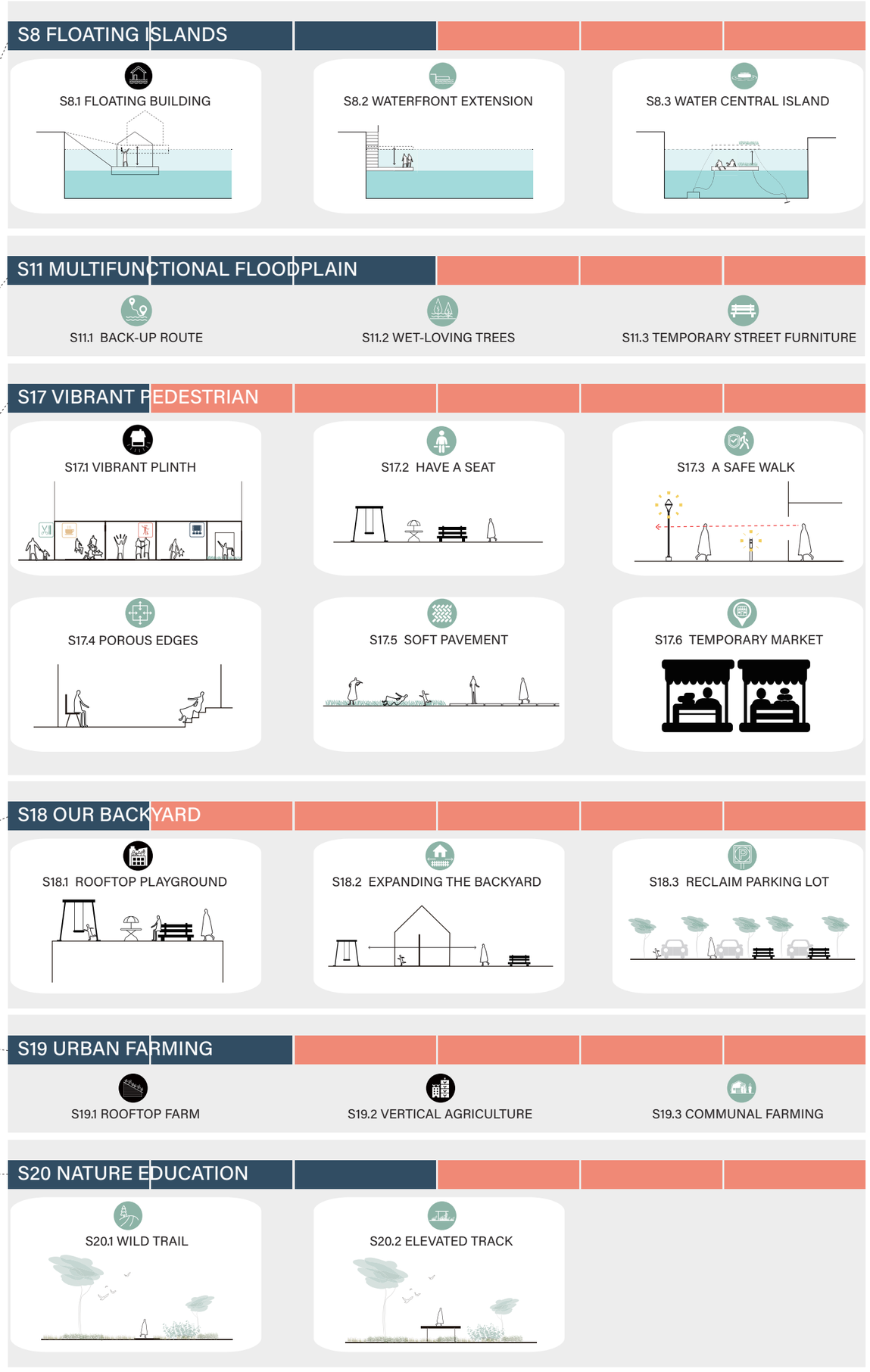


A city that can fully exploit its socio-spatial potential to promote the development of its leisure industry and reveal its cultural heritage (Figure 4.2.2.1).

Figure 4.2.2.1 Design goals of leisure cultural city
Source: Author

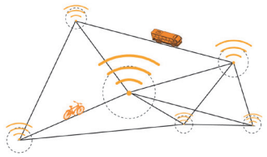
Create densified leisure activity networks by vibrant pedestrian areas and accessible natural landscapes.



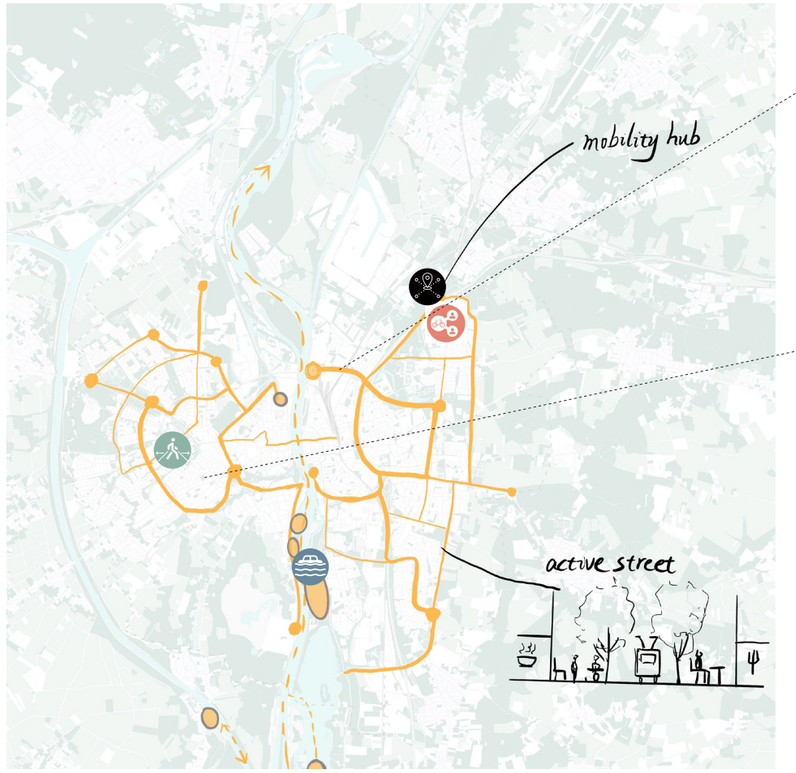


Complete public transportation

by diverse transportation options and shared mobility systems.

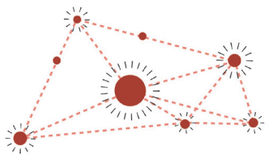


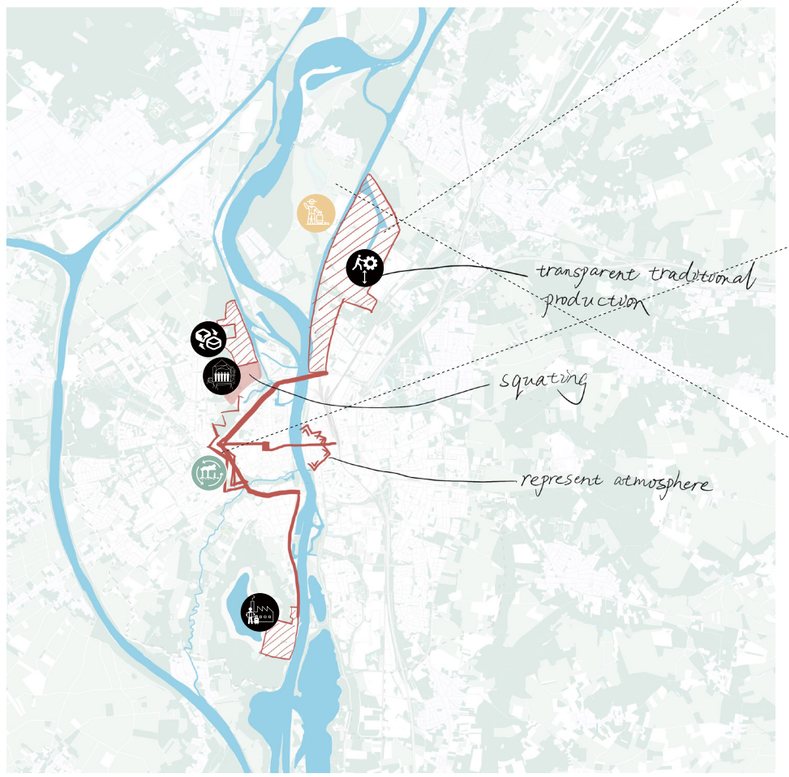
Centralized and intensified public transportation forms the backbone of the city



Reviving history and culture value

by reconnection of cultural landscape and inspiring past behaviors.

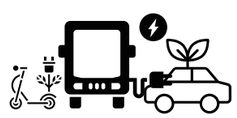




S15 CONTINUOUS PUBLIC TRANSPORTATION

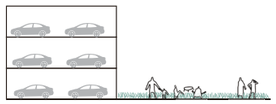
S15.1 GREEN WATERBUS

S15.2 MOBILITY HUB



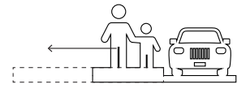
S16 EVERYBODY SLOW DOWN

S16.1 CENTRALIZED PARKING



S16.2 SHARED MICRO MOBILITY

S16.3 LARGER PEDESTRAIN



S21 INDUSTRIAL LEGACY PRESERVATION

S21.1 VERTICAL PRODUCTION

S21.2 SQUATTING

S22 REPURPOSING OF RELICS

S22.1 ENABLING FUNCTIONALITY

S22.2 BLENDING OLD AND NEW

P2 TOURISM OF TRADITIONAL INDUSTRIES

P2.1 VISUAL INDUSTRIAL PRODUCTION

P2.2 AGRICULTURAL EDUCATION

4.2.2 Maximization scenario: leisure culture city

SYSTEM OF LEISURE CULTURE CITY

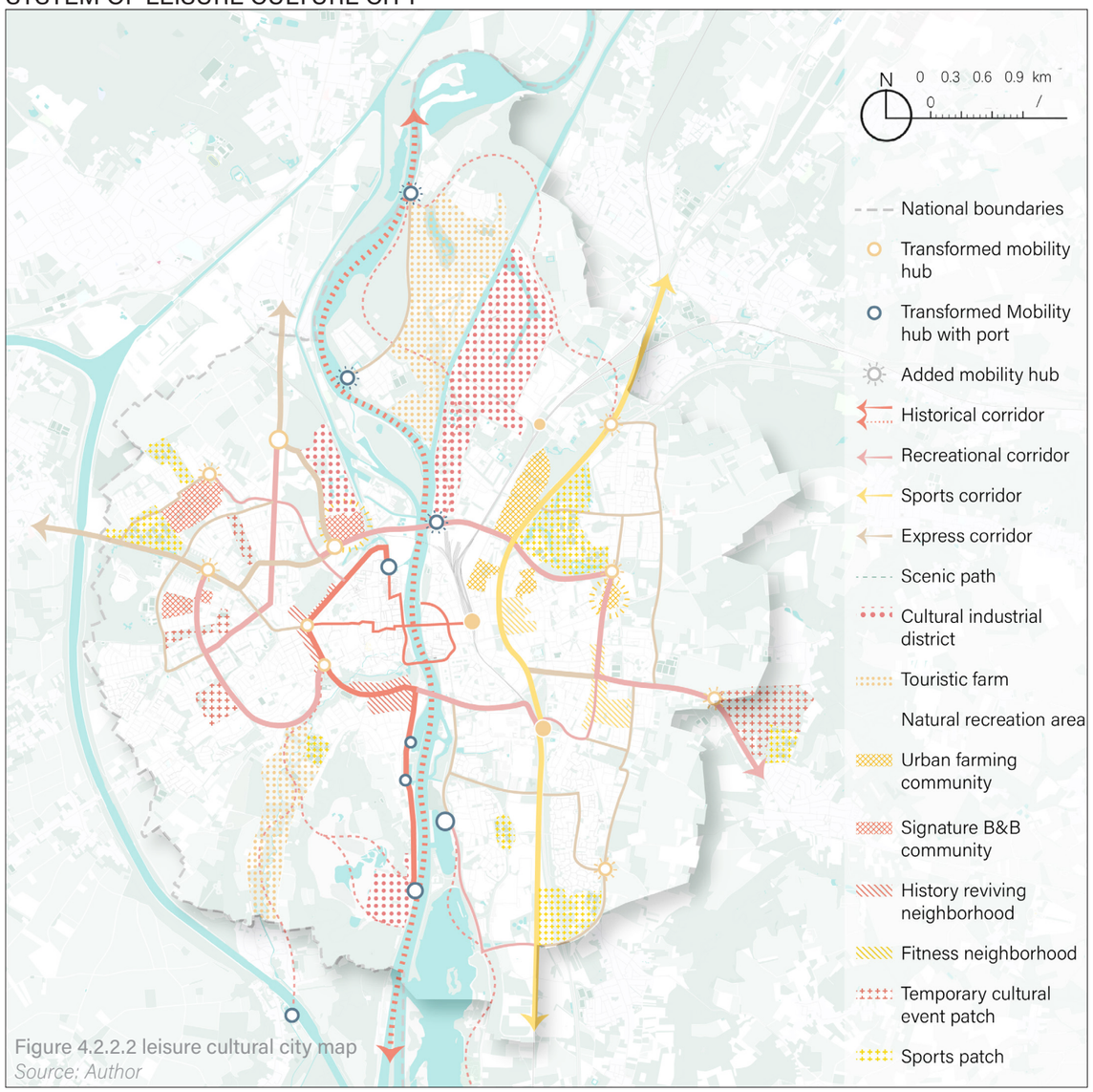


Figure 4.2.2.2 leisure cultural city map
Source: Author

The maximization scenario of the Leisure Culture City aims to create a vibrant urban environment where public transport is efficient, and residents have access to a wide range of leisure activities within the cultural landscape of Maastricht city. In this scenario, the spatial elements within the city are classified into different categories based on their local characteristics. The categories include historical and cultural elements, sport elements, leisure elements, and express elements (Figure 4.2.2.2).

The proposal aims to create diverse and unique leisure activities in different neighborhoods, promoting connectivity through a comprehensive public transportation system. This approach intends to alleviate population pressure in the city center by distributing recreational opportunities across various areas (Figure 4.2.2.3).

However, it is important to note that the current scenario does not include environmental and educational organizations, as well as the energy sector. Their involvement and consideration need to be addressed during the specific implementation phase to ensure a comprehensive and sustainable approach to urban development (Figure 4.2.2.4).

- Systemic Section

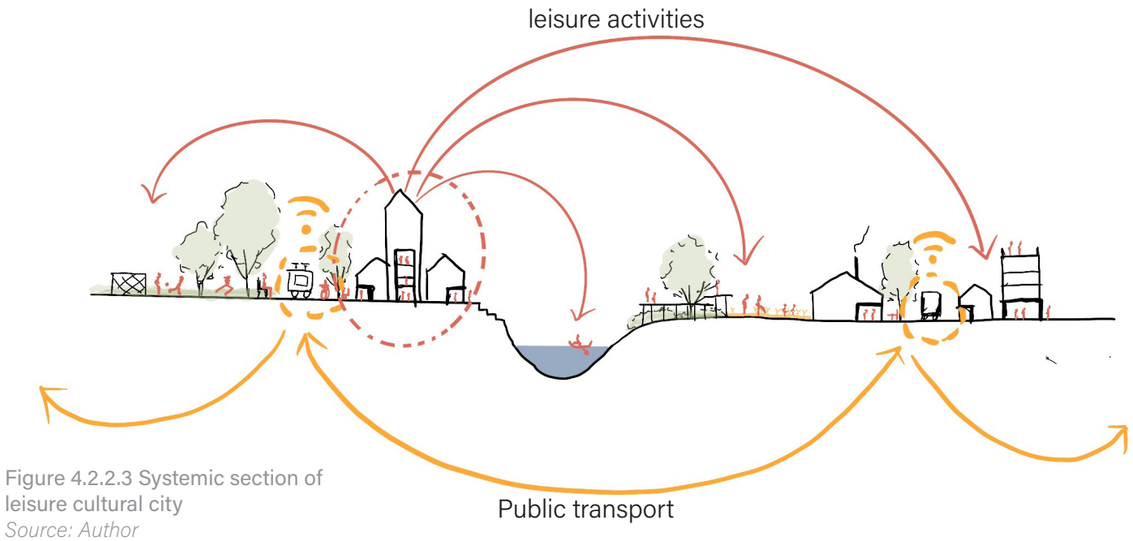


Figure 4.2.2.3 Systemic section of leisure cultural city
Source: Author

Enhance regional connectivity (in terms of transportation, social and cultural aspects)

- Stakeholder Evaluation

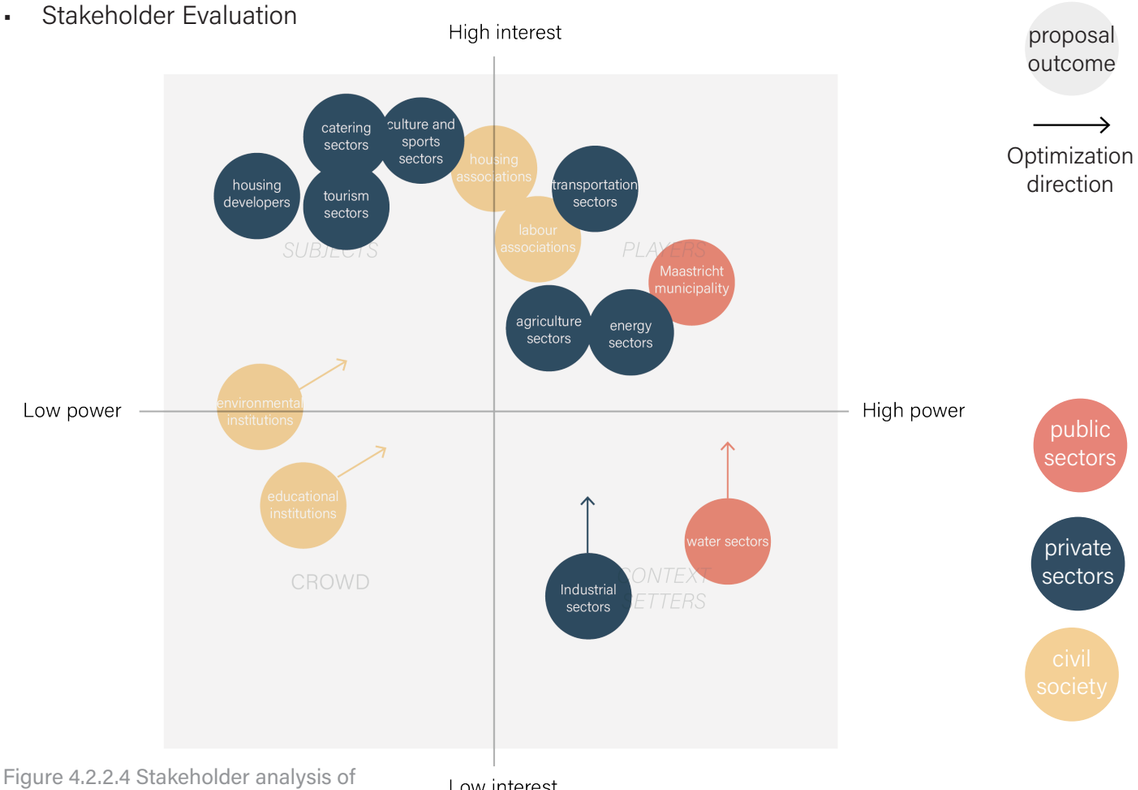


Figure 4.2.2.4 Stakeholder analysis of leisure cultural city
Source: Author

LEISURE SCENARIO EXPERIMENT AT NEIGHBORHOOD SCALE

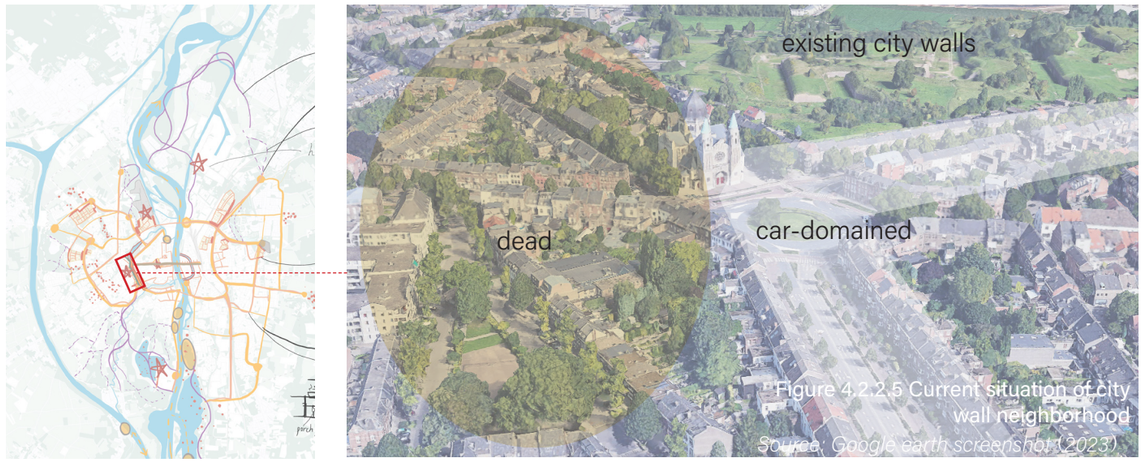


Figure 4.2.2.5 Current situation of city wall neighborhood
Source: Google earth screenshot (2023)

- CONCEPT: Rebuild the porous city wall

This neighborhood was once the site of the Maastricht city walls, which were demolished during the industrial era for the construction of a large number of houses, resulting in a loss of historical and cultural value (Figure 4.2.2.5). In order to restore the cultural value of this area and to stimulate the vitality of the area, this design experiment will extract the way the old city walls were built and used to recreate the spatial sense of the walls within the neighborhood and connect it to the existing walls (Figure 4.2.2.7).

Figure 4.1.2.5 Historical Maastricht city drawing
Source: Google image (2013)

Figure 4.2.2.6 Photo of existing historical city wall
Source: Google image (2021)

Ancient Maastricht had a special type of defense: **double walls**. Since most of the walls were not surrounded by water, to protect the city from invaders they built another wall that faced the first wall and had long brick tunnels in that wall.

When the enemies crossed the dry canal trying to climb the first wall and **enter the dry canal (trap)** surrounding the second wall of Maastricht (Figure 4.1.2.5). The **soldiers crouching inside the tunnels of the second wall launched a surprise attack**. These holes were located where they could be shot into the canal without hitting the wall. The wall was built like a star shape and they would shoot into each corner (Figure 4.2.2.6). This excellent method of defense kept Maastricht safe for a long time.

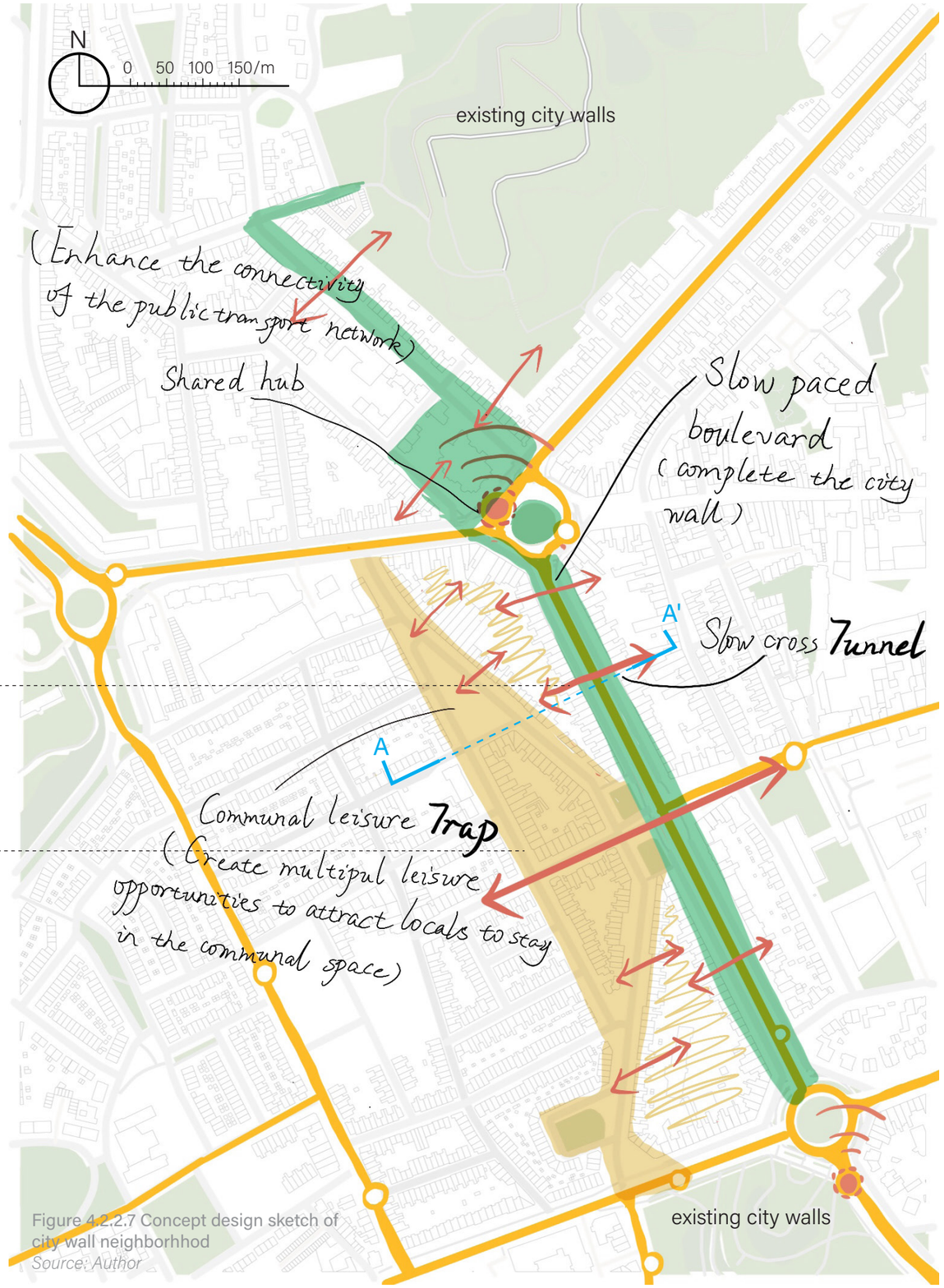


Figure 4.2.2.7 Concept design sketch of city wall neighborhhod
Source: Author

4.2.2 Maximization scenario: leisure culture city

IMPLEMENTATION SCENARIO AT NEIGHBORHOOD SCALE

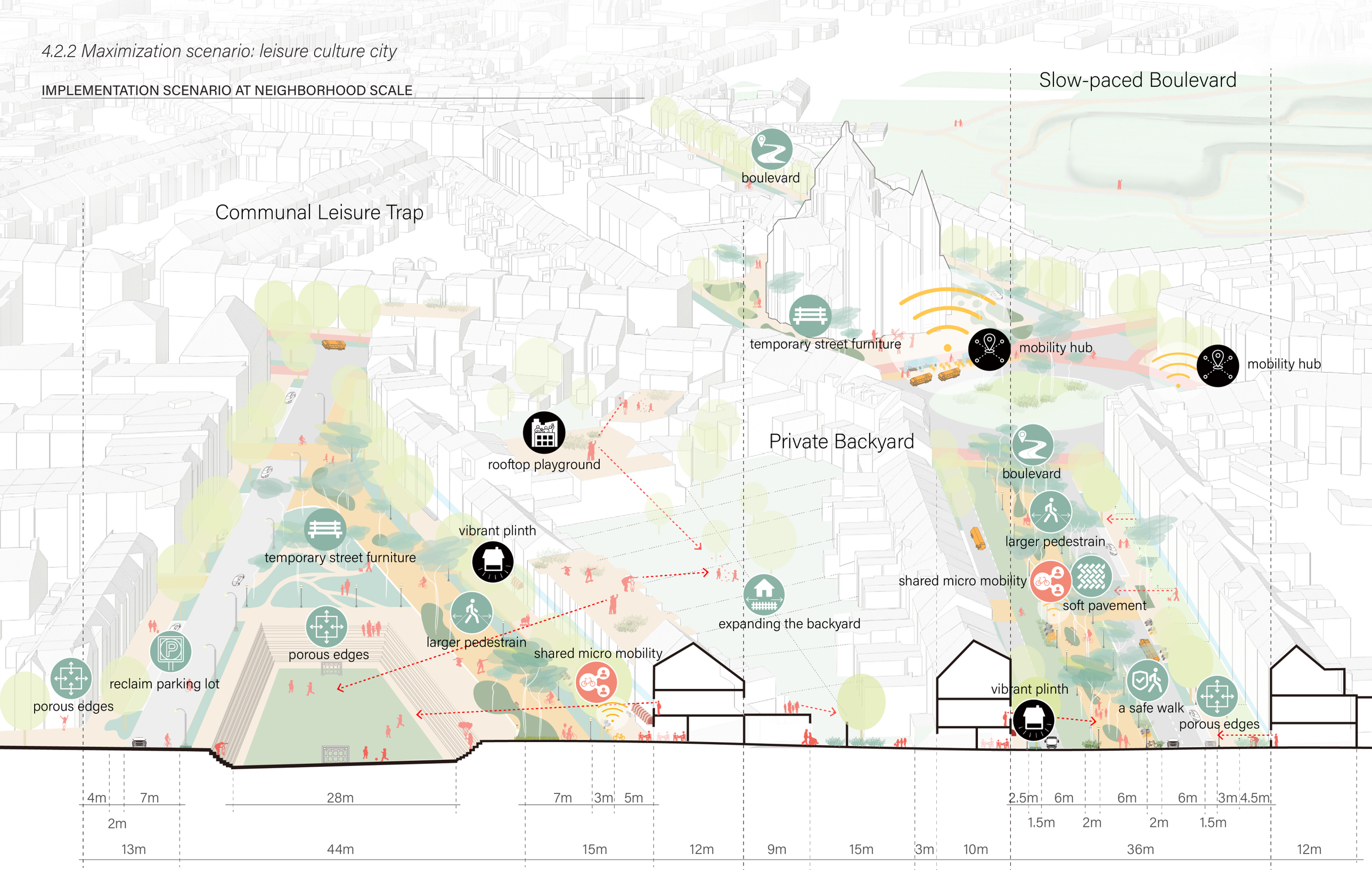
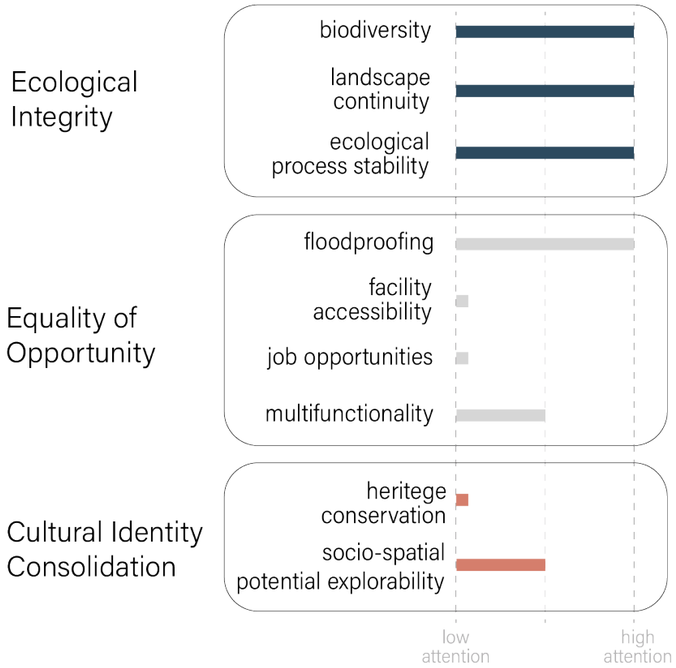


Figure 4.2.2.8 Implementation of leisure culture city scenario at neighborhood scale
Source: Author

Perspective section AA' 1: 450

4.2.3 Maximization scenario: eco-water city

LAYERS OF ECO-WATER CITY

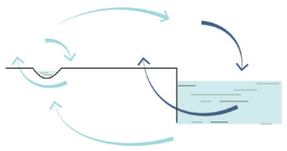


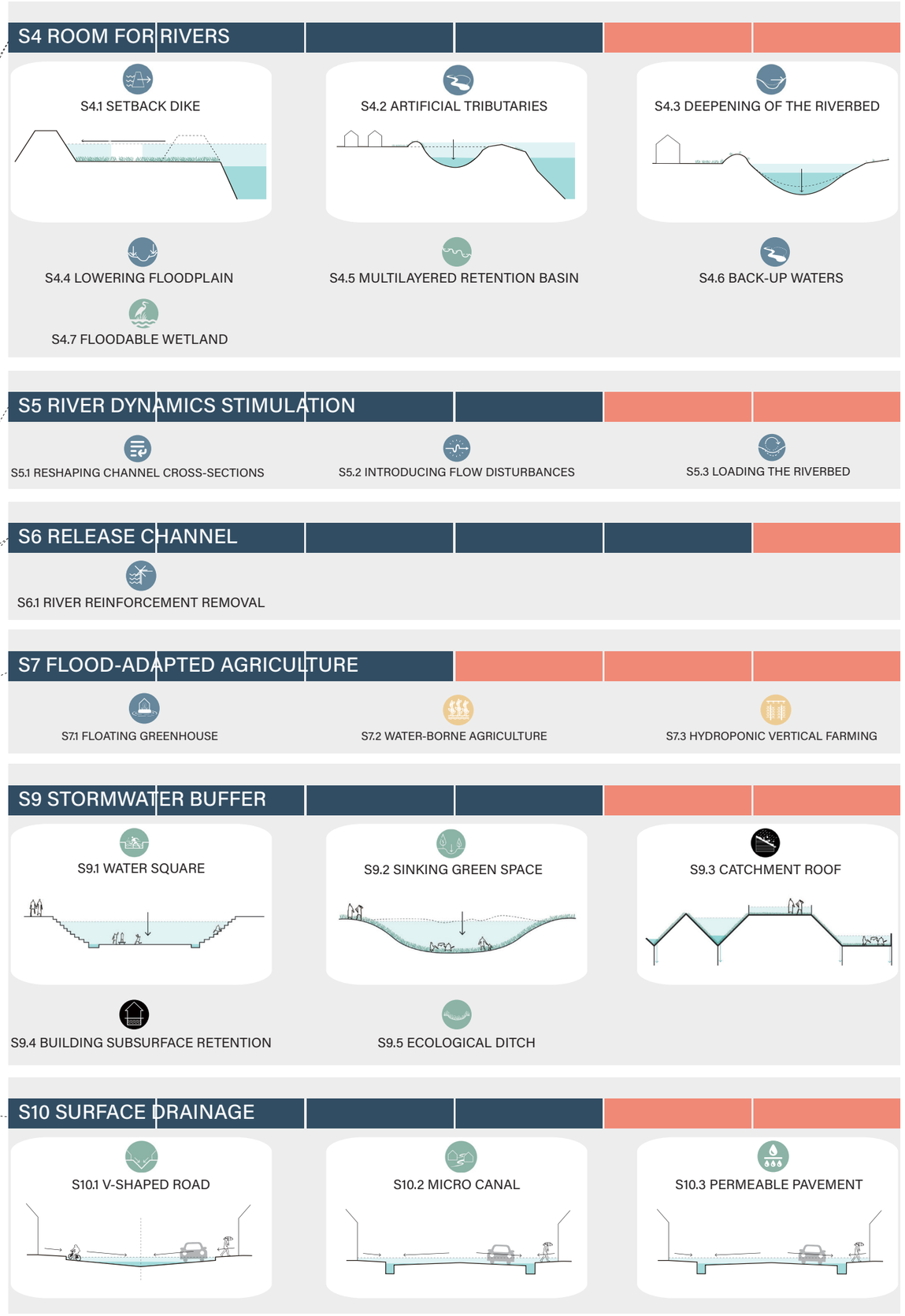
A city retains the maximum amount of water and respects the ecological integrity of the territory (Figure 4.2.3.1).

Figure 4.2.3.1 Design goals of eco-water city
Source: Author

Close sensitive water loop

by highly water-sensitive public spaces with connected water systems.



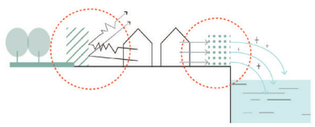


Stitch up green

by urban ecological corridors and natural patches.

Insurance on eco-quality

by purification and isolation systems at the urban interfaces



S1 BUZZING NATURE

S1.1 MULTI-LAYERED VEGETATION

S1.2 LEAVE NATURE WILD

S1.3 ECOLOGICAL IRRIGATION CANAL

S2 URBAN FRAGMENTED GREEN

S2.1 BOULEVARD

S2.2 ECO-FACADE

S2.3 ROOF GREEN

S3 KEEP THE POWER ON

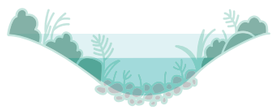
S3.1 SOLAR ROOF

S3.2 FLOATING SOLAR PARK

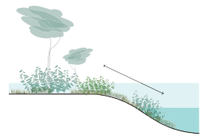
S3.3 WIND TURBINE PARK

S12 PURIFYING BEFORE RETENTION

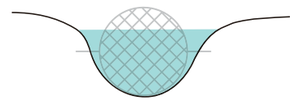
S12.1 BIOSWALES



S12.2 WATER PURIFICATION PLANTS

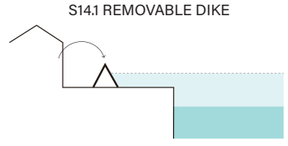


S12.3 STRAINERS

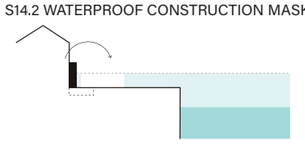


S14 TEMPORARY FLOOD RESISTANCE

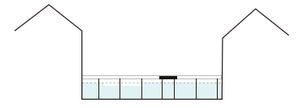
S14.1 REMOVABLE DIKE



S14.2 WATERPROOF CONSTRUCTION MASK



S14.3 PASSAGE IN FLOODS



4.2.3 Maximization scenario: eco-water city

SYSTEM OF ECO-WATER CITY

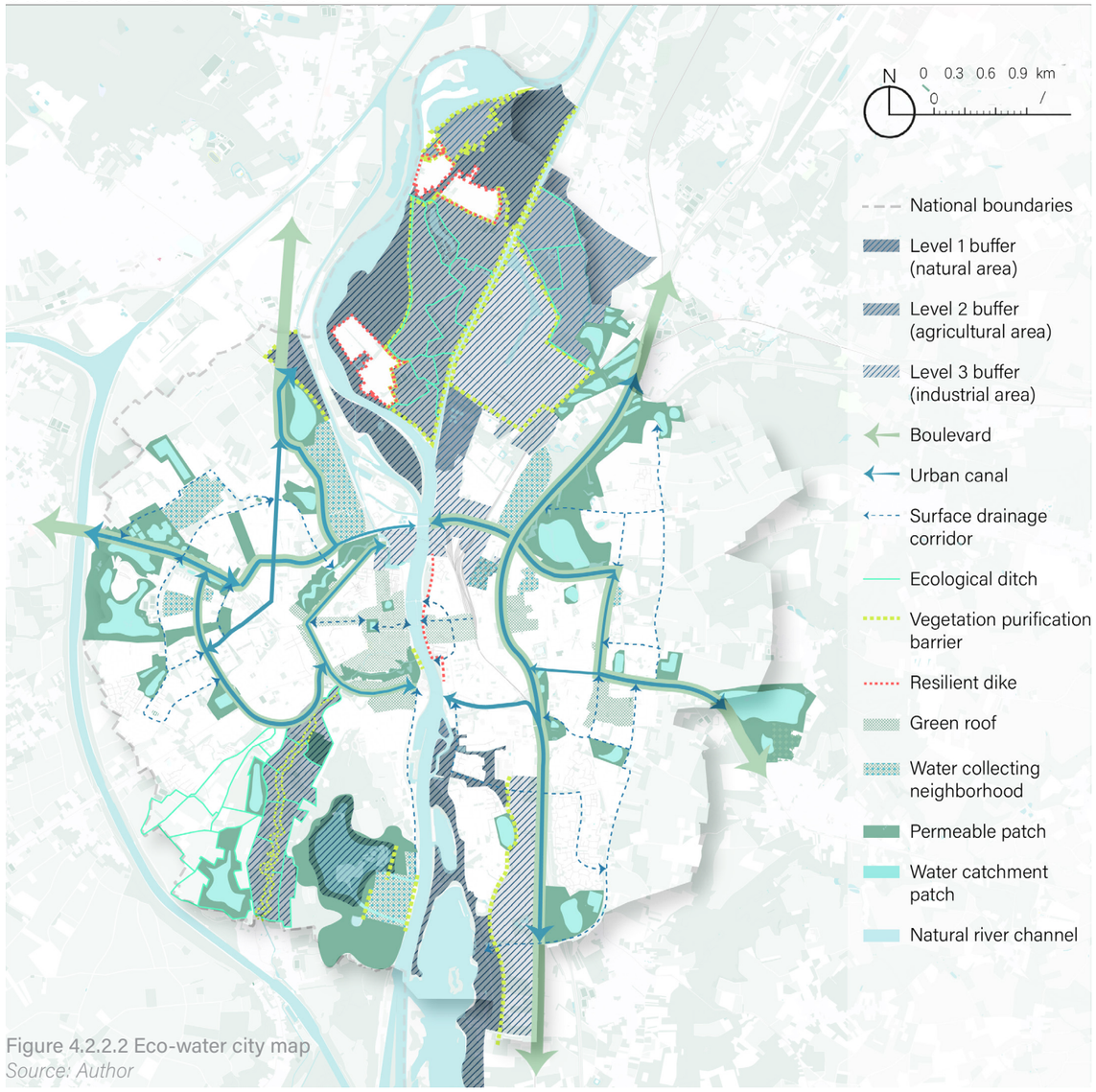


Figure 4.2.2.2 Eco-water city map
Source: Author

In the eco-water city scenario, the transformation of Maastricht's cultural landscape into blue-green infrastructure prioritizes flood resilience and ecological improvement (Figure 4.2.2.2). The proposal emphasizes the creation of a local water circulation loop, treating rainwater within the city and expanding river buffers (Figure 4.2.2.3). Water purification facilities in each neighborhood ensure water quality (Figure 4.2.2.3).

However, the proposal may face challenges in providing direct benefits to private sectors and addressing social issues through job creation (Figure 4.2.2.4). It is crucial to consider the integration of private sector participation and address social concerns during the concrete implementation phase.

- Systemic Section

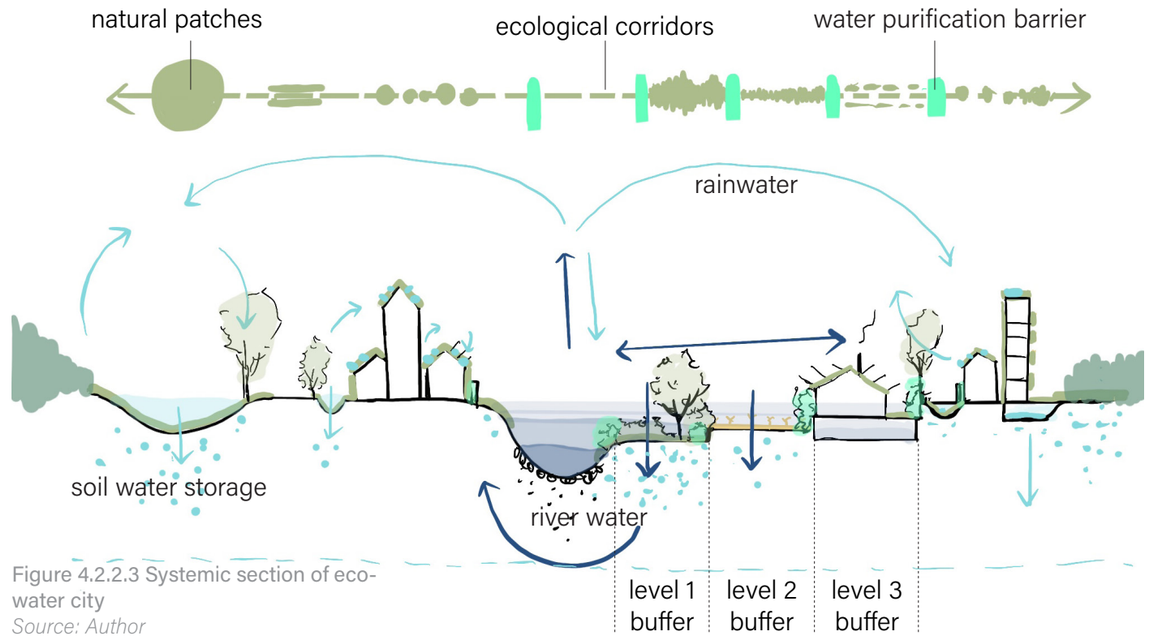


Figure 4.2.2.3 Systemic section of eco-water city
Source: Author

Enhancing regional connectivity (in terms of ecosystem, water circulation, urban interface)

- Stakeholder Evaluation

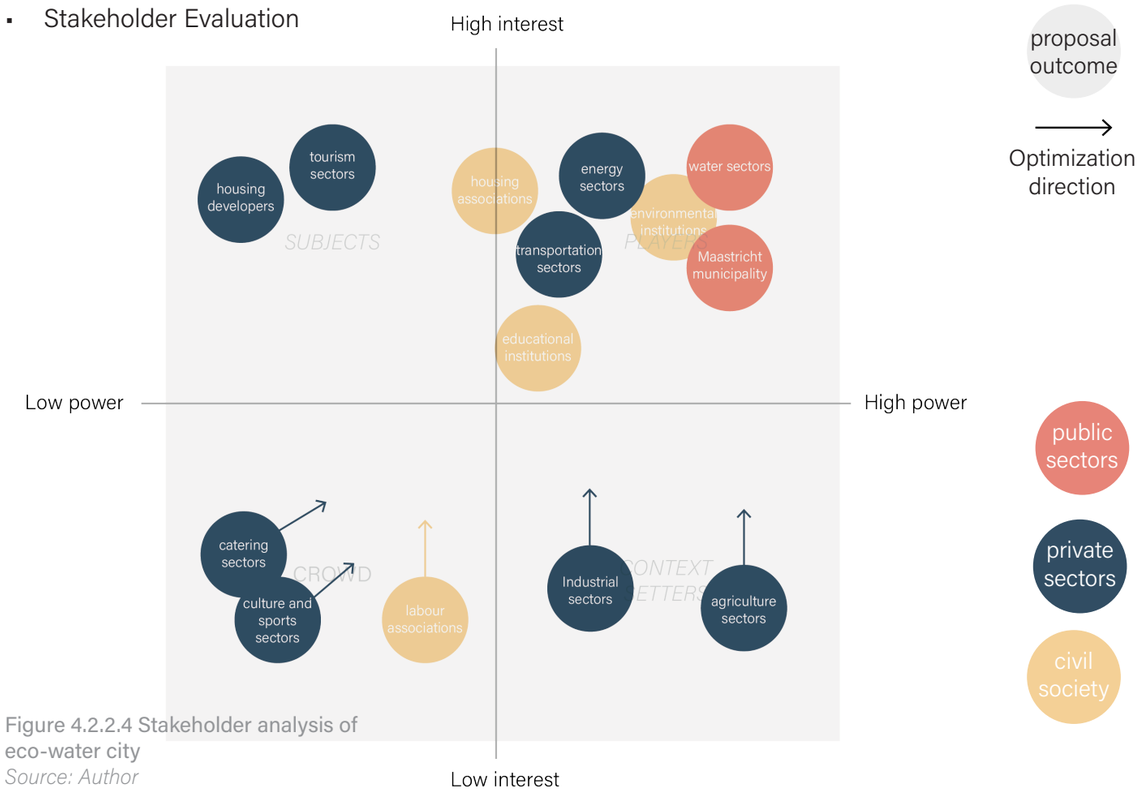


Figure 4.2.2.4 Stakeholder analysis of eco-water city
Source: Author

4.2.3 Maximization scenario: eco-water city

IMPLEMENTATION SCENARIO AT NEIGHBORHOOD SCALE

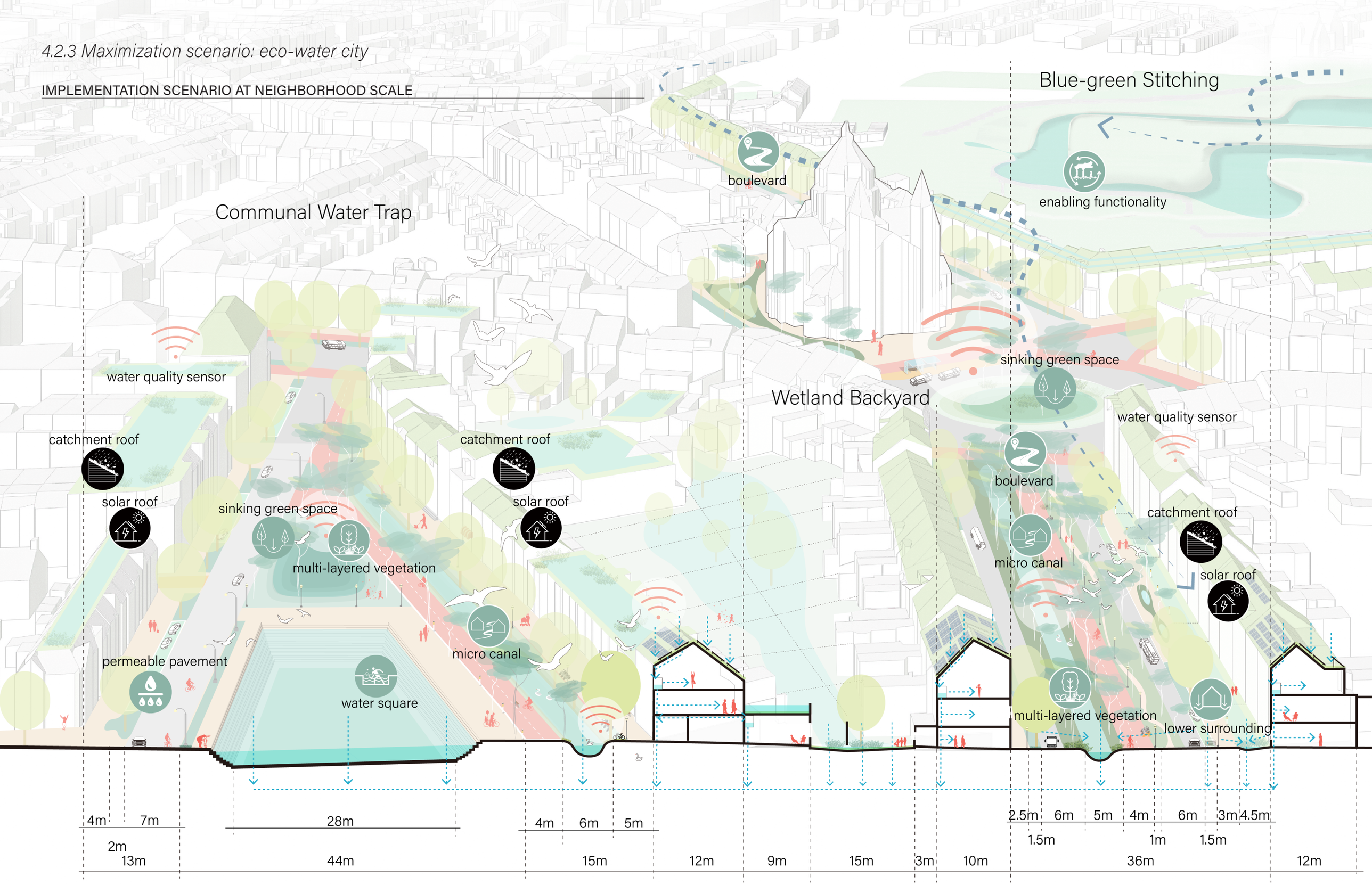
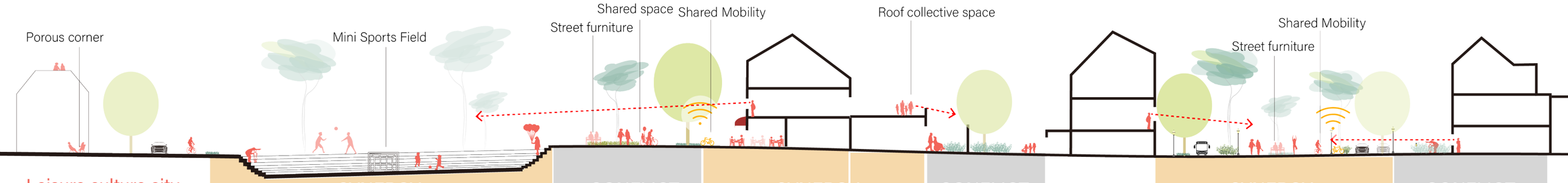


Figure 4.2.2.5 Implementation of eco-water city scenario at neighborhood scale
Source: Author

Perspective section AA′ 1: 450

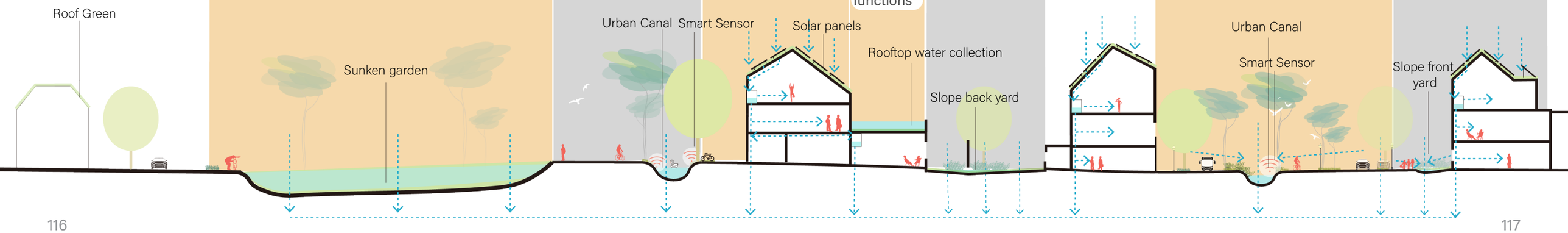
CONFLICTS AND SYNERGIES AT NEIGHBORHOOD SCALE



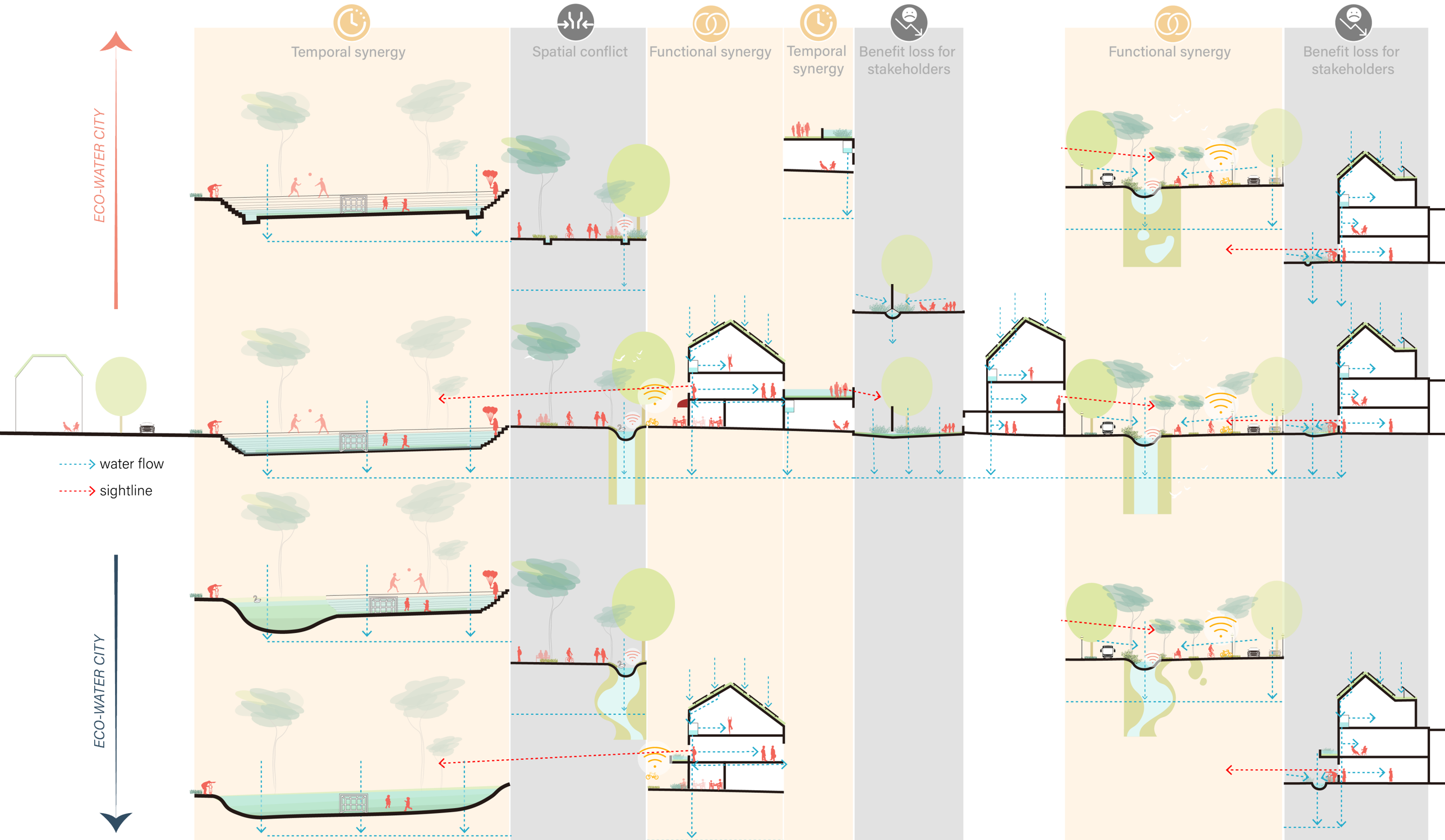
Leisure culture city

SYNERGY	CONFLICT	SYNERGY		CONFLICT	SYNERGY	CONFLICT
Temporal synergy	Spatial conflict	Functional synergy	Temporal synergy	Benefit loss for stakeholders	Functional synergy	Benefit loss for stakeholders
The sunken plaza collects and purifiys rainwater when it rains, and serves as a mini sports field to provide more leisure activities for residents during the normal time.	The street is functionally complex but space is limited to accommodate wide pedestrian paths, green spaces and waterways at the same time, and the footprint of these objects will need to be adjusted.	The energy saved by the solar panels on the roof and the water collected can be used by the leisure businesses on the ground floor, thus reducing their operating costs and carbon footprint and facilitating the closing of the water loop.	The roof collects rainwater when it rains, and serves as a communal space to provide more leisure activities for residents during the normal time.	Due to the time needed for water to infiltrate, private owners have less time to use the backyard, and in addition, the extra rain increases the amount of work required to clean up afterwards.	Canals provide recreational activities and help regulate the urban microclimate, improving the quality of the pedestrian environment.	Due to the time needed for water to infiltrate, private owners have less time to use the front yard, and in addition, the extra rain increases the amount of work required to clean up afterwards.
Strictly limit the use time of different functions	Adjust the footprint of these objects.	Leisure businesses participate in roof renovations	Strictly limit the use time of different functions	Programs or space measures to compensate private owners	Create more recreational spaces and facilities for water-related leisure activities	Programs or space measures to compensate private owners

Eco-water city



VARIATION IN DESIGN AT NEIGHBORHOOD SCALE



CONFLICTS AND SYNERGIES AT CITY SCALE

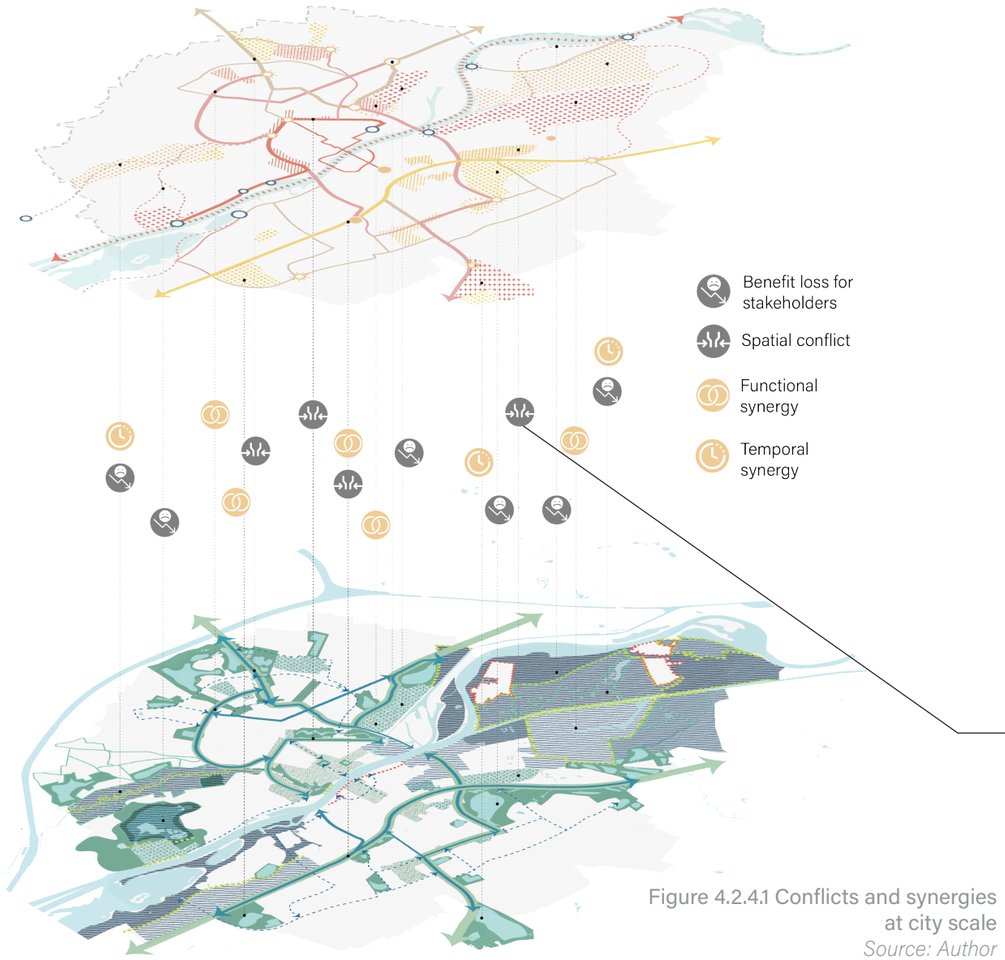


Figure 4.2.4.1 Conflicts and synergies at city scale
Source: Author

- **Functional Synergy:**

Promote functional synergy in urban design by integrating diverse functions through **mixed-use development, incorporating blue-green infrastructure, prioritizing walkability, connectivity, and amenities,** while emphasizing efficient transportation and supportive infrastructure to enhance overall functionality and community vitality.

- **Spatial conflict:**

Analyze spatial conflicts, utilize zoning regulations, mixed-use development, and buffer zones, foster stakeholder collaboration, and design interventions for conflict resolution and urban enhancement.

- **Benefit Loss for Stakeholders:**

Conduct thorough stakeholder analysis, engage in **inclusive decision-making**, and seek win-win solutions to address stakeholder needs, concerns, and desires while minimizing potential losses through **careful planning, resource allocation, negotiation, and compensation**.

- **Temporal Synergy:**

Maximize urban space utilization and efficiency by effectively managing complex functions through **strategic differentiation of timing**, **implementing schedules**, and **considering weather conditions**, thereby minimizing conflicts and enhancing operational smoothness.

DECISION MAKING

The Maximization Scenario approach seeks to integrate both design scenarios to maximize design goals, followed by stakeholder discussions on synergies and conflicts for the final decision (Figure 4.2.4.1). However, due to time constraints, this study lacked stakeholder workshops and relied on the researcher's design experience. Nevertheless, recognizing the importance of stakeholder engagement in real projects, this study will use the work of "Cities of Making" as an example to demonstrate the decision-making process (Figure 4.2.4.2, 4.2.4.3).

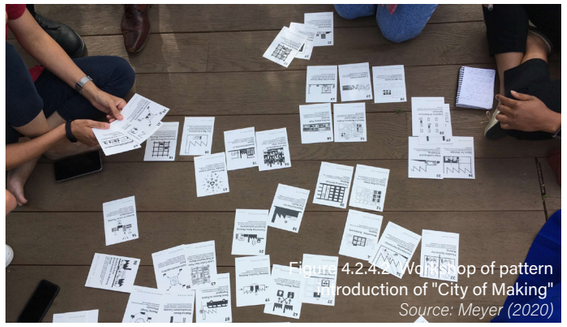
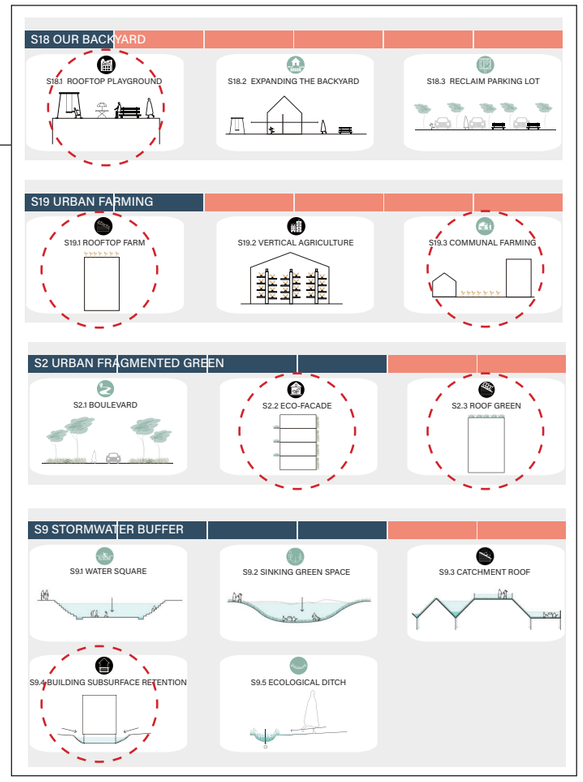


Figure 4.2.4.2 Workshop of pattern introduction of "City of Making"
Source: Meyer (2020)

Figure 4.2.4.3 Workshop of pattern application of "City of Making"
Source: Meyer (2020)

Eg:



- **Communicate the patterns:**

Present the pattern language related to each synergy and conflict separately to relevant stakeholders (Figure 4.2.4.2), including Maastricht municipality, water sectors, tourism sectors, catering sectors, transportation sectors, agriculture sectors, industrial sectors, energy sectors, culture and sports sectors, housing developers, educational institutions, environmental institutions, housing associations, and labour associations. Explain the purpose and meaning of each pattern, emphasizing how they address specific design challenges and contribute to the overall goals of the city.

- **Apply the patterns:**

Stakeholders are encouraged to select or modify these patterns in their decision making process. During design discussions, the pattern language is referenced to guide the implementation and resolution of synergies and conflicts, making the final design choices and evaluation of solutions (Figure 4.2.4.3).

- **Iterate and refine:**

As the design process progresses, continuously evaluate and refine the pattern language. Seek feedback from stakeholders and incorporate their insights into the language. Patterns that prove successful in addressing design challenges can be reinforced, while new patterns may emerge based on the unique context of the city.

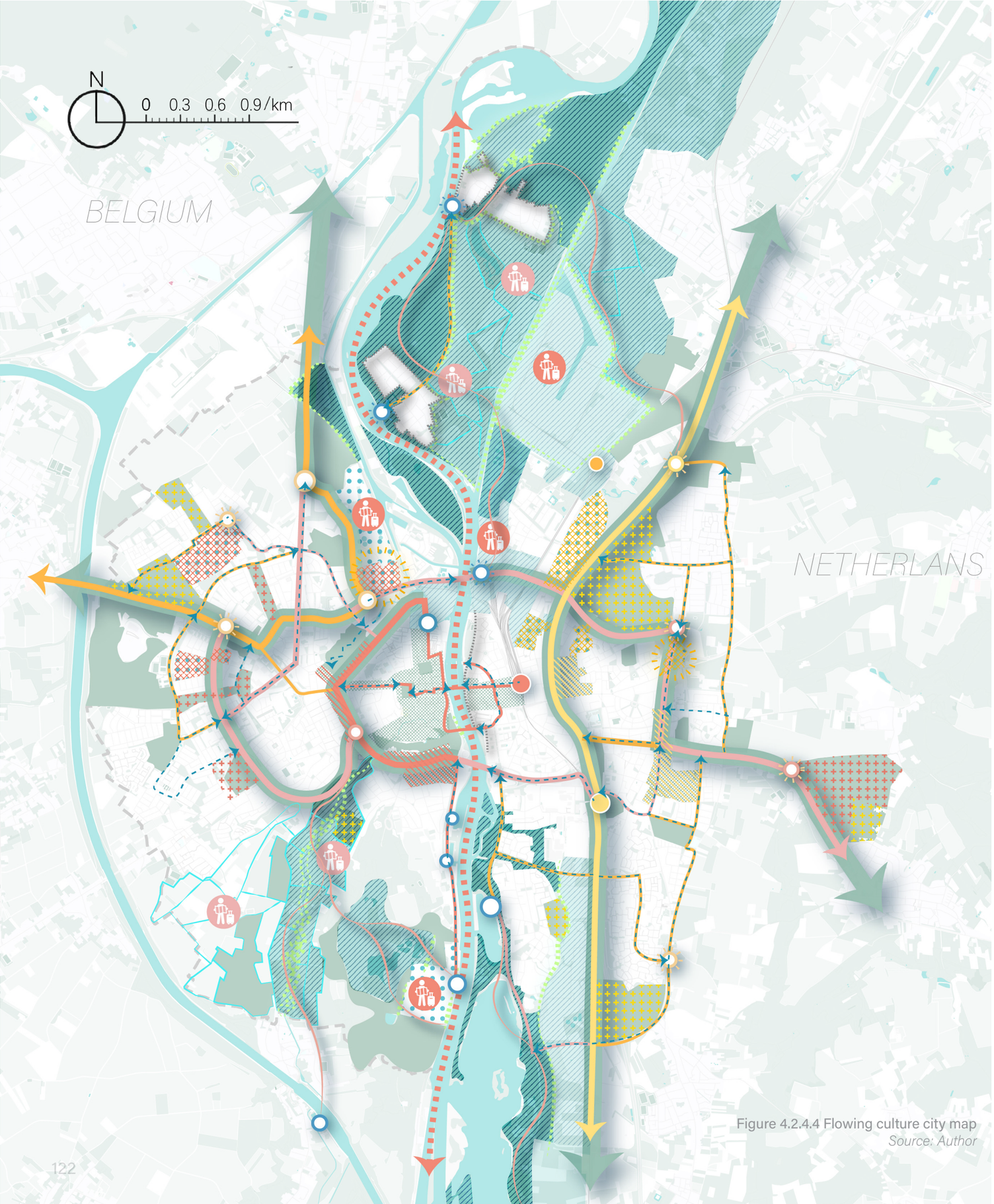


Figure 4.2.4.4 Flowing culture city map
Source: Author

4.2.4 Integrated design proposals

FLOWING CULTURE CITY

By carefully considering the synergies and conflicts between the two maximized scenarios, the study aims to reconcile the claims of both and integrate them into the concept of a "flowing culture city." This design scheme incorporates the six predefined visioning typologies but further refines them into functional categories that are tailored to the complexities of the urban system, taking into account the specific positioning of different neighborhoods and their surroundings (Figure 4.2.4.4).

Importantly, this design is not limited to the city boundaries but extends to the surrounding suburbs through corridors, rivers, and buffers, thereby enhancing ecological and cultural benefits and promoting broader connectivity and integration.

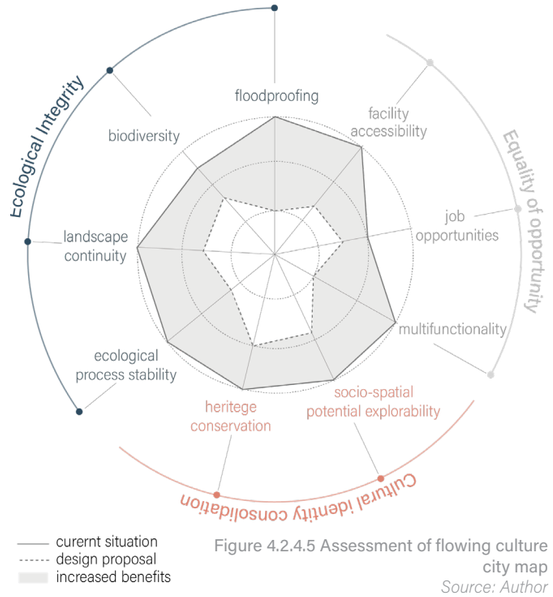


Figure 4.2.4.5 Assessment of flowing culture city map
Source: Author

In addition, the value of each pattern, which contributes to the design goal, is summed by assigning a percentage weight based on the area covered by different patterns, and the resulting total score can be used to evaluate the holistic design (Figure 4.2.4.5).

- National boundaries
- Natural river channel
- Level 1 buffer (natural area)
- Level 2 buffer (agricultural area)
- Level 3 buffer (industrial area)
- Vegetation purification barrier
- Ecological ditch
- Resilient dike
- Canal Boulevard
- Surface drainage corridor
- Water mobility hub
- Green roof
- Water-sensitive industrial area
- Catchment green hub
- Express corridor
- Key mobility hub
- Mobility hub
- Historical corridor
- Historical mobility hub
- Historic scenic neighborhoods
- Temporary cultural event hub
- Industrial culture tourism
- Recreational corridor
- Sports mobility hub
- Water-sensitive urban farming neighborhood
- Water-sensitive B&B community
- Agritourism
- Scenic path
- Sports corridor
- Sports mobility hub
- Water Fitness Neighborhood
- Sunken sports green hub

SELECTION OF LOCATIONS

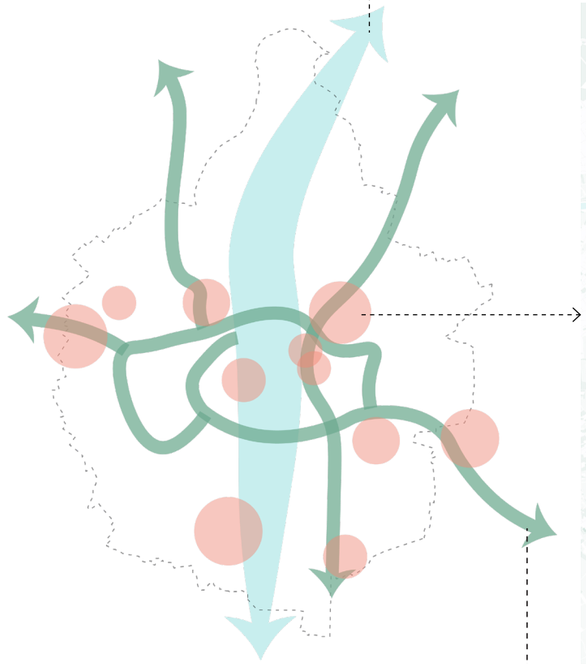
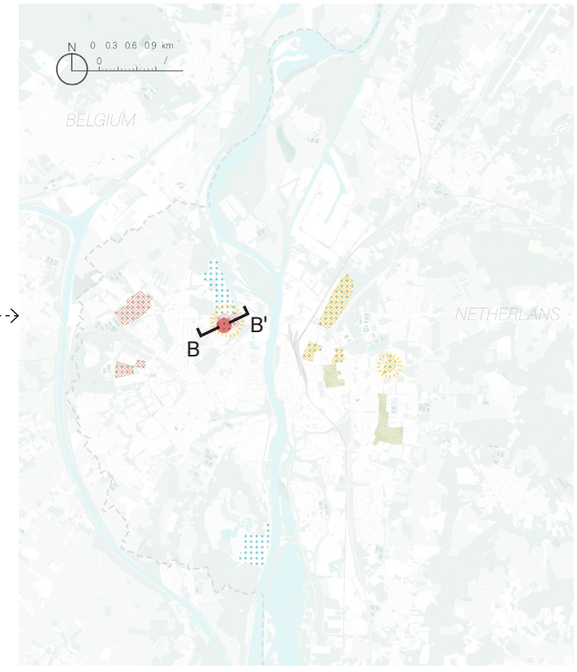


Figure 4.3.1.1 Key structure of Flowing Culture City
Source: Author

Benefit Densification

Main role: Enhance cultural core

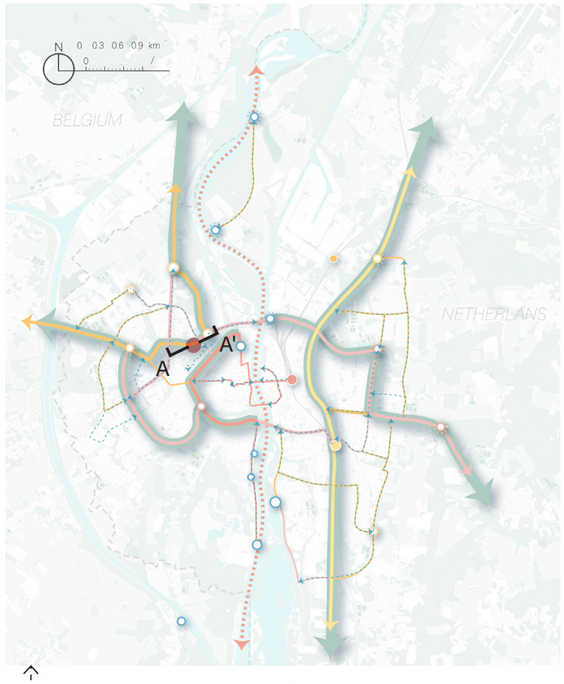


plan:

More affordable housing and jobs opportunities for low-income residents.

City Skeleton

Enhance connectivity of Ecology and Transportation

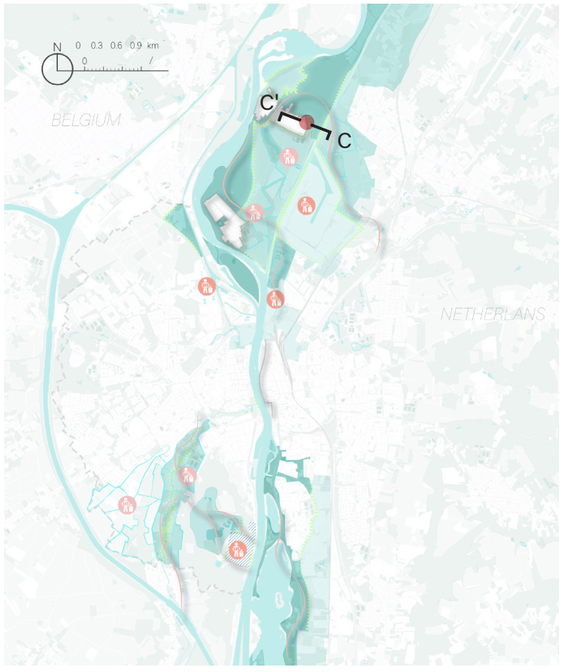


plan:

Establish a regional leisure chain to expand the advantages and involve more stakeholders in the pursuit of more leisure opportunities and related benefits.

Buffer

Extend water management



plan:

Stabilizing the water level of the Maas River in different seasons to ensure navigation.

The Flowing Culture City plan presents a comprehensive outline of the cultural landscape within the core and corridor areas (Figure 4.3.1.1). It aims to address the residents' needs for seamless public transportation and affordable housing. To demonstrate the spatial atmosphere and the plan's effectiveness, three carefully selected locations have been designated as representative examples (Figure 4.3.1.1).

At a human level, these pilot projects play a crucial role in showcasing the integration of flood management strategies with the leisure industry. They serve as practical demonstrations of how these elements can harmoniously coexist. By successfully merging flood management measures with leisure activities, these initiatives contribute to shaping and enhancing the overall spatial atmosphere of the city.

These selected locations are integral to the success of the plan, as they highlight their unique characteristics and their ability to meet the demands and preferences of the local community. Through these representative locations, the plan demonstrates their significant contributions to the overall fabric and development of the city.

In summary, the Flowing Culture City plan strategic elements such as public transportation, affordable housing, flood management, and leisure industry integration. By showcasing the seamless fusion of these components, the plan effectively shapes and enhances the spatial atmosphere, while meeting the diverse needs of the local community.

BENEFIT DENSIFICATION IMPLEMENTATION

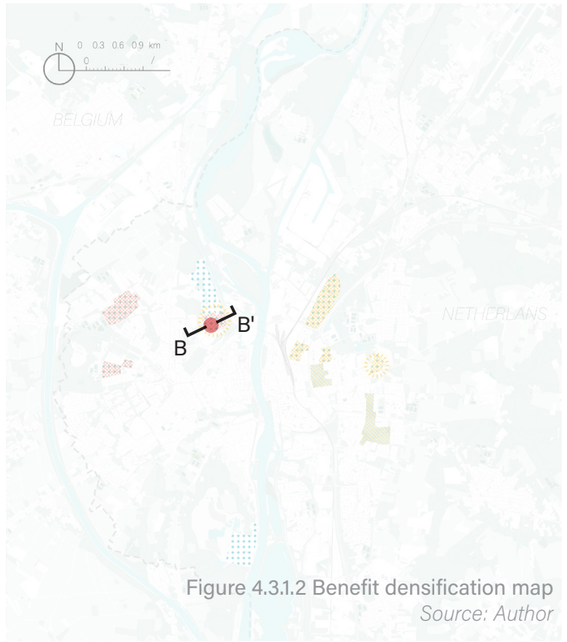


Figure 4.3.1.2 Benefit densification map
Source: Author

The regeneration of Maastricht's industrial areas has always been part of the municipality's plans. The demolished industrial area has a huge potential for densification projects, considering the urgent need for affordable housing for local residents. In addition, it offers a unique opportunity to demonstrate how new buildings can address Maastricht's future challenges, such as flooding and the development of the leisure industry (Figure 4.3.1.2). By using this space for development, the city can demonstrate its commitment to a sustainable and adaptive future, while meeting the housing needs of its residents.

The process will encounter a number of opportunities and challenges. One opportunity lies in preserving industrial heritage, repurposing historic structures to enhance the cultural identity of the new residential area (Figure 4.3.1.3). However, challenges include integrating sustainable drainage systems, implementing flood-proof building designs, and creating suitable evacuation routes. The preservation of existing industrial heritage structures further complicates the process.

To tackle these challenges, stakeholders must collaborate effectively. The Maastricht municipality should lead the coordination efforts, bringing together developers, architects, engineers, and local residents (Figure 4.3.1.4). Open communication, shared expertise, and regular consultations are vital to ensure the integration of flood management measures and the preservation of industrial heritage. Involving the community in decision-making processes fosters a sense of ownership and promotes a successful transformation that meets the needs of all stakeholders.

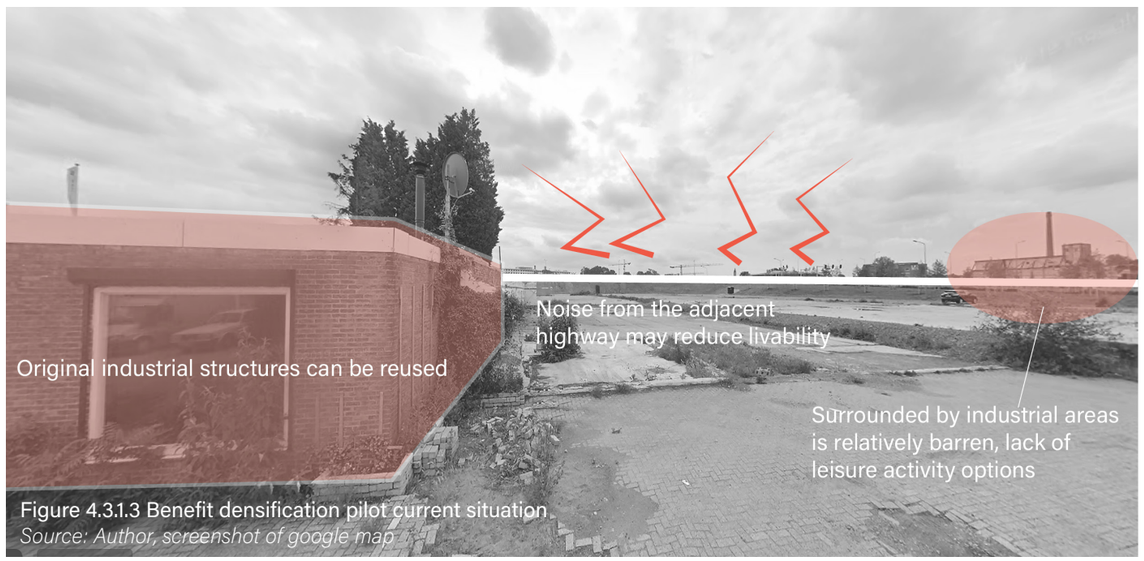


Figure 4.3.1.3 Benefit densification pilot current situation
Source: Author, screenshot of google map

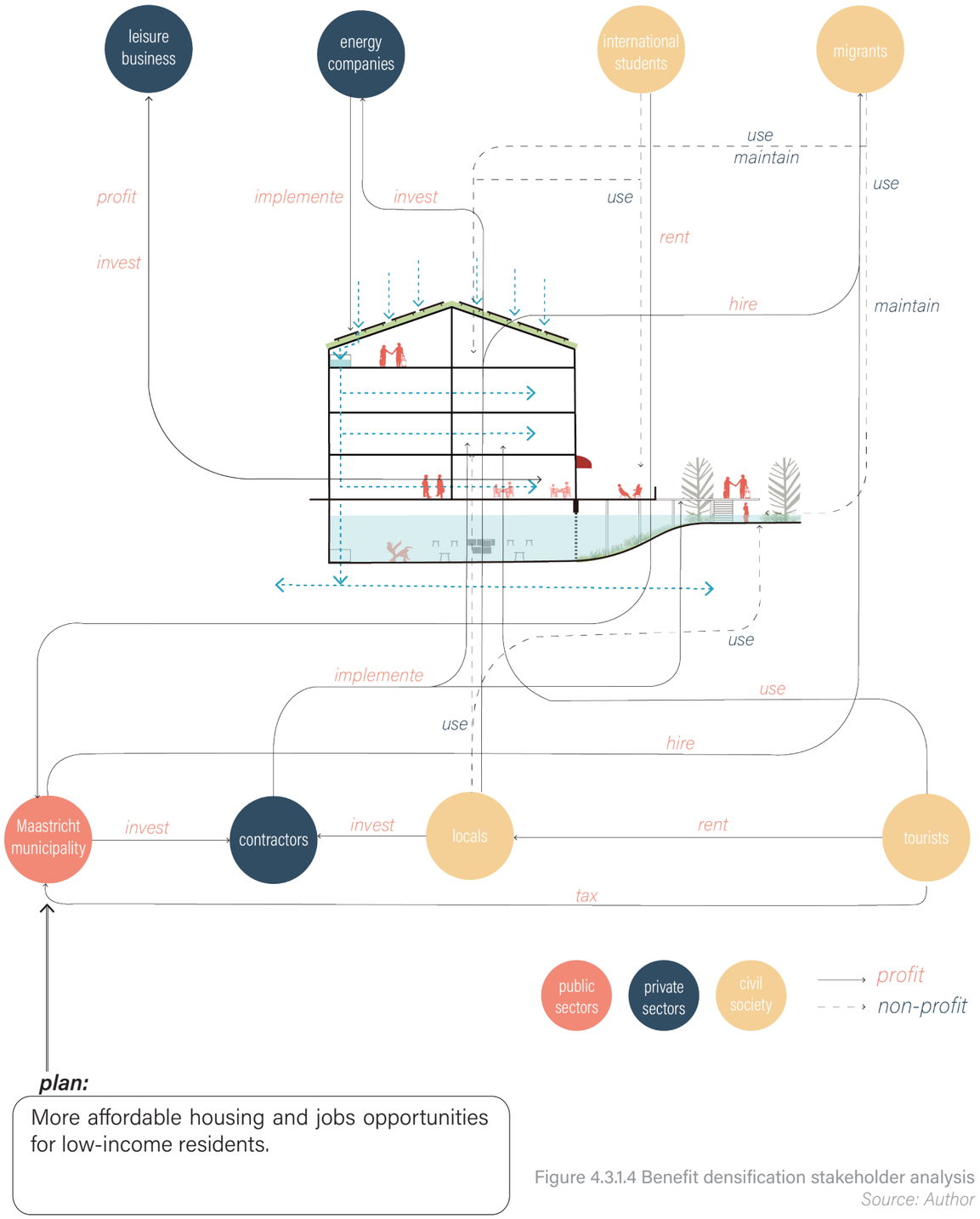


Figure 4.3.1.4 Benefit densification stakeholder analysis
Source: Author

Water sensitive B&B community BB' 1:450

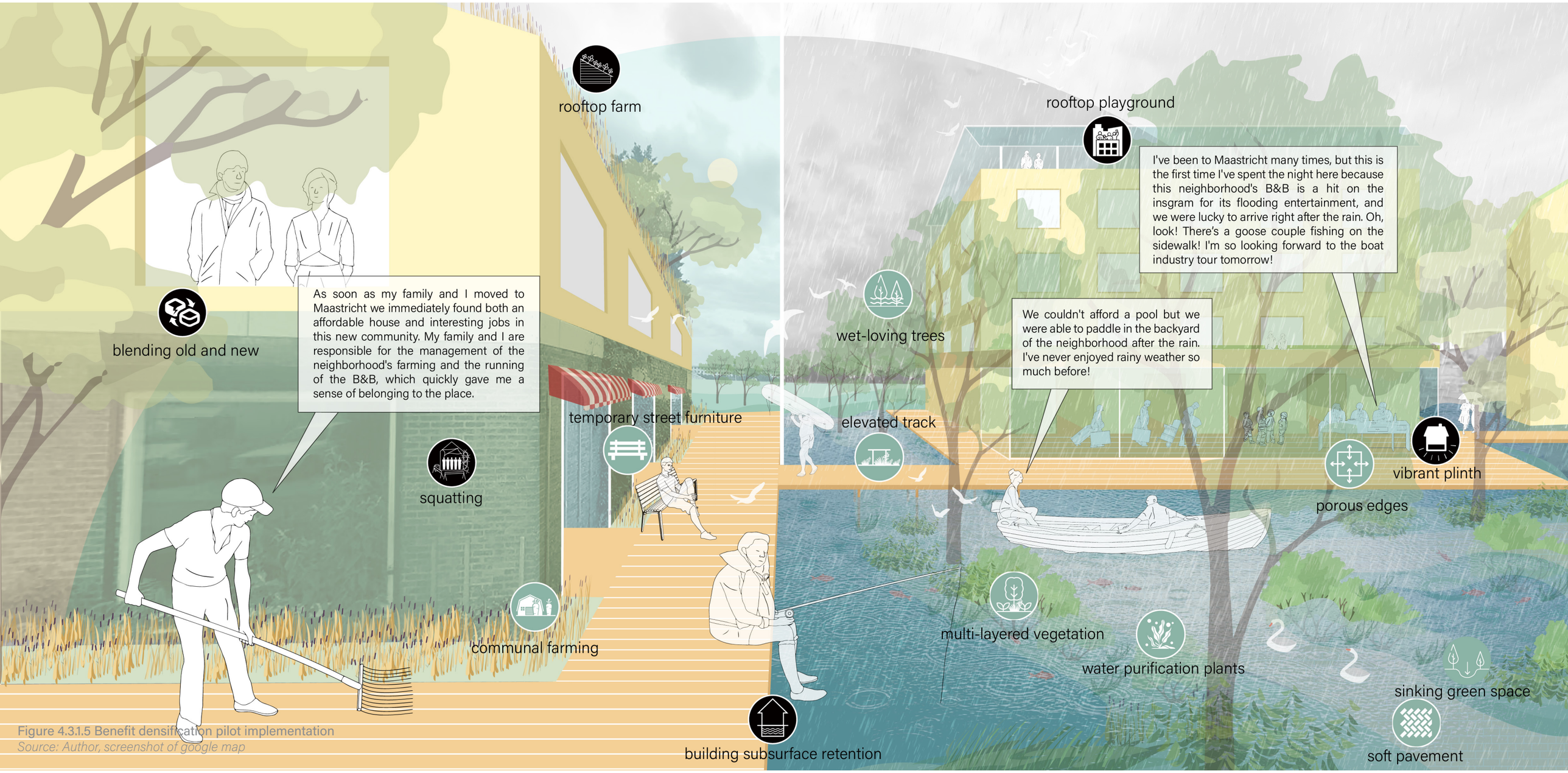


Figure 4.3.1.5 Benefit densification pilot implementation
Source: Author, screenshot of google map

To address the challenges and meet the requirements of densification, the design approach for converting industrial areas into residential spaces employs strategic solutions (Figure 4.3.1.5). It involves preserving selected industrial structures of architectural value while incorporating new elements such as housing, restaurants, and amenities. Vertical expansions are utilized to create more affordable housing, and the underground space is repurposed as a reservoir for excess rainwater, effectively combining contemporary housing and flood management needs with the preservation of industrial heritage (Figure 4.3.1.5).

Moreover, the renovated community is designed to be flood-resilient, featuring an elevated track system that ensures uninterrupted access during floods. This innovative approach not only enhances resilience but also provides opportunities for open water recreational activities such as boating and fishing, which are uncommon in social housing-dominated communities. The maintenance and operation of recreational areas can generate job opportunities, aligning with the design's goal of promoting equal opportunity (Figure 4.3.1.5).

4.3 Integrated Strategies And Implementations

4.3.1 Integrated implementations of the neighborhood scale

CITY SKELETON IMPLEMENTATION

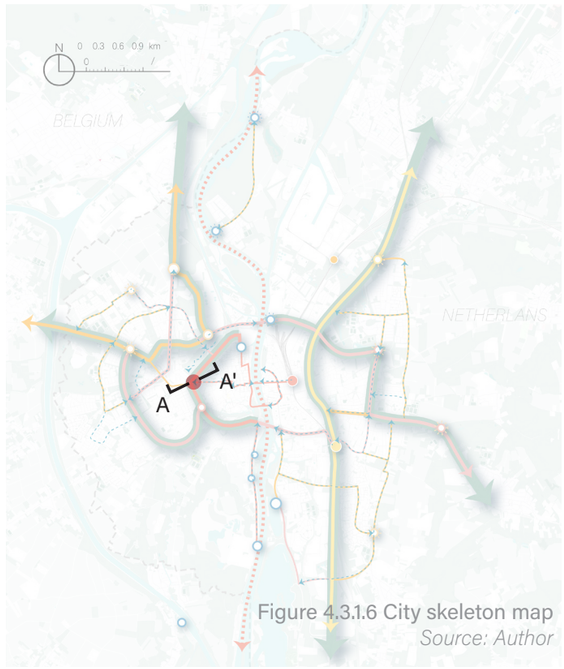


Figure 4.3.1.6 City skeleton map
Source: Author

The city's skeleton plays a pivotal role in realizing the integration of ecology and culture, as it serves as the foundation for urban connectivity and the extension of benefits (Figure 4.3.1.6). In this study, the pilot project is strategically positioned within the city's historical corridor, capitalizing on insights gained from previous maximization scenarios to explore specific applications at the neighborhood level (Figure 4.3.1.7, 4.3.1.7).

This section of the study places emphasis on the stakeholders involved in the construction of this typology and their interactions (Figure 4.3.1.8). By examining the relationships between stakeholders, the study aims to understand the dynamics and collaborations that shape the development process. Furthermore, it investigates the spatial atmosphere created within the neighborhood as a result of this typology, analyzing how it influences the overall ambiance and character of the area.

By studying the city's skeleton and the interactions among stakeholders, this research provides valuable insights into the integration of ecology and culture. It contributes to a deeper understanding of the significance of urban connectivity and the extension of benefits, while also shedding light on the spatial atmosphere that emerges within the neighborhood.

Figure 4.3.1.7 City skeleton pilot current situation
Source: Author, screenshot of google map

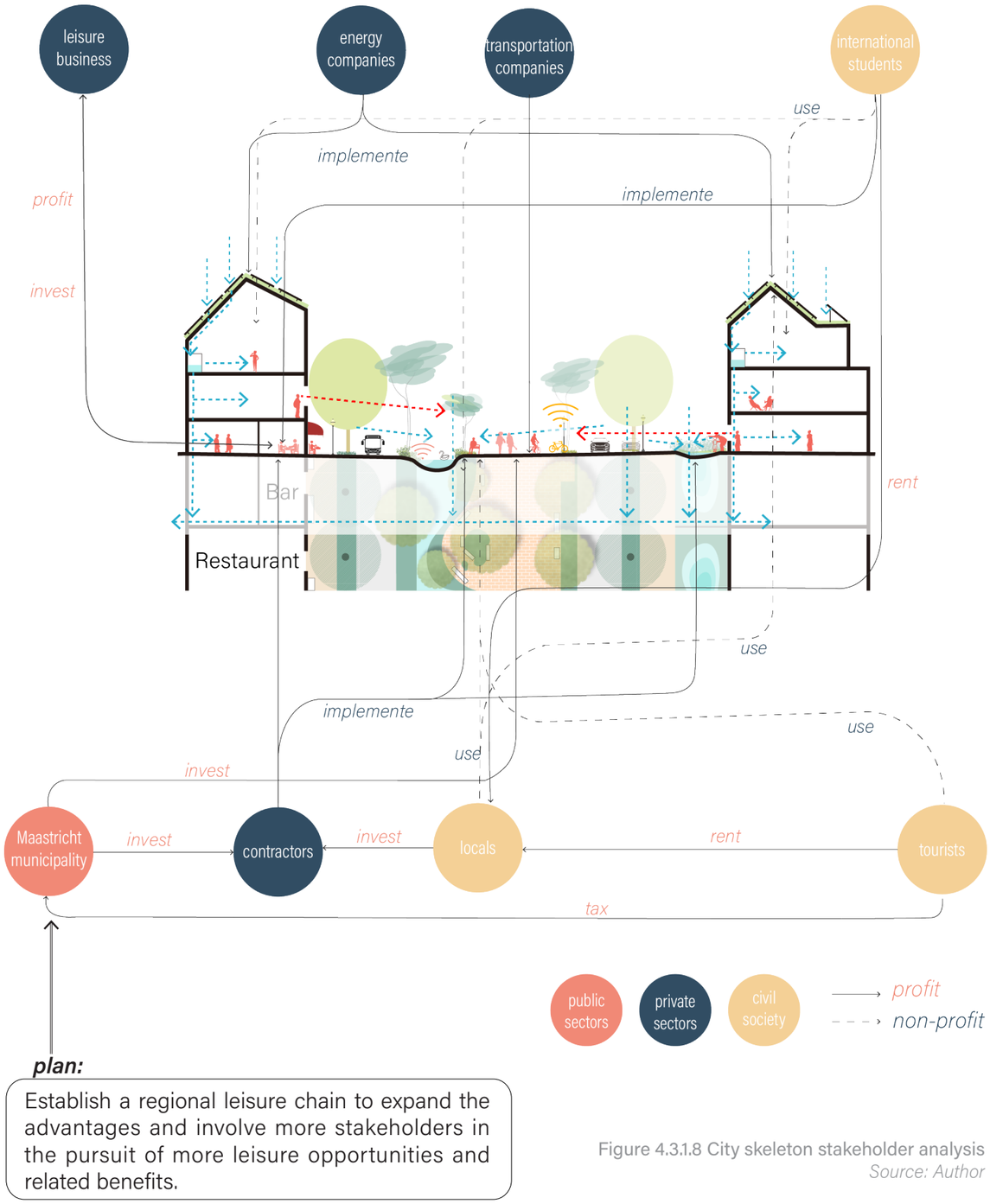


Figure 4.3.1.8 City skeleton stakeholder analysis
Source: Author

Historical corridor section AA' 1:450

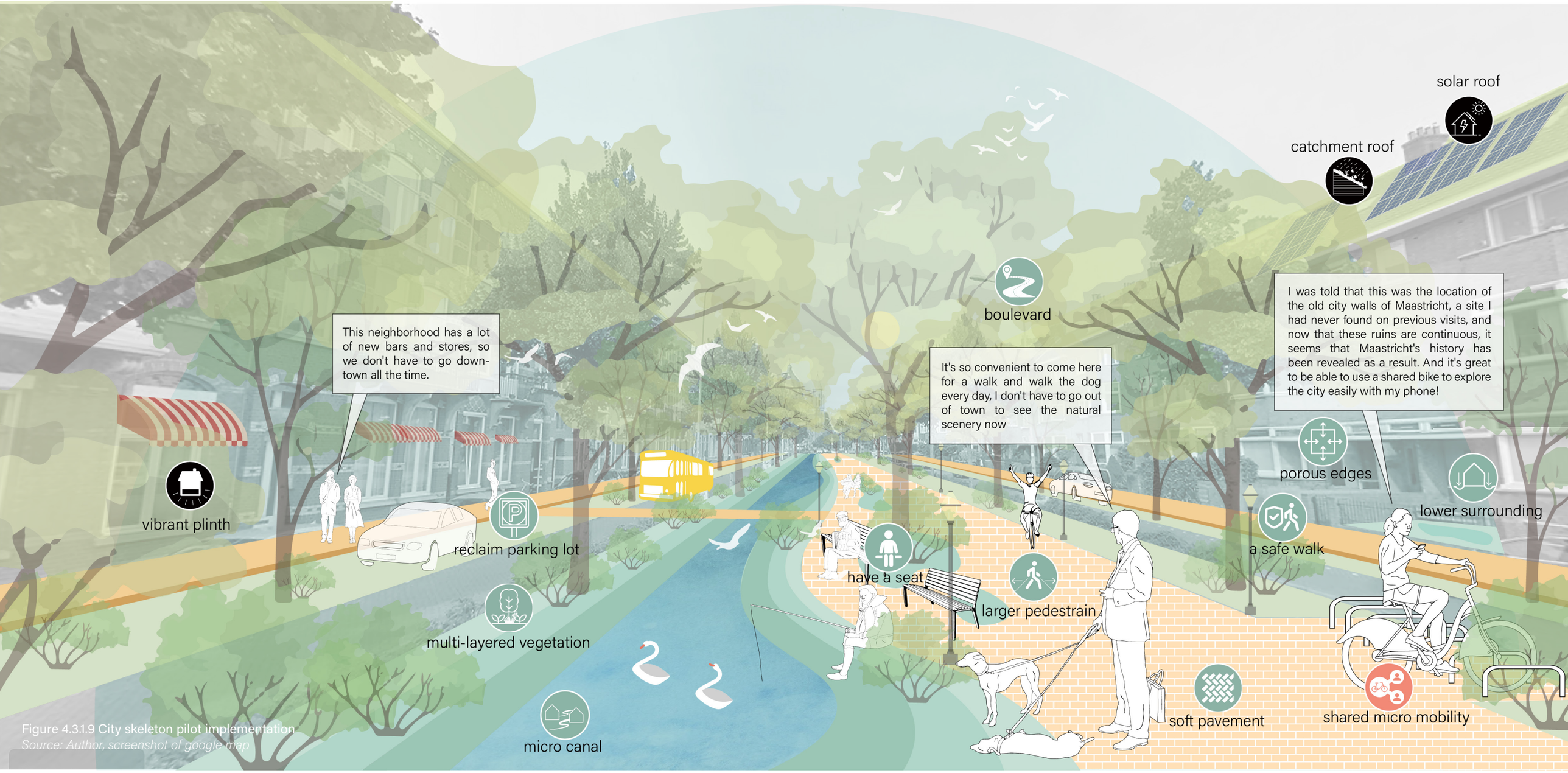


Figure 4.3.1.9 City skeleton pilot implementation
Source: Author, screenshot of google map

The main streets of Maastricht suffer from a predominant presence of cars, leaving very limited room for pedestrians and a lack of inviting spaces. This results in a lifeless urban environment (Figure 4.3.1.7).

However, a solution presents itself in the form of a boulevard positioned in the center (Figure 4.3.1.9). By introducing this boulevard, the continuous flow of vehicular traffic is disrupted, and the addition of a canal revitalizes the spatial ambiance reminiscent of the city's old walls. Moreover, this canal helps regulate the local microclimate and creates a pedestrian-friendly atmosphere (Figure 4.3.1.9). Furthermore, the inclusion of seating areas and ground-floor amenities encourages people to spend more time, fostering a vibrant street environment that caters to the diverse needs of residents, immigrants, international students, and tourists. This inclusive and active environment enhances the overall appeal of the streets, making them more accessible and enjoyable for everyone.

BUFFER IMPLEMENTATION

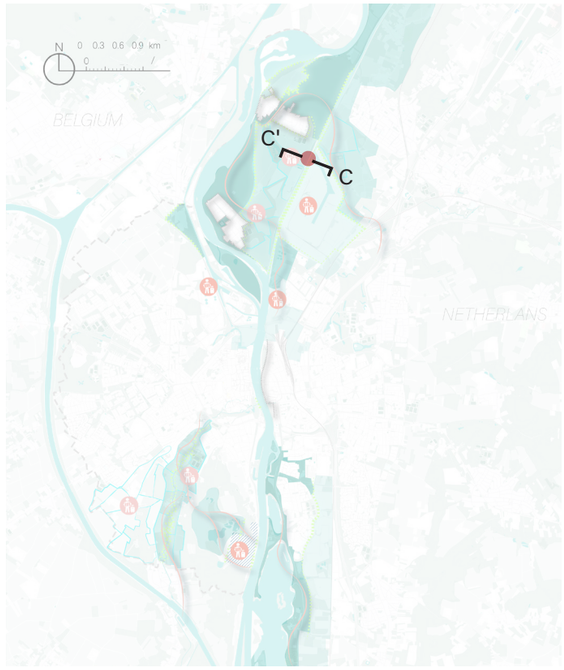


Figure 4.3.1.10 Buffer map
Source: Author

In order to give more room to the river and to preserve the function of leisure activities along the river, this study divided three levels of buffer according to the intensity of human activities, and this pilot focuses on the second level of buffer: the agricultural area (Figure 4.3.1.10).

Stakeholder collaboration is critical in transforming buffer. Through their collaborative efforts, a range of benefits can be realized, including enhanced flood management, improved water quality, biodiversity preservation, and the creation of recreational opportunities (Figure 4.3.1.12). The city council takes the lead in planning and works alongside experts in the field. Garnering support from residents is vital during the transformation process, and subsidies may be provided to farmers to facilitate their participation. Effective communication with tourists and seamless coordination with transport and energy companies are key to ensuring the success of the project. By working together, stakeholders can ensure a smooth and prosperous transformation of the agricultural area into a functional and sustainable river buffer.

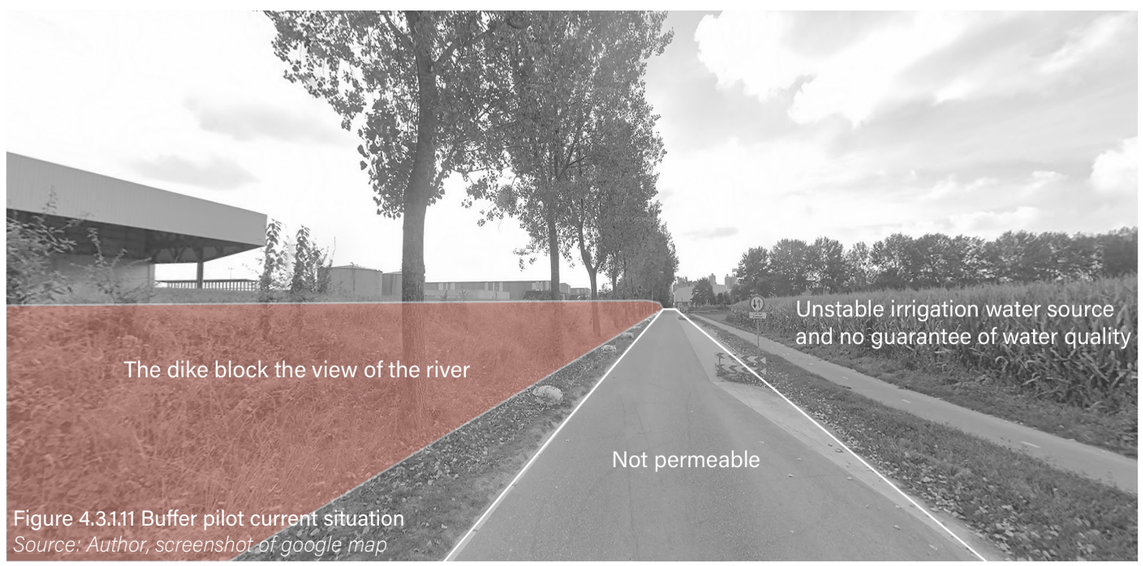
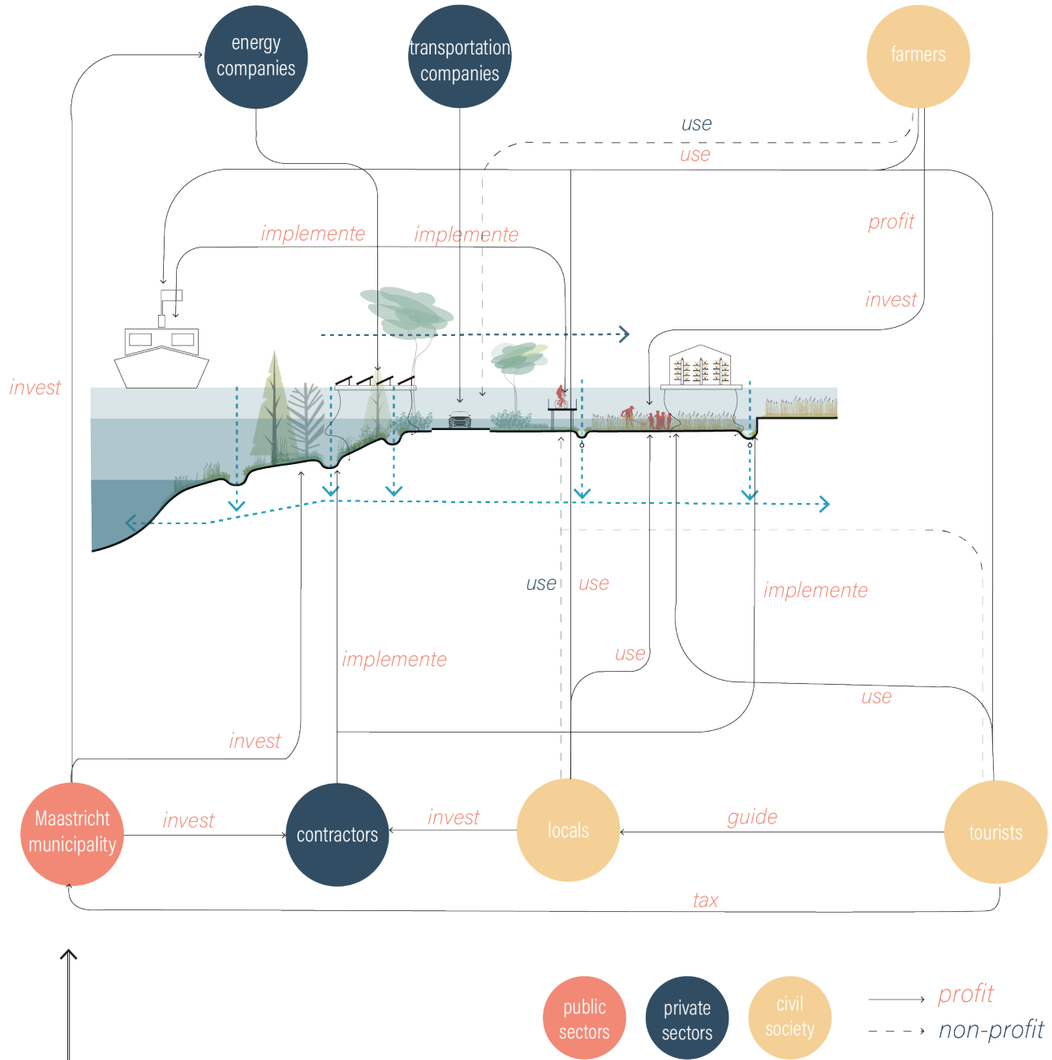


Figure 4.3.1.11 Buffer pilot current situation
Source: Author, screenshot of google map



plan:

Stabilizing the water level of the Maas River in different seasons to ensure navigation.

Figure 4.3.1.12 Buffer stakeholder analysis
Source: Author

Level 2 buffer (agriculture area) CC' 1:450

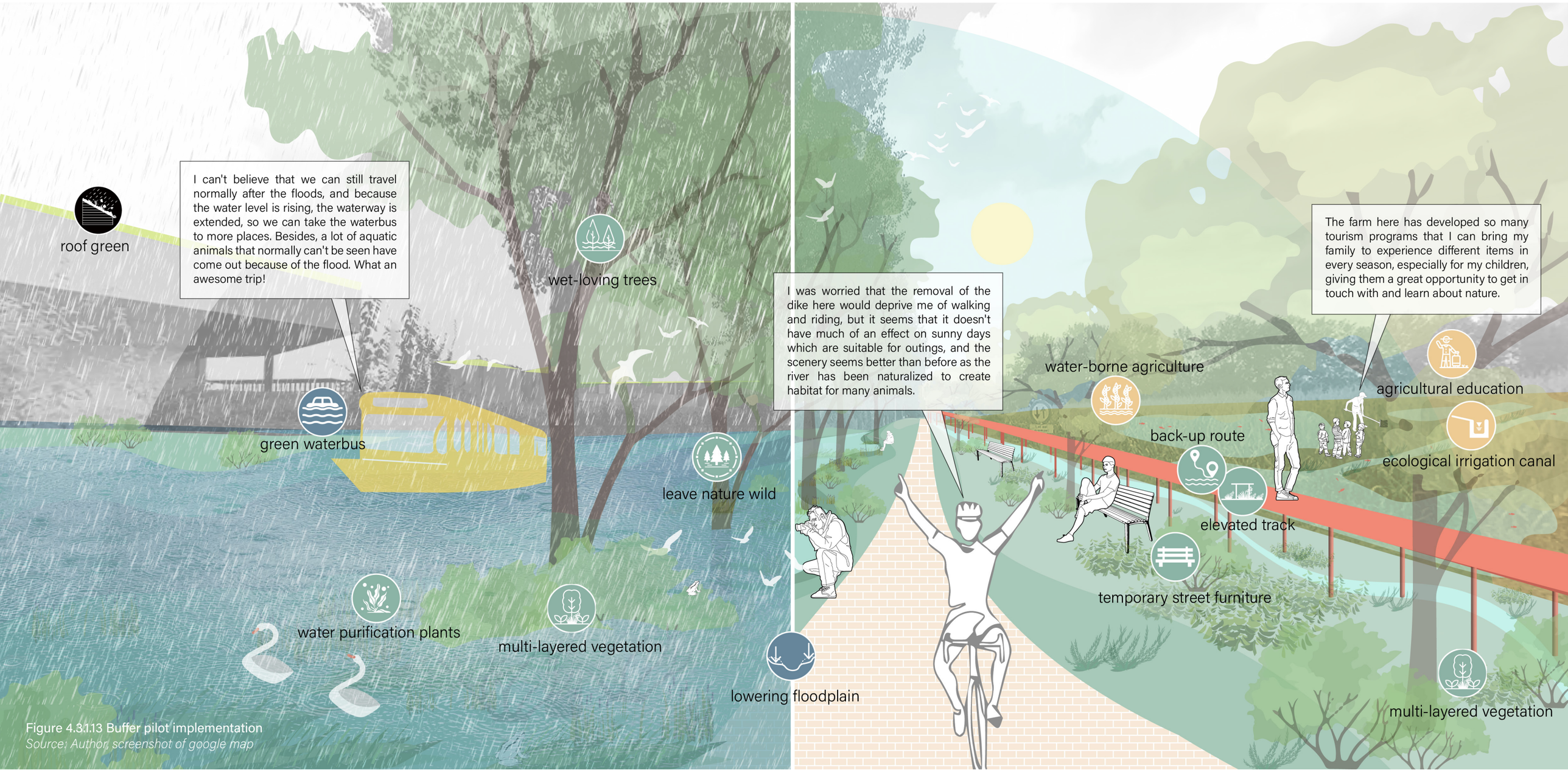


Figure 4.3.1.13 Buffer pilot implementation
Source: Author, screenshot of google map

Currently, most of the agricultural areas along the riverbanks in Maastricht are protected by levees. However, continuing with this flood management approach would require constant raising of the levees as water levels rise, resulting in high maintenance costs and obstructing the view of the river (Figure 4.3.1.11). On the other hand, the outskirts of Maastricht face water scarcity and drought issues during the summer season. If floods could be stored, there is an opportunity to enhance the stability of irrigation water sources (Figure 4.3.1.11).

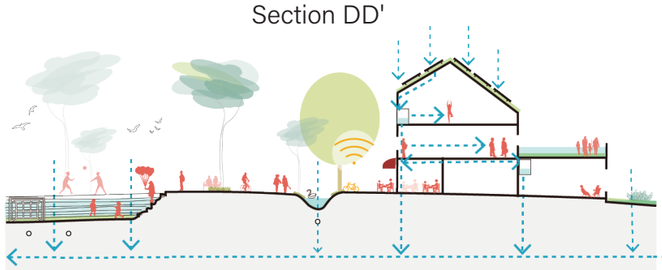
However, transforming the agricultural area into a water-adapted system, like a fish farm, can eliminate the need for dike protection and allow for agrotourism and alternative agricultural practices. This shift offers economic benefits and reduces maintenance costs. Improved accessibility during high water situations can be achieved through waterbuses and elevated tracks, while the integration of multi-layered vegetation enhances biodiversity and supports high water tourism. This example demonstrates how flooding can be turned into a resource, promoting ecological sustainability, income generation, and tourism while addressing water management challenges (Figure 4.3.1.13).

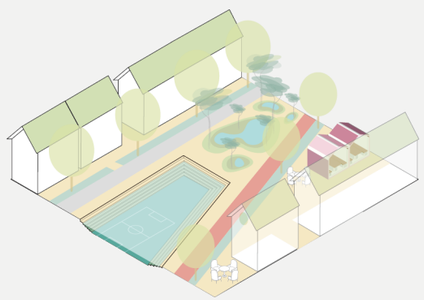
4.3.2 Integrated typologies of the city scale

SYSTEM PERFORMANCE OF FLOWING CULTURE CITY

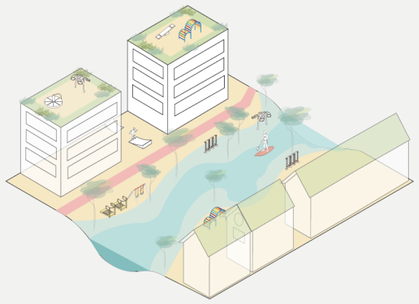
Type 6: Multi-chance neighborhood

Section DD'





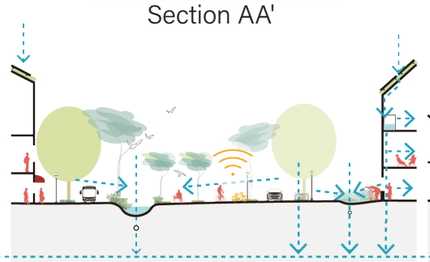
Historic scenic neighborhoods

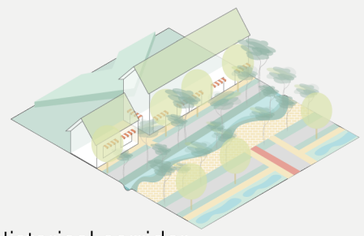


Water Fitness Neighborhood

Type 3: City skeleton

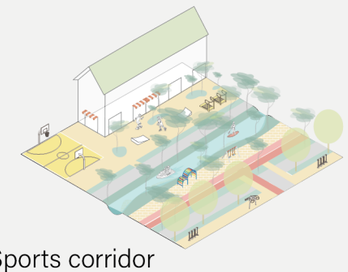
Section AA'



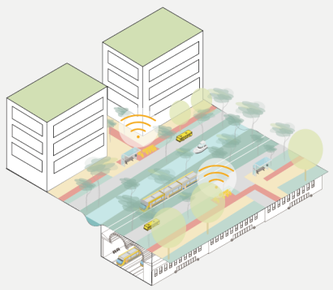


Historical corridor

Recreational corridor



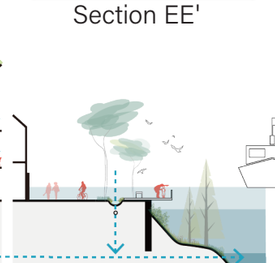
Sports corridor



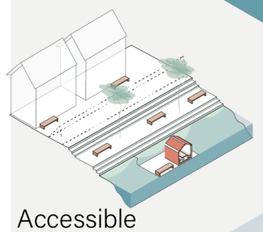
Express corridor

Type 5: Dynamic water bodies

Section EE'



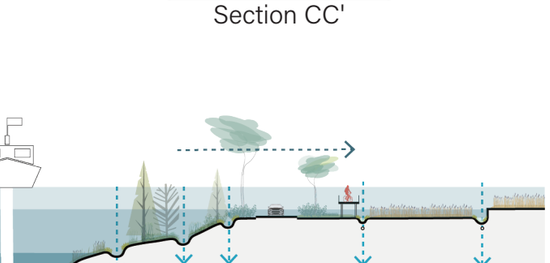
Released riverbank



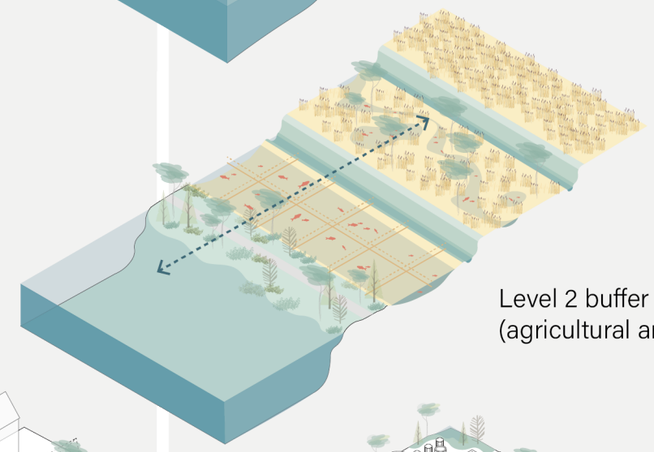
Accessible riverbank

Type 4: Buffer

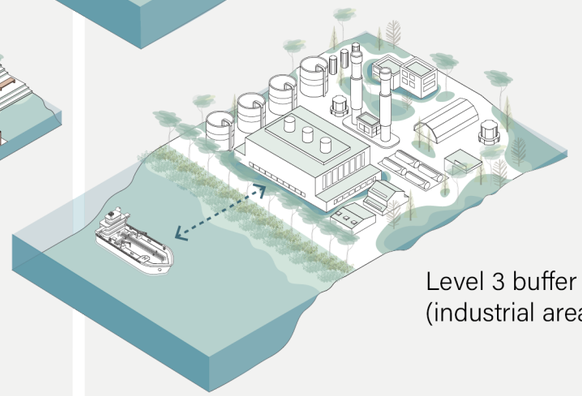
Section CC'



Level 1 buffer (natural area)



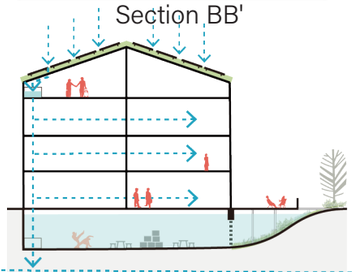
Level 2 buffer (agricultural area)



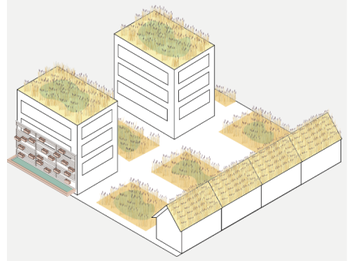
Level 3 buffer (industrial area)

Type 1: Benefit densification

Section BB'



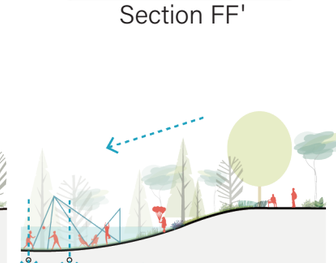
Water-sensitive B&B community



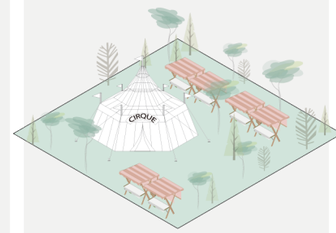
Water-sensitive urban farming neighborhood

Type 2: Nature hub

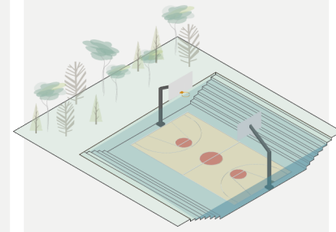
Section FF'



Catchment green hub



Temporary cultural event hub



Sunken sports green hub

Figure 4.3.2.1 Typologies of Flowing Culture City
Source: Author

SYSTEM PERFORMANCE OF FLOWING CULTURE CITY

Figure 4.3.2.2 Distribution of new leisure businesses of Flowing Culture city
Source: Author

Table 4.3.2.1 Number of jobs offered by different types and sizes of leisure businesses in Maastricht
Source: Author, derived information from He et al. (2019)

	Small		Medium		Large	
	direct	*indirect*	*direct*	*indirect*	*direct*	*indirect*
Cultural institutions	5-50	10-30	50-200	30-100	200-1,000	100-500
Others	5-20	5-15	20-100	10-50	100-500	50-200

Type 1: Benefit densification

- Water-sensitive urban farming neighborhood
- Water-sensitive B&B community

↓

- Cultural Events
- Sports Facilities
- Water-based Activities
- Educational Workshops
- Community Events
- Nightlife & Entertainmen
- Wellness & Spa Facilities

Type 2: Nature hub

- Catchment green hub
- Temporary cultural event hub
- Sunken sports green hub

↓

- Outdoor Recreation
- Cultural Events
- Sports Facilities
- Water-based Activities
- Educational Workshops
- Family-Friendly Activities

Type 3: City skeleton

- Express corridor
- Historical corridor
- Recreational corridor
- Sports corridor

↓

- Outdoor Recreation
- Sports Facilities
- Water-based Activities
- Culinary Experiences
- Family-Friendly Activities

Type 4: Buffer

- Level 1 buffer (natural area)
- Level 2 buffer (agricultural area)
- Level 3 buffer (industrial area)

↓

- Outdoor Recreation
- Sports Facilities
- Water-based Activities
- Educational Workshops
- Family-Friendly Activities

Type 5: Dynamic water body

- Released riverbank
- Accessible riverbank

↓

- Outdoor Recreation
- Cultural Events
- Sports Facilities
- Water-based Activities
- Educational Workshops
- Nightlife & Entertainmen
- Family-Friendly Activities

Type 6: Multi-chance neighborhood

- Historic scenic neighborhood
- Water fitness neighborhood

↓

- Cultural Events
- Sports Facilities
- Culinary Experiences
- Community Events
- Nightlife & Entertainmen

- New leisure activitiies
- New leisure activities with job opportunities

SYSTEM PERFORMANCE OF FLOWING CULTURE CITY

In this study, six distinct typologies of urban spaces have been designed, taking into account specific local spatial, functional, and other characteristics. The urban design proposal presented here will capitalize on the value of the urban cultural landscape, enhance the retention capacity of Maastricht city to effectively address future weather extremes, and facilitate the provision of diverse ecological services. Additionally, the proposal seeks to foster a wide array of leisure activities with urban features in each neighborhood, which have the potential to generate significant employment opportunities.

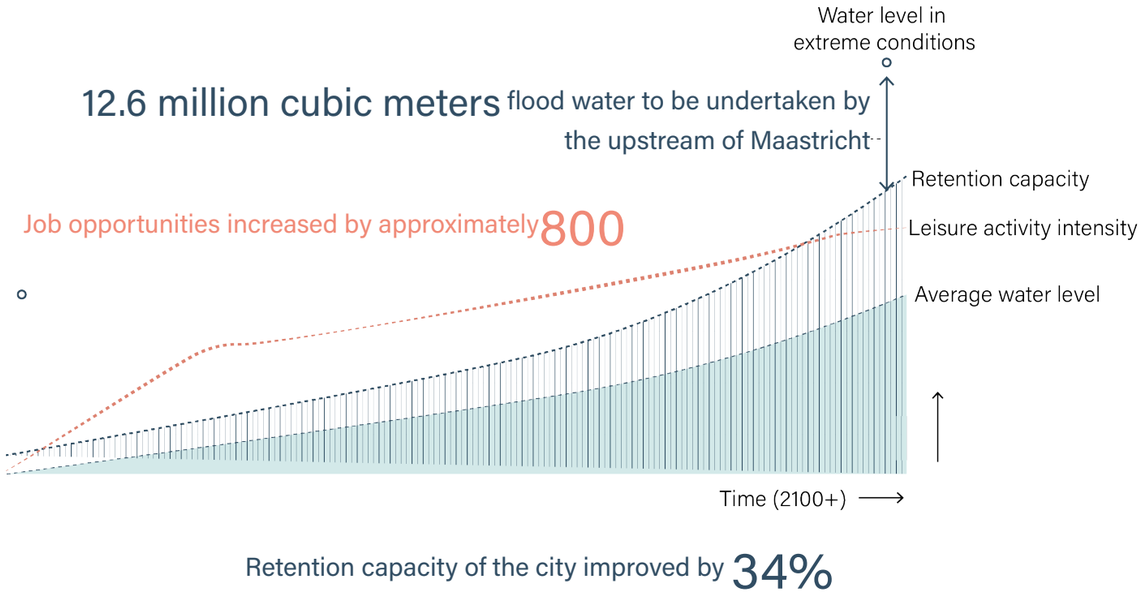


Figure 4.3.2.3 Benefits of Flowing Culture City
Source: Author

- Socio-economic Benefits Of The Flowing Culture City

Based on the types and distribution of existing leisure businesses in Maastricht, this study provides a rough estimate of the potential locations of new leisure businesses and their resulting socioeconomic benefits in an integrated urban transformation program, quantifying them in terms of job opportunities (Table 4.3.2.1, He et al., 2019). The added leisure industry businesses primarily fall into six categories: cultural institutions, sports centers, water-based recreation businesses, education providers, entertainment venues, and catering. They can provide varying degrees of direct and indirect employment opportunities based on their type and size (He et al., 2019).

For example, small cultural institutions may employ several to dozens of staff members and generate indirect employment opportunities for around 10 to 30 individuals, including freelance artists, performers, technicians, or event support staff (Zhao & Liu, 2021). Among these categories, cultural institutions have the potential to offer more positions with a wider fluctuation range, while job creation in other types of businesses is similar. The transformed city is expected to generate multiple new leisure hubs in areas outside the city center, with different types of leisure businesses triggered by the characteristics of their respective neighborhoods, with at least two businesses in each category (Figure 4.3.2.2, Erfurt-Cooper, 2009).

Considering Maastricht's population density and urban scale, the city is expected to have a maximum of two medium-sized cultural and water-based recreation businesses, while others would be small-scale enterprises. Approximately eight new cultural institutions and a total of around 80 new businesses in other categories can be increased (Figure 4.3.2.2, Table 4.3.2.1).

For the purpose of calculation convenience, the median employment numbers for each category are used. Overall, the proposed "FLOWING CULTURE CITY" plan is estimated to create over 800 new job opportunities, which can contribute to reducing the city's unemployment rate and promoting equal opportunities. However, due to Maastricht's population size and resource limitations, the development of large-scale leisure businesses that can provide extensive job opportunities is unlikely.

- Environmental Benefits Of The Flowing Culture City

Additionally, the study calculates the current and projected retention capacity of Maastricht based on the water storage performance and area of different urban overlays (detailed calculations in Appendix 4: Calculation of Urban Retention Capacity, Koiv-Vainik, 2022). The retention capacity is expected to increase from 7.4 million cubic meters to 9.9 million cubic meters, representing a 34% increase. However, the city's retention capacity is limited, and by the next significant flood event in 2060, the flood-prone area will expand to 22.5 million square meters, assuming a floodwater level of 1m. At least 12.6 million cubic meters will exceed the city's retention capacity, requiring coordination with surrounding areas (Figure 4.3.2.3.).

- Benefit Extensibility And Regional Support

Maastricht's integrated urban transformation plan envisions the development of a vibrant and expanding cultural landscape (Figure 4.3.2.2). It aims to extend the existing leisure network within the city through various corridors, extending to the suburbs and the larger Maas River basin. This extension enhances the overall benefits to the city and its residents. In addition, the expansion improves connectivity between the city and the region, bringing flooding and employment challenges that cannot be fully addressed at the city scale to the regional level, greatly increasing the likelihood of finding comprehensive solutions.

CONNECTIVITY OF MAAS RIVER BASIN

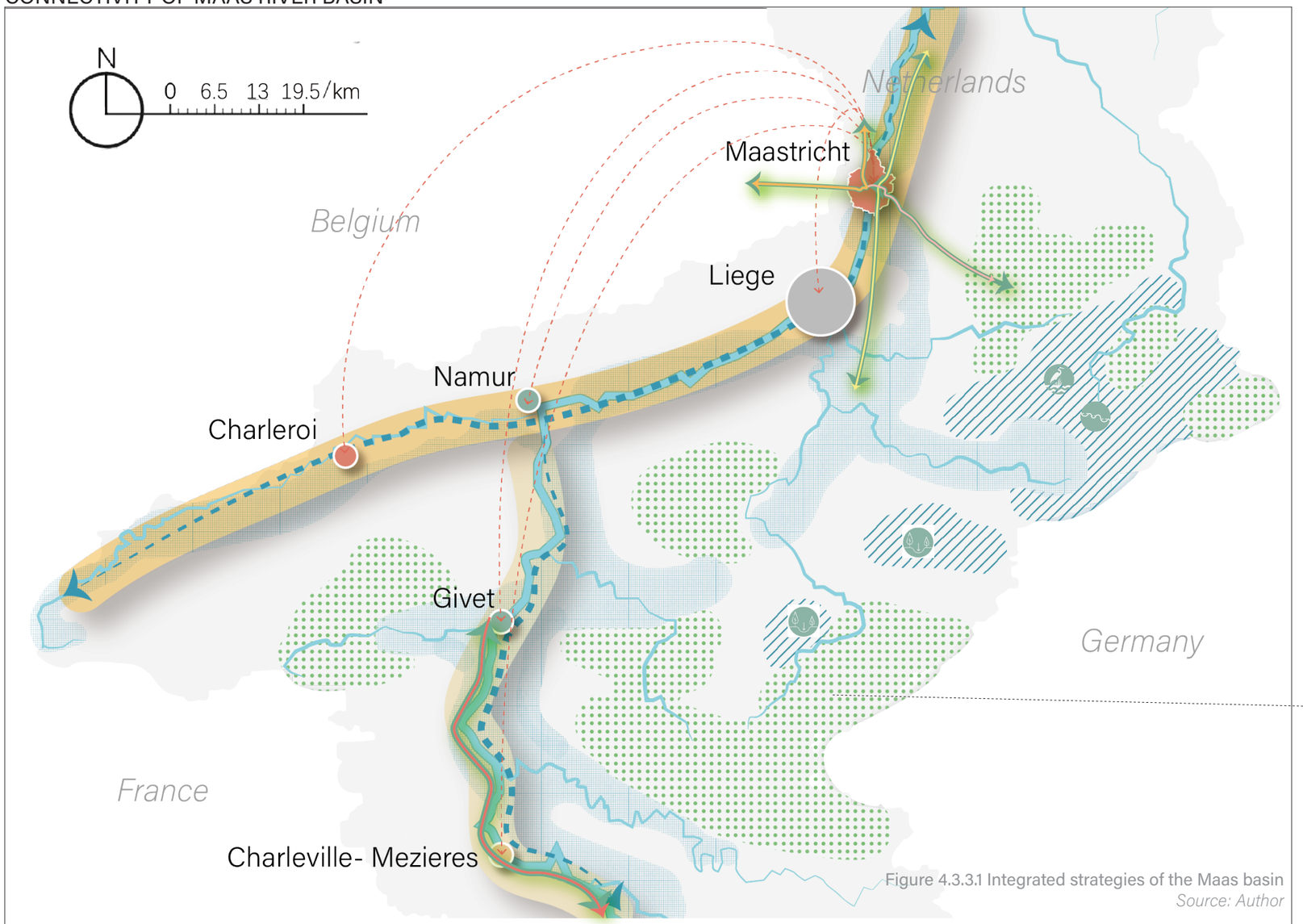
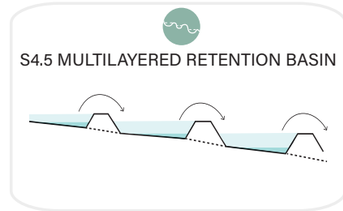
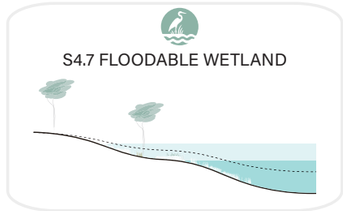
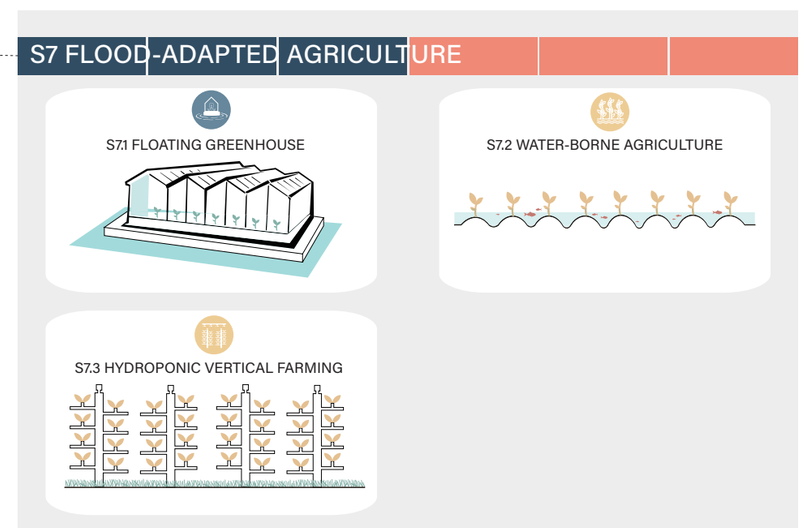


Figure 4.3.3.1 Integrated strategies of the Maas basin
Source: Author

- Maas basin
- Enhanced express corridor
- Intensified sightseeing corridor
- International water bus route
- New bike route
- Green corridor
- Art & history hub
- Industry & innovation hub
- Outdoor activity hub
- Puppetry hub
- Practice experience
- Lowered floodplain
- Multilayered retention basin
- Flood-adapted agriculture







CONNECTIVITY OF MAAS RIVER BASIN

- **City-to-City Connectivity:**

The integrated transformation experience in Maastricht can serve as a valuable model for other cities along the Maas River, facilitating enhanced connectivity on ecological, economic, cultural, and transportation levels, ultimately leading to regional benefits (Figure 4.3.3.1.).

From an ecological standpoint, the establishment of a green corridor ensures the preservation of the natural structure and promotes environmental continuity. In terms of economic and cultural aspects, the cities within the middle reaches of the Maas Basin possess distinct characteristics and rich historical backgrounds. By creating a regional leisure industry chain, the economic and cultural potential of each city can be fully harnessed. Moreover, improvements in transportation infrastructure, both water and land-based, facilitate better integration and connectivity. Previously lacking continuous cross-country public water transport for the general public along this stretch of the river, the proposed enhancements provide a more comprehensive and accessible transportation system. These three dimensions of connectivity—ecological, economic and cultural, and transportation—reinforce one another.

A well-connected transportation system serves as a physical link between nature and culture, a greener ecological environment offers enhanced cultural ecological services and a more pleasant transportation experience, and a sustainable leisure industry model fosters a sense of ecological conservation and nurtures a culture of environmental protection.

- **Urban-Suburban Connectivity:**

The proposed plan presents significant benefits that transcend the mere establishment of city-to-city connectivity, as it incorporates urban-suburban connections through the thoughtful deployment of corridors and buffer zones. This strategic approach showcases remarkable efficacy in rejuvenating the cultural landscape of the Maas River Basin at a regional scale, consequently fostering augmented linkages between urban and suburban areas (Figure 4.3.3.1.). Moreover, this endeavor highlights the inherent synergy between regional cooperation for flood management and the development of the leisure industry (Figure 4.3.3.1.).

By implementing corridors and buffer zones, the proposed plan effectively enhances not only physical connectivity but also cultural exchanges and shared experiences among the diverse urban and suburban components within the Maas River Basin. This synergy of regional cooperation is particularly pertinent in the context of flood management, as it promotes a collective and coordinated approach to mitigating the risks associated with flooding events. Furthermore, the simultaneous development of the leisure industry complements these efforts by leveraging the cultural landscape, thereby enhancing economic opportunities and reinforcing the regional identity.

Through the strategic interplay of urban-suburban connections, flood management, and leisure industry development, the proposed plan not only fosters a sense of unity and interdependence within the Maas River Basin but also maximizes the potential for sustainable growth and resilience. This comprehensive approach envisions a harmonious integration of cultural heritage, environmental stewardship, and economic development, thereby offering a multifaceted framework for the region's overall progress.

THE BENEFITS OF REGIONAL CONNECTIVITY FOR THE CITY

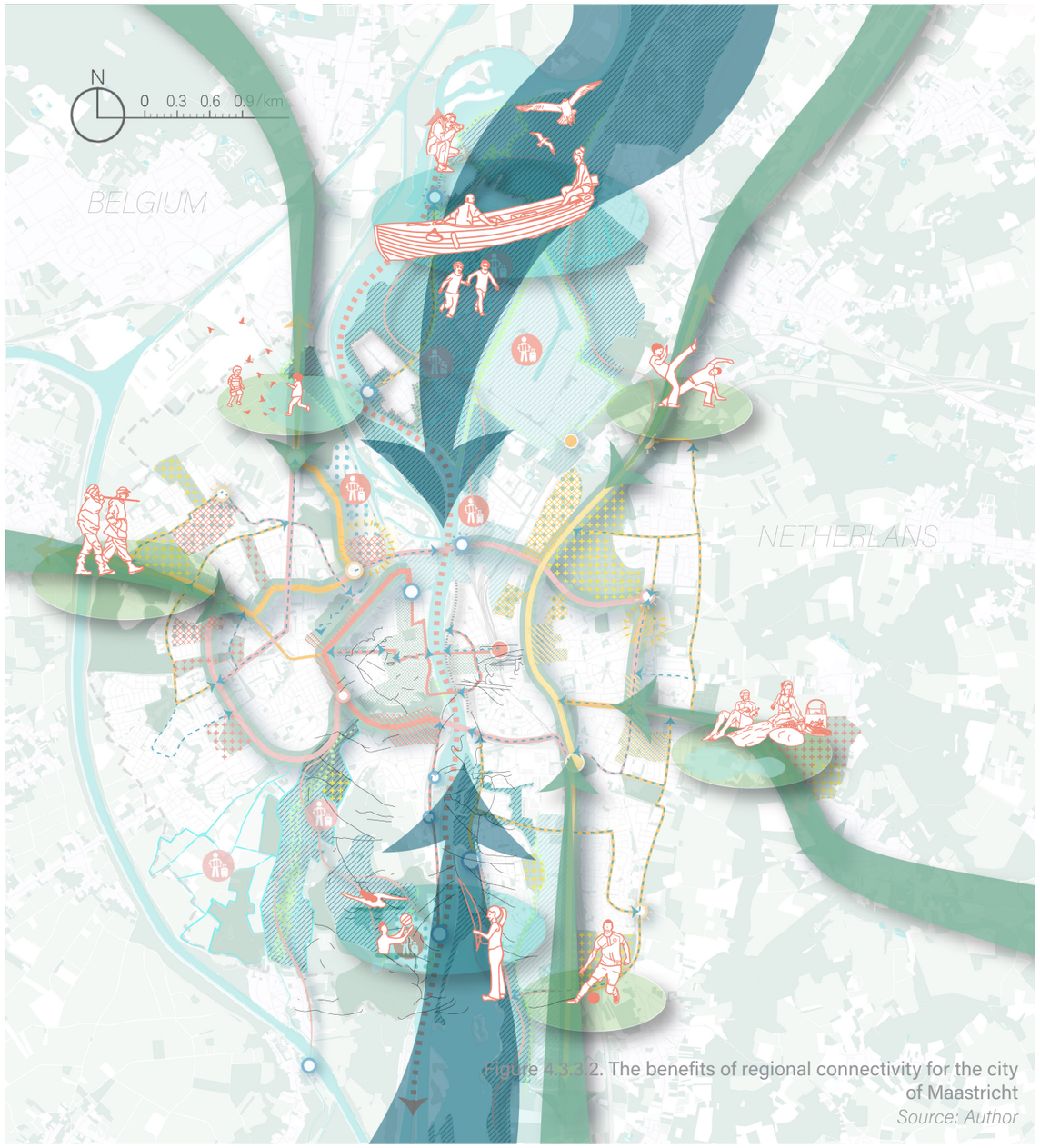


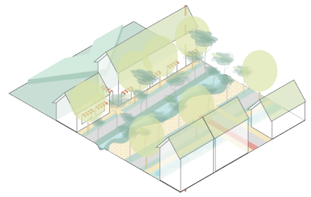
Figure 4.3.3.2. The benefits of regional connectivity for the city of Maastricht
Source: Author

The increased connectivity of the cultural and natural environment in the Maas River basin can have reciprocal benefits for urban development and the environment in Maastricht. This includes improving **transportation connectivity**, particularly for navigation, ensuring uninterrupted during river flooding, and promoting **ecological circulation** and **leisure activities** in the suburban interface (Figure 4.3.3.2.).

Regional scale:
Maas river basin assessment

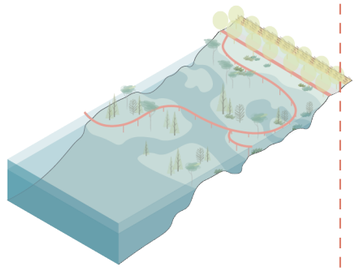
Implementing integrated projects in neighborhoods in urgent need of regeneration as a pilot to adjust urban-scale transformation plans.

Neighborhood scale:
Historical corridor



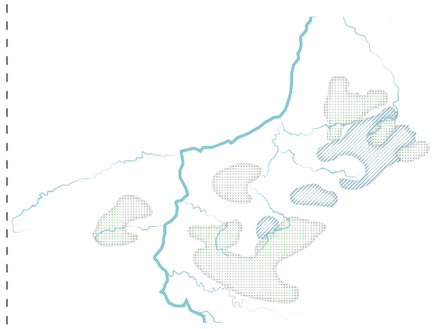
City scale:
Urban structure of Maastricht

Neighborhood scale:
Buffer of natural area



Regional regulation of rural catchment area based on the required buffer retention capacity.

Regional scale:
Rural areas of middle and lower Maas river basin



Preliminary Assessment & Visioning Phase

2023

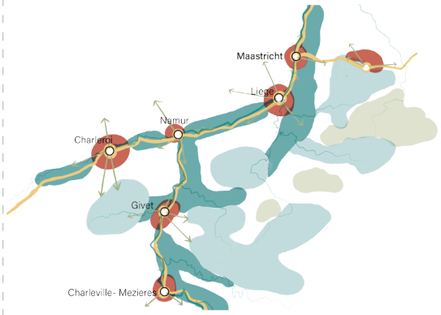
Design & Implementation Phase

2100+

2050

Monitoring & Adaptation Phase

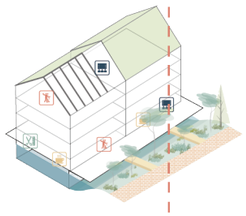
Expanding integrated network



Regional scale:
Vision of middle and lower Maas river basin

Analysis of the city's potential to complement the regional vision.

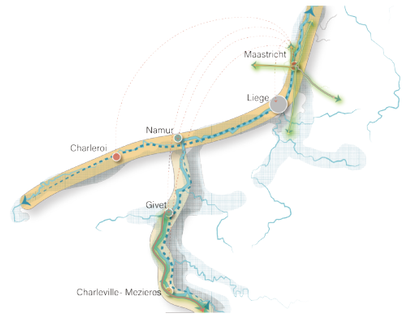
City scale:
Maastricht city vision



Neighborhood scale:
Water-sensitive B&B community

Create first-level buffers for experiments to adjust other buffer designs with more complex ownership.

City scale:
Maastricht river space



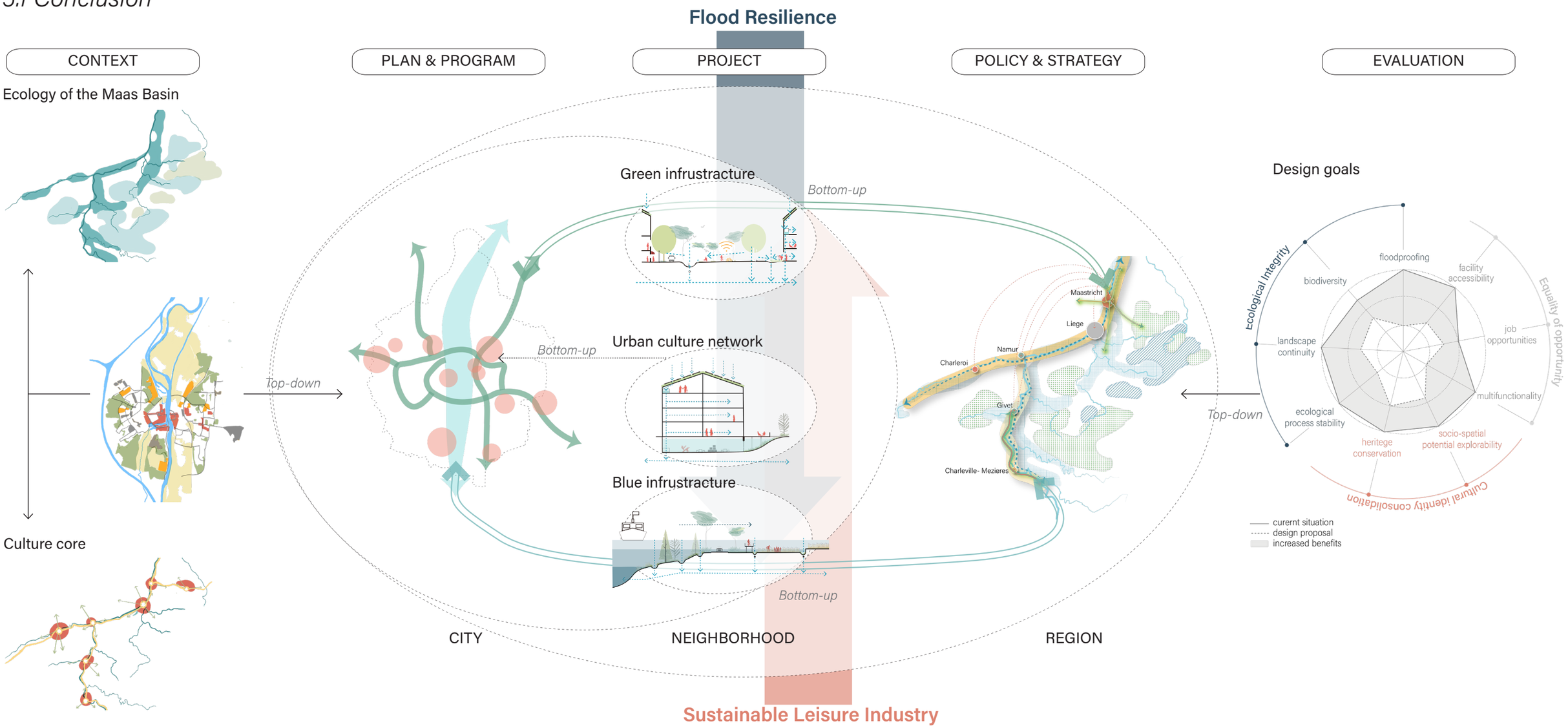
Regional scale:
Urban structures of middle and lower Maas river basin

Extending the benefits of urban design to the Maas Basin by extending the corridor and buffer and sharing practical experience.

Figure 4.3.4.1. Implementing phasing of the integrated urban transformation proposal across three scale
Source: Author

05 CONCLUSION & REFLECTION

5.1 Conclusion



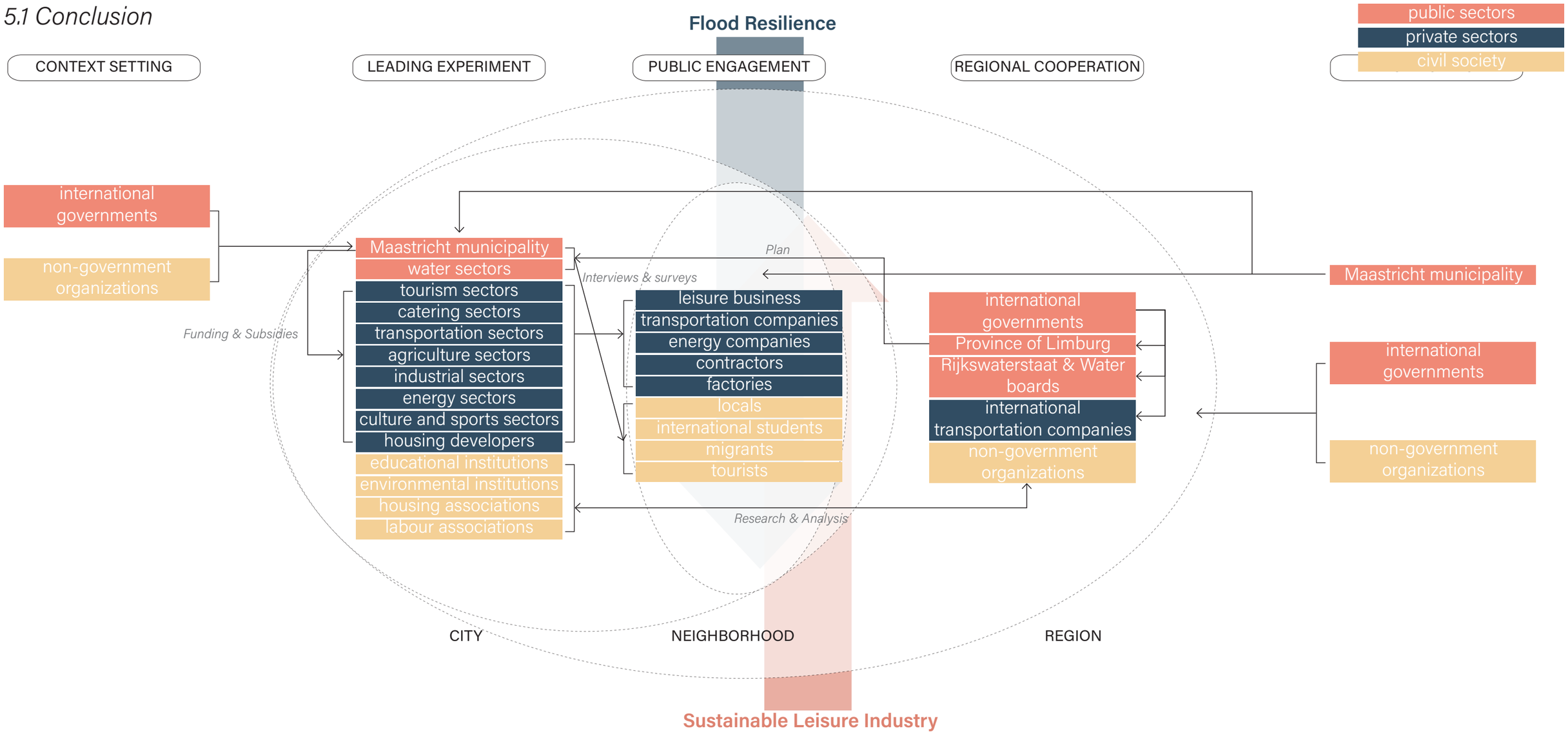
SPATIAL STRATEGIES

This study presents a comprehensive landscape structure composed of cultural cores and corridors, which integrates blue-green infrastructure and cultural landscapes at multiple scales (regional, urban, and neighborhood) to enhance flood resilience and promote sustainable development of the leisure industry in Maastricht.

The research initially identifies the context of Maastricht basin as consisting of two distinct components: the natural ecosystem and the urban areas along the river, which serve as cultural cores. By adopting a top-down approach, the study explores the spatial potentials of these components in terms of flood management and leisure industry development. Subsequently, a bottom-up approach is employed, involving on-site investigations and interviews, to formulate spatial strategies at different scales.

At the urban scale, the plan involves the establishment of urban culture networks, functioning as a new cultural and leisure center, complemented by blue-green infrastructure with corridor structure. These green corridors and river buffer projects at the neighborhood scale extend from the suburbs to the broader Maas river basin, while inspiring other cities along the Maas river to adopt similar landscape structures. The resulting network of corridors seamlessly integrates the entire Maas basin's ecosystem, fostering the formation of industrial clusters and a thriving leisure industry chain.

By adopting this integrated urban transformation scheme, Maastricht can significantly enhance its retention capacity by approximately 34% and create around 800 new job opportunities. Moreover, in conjunction with the extensive retention areas in the surrounding suburbs, these proposed strategies are expected to effectively prepare Maastricht for projected major flood events until 2060. The development of a leisure industry chain within the Maas river basin not only contributes to the stability of industrial operations in Maastricht but also enhances the city's overall economic resilience.



GOVERNANCE COLLABORATION

This integrated urban transformation plan, acrossing three scales, requires the collaborative support of stakeholders at each level of governance. All design decisions should be made in consultation with the relevant stakeholders. Given the large number of stakeholders involved and the complexity of their cooperation, it is essential to establish platforms or organizations at each scale to lead and coordinate stakeholders at the same level as well as across different levels.

As a key region and primary beneficiary of the proposal, the city of Maastricht plays a pivotal role. The Maastricht Municipality should be involved in the entire project, from setting the context, taking the project lead, contributing to design and implementation, to monitoring the post-project performance. The municipality acts as a coordinator for stakeholders at various scales, ensuring effective collaboration throughout the process.

LIMITATIONS

The current study acknowledges several limitations that should be taken into consideration. Firstly, due to time constraints, there were no workshops or meetings conducted with stakeholders at each level of design decision-making to gather multiple perspectives, which slightly compromises the feasibility of the project. However, extensive research (literature review and on-site visits) was conducted by the researchers in the preliminary design phase, and interviews and questionnaires were administered to local residents to gain insights into their perspectives on the city, which helped align the project direction with real-world needs to some extent. Furthermore, there is a limitation in terms of the researchers' expertise, particularly regarding the operation of leisure businesses and the establishment of industry chains. This aspect was only roughly explored through relevant literature and Maastricht government data. In practical implementation, collaboration with experts in the respective fields is essential to effectively integrate leisure industries with flood management and promote urban development. Future research should address limitations by fostering stakeholder relationships, involving professionals, and ensuring feasibility and success in Maastricht's transformation.

5.2 Reflection

THE INTRINSIC RELATIONSHIP BETWEEN THE PROJECT AND URBANISM

The tension between urban development and nature conservation has long been a critical concern within the field of urbanism. Through my participation in the Design of the Urban Fabric studio, I gained valuable insights that helped me recognize the significance of integrating economic development, livability, and flood management in my project.

My master's program sparked my profound interest in the relationship between cities and nature, and my graduation project further deepened my approach to addressing urban challenges through the utilization of scenarios and pattern language. This journey has reinforced my conviction that design possesses the transformative power to enhance the relationship between people and nature. It has also solidified my belief that urban development can play a pivotal role in becoming an integral part of the ecological cycle in the future.

Overall, my academic journey and the progression of my graduation project have nurtured a holistic perspective on urbanism, emphasizing the importance of integrating economic, social, and environmental aspects. I am now firmly convinced that through thoughtful design and the recognition of the interconnectedness between human activities and natural systems, we can forge a harmonious and sustainable coexistence between cities and nature.

THE INTRINSIC RELATIONSHIP BETWEEN RESEARCH AND DESIGN

The interaction between research and design is critical for achieving the integration of flood resilience and the leisure industry in this report. It occurs through various stages and processes.

In the initial stage, research provides a foundation for the design process by offering evidence-based knowledge and insights. This includes research on the hydrological patterns of the Maas River, the impacts of flooding in Maastricht, the economic and social dimensions of the local leisure industry, and the concept of cultural landscape. By understanding these aspects, the design can effectively address the challenges and opportunities associated with flood resilience and leisure industry.

As the project progresses, design itself becomes a form of research. Through exploring the potential of Maastricht's urban spaces, I identified cultural landscape, developed porosity maps, and categorized different neighborhood spaces. This process requires the designer to have preconceptions of space and assess spatial quality, taking into consideration factors such as flooding patterns, environmental impacts, community needs, and economic viability. The design process generates new data, insights, and solutions that further inform the research findings.

The integration of flood resilience and the recreation industry is made possible by the synergy between research and design. Research provides a solid knowledge base and empirical evidence that ensure the design solutions are grounded in a deep understanding of the subject matter. Design, on the other hand, generates innovative ideas and practical applications that test and refine the feasibility and effectiveness of the research-based concepts. This collaborative approach ensures that the design solutions are evidence-based, contextually relevant, and aligned with the research goals.

WORK PROCESS ASSESSMENT

- **Effectiveness**

In this project, I employed the cultural landscape, pattern language, and maximization scenario as key approaches to address my research questions. These three approaches proved to be effective in integrating flood management and the leisure industry.

The cultural landscape served as both my design concept and approach, guiding my perspective on the relationship between flooding and the leisure industry. It allowed me to adopt an integrated viewpoint and uncover the opportunities and challenges of urban transformation within the complex intersection of ecology and culture.

IInitially, translating abstract research concepts like flood resilience and cultural landscapes into practical applications posed challenges. However, adopting a pattern language approach helped overcome this hurdle. Instead of constructing a research framework from scratch, I summarized previous design methods and categorized them based on the type of space they pertained to. I compared these methods to specific sites, identified missing elements, and sought relevant references. By evaluating existing patterns, adding missing ones, and establishing hierarchy and connections, a systematic research system was developed through an iterative process of design research.

Throughout the research by design process, the maximization solution approach compelled me to identify the essential qualities of the project and the associated spaces. It reinforced the advantages of utilizing pattern language as a tool. By applying the maximization approach, I was able to emphasize the most important aspects and qualities, ensuring a robust integration of flood management and the leisure industry.

In conclusion, the cultural landscape, pattern language, and maximization scenario proved to be valuable approaches in this project. They provided a comprehensive framework for addressing the research questions and effectively integrating flood resilience and the leisure industry. The combination of these approaches facilitated a holistic understanding of the subject matter and guided the creation of innovative and contextually relevant design solutions.

- **Limitations**

However, my research also has many limitations in this process, mainly in the relatively subjective assessment of the spatial potential of the research by design process.

The assessment of Maastricht's cultural landscape relies on relevant literature, field research, and personal judgments, but lacks input from local residents, potentially leading to biased results. To ensure a more comprehensive and objective evaluation, it would be beneficial to gather input from local residents to better understand their perceptions and insights.

Furthermore, flood management and leisure industry development were not fully prioritized in the maximization scenario approach due to site constraints, resulting in a scheme that may not fully realize the site's potential. While acknowledging these constraints, it is crucial to explore the benefits of maximizing flood management and leisure industry development within the design.

Moreover, an alternative approach, setting three maximization scenarios aligned with specific design goals instead of two themes, would have been advantageous. This adjustment would have allowed for a more comprehensive discussion of implementation effects and a deeper exploration of the site's potential. Diversifying the scenarios based on distinct objectives would have provided a more nuanced understanding of the impacts and trade-offs involved.

5.2 Reflection

VALUE AND CONSIDERATION

- **Scientific Relevance**

The existing body of research predominantly concentrates on the concept of expediting drainage systems and preventing river floods from infiltrating urban areas. However, limited attention has been given to embracing and capitalizing on floods from an urban design standpoint.

Simultaneously, only a few studies have delved into the intricate relationship between urban economic and cultural development and flood management, as well as the potential for mutual facilitation between these two domains. Consequently, this study aims to adopt this perspective and address the dearth of knowledge regarding integrated urban design approaches that encompass river flood adaptation and sustainable leisure industry development.

By exploring the nexus between flood management and urban development, this research endeavors to bridge the existing knowledge gap and offer insights into innovative and comprehensive urban design strategies. Through a holistic approach, the study aims to contribute to the advancement of urban resilience, while simultaneously fostering economic growth and cultural enrichment within flood-prone areas.

- **Ethical Considerations**

The primary data collected in this study through surveys and Interviews will inform the participants of the purpose of the study in advance, and will not reveal or violate any of their privacy during the research, and they can discontinue their participation at any time. The secondary data and information collected is through legal means, either from public repositories, or if it is from elsewhere, it is permitted and authorized. Overall, this research will be conducted in compliance with all research ethics.

- **Societal Relevance**

This study presents a unique opportunity for the city of Maastricht to adopt an urban design perspective across multiple scales (regional, urban, and neighborhood) to effectively address river flooding while promoting a sustainable leisure industry. Through a series of spatial interventions, the study explores the transformation of flooding into a resource, thereby offering flood protection measures that also facilitate the development of the leisure industry.

Furthermore, these interventions have the potential to deepen the engagement of residents in ecological circulation, allowing human activities to contribute to the overall health and well-being of the Maas basin. By incorporating the leisure industry as a catalyst, the study establishes a framework where inhabitants actively participate in ecological conservation efforts and become stewards of the environment.

Moreover, the findings and recommendations from this study can serve as a valuable model for urban transformation in other cities facing similar threats of fluvial flooding. By demonstrating a successful integration of urban development and nature conservation, it offers a pathway for reconciling these seemingly divergent goals. The lessons learned from Maastricht can inform and guide other cities in their pursuit of sustainable urban development amidst the challenges posed by fluvial flooding, contributing to the broader discourse on resilient and nature-conscious urban planning.

TRANSFERABILITY OF THE OUTCOMES

The integrated flood resilience and leisure industry urban transformation model is transferable and applicable to cities facing similar challenges. It offers benefits in terms of:

- **Similar environmental context:**

Cities located in river flood-prone areas and with a rich history and culture, or areas with similar environmental characteristics can benefit from the transferability of this approach. Strategies such as mixed-use green infrastructure adapted from historic sites, floodplain management with recreational functions, and resilient building design can be adapted to address local flood risk and increase overall resilience while recreating local history and culture.

- **Shared urban development goals:**

Cities aiming for sustainable urban development, economic growth, and the promotion of recreation and tourism industries can utilize the integrated approach to combine flood resilience measures with the development of recreational spaces, waterfront amenities, and cultural attractions.

- **Knowledge exchange**

Successful case studies and best practices can be shared among cities to inform and guide the adaptation and implementation of strategies in different urban contexts.

- **Adaptation to local contexts**

Each city has unique characteristics and needs, requiring tailored approaches that consider the local natural environment, cultural heritage, and socioeconomic factors for effective implementation.

- **Collaboration and learning networks:**

Collaboration platforms allow cities facing similar challenges to share experiences, lessons learned, and innovative solutions, enabling collective improvement of flood resilience and leisure industry development efforts.

- **Example:**

An example of a city in Europe along a river with a rich history where the integrated flood resilience and leisure industry urban transformation approach could be applied is Prague, Czech Republic.

Prague is situated along the Vltava River and is renowned for its historical significance and architectural beauty. However, the city faces challenges related to flood risks due to its location in a river basin.

By adopting the integrated approach, Prague can enhance its flood resilience while preserving and promoting its rich historical heritage. The city could implement strategies such as constructing flood protection infrastructure, implementing riverbank stabilization measures, and enhancing water management systems to mitigate the impact of potential floods.

In terms of leisure industry development, Prague can capitalize on its historical charm and riverfront location. This could involve revitalizing the riverfront areas with recreational amenities, creating pedestrian-friendly promenades, and preserving historic buildings and landmarks along the riverbanks. The integration of cultural attractions, outdoor cafes, and parks along the riverfront can enhance the leisure and tourism experience for both locals and visitors.

By balancing flood resilience measures with the development of leisure industry infrastructure, Prague can protect its historical heritage while creating vibrant and resilient riverfront areas. This approach can contribute to the city's overall livability, tourism appeal, and economic growth.

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APPENDIX

Appendix 1: Essential session of Design of the Urban Fabric

To be kept

Historical texture
- Monuments
- River
- Housing

Livability

Microclimate regulation

To be reinforced

Diverse culture
- Plinth
- recreational places
- office
- Bike lane& sidewalk
- Shared system
- Stayable space
- Roofs
- River

Mixed land use

Vitality

Micro mobility

Clean

To be added

Sports atmosphere
- Plinth
- Mobility
- Sports facilities
- Permeable pavement
- Public transport
- Renewable energy infrastructure
- Green area
- Green drainage system
- Water storage space
- affordable housing
- Stayable space
- Roofs

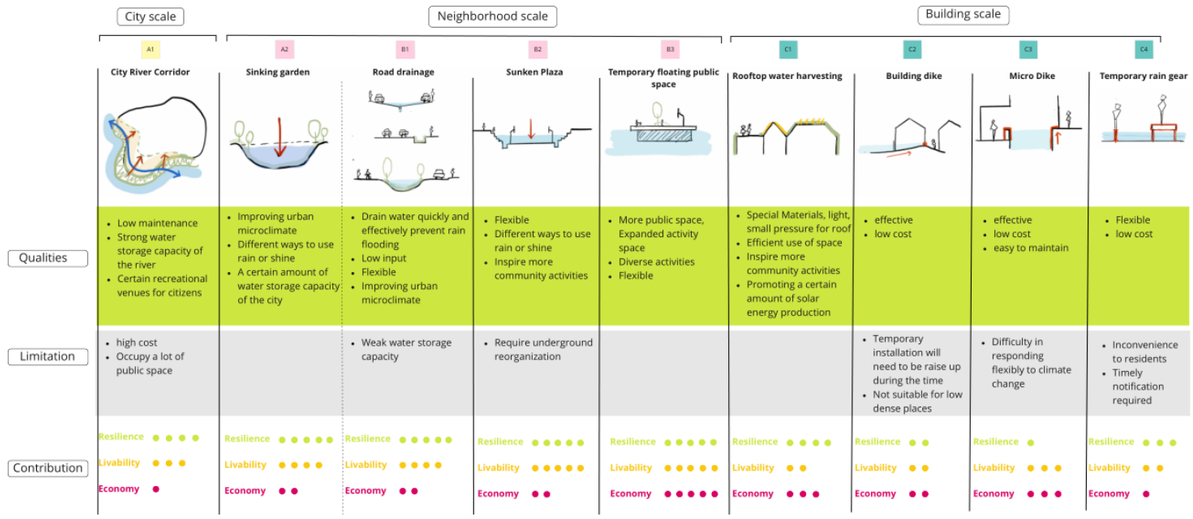
Resilience

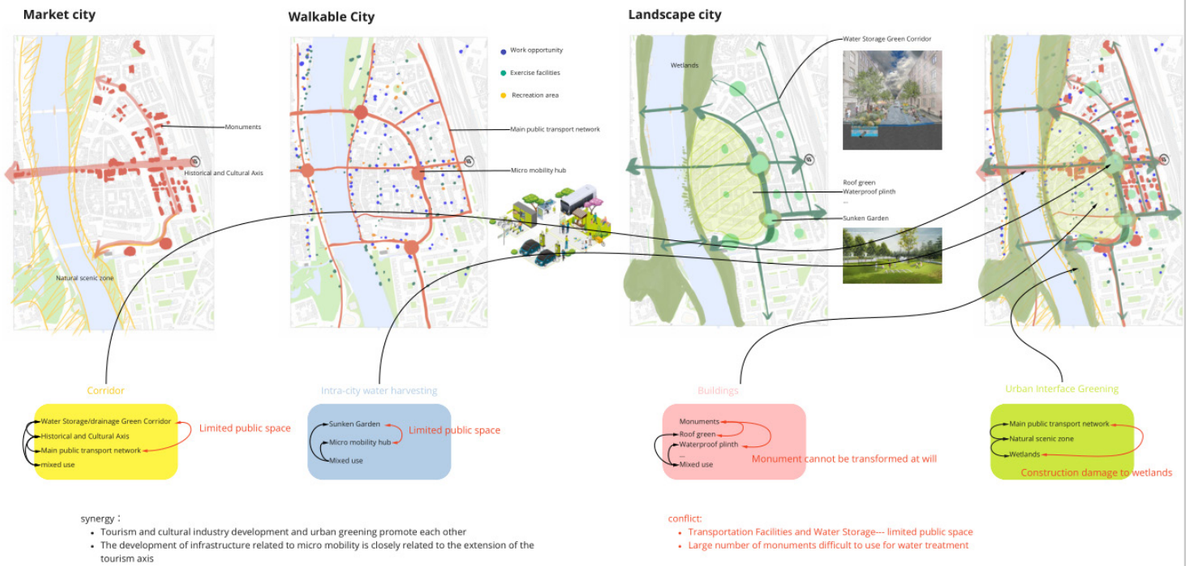
Green Downtown

Accessibility

To be removed/transformed

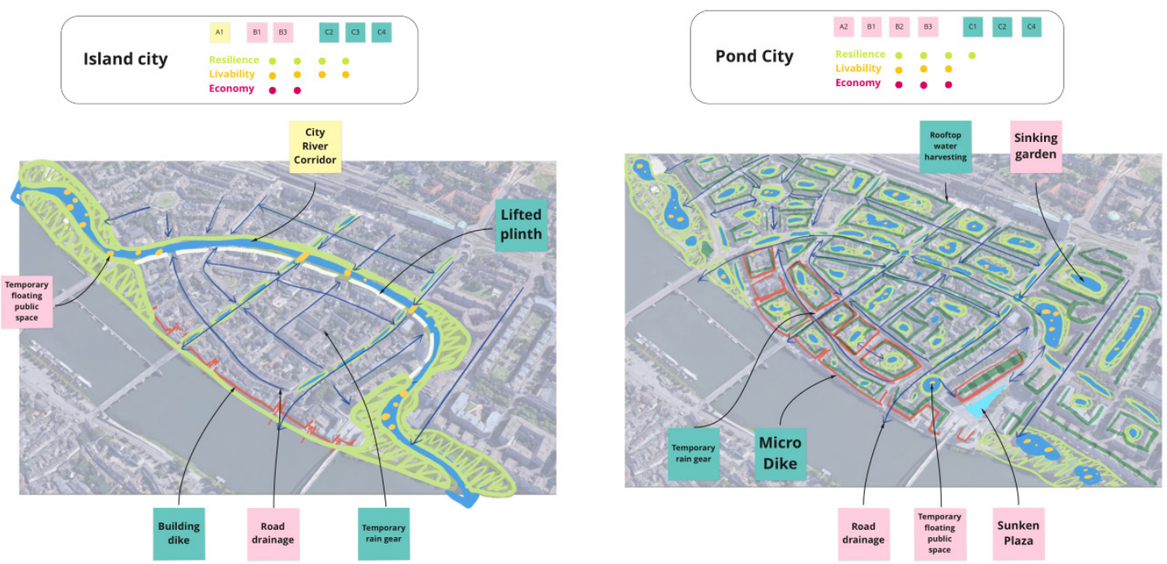
Vulnerable to flooding
- Dikes
- Plinth
- recreational places
- Buildings
- Traffic infrastructure
- Sewage system
- Stayable space
- Pipelines and energy lines



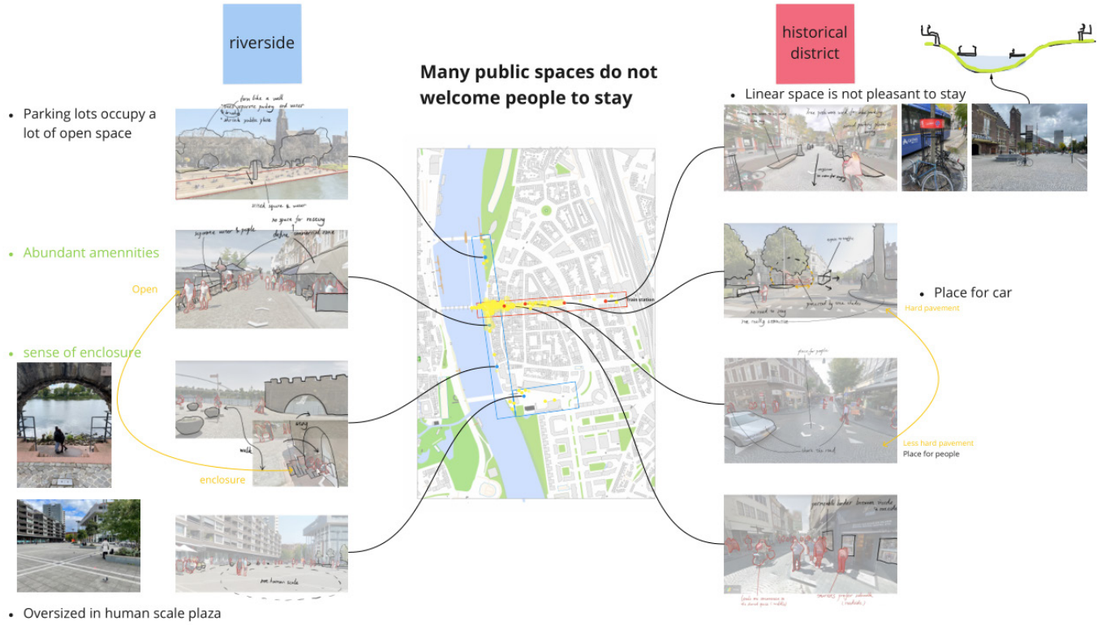


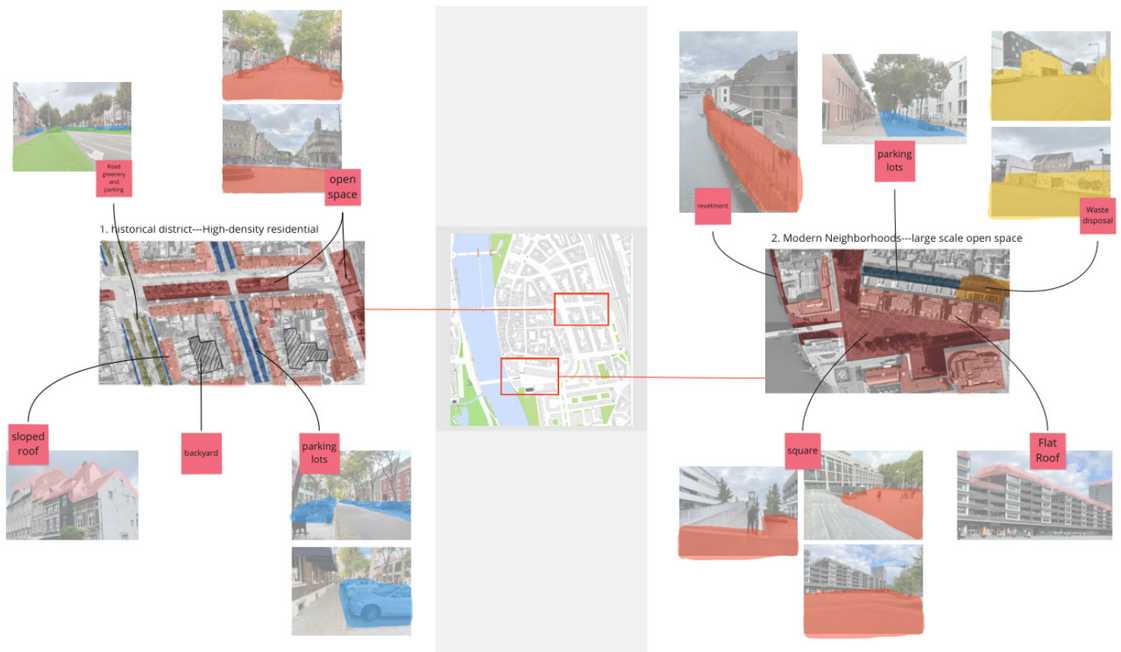
synergy：
- Tourism and cultural industry development and urban greening promote each other
- The development of infrastructure related to micro mobility is closely related to the extension of the tourism axis

conflict:
- Transportation Facilities and Water Storage--- limited public space
- Large number of monuments difficult to use for water treatment



Appendix 2: Fieldwork





Survey on the leisure activity preferences of Maastricht residents

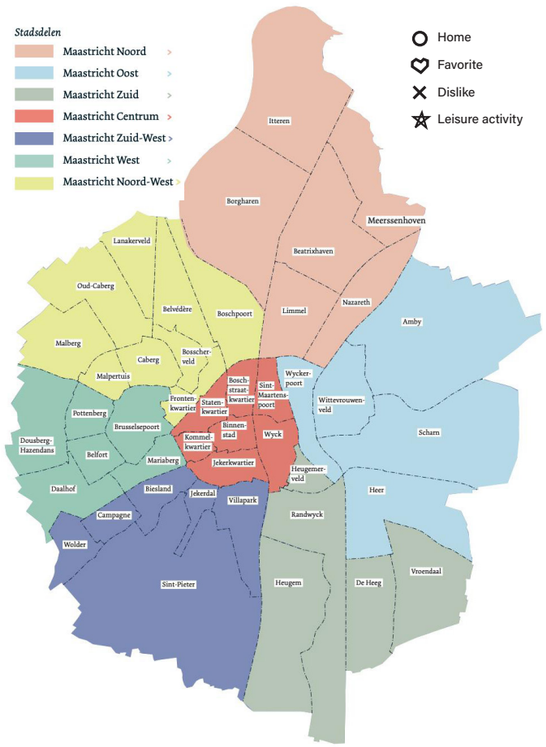
You are being invited to participate in a research study integrated urban transformation for river flood resilience and sustainable leisure industry in the city of Maastricht. This study is being done by Danyi Xiang from the TU Delft.

The purpose of this research study is exploring integrated transformation from an urban design perspective for the city of Maastricht to adapt to river flooding and to promote sustainable leisure industry, and will take you approximately **5 minutes** to complete. The data will be used for pointing the way to the development of the leisure industry in Maastricht in the future and increase the feasibility of the project. We will be asking you to answer the questions in short words.

As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by making sure that the survey is completely anonymous and will not involve with any personal questions.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions.

Responsible investigator: Danyi Xiang (D.XIANG@student.tudelft.nl)
Responsible Researcher: Claudiu Forgaci (C.Forgaci@tudelft.nl)



1. Do you live/work/study in Maastricht? For how long?

- ☐ live _____
- ☐ work _____
- ☐ study _____

2. Which neighborhood/distrinct do you live in?
(Highlight it on the map with ○)

3. Do you like this city? Why?

4. Where is your favorite place in Maastricht? Why?
(Highlight it on the map with ♡)

5. Where is your most disliked place in Maastricht? Why?
(Highlight it on the map with ✕)

6. What's your favorite leisure activity? *(Such as walking, boating, dining with friends...)*

7. How often and when do you usually do it?

8. Where do you usually do it? Is it in the city of Maastricht?
(Highlight it on the map with ☆)

9. Is there anything you think Maastricht could improve on?
(Related to leisure / culture / social services, etc.)

Appendix 4: Calculation of Urban Retention Capacity

- Current retention capacity:

7350589 m3

Land cover type:	The surface of your area	total amount of water that comes down in m3 for the time period you have entered	**depression storage**, the amount of water that sticks to the surface in mm	**Infiltration loss**, the water that runs off in mm/per hour	amount of water that enters the area (it can be negative when it is immediately discharged to the natural system) in m^3	the negatives in column F are changed to 0 because water can not be settled		Specific storage, the capacity of the surface to store water, in m^3 water per m^2	This is the delay per surface in minutes, this plays a role when the storms takes a longer time	Retention capacity for different space types
OPEN BODEM	OPEN SOIL									
private	private									
gareden with open soil	1,305,330	0	15	50	-19579.95	0.00		0.1	15	130533
public	public									
open water	4833645	0	300	0	-1450093.50	0.00	G24: if the number becomes positive then the storage capacity of the open water has reached its maximum.	0.5	0	2416822.5
rain garden	0	0	25	75	0.00	0.00		0.1	60	0
grass	24,168,224	0	15	50	-362523.36	0.00		0.1	15	2416822.4
play ground	11,332,521	0	5	5	-56662.61	0.00		0.1	5	1133252.1
Wadis	604,205	0	50	75	-30210.25	0.00		0.5	30	302102.5
SEALED SOIL										
private	private									
Roofs – sloping	4,568,655	0	1	0	-4568.66	0.00	*sewer*	0	0	0
Roofs – flat, tar	1,957,995	0	5	0	-9789.98	0.00	*sewer*	0.05	10	97899.75
Green roofs – extensive	0	0	10	0	0.00	0.00	*sewer*	0.1	15	0
Green roofs – intensive	0	0	25	0	0.00	0.00	*delayed sewer*	0.2	30	0
Garden tiled	978,997	0	3	8	-2936.99	0.00	G35: Is it a frond or back yard? Is it connected to the sewer?	0.05	5	48949.85
Permable terras or parking	978,997	0	3	40	-2936.99	0.00		0.05	5	48949.85
public	public									
Roads, car parks – asphalt	3,021,027	0	1	0	-3021.03	0.00	*sewer*	0.05	5	151051.35
Roads, car parks – porous asphalt	3,021,027	0	1	40	-3021.03	0.00	*delayed sewer*	0.05	5	151051.35
Roads, car parks – brick	3,021,027	0	3	10	-9063.08	0.00	*sewer*	0.05	5	151051.35
Roads, car parks – porous pavement	3,021,027	0	3	40	-9063.08	0.00	*delayed sewer*	0.05	5	151051.35
Sidewalk, terraces –tiles	3,021,027	0	3	8	-9063.08	0.00	*sewer*	0.05	5	151051.35
total privat land m^2 /water in m^3 for the entered time period	9789974	0								
total public land m^2 / water m^3 for the entered time period	56043730	0	F45: capacity of the sewer: (= combined system) 21 mm/hour							
Total size of the area m^2, and total amount of rain in m3 for the entered time period (A18)	**65,833,704**	**0**	water to the sewer in mm/hour: **#DIV/0!**		0.00	m^3 directly to sewer (roof and stree)				7350588.7

- Transformed retention capacity:

9862750 m3

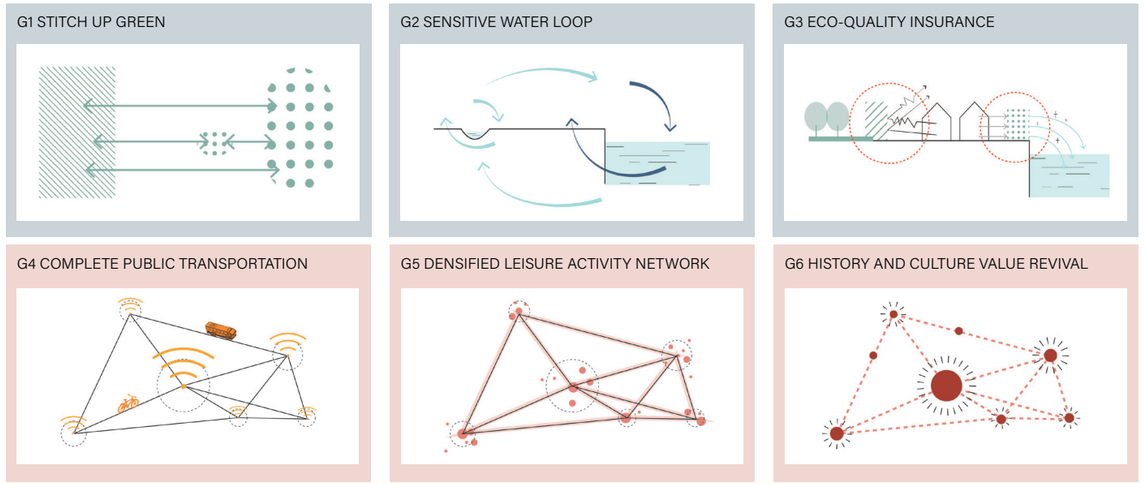
Land cover type:	The surface of your area	total amount of water that comes down in m3 for the time period you have entered	**depression storage**, the amount of water that sticks to the surface in mm	**Infiltration loss**, the water that runs off in mm/per hour	amount of water that enters the area (it can be negative when it is immediately discharged to the natural system) in m^3	the negatives in column F are changed to 0 because water can not be settled		Specific storage, the capacity of the surface to store water, in m^3 water per m^2	This is the delay per surface in minutes, this plays a role when the storms takes a longer time	Retention capacity for different space types
OPEN BODEM	OPEN SOIL									
private	private									
gareden with open soil	1,974,000	0	15	50	-29610.00	0.00		0.1	15	197400
public	public									
open water	9,063,000	0	300	0	-2718900.00	0.00	G24: if the number becomes positive then the storage capacity of the open water has reached its maximum.	0.5	0	4531500
rain garden	3,021,000	0	25	75	-75525.00	0.00		0.1	60	302100
grass	27,189,000	0	15	50	-407835.00	0.00		0.1	15	2718900
play ground	8,333,000	0	5	5	-41665.00	0.00		0.1	5	833300
Wadis	604,000	0	50	75	-30200.00	0.00		0.5	30	302000
SEALED SOIL										
private	private									
Roofs – sloping	3,290,000	0	1	0	-3290.00	0.00	*sewer*	0	0	0
Roofs – flat, tar	1,316,000	0	5	0	-6580.00	0.00	*sewer*	0.05	10	65800
Green roofs – extensive	658000	0	10	0	-6580.00	0.00	*sewer*	0.1	15	65800
Green roofs – intensive	1,316,000	0	25	0	-32900.00	0.00	*delayed sewer*	0.2	30	263200
Garden tiled	526,000	0	3	8	-1578.00	0.00	G35: Is it a frond or back yard? Is it connected to the sewer?	0.05	5	26300
Permable terras or parking	329,000	0	3	40	-987.00	0.00		0.05	5	16450
public	public									
Roads, car parks – asphalt	2,160,000	0	1	0	-2160.00	0.00	*sewer*	0.05	5	108000
Roads, car parks – porous asphalt	2,160,000	0	1	40	-2160.00	0.00	*delayed sewer*	0.05	5	108000
Roads, car parks – brick	2,160,000	0	3	10	-6480.00	0.00	*sewer*	0.05	5	108000
Roads, car parks – porous pavement	2,160,000	0	3	40	-6480.00	0.00	*delayed sewer*	0.05	5	108000
Sidewalk, terraces –tiles	2,160,000	0	3	8	-6480.00	0.00	*sewer*	0.05	5	108000
total privat land m^2 /water in m^3 for the entered time period	9409000	0								
total public land m^2 / water m^3 for the entered time period	59010000	0	F45: capacity of the sewer: (= combined system) 21 mm/hour							
Total size of the area m^2, and total amount of rain in m3 for the entered time period (A18)	**68,419,000**	**0**	water to the sewer in mm/hour: **#DIV/0!**		0.00	m^3 directly to sewer (roof and stree)				9862750

- Increased retention capacity:

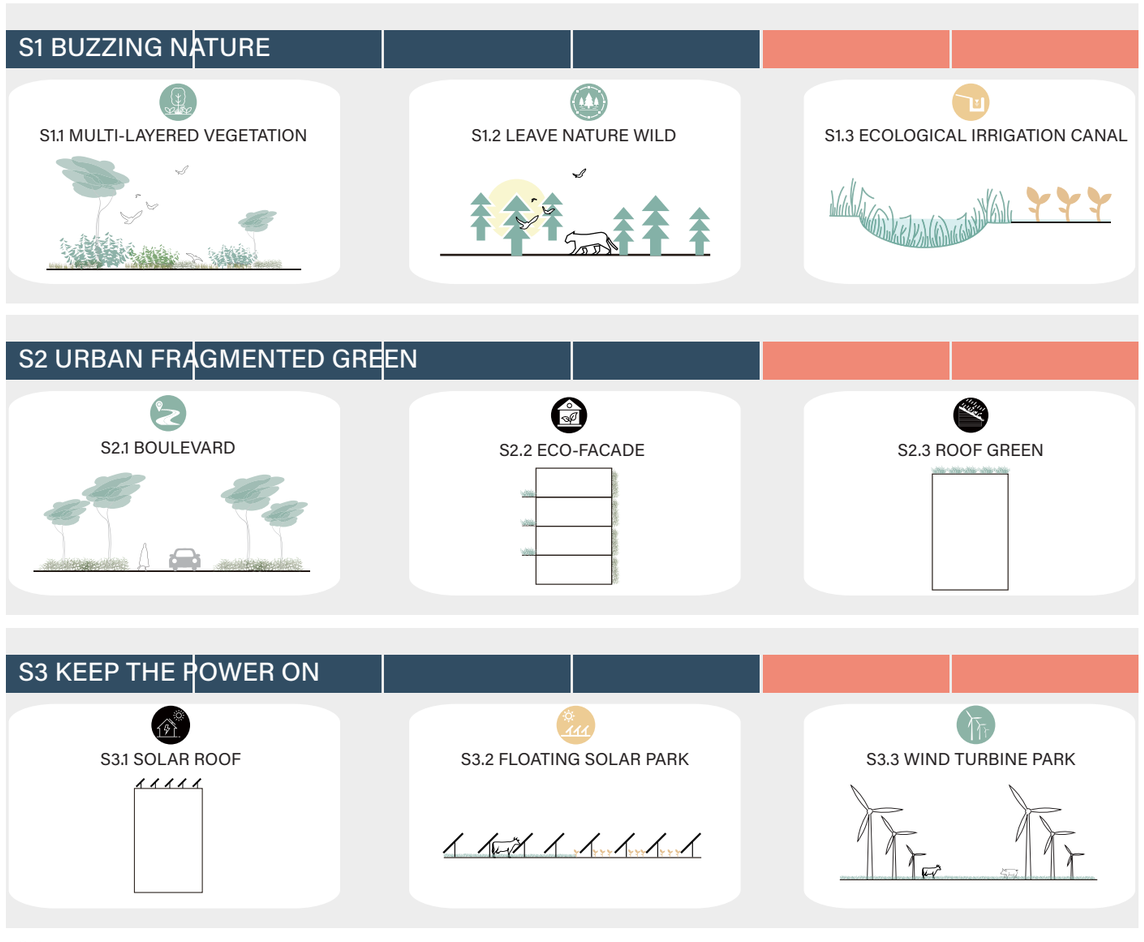
9862750 - 7350589 = 2512161 m3

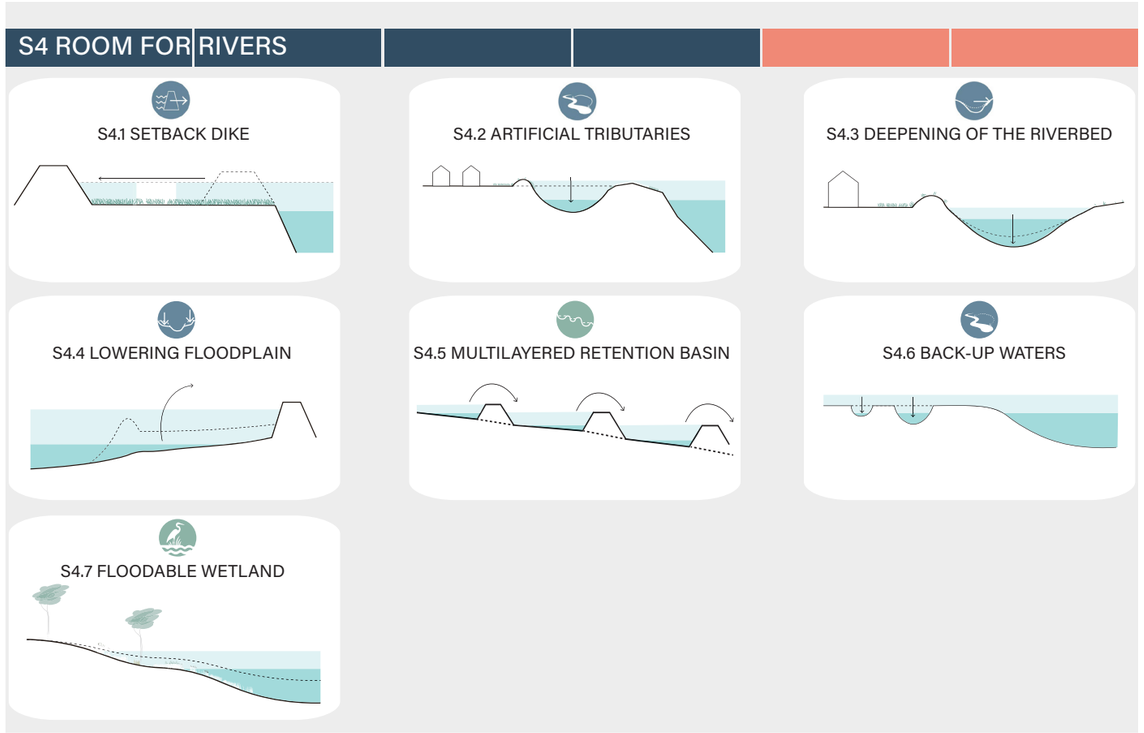
Appendix 5: Pattern Box

- Guideline



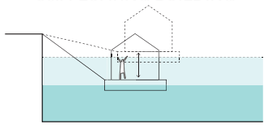
- Spatial Strategy



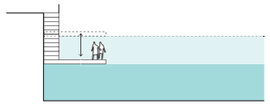


S8 FLOATING ISLANDS

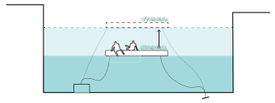
S8.1 FLOATING BUILDING



S8.2 WATERFRONT EXTENSION



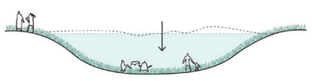
S8.3 WATER CENTRAL ISLAND



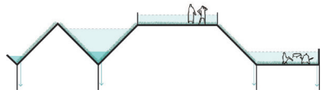
S9 STORMWATER BUFFER

S9.1 WATER SQUARE

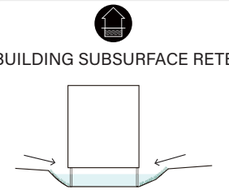
S9.2 SINKING GREEN SPACE



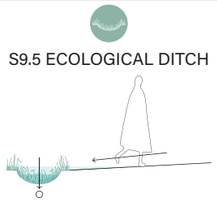
S9.3 CATCHMENT ROOF



S9.4 BUILDING SUBSURFACE RETENTION

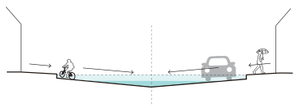


S9.5 ECOLOGICAL DITCH

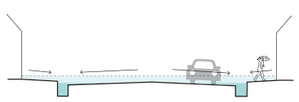


S10 SURFACE DRAINAGE

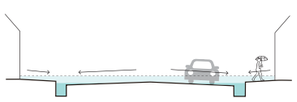
S10.1 V-SHAPED ROAD



S10.2 MICRO CANAL

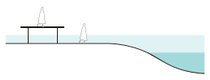


S10.3 PERMEABLE PAVEMENT

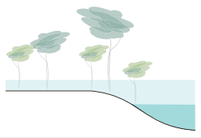


S11 MULTIFUNCTIONAL FLOODPLAIN

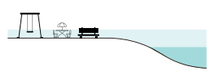
S11.1 BACK-UP ROUTE



S11.2 WET-LOVING TREES

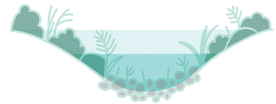


S11.3 TEMPORARY STREET FURNITURE

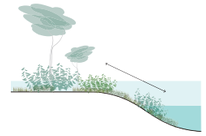


S12 PURIFYING BEFORE RETENTION

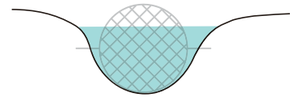
S12.1 BIOSWALES



S12.2 WATER PURIFICATION PLANTS

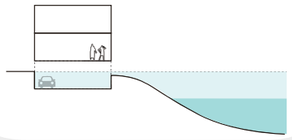


S12.3 STRAINERS

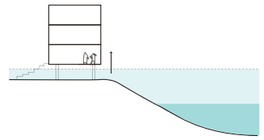


S13 FLOOD-PROOF PLINTH

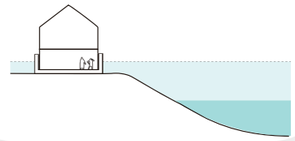
S13.1 SACRIFICIAL LOWER TIER



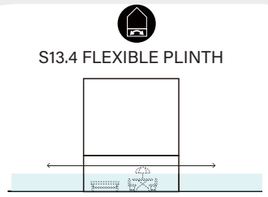
S13.2 HIGH-HEELED PLINTH



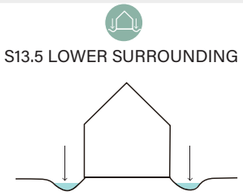
S13.3 SEALED PLINTH



S13.4 FLEXIBLE PLINTH

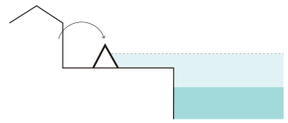


S13.5 LOWER SURROUNDING

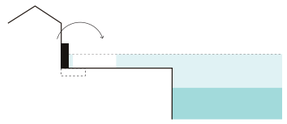


S14 TEMPORARY FLOOD RESISTANCE

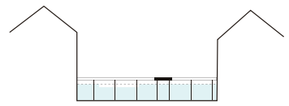
S14.1 REMOVABLE DIKE



S14.2 WATERPROOF CONSTRUCTION MASK



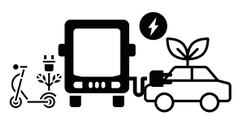
S14.3 PASSAGE IN FLOODS



S15 CONTINUOUS PUBLIC TRANSPORTATION

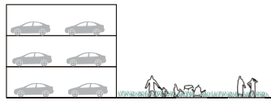
S15.1 GREEN WATERBUS

S15.2 MOBILITY HUB



S16 EVERYBODY SLOW DOWN

S16.1 CENTRALIZED PARKING

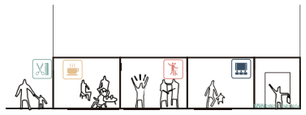


S16.2 SHARED MICRO MOBILITY

S16.3 LARGER PEDESTRAIN

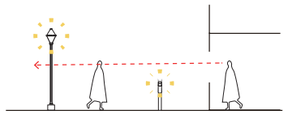
S17 VIBRANT PEDESTRIAN

S17.1 VIBRANT PLINTH



S17.2 HAVE A SEAT

S17.3 A SAFE WALK



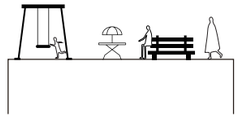
S17.4 POROUS EDGES

S17.5 SOFT PAVEMENT

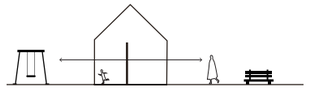
S17.6 TEMPORARY MARKET

S18 OUR BACKYARD

S18.1 ROOFTOP PLAYGROUND



S18.2 EXPANDING THE BACKYARD

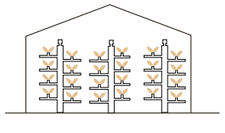


S18.3 RECLAIM PARKING LOT

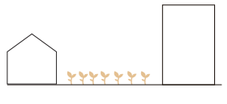
S19 URBAN FARMING

S19.1 ROOFTOP FARM

S19.2 VERTICAL AGRICULTURE

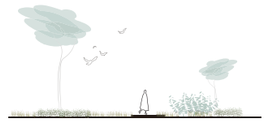


S19.3 COMMUNAL FARMING



S20 NATURE EDUCATION

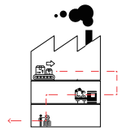
S20.1 WILD TRAIL



S20.2 ELEVATED TRACK

S21 INDUSTRIAL LEGACY PRESERVATION

S21.1 VERTICAL PRODUCTION



S21.2 SQUATTING

S22 REPURPOSING OF RELICS

S22.1 ENABLING FUNCTIONALITY

S22.2 BLENDING OLD AND NEW

- Program

P1 LOCALS GUIDE PLATFORM

P1.1 TOURISM SERVICE CENTER

P1.2 LOCALS GUIDE APP

P2 TOURISM OF TRADITIONAL INDUSTRIES

P2.1 VISUAL INDUSTRIAL PRODUCTION

P2.2 AGRICULTURAL EDUCATION