Towards a Flood-Resilient Civil Society

Explore Flood Risk Adaptive Design and Governance Strategies in Roermond

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P5 Report
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The illustration on the front page is adapted from Agnieszka Żurawska (2021), and the aerial photos on the title pages are from Siebe Swart (2011).

Acknowledgement

In a flash, the graduation thesis is nearing its end. Seven months ago, I chose this direction amidst the onslaught of worldwide flooding events, when I knew nothing about flood management. This report has recorded the whole process of my research, witnessed the detours I have taken and memorized the help I have received from many people.

To my main mentor, Fransje, thank you for your consistent guidance. It has become a habit for me to look forward to meeting you every Friday. Building flood resilience with interdisciplinary and cross-sectoral collaboration is the topic you inspired me to formulate. This is new territory for me, and your professional and precise vision has saved me many detours. I admire your ability to stay active while wearing so many hats. I hope I can be as efficient and professional as you when I start my career.

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To Martine and my colleagues in the Limburg Group, thank you for your different perspectives. I am a special presence in this team of water management engineers, but this collision of perspectives inspired me to revise my overly ideal concept in design. I enjoyed listening to your project progress during the sharing sessions, which expanded my hydrological knowledge.

Last but not least, to my family and friends around the world, thank you for always being there. The two years of my master's degree were also the two years of the pandemic when socializing became a luxury. Chatting with you always makes me lose track of time and look forward to seeing you soon.

Isolated holiday houses because of the high waters.

Photo by Siebe Swart, 2011

Abstract

Flooding is one of the most destructive climate disasters. Since the 21st century, the United States, Thailand, China, and many other countries have been hit by flash floods, which not only exposed the vulnerability of the urban system expansively but also serves as an opportunity to promote resilient city construction. The research begins by reviewing the major policy and project progress in the field of flood mitigation. It turns out that most countries rely heavily on engineering facilities for flood control to hold back floods, ignoring the uncertainty caused by climate change and urban expansion, which is not a long-term effective solution to the flooding problem.

Given the literature review of flood resilience, the result shows that it remains largely unpracticed in contemporary urban planning and design, mainly manifested in the insufficient participation of spatial planning science in flood risk management. Based on Dutch policy systems and planning approaches, the project will evaluate existing flood risk management frameworks, develop mechanisms for stakeholder engagement, explore the most efficient flood adaptation strategies, and provide guidance on how to establish urban flood resilience using design tools and planning approaches. Finally, areas along the Meuse and inland will face climate change with greater confidence.

Keywords: flood resilience, flood risk management, spatial planning, stakeholder engagement

The water is advancing in Roermond, but: 'We are diehards, we will stay'.

Photo by Mac van Dinther, 2021

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I. INTRODUCTION

1 Context

1.1 Climate crisis

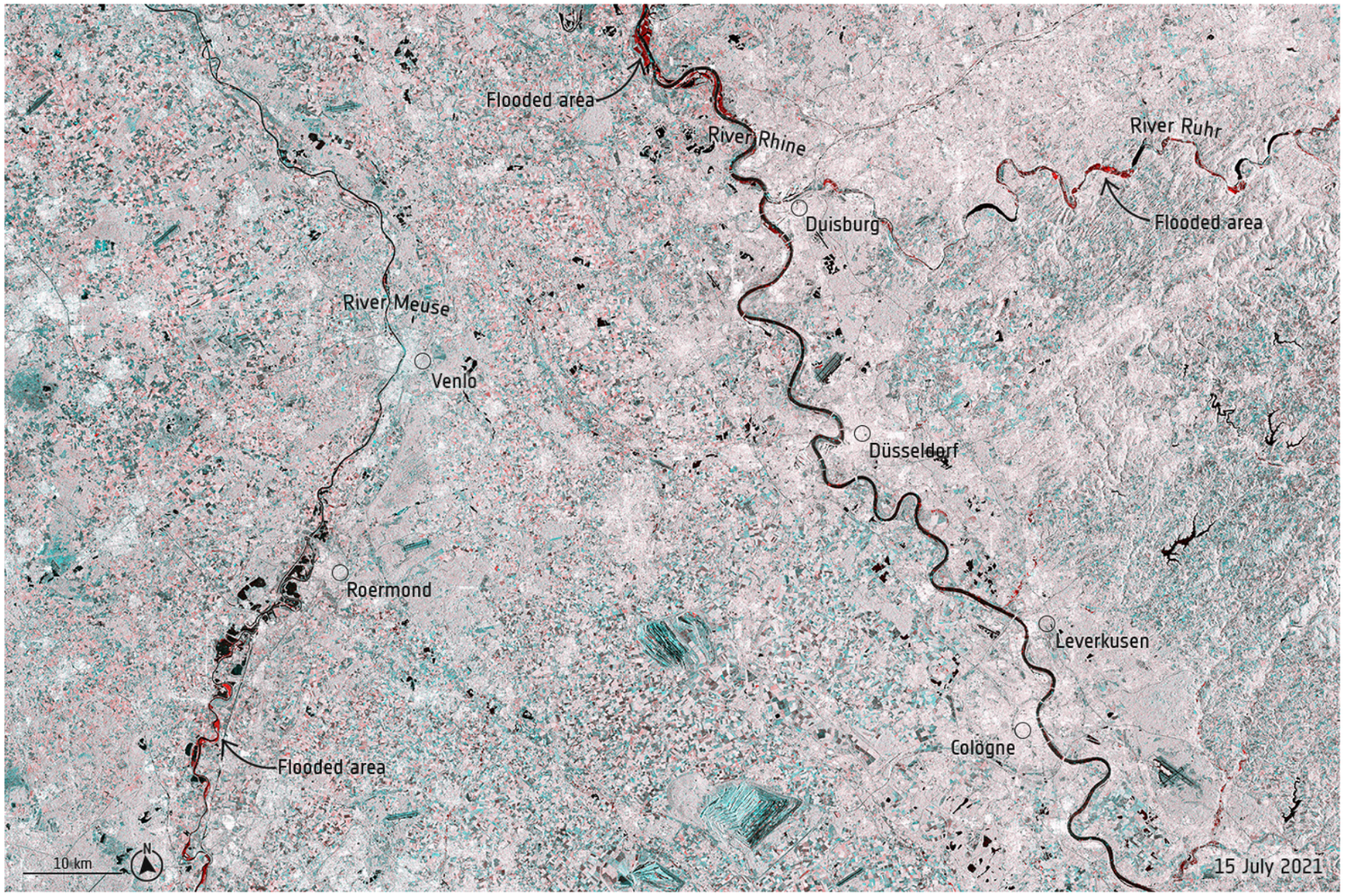
Extreme weather events - including powerful heat waves and devastating floods - are now the new normal, says the World Meteorological Organisation (2021).

The year just past 2021 saw a particularly large number of extreme weather events around the world. Severe flooding in parts of Europe, causing dozens of casualties and billions of euros in economic losses. One inland Chinese city received as much rain in three days as it did in the whole of last year. Successive droughts in South America have reduced the flow of river basins and indirectly affected agriculture, transport and energy production. For the first time ever, it rained rather than snowed in Greenland... The State of the Climate 2021 report found that the past seven years are likely to be the hottest on record, with concentrations of greenhouse gases in the atmosphere reaching new highs. Rising temperatures are pushing the planet into "uncharted territory", leaving current and future generations in limbo, the report said.

Among all kinds of climate disasters, floods attract more attention because of their instantaneous destructive power. Combined with rising sea levels, increased storm surges and extreme weather caused by climate change pose a major flooding threat to countries around the world, especially low-lying deltas like the Netherlands. The devastating floods in Germany and Belgium in 2021 are a reminder that flood risk management should not be taken lightly. Crises have always existed and are growing.

Satellites map 2021 floods in western Europe.

Map by European Space Agency(ESA), 2021



1.2 Thesis location

Roermond, Limburg, NL

The Meuse River originates in France, flows through Germany, Belgium, the Netherlands, and empties into the North Sea. It is an important river in Western Europe. The high water level at the Meuse River in July 2021 was an extreme and exceptional event for the Netherlands and surrounding countries, with major social implications. In research from Jonkman (2021), such an event is estimated to occur only once every 100 to 1,000 years, causing hundreds of deaths and billions of euros in damage in Germany and Belgium.

In this case, Limburg was the worst-hit province in the Netherlands. Thousands of people in Roermond, Roerdalen, and elsewhere had to be evacuated, but no one was hurt because of the flood protection system. However, despite all the measures, the Meuse was barely able to hold the high volumes of water discharged within a short time. It is evident that with increasing climate change, the occurrence of hazards such as floods will only become more frequent. Will Meuse's flood defenses hold up when the next flood hits?

The Meuse Valley in the Netherlands is both an important urban habitat and a constant risk of high-speed upstream flood discharge. This unique location makes Limburg an ideal place to conduct innovative climate adaptation experiments, with the diverse international environment also playing a role.

In order to find innovative measures and solutions to mitigate flooding and form cooperation between spatial planning and water management, this thesis chose Roermond as the research location (Figures 1 and 2). At Macroscale, hydrological characteristics such as topography, river bed, and water level were studied. At Microscale, flood adaptive measures such as multifunctional land use and co-creation were explored.

Figure 1. Multiscale site selection

The author, 2022

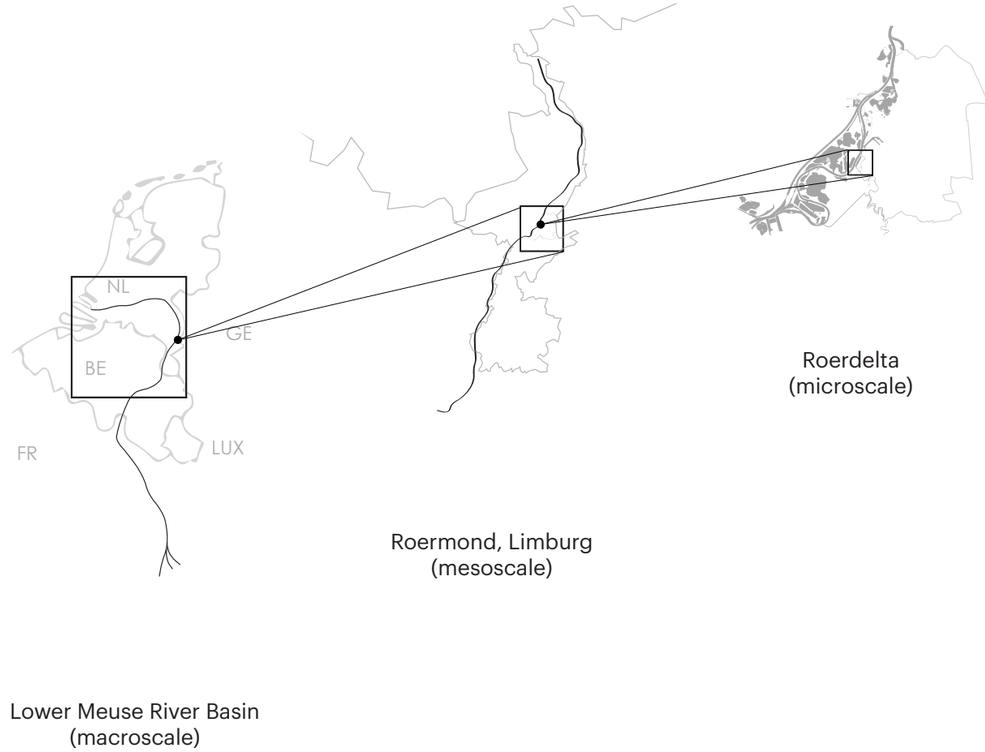


Figure 2. Satellite map of Roermond

Image from Google Earth, 2022

Panoramic view of Roermond flood.

Photo by Siebe Swart, 2010

Overview of inner city with river Roer, office tower, cathedral and Designer Outlet.

Photo by Siebe Swart, 2010

People laying sandbags near flooding on the Meuse river in Roermond.

Photo by Cris Toala Olivares, 2021

A flood plain after the flood receded in Roermond.

Photo by the author, 2021

2 Problem Field

2.1 Problem statement

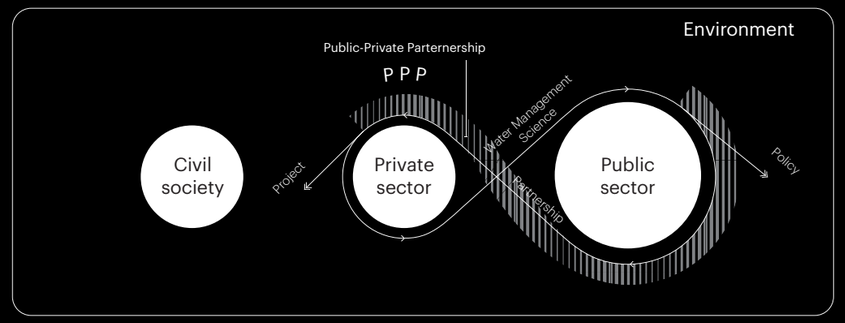
As climate change intensifies, coastal cities are no longer the only ones at risk from hydrological hazards. Since 12 July 2021, one of the worst floods in European history severed infrastructures in Belgium and Germany, damaged telephone and electricity systems, killed 242 people, and resulted in total property damages of €2.55 billion. Within a month, extreme precipitation also occurred in Turkey, China, India, Afghanistan, Pakistan, the United States, and New Zealand. Landward cities are suffering from an increased frequency of typhoons, intensive rainstorms, and storm surges (Webster et al., 2005). However, most countries around the world still rely on physical geographical indicators to predict flood risk, with little regard for the uncertainties of rapid urbanization and extreme weather. The same is true of Flood Risk Management (FRM) strategies, which focuses on flood control measures through the construction of dikes and weirs, whilst the potential role played by the other sciences, such as spatial planning and social science, has been somewhat neglected.

Limburg, located in Meuse riverine areas, is highly exposed to fluvial floods and pluvial floods. The 'Ruimte Voor de Rivier (Room for the River)' Project in the Netherlands has greatly reduced the damage of floods over the years, but Limburg was still devastated by the flood in the summer of 2021, suggesting there is room for improvement, especially in non-structural measures implemented in partnerships between the public, private, and civils. As Figure 3 indicates, sometimes complete engineered measures may create more risks as both the citizens and decision-makers may put too much faith in engineering, while paying comparatively less attention to flood preparedness and awareness as well as a contingency plan (Birkholz et al., 2014). This project aims to take Limburg as an example, unite the available forces of the private sector and civil society, and explore flood adaptive design measures as additional FRM strategies.

In the future, both inland and coastal cities should develop respective FRM plans based on scientific risk levels, covering the whole process of flood prevention, rescue, and rehabilitation, with the participation of multiple agencies and stakeholders. The risk of urban space can be reduced through a design approach, and flood risk governance policies can be proposed through a planning approach. The two approaches jointly deal with the uncertainty of climate change and establish urban flood resilience.

Figure 3. People put too much trust in flood defenses

Adapted from Agnieszka Żurawska, 2021



2.2 Research aims

The research aims of this project are twofold: firstly, enrich the existing flood risk management strategies, which corresponds to the lack of participation of spatial planning in flooding issues; Second, establish flood resilience at the municipal level, which is to solve the problem of over-reliance on public sectors for flood control. To achieve those aims, cross-scale research needs to set respective objectives:

Macroscale objective: To examine the top-down transmission and implementation of flood risk management strategies.

From the EU to the local level, flood risk management involves a variety of laws and policies such as the Water Framework Directive, Dutch Water Act, Environmental Law, etc. The continuity and coordination of policies are the focus of this project research. In addition, flood risk management requires the joint efforts of the European Commission, Dutch Ministries, water boards, and municipalities, which have respective responsibilities and have developed their own action plans. The project will assess whether there is a clear division of jurisdiction in the public sector and look for opportunities for civils and the private sector to intervene.

Mesoscale objective: To propose new policies and strategies by interdisciplinary policy analysis.

The city is an appropriate scale for both policy research and spatial planning. This study intends to compare the policy concerns of different fields and explore the possibility of translating water management policy concerns into an environmental vision.

Microscale objective: To explore an urban design for water detention, retention, and discharge while improving spatial quality.

In the face of the environmental pressures of space constraints and soil degradation, it is not sustainable to expand flood plains or raise flood defenses. Enhancing urban stormwater storage capacity needs to be focused on the details. This project will explore spatial design tools applicable to various functions of spaces, considering the feasibility of practical implementation and the impact on spatial quality.

2.3 Research question

In order to transform aims and objectives into research questions that can be studied, it is necessary to identify the concepts and tools that the thesis primarily uses, which can be studied separately or rearranged to produce new effects. The primary research question is:

*"What role can **Public-Private-Civil Partnership (PPCP)** play in facilitating the mechanisms of a **Science-Policy Interface (SPI)** that aim at **flood resilience**?"*

The key concepts are Public-Private-Civil Partnership (PPCP), Science-Policy Interface (SPI) and flood resiliency, among which, flood resiliency is the main aim, and PPCP and SPI are the tools to achieve the aim. In this thesis, the above concepts are precisely defined as:

[A] Public-Private-Civil Partnership (PPCP) is a collaborative approach to flood resiliency. In this model, three parties work together to develop a mutually beneficial spatial intervention and provide maximum benefit to the wider civil society and spatial quality. Within this partnership, the private sector will reap long-term benefits from innovative projects with more business value. The public sector will benefit from the value of additional resources and the guarantee of participation and ownership. And civils will benefit from having their experiences, opinions, and culture respected.

[B] Science-Policy Interface (SPI) has been defined as "social processes which encompass relations between scientists and other actors in the policy process, and which allow for exchanges, co-evolution, and joint construction of knowledge with the aim of enriching decision-making" (van den Hove, 2007). Gluckman argues that there are four categories of roles inside: knowledge generators, knowledge synthesizers, scientists who aggregate and try to understand the knowledge, and knowledge brokers (Gluckman, 2018).

[C] Flood resilience can be considered as a city being prepared, ready to respond, able to cope and recover from a flood event. It is a state in which people live in a flood and plan to cope with it, including a series of spatial strategies before, during, and after the flood.

The secondary research questions are pairwise combinations of the three main concepts mentioned above, and the research logic is sorted out by thinking about the potential relationships between concepts. The secondary questions are:

SUB 1: What is the relationship between public-private-civil partnership and science-policy interface?

[A+B]

SUB 2: What impact can public-private-civil partnership have on flood resilience?

[A+C]

SUB 3: In what way does science-policy interface help with flood resilience?

[B+C]

After literature review and conceptual framework construction, SUB 1 will be preliminarily answered in Chapter 3.2. SUB 2 and SUB 3 will be analyzed and explored along with the research, and further improved in the final conclusion.

2.4 Research significance

Scientific relevance

Policy transition is often stimulated by flooding events in the real world while neglecting the role played by Science-Policy Interface (SPI). Recent research in the field of flood risk management demonstrates how SPI fostered the uptake of knowledge and technologies in practice (Liefferink et al., 2018). Also, previous studies have emphasized the importance and necessity of planning in flood affairs to promote flood resilience, but few have mentioned specific interventions (Waylen et al., 2018). This thesis will address this gap by analyzing flood risk management policies and partnerships under the Dutch context, and look for design tools in which spatial planning can be involved in flooding issues to further enrich flood risk management strategies.

This thesis also documents key contributions made to the fields of stakeholder engagement. By analyzing the actors behind each design strategy, the research can identify the scope of stakeholders in flood issues and propose more targeted incentives. With more solidarity, it also helps to promote the implementation of top-down policies to adapt to flood resilience.

Societal relevance

This project's findings will redound to social benefits, considering that flood is a problem that threatens everyone's interests. Thus, municipalities and provinces that apply the recommended approach derived from the results of this study will face less human and property loss when floods do come. Decision-makers will be guided on what extra policy options should be considered. For the researchers, this investigation will shed light on key areas of collaboration in water management and urban planning that many researchers have yet to explore. For landowners, the results of this study can help build flood awareness and provide a selection of guidelines for flood adaptation measures.

In general, since the project outcomes are optimal solutions proposed from the standpoint of the public sector, private sector, citizens, academia, and the environment, they can promote mutual understanding among different groups, improve the efficiency of design measures, and thus enhance social cohesion.

II. RESEARCH DESIGN

3 Literature Review

3.1 Theoretical framework

IV. Institutional theory

Institutional theory is a theory that emphasizes resilient aspects of social structure. It considers the processes by which structures, including schemes, rules, norms, and routines, become established as guidelines for social behavior (Scott, 2005). The term "institutional entrepreneurship" refers to the "activities of actors who leverage resources to create new institutions or to transform existing ones" (Maguire et al., 2004), using means of "framing, theorization, lobbying, negotiation, etc" (Woolthuis et al., 2013).

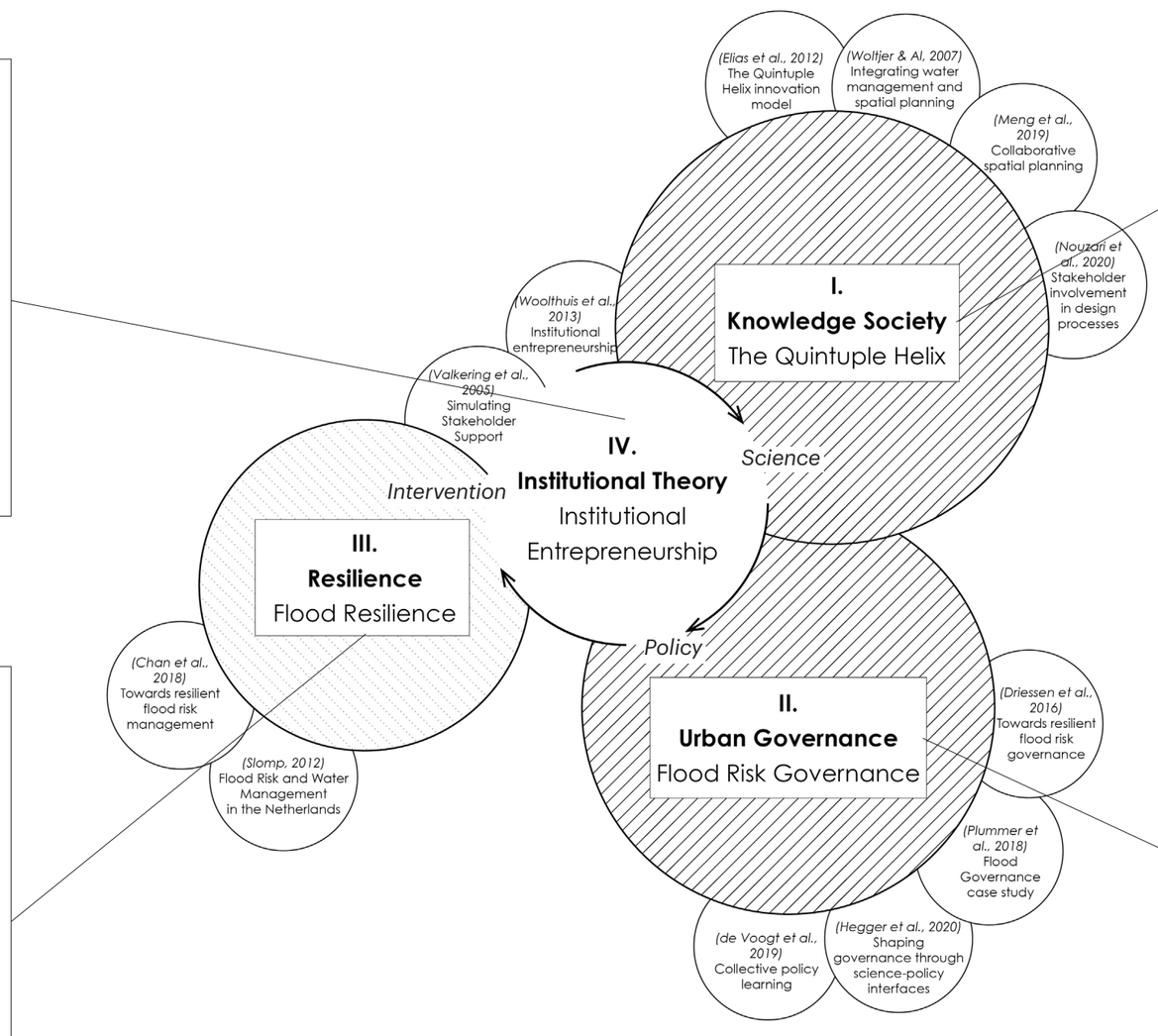
III. Resilience

In 1973, C. S. Holling introduced the term "resilience" into the ecological literature, referring to the amount of disturbance (defined as an alternative stable state) that an ecosystem can withstand without changing self-organizing processes and structures (Holling, 1973). It is also increasingly being used in policies, particularly with regard to climate change and water-related hazards.

Flood resilience is the result of authorities taking proactive steps to adequately prepare before and after floods (Chan et al., 2018).

Figure 4. Theoretical framework

The author, 2022



I. Knowledge Society

According to UNESCO, knowledge societies are about capabilities to identify, produce, process, transform, disseminate and use the information to build and apply knowledge for human development (Bindé, 2005). Knowledge is a public good that can be used and created by all people to help policymakers make the best decisions. Developments in information and communication technologies have the potential to transform the way people live and solve problems, and knowledge is a public good that can be created by all, helping policymakers make best decisions.

In a quintuple helix model, knowledge and technology are created and transformed and circulate as inputs and outputs in a way that affects the natural environment (Carayannis et al., 2012). This interaction could help solve the flooding problem.

II. Urban Governance

Urban governance is the process by which governments (local, regional and national) and stakeholders decide how to plan, finance, and manage urban areas, involving the distribution of physical resources as well as political power. It also encompasses many economic and social factors, including labor markets, goods and services; household, kinsmen and social relationships; and basic infrastructure, land, services, and public safety (Devas et al., 2004). Urban governance is a means for cities to cope with climate change, and climate change is also forcing a transformation of urban governance (Driessen et al., 2016).

3.2 Conceptual framework

In the Quintuple Helix theory, knowledge is transmitted in five groups: university, industry, government, public, environment (Carayannis et al., 2012). This project further simplified the classification method by including universities into the private sector, so that social groups can be divided into the public sector, private sector, and civil society. Environment, as the carrier of human life, becomes the fourth important role. The thesis will explore how to deepen the interaction of these four roles and in this way enrich flood risk management strategies.

According to Figure 5, in the existing flood risk management framework, water management is the main discipline that policy-making relies on to solve problems such as how to use weir to control water levels, and how to transform urban drainage systems to improve drainage efficiency. These technical solutions are fit for general flooding, but not for extreme conditions. In addition, there are some cooperative partnerships between government and enterprises, such as water boards and construction companies to build dams together, but most of the cooperation is carried out in the form of bidding, resulting in a lack of innovative schemes.

Therefore, the thesis aims to engage civil society to build flood preparedness and awareness among all, and to respond to the risks posed by climate change with diverse policies and projects. The first concept is the Public-Private-Civil Partnership(PPCP), in which government, industry, and citizens work together to develop mutually beneficial flood adaptation solutions that provide maximum benefit to a wider range of society. The second concept is Science-Policy Interface(SCI), which aims to provide a platform for knowledge innovation and thereby promote policy renewal. Flood risk management relies not only on expertise in the field of hydrology but also on advice from the field of urban planning, experience, and culture of citizens.

Ultimately, new policies and new flood adaptation projects will act on the space, guided by design tools. Specific stakeholders, project types, and policy types involved in each group are shown in the detailed framework diagram on the next page (Figure 6).

Figure 5. Concept generation, from current to future

The author, 2022

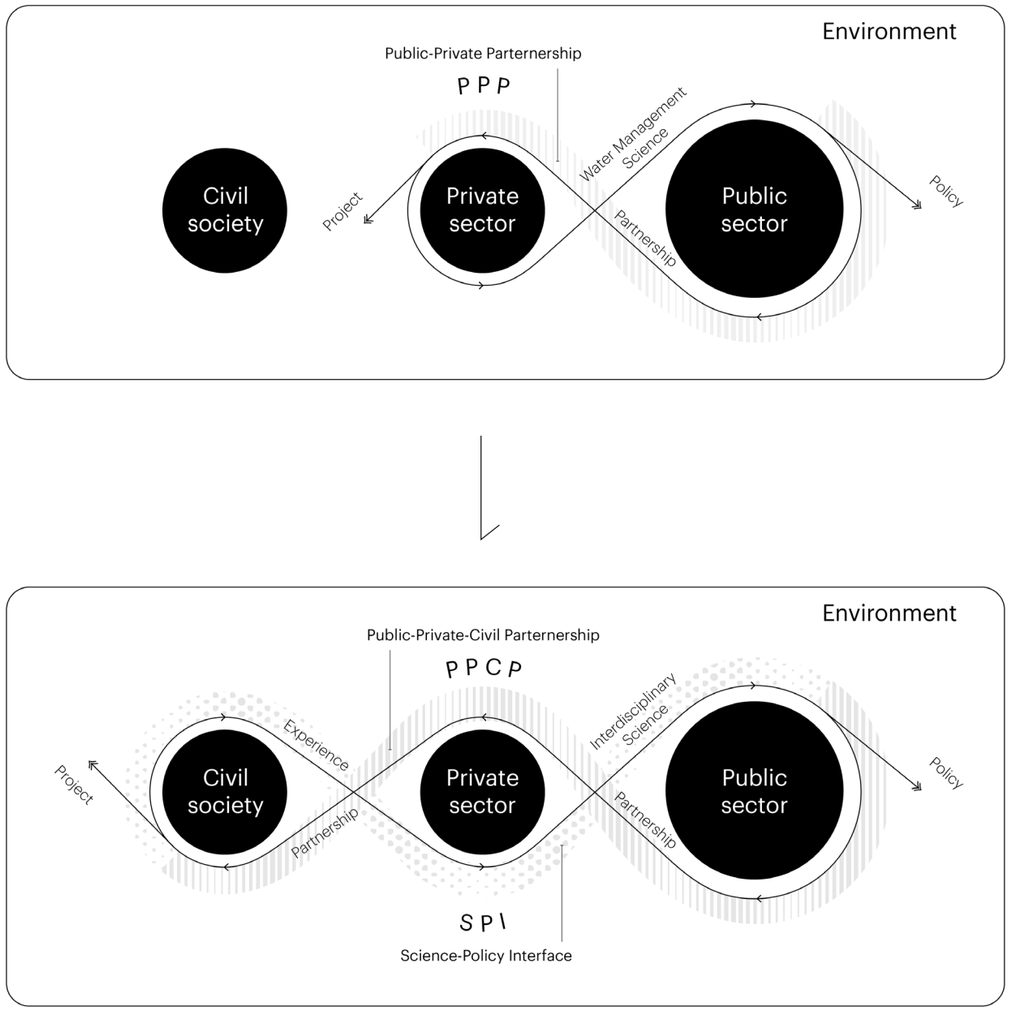


Figure 6. Conceptual framework

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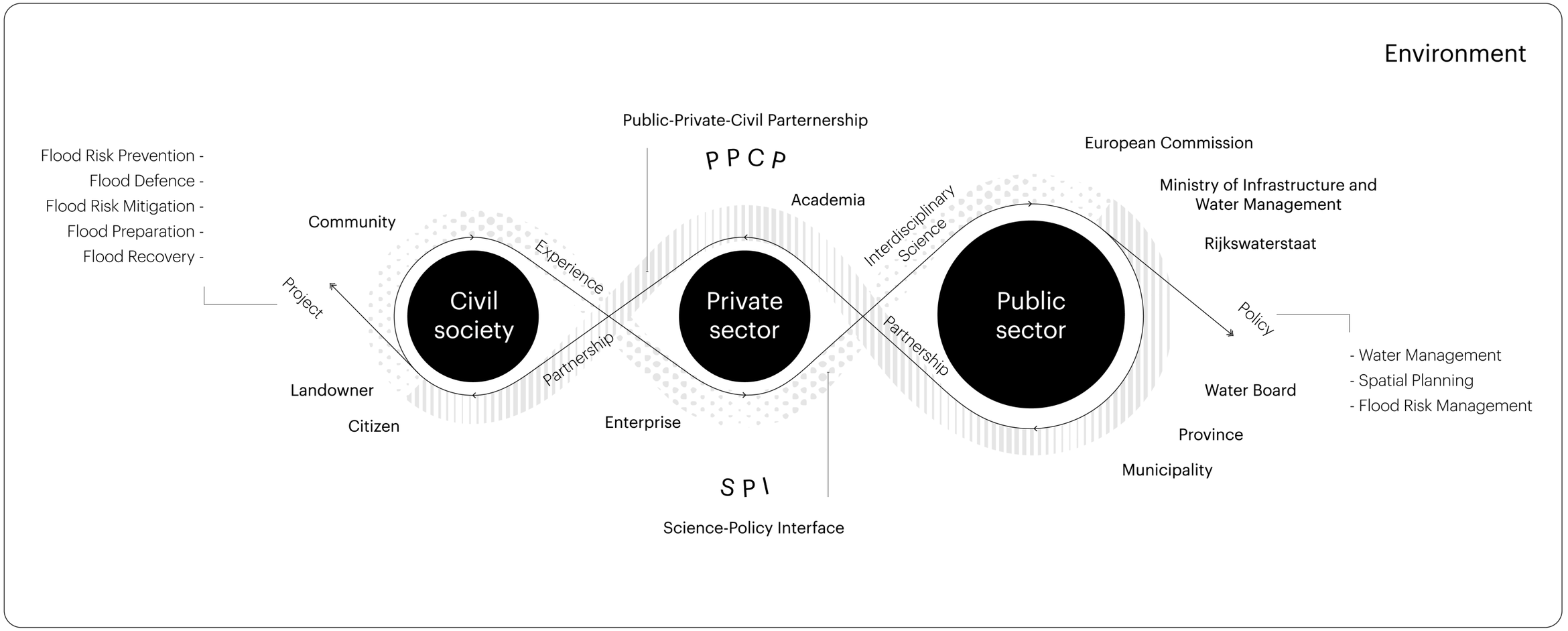

Figure 7. Research design

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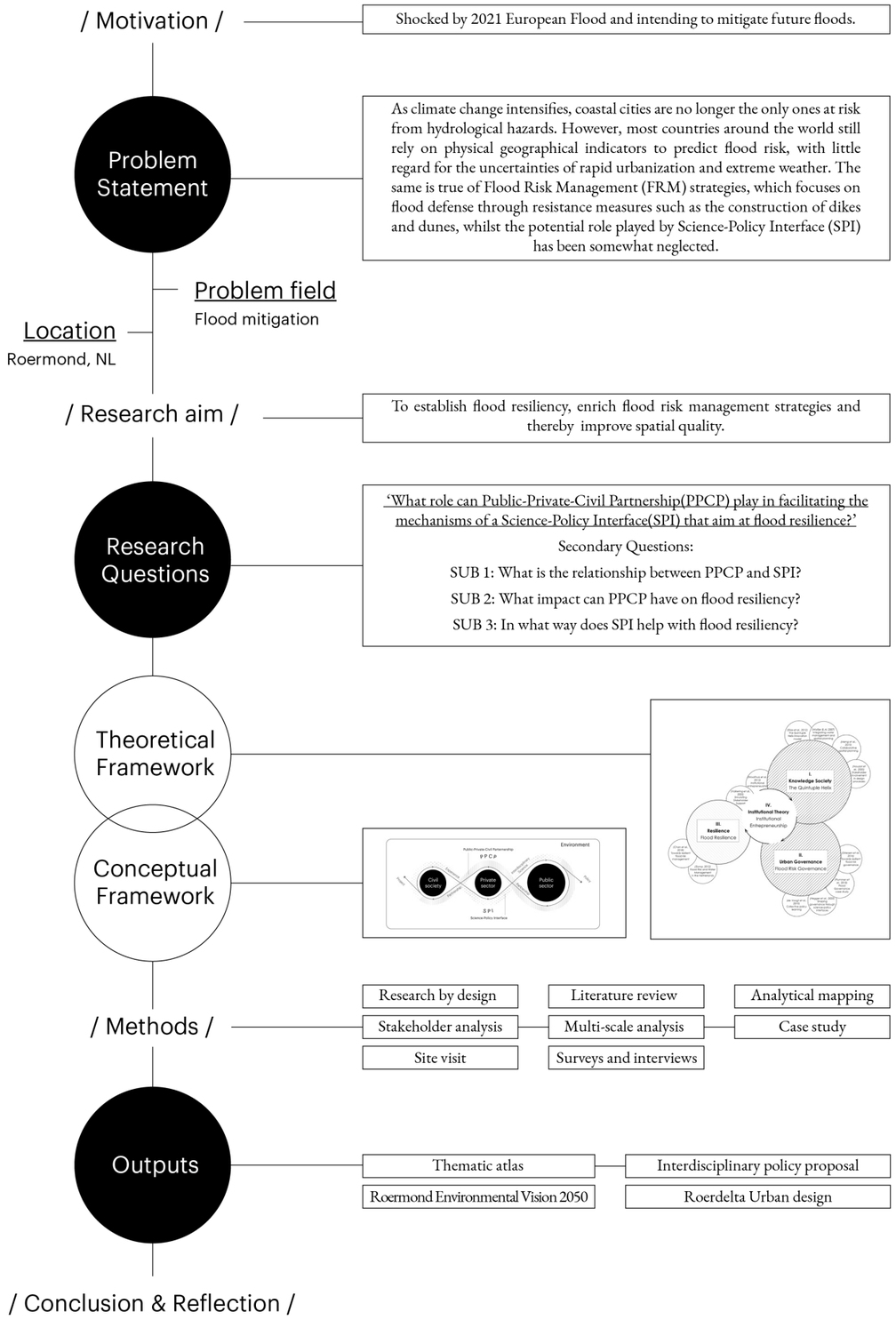


4 Methodology

4.1 Research methods

Given the extreme weather disasters worldwide in 2021, this project chooses flood mitigation as the problem field. The following research framework attempts to clarify the complexity of this problem field and explore the urgency and opportunities of designing location.

The framework provides an action guide for the research, see Figure 7. So far, the thesis has completed all the steps. Methods are explained below:

(1) Research by design
A method of academic investigation, which promotes the progress of research by means of design and also uses research results to promote design.

(2) Literature review
A holistic approach to demonstrating knowledge and theories on a specific topic placed in context. Sources covered in the review include scholarly articles, books, documents, policies, spatial plans, etc.

(3) Analytical mapping

A means of spatial analysis that attempts to make it clear and easy to identify patterns and trends in the field concerned. It includes digital processing and visualization of data.

(4) Multi-scale analysis
A method of studying complex problems, usually a particular problem at multiple times, spaces, or other scales.

(5) Stakeholder analysis
A process of identifying target actors before design. Group them according to their power, interest and attitude, and then decide how best to engage and communicate with each group.

(6) Case study
A detailed approach to a particular topic, such as flood organization, flood mitigation strategies, climate adaptation design, etc.

(7) Site visit
Often lasting several days. Visiting location includes the site of the proposed design, the site of the case study, etc. The goal is to get real, in-depth information.

(8) Surveys and interviews
A survey is a questionnaire in which people are asked to write down their answers to questions. Interviews, which involve asking people questions and recording their responses, usually have a higher response rate than surveys. These two methods are suitable for selecting representative stakeholders for qualitative analysis.

4.2 Research outputs

4.2.1 Analysis output

Thematic atlas
The thematic atlas is a series of maps that depict the geographic pattern in the field of flood mitigation around Roermond. Using four lines of inquiry as a clue, the atlas tells a story of Roermond's development and change in Matter, Topos, Habitat, and Geopolitics, and is thus a useful tool for the broad target audience to understand the city, which includes the researchers, officials, and the visitors.

4.2.2 Planning outputs

Interdisciplinary policy proposal
The proposal contains policy recommendations for improvements in the making of Roermond Environmental Vision 2050. New policies emerged from a comparison of water management policies and spatial planning policies.

Roermond Environmental Vision 2050
A planning proposal for Roermond from a flood mitigation starting point, including a zoning plan, district-specific strategies, making process, and science-policy interfaces(SPI).

4.2.3 Design output

Roerdelta Urban design
A design proposal for Roerdelta, to achieve flood resilience. It includes analysis, spatial interventions, public-private-civil partnerships(PPCP), and spatial artifacts.

III. CONTEXT ANALYSIS

5 Spatial Analysis

5.1 Historical changes

A Hansa city on the Meuse

Roermond was a fortified city and originated at the place where the river Roer flowed into the Meuse. In the 14th century, a portion of the Meuse River was moved towards the city to further improve its strategic location. However, there was a time when Roermond was not located directly on the Meuse River. As Figure 8 indicates, between the city and the water, there was a landscape known as “Bonne Aventure”, which is now Roerdelta. The landscape between the inner city and the river Meuse has been urbanized and the riverine area has been used for port activities. The introverted character of the area forms a barrier between both worlds.

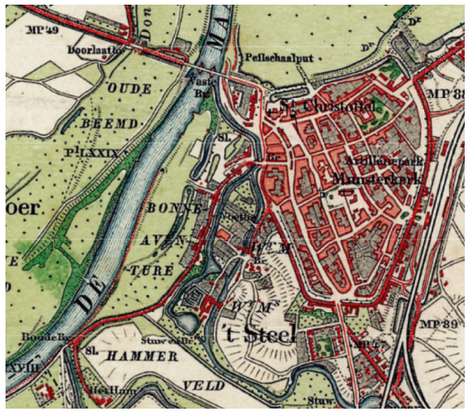


Figure 8. Roermond in 1900

Map from Topotijdreis.nl, 2022

Since the 19th century, Roermond has been hit by frequent floods (Figure 9). This situation was not improved until 1995 when the Room for the River Programme was launched. However, in the summer of 2021, extreme precipitation brought flooding to the citizens once again, affecting both the floodplain and the city center to varying degrees (Figures 10 and 11).

Figure 9. Flooding history of Roermond

The author, 2022

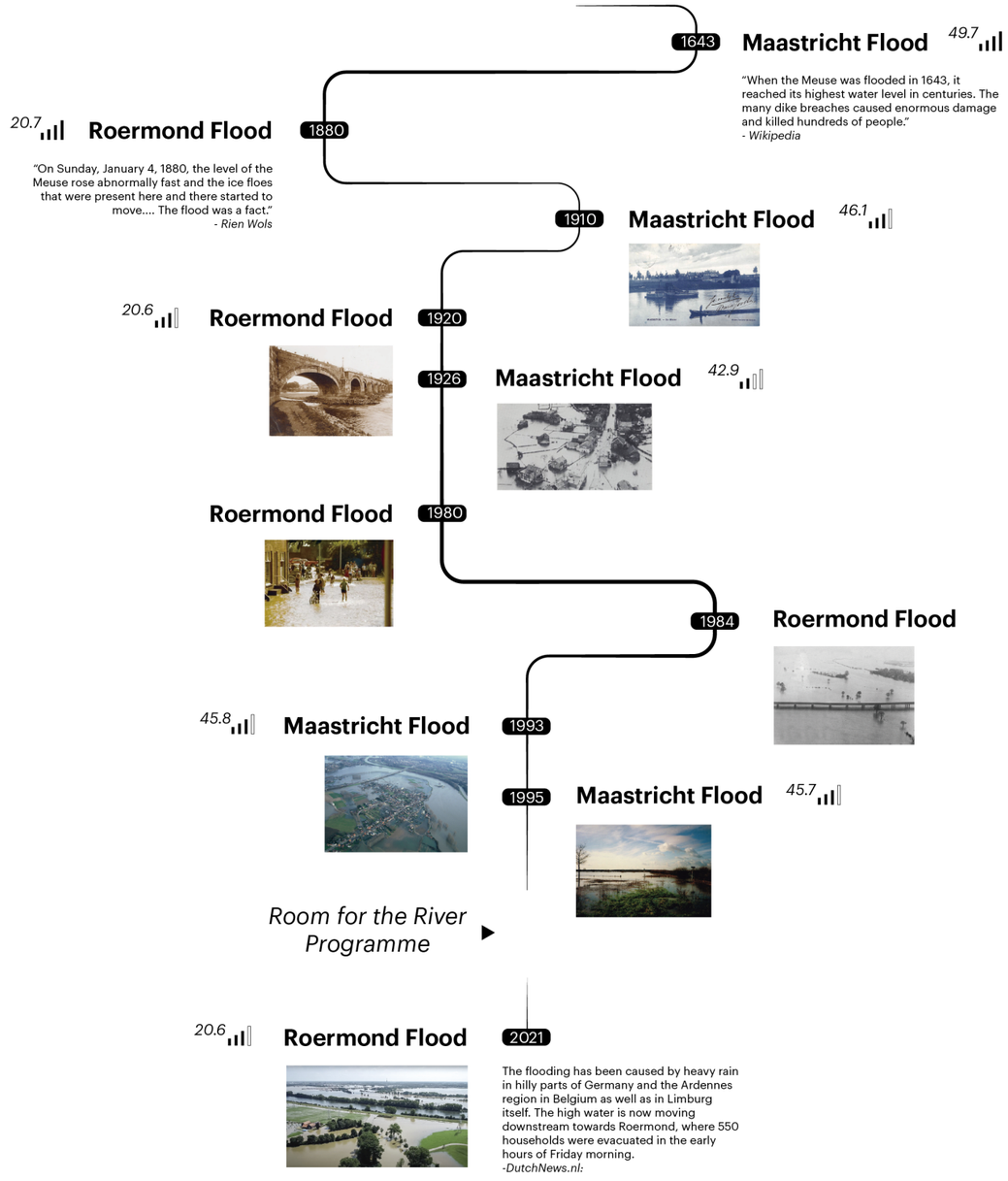


Figure 10. Fluvial flooding in 2021

The author, 2022
Data from Slager, Jonkman, de Moel & Strijker (2021)

Figure 11. Pluvial flooding in 2021

The author, 2022
Data from Slager, Jonkman, de Moel & Strijker (2021)

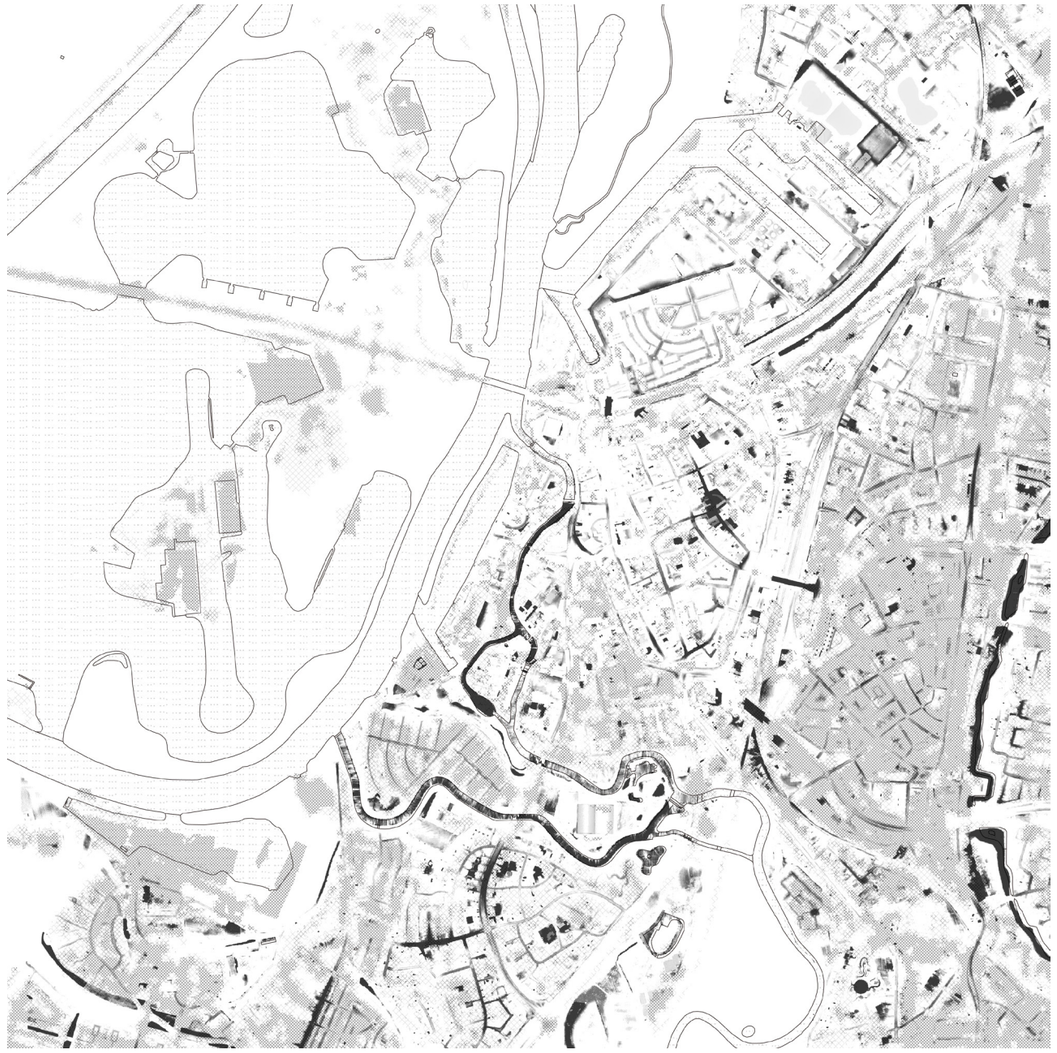


Figure 12. Thematic analysis directory

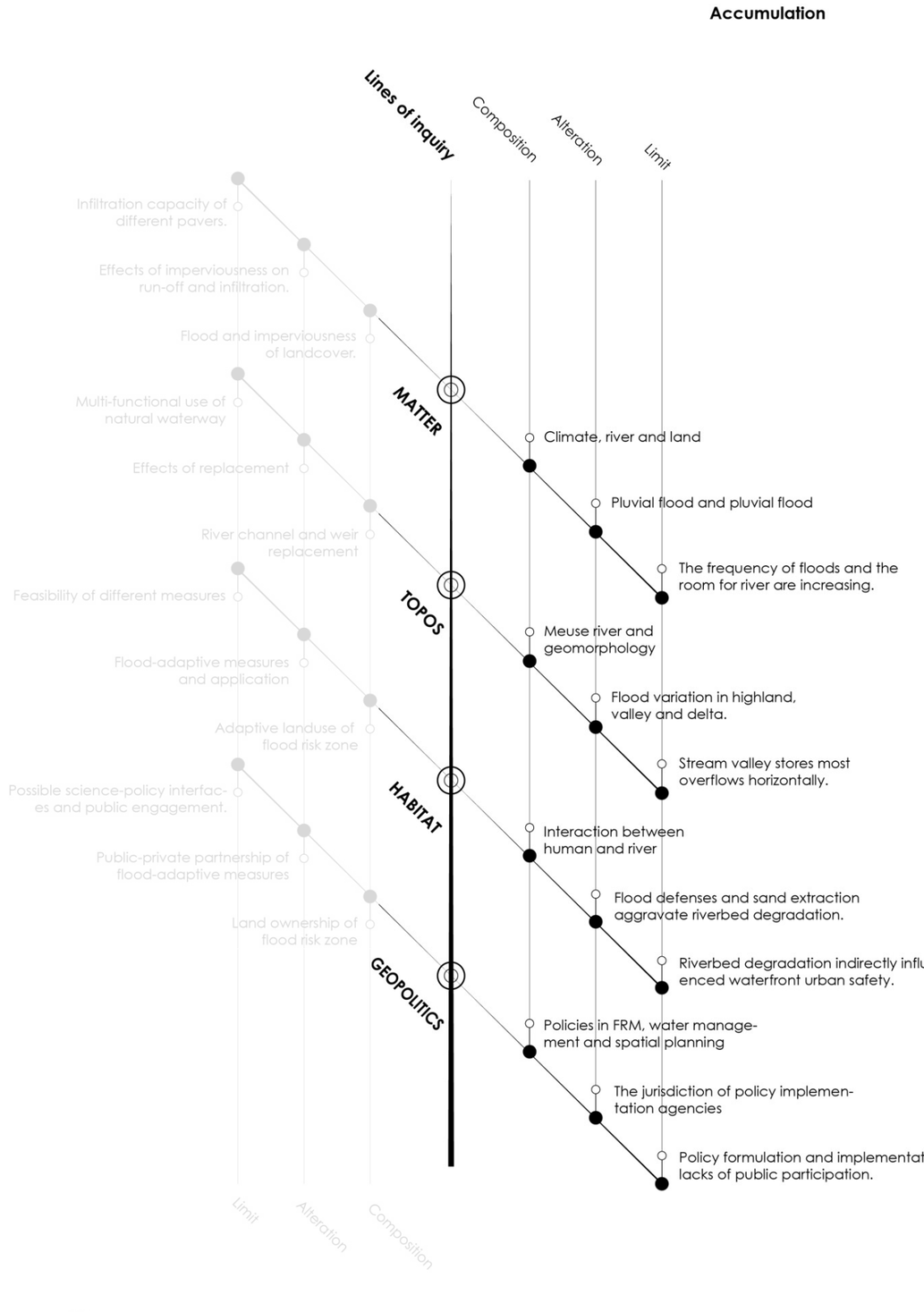
The author, 2022

5.2 Monograph: Accumulation

Lines of inquiry

Based on geographic information and real flood data in July 2021, this series of studies aims to explore the causes, effects, and regimes of floods. As depicted in Figure 13, the first two inquiry lines focus on the relationship between the physical geographical characteristics of the Meuse River Territory and floods, including climate, catchment, and geomorphology, so as to obtain current information and predict future development trends. Starting from the “habitat”, human activities are introduced into the analysis to critically assess the impact of river exploration on flood control effectiveness. The "geopolitical" analysis focuses on policies and institutions related to flood management, helping to identify policy gaps and jurisdictional conflicts.

A series of successive monographs on matter, topos, habitat, and geopolitics have identified key issues of riverine territories and future spatial strategy (See Appendix). Together, they constitute the research background of this thesis and provide evidence support for the elaboration of the problems stated in Chapter 2.



5.2.1 Matter

Climate, river, and land

Composition

In Roermond, one of the worst-hit municipalities in 2021 European Floods, 550 homes were evacuated by police (Lorimer, 2021). In order to investigate the causes of flooding in the population, it is necessary to first understand the Meuse River catchment, land, the extent of overflows, and microclimate characteristics. The map shows that both the main and tributaries of the Meuse River have overflowed, with lands affected by flooding on the west and south sides of Roermond. On this scale, there is no obvious relationship between flood overflow and humidity.

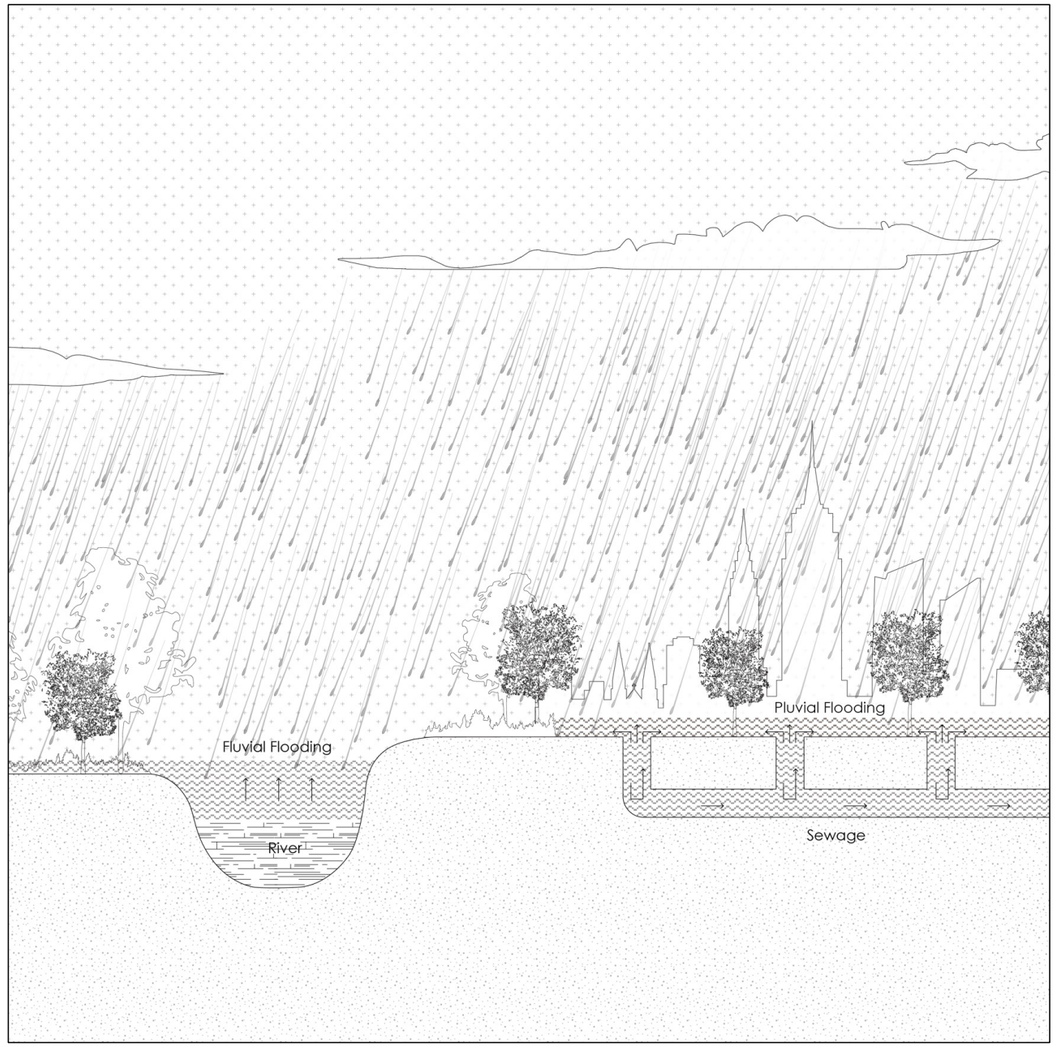
Figure 13. Composition of Roermond flood

The author, 2022

Data from Slager, Jonkman, de Moel & Strijker (2021) and Copernicus.eu

Figure 14. Main flooding types

The author, 2022



Alteration

Unlike most cities, waterfront cities are vulnerable to both types of flooding due to their particular geographic location, especially in the event of extreme rainfall. Fluvial flooding occurs when the water level of the river exceeds the height of the dam, which is usually caused by water discharges from the upstream and downstream. It lasts for a long time and has great influence. Pluvial flooding is relatively mild and tends to occur in stormy weather if a city's drainage system is unable to accommodate large amounts of precipitation in a short period of time (Chen et al., 2010). Both flood types are associated with precipitation and should be considered seriously in the context of climate change.

Limits

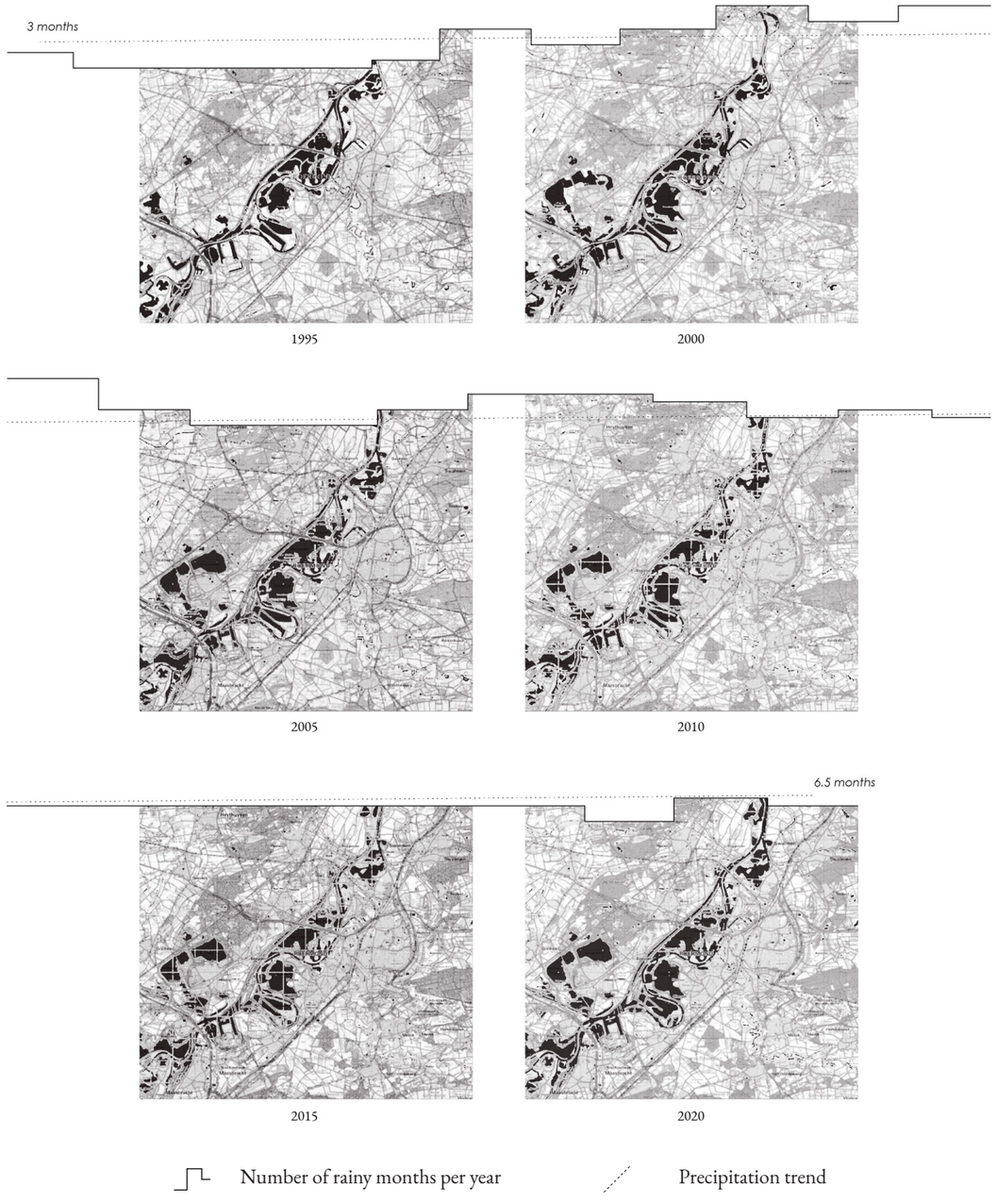
Over the past 30 years, the Meuse River near Roermond has changed a lot, mainly as its catchment has increased and there is more room to hold and store the water from upstream. Room for the River Programme has enabled Roermond to change its history of flooding. At the same time, however, rainfall also tends to increase. By 2020, the number of rainy months in the Netherlands has increased from 3 to 6.5, as shown in the diagram.

With extreme weather events becoming increasingly common, it remains to be seen whether current measures will be enough to prevent future flooding risks.

Figure 15. Tempo-spatial transition of river and land

The author, 2022

Data from Topotijdreis.nl and CRU TS 4.01 dataset



5.2.2 Topos

Meuse river and geomorphology

Composition

The River Meuse flows over a distance of 950 km, through Haute-Marne, Vosges, Meuse, Ardennes, Belgium, and the Netherlands before reaching the North Sea. Surprisingly, the worst flooding occurred not in the most intense rainfall upstream, nor the downstream delta, but in Limburg Province in the middle. To figure this out, analysis needs to be done at a macro scale.

The map depicts the terrain of the lower and middle Meuse River. The river basin that flows through Belgium belongs to a highland valley. Limburg is the Dutch province bordering Belgium, most of which belongs to a stream valley. Downstream, deltas are on the plain protected by embankments.

Figure 16. Geomorphology composition of lower Meuse River Basin

The author, 2022
Data from Copernicus.eu

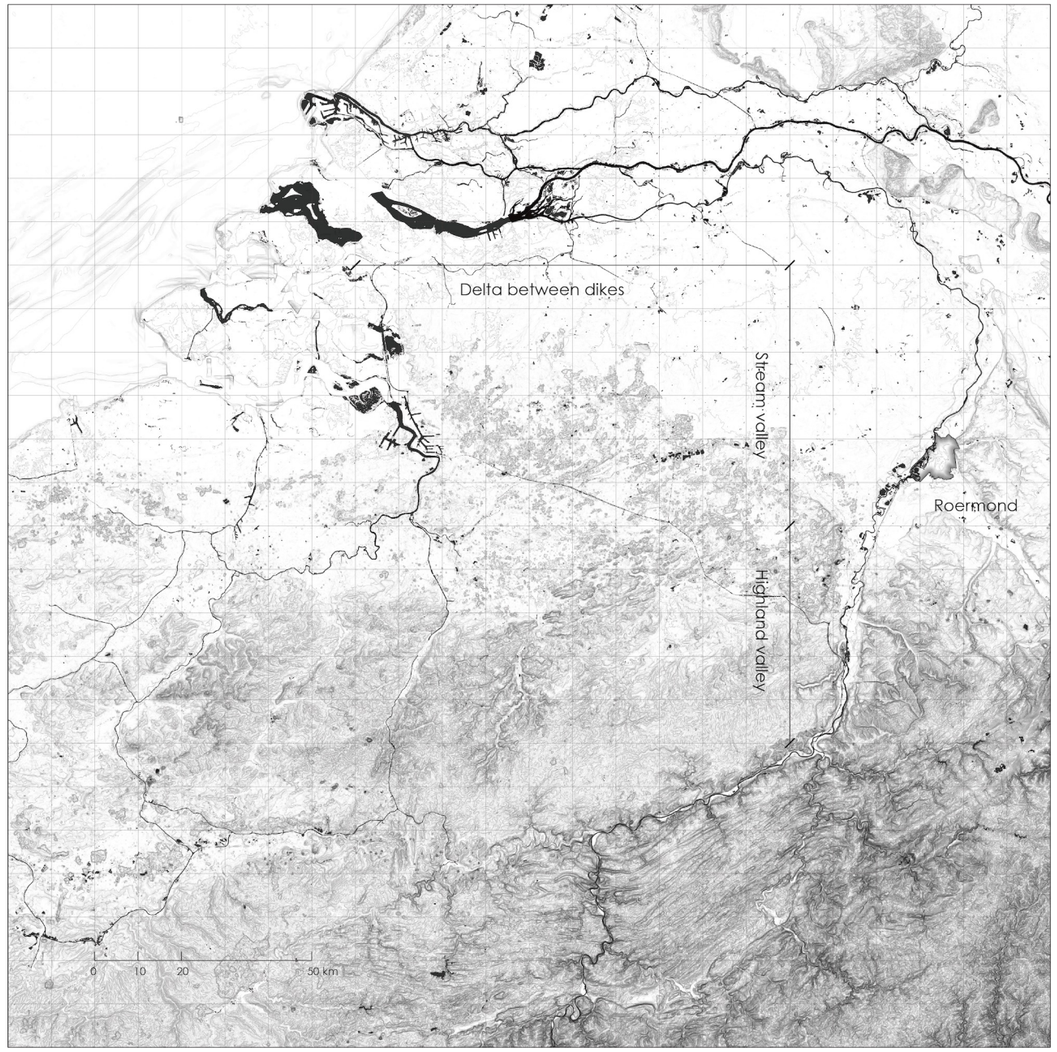
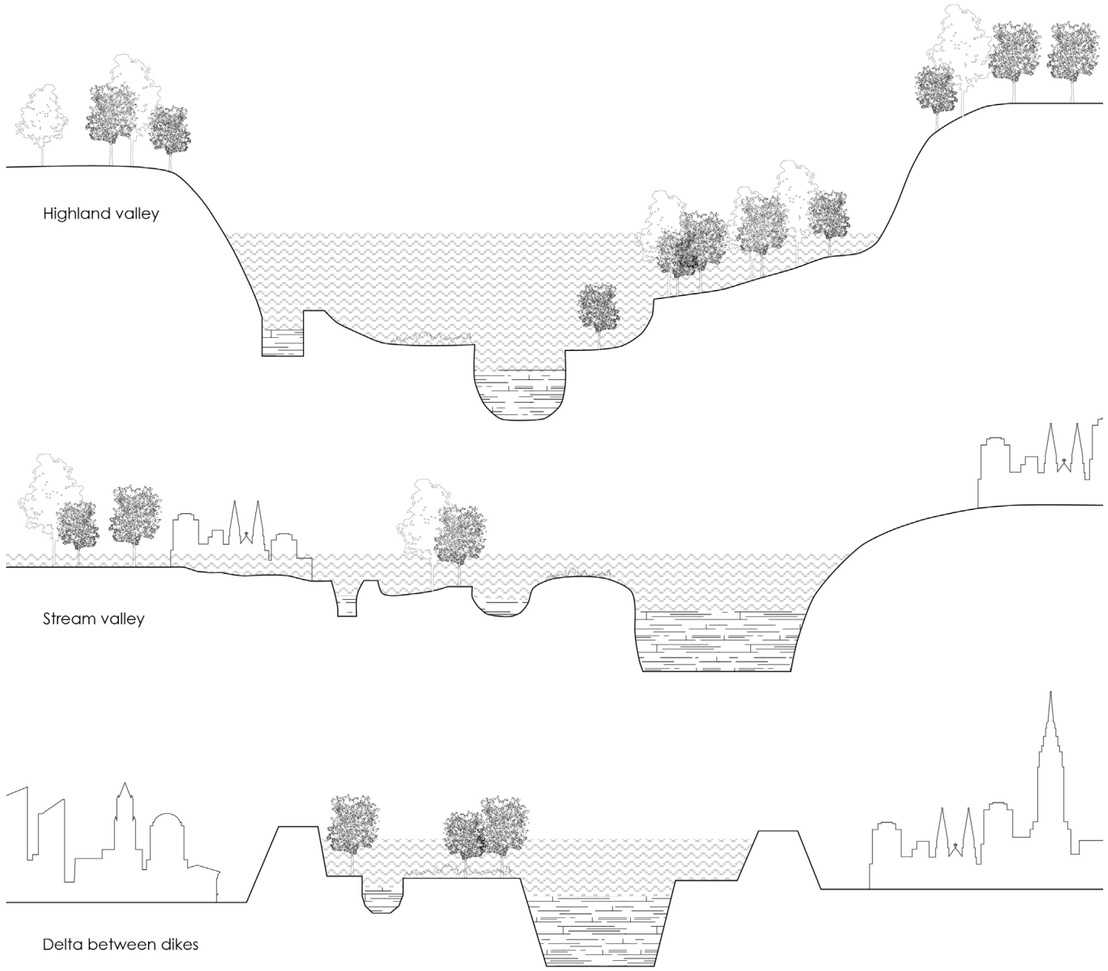


Figure 17. Water level alteration upstream and downstream

The author, 2022



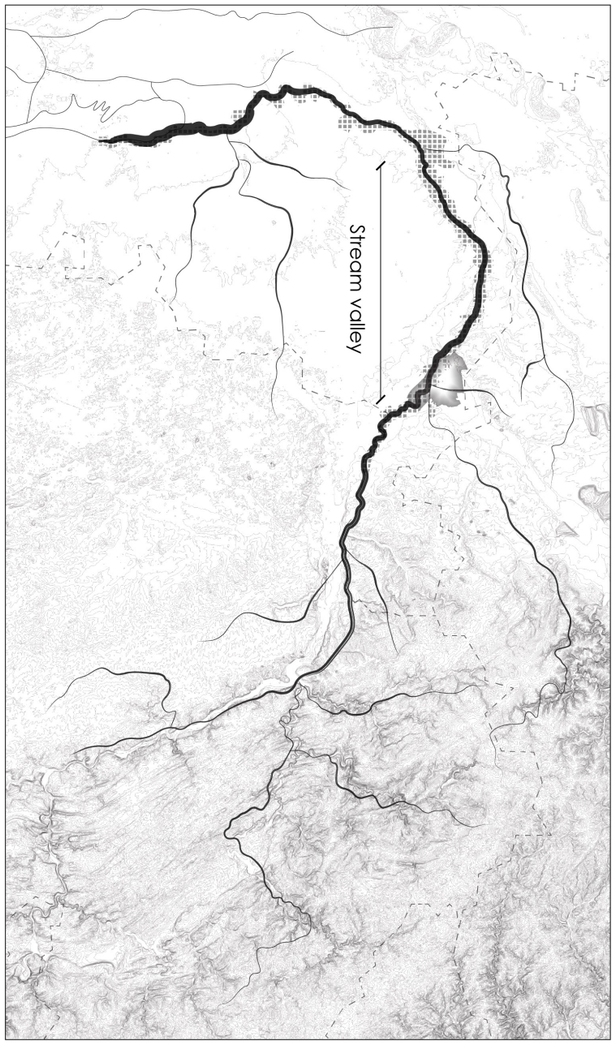
Alteration

Topographically, a stream valley doesn't have as much natural space to accommodate floods as a highland valley. Therefore, the same volume of water does not cause losses in the highland valley and may flood the waterfront habitat if it flows into the stream valley.

In the case of the Netherlands, the Hague, Rotterdam, and other densely populated cities are located on the lower reaches of the Meuse River. To better protect them, Limburg will have to take on the responsibility of releasing the water, reducing the water levels as much as possible as it passes through it, to relieve pressure on the dikes downstream (Dutch Ministry of Infrastructure and Water Management, 2021).

Figure 18. Spatial limitations with excessive flood discharge

The author, 2022
Data from Wesselink, de Vriend, Barneveld, Krol & Bijker (2009)



Overflowing Meuse at a discharge of 3950 m^3/s

Overflowing Meuse at a discharge of 4600 m^3/s

Limits

As a result, many municipalities in the stream valley, such as Roermond, will have overflows when the upstream discharge increases from 3,950m^3/s to 4,600m^3/s (Wesselink et al., 2009). This requires them to reserve as much space as possible for the flood plains and develop adequate risk plans.

5.2.3 Habitat

Interaction between human and river

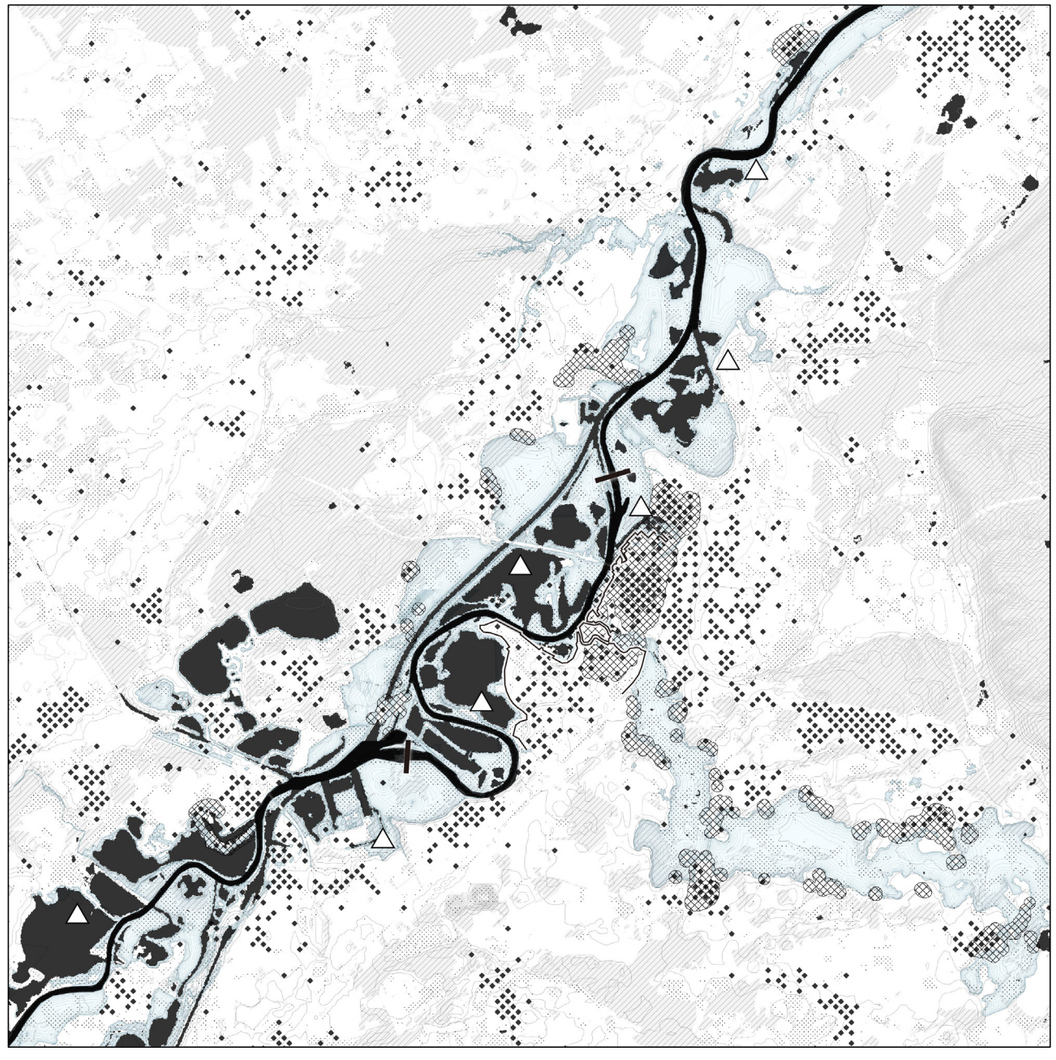
Composition

Chronically at risk of flooding, people who live along the riverfront take measures to resist the water and find ways to use it. In the case of Roermond, the map charts the ways humans resist and use rivers, including weirs, dikes, sand mining, and waterways. In turn, rivers can also have some negative effects on human life, such as the emergency evacuation area highlighted on the map. The value and risk of rivers coexist, and how to balance them is a problem that human beings need to consider further.

Figure 19. Interaction between rivers and human activities

The author, 2022

Data from Slager, Jonkman, de Moel & Strijker (2021) and Copernicus.eu



Alteration

The section illustrates how the construction of flood defenses and sand extractions aggravated the erosion of riverbeds (Huismans et al., 2021). For one thing, there is not much sediment from the upstream of Meuse, as a result of river normalization. However, humans downstream continue to extract sand from the bottom of the river, leaving the riverbed exposed and sinking over the years. The solid parts of the weir along the way also partly trap sediment, preventing it from being transported downstream.

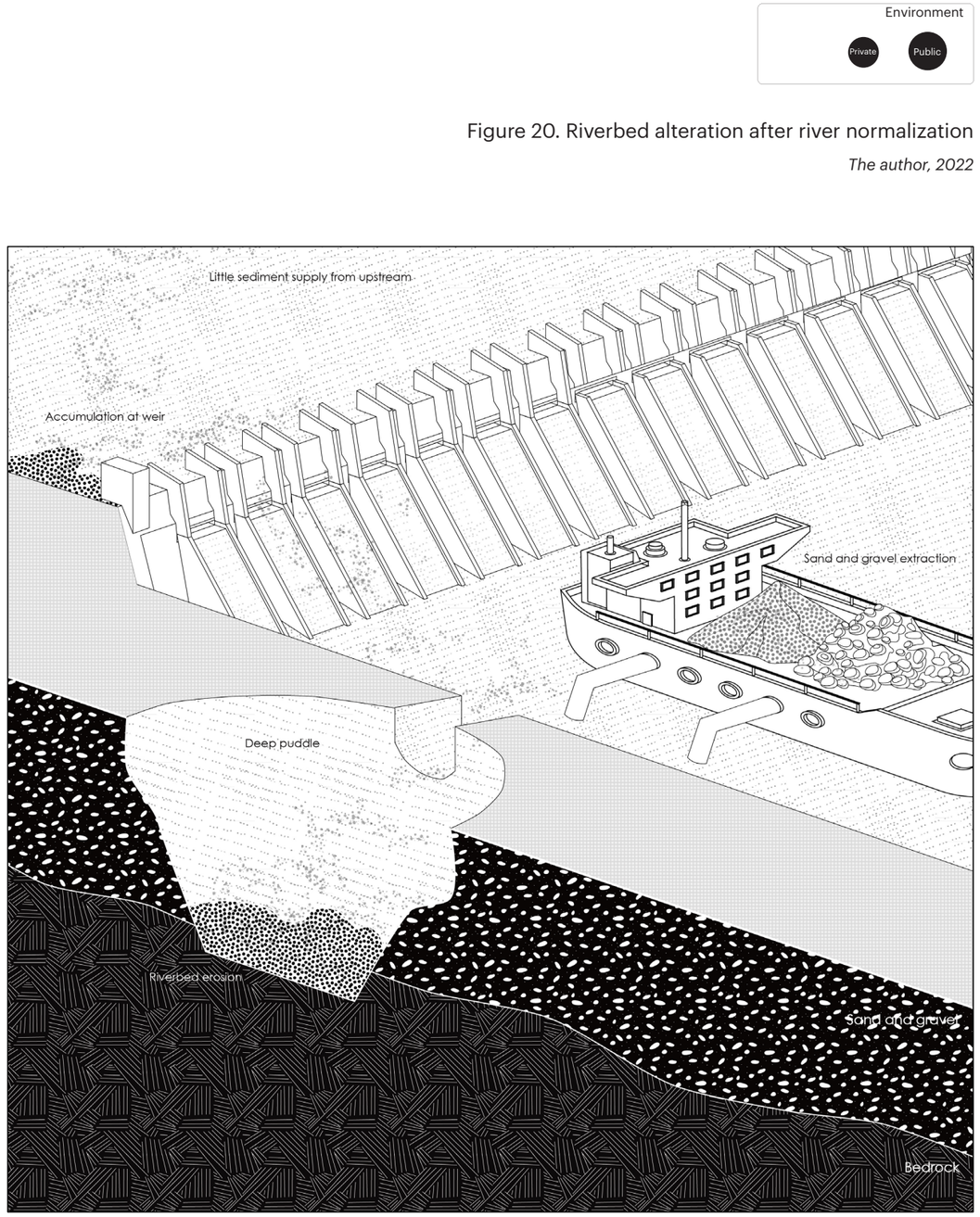


Figure 20. Riverbed alteration after river normalization

The author, 2022

Limits

As a result, Roermond is surrounded by large puddles created by sand extraction. In this diagram, Noorderplas is used as an example to sort out the possible impact of riverbed degradation on the environment. For the river itself, erosion can cause problems with weir function, bridge stability, and canal navigation. Also, riverbed degradation can change the groundwater level in waterfront areas, affecting drinking water supplies, agriculture irrigations, and building foundations (Berkhof, 2008).

Paradoxically, some people are building flood defenses while others are mining sand, which may undermine those defenses. This is not the only paradox. The defense and use of rivers need to be linked to the wider process of urban metabolism.

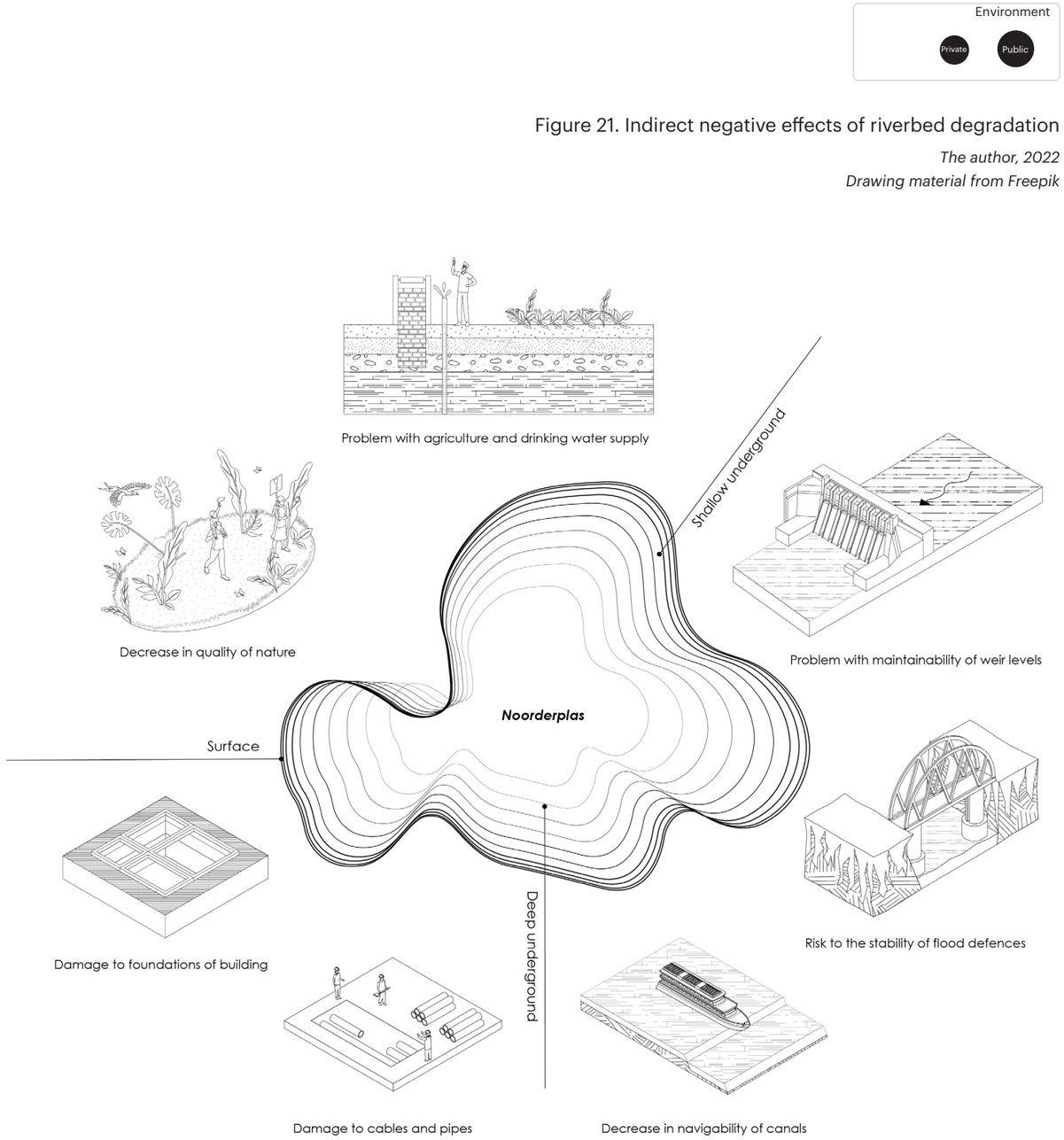


Figure 21. Indirect negative effects of riverbed degradation

The author, 2022
Drawing material from Freepik

5.2.4 Geopolitics

Flood management Institutions

Composition

Given the extent and causes of flooding in 2021, it is necessary to compare them with relevant management policies and plans to determine the accuracy of previous forecasts. The map covers management policies in three areas: water management, flood risk management, and spatial planning. The catchment of Meuse River belongs to the category of water management, the flood risk areas defined in EU Directive belong to the category of flood risk management, and the administrative boundaries and nature reserves defined in Nature 2000 belong to the category of spatial planning.

Overlaying the above special management areas with the actual flood areas in 2021, it is not difficult to find that the main Meuse overflow is not beyond the predicted flood risk area, while the tributaries of the Rur have some overflows beyond the nature reserve.

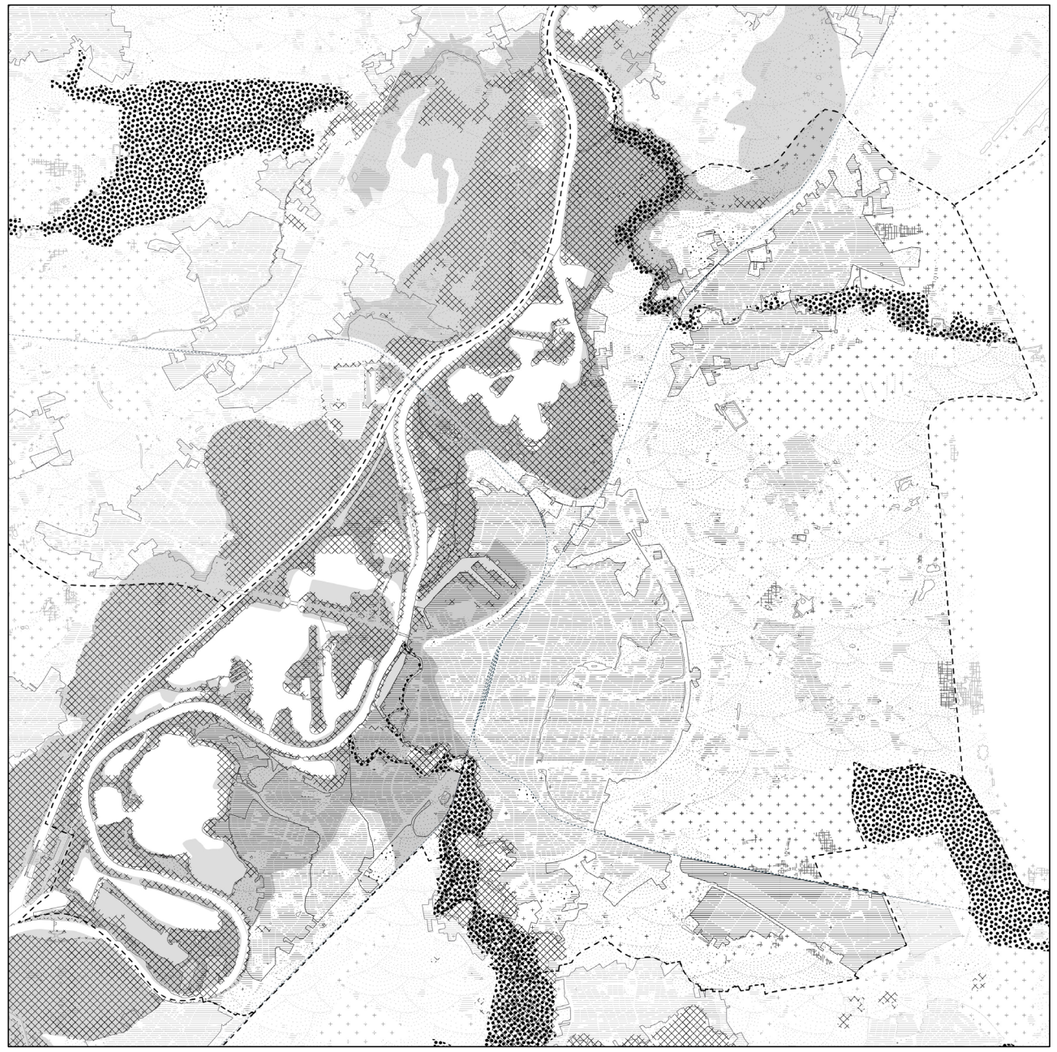
Environment

Private Public

Figure 22. Spatial implications of space and water policies

The author, 2022

Data from Slager, Jonkman, de Moel & Strijker (2021) , EU Directive and Nature 2000



Alteration

Theoretically, from the waterfront to the interior, flood-related spatial governance at the municipal scale is primarily the responsibility of three agencies under the Dutch context. Rijkswaterstaat manages large water bodies and national flood defenses. Waterboard Limburg manages the portion between the water edge and the city, including regional flood defenses and flood plains. Municipality Roermond is responsible for spatial planning within the city and the sewer system underground.

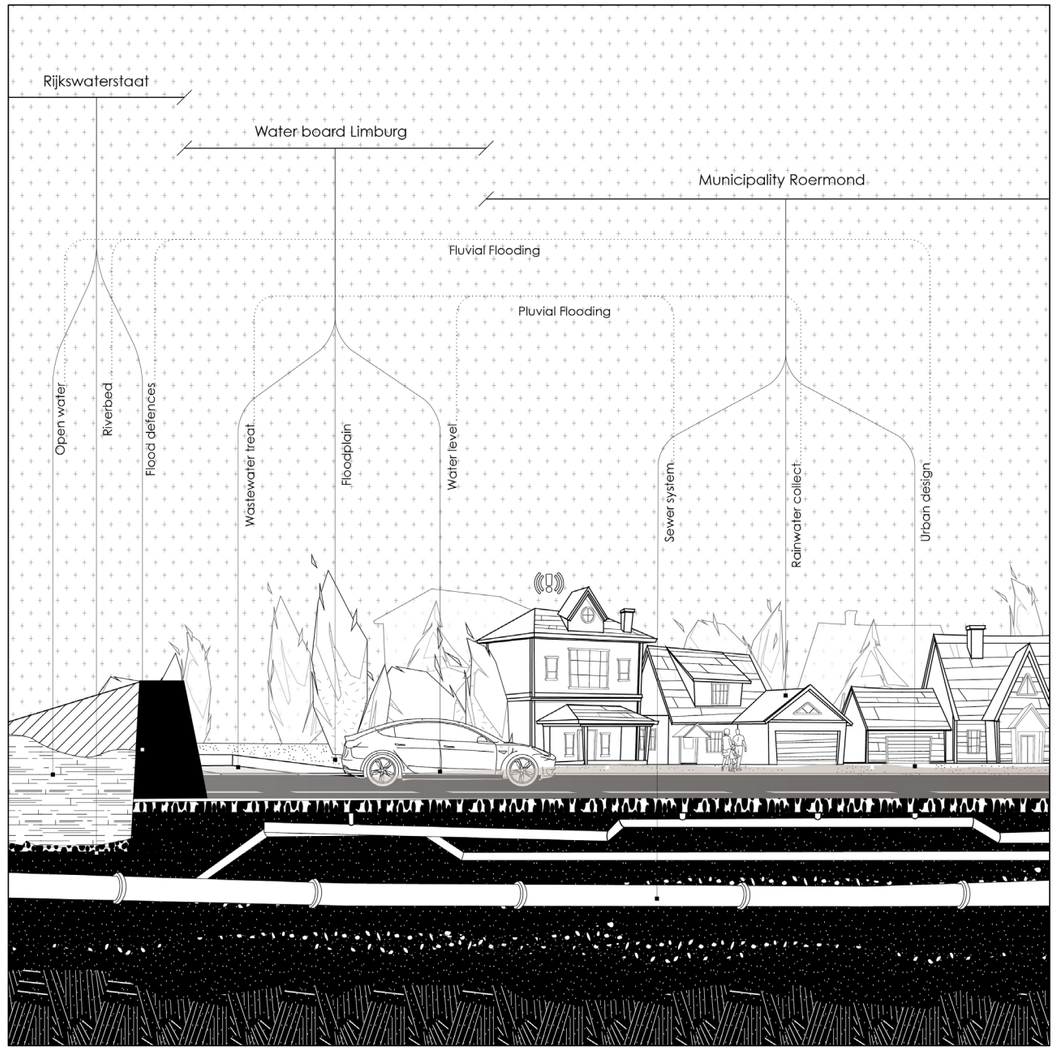


Figure 23. Division of jurisdiction of water management agencies

The author, 2022
Drawing material from Freepik

Limits

Across sectors and scales, there are management plans supported by policies and regulations in all sectors, from the EU to the local level. Especially when the new environmental law takes effect in 2022, policies at different scales will become more consistent. In addition, there is a lot of cross-departmental collaboration, both horizontal and vertical.

Overall, the current flood management in the Netherlands is top-down. Except for the consulting firm responsible for the environmental impact assessment, which is the private sector, all the remaining agencies involved are the public sector. Meanwhile, the main management responsibilities are concentrated in Rijkswaterstaat and Waterboard at the regional level, while the planning at the municipal level is backward, and the flood awareness of citizens is not fully mobilized.

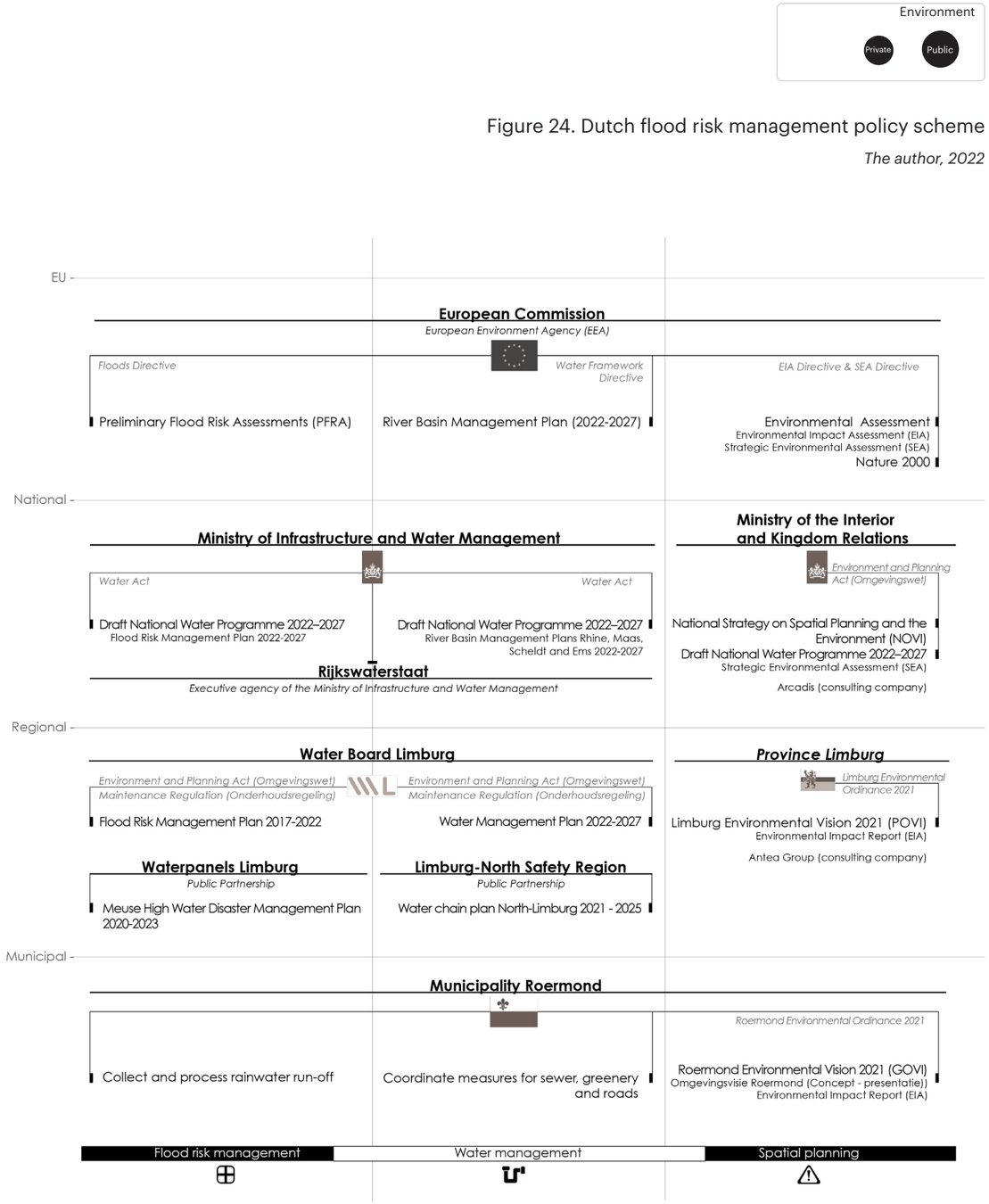


Figure 24. Dutch flood risk management policy scheme

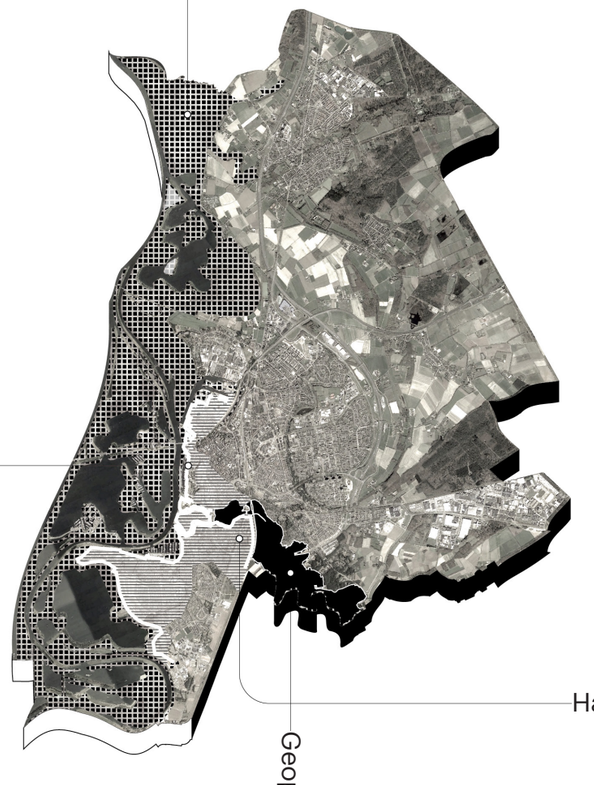
The author, 2022

5.2.5 Synthesis

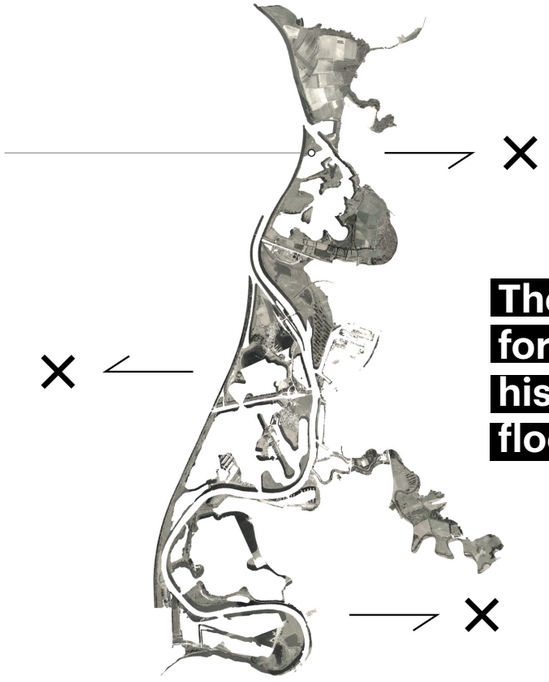
Problems and urgencies

In the interests of national security, the priority is to store water, not resist it.

Topos

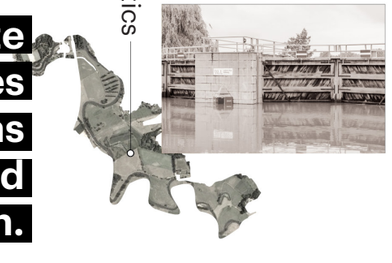


Matter



There is a battle for space between historic towns and flood plains.

Geopolitics



The impact of climate change and tributaries on Meuse flooding has been underestimated in flood prediction.

Habitat

The effect of flood is not only on the surface, but also on the foundations and basements of waterfront built-ups.

5.3 Functional spaces

Catering & Retail

Roermond has a historic and characteristic town center with a diversity of stores: a mix of boutiques, exclusive stores, and the Designer Outlet Roermond. Over the past 20 years, this outlet center has grown to become the largest and most successful outlet in Europe, with more than 200 stores and 25 dining venues (Shoppen Roermond, 2022).

Roerkade is a gathering place for restaurants, cafes, and terraces. A stone bridge connects it closely to the suburb of St. Jacob in Roermond, an attractive district with beautiful houses and national monuments. There is also a large furniture market not far away on the east side of the inner city. These stores make Roermond a great tourist town for shopping and enjoying good food.

Figure 25. Catering street and retail spaces in city center

The author, 2022

Square & Park

Not only is the Munsterkerk beautiful, but next to it there is a small square surrounded by restaurants and bars. The lively Wednesday market is also held here. Another Monastery Park in the inner city is very different. The park is full of greenery and is quiet and peaceful.

Akcros Park is a newly built green park located in the middle of the Roerdelta. Together with two restored monumental buildings, it connects the area to its rich past.

For the citizens of Roermond, there are only a handful of green spaces in the city center.

Figure 26. Squares and parks in the city center

The author, 2022

Work & Industry

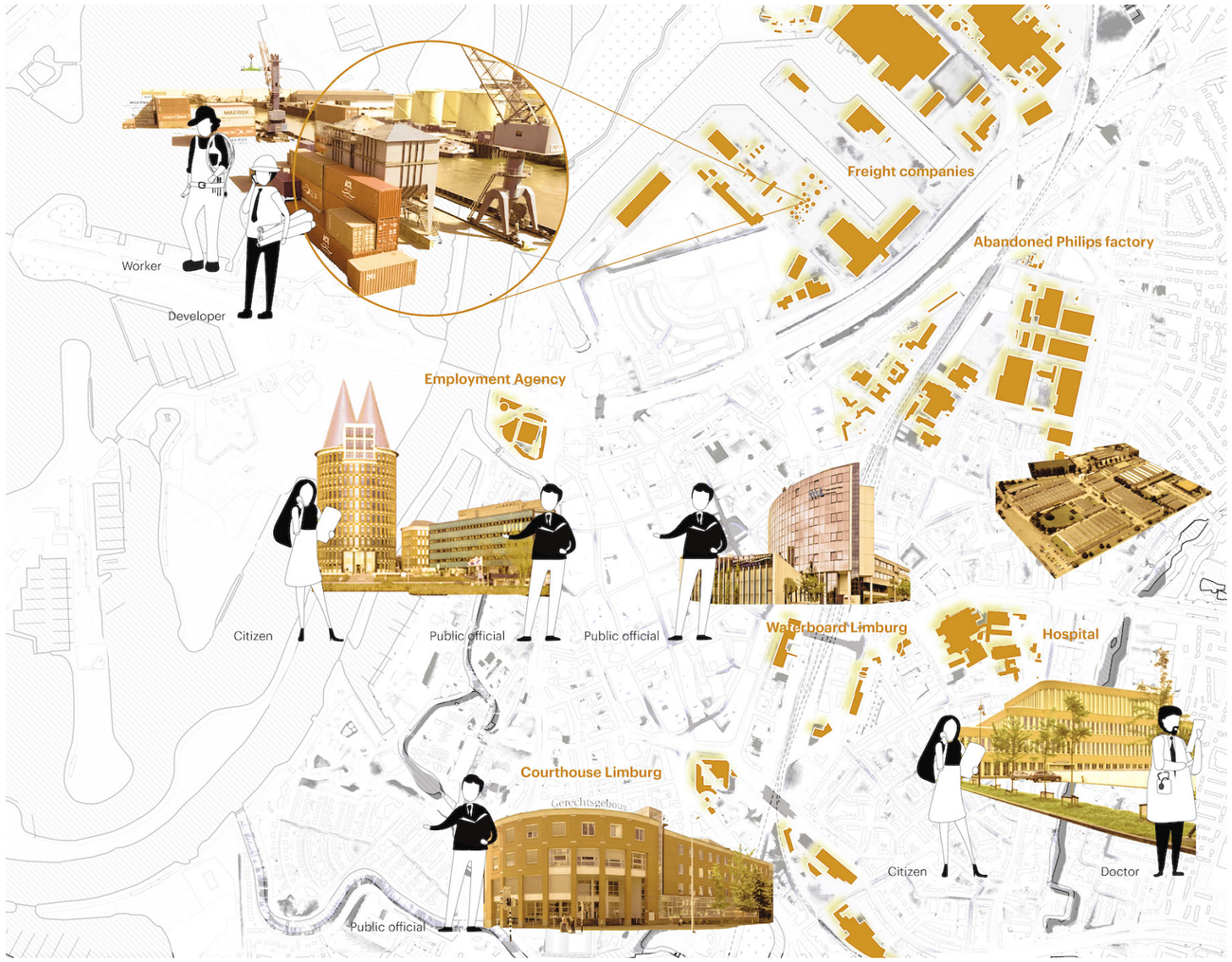
Just a stone's throw away from the historic city center and right next to the river Maas, the Willem-Alexander business park is characterized by its unique location. Freight companies are committed to operating in a sustainable manner around the inner harbor.

As for work locations, Roermond has a diverse range of offices, including supra-regional ones: Waterboard Limburg, courthouse, and hospital that might attract commuters from other cities and international workers.

All of the above functional spaces face waterlogging problems in extreme precipitation.

Figure 27. Work locations and industries in the city center

The author, 2022



6 Stakeholder Analysis

6.1 Methodology

Using a three-dimensional grid, Murray-Webster & Simon (2006) categorized a set of roles with different powers, interests, and attitudinal traits, as shown in Figure 28. The stakeholder analysis for this thesis is based on the methodology since a three-dimensional grid can better stimulate thinking and inform projects than a two-dimensional one.

Analysis dimensions

1. Power. This refers to the stakeholder's position in the organization, the resources they hold, or the influence they have as a leader or expert.

2. Interest. Measured by how actively or passively they are informed about the project.

3. Attitude. Measured by the extent to which they are 'for' or 'against' the content of the project.

Traits of actors

Saviors are those with power, high interest, and positive attitudes. They need to be noticed. Urban planners or institutional entrepreneurs should go out of their way to cater to their needs and gain their support.

Friends are with high interest and positive attitude, but little power. They can be useful in passing on information.

Saboteurs are powerful, active obstructionists. They can reverse the course of a project and a reaction plan is needed in place for the parts where they appear.

Irritants are with little power and great interest, but with a negative attitude. Their participation is inconsequential to the project. They tend to withdraw after learning all the information.

Sleeping giants are influential, passive, and supportive. They need to be awakened, so special means are to be used to attract them to the project at the beginning.

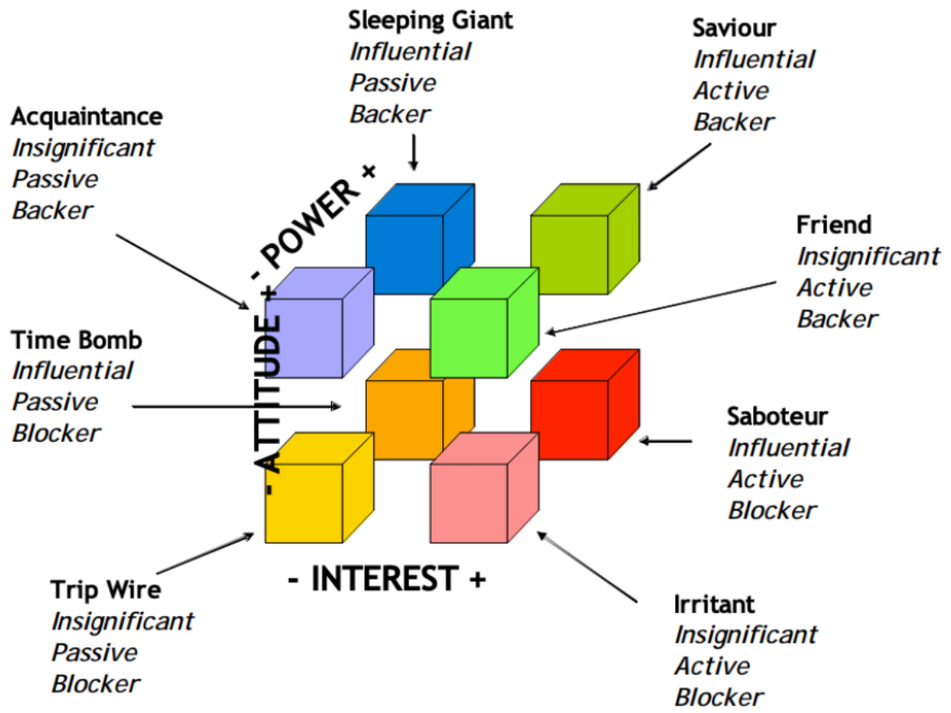
Acquaintances are those who have little power and are passive and supportive. They need to be kept informed of the progress of the project, but may not give feedback.

Time bombs are powerful, low interest, and negative. Project initiators need to understand their intentions so that they can defuse them "before they go off".

Trip Wires have little power, little interest, and a negative attitude. They tend to be rarely involved, but they also need to be guarded against popping up to stir up trouble.

Figure 28. Stakeholder role delineation

Image from Murray-Webster & Simon (2006)



6.2 Power-interest-attitude matrix

6.2.1 Stakeholder identification

The urban transformation process involves many stakeholders. In addition to cooperation in design, construction, and maintenance, a consensus is also needed at the governance and social levels. Using Roermond as a backdrop, this section discusses the stakeholders on the topic of flooding and briefly describes their roles and interests.

Public sector

The public sector includes all levels of government and government agencies. In this thesis, the design scale is relatively small, and only provincial and local governments of the governmental system are selected for analysis: Province Limburg and Municipality Roermond. Within the context of flood adaptive projects, provincial and local governments can take responsibility for issues such as discharging water, promoting and implementing innovative solutions to flooding, and creating high-quality green spaces for citizens. In addition, municipalities can also optimize policy development by supporting knowledge exchange.

In the Netherlands, water authorities are an independent government agency, also divided into national and regional levels, such as Rijkswaterstaat and Waterboard Limburg. They are responsible for surface water treatment outside of cities, including managing dikes, maintaining water levels, ensuring water quality, sewage treatment, and maintaining certain out-of-town roads, among other things (Ministerie van Algemene Zaken, 2019). In addition to these primary responsibilities, water authorities may also work with other organizations to undertake secondary tasks such as engineering consultation and financial support.

Private sector

The private sector covers a wide range of businesses of different sizes, such as stores, restaurants, developers, and port companies. It also includes some real estate owners, such as landowners or homeowners.

When small businesses are faced with water problems, they often put pressure on local governments to solve them. They are often less concerned with the aesthetics of the solution and more concerned with cost-effectiveness.

Civil society

Civil society is divided into three categories: residents, citizens, and visitors. Residents are the specific citizens who live within the design area and are high-frequency users of the space. Correspondingly, citizens are those who live outside the design scope but also visit occasionally. Visitors are people from other provinces and cities or even abroad, who will only visit the most attractive spaces.

Public participation in urban development projects is often in the form of civic organizations, such as neighborhood associations, tenant associations, etc. Civic organization projects often have a broad base of support and reach out to people in the community with diverse backgrounds and interests.

6.2.2 Power-interest-attitude matrix and engagement strategy

The power, interest, and attitude of each of the 12 stakeholders identified above were analyzed using a broad range of "flood resilience issues" as the hypothesis. Then, comparing them with the eight roles defined in the methodology. The results show that there are six roles for the stakeholders in this thesis: sleeping giants, saviors, saboteurs, acquaintances, friends, and irritants (Figure 29).

Sleeping giants

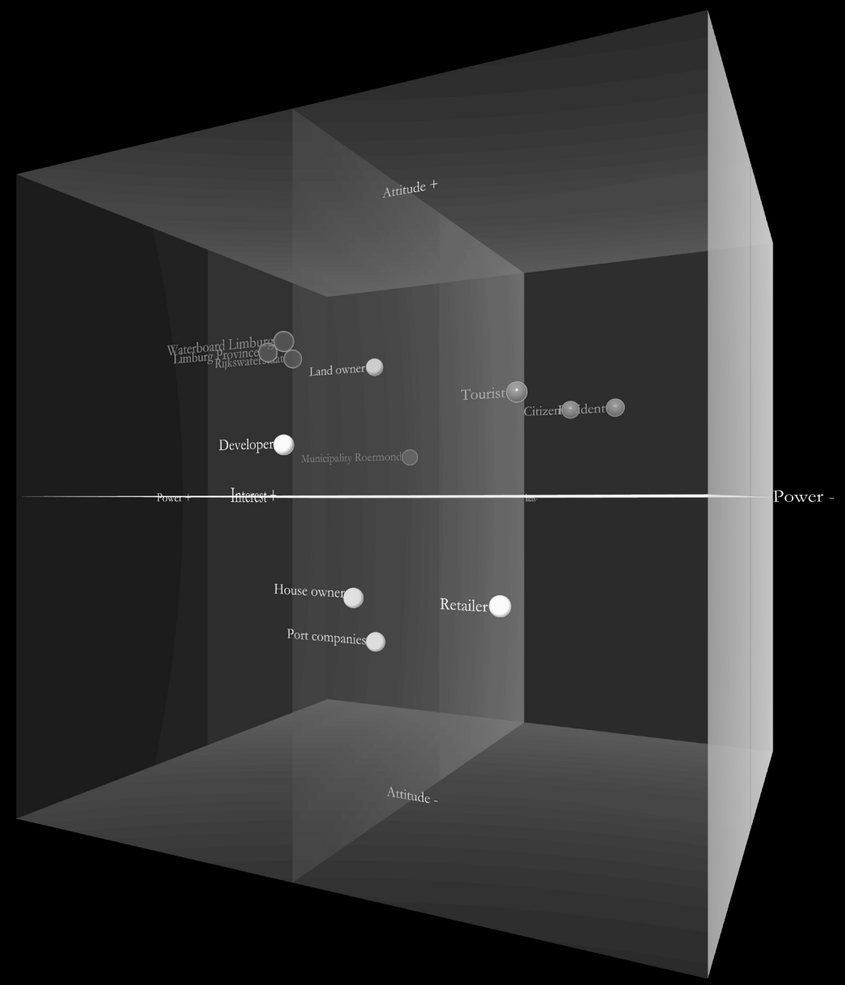
Landowner and Municipality Roermond are influential, passive, and supportive. The main barriers at the moment are a lack of urgency and knowledge of flood risk. There are also concerns about development and maintenance costs. For landowners, better policies, regulations and expert advice can help in this regard.

For Municipality Roermond, more data collection and analysis could improve confidence in the effectiveness of flood adaptation measures. The urban designers of a municipality can also play an influential role by using their expertise to solve flooding problems. Also, it is useful to let market principles guide.

Common sense building for flood adaptation coupled with a minimal expectation for results can be instrumental in attracting them to join at the beginning of the project.

Figure 29. Power-interest-attitude analysis for Roermond's stakeholders

The author, 2022



Saviors

Developers, Province Limburg, Rijkswaterstaat, and Waterboard Limburg are with power, high interest, and positive attitudes. As the lead for projects, developers can play an important role in implementing flood adaptation programs. Their biggest drawback is that they are profit-oriented in their actions. To address this, governments can incentivize developers through policy tilt to push them towards flood resilience in their projects.

The provincial government should financially support municipalities as they implement innovative projects, which can then be replicated and disseminated to other municipalities.

The responsibilities of water authorities could be further expanded, for example, with small-scale rainwater harvesting projects within cities. In this way, Waterboard Limburg could work with developers, landowners, and house owners to develop projects, which will reduce the pressure on municipalities.

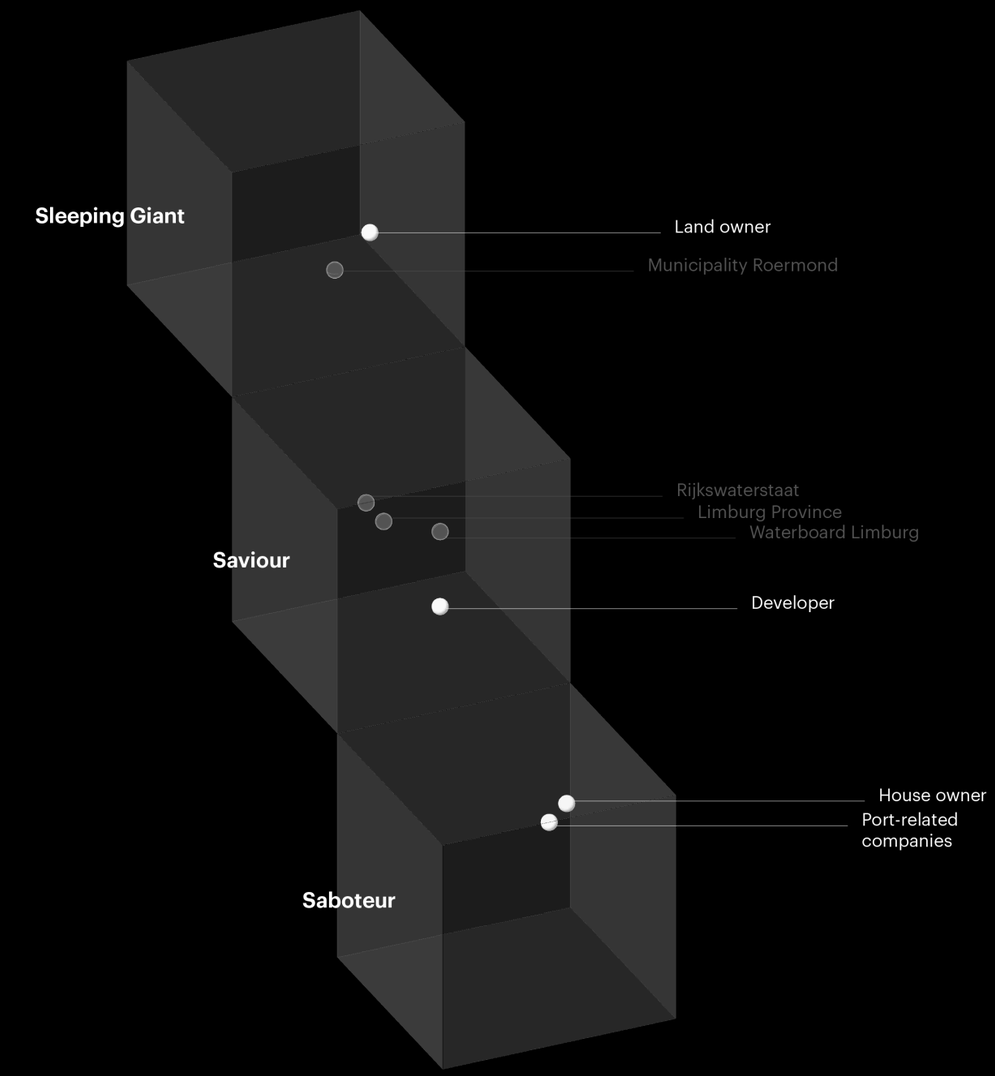
Saboteurs

House owners and port-related companies are powerful, active obstructionists. The house owner has absolute control over his or her home. They may be willing to cooperate if their neighborhood has been flooded before; larger investors and house owners without risk awareness are less likely. To motivate private homeowners to take action, organizing workshops, garden competitions, information sessions, and subsidies may be effective.

Flood defenses tend to hurt port-related companies, so they are most often opposed to them. However, in the event of a flood, the port companies are the most damaged ones. This can be a breakthrough in finding common interests, where the government, Waterboard, and port-related companies work together in a co-creative way to find innovative approaches.

Figure 30. Sleeping giant, saviour and saboteur

The author, 2022



Acquaintances

Residents and citizens are those who have little power and are passive and supportive. They are not just recipients of information, but groups that focus on local or specific social issues can also initiate projects. It is a challenge for municipalities to trust these dynamic citizen organizations and to stay engaged with them. If well-led, citizen movements can also influence policymakers.

Friends

Tourists are with high interest and a positive attitude, but little power. They don't come specifically to visit flood-resilient cities, so innovative projects must be sited close to city landmarks or become landmarks themselves to attract their attention.

In addition, tourists are powerful promoters of the city. If Roermond's flood adaptation initiatives gain their approval, the municipality can save some of the financial expenses spent on tourism promotion. This is because tourists will spread the word by word of mouth, for example by posting photos on social media, reviewing popular attractions, etc.

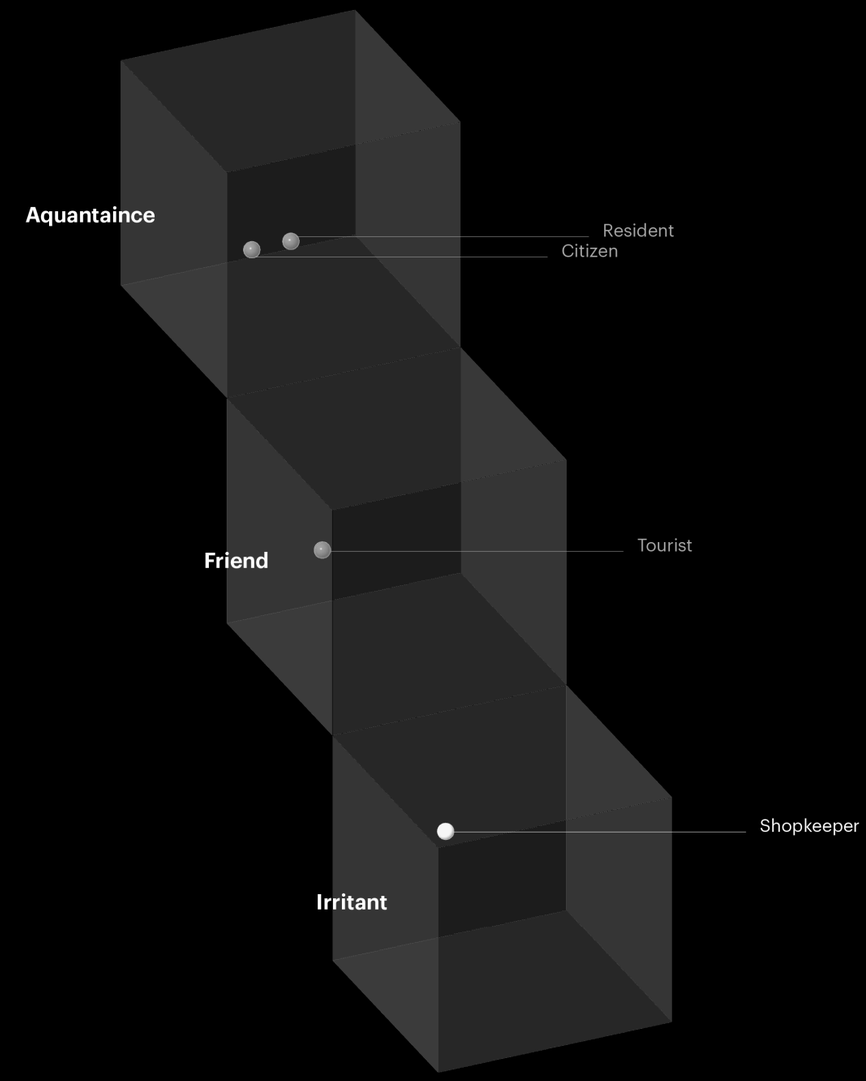
Irritants

Shopkeepers are with little power and great interest, but with a negative attitude. Shopkeepers are often tenants of the houses and have little say. Changes such as creating a green roof or disconnecting drains can only be made after consultation with the house owner.

However, when residents decide to design their gardens with flood-adaptive measures, materials are often purchased at garden centers or home improvement stores. This is a great opportunity for shopkeepers to make the transition, especially in the face of e-commerce. By supporting souvenir shopkeepers in their transition to gardening and home décor businesses, residents can also be indirectly pushed to adapt rain gardens.

Figure 31. Aquantaince, friend and irrirant

The author, 2022



7 Policy Analysis

The physical living environment covers all aspects of housing, landscape, energy, water, etc. Under each theme, there are a series of policies from the national to the local level to guide the implementation of plans, as sorted out in chapter 5.2.5. This thesis explores the potential for interdisciplinary collaboration to drive policy innovation, using flooding as a topic. The main themes used in the research are spatial planning and water, that is, improving spatial planning policies by drawing on the points of water management policies. The policy analysis serves three purposes:

1. A summary of all current policies related to spatial planning and water management around Roermond. Such an overview is important, especially in the transition to the new Environmental Act.

2. Identifying policy loopholes in spatial planning policies. These loopholes will arise from key points of water management policies and be translated into new policies through science integration.

3. This emphasizes that thematic policies are not isolated and can serve other themes as well. In terms of the scope of the urban planner's responsibilities, this will make the long-term environmental vision more holistic.

Since some relevant policies are still being developed and not officially released, the policy loopholes derived from the analysis and comparison are not necessarily accurate. However, it provides some perspectives worth thinking about for policymakers. The list below includes policy documents in both the spatial planning and water management areas (Figure 32). Of these, the main ones used for research are Environmental Vision Roermond 2050 and National Water Programme 2022-2027.

Water Management Policies

- National Water Program 2022-2027
- Limburg Water Management Program 2022-2027
- Flood defense management plan 2017-2022

Spatial Planning Policies

- Draft Nationale Omgevingsvisie 2030-2050 (NOVI)
- Omgevingsvisie Limburg 2030-2050 (POVI)
- Draft Omgevingsvisie Roermond 2030-2050 (GOVI)

Figure 32. Documents used in the policy analysis

Screenshot of document covers, 2022

7.1 Environmental Vision Roermond 2050

In the Netherlands, the Environmental Vision (Omgevingsvisie in Dutch) is part of a so-called policy cycle. As Figure 33 displays, the Environmental Planning Act distinguishes four phases: policy development, policy implementation, and feedback implementation (Municipality Amsterdam, 2021). Based on monitoring and evaluation, the cycle can be repeated. The policy cycle gives shape to the management of spatial qualities and their coherence between projects and at the level of the city and the region.

This section will summarize the main conclusions of Environmental Vision Roermond 2030-2050 on the city's strengths and weaknesses, and future directions of development.

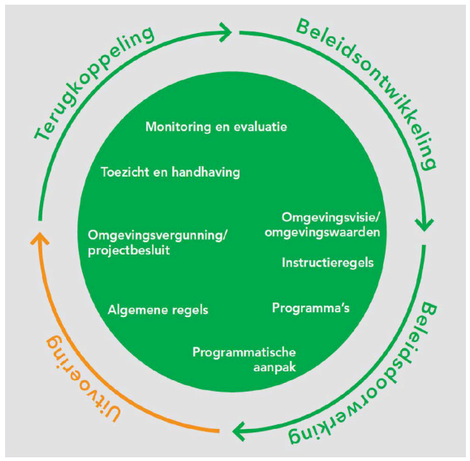


Figure 33. Policy cycle of Environmental Planning Act

Image from Municipality Amsterdam, 2021

7.1.1 Strenghths

Roermond in the region

- The attractive historic center with catering, retail, Designer Outlet, and events.
- Touristic recreational region.
- International and national position of business activity.
- Attractive residential environment.
- Good public transport and road connections.
- Many available jobs.
- Regional facilities such as Laurentius Hospital and Courthouse Limburg.

Built-up area

- The city center is also the historic porch, adjacent to the later realized Maasplassen and Designer Outlet Roermond.
- The historic center has many monumental and iconic buildings.
- A dynamic, cultural, and tourist heart for residents, visitors, and entrepreneurs.
- Good accessibility by water, road, and rail.
- Living near the water in Jazz City and Roerdelta.
- A great diversity of living environments, with sufficiently accessible neighborhood facilities.
- A compact city close to the historic center and water, with green areas in the suburbs not far away.
- Green structures along the Maasnielderbeek and the Roer.
- A diverse range of business parks, including port-related.
- Supra-regional business parks and retail clusters, both inside and outside the city.
- The large presence of the manufacturing industry.
- The small economy in residential areas.
- Redevelopment opportunities for old industrial estates.

Suburban, nature, and Landscape

- Village sight in Asselt, lying in the middle of the old Meuse landscape.
- Historic ribbon development in Boukoul and Asenray on the high ground along the old Meuse.
- Proximity to the city of Roermond
- Recognizable parts of the river landscape with the Meuse valley, the old Meuse arm (with Maasnielderbeek), and stream valleys
- Variations between open agricultural areas, forest, and natural areas, and variations

between the stream valleys of the Roer and Swalm rivers.

- Small-scale and varied landscape with hedgerows and tree-lined avenues.
- Visible height differences in the landscape.
- Opportunities for recreation, including routes for fetching, walking, and horseback riding.
- Proximity to Germany.

The Meuse River

- The wide expanse of the water contrasts with the compact buildings along the Meuse.
- The natural course of the Meuse with natural banks.
- The location is close to the city center, close to residential areas.
- Water recreation, marinas, and residential recreation along the lakes.
- Beach clubs, city beaches, and events around De Weerd.
- Natural values in and around the Asseltse Plassen and the Loop of Linne.
- Ecological diversity in water, meadow, nature, and landscape elements.

7.1.2 Weaknesses

Roermond in the region

- The influx of disproportionately vulnerable regional populations puts pressure on skilled nursing, housing, and welfare services.
- Roermond has no higher education institution.
- Lack of connection between the inner city and cultural facilities.
- No good public transport connection with Germany.

Built-up area

- The city lies with its back and at a distance from the water.
- Few slow traffic routes between residential areas and the inner city.
- Station, city center, Designer Outlet Roermond and Maasplassen are not well interconnected.
- Room rentals and small studios reduce the quality of life for inner-city residents.
- Lack of attractive public spaces.
- Social and physical security is an ongoing concern.
- In the long run, there is a restructuring task for business parks and vacant sites.
- The port is not sufficiently equipped to facilitate water transport.

Suburban, nature, and Landscape

- The Swalmen Valley has limited accessibility and scatted facilities.
- Due to the A73, the center of Roermond has limited accessibility to the suburbs, especially between Asselt and Asenray and Boukoul.
- The natural areas are not well connected to each other.
- Some companies are not suited to operate in rural areas.

The Meuse River

- Awareness of the Meuse River in the landscape is limited.
- The Meuse is poorly connected to urban and rural areas with only one bridge, the N280. The bridge is designed for car and bicycle traffic only and there is no possibility for pedestrians to cross the Meuse.
- Maasplassen could be made more visible and recognizable.
- Along the Maasplassen there is no contiguous route for walking, cycling, and fetch.

7.1.3 Future direction

- The healthy and safe city.
- Attractive living and working city.
- The sustainable city.
- City of three major attractions: Maasrijk, Kleurrijk, and Grensrijk (Figure 38).

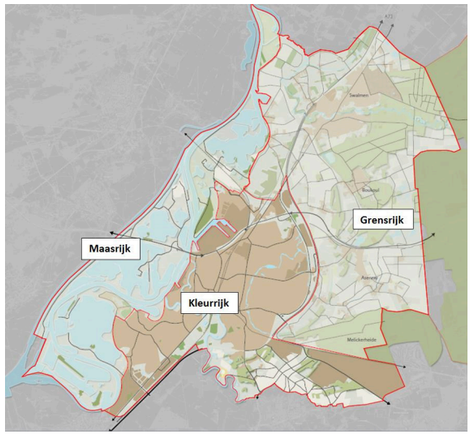


Figure 34. Three major attractions of Roermond

Map from Municipality Roermond, 2021

7.2 National Water Programme 2022-2027

The water-related challenges in the Netherlands are extensive and will only get bigger in the future. For this reason, the Ministry of Infrastructure and Water Management, together with other departments, has developed the National Water Programme (NWP) 2022-2027. The NWP describes the country's overall water policy and the management of water and waterways. With regard to water policy, the NWP is an elaboration of the new National Spatial Planning and Environmental Strategy (NOVI). The NWP consists of a River Basin Management Plan, a Flood Risk Management Plan, and a North Sea Plan 2022-2027 (Ministry of Infrastructure and Water Management, 2022). Among them, the Flood Risk Management Plan is closely related to this thesis, and the main points applicable to Roermond of it are described below.

7.2.1 Risk assessment and risk areas

- The risk of flooding was reduced following the construction of the Maaswerken and Space for the River programmes.
- The risk assessment focuses on flooding which could lead to a significant risk: flooding from the main water system and the regional water system. It does not include flooding from groundwater and sewer systems. Whether flooding caused by intense rainfall in the future will need to play a role in the interim risk assessment will be studied further.
- The consequences for each flood scenario are determined, including the potential economic damage, the number of fatalities and the number of locations with vulnerable nature, historic monuments and IED installations (such as nuclear reactors, chemical industry and storage places of hazardous substances)
- The Netherlands has designated the following as 'areas of potential significant flood risk' :

Type A: unprotected areas along the main river.

Type B: protected areas along the main river.

Type C: protected areas along the regional water system

Type D1: unprotected areas along four regional waters in the Meuse river basin and one regional water in the Rhine river basin.

In Roermond, there are three types of flood risk zones: A, B, and D1 (Figure 35).

7.2.2 Measures

Goal 1: Be prepared for future developments

- Every year, draft and implement a long-term Delta Programme.
- Delta Decisions and preferential strategies will be revised every six years.
- Implement knowledge programme relating to rising sea levels.
- Draw up Programme Integral River Management.
- Update KNMI scenarios.

Goal 2: In 2050, the Netherlands is climate proof with a water robust organisation

- Implement Delta Decision on Spatial Adaptation.
- Strengthen, extend and apply water assessment.

Goal 3: The Netherlands is prepared to act adequately in the case of (potential) flooding

- Update crisis and contingency plans.
- Timely flood warning.
- Education, Training and Exercises.
- Promote water awareness and cooperation.
- Knowledge development and cooperation.

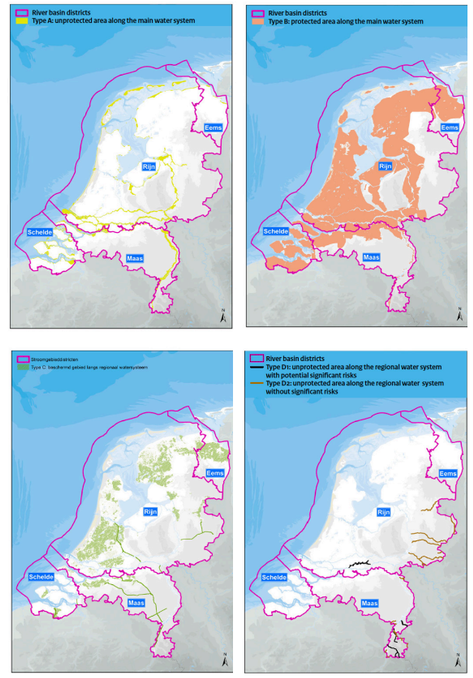


Figure 35. Designated areas A, B, C, and D in the framework of the Floods Directive

Map from Ministry of Infrastructure and Water Management, 2022

IV. PLANNING & DESIGN

8 Interdisciplinary Policy Proposal

As can be seen from the spatial and policy analysis in the previous chapter, Roermond faces complex flood risks. There are both national and regional rivers within the administrative boundary; built-up areas of the city are protected by dykes, and floodplains and nature reserves are without dykes.

National Water Programme has repeatedly emphasized the importance of knowledge sharing and sectoral cooperation in addressing flood risk. However, these two points remain unrecognized in spatial planning policies. In the Environmental Vision Roermond 2030-2050, flood risk is only briefly mentioned as a 'physical security' issue in the weaknesses of the built-up area and not included in the future direction of development.

Based on the existing policy statements, this thesis uses an interdisciplinary and collaborative policymaking approach to fill the policy loopholes in spatial planning with new policies. In this chapter, Roermond is divided into five districts: Roermond-center, Roermond-south, Maasplassen, Maasniel, Swalmen & Asenrey (Figure 36). The "strengths" of the environment combined with flood resilience become "opportunities", and the "weaknesses" combined with flood resilience become "threats".

In Chapters 8.1 and 8.2, existing policies in the Environmental Vision are shown in white boxes, and new policies are shown in black boxes.

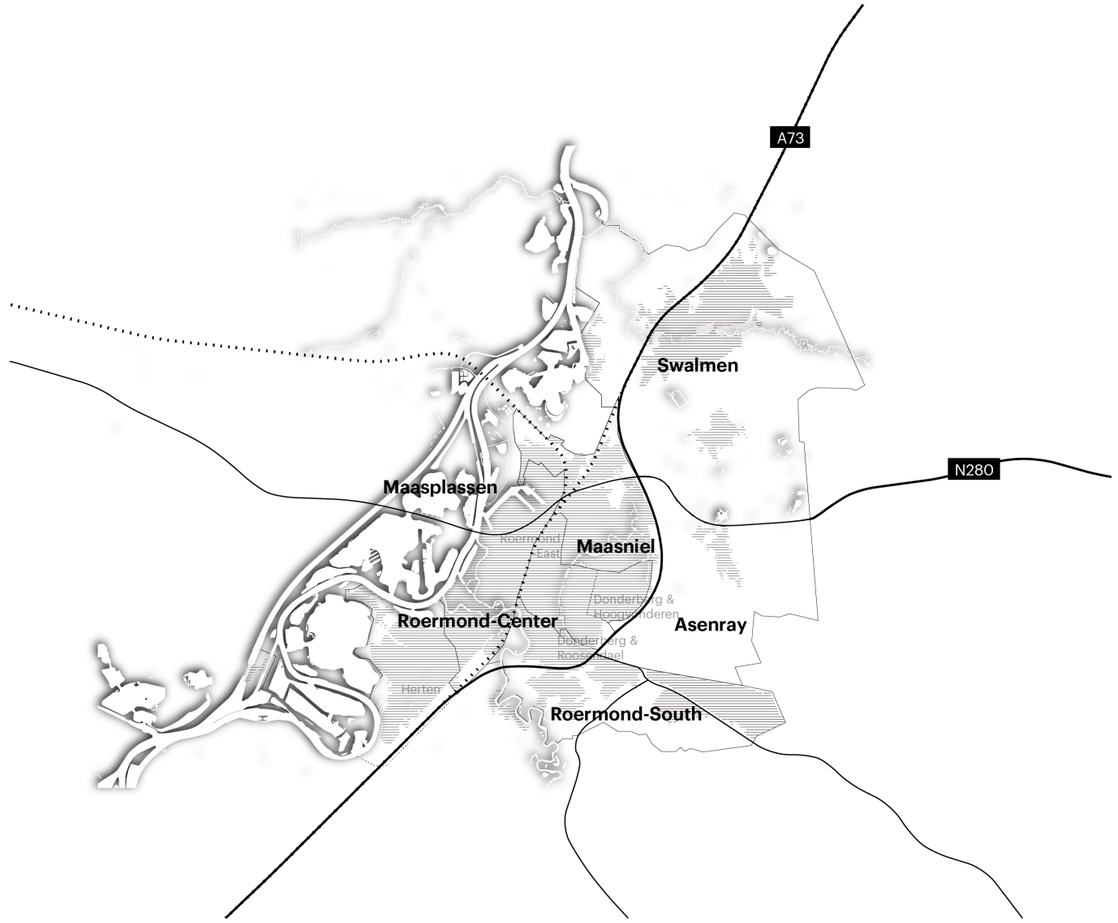


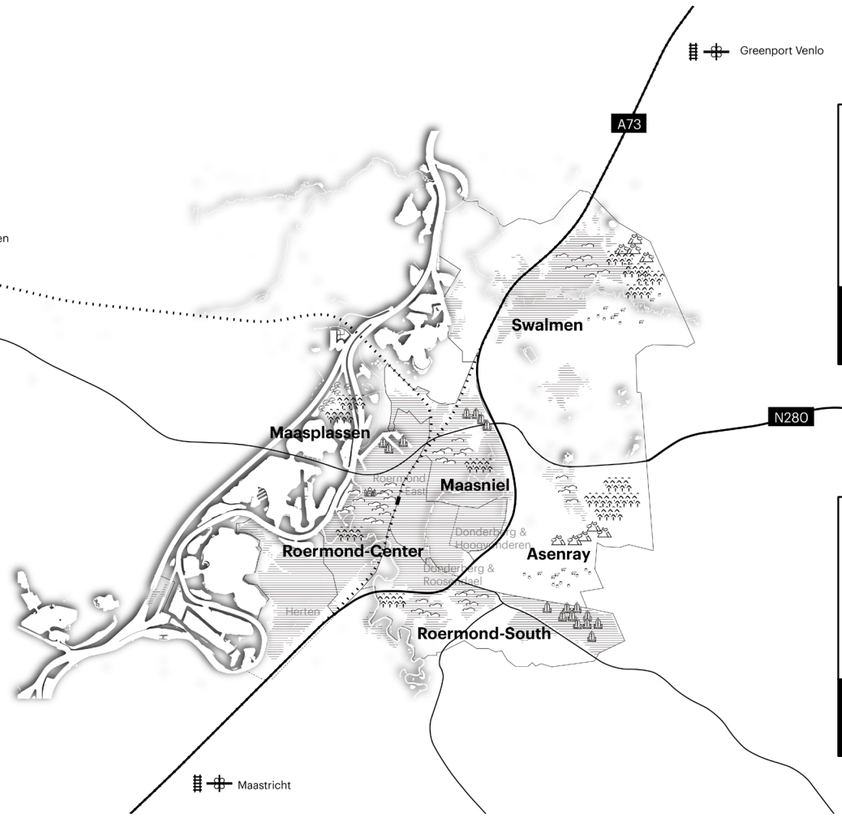
Figure 36. Main districts of Roermond

The author, 2022

Figure 37. Opportunities in spatial planning policy and water management policy

The author, 2022

8.1 Opportunities



Maasplassen
•Protect natural values of meandering, natural course of the Maas with natural banks, in particular the Asseltse Plassen and the Linne Loop.
•Conservation of underwater biodiversity, and biodiversity of swarm and rudders.
•Make physical and visual connections with city center and residential areas.
•Attractive water recreation areas, such as the marina, beach clubs and city beaches around De Weerd.

•River widening can be a (partial) alternative for dyke reinforcement (National Water Program 2022-2027).

Roermond-South
•Create international and domestic business activity and jobs.
•Stimulate the development of small economies in residential areas.
•Redevelopment opportunities for old industrial buildings.
•Protect the Nature Reserve Zone along the Roer.
•The landscape is rich with open agricultural areas, forests, nature reserves, stream valleys of the Roer and Swam.

•Take physical measures along the Roer, might include the creation of water storage areas, stream widening and locally also flood defence facilities around built-up areas. Implementing these measures requires the input of water board, municipalities, public, farmers, businesses, site managers and often takes several years. (Limburg Water Management Program 2022-2027).

Maasniel
•Create international and domestic business activity and jobs.
•Stimulate the development of small economies in residential areas.
•Redevelopment opportunities for old industrial buildings.
•Strengthen green structure along the Maasnielderbeek.
•Continuing the atmosphere of the compact city and strengthening the connection with the inner city, the water and the countryside.

•Redevelop Maasnielderbeek to connect River Roer and Swalm (Limburg Water Management Program 2022-2027).

Asenray & Swalmen
•Historic ribbon pattern, located on high ground along the Maas River
•Green living in the villages.
•The landscape is rich with open agricultural areas, forests, nature reserves, stream valleys of the Roer and Swam.
•Opportunities for recreation, including routes for fetching, walking and horseback riding.

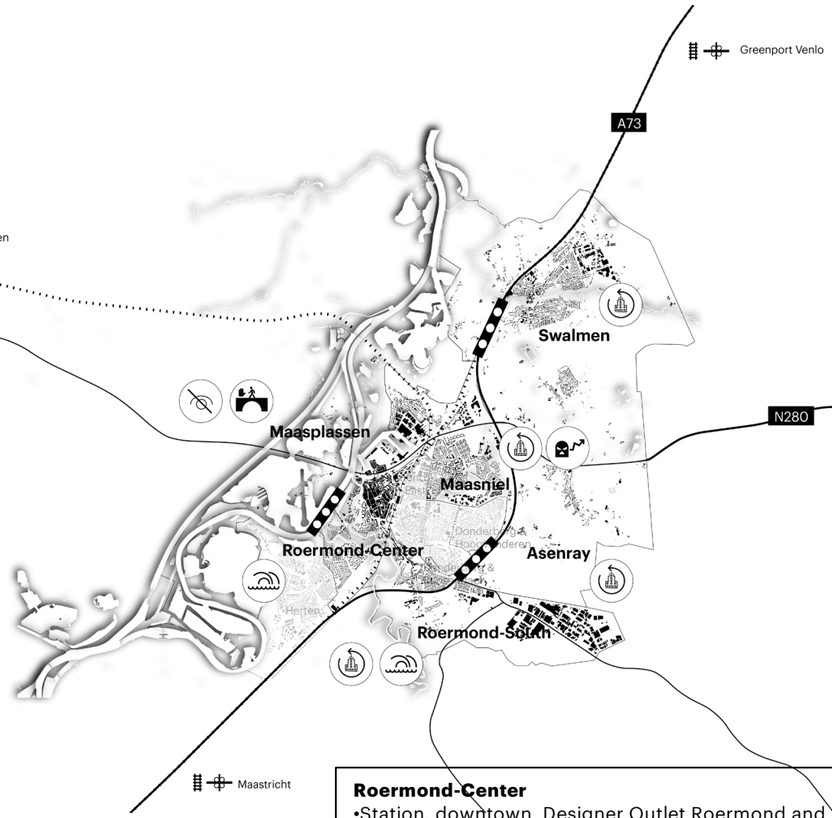
•Maasnielderbeek-bovenloop stream restoration (Limburg Water Management Program 2022-2027).

Roermond-Center
•Attractive historic town centre with monumental buildings, catering, retail, DOR and events。
•Characteristic historic spatial pattern of ring with gates, the grid and the squares and accents.
•Create international and domestic business activity and jobs, including port related.
•Good public transport and road connections.
•Living near the water in Jazz City and Roerdelta.
•Compact city with green areas (Roer) at a short distance.

Figure 38. Threats in spatial planning policy and water management policy

The author, 2022

8.2 Threats



Maasplassen
•The identity of the various Maasplassen could be made more visible and recognizable.
•Access to the Maasplassen is only possible via the N280 road, which is designed for car and bicycle traffic only and not for pedestrians.
•Along the Maasplassen there is no contiguous route for walking and cycling and fetch.
•The city lies with its back and at a distance from the water.

•Enlarging the storage and drainage capacity of flooding waters(National Water Program 2022-2027).
•Flooding impact to swimming water locations (National Water Program 2022-2027).

Roermond-South
•Social and physical security (flood) is and ongoing concern.
•The natural areas are not well connected to each other.
•There are companies that do not fit into rural areas.
•Give obsolete and vacant business parks a new purpose.

•Flooding impact to Nature 2000 zones(National Water Program 2022-2027).
•In the area outside the dykes, municipalities are responsible for assessing the safety situation and informing the users to take measures themselves (National Water Program 2022-2027).
•Where new paved surface is laid, compensation is required by creating extra space for water storage and infiltration near the intervention. (National Water Program 2022-2027).

Maasniel
•Social security is an ongoing concern.
•In some neighborhoods little public green space or little accessible to green space.
•Give obsolete and vacant business parks a new purpose.

Asenray & Swalmen
•Due to the presence of the A73, Asenray and Swalmen have limited accessibility to the city of Roermond, both in the east-west and north-south directions.
•The natural areas are not well connected to each other.
•Give obsolete and vacant business parks a new purpose.
•There are companies that do not fit into rural areas.

Roermond-Center
•Station, downtown, Designer Outlet Roermond and Maasplassen not well interconnected.
•The quality of life suffers due to the presence of room rentals and small studios in the inner city.
•Lack of attractive public space.
•Social and physical security (flood) is an ongoing concern.
•The port is not sufficiently equipped to facilitate water transport.

•Maintain, manage and reinforce flood defenses(National Water Program 2022-2027).
•Water logging impacts to historic buildings (National Water Program 2022-2027).
•Consequences of flood for the chemical industry and logistic sites(National Water Program 2022-2027).

8.3 General guidelines

Addressing the opportunities and threats for Roermond, a set of general guidelines has been developed to guide the subsequent zoning plan in four areas: water, landscape, vitality, and economy. The main objectives of these guidelines are:

- *To bring water into the city with safety in mind;*
- *To protect landscape features while enhancing permeability;*
- *To promote inner-city vitality through flood adaptive measures;*
- *To foster the small economy and knowledge innovation.*

Water

1. Develop innovative alternatives before dyke reinforcement.
2. Enhance cooperation between citizens, the Municipality, and Waterboard.
3. Redevelop Maasnielderbeek.
4. Stream restoration.
5. Avoid the sense of obstruction while raising the dike.
6. Enlarge the storage and drainage capacity of rainwater and floodwater.

Landscape

7. Protect the natural values of floodplains and nature reserves.
8. Strenthen the green structure along Maasnielderbeek.
9. Consider flooding impact on nature.
10. Develop routes between forest, farmland, and stream valleys.

Economy

11. Create jobs for domestic and international workers.
12. Stimulate the development of small economies in residential areas and the city center.
13. Redevelop the old industrial building.
14. Promote the diverse Massplassen.
15. Give vacant industrial buildings a new purpose.
16. Consider flooding impact on monuments and logistic sites.

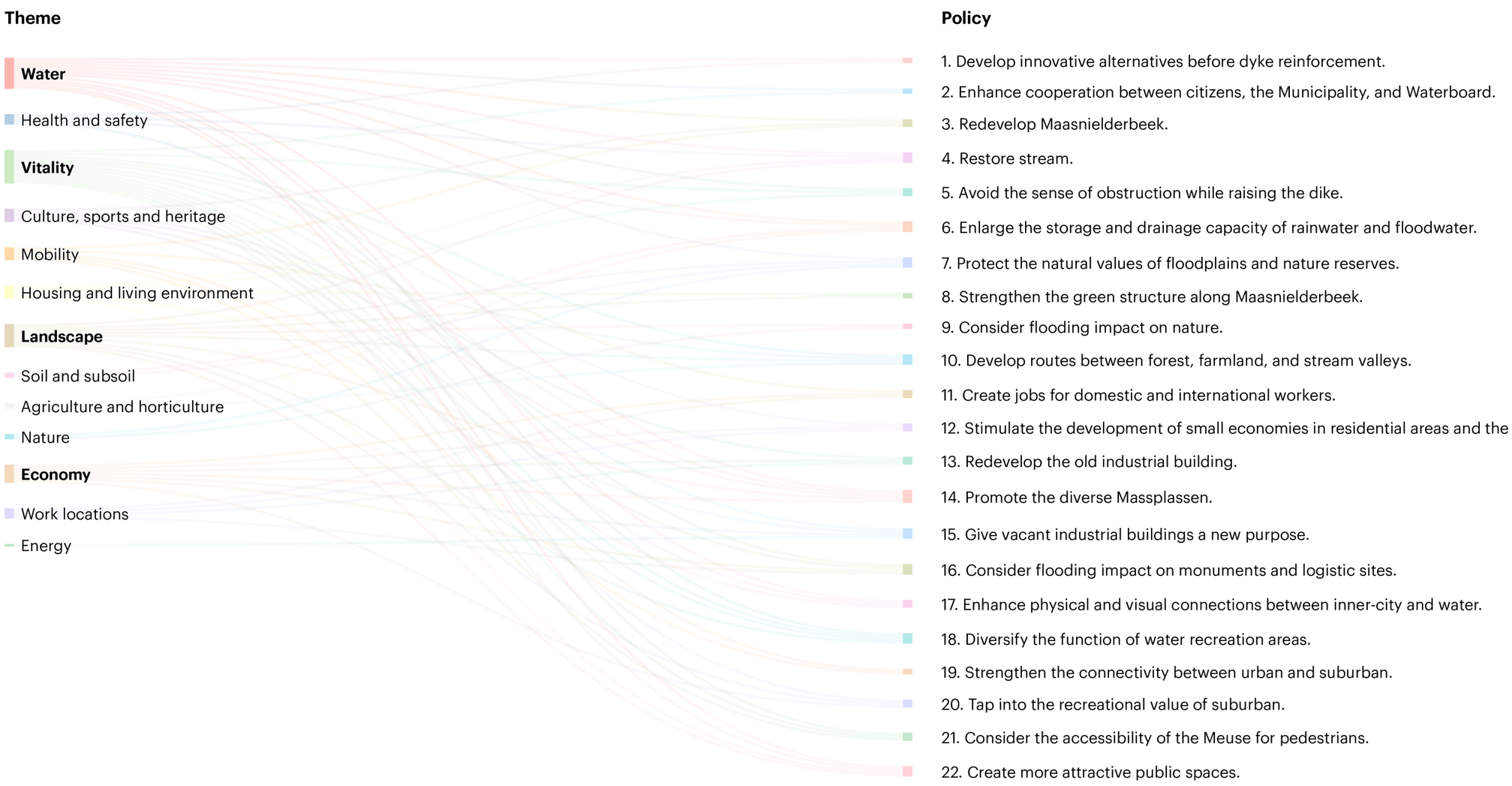
Vitality

17. Enhance physical and visual connections between inner-city and water.
18. Diversify the function of water recreation areas.
19. Strengthen the connectivity between urban and suburban.
20. Tap into the recreational value of suburban.
21. Consider the accessibility of the Meuse for pedestrians.
22. Create more attractive public spaces.

Figure 39. Classification of new policies

The author, 2022

8.4 Contributions to other environmental themes



9 Blue-Green Roermond 2050

9.1 Roermond towards 2050

Roermond is traditionally made up of one urban core, surrounded by two rivers and a diverse and attractive landscape (Figure 40). Towards 2050, the city will function as a coherent system in which each district fulfills a specific role and complement each other. With the Roermond-South, the new campus and the business park area, for example, the district has a knowledge gateway with many opportunities for innovation around flood adaptive. Add to that the recreational opportunities in Massplassen, the attractive residential environments in Massniel, the pioneering spirit of flood resilience and the characteristic historic town of Roermond-Center, and the green living of Asenray and Swalmen.

A feature of the vision is that local, regional, national, and international rivers and people are gathered here. This makes Roermond a hub for flood adaptation measures, but above all for stakeholders and knowledge. Spatial quality, with high densities of living, working facilities, and lively public spaces, is paramount to achieving this vision.

Within the municipal boundary, it is a zoning plan for the city towards 2050. In the spatial-programmatic framework (see Chapter 9.2), the various components are worked out in more detail.

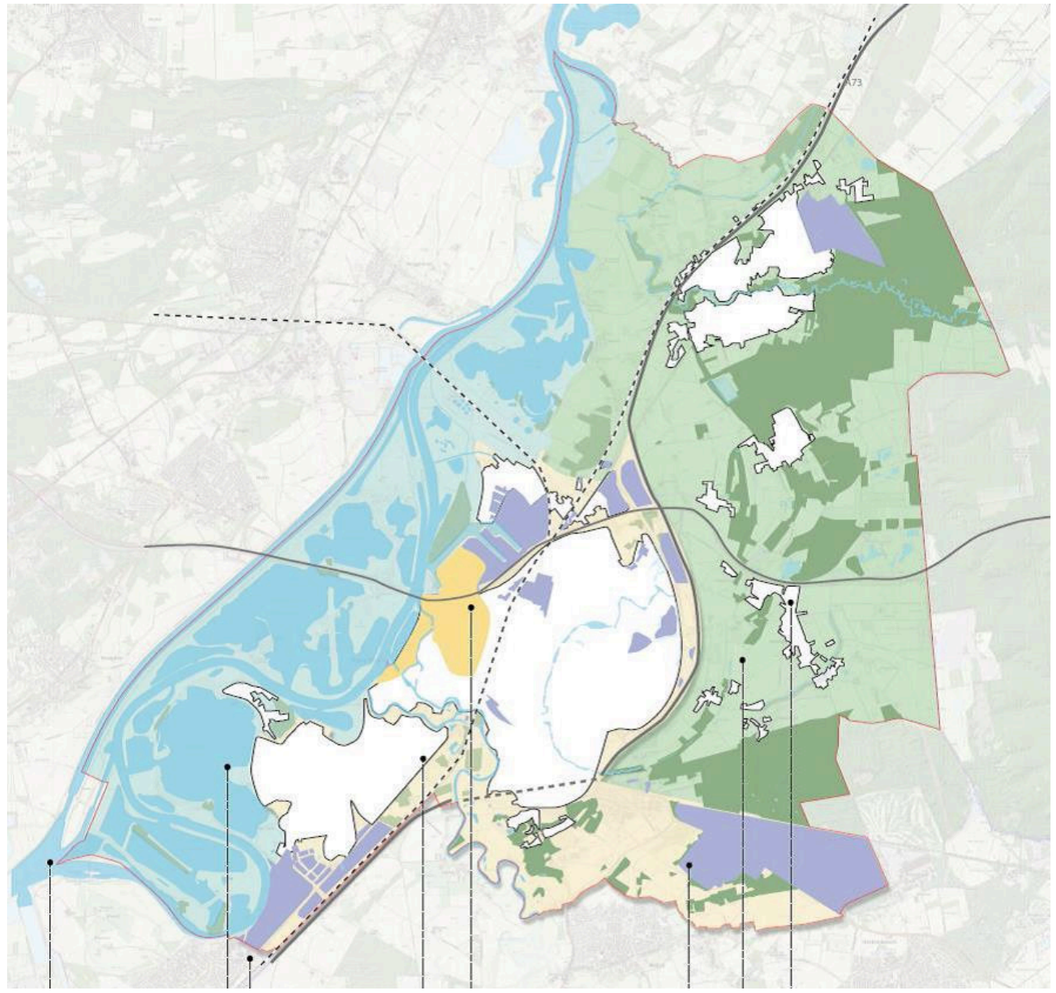


Figure 40. Current landuse map of Roermond

Map from Municipality Roermond, 2021

Roermond Environmental Vision 2050

Water
- Channel reopening
- Stream restoration

Landscape
- Nature 2000
- National park
- Nature-based Agriculture

Economy
- Innovation hub transformation
- Small economy transformation
- New railway station

Vitality
- Flood resilience pilot area
- Social housing transformation
- Multi-functional floodplains
- Cycling route

General
- River
- Modern urban area
- Mixed urban area
- Historic urban area
- Office
- Retail
- Forest
- Grass
- Agricultural land
- Port-related industry
- Business park
- Administrative boundary
- Raiway
- Dikes

9.2 Spatial-programmatic framework

The purpose of making an Environmental Vision is to experiment with new policies proposed by interdisciplinary collaboration and to create a flood-resilient city. The zoning plan contains four spatial-programmatic concepts that provide direction for urban development: Industry Renewal, Blue Belt, Green Belt, and Vibrant Belt (Figure 41). They should lead to a vibrant city and the realization of a blue-green living environment. A place that is attractive for residents and visitors alike.

Figure 41. Design concepts of the Environmental Vision

The author, 2022

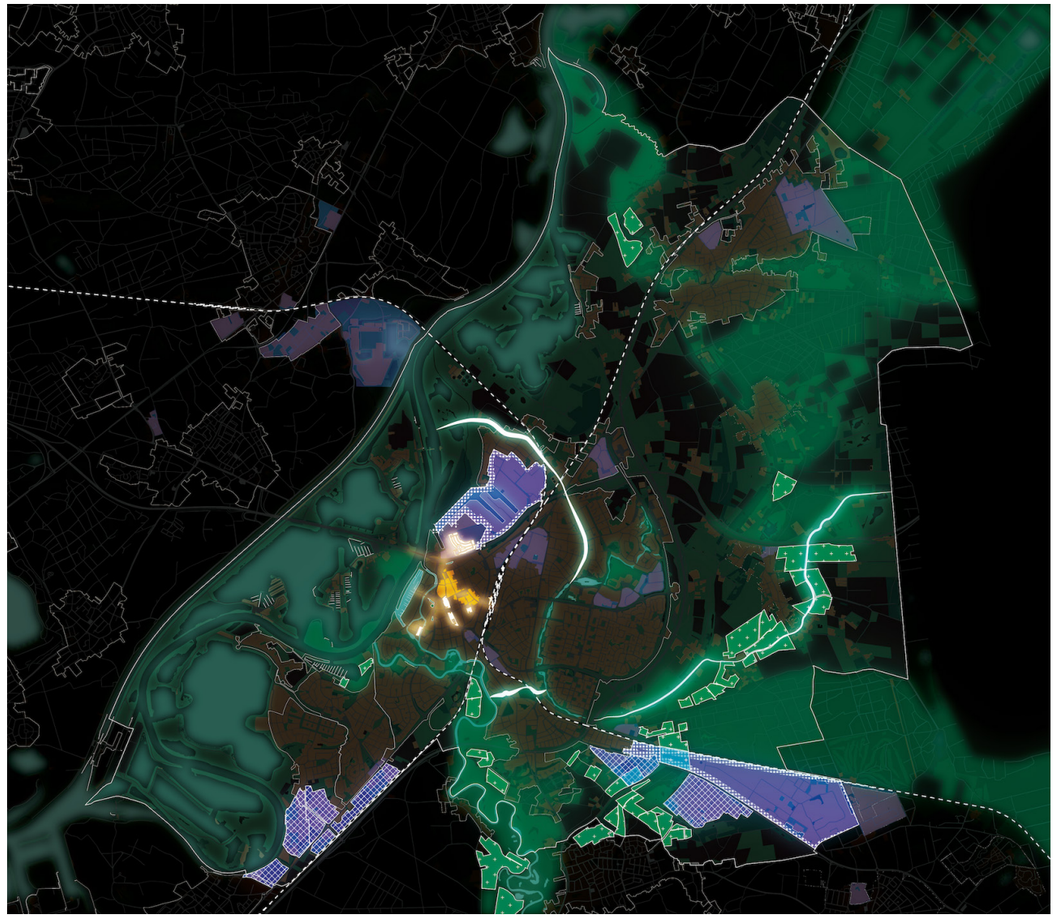
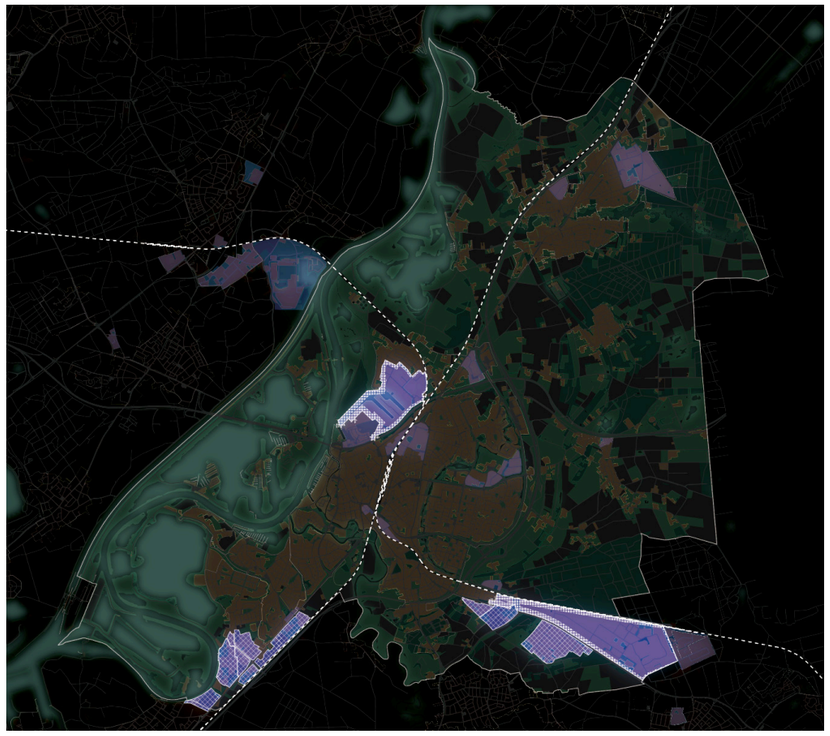


Figure 42. Industry renewal clusters

The author, 2022



Industry Renewal

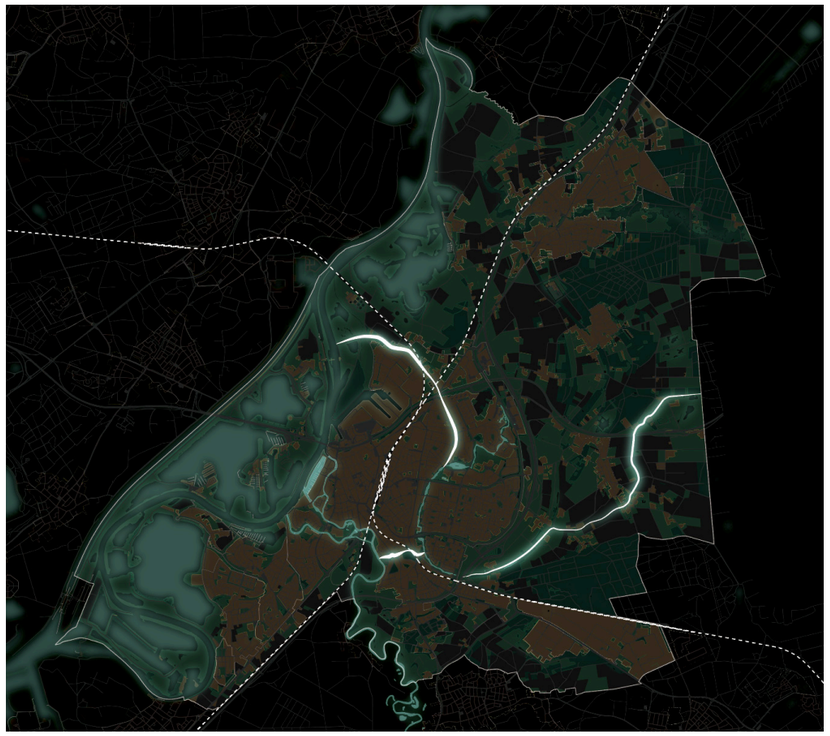
The Roermond Atlas shows that industrial parks in Roermond-South, Herten and Maasniel currently have high vacancy rates and that these industrial parks are in need of renewal (De RoermondAtlas, 2021). Educational institutions and schools could be the way forward for the transformation of the industrial park in Roermond-South, an initiative that could also compensate for the lack of higher education in Roermond. Universities can often bring freshness and creativity to local flood adaptation projects.

The vacant buildings in Herten are located close to the Meuse in a flood risk area, but are protected by a dike system. They can be converted into social housing and leased to international workers and students.

Maasniel's industrial park is located in a high-density residential area and close to the city center. It is suitable for the development of a small economy, such as the production and sale of gardening supplies and the promotion of rain gardens in residential areas.

Figure 43. Blue belt

The author, 2022



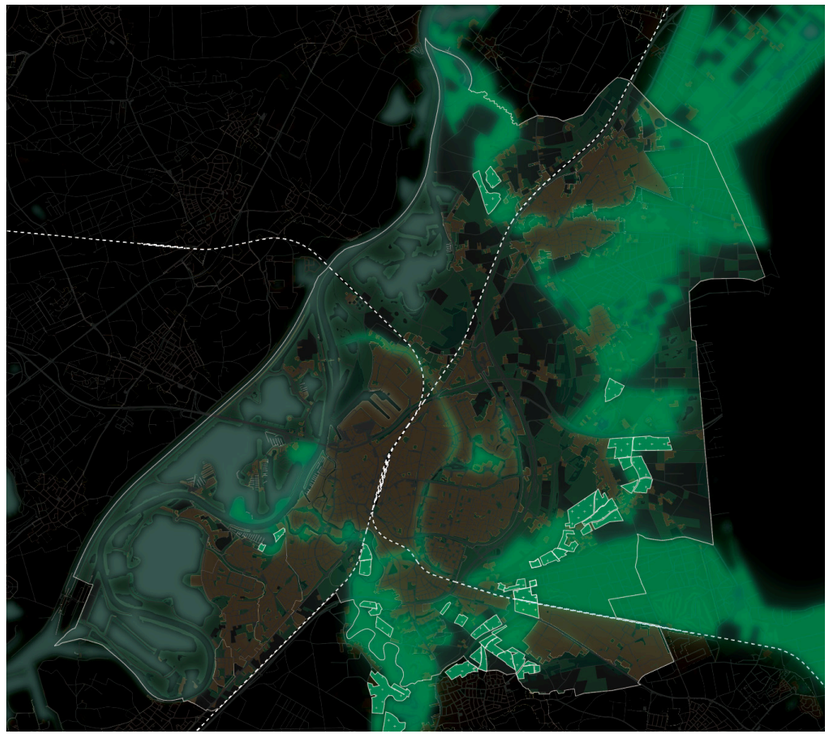
Blue Belt

The Blue Belt contains three renovations. The first is the re-excavation of the historic Maasnielderbeek along the fabric of the street. The second is the creation of a river connection between the Roer and the Maasnielderbeek in Roermond-South. In this way, the river has more space. When the water level in the upper Roer in Germany is too high, there can be a controlled release downstream and into the Maasnielderbeek. The same is true for the Meuse when the water level is too high.

The third river excavation is in the suburbs. The new river can be used to divert water for irrigation and also provides a new way of transportation into the city for those living in the villages.

Figure 44. Green belt

The author, 2022



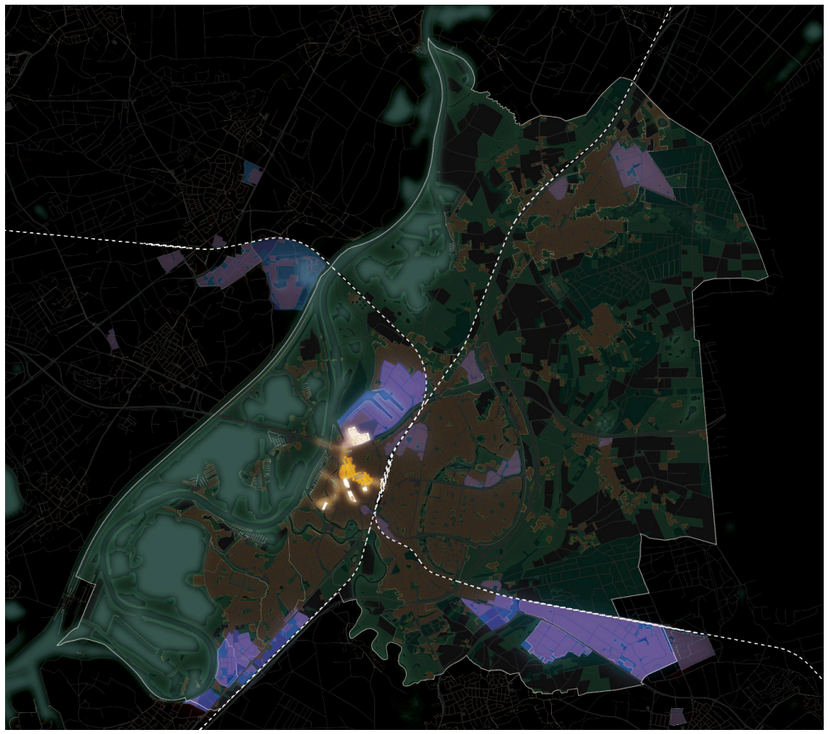
Green Belt

To a certain extent, the Green Belt was created along with the Blue Belt. The riverfront beautification of Maasnielderbeek will create a linear waterfront park for the surrounding residents and will also enhance biodiversity.

Another way is to develop nature-based agriculture. This shift occurs in suburban farmlands, which are located among scattered forests and meadows. This transition will be done by integrating native flora into cattle pastures or restoring habitats crucial to watershed health.

Figure 45. Vibrant belt

The author, 2022



Vibrant Belt

The Vibrant Belt aims to create an area where flood resilience is consistent with other goals such as quality of life, mobility and aesthetics. Citizens want a rich and interesting living environment, and innovative flood adaptation measures can satisfy them. For example, cycling on the dike, playing soccer on the grass with hidden water storage tanks, and celebrating carnival in the water square. Through careful design and siting, various functional spaces in the city center can be linked together and linked to the River Meuse.

9.3 District-specific strategy

Roermond-Center:
a place to be and meet

The ambition for the city center is to enhance the quality of space and neighborhoods, organizing public spaces in such a way that people are invited to meet each other. In the near future, the catering street will be a compact urban block providing entertainment, jobs, stores and restaurants for citizens. It will be an experimental development, providing space for a combination of flood adaptation measures and multiple functions. Diversity is also encouraged in terms of commercial facilities, cultural creations and sports fields. The visitor economy will continue to provide jobs and income and support the international and open character of the city.

Citizens are essential users when it comes to livability, vitality and participation. Therefore, the municipality will work with residents, homeowner associations, landowners, and developers to transform public spaces such as canals, streets, plazas, parks, and harbors, with a focus on rainwater harvesting and utilization. Automobile traffic will be significantly reduced, with due consideration given to parking, especially near the harbor. This will free up more room for greenery.

Figure 46. The direction of Roermond-center development

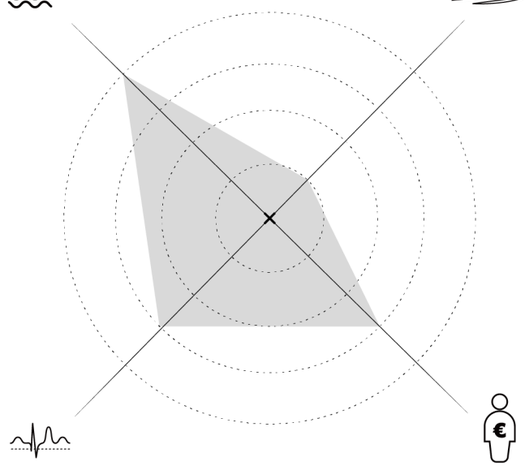
The author, 2022

Incorporate flood adaptation measures in a variety of functional spaces such as restaurants, parks, and ports to mitigate urban flooding.

WATER

Transform several existing public spaces into accessible and attractive green spaces for citizens, with links to the Meuse River and the suburbs.

LANDSCAPE



VITALITY

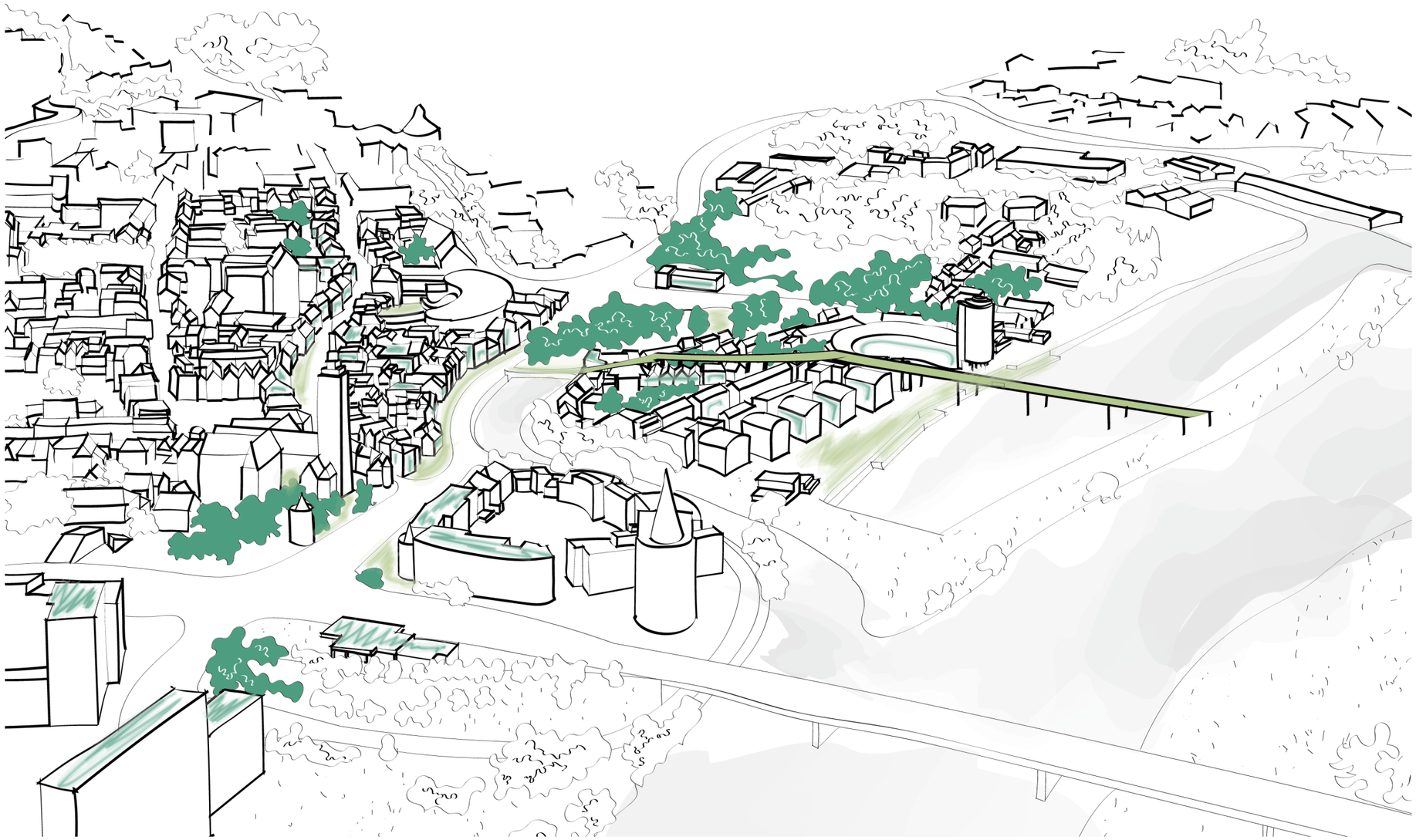
Raising the visibility of landmarks beyond the outlet, enriching the types of activities in the old town, and creating special flood education routes.

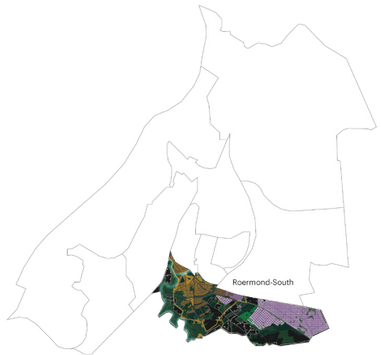
ECONOMY

Refocus economic development away from retail and toward the innovation of device production needed for flood resilience, such as garden centers, home improvement stores, etc.

Figure 47. An aerial view of Roermond-center in 2050

The author, 2022





Roermond-South:
innovation hub

To the south, a new urban center is taking shape around the new Roermond-South station. There is a concentration of higher education and research institutions, as well as knowledge-intensive companies. It becomes a Transit-oriented development where people work, study and live in a concentrated area.

Roermond-South plays an increasingly important role in the surrounding area, the functioning of the city as a whole and the economic position of the region.

Figure 48. The direction of Roermond-senter development

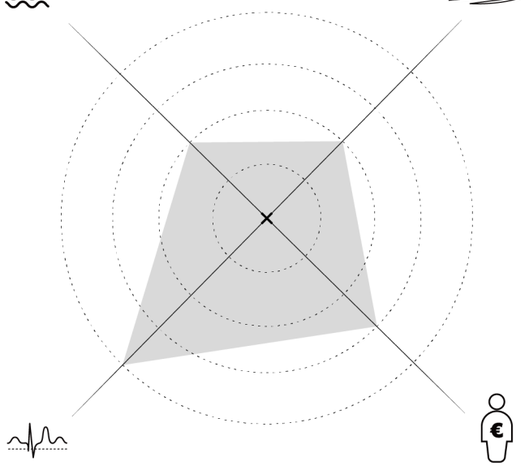
The author, 2022

Re-predict the impact of upstream flooding on the Roer River. River widening could be a (partial) alternative to building a new dike system.

WATER

Protect the stream valleys of the Roer River and reinforce the landscape differences between open agricultural areas, forests and nature reserves.

LANDSCAPE



VITALITY

Transform vacant buildings in industrial parks into social housings for vulnerable groups and international workers.

ECONOMY

Plan higher education and research centers in the region close to the Roer River to foster an innovation base for flood risk management.

Figure 49. An aerial view of Roermond-south in 2050

The author, 2022

Maasniel:
a healthy and safe neighborhood

Parts of the Maasniel are increasingly becoming part of the city center. The riverfront beautification of Maasnielderbeek will attract residents from throughout the city and is also an important destination for visitors. The goal for this area is to find a balance between safety and quiet.

The area is a transition from the city center to the suburbs. The spatial quality of the neighborhoods here will be improved by promoting a small economy, greening public space, and strengthening transportation convenience.

Figure 50. The direction of Maasniel development

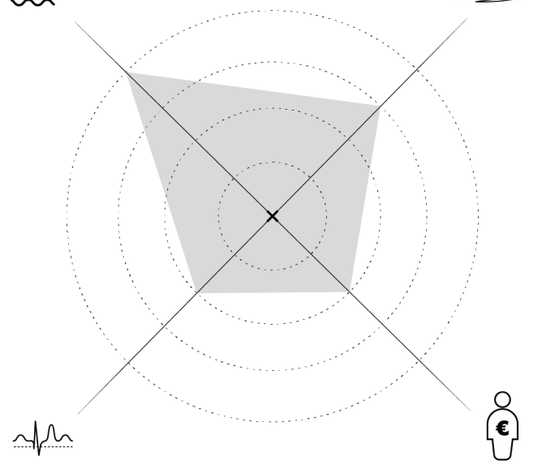
The author, 2022

Re-establish Maasnielderbeek hydrological conditions similar to historical ones, expand the flood-plain, and mitigate flood hazards on the Meuse and Roer.

WATER

Create small-scale and diverse landscapes with hedges, walking trails and boulevards along the river.

LANDSCAPE



VITALITY

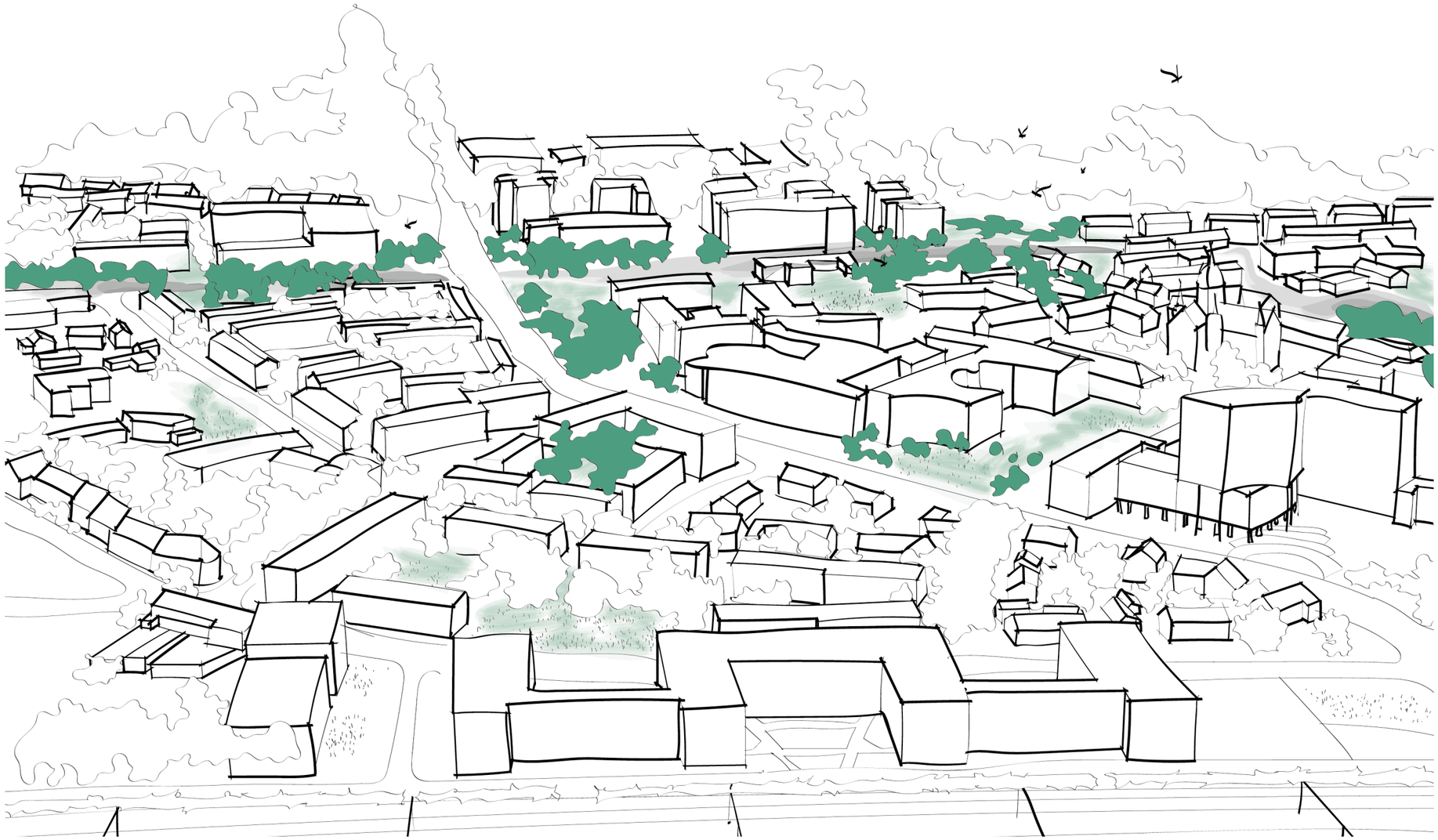
In the long run, the river restoration will bring more public space and improve the overall spatial quality and attractiveness of the neighborhood.

ECONOMY

Drive the employment attractiveness of the region by improving spatial quality and attract suburban labor by enhancing river mobility.

Figure 51. An aerial view of Maasniel in 2050

The author, 2022



Maasplassen:
water as a brand

Maasplassen will quickly develop into a popular sport, vacation, and recreational destination. Stadshaven Marina Park will become a new central green space in Roermond. Spatially and visually connecting the River Meuse to the city is an important task and the barrier effect of existing flood defenses will be reduced.

The floodplain is home to a number of popular waterside spaces that attract water sports enthusiasts from both national and international communities. During the summer, the area needs reliable water level monitoring and weather forecasts to be used safely for recreation. This requires a thorough analysis of recreational activities along the water and attention to design and management.

Figure 52. The direction of Maasplassen development

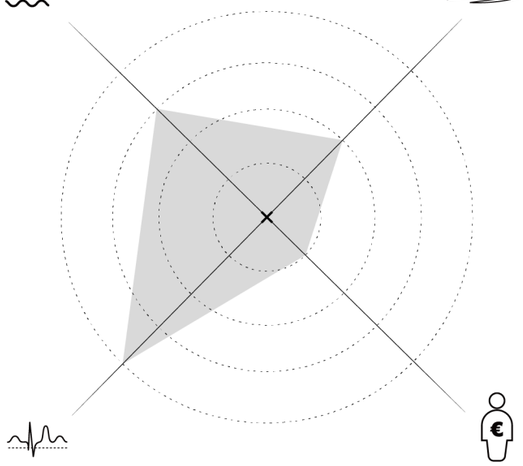
The author, 2022

After the new Maasnielderbeek River was opened, the water level management plan was redeveloped to restore the historical natural form of the river as much as possible.

WATER

Preserve the historical identifiable portions of the river landscape and develop bicycle trails to connect with suburban forest parks.

LANDSCAPE



VITALITY

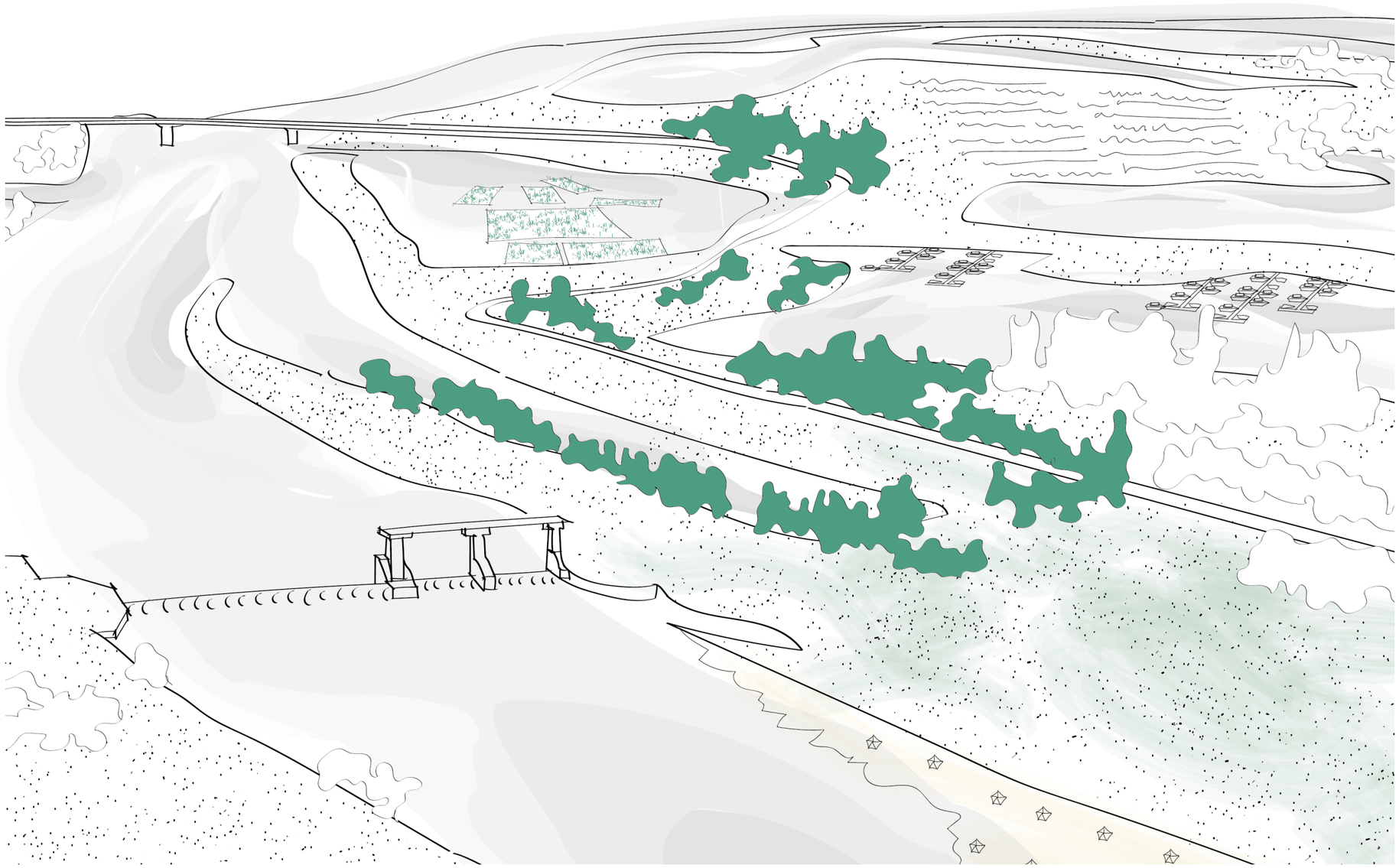
Enrich the types of activities in the floodplains, convert some of the camping sites into waterfront public spaces, and create a promenade connecting to the city center to improve accessibility for pedestrian.

ECONOMY

Increase publicity at home and abroad to expand the popularity of water sports bases.

Figure 53. An aerial view of Maasplassen in 2050

The author, 2022



Asenray & Swalmen:
green living villages

Asenray and Swalmen are two predominantly shaded villages, consisting of neighborhoods and farms characterized by green habitation. The stream valleys and the Meinweg National Park also give them a unique landscape quality. All those who live in Asenray and Swalmen expect better connections to the city center, new facilities and workplaces. The expansion of Maasnielderbeek will offer this possibility.

A regional bicycle route will also run through them. The new bicycle route will connect the forest in the east, the Meuse River in the west and the city center. By developing ecotourism, villagers will benefit from the development of their area.

Figure 54. The direction of Asenray development and Swalmen development

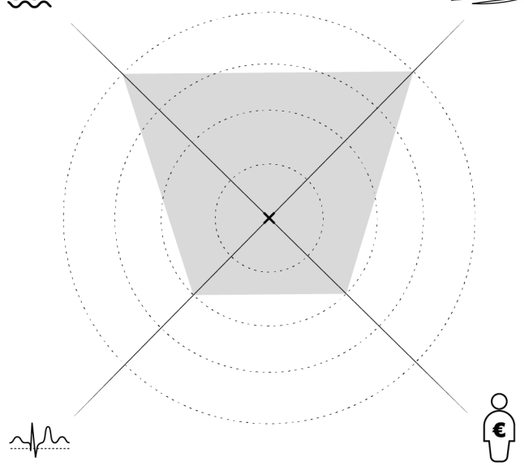
The author, 2022

Excavate Maasnielderbeek to provide irrigation water for agricultural land and improve water quality through stream restoration.

WATER

Change land-based agriculture to nature-based agriculture to connect fragmented forests and national parks.

LANDSCAPE



VITALITY

Introduce bicycle touring paths in a continuous green structure to attract national and international visitors.

ECONOMY

The new river channel connecting the Meuse River provides an alternative means of transportation between the suburbs and the city center, which could boost the tourism economy.

Figure 55. An aerial view of villages in 2050

The author, 2022

9.4 Making process, sciences and cooperations

Environmental visions are often developed by municipalities in conjunction with professional parties such as housing corporations, project developers, and consultants, but should also seek to broaden the development palette. Simply put, one is to invite more professionals in the field of water management and social sciences to participate in policy development. Another clear desire is to give the citizens of Roermond a more active and equal role. This applies to the governance and planning of their own living environment, the space for local entrepreneurship, but also to the actual construction of the city and the realization of a flood-resilient city. The arrival of the Environment Act was a major stimulus for such advocacies. It challenged urban planners to look at the construction of cities in a new light, with a new mandate to democratize urban development and provide more space for a "bottom-up" approach to visioning.

In the future, urban planners should make greater use of interdisciplinary knowledge to support the creation of a local vision. Two approaches can be used in the policymaking process:

1. providing communicative contexts for diverse stakeholders to suggest ideas;

2. creating interfaces for interdisciplinary knowledge exchange.

9.4.1 Provide communicative contexts for diverse stakeholders

The city is challenging itself and professional parties to do better justice to the increasing involvement of local entrepreneurs and citizens. This involves a wide variety of stakeholders and initiators, large and small, public and private (see Chapter 6.2 for details). With this, future planning strategies can be more diverse. I have broken down the opportunities and challenges that Roermond currently faces into categories. In the vision proposal presented, the focus is more on flood risk management.

Public parties

Roermond has a regional role as a center in the province of Limburg and is responsible for the development of his neighboring cities, regional partners, and western Germany. Spurred on by large office parks and convenient transport facilities, Roermond has become a hub for international workers and immigrants in the province (Omgevingsvisie Limburg, 2021). Considering its special status as a supra-regional city, cross-border public parties should be involved in the early development stages of the planning strategy. For example, a new campus proposed in Roermond-South may increase housing pressure in bordering German cities. Urban planners should be aware of the possible impacts of these interventions at administrative boundaries and take into account the views and interests of other stakeholders when making decisions.

Responsibilities also need to be divided among various public agencies and other institutions for measures that will significantly change the river basin or the physical environment. For example, Roermond relies on the national and provincial governments for legislative and financial resources. Municipalities are also needed to implement new policies. And if the Meuse river needs to be transformed, the help of other specialized public institutions such as Rijkswaterstaat and Waterboard Limburg is also needed.

Private parties

Small developments must be able to emerge and grow in the city as a prerequisite for a thriving local small economy, including innovative (rainwater harvesting processes) manufacturing, retail and cultural entrepreneurship, and all hybrid forms of these. The Blue-Green Vision creates these small-scale, affordable, and flexible spaces in both the city center and suburbs for private parties to preserve their rights. From a policy-making perspective, there is also a need to provide space for them. Entrepreneurial voices can help achieve the goals of equity, climate adaptation, and nature-based agriculture, as well as the desire to make decaying neighborhoods economically prosperous again.

Civil society

It is essential to give the users of the space more ownership of future development. Inspired by the case of the co-creation project in Klaprozenbuurt (Klaprozenbuurt – B+B, 2020), when residents are not satisfied with the plans developed by the municipality, the municipality can invite local design offices to create a new zoning plan and encourage a unique participatory process in which private and public interests can be realized at the same time.

There is also the need to create new ways to make planning decisions more accessible, such as flood resiliency demonstration areas proposed in the city center. This dilemma is related to the distance between the government and some groups in society, where language barriers and cultural differences often prevent good cooperation. In addition, due to mobile work and informal social life, many groups in the city are not involved in local decision-making, especially international workers and tourists.

9.4.2 Create interfaces for interdisciplinary knowledge exchange

A scientific urban development plan is based on the use of collective knowledge and accessible decision-making. A science-policy interface is an effective tool, and this section presents a range of possible forms of this "interface".

Institutional Entrepreneurs

The Blue-Green Vision wants to keep strengthening the culture of creation and the highly self-organized atmosphere in Roermond. This idea is not only reflected in the renewal of the southern industrial park but also in the vision-making process to provide more space for institutional entrepreneurs. Ultimately, everyone who actively promotes interdisciplinary collaboration is an institutional entrepreneur. They can shift between the fields of urban planning and water management and have the ability to use innovative approaches to look at complex problems from different perspectives. Therefore, the municipality needs to identify these professionals with special skills and work more closely with them.

Figure 56 illustrates the success story of EVA-Lanxmeer that initiated by the institutional entrepreneur, the citizen Marleen Kaptein (EVA-Lanxmeer | EVA-Lanxmeer, 2009). The district is now home to 300 families who jointly manage public green spaces, sustainable energy, and urban farms. Kaptein's foundation has grown gradually. At its inception, the foundation carried out public-private partnerships between residents, government, and companies. Later, roles such as architects, urban designers, developers, energy companies, and waterboard were brought in, creating a truly interdisciplinary team of professionals.

Communicative activities

Municipalities have the primary responsibility for information transfer. A few simple interventions can be effective in improving the accessibility of planning decisions. For example, an information board at the site of an upcoming development can be set up to inform the neighborhood of upcoming changes at an early stage. Once in the design phase, municipalities can also engage directly with the neighborhood and hold workshops to bring in knowledge and experience of the neighborhood. The transfer of information and knowledge goes both ways, safeguarding the residents' right to know and preventing the design from being divorced from reality.

Flood Risk Management Advisory Committee

The increasingly diverse climate crisis calls for more diverse ways of shaping cities. For cities where flood risk is particularly prominent, considerations for flood protection must be reflected in urban planning strategies. For this reason, the process of developing an Environmental Vision could be enriched in a structured way by the establishment of a Flood Risk Management Advisory Committee. Also, this cooperation should be continued in the subsequent implementation and evaluation of the Environmental Vision.

Figure 56. EVA-Lanxmeer

Image from EVA-Lanxmeer, 2009

10 Roerdelta: A Pioneer towards Flood Resilience

Design area of Roerdelta.

Adapted from Google Earth, 2022

An aerial photo of Roerdelta.

Photo by John Gundlach, 2017

10.1 Roerdelta and its main structure

Building

Roermond is characterized by a historical and inviting inner city with catering streets, monuments, and squares.

Roerdelta is located on the west side of the inner city, where two urban development projects are taking place. Roerdelta Phase I (Figure 57), just completed in 2021, is located on the southwest side of the design area and supplies multiple types of houses with ground-level access.

Building on the results of Phase I, Roerdelta Phase II will have its own character, with a special focus on sustainability. The realization of the first homes of Phase II is expected to start in 2023 (Roerdelta – Fase 2, 2021). This will satisfy the wish to create an attractive promenade along the Maas, where residents and visitors can enjoy beautiful views. The commercial functions and the marina will provide the area with extra atmosphere and liveliness on the water.

The Voorstad already existed in the 14th century. It was mainly populated by fishermen and poor people. After 1854 it became quieter, the transit function was taken over by a new road Maastrichterweg and from 1865 also by the railroad Maastricht-Roermond (Roerkade en Voorstad St. Jacob Roermond, 2022).

Since Voorstad is a historic district and the construction of Roerdelta Phase I has just been completed, there is limited space for the transformation of these two areas. The urban design interventions in this project will focus on the area of Roerdelta Phase II and will meet the objective of strengthening Roermond's relationship with water.

Figure 57. Roerdelta Phase I

Photo from Roerdelta.nl, 2021

Figure 58. Building analysis map

The author, 2022

Landscape

Roerdelta is sandwiched between the landscape of the Meuse and the landscape of the Roer, which have completely different appearances. As Figure 59 indicates, the Meuse is characterized by its spaciousness and, in addition to commercial navigation, the river is used for recreational shipping and forms an important network for water sports.

On the other side of the Roerdelta flows the Roer, a small river with a strong meander that cuts through the landscape (Figure 60). The river is particularly rich in flora and fauna and is a habitat for a variety of animals, such as beavers and salmon. The Roer flows partly through the city, where the buildings are largely set back from the river. This makes the Roer feel like a backwater, a forgotten landscape element in the urban fabric.

Akcros is a newly built city park. The park's layout is simple, with basic lawns and trees, and does not create an atmosphere that invites people to meet or live.

The unique landscape value of the Meuse and the Roer rivers deserves to be explored in future development. In addition, Akcros park should be functionally enhanced as the main public space connecting the Roerdelta with the inner city.

Figure 59. Meuse landscape

Photo from ivn.nl, 2018

Figure 60. Roer landscape

Photo from Roerdelta.nl, 2021

Figure 61. Landscape types

The author, 2022

Water & Barrier

Stadshaven is one of the most important ports in Roermond. Currently, the entire delta is used by the port, so that the spatial effects of water do not reach everyone in the city.

As Figure 62 depicts, the current dikes do not meet the legal requirements, which means that the dike system must be upgraded and strengthened as a whole (Dijkversterkingen en dijkverleggingen in Limburg, 2021). In most places, the current form of the dike is a wall with cutoffs that can be closed during high water. If the existing flood defenses are strengthened and raised, the wall will become so high that it will no longer be possible to see the River Meuse behind it, in which case the dike becomes a barrier. This challenge is most acute at Voorstad and Stadshaven.

On the south side of the Roerdelta, there is a 'secondary channel'. It is low in the terrain that, in case of a combination of a high water level in the Meuse and an extremely high water level in the Roer, can be used to discharge water from the Roer into the Meuse.

Figure 62. Dike reinforcements and relocations in Limburg

Map from Waterchap Limburg, 2021

Figure 63. River and dike analysis map

The author, 2022

Mobility

Roermond has a ring road around the historic inner city, which connects to the N280. Along this road, there are several parking garages. The Roerdelta is currently accessed by a circular driveway, in addition to slow traffic on the east side, whereby a bicycle path runs from the Voorstad, via the Akcros park, to the city center, so that Roermond station can be reached by bicycle within 5 minutes.

Stadshaven functions as a marina, which means that the harbor is filled with boats all year round and there are few dynamics. Stadshaven is operated by multiple companies (LEIDEND KADER ROERDELTA, 2020). The headland, which separates the port from the River Meuse, is now used as an illegal parking lot for port visitors and is not available to the public. In the Parking Plan ("Parking Enforcement Order 2018," 2018), however, this area is designated as a green category (Figure 64).

Figure 64. Parking Plan of Roermond

Map from Municipality Roermond, 2018

Figure 65. Mobility analysis map

The author, 2022

10.2 Design proposal

The transition requires a new way of working, based on a common goal and ambition: to create a flood resilience area for the people of the city. As a result, the phasing is based on current administrative priorities, policy initiatives, and feasibilities. This phased outline indicates what the goals of the Roerdelta are at each stage and the role it plays in the Environmental Vision.

Phase 1: 2022-2025

The municipality of Roermond and port-related companies must first reach a consensus, which is to form the missing link between the city and water in Stadshaven. In the first phase, five vessel berths on the north side of the port needed to be removed or relocated, and two additional berthing areas are added at the southern end of the harbor. The connection between the headland and the city needs to be cut, for reasons that will be explained later. The clearance of berths and partial headland is to be completed by 2025, as will the waterfront public spaces. Preparations are made for the subsequent construction of new infrastructures.

Phase 2: 2025-2027

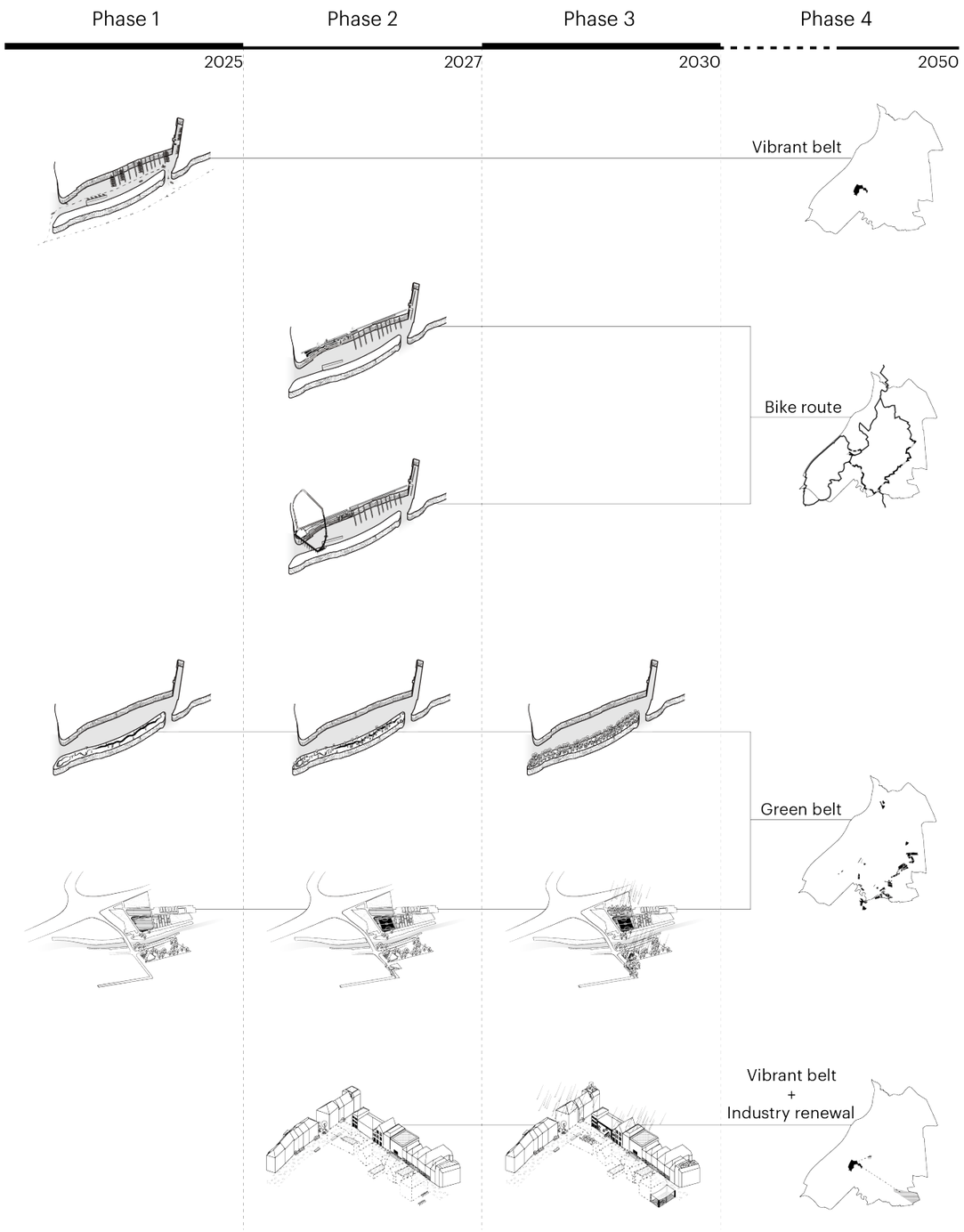
The multifunctional dike together with a promenade is explicitly designed in such a way that the municipality, developer, designers, and Waterboard Limburg are challenged comprehensively considering flood control and spatial quality. At the same time, the design and construction of the forest park on the headland will be gradually underway, and many trees were planted during this period. Flood adaptation measures led by the public sector, such as replacing street paving materials and adding wadi with vegetation, were first tested on Blue Street.

Phase 3: 2027-2030

The final step will be to complement the connection between the inner city and the water and vitalize Blue Street. This process is largely led by the municipality and will require a significant amount of time. Examples include identifying public spaces on the west side of Akcros Park that have the potential for transformation, discussing specific needs with surrounding residents, persuading house owners to install rainwater roofs, etc. By 2030, the trees in the forest park will also be mature enough to open for business.

Phase 4: 2030-2050

Roerdelta's design goals align with Roermond's environmental vision. The transformed port will be the end of a Vibrant Belt and become an equally attractive space as the inner city. The promenade and multifunctional dikes extend the accessibility of slow traffic, tying in with regional cycling routes. The extension of Akcros park adds greenery to the city and becomes part of the Green Belt. Blue Street serves as an experimental area for innovative projects, becoming a hub for two industrial renewal areas - higher education institutions designing projects and small economy communities manufacturing products.



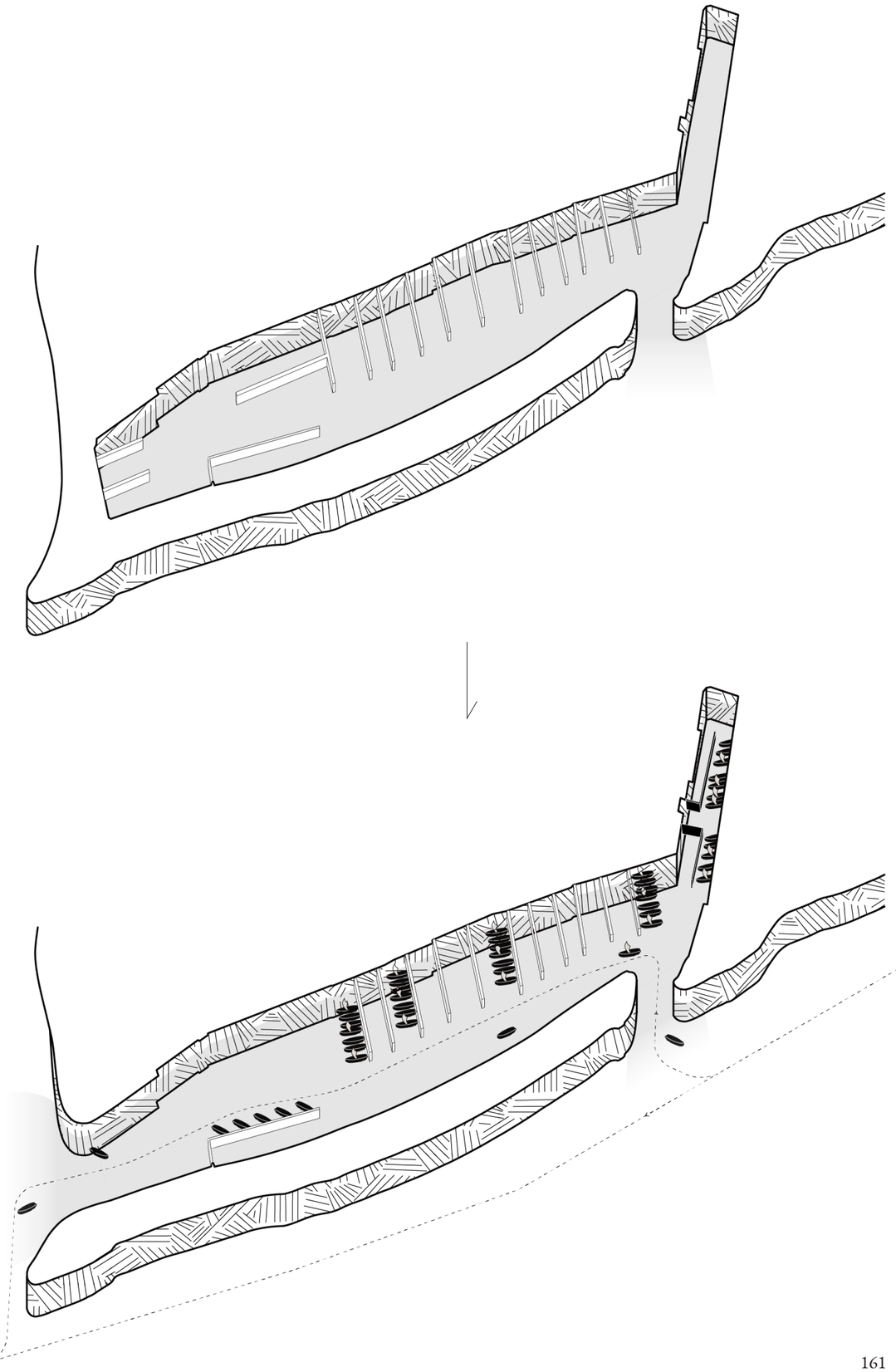
With the development of the Roerdelta Phase II, Roermond will get the last chance to connect the city center with the river Meuse, bringing the citizens to the water. The area will be transformed into a pioneering flood resilience demonstration area, will be a new tourist destination, and will connect with the already present places in Roermond. The Roerdelta will be a nautical spot that Roermond citizens visit to enjoy the Meuse and water activities without fear of being flooded. This goes hand in hand with slow traffic, the willingness to share facilities, valuing greenery and ecology, multifunctional dikes, etc. A wide range of flood adaptive measures will be realized so that everyone can be inspired by future responses to the flood.

10.3 Spatial interventions

10.3.1 Port replanning

The relationship between the shore and the water is minimal since the entire delta is used as a harbor, with a channel running through the middle. This is why a replanning of the harbor will take place, freeing port space on the north side of the site where the buildings are relatively dense. The development will turn towards the Meuse, by shifting berths and creating fronts along the water. This will activate the river and make it part of the city.

In addition, the shoreline pattern of the Stadshaven, which is open on one side and closed on the other, can exacerbate the risk of flooding in the delta. Water entering the harbor from upstream is not able to drain northward smoothly, and the water level in the harbor continues to rise until it floods the headland. This situation can be changed by cutting the connection between the headland and the delta. In this way, the water entering the harbor will rejoin the Meuse River and get more space.



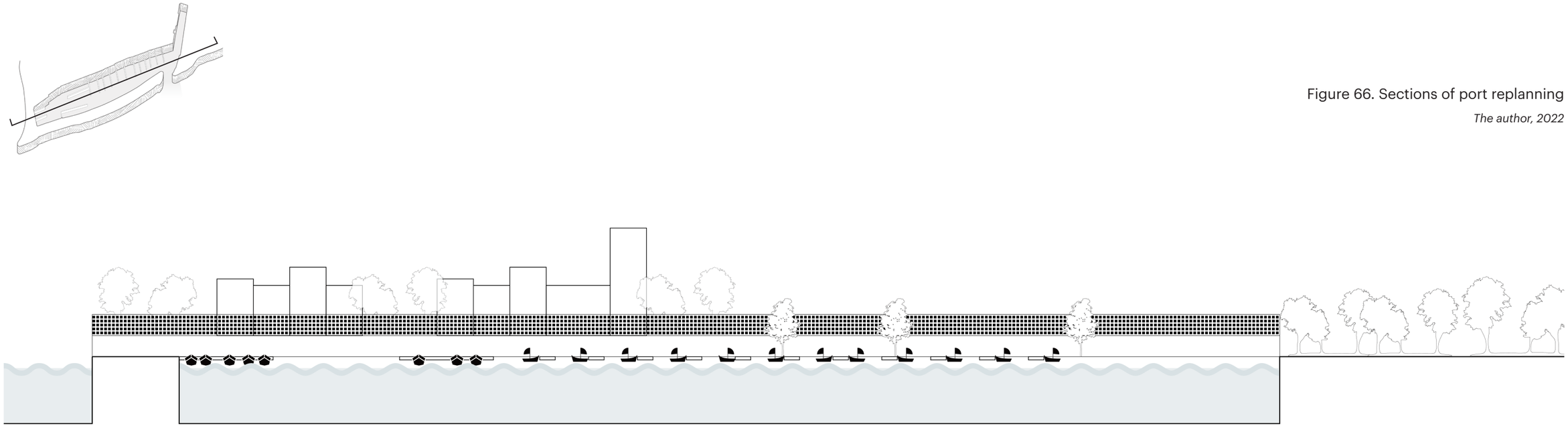


Figure 66. Sections of port replanning

The author, 2022

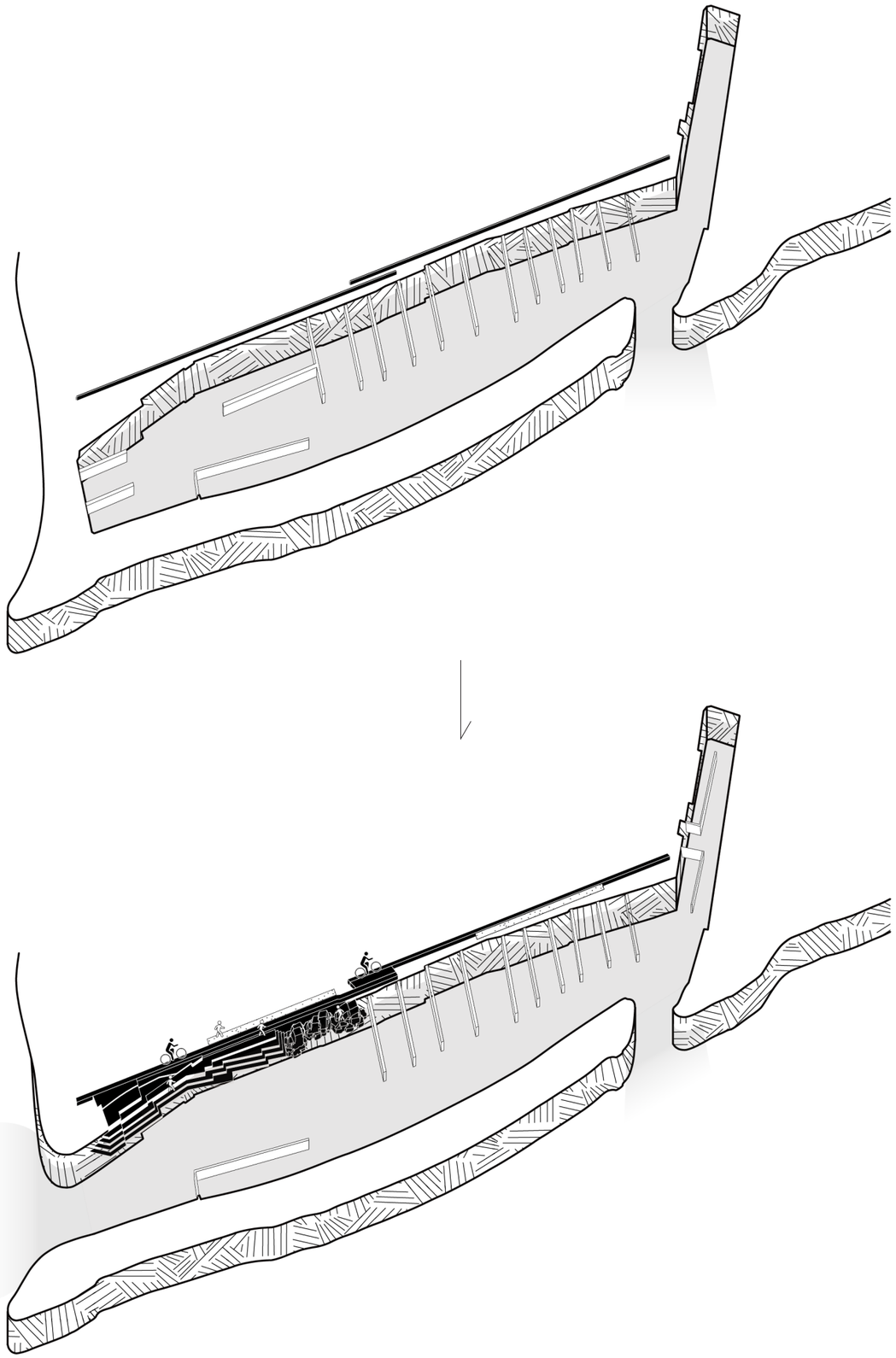
Before

After

10.3.2 Multifunctional dikes

The elevation of the flood defenses is an opportunity to restore the relationship between the water and the city. Dike has the potential to be integrated with nature, recreation, transportation, housing, etc., and adding some other functions can provide synergies and reduce flood risk. In this case, where there is a high degree of road connectivity, the dike will have a gentle slope transition to the urban side, guiding pedestrians and bicycles up to the top of the embankment to function as a road.

On the waterfront side, the height of the dike steps down and gradually extends deeper into the water. It is a place for citizens to gather, relax, and celebrate festivals.



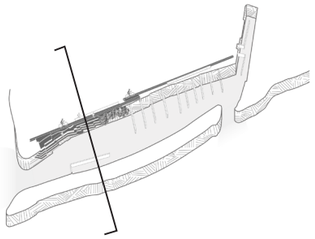
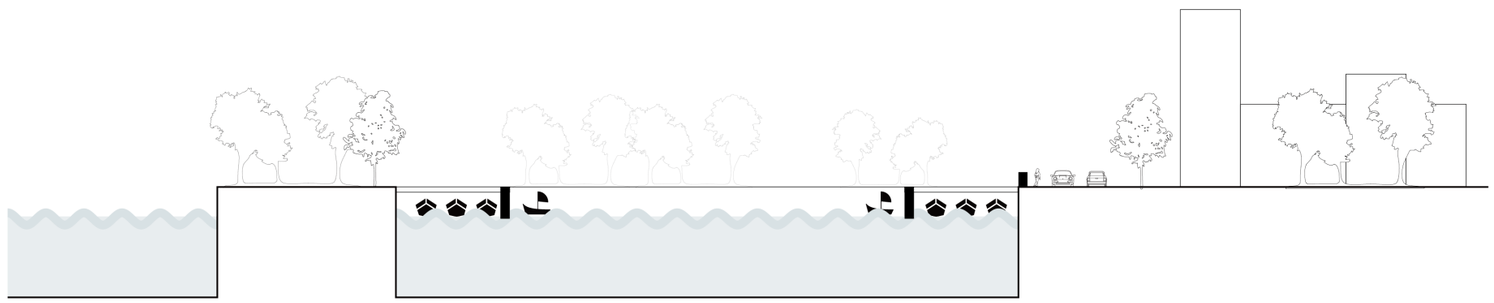


Figure 67. Sections of multifunctional dikes

The author, 2022



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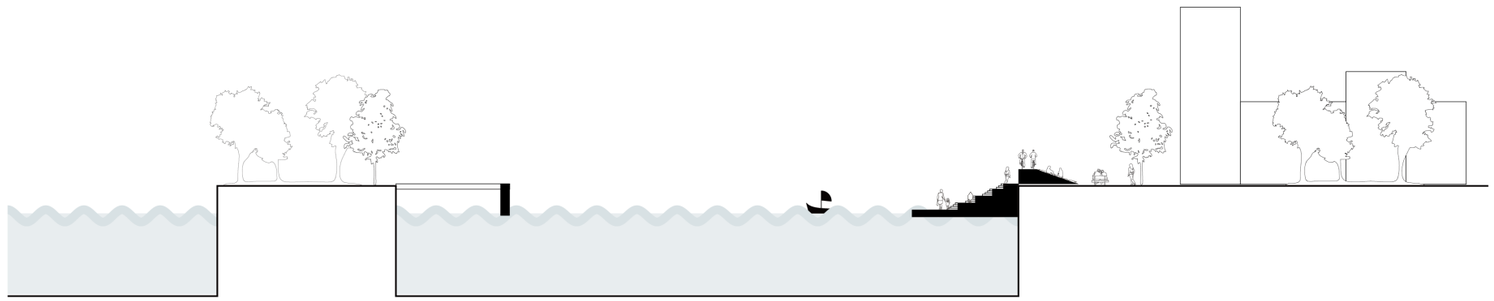


After

Reference case:
The Rotterdam Roof Park, NL

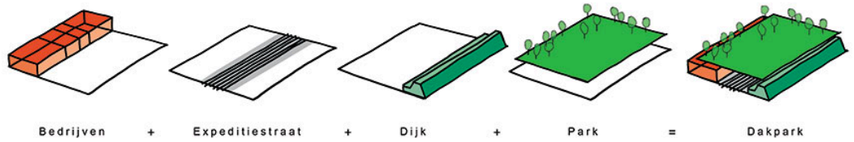
Rotterdam Roof Park is a catalyst for the transformation of the port city, combining offices, stores, and schools with a seawall and a public park on top. This project is a groundbreaking combination of parks, stores, dikes, and streets, and creates an easily accessible green park for the city (Figure 68).

One side of the park is at the top of the shopping street, 8 meters above the ground. The other side is directly connected to the adjacent neighborhood. Overgrown trees are scattered across the central grassy area of the rooftop park. The design of the park has four special features: a Mediterranean garden, a sloping water feature with fountains, a playground, and a community garden.

The Dakpark is a good example of spatial renewal that responds to a changing climate, with effects such as drought, heat stress, flooding, and waterlogging. A stony area has been transformed into a green lung, which has a cooling effect on the city. A working sea wall has been integrated into the Dakpark, which plays an essential role in flood defense.

Figure 68. Intention pictures of multifunctional dikes

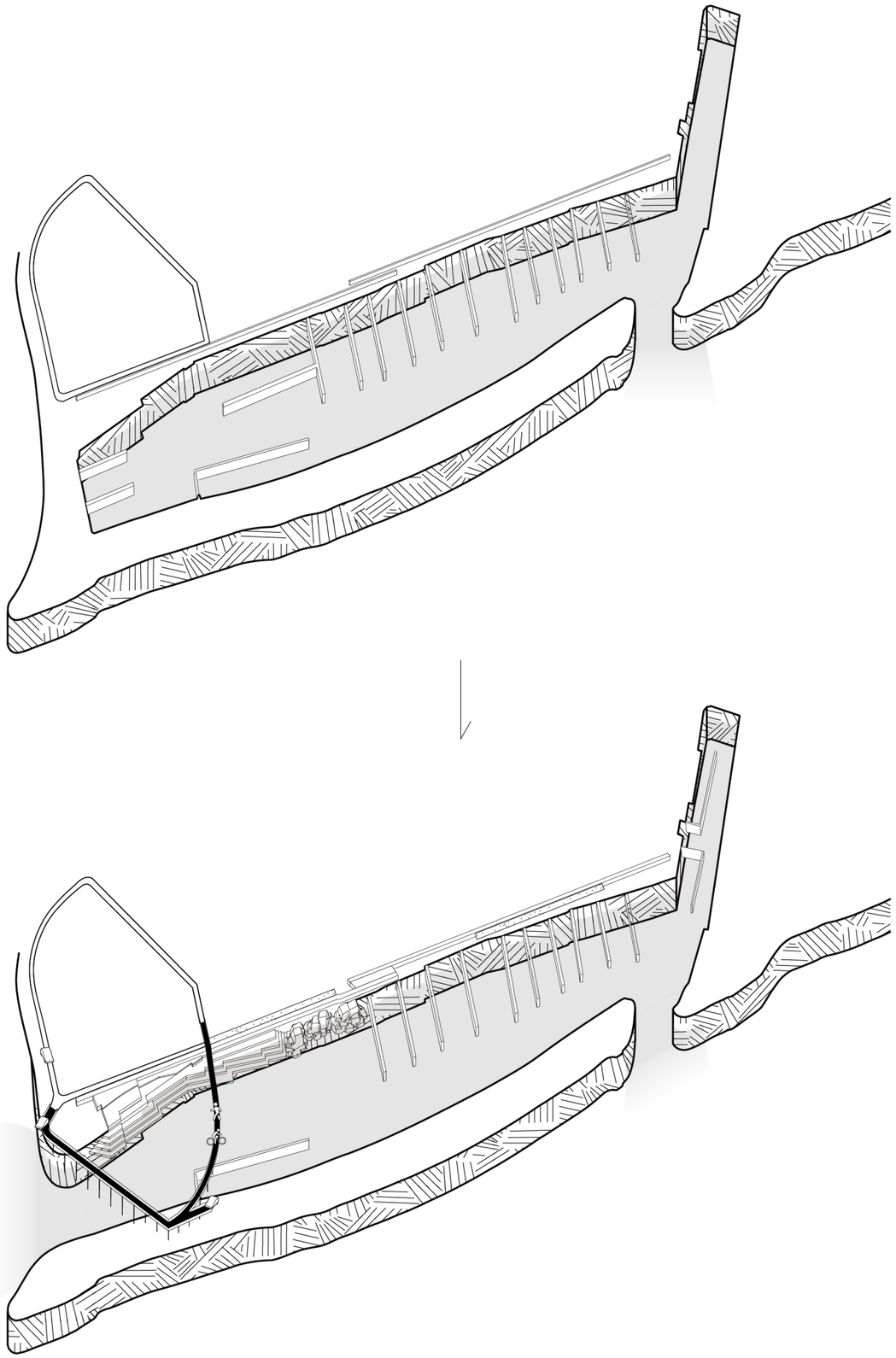
Images by Buro Sant en Co, 2014

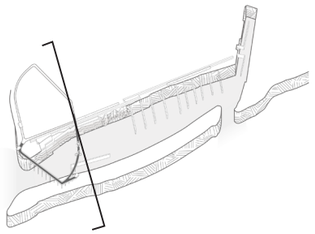


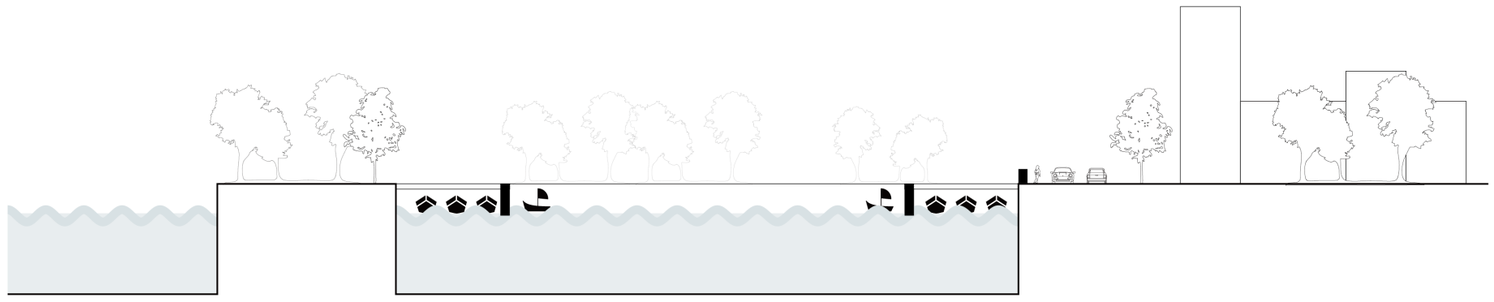
10.3.3 The promenade

After the headland is cut off, a bridge will be built over the harbor, creating a recreational route through the inner city, Voorstad, and headland. The Promenade will become a new landmark in Roermond and together with the road system will form an important slow route from the inner city. In extreme floodings, it can also be used as an escape route.

Together with the multifunctional dike, the promenade will transform the almost inaudible harbor into one of the most interesting public spaces in Roermond. This circular promenade has a motorized lane on one side and a non-motorized lane on the other, providing equal access to the water for citizens and visitors.







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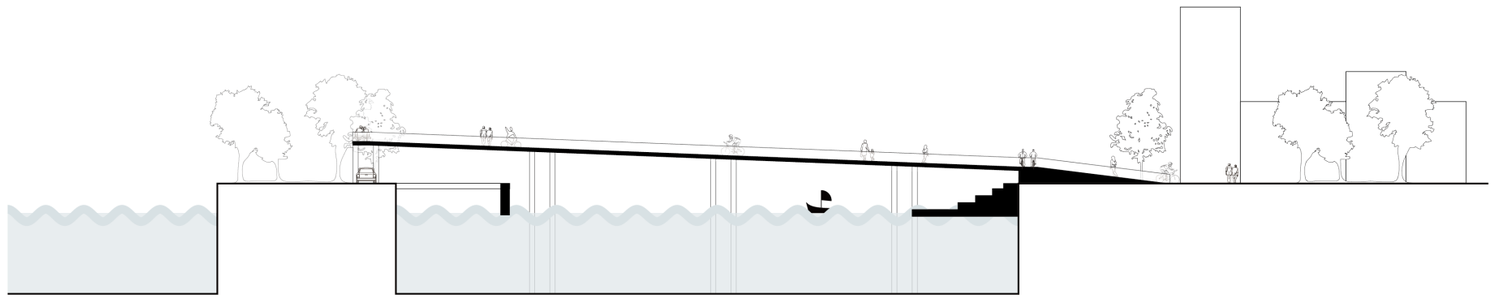


After

Figure 69. Sections of the promenade

The author, 2022

Reference case:
Keelung Maritime Plaza, CN-TW

Keelung Port is a historical port on the island of Taiwan, adjacent to the central business district. Its renewal ambition is to improve spatial quality, oriented toward defining the interaction between the port and the city (Figure 70), which is the same as the objective of Roerdelta.

Specific strategies of the project are:

- To create a symbolic and functional centrality.
- To reinforce the urban structure connecting the east and west of the city with a civil axis.
- To obtain new spaces of public amenities.
- To reinforce relational uses.
- To reorganize the transport area.
- To restructure the area of socio-cultural amenities.
- To extend the area of pedestrian connection.

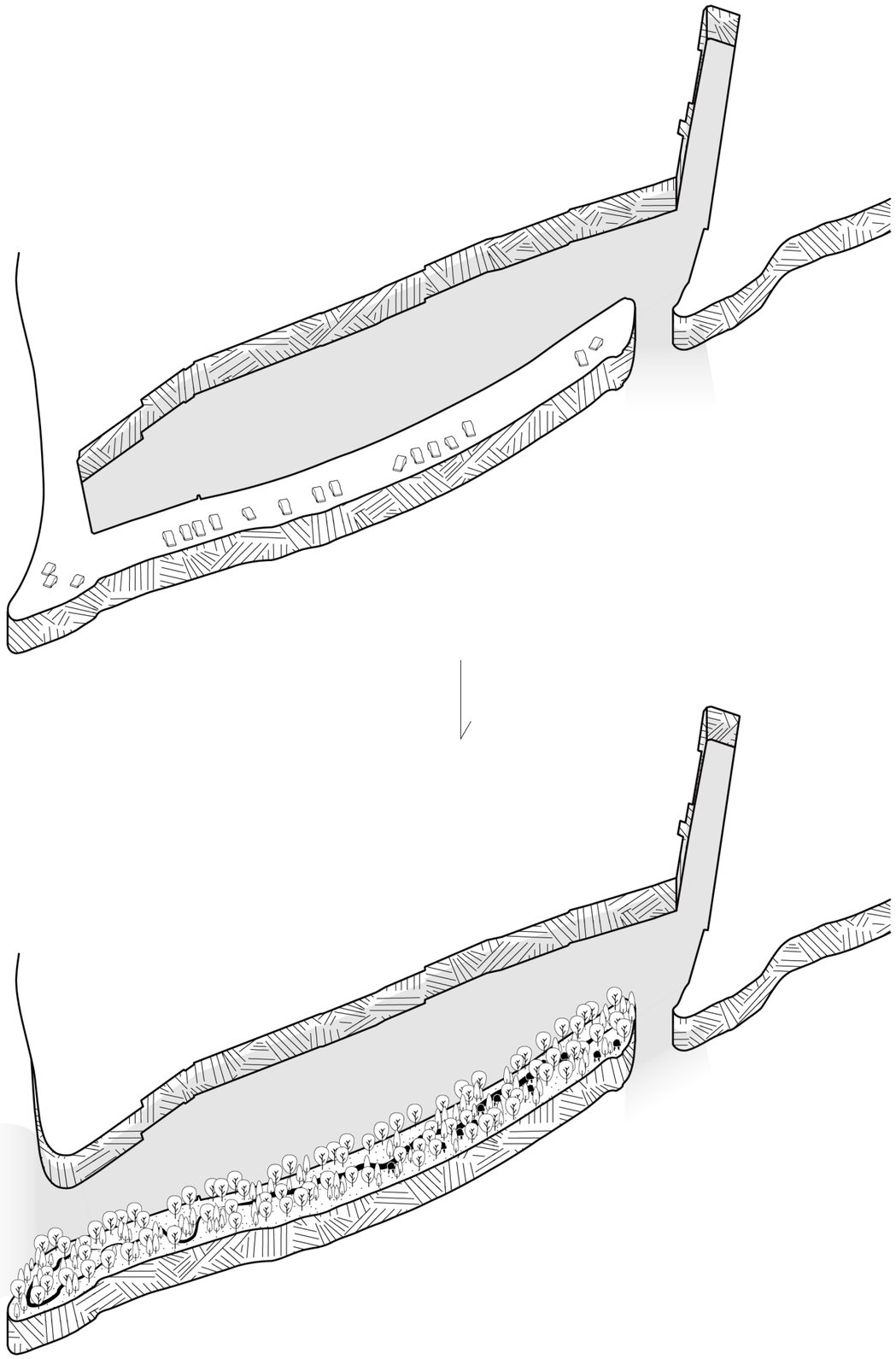
Figure 70. Intention pictures of the promenade

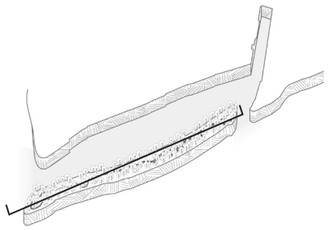
Images from Guallart.com

10.3.4 From parking to park

The illegal parking problem must be solved first. Instead of the headland, visiting cars from the port can park at the camping site on the south side of Roerdelta. Sharing will become the new norm for the camping area. In addition, consideration could also be given to incorporating the parking lot into the embankment slope, if the foundation is strong.

Subsequently, the headland will be raised using permeable materials and transformed into a resort forest park. The promenade is responsible for transporting visitors to the new park. A treehouse is a form of building that can be adapted to the flooding, so that park visitors can find shelter even if the water level rises intensively.





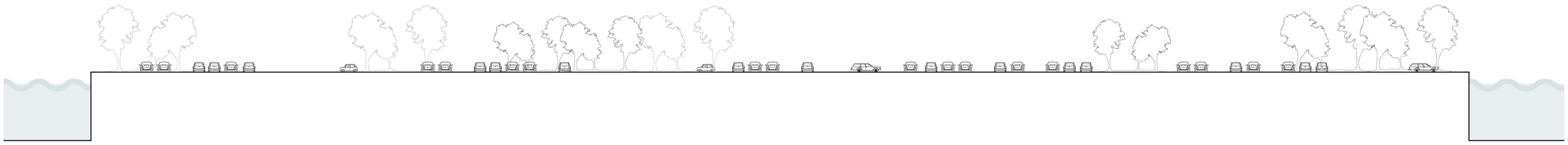


Figure 71. Sections of the Forest Park

The author, 2022

Before

After

Figure 72. Intention pictures of the Forest Park

Photos from WH Studio

Reference case:
"Tree House" Resort, CN

WH Studio has built a set of tree house cabins in Hangzhou, China. The cabins are nestled in the mountainous landscape and blend in with the surrounding trees (Figure 72). Each set of cabins includes six cabins that guests can access via a climbing-like outdoor herringbone path, while exterior terraces at different heights act as "branches" for outdoor activities.

Conceptually, each treehouse is developed as a "big tree" consisting of three main elements: a path, a platform, and a hut. These units were stacked on top of each other to create the experience of "climbing the tree" as guests walked around.

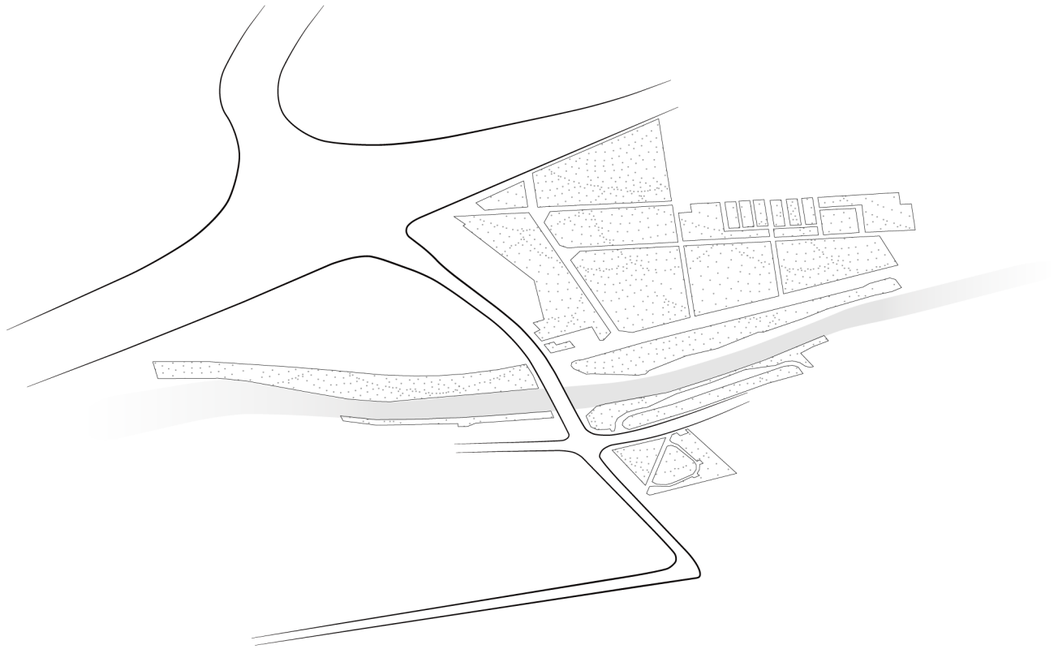
A tree house is a type of vertical housing that can be a solution to flooding problems that occur around residential areas. Such structures are designed to create a safe haven from flood hazards and are often equipped with water and waste disposal systems to respond to extreme conditions independently.

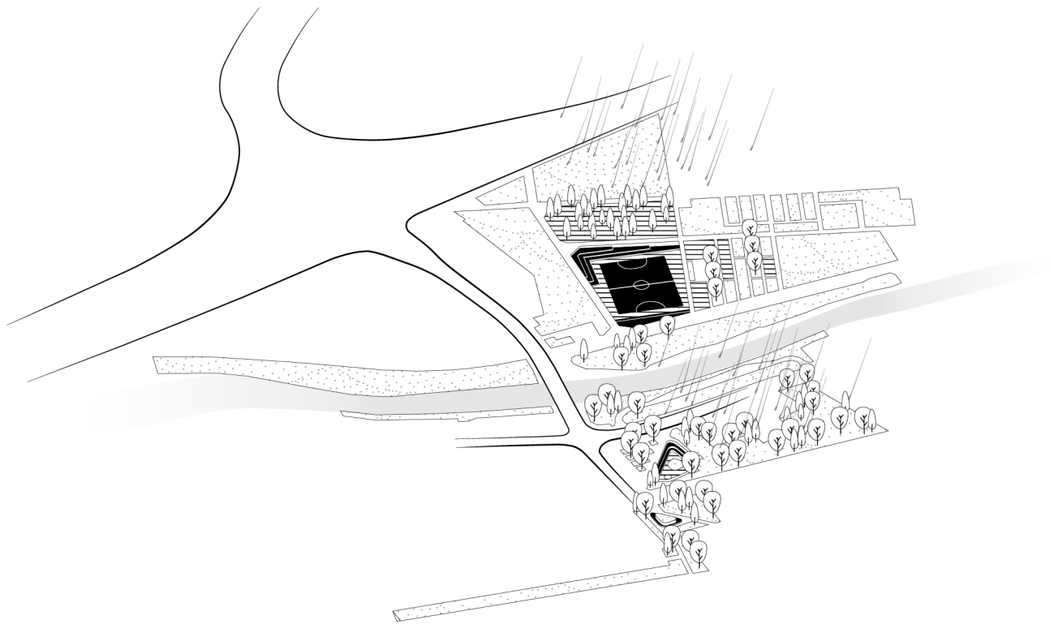
10.3.5 Akcros Park extension

The Roerdelta will be a place where people meet their neighbors, recreation is encouraged, and has a positive effect on the health of its residents. This expectation will be achieved by linking the Akcros park to the waterfront and enhancing the quality of existing public spaces.

The area within Akcros park is characterized by green collection spaces, which differ from each other and are designed according to the wishes of the residents. The movement will be stimulated by, for example, making it attractive to take the stairs and applying playgrounds. The multifunctional dike combined with the linear grass slope is a place for public contact and activity, but also provides a place to relax for all age categories. The motorway between these two large parks will be cut off and replaced by slow traffic to connect with the historic city fabric. This continuous green park will be interesting for residents living in Roerdelta, but also for citizens of Roermond.

At the level of flood resiliency, attention is paid to rainwater collection and natural inclusiveness, such as increasing greenery on plots, using stormwater from the water square, stormwater buffers for public spaces, projects that contribute to the task of increasing biodiversity, and a wide variety of public greenery.





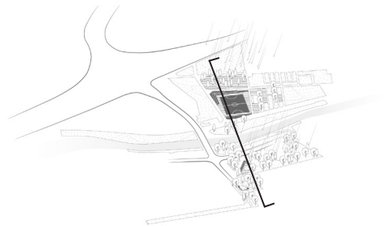
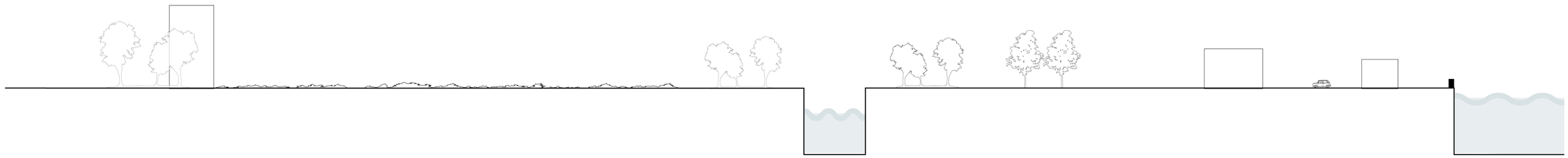
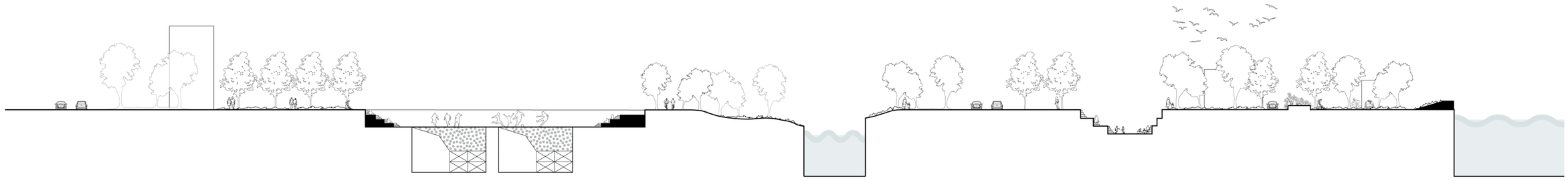


Figure 73. Sections of Akcros Park extension

The author, 2022



Before



After

Figure 74. Intention pictures of the water square

Images by DEL RIO BANI, 2020

Reference case: La Pau Square, ES

The new entrance plaza in front of La Pau School brings new life to an abandoned space by making it natural. The plaza encourages spontaneous and creative play in the street, and the inclusion of flood adaptation considerations in the design is an inspiring case for the Akcros park extension.

The original plaza lacked permeability and was accompanied by a lack of vegetation. For this reason, it was necessary to replace the paving on the surface of the plaza to improve the natural infiltration of water through a gradual layering of natural drainage strategies. It was also necessary to re-naturalize it to incorporate diverse vegetation to increase biodiversity (Figure 74). These green areas are complemented by a welcoming environment conducive to play.

Figure 75. Intention pictures of the soccer field in Akcros park

Photo from PITCHAfrica

Water-Harvesting Soccer Field, KE

In Kenya, where rainfall is far below population demand, rainwater is a precious and underutilized resource. The soccer field is designed to transform the human relationship with water, capture and store rainwater, and lead to systemic change in the end.

The rainwater harvesting soccer field is multifunctional in design. Its bleachers incorporate reservoirs that can hold up to 3 million gallons of water (Figure 75), which together with the surrounding classrooms, restrooms, clinics, and agricultural facilities form a rainwater harvesting and use system.

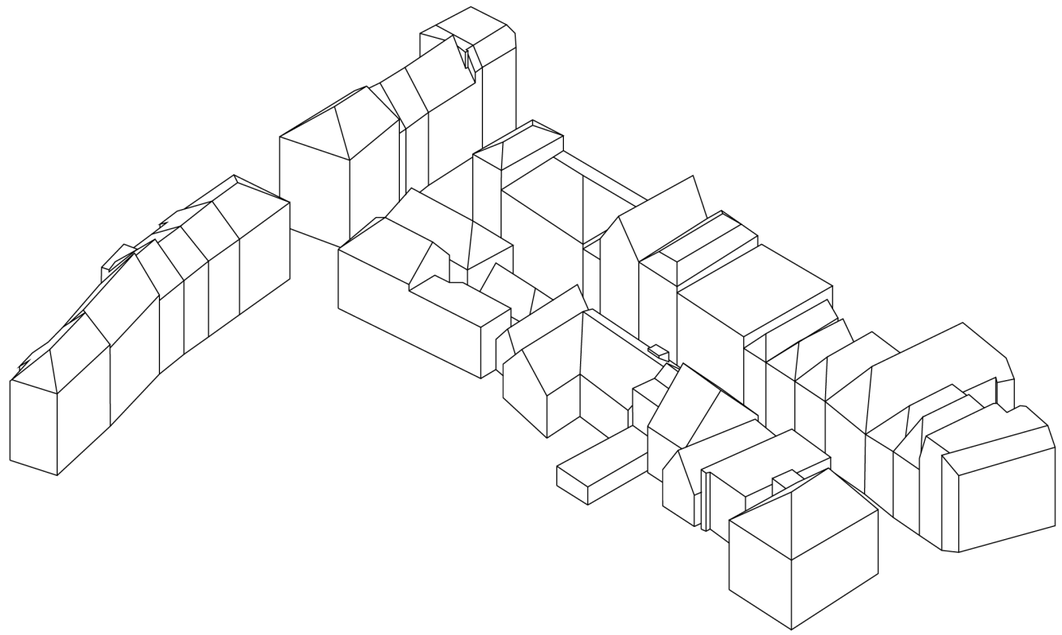
At the same time, this multifunctional soccer field may bring change to the atmosphere of a community. Soccer not only means passion but also brings in spectators and creates a space for socializing. This could make the desire to collaborate and share knowledge of flood resiliency practices a reality, while also informing the organization of multiple spaces once the park is extended. while also informing the organization of multiple spaces once the Akcros park is extended.

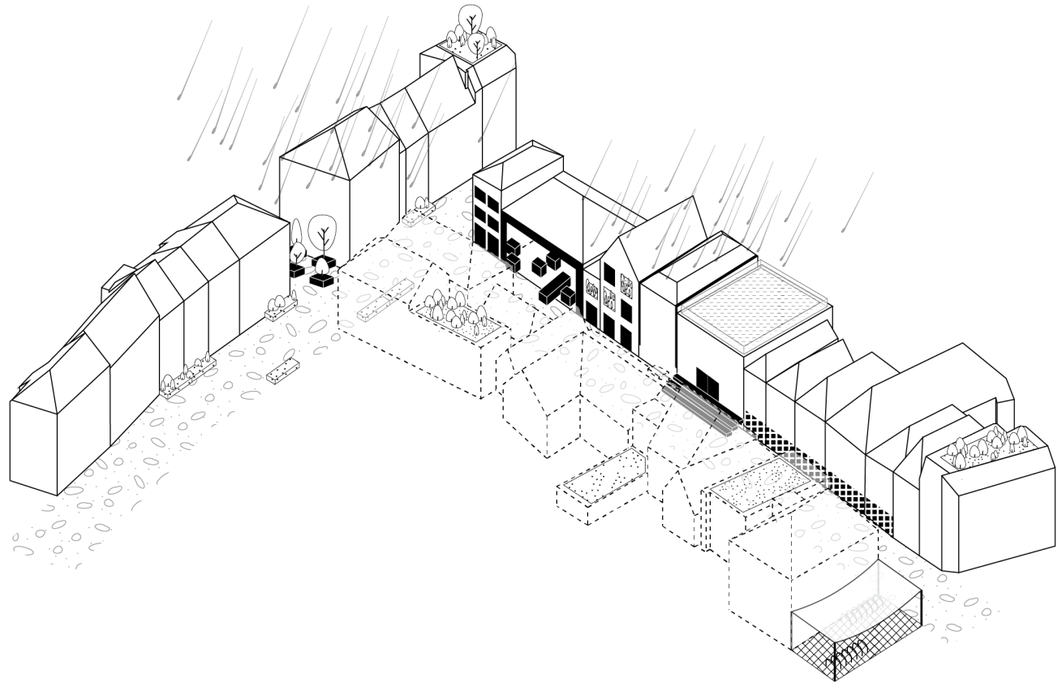
10.3.6 The Blue Street

The Blue Street is a testing ground for flood-adaptive innovations, in the historic center of Roermond. It is an open-air laboratory for experiments with new technologies for the shop, office, residential and living environment. Innovations in the higher education institutions of Roermond-South need space to experiment and gather feedback from citizens and visitors, and the function and location of the Blue Street provide just such an opportunity. Therefore, Roermond will develop a flexible environmental plan for the area, including rules for the transformation of buildings and public spaces. This will take the form of an experiment in anticipation of the introduction of the Environment and Planning Act.

The Blue Street fits in with the climate adaptation ambitions of the provincial government and municipality. However, some innovations may not fit into existing regulations. The Blue Street will give a green light to these ideas and encourage innovation by streamlining regulations. For example, it will be possible to build here without environmental permits. The Blue Street can therefore respond quickly to new developments and update iterations.

At the Blue Street, entrepreneurs, researchers, and designers work together on new innovative products to better deal with flooding in the city as a result of the changing climate in the Netherlands. Test some solutions such as rainwater roof gardens, water storage parking sheds, underground reservoirs, smart rain barrels, and concrete blocks for stormwater drainage.





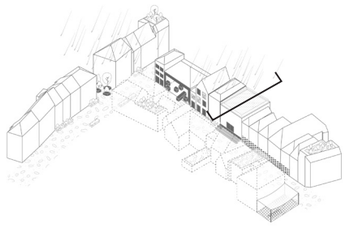
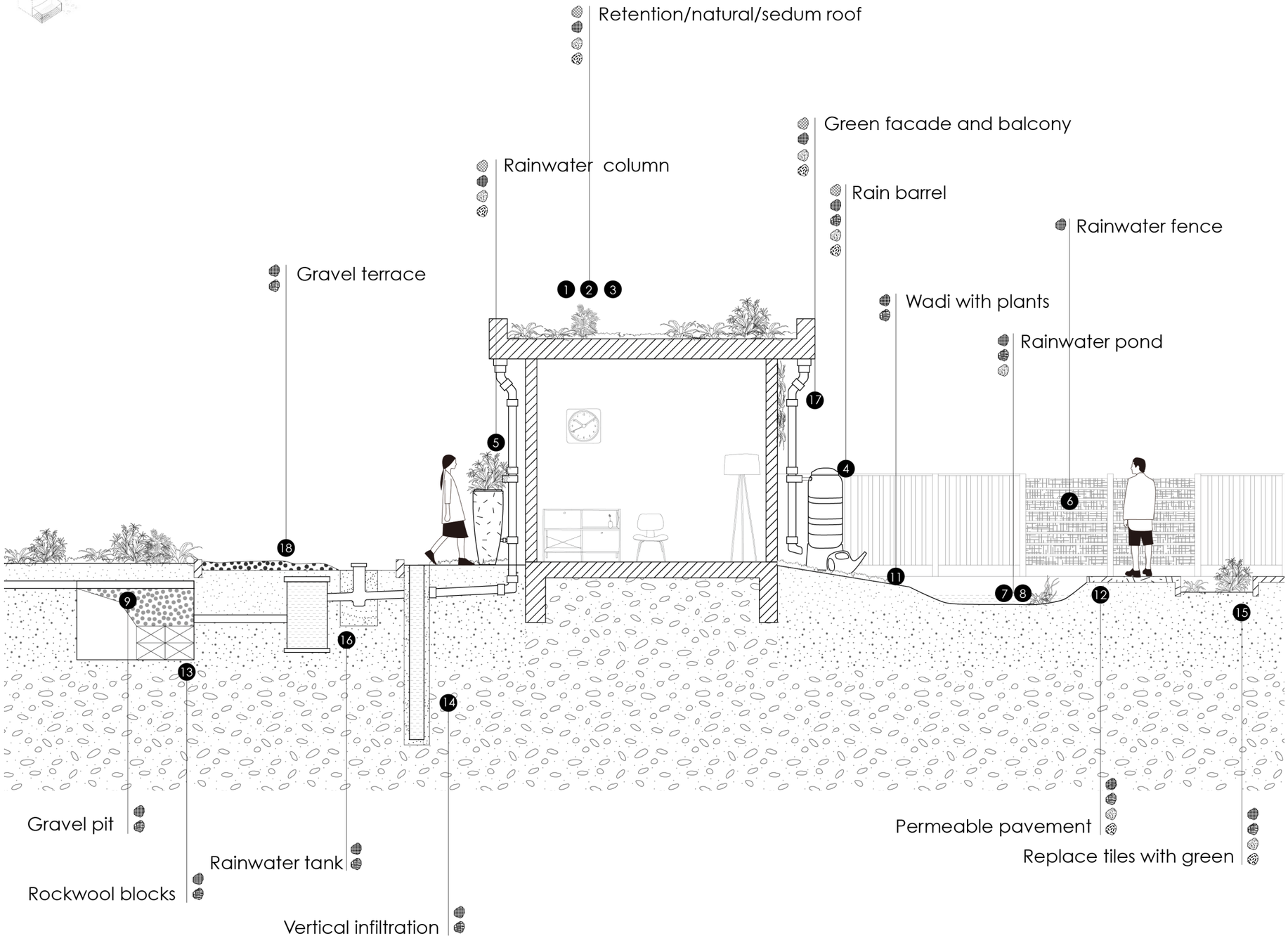


Figure 76. Detailed section of the Blue Street

The author, 2022



Reference case:
The Green Village, NL

Green Village is a testing ground for sustainable innovation on the campus of TU Delft. Researchers, students, startups, entrepreneurs, and government agencies work on innovation challenges of today and tomorrow within three themes: sustainable buildings, future energy systems, and climate-adaptive cities (Figure 77). They work not only on the technical aspects of innovation but also on the social and policy aspects of development, in order to accelerate the application of sustainable innovation in all parts of society.

Green Village offers space for innovation in the field of urban flooding, called Water-Straat, where researchers and entrepreneurs work together to test solutions such as underground reservoirs, smart rain barrels, and concrete blocks for stormwater drainage and buffering. After initial research and testing at the Green Village, these technologies will be scaled up to other cities.

The success here is inspiring for the design of Blue Street in this project. The difference is that Green Village is on the campus and Blue Street is in the historical city center.

Figure 77. Intention pictures of the water square

Photos by Alwin Wink, 2021

10.4 PPCPs and SPIs

The six interventions mentioned above will be put together with various stakeholders, guiding future development and making it verifiable, to achieve a flood-resilient and pleasant neighborhood that adds new spatial quality to Roermond. By accumulating the ambitions of all parties and creating a collaborative model, the Public-Private-Civil Partnership. This should lead to unexpected opportunities to realize a living environment with a sense of participation. For citizens and visitors alike, this is a place to stay.

The process of carrying out a project is usually linear: the developer selects a designer group, discusses the plans with the municipality, and finally carries out the construction (Figure 78). Only at a later stage are other stakeholders, such as water and green experts, involved. As a result, the different disciplines in a project are usually dealt with separately.

However, creating a flood-resilient city requires a holistic approach. For example, when designing a multifunctional dike, different stakeholders such as transportation experts, water management experts, and green experts must work together. With transportation experts working to create efficient infrastructure, water management experts concerned about the height and robustness of the levee (also known as water science), and green experts choosing species suitable for survival (environmental science), these claims may conflict and therefore need to be negotiated. This consultative process is Science-Policy Interface. SPI is an innovative platform that facilitates dialogue between citizens, scientists, and policy makers (Figure 79). The innovative parts of the dialogue will be summarized into policy provisions for future projects of the same kind.

Building on these two forms of collaborations, all steps towards flood resilience in the Roerdelta, such as financing, design, and maintenance, are discussed below in the context of specific spatial interventions, culminating in action guidelines.

Seed Stage: ***Build to Learn***	**Alpha Stage** ***Build to Engage***	**Beta Stage:** ***Build to Grow***	**Stability Stage:** ***Build to Deliver***
Problem/Solution Fit	***Problem/Market Fit***	***Growth***	***Profitable at Scale***
• Government has clearly defined need, budget allocated, and tender set • We can deliver high volume at low cost, deliver outcomes • Determine if partner needed, if new entity formed	• Tender won for ability to deliver high volume, low cost, and other determine outcomes metrics • Positive NPV for contract vs. risks • Favorable investment terms	• Project implemented, with upfront investment financed • Risk mitigation and project management of implementation	• Profitability maintained as service scales to large share of market • Outcomes maintained • Performance-based aspect of contract earned

Figure 78. PPP models

Image from Reasonstreet. co, 2021

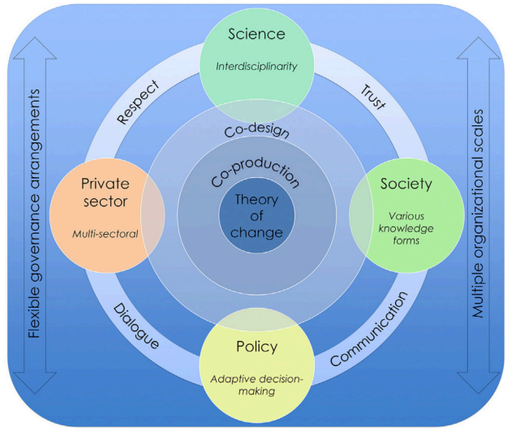
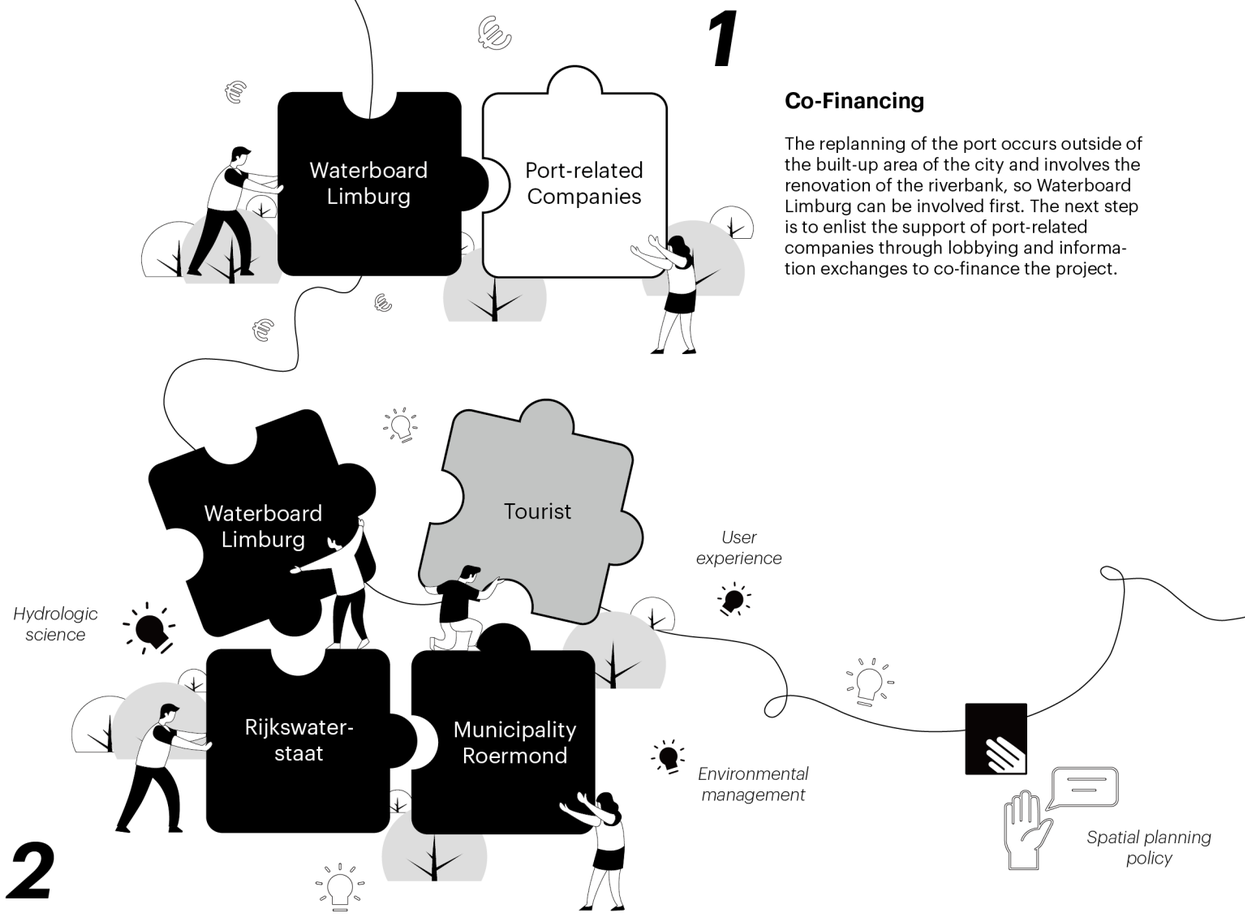


Figure 79. Science-Policy Interface within the broader context of the development

Figure by Claudet et.al, 2020

10.4.1 Port Replanning



1

Co-Financing

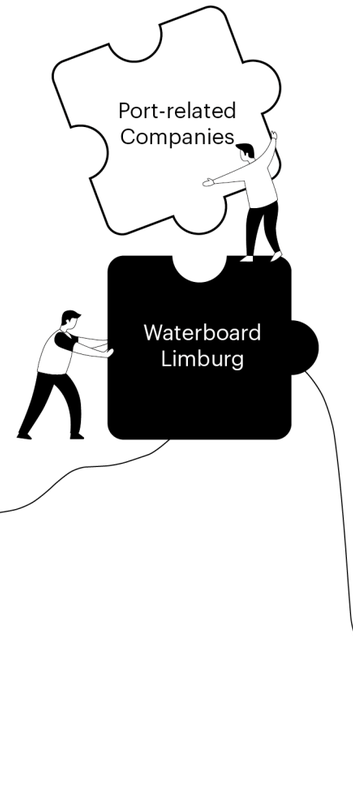
The replanning of the port occurs outside of the built-up area of the city and involves the renovation of the riverbank, so Waterboard Limburg can be involved first. The next step is to enlist the support of port-related companies through lobbying and information exchanges to co-finance the project.

2

Co-Design

Subsequently, together with urban designers from the Municipality Roermond, the Waterboard developed a design proposal for the port. The cut-off of the river bank could affect the flow and direction of the water in the Meuse River and advice was needed from the Rijkswaterstaat, which manages national rivers.

The program still needs to be modified based on visitors' suggestions and feedback. The port's main business is water sports and berth rentals. Will the renovated port still be popular with water sports enthusiasts? Positive feedback from visitors can help build confidence in port-related companies, while negative feedback can inspire the public sector to modify the program in a timely manner.



3

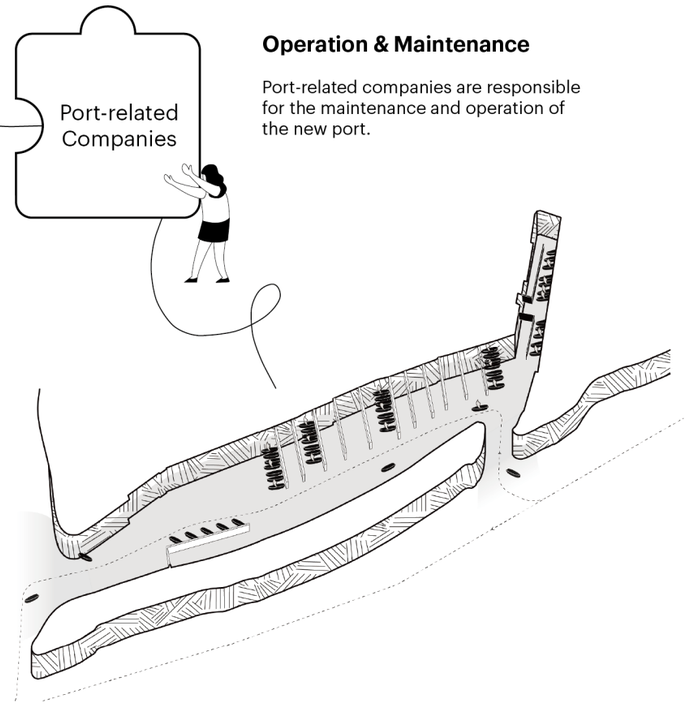
Co-Production

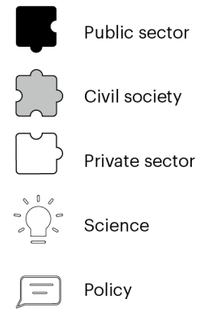
After the program was finalized, the Waterboard and port-related companies implemented the riverbank renovation and berth renovation respectively.

4

Operation & Maintenance

Port-related companies are responsible for the maintenance and operation of the new port.





Public sector

Civil society

Private sector

Science

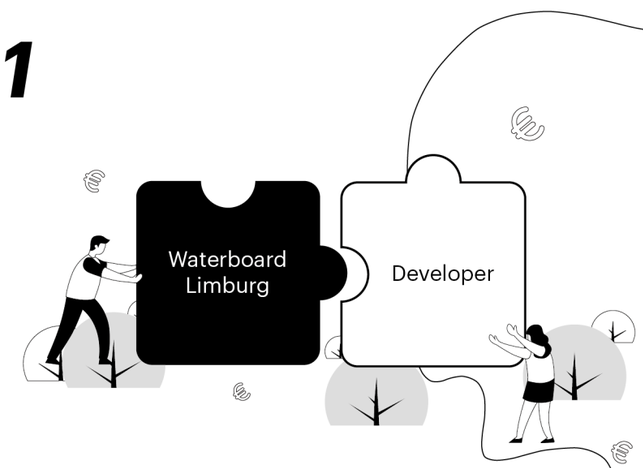
Policy

10.4.2 Multifunctional Dikes

1

Co-Financing

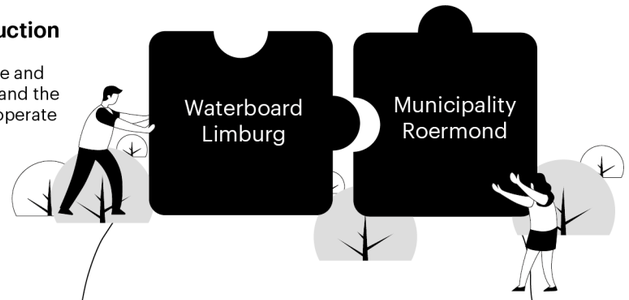
The dike will be transformed into an infrastructure that combines transportation, recreation, and flood control functions. This change in nature makes dikes no longer the sole responsibility of the Waterboard. The creation of a new attraction may increase the development value of the site, so there is an opportunity for developers working on project Rperdelta Phase II to be brought in and co-financed with the public sector.



3

Co-Production

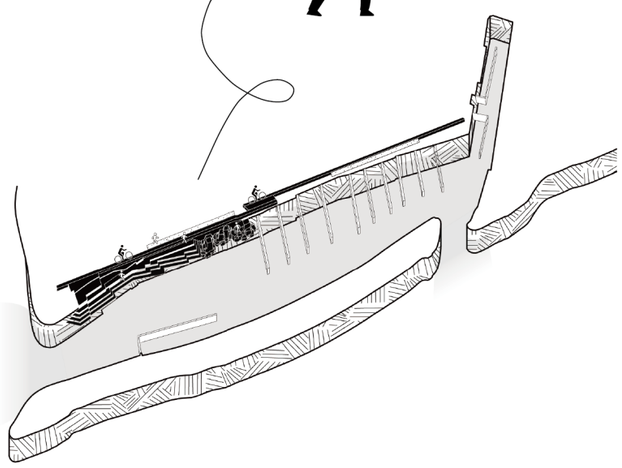
The dike is functionally diverse and located at the city boundary, and the two public authorities will cooperate in its renovation.

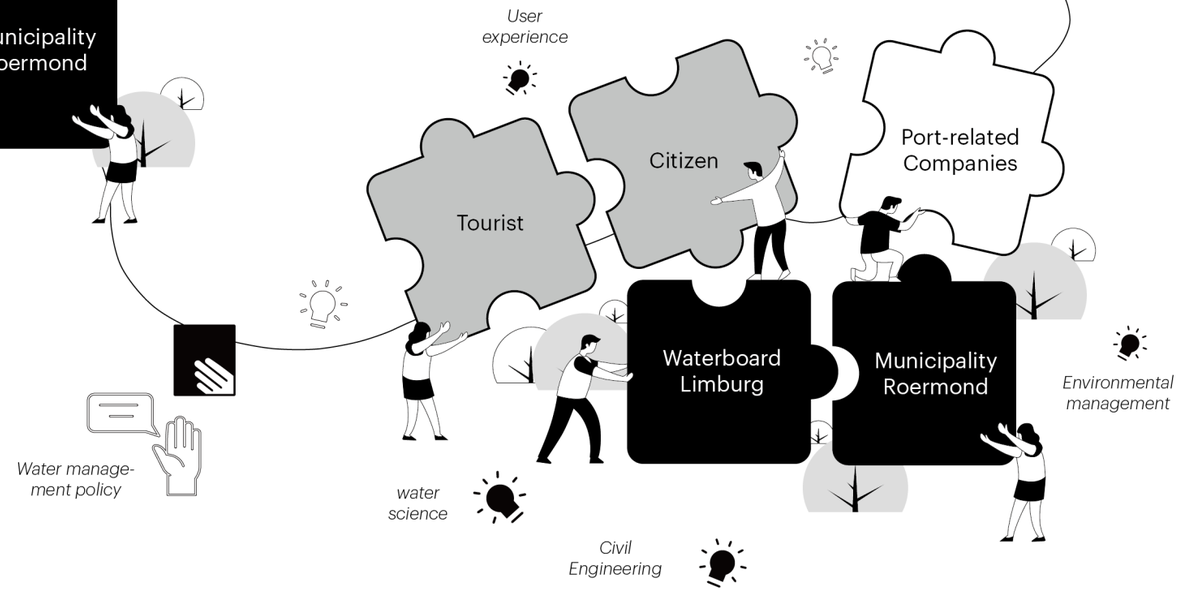


4

Operation & Maintenance

The Waterboard is responsible for the operation and maintenance of the dike.



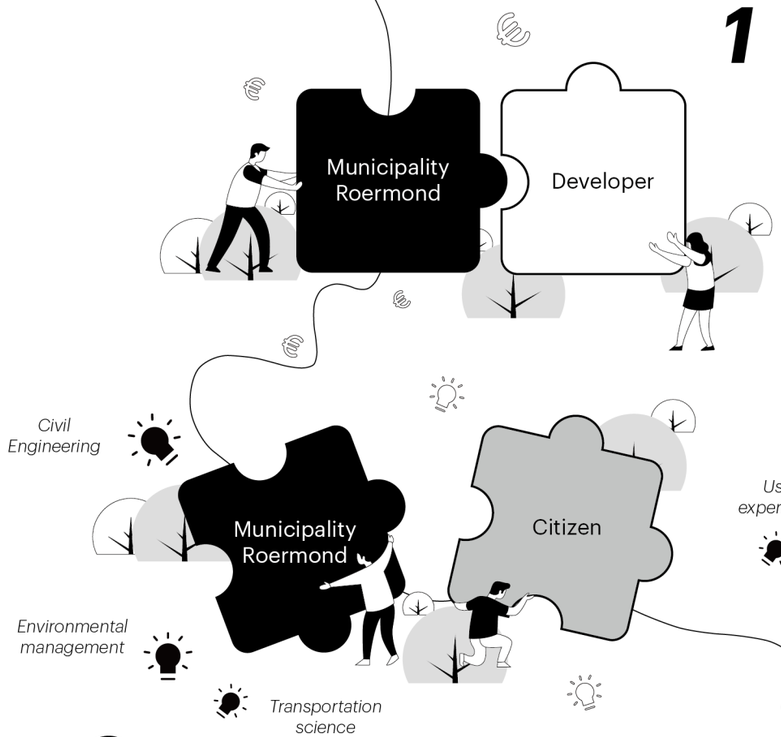


Co-Design

2

Citizens need to be involved early on in the design stage, working with water management experts, green experts, transportation experts, and designers to design multifunctional dikes. The original intent of the dike renovation was to provide an accessible public space at the riverine and to enhance the connection between the water and the city. The target users are therefore not only the residents of the neighborhood but the citizens of all of Roermond. The dike system and the port are closely linked, so the views of port-related companies and visitors also need to be carefully considered.

10.4.3 The Promenade



1

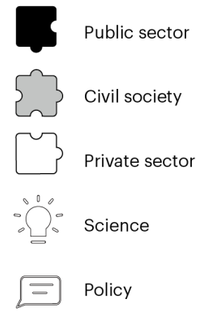
Co-Financing

The promenade will be the only connection between the headland and the city. Its location is so conspicuous that it is not enough to serve as a bridge; it needs to be paired with a subtle form to become a landmark. This requires attracting sufficient funding from a developer to co-design and operate the promenade with the municipality. The developer of Forest Park would be up for grabs.

2

Co-Design

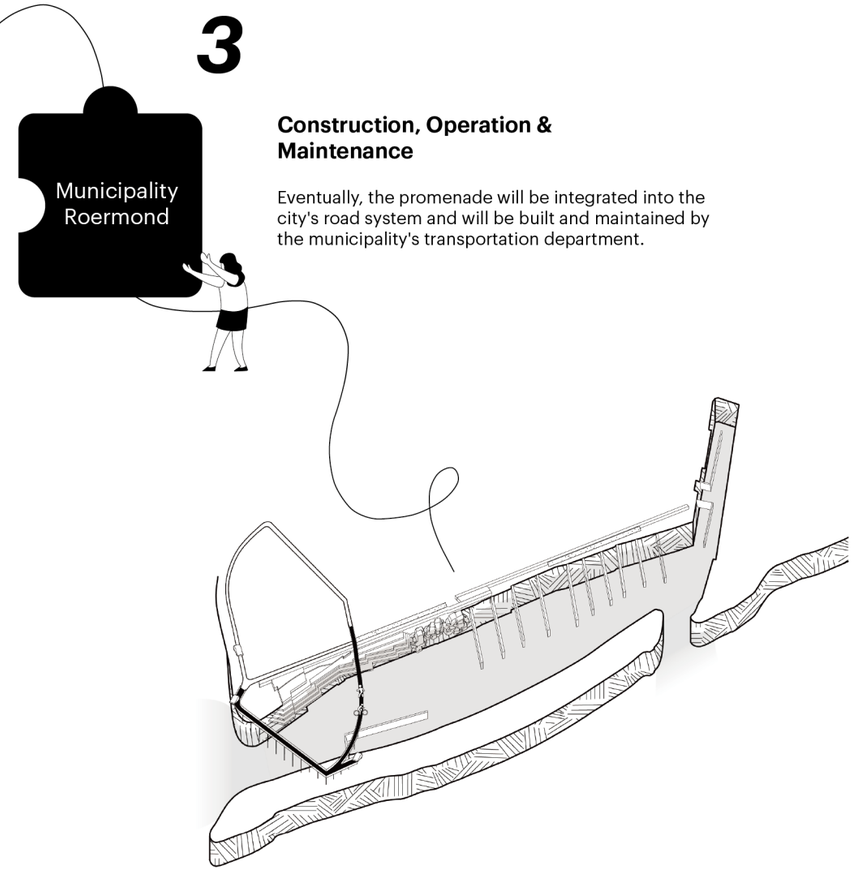
The promenade primarily provides transportation functions while mitigating negative impacts on the river and riverbed, so knowledge is shared among relevant professionals within the municipality. The public needs to be informed of the project's progress and get involved through hearings, workshops, etc.



3

Construction, Operation & Maintenance

Eventually, the promenade will be integrated into the city's road system and will be built and maintained by the municipality's transportation department.



10.4.4 From Parking to Park

Public sector

Civil society

Private sector

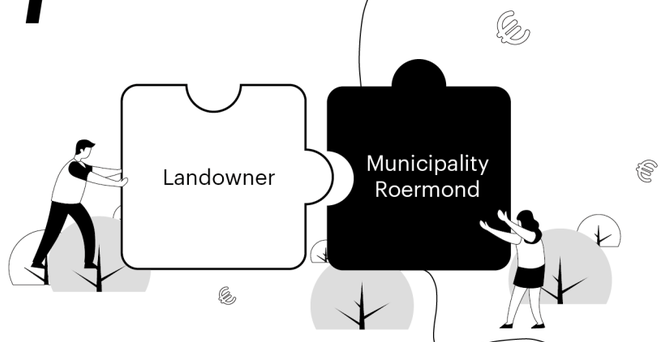
Science

Policy

1

Stimulation

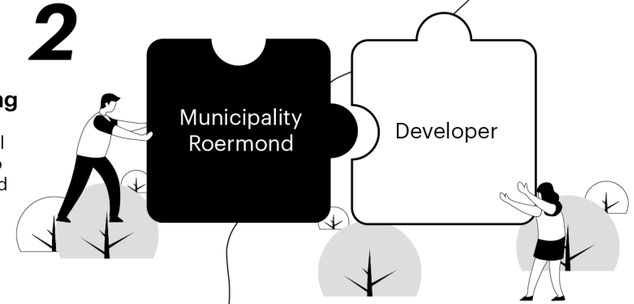
The development of the Forest Park will be a newly launched project. The municipality will need to first communicate with the landowner, describing the project's prospects and the value of addressing the climate challenge. Where necessary, appropriate financial subsidies could also be granted to obtain permission for development.



2

Tendering

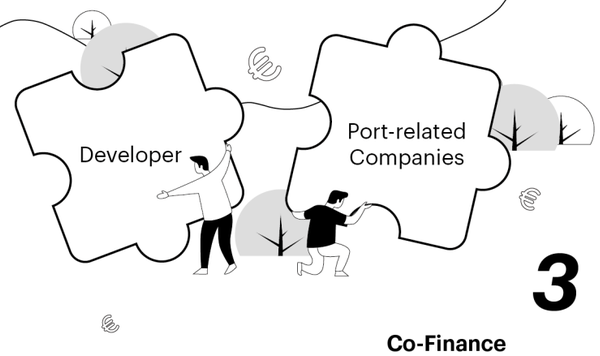
After that, the municipality will conduct a tender campaign to select a suitable developer and provide a co-creative environment for the developer and port-related companies.



3

Co-Finance

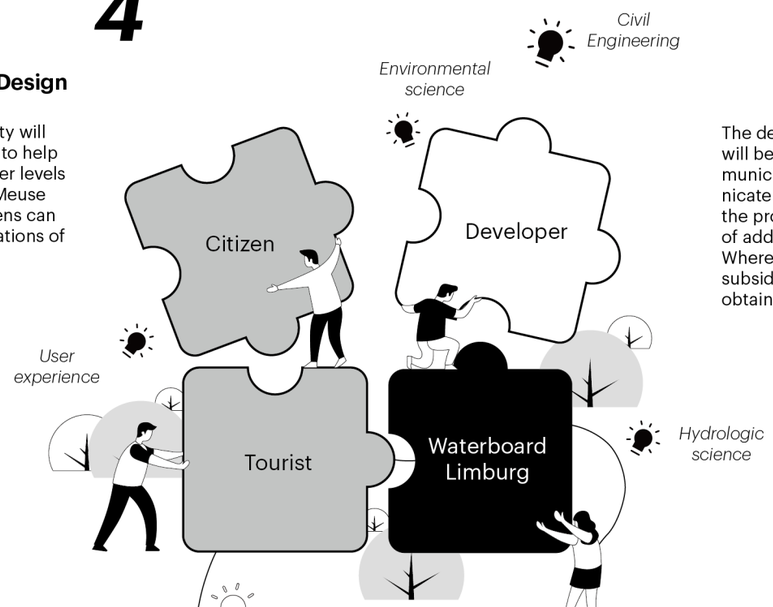
The functions and recreational activities of the port have the potential to be combined with the Forest Park, so port-related companies should invest in the park construction together with the developers.



4

Co-Design

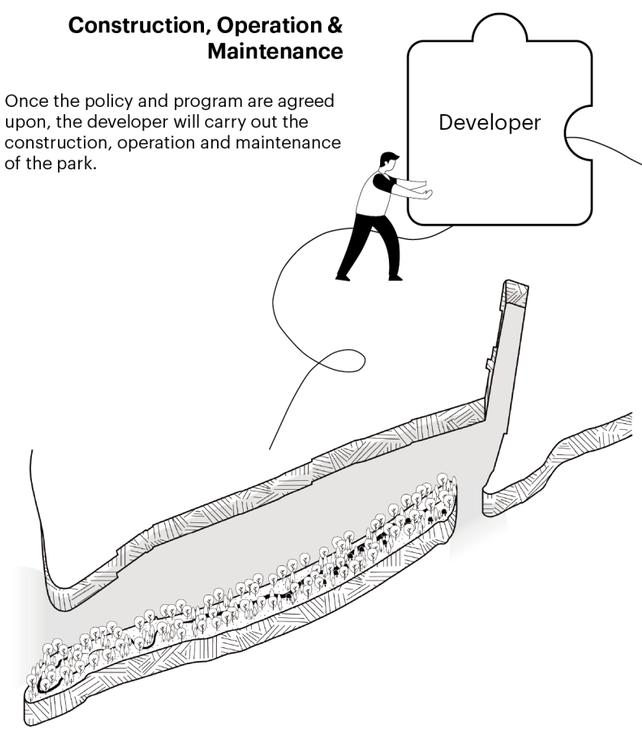
During the design phase, the municipality will also invite experts from the Waterboard to help designers understand the changing water levels and hydrological characteristics of the Meuse River. Comments from visitors and citizens can help designers understand their expectations of the space and the form of treehouses.



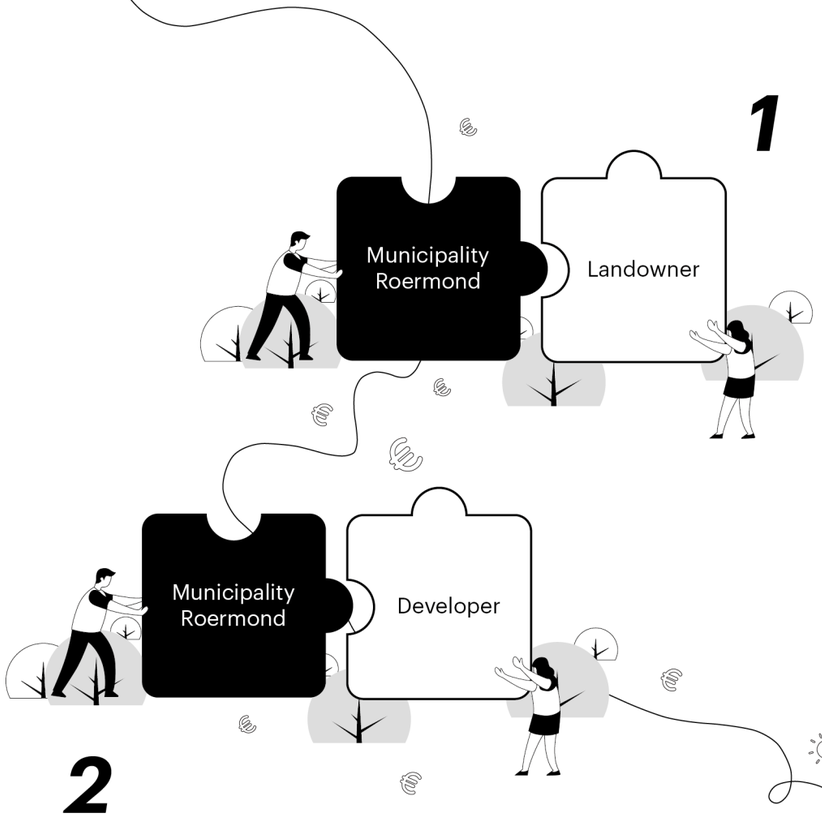
5

Construction, Operation & Maintenance

Once the policy and program are agreed upon, the developer will carry out the construction, operation and maintenance of the park.



10.4.5 Akcros Park Extension



1

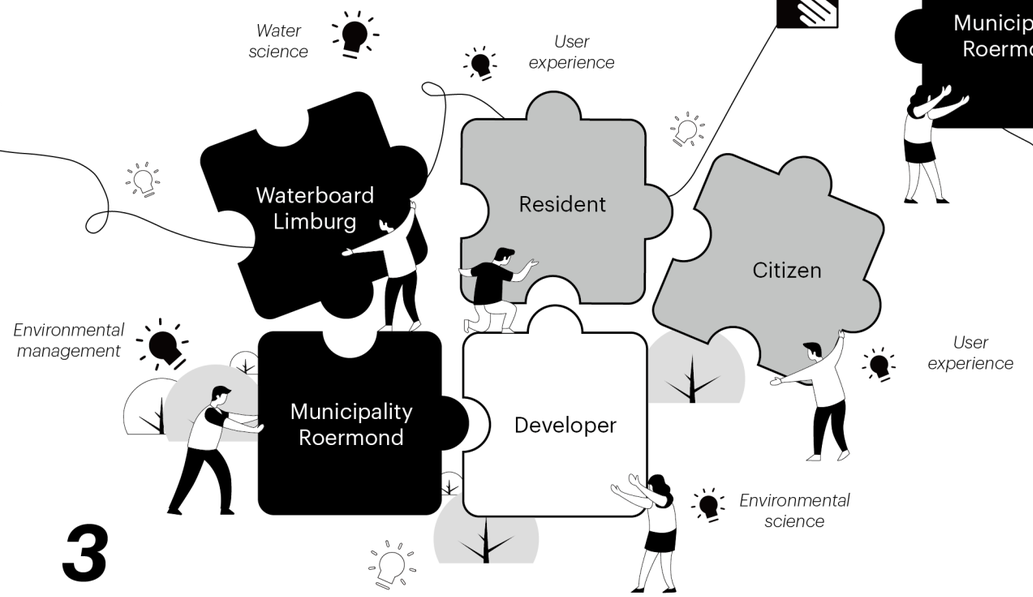
Stimulation

The extension of green spaces will involve the transformation of several parcels, which means communication with several landowners. As with the beginning stages of Forest Park, the municipality will need to first obtain landowners' permission to develop these parcels through lobbying and subsidies.

2

Co-Finance

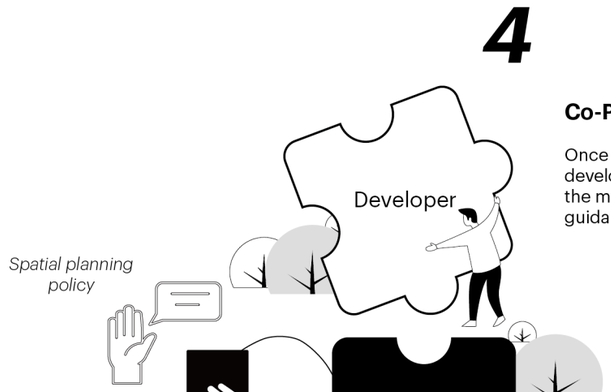
After that, a team of developers will work together to invest and design. The municipality will cover the development expenses of public-owned lands.



3

Co-Design

Municipality Roermond should act as a bridge between developers to ensure information transparency and progress sharing. On the one hand, public spaces need to be functionally heterogeneous, and on the other hand, they need to meet the requirements of flood resilience. This process is supervised by the municipality in conjunction with citizen and resident organizations. Experts from Waterboard Limburg can provide expertise in water management.



4

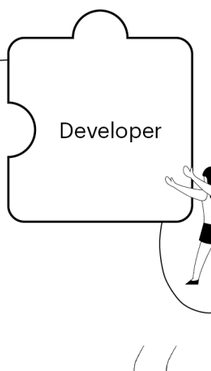
Co-Production

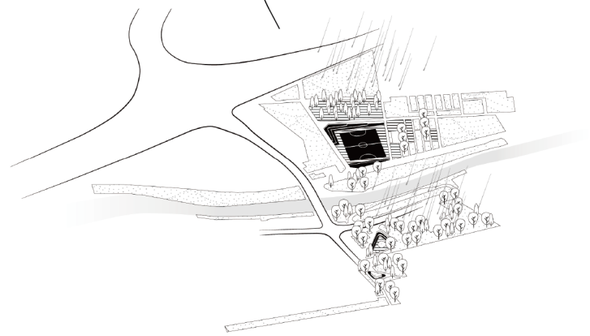
Once the design is agreed upon, the developers will begin construction, with the municipality providing technical guidance and supervising the work.

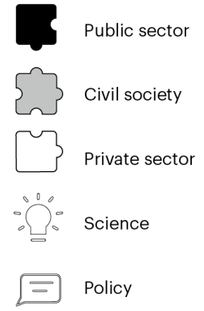
5

Operation & Maintenance

Ultimately, the developers themselves are responsible for the park's operation and maintenance.







Public sector

Civil society

Private sector

Science

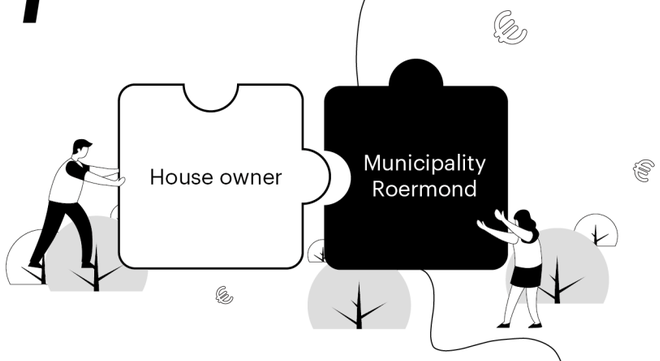
Policy

10.4.6 The Blue Street

1

Stimulation

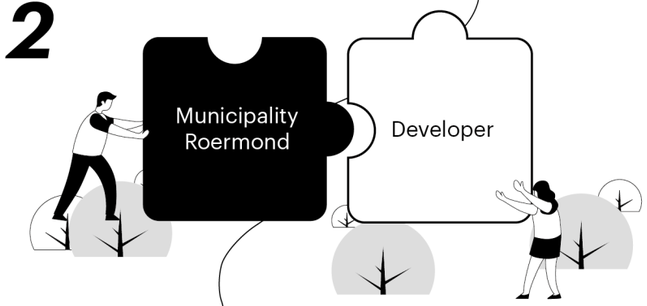
Blue Street is a project in which the government acts as a facilitator and regulator. The project is to explore the possibility of combining streets, buildings, and public spaces with flood adaptation measures provided that the original function of these spaces is not damaged. This needs to be emphasized and argued when communicating with house owners.



2

Tendering

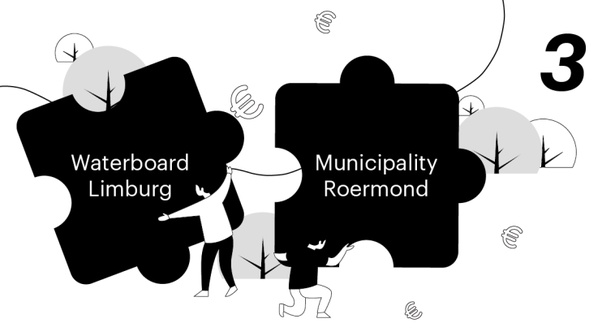
In cooperation with the universities and research institutes in Roermond, the municipality launched a tender for innovative solutions. Potential projects and spaces are selected by the municipality.



3

Co-Finance

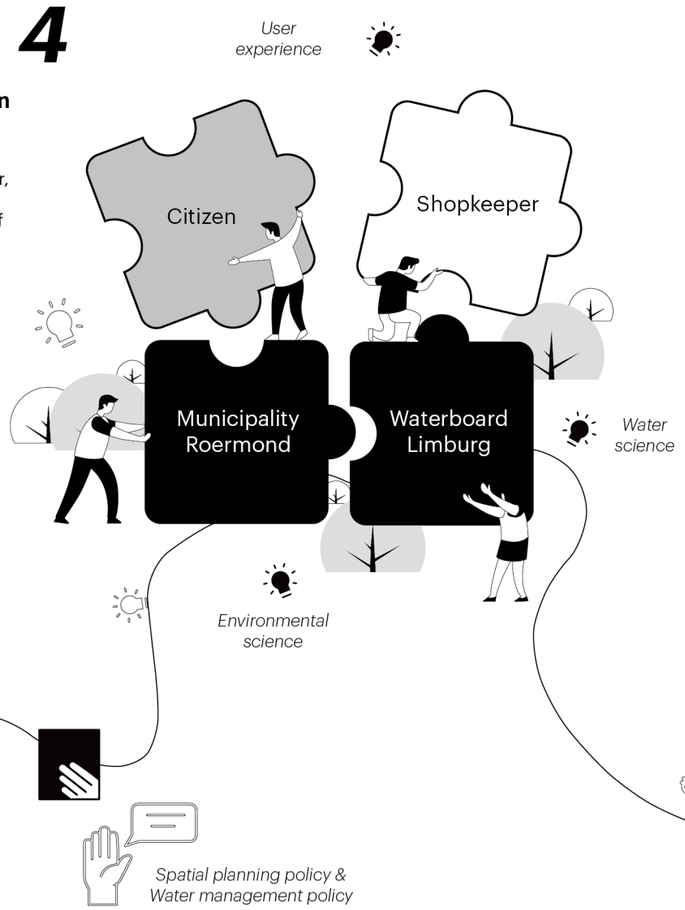
The municipality and Waterboard Limburg will share the financial expenses of projects to encourage rainwater retaining, detaining, and discharging initiatives.



4

Co-Creation

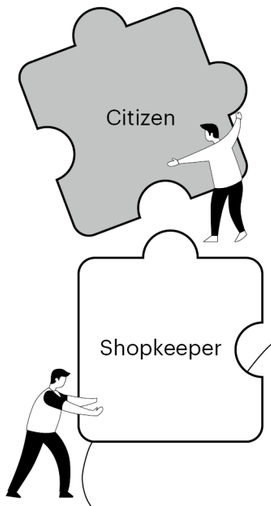
After gaining the support of the house owner, the municipality has to work with the house user, which is the shopkeeper, to develop a specific transition solution. The science and feasibility of the solution can be reviewed with the help of Waterboard Limburg. After the program has a prototype, it will be optimized based on the evaluation of citizens.

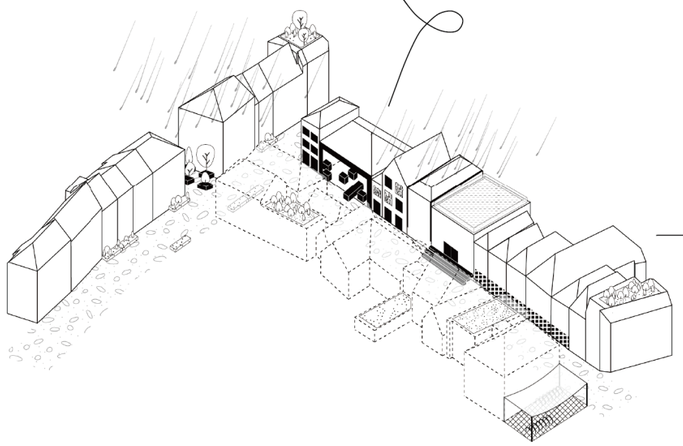


5

Co-Maintenance

After construction is completed, the subsequent maintenance is designed as attractive and educational activities that citizens and shopkeepers are invited to complete. For example, “rainwater planter adoption”, “cistern duty”, “rainwater garden competition”.





6

Co-Promotion

Eventually, the success of the experiment in Blue Street will be extended to other cities through Province Limburg. Visitors' reviews on social media will also raise the profile of Blue Street.

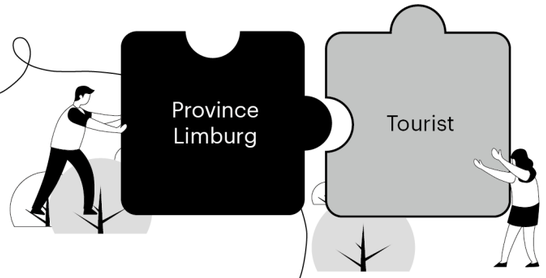


Figure 80. Flood-adaptive catering street

The author, 2022

Materials from Freepik.com

10.5 Spatial artifacts

Figure 81. Flood-adaptive port

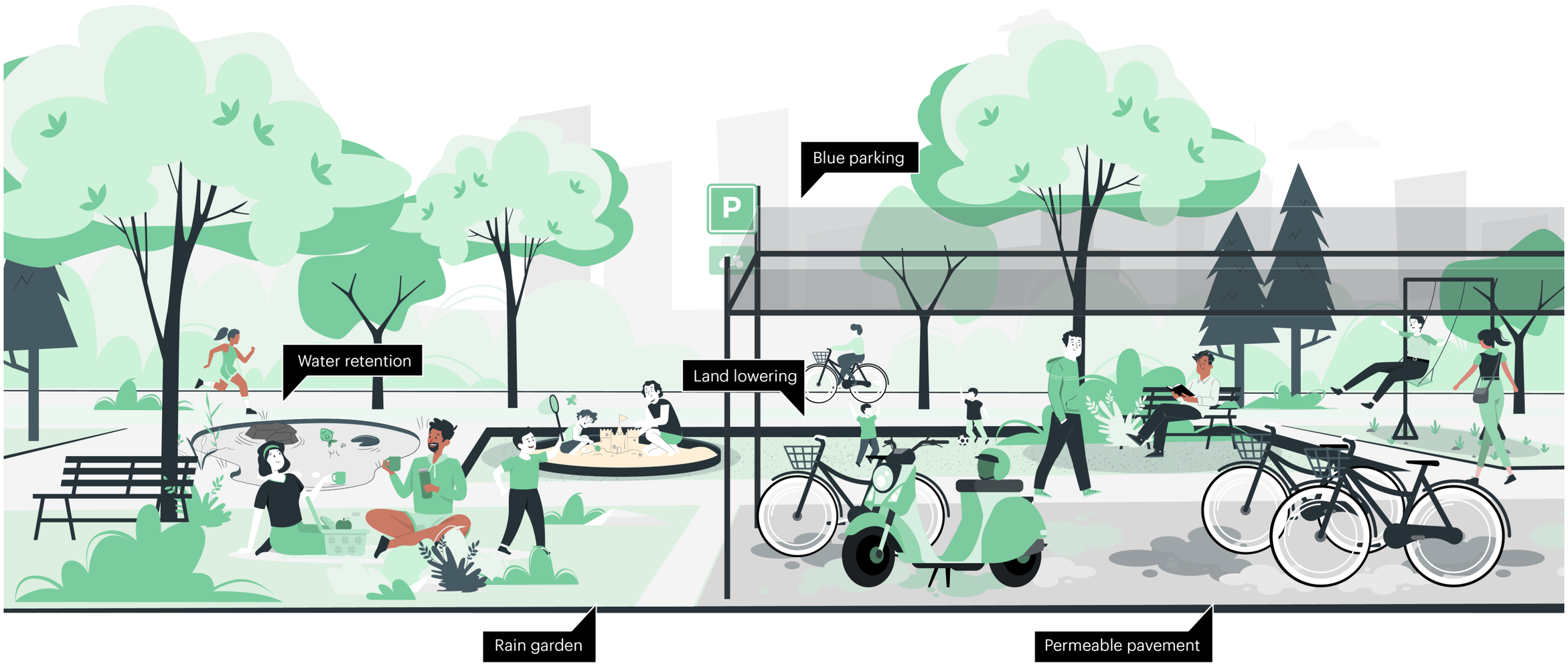
The author, 2022

People illustration by Storyset

Figure 82. Flood-adaptive park

The author, 2022

People illustration by Storyset



V. CONCLUSION & DISCUSSION

11 Conclusion

Supported by the exploration of planning and design, the three secondary questions raised in the introduction can be answered first, and then the main question.

SUB 1: What is the relationship between public-private-civil partnership and science-policy interface?

Broadly speaking, the concepts of Public-Private-Civil partnership and Science-Policy Interface are used to solve different problems. Spi provides interdisciplinary support for decision-making and policy-making, while PPCP ensures the smooth implementation of design strategies. The two concepts seem to be applied at different stages, but they can also be mutually fulfilling.

For one thing, some partnerships can be applied to policymaking situations and will be seen as a form of SPI. For example, a public hearing on a new policy usually invites the participation of academia, government, and citizens. If all three parties actively participate, provide constructive suggestions for revision and continue to follow up, then the three parties will establish a cooperative partnership, which is PPCP, and the cooperation results in policy revision.

Similarly, artifacts from the science-policy interface (new knowledge or new policies) can be further exploited in PPCPs. For example, in the science-policy interface, hydraulic engineers and urban planners discuss new measures to transform flood plains, which need to be implemented in accordance with development permits and local cultural characteristics and find a suitable construction company. This process is exactly the main function of PPCP, which enables the new knowledge and technology generated by SPI to be applied more efficiently.

SUB 2: What impact can public-private-civil partnership have on flood resilience?

Flood resilience can be roughly divided into three stages: pre-flood, mid-flood, and post-flood. The pre-flood PPCP is mainly microscale spatial measures, the mid-flood PPCP includes emergency response and rescue plan, and the post-flood PPCP is mainly post-disaster reconstruction.

Before the floods, citizens aware of the urgency of climate change can get a head start, using partnership models to transform their own roofs and gardens. While improving the water storage capacity of the environment in a small way, it plays a driving role in the neighborhood.

During a flood, the rescue efficiency can be improved by following the pre-established emergency rescue plan. The government, communities, NGOs, and residents acted simultaneously to reduce property losses and life threats.

After the floodwaters recede, recovery efforts include listening to residents, making renewal plans, assessing residents' damage, and settling claims from insurance companies. Each link requires the participation of multiple stakeholders under the guidance of the corresponding partnerships.

SUB 3: In what way does the science-policy interface help with flood resilience?

The science-policy interface promotes flood resilience in the form of producing new knowledge and new policies. By identifying opportunities for interdisciplinary collaboration and providing corresponding platforms, the collision of knowledge facilitates technological innovation and solves intractable problems. For example, the current policy formulation of flood risk management can only rely on flood prediction models, which do not take into account the impact of climate change, urbanization, and socio-economical factors on flood and is not accurate enough. In SPI, the input of climate scientists and urban planners may fill in the gaps.

Finally, looking back at this main research question,

"What role can Public-Private-Civil Partnership (PPCP) play in facilitating the mechanisms of a Science-Policy Interface (SPI) that aim at flood resiliency?"

The answer is that PPCPs can incentivize the creation of flood resilience in the form of players and guarantors.

In facilitating science-policy interactions, PPCP can be the interface itself, creating a communicative environment for citizens, experts, and officers to hone in on new knowledge and new policies in accomplishing ambitions together, as in the case of the Blue Street Partnership. Innovators in the private sector develop flood adaptation projects and submit them to the municipality. The municipality reviews the solutions and finds suitable spaces for testing, lobbying and motivating space owners to agree to the testing. Once the solutions are in place, space users (shopkeepers, residents, and citizens) work together to maintain the new infrastructure and give feedback to the innovators. After several rounds of adjustment, a reliable project scheme is formed, which contains "new science". Eventually, a higher public body (such as the Province Limburg) developed new tested schemes into flood risk management strategies, which were disseminated to other cities in the form of new policies.

The PPCP can also be the guarantor of the SPI. Both the test of new knowledge and the implementation of new policies need to use space as the carrier. This thesis proposes to tap the potential of civil society and further improve the partnership. Among the citizen groups are community organizations, tenant associations, visitors, and other players whose perspectives can reinforce the localization of the program. Instead of programs catering only to a small group of professionals, it is important to make design and decision-making more accessible and information on a more equal footing. A comprehensive partnership provides a friendly environment in which interaction between science and policy is encouraged, thus contributing in turn to the goal of flood resilience.

12 Discussion

12.1 Limitations

In attempting to answer the research question, the project produced three outputs: a set of new policies proposed after comparing spatial planning and water management policies; an environmental vision for Roermond that addresses new policies; and an urban design for Roerdelta that targets flood resilience. These three outputs are not entirely reliable and each has its own limitations.

For the new policy proposal, the limitations of the study mainly lie in the incomplete source policy document. In the face of the reform of the new Environmental Planning Act, policies in various fields have to respond and adjust. Everything is in the exploration stage and there are no "paradigms" to follow. In addition, different cities and provinces have different policymaking schedules. For example, the Environmental Vision 2050 for the province of Limburg and the municipality of Amsterdam has been completed and published, while that of Roermond is still at the conceptual stage. Such incompleteness of source documents can lead to bias in the conclusions of the thesis. It is possible that the policy loopholes outlined in Chapter 8 have not gone unnoticed by planners, simply because the schedule has not progressed there yet.

For the other two outputs, the limiting factors were time and language. Due to the lack of possibilities to conduct large questionnaires and interviews, the analysis of stakeholders' attitudes and interests in this project is based on common sense speculation or references to other scholars and consulting organizations, rather than from the real world. In addition, project management is a professional category of business, so the partnership models I proposed in Chapter 10.4 from the perspective of an urban planner may not be practical.

12.2 Recommendations for further research

Applications in other political contexts

It is innovative to involve citizens and private enterprises in social affairs and to develop projects in a "bottom-up" way. However, these achievements are developed in the Dutch context, which means that the same framework cannot be directly applied to other countries. For example, Waterboards, Rijkswaterstaat, and Safety Regions are public authorities that unique to the Netherlands. The partnerships proposed in Chapter 10.4 can be applied to other political contexts, but participants need to be adjusted according to the real situation.

Interdisciplinary cooperation between spatial planning and other disciplines

As mentioned above, climate adaptive design also needs to consider the effects of other hazards, including droughts, floods, hurricanes, etc. From this perspective, the same interdisciplinary policy analysis approach can also be used for spatial planning and drought management.

In addition to climate issues, spatial planning has the potential to intersect with social sciences, business, and other disciplines to address difficult societal issues.

Innovative ways to communicate with stakeholders

In chapters 6.2 and 9.4, this project briefly mentions strategies to engage stakeholders, such as creating information boards, holding workshops, forming thematic committees, etc. All these approaches are based on effective information transfer, that is, how to explain spatial design proposals to non-specialists and how to help them spatialize their ideas. This is a very important part of urban governance, and it is also the responsibility of urbanists. Due to time constraints, I did not address these issues, but it is a very socially valuable research direction for interested researchers.

13 Reflection

1. What is the relation between your graduation project topic, the studio topic, your master track (A/U/BT, LA, MBE), and your master programme (MSc AUBS)?

The thesis focuses on flood adaptation measures in riverine areas, including pluvial flooding and fluvial flooding. The study of fluvial flooding requires attention to the relationship between upstream and downstream. Studying pluvial flooding, on the other hand, requires recognizing the urgency of climate change and increasing risk awareness. The application of flood adaptation measures and the engagement of stakeholders will be accompanied by changes in the function and form of the spaces, which is the "accumulation" and "clearance" processes that Transitional Territories Studio stress.

Theoretically, the project combines knowledge and concepts from design practice, social sciences, technology, and engineering to explore innovative approaches to flood resilience. This way of researching stems from the MSc Architecture, Urbanism and Building Sciences programme, which has developed my interdisciplinary problem-solving skills.

The research and design of this thesis are carried out at the urban scale, which is divided into macro, meso, and micro. The process uses methods such as spatial analysis, cross-scale analysis, and research by design, all of which are explored in the Urbanism Track.

2. What is the relation between research and design in your graduation project?

Research by Design is the research methodology that runs through my entire project. In the stage of establishing the thesis, research was dominant, while design always existed as a subconscious in the mind. As in the site analysis, I not only used the four lines of inquiry to research the accumulation of urban elements but also conducted design explorations during this phase (see Appendix). Upon entering the planning and design phase, design transcends research to become the dominant approach, and smaller-scale case studies are conducted alongside the use of design tools. As shown in Chapter 10.3, best practices with similarities can assist in illustrating design effects. Finally, these two approaches accomplish each other and form the desired outcome.

As an urban planner and designer, the project has both planning and design outputs. The planning output is a series of new spatial planning policies derived through interdisciplinary policy analysis. The design output is an urban design proposal using Roerdelta as an example.

3. How do you assess the value of your way of working (your approach, your used methods, used methodology, studio methodical line of inquiry, scientific relevance of the work)?

In the establishment stage of the project, I planned to use methods including research by design, literature review, analytical mapping, multi-scale analysis, stakeholder analysis, case study, site visit, surveys, and interviews. In retrospect, this was overly ambitious. Due to time constraints, surveys and interviews were not used, and the literature review and case study were not sufficient.

Other than those, the use of approaches has brought me enlightening conclusions, especially policy analysis and stakeholder analysis. Interdisciplinary collaboration has been the focus of scientific advocacy, but it remains unclear how to do this in practice and what the results will be. The planning and design results of this project have demonstrated that this approach is feasible and meaningful.

The studio's methodical line of inquiry helped me to explore many design possibilities during the initial phase of the project (see Appendix). Although not every inquiry was adopted by subsequent designs, this approach expanded my knowledge base in a short period.

4. How do you assess the academic and societal value, scope and implication of your graduation project?

In terms of academic value, this project summarizes and compares research advances in the fields of institutional theory, resilience theory, knowledge society, and urban governance.

Then, the intersection between them is found, based on which the new concept of Public-Private-Civil Partnership is proposed. In research by Sharma and Nayak (2013), the literature on public-private partnerships for water management is limited, so future research must provide further insight into this approach to water issues. The approach introduces civil society to the partnership, incorporating water management and spatial planning. The results of this study demonstrate the promise of Public-Private-Civil Partnerships in raising mass flood risk awareness.

In addition, this thesis elaborates on the forms and mechanisms of the Science-Policy Interfaces. Recent research in the field of flood risk management has shown that SPIs promote institutional learning and encourage the assimilation of knowledge in practice, but ignores the context in which they arise and function (Hegger et al., 2020). Chapter 10.4 of this thesis demonstrates in detail the mechanism of spatial interventions from initiation to landing, and the role SPIs play in it.

A transition from less to more stakeholder engagement in flood management is taking place in Belgium, the UK, and the Netherlands (Soma et al., 2018). From the perspective of social value, this project further explored and detailed how stakeholders can be involved in flooding issues in the Dutch context, such as which groups can be involved in which stages

of the project, and how to motivate them to participate. Although the relevant strategies have not been tested in practice, the findings can provide direction for other researchers. Moreover, this project has proposed a series of spatial solutions following an interdisciplinary policy analysis. These solutions can be provided to the urban planning department of Municipality Roermond to inform the development of an Environmental Vision for 2050.

5. How do you assess the value of the transferability of your project results?

The transferability of research results was considered at the beginning of site selection. Firstly, compared to other riverine cities in Limburg, Roermond has a more diverse spatial composition, including floodplains, camps, ports, historic urban areas, and modern commercial streets. Different types of waterfront space will have different design strategies for adapting to floods, which also provides more application scenarios for knowledge promotion.

Secondly, the analysis deliberately downplays the complex geopolitics of Limburg considering the broader research implications. Since it is located at the junction of the three countries, its geographical location is too unique to apply relevant research results to most provinces and cities. Therefore, the study focuses more on Limburg's cross-scale collaboration within the Netherlands.

Furthermore, international case studies were conducted while designing Roerdelta, so the spatial interventions proposed in this project have a wide range of application possibilities. The interdisciplinary policy proposal applies only to Roermond, but the approach used is applicable to other cities and countries.

6. Discuss the ethical issues and dilemmas you may have encountered in doing the research, elaborating the design and potential applications of the results in practice?

Ethical dilemmas often exist when viewed through the lens of water management and urban planning at the same time. For example, the conventional approach to flood control is to raise and strengthen the dike system. However, when the height of the dike is increased to a certain level, it will completely block people's view and become an obstacle in the city. This is the dilemma faced by Roermond, where the city has difficulty connecting to the water, despite its proximity to the Meuse. In the design, my solution was to make a stepped or sloping treatment on both sides of the embankment. This provides the possibility for citizens to ascend and use the dike, although it is still visually impermeable.

Another dilemma is how to use the space in the flood risk area. Many of the industrial parks in Roermond-South have building vacancies, some of which are adjacent to the Roer River. The strategy I proposed in the Environmental Vision is to convert them into social housing. This provides quality housing and landscape for a vulnerable group but also brings with it an ethically controversial flood risk. Roermond-South is not a priority design area for this project, so this strategy was not explored in-depth, but it provides an idea for using flood-risk areas and points out the possible ethical dilemma.

Convincing the port-related companies to give up waterfront space was the difficult part of designing the Roerdelta. This project started by investigating the current land use and found that the parking lot on the headland is illegal, so the space there deserves to be released. In addition, this project cleared four berths close to neighborhoods and also planned two new berths on the west side of the port to mitigate the loss of port companies. The project also establishes a partnership between port companies and the forest park developer to explore new ways for port companies to make profits.

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Appendix

Clearance

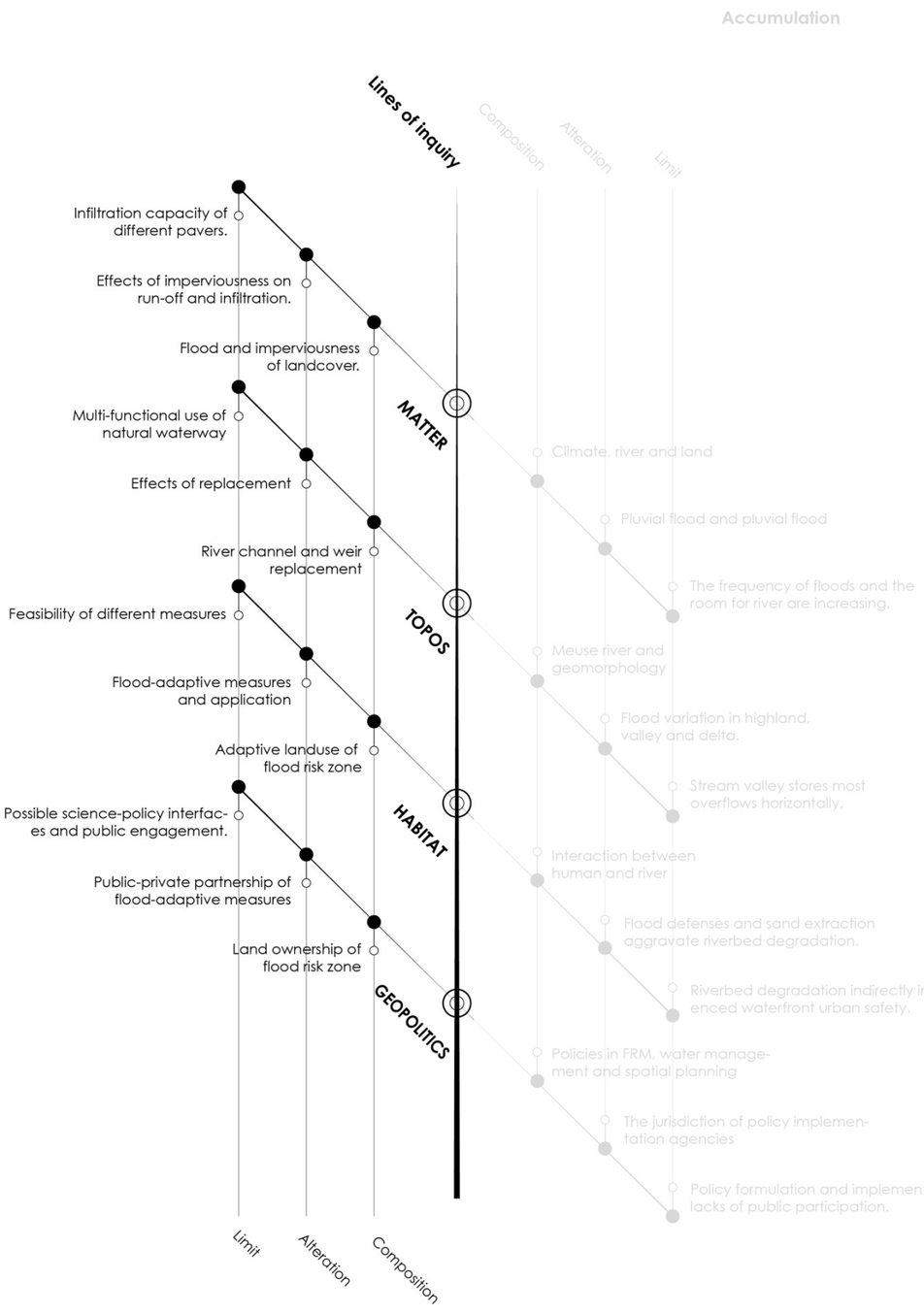
Lines of inquiry

Following the same lines of inquiry, the following research will explore possible solutions to the problem (Figure 1). As analyzed previously, with the clue "Matter", the frequency of extreme weather is increasing and the future shouldn't be taken lightly with existing measures. Therefore, the possibility of optimizing the permeability of land pavement will be explored during the clearance operation. The problem with "Topos" is that in order to protect national security, Limburg has to leave a lot of space ready to release the water at all times. The possibility of removing some non-essential flood defenses and making use of flood plains will be explored here. As for "Habitat", the conclusion is that the normalization of rivers is aggravating the degradation of river beds. Thus, to resist a higher frequency of floods in the future, human beings should not only rely on flood defenses but also think from the perspective of co-existence with floods and propose ways for different land types to adapt to floods. The set of analyses by "Geopolitics" identifies underutilized civil groups and private sectors, and this chapter will explore the possibility of incorporating them into an existing flood management system.

The purpose of this phase of exploration is to accumulate design tools, think about the feasibility of various measures from the perspective of time and space, and lay a foundation for the next phase of specific spatial design.

Figure 1. Thematic design exploration directory

The author, 2022



Clearance

Matter

Flood and land imperviousness

Composition

In order to show the details of the information more clearly, the micro-scale has been chosen for the analysis here. The map focuses on the location of the worst flooding, which is also in the center of Roermond.

The map shows the impermeability of the area in shades of gray, as well as the types of land covers in the less permeable areas where the flood passes, namely the built-up, wood, and shrub. These areas are the focus of the next step of optimization.

Figure 2. The composition of impermeable space for modification

The author, 2022

Data from Slager, Jonkman, de Moel & Strijker (2021) and Copernicus.eu

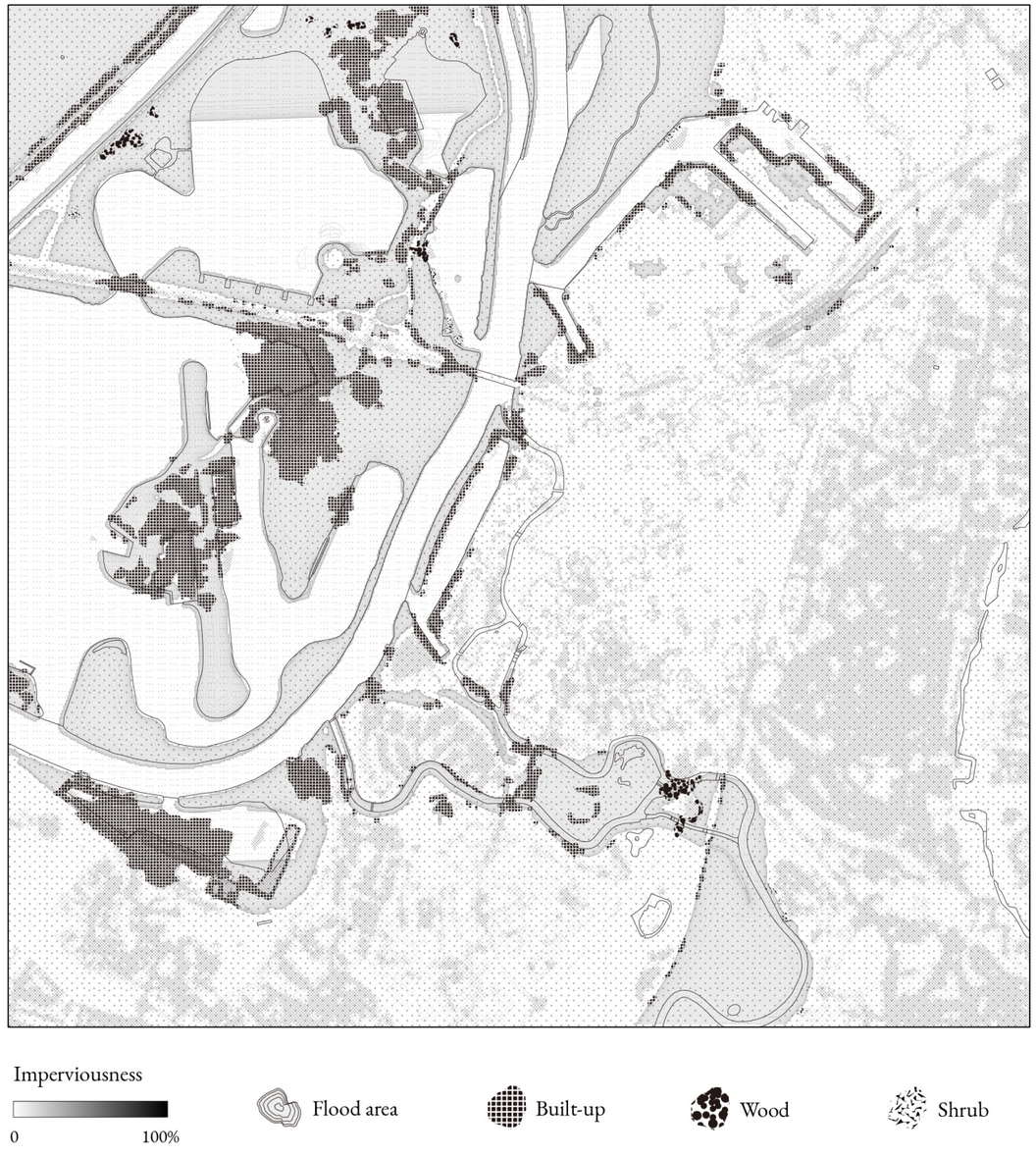
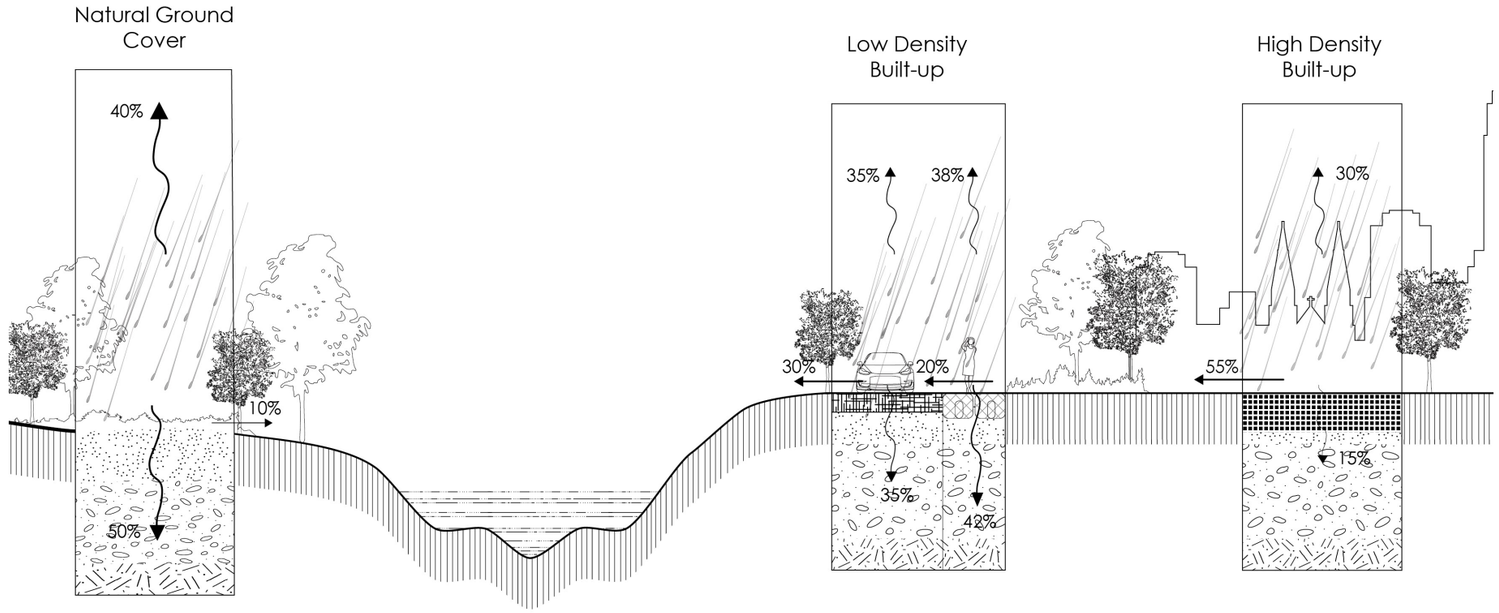


Figure 3. Relationship between urban density and land permeability

The author, 2022
Data from Tantibanchachai (2020)



Alteration

The section further illustrates the permeability degree in different build-ups (Tantibanchachai, 2020). The covering of the natural surface is usually soil, which absorbs the highest proportion of rainwater. The ground cover of the built-up area is usually concrete, asphalt, and paver. And high density built-up is usually covered by concrete, where water permeability is poor. During heavy rains, a large amount of rainwater can accumulate on roads or flow into rivers, increasing the pressure on flood defenses.

Limits

A comparison of three commonly used surface covering materials, asphalt, paver, and concrete, shows that asphalt is the most permeable that would help rainwater seep into the underground soil for storage (Danz et al., 2020). Concrete has the worst permeability and should be avoided in newly built areas.

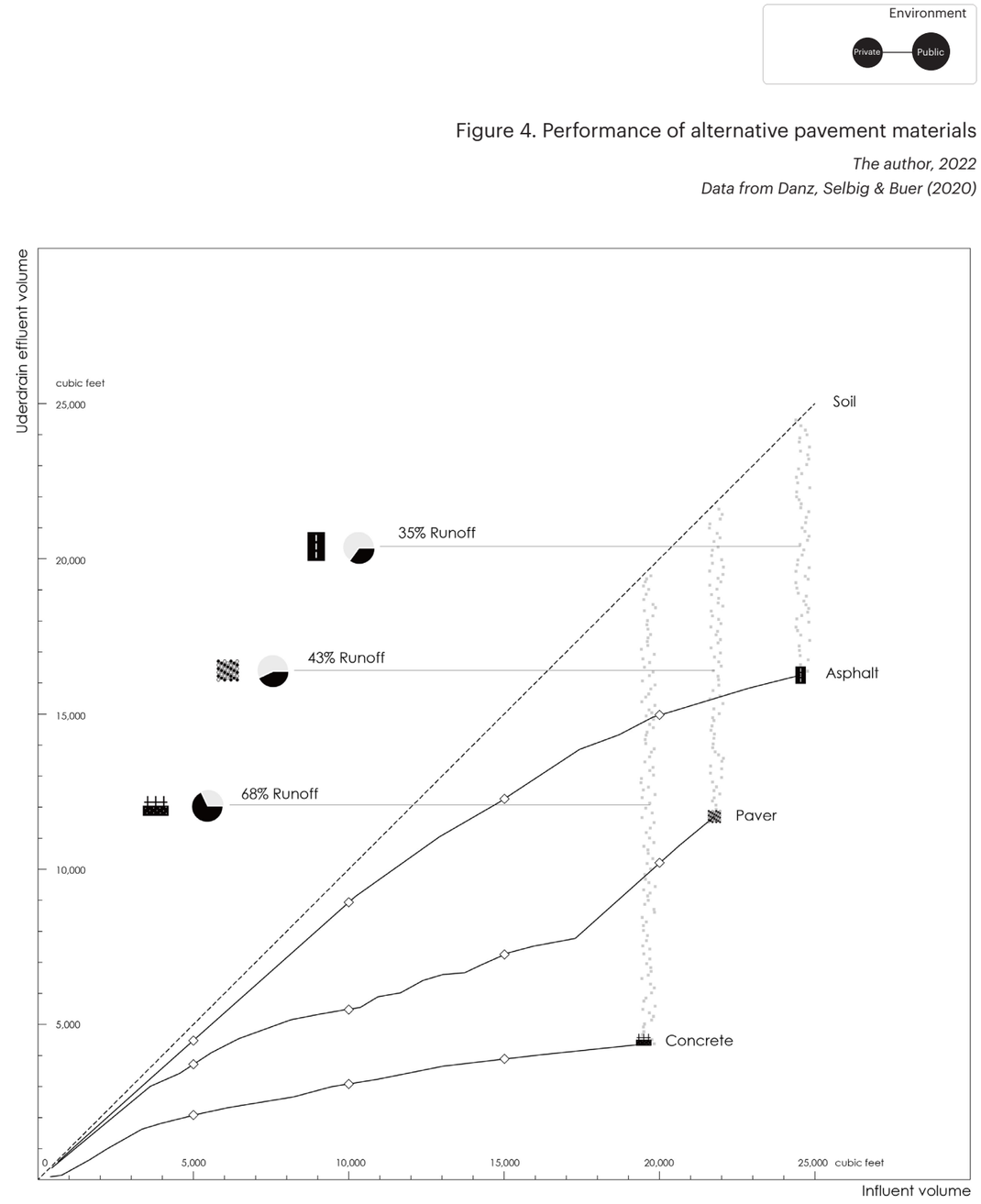
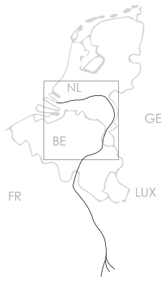


Figure 4. Performance of alternative pavement materials

The author, 2022
Data from Danz, Selbig & Buer (2020)

Topos

Weir replacement and water level



Composition

There are currently seven major weirs on the Meuse in the Netherlands. They share responsibility for controlling water levels, storing water at low levels, and draining it at high levels. However, some weirs that are not in the main waterway have the potential to be modified. The Weir Roermond, for example, has a wider man-made channel on the west side of the channel that serves navigation. If the Weir Roermund was removed and the downstream Weir Belfeld slightly raised, the negative impact of flood control on the riverbed would be reduced and the floodplain would be more likely to be utilized with a more natural waterway.

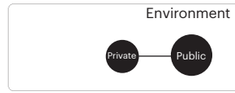


Figure 5. Weir composition and replacement strategy

The author, 2022
Data from Copernicus.eu

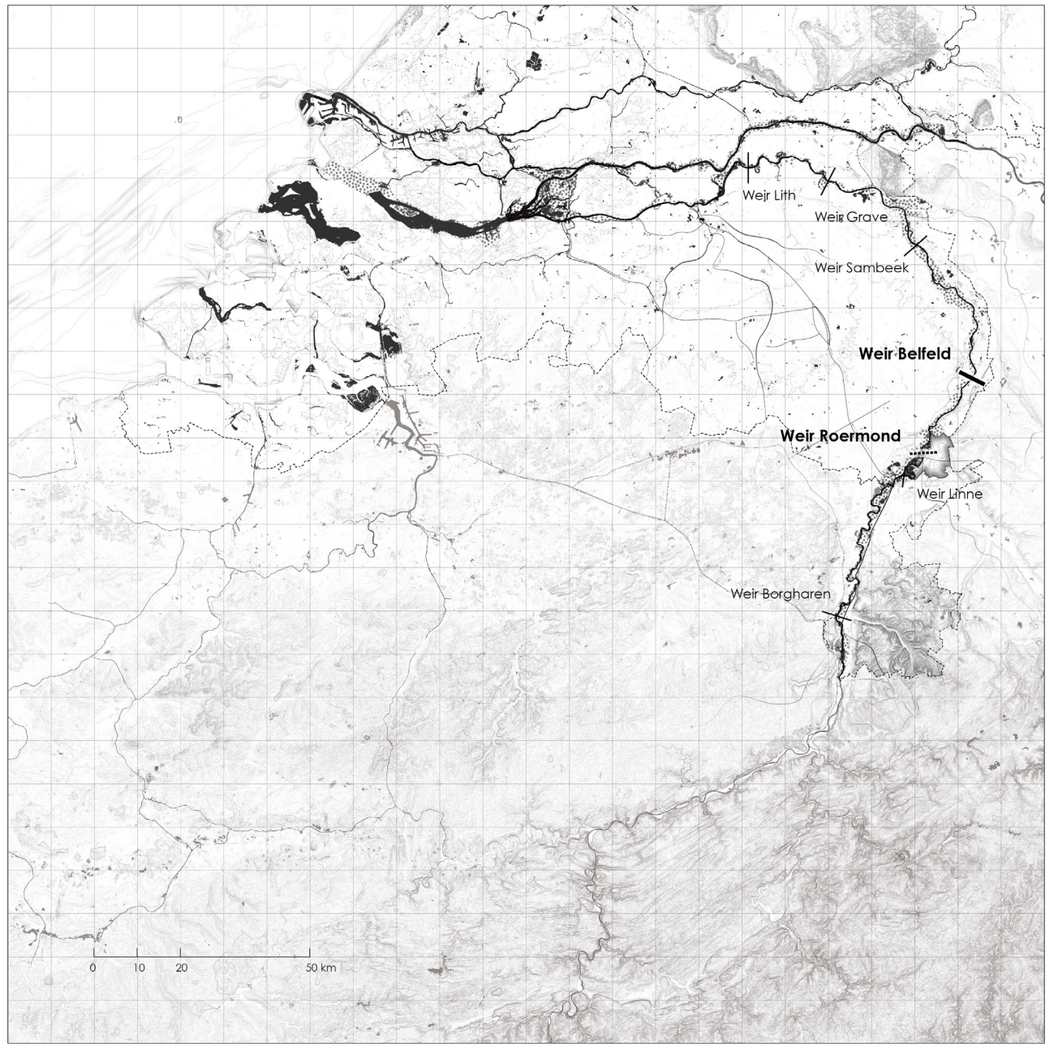
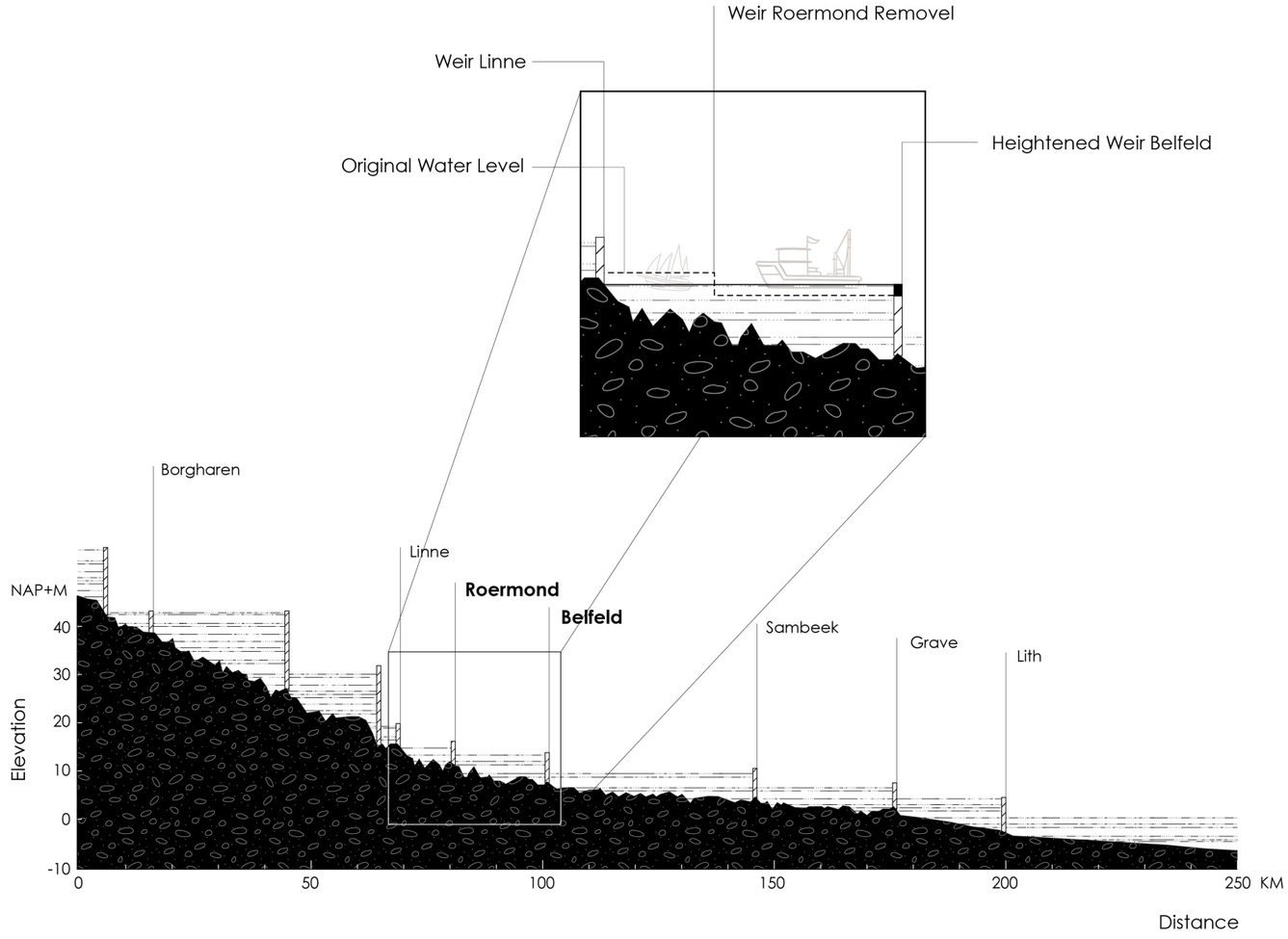


Figure 6. Alteration in water levels and function

The author, 2022
Data from Frijns (2019)



Alteration

A section shows the riverbed height and water level control of the Meuse reach in the Netherlands. If Weir Roermond is removed, the water level upstream of the weir will be reduced to a level unsuitable for cargo ships, but small pleasure boats will still be able to travel. In addition, the water level downstream of the Roermond weir will rise accordingly, requiring a higher design level for the Weir Belfeld (Frijns, 2019).

Limits

After the weir is removed, a natural form of the river will have higher ecological and recreational value. Wetland, ice rink, water sports, and other corresponding functions can be introduced into the river channel and the nearby flood plain, not only without damaging the permeability of the surface but also make full use of the space.

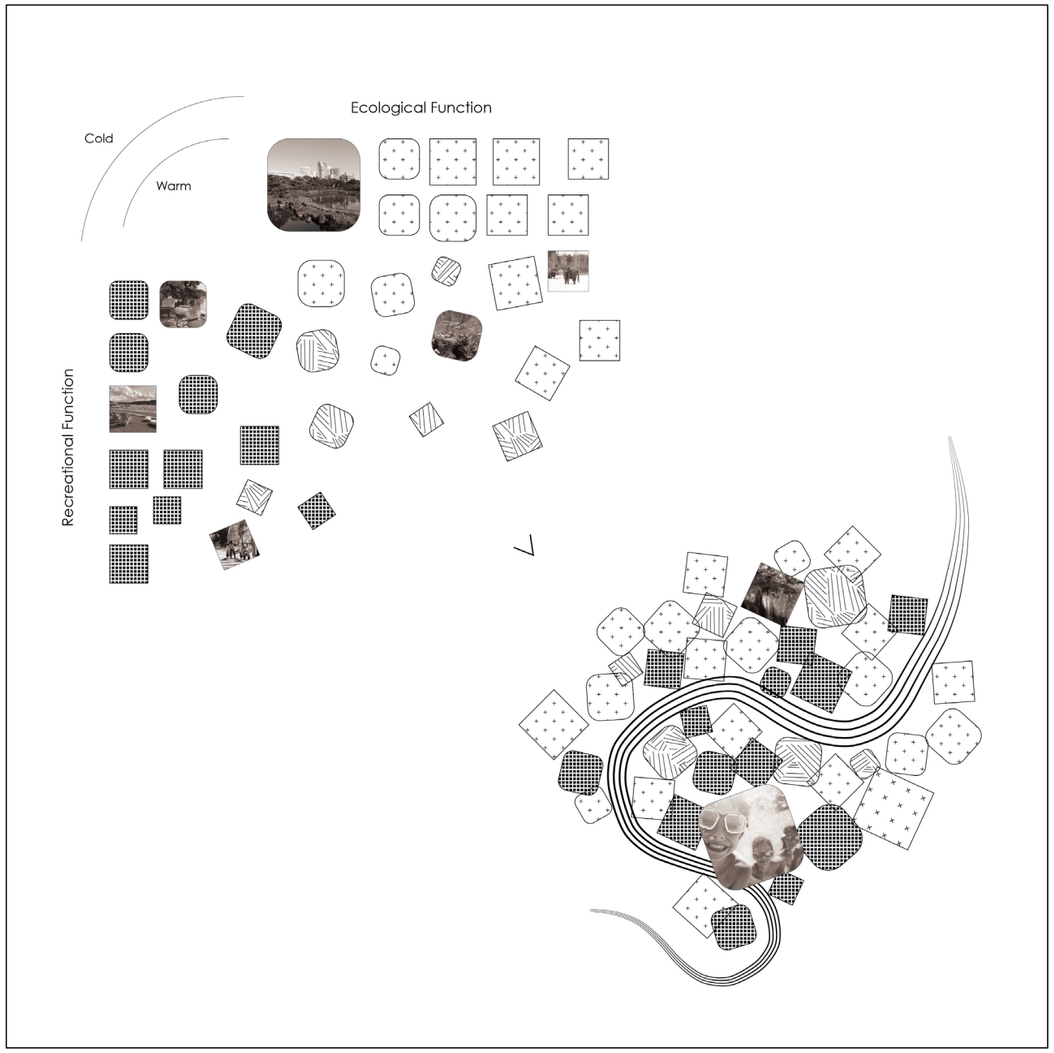


Figure 7. Proposal for floodplain function after weir removal

The author, 2022

Habitat

Flood-adaptive land use

Composition

During the 2021 European Floods, Roermond was protected by a reliable flood control system. But at one point, water levels reached warning levels, and no one knows if the next flood will be worse. Therefore, all sites located in flood risk zones, whether residential, commercial, recreational, or office, should be prepared to live with flooding and reduce human and financial losses if flooded.

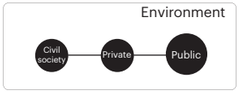


Figure 8. Types of land requiring adaptive modification

The author, 2022

Data from Slager, Jonkman, de Moel & Strijker (2021) and Copernicus.eu

Alteration

The section illustrates some of the flood adaptation measures at the micro-scale. For the building, some facade and roof greening measures can act as water storage. At the same time, some small rainwater treatment devices, such as rainwater barrels and rainwater columns, can be used to reuse rainwater. For outdoor spaces, such as plazas and backyards, the discharge of pluvial flooding can be accelerated by changing paving, digging drainage channels, and installing rain gardens. Some underground installations, such as vertical infiltration and rainwater tank, can also collect and store rainwater to relieve the pressure of flood discharge.

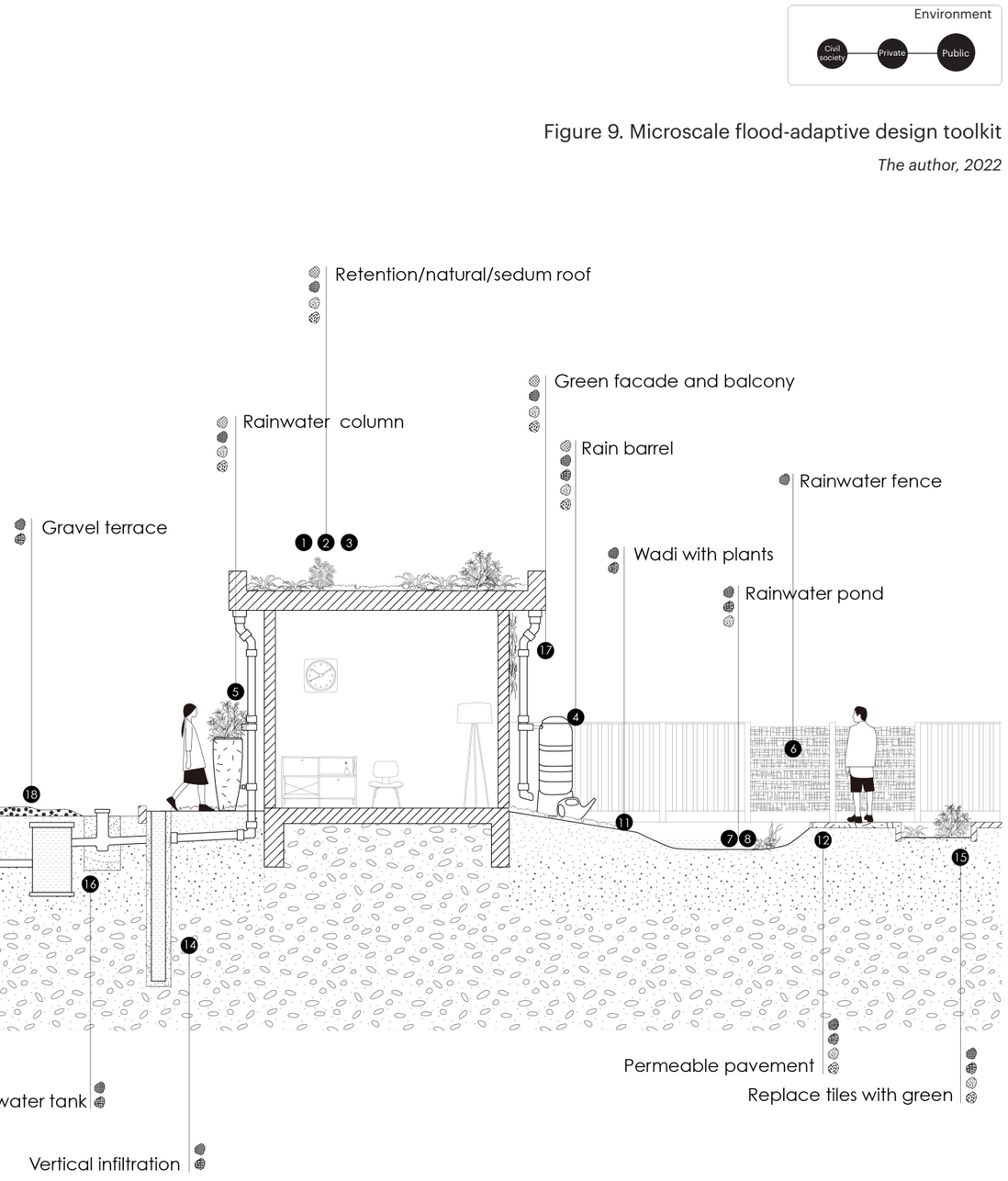


Figure 9. Microscale flood-adaptive design toolkit

The author, 2022

Limits

From the point of view of feasibility, the above measures correspond to different costs, space occupancy, construction and maintenance difficulties, as well as differences in the effectiveness of flood mitigation and improvement of spatial quality (Waterklaar, n.d.). Generally speaking, wadi with plants, replacing tiles with green and rain barrels are the most cost-effective measures and deserve to be widely applied to all types of land. Other measures can be matched to the corresponding land use according to specific needs.

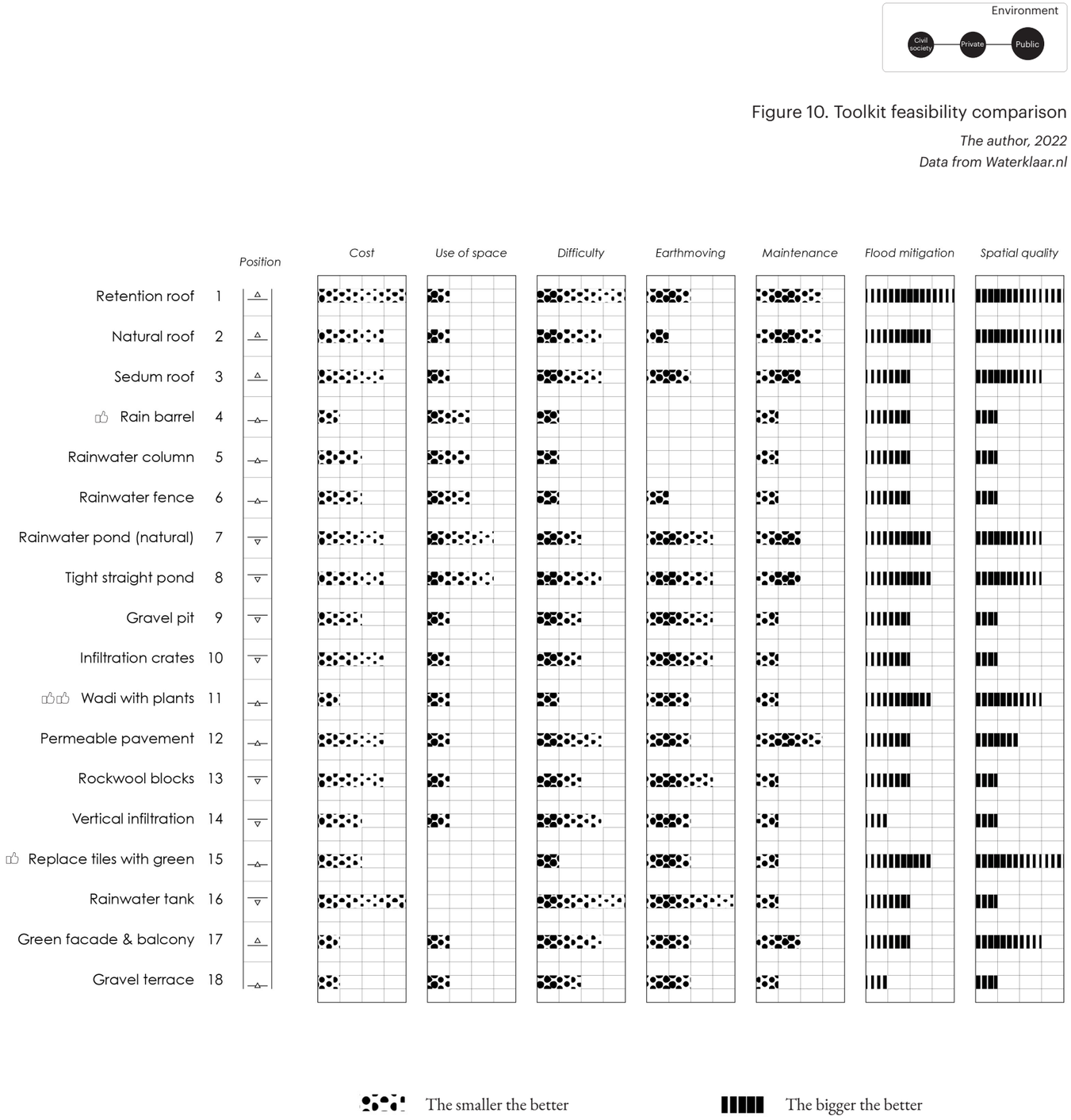


Figure 10. Toolkit feasibility comparison

The author, 2022
Data from Waterklaar.nl

Geopolitics

Co-ownership and co-management

Composition

Changes in land use require the consent of landowners, so the analysis requires ownership information on the land to make a persuasive case or explore possible public-private partnerships.

Most of the land in Roermond's flood-risk area is private, with a few leases held by the government and a small amount of land held jointly by both the government and the private. These lands would correspond to different forms of public-private partnerships, depending on the type of flood adaptation measures they will apply.

Figure 11. Composition of land ownership in flood area

The author, 2022

Data from Slager, Jonkman, de Moel & Strijker (2021) and PDOK datasets

Alteration

Related to the flood adaptation measures proposed in the "Habitat" analysis, the stakeholders involved behind them are further detailed in this diagram. Among them, private landowners and householders may be resistant to new measures, because they mean extra construction and costs. In this case, the Roermond municipality and other public sectors need to intervene to encourage them to accept the new measures through subsidies.

For the private sector, such as landscape companies and fence companies, flood adaptation means new business opportunities, and their attitude will be positive. The public sector can take the lead between enterprises and consumers in establishing a one-stop cooperation model from product development to product installation to ensure the smooth implementation of flood adaptation measures.

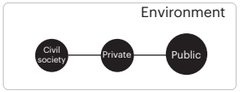
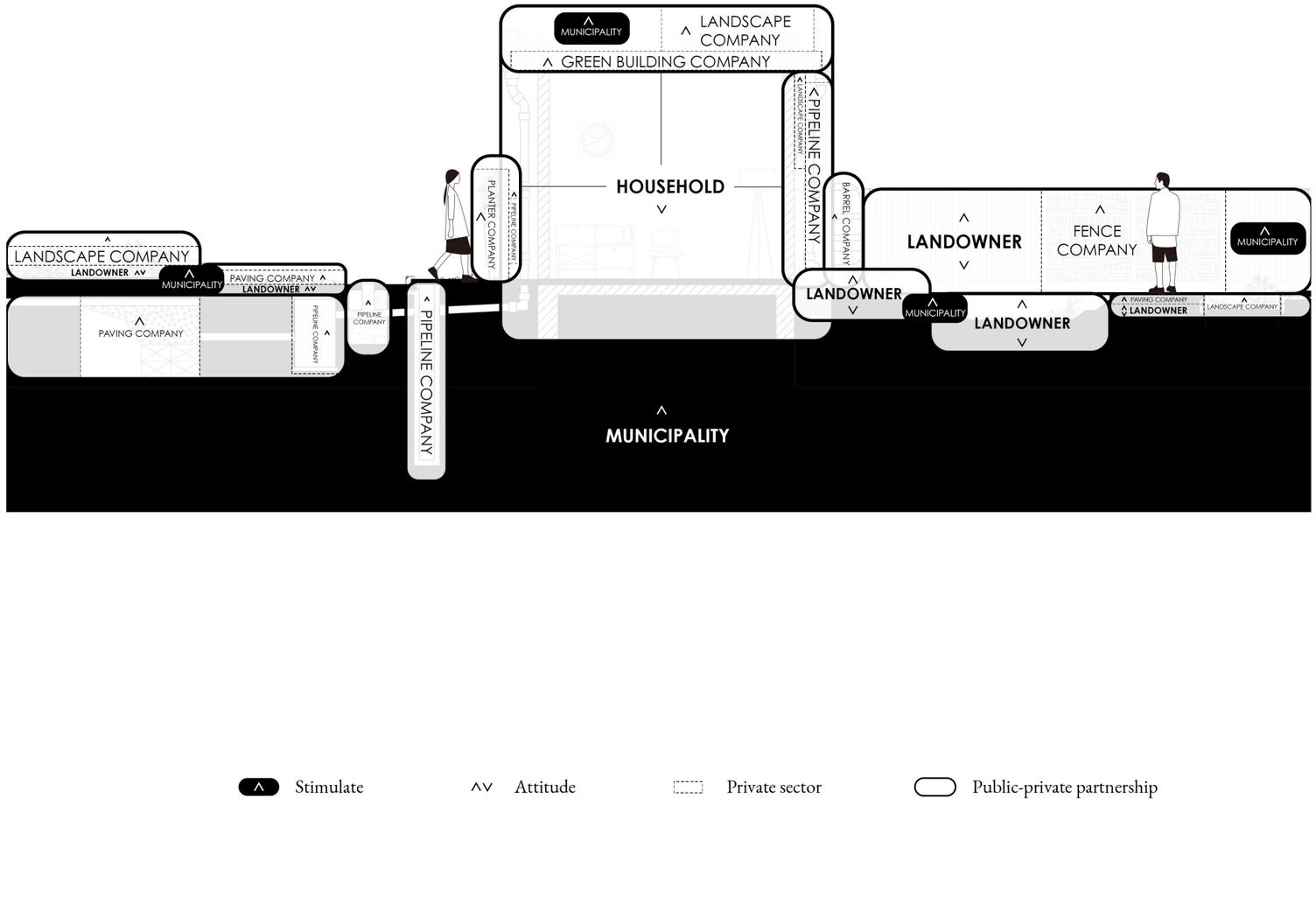


Figure 12. Public-private-civil partnerships that align with the toolkit

The author, 2022



Limits

At the policy level, the involvement of more forces could also fill existing science-policy gaps. For example, at the regional and urban scale, decision-makers can bring together scholars from different fields to formulate water management and flood risk management policies. Just like the National Water Programme (Government of the Netherlands, 2021), water management and flood risk management exist as different chapters of a complete plan to serve a common development vision.

In addition, the public-private partnerships mentioned above can also be incorporated into municipal flood risk management policies to enhance citizens' sense of participation and flood risk awareness.

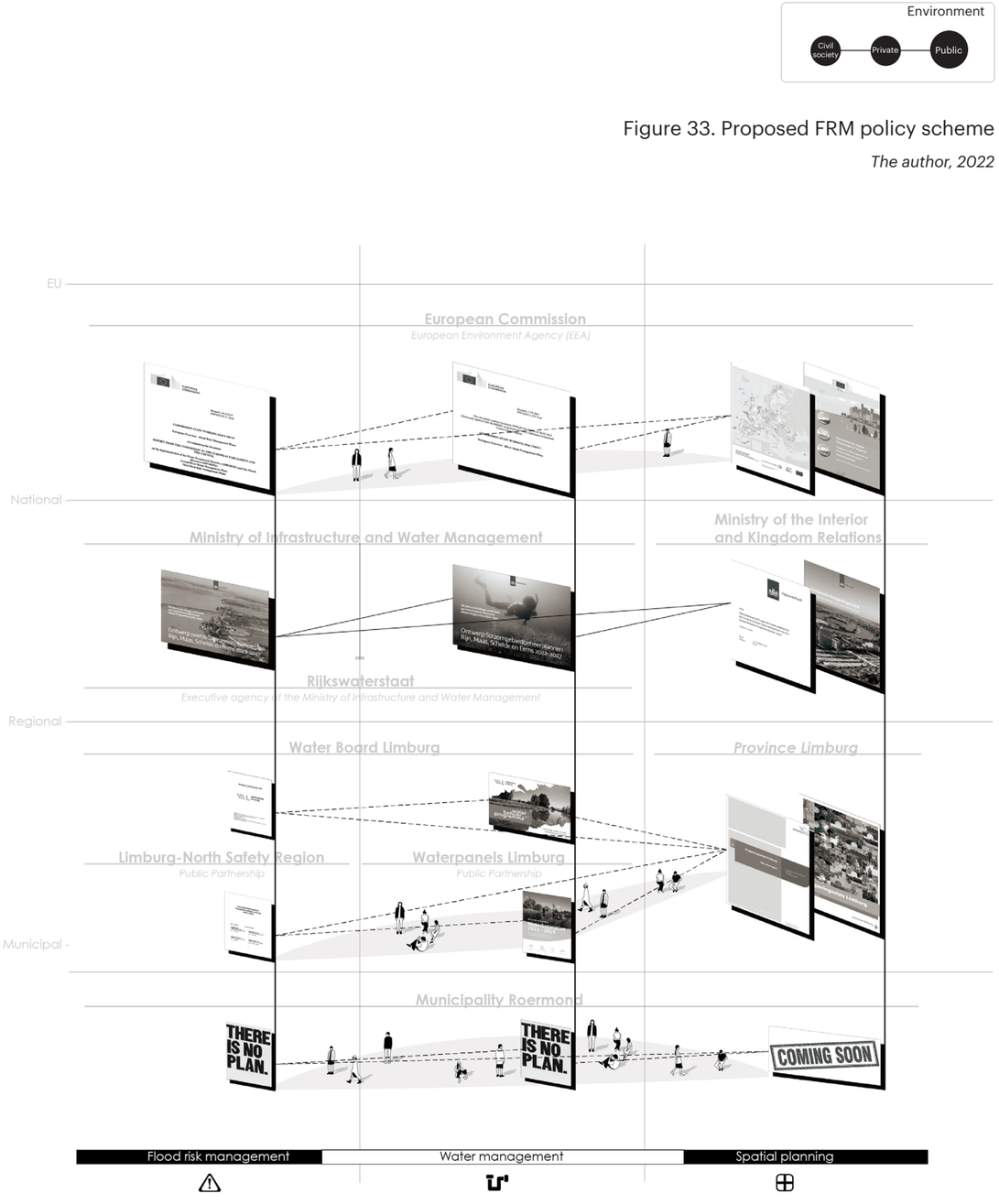


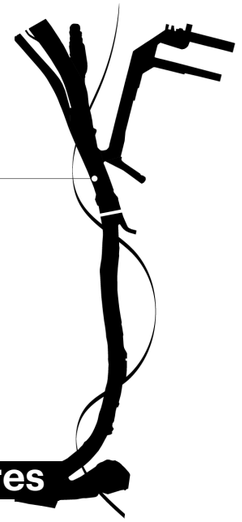
Figure 33. Proposed FRM policy scheme

The author, 2022

Synthesis

Opportunities and explorations

Topos



Systematically promote planning, landscape and engineering measures to promote river ecological restoration.

Matter

The water storage capacity of flood plain can be further improved by improving pavement materials.

Habitat

Geopolitics

Develop flood adaptive spatial measures using co-ownerships and PPCPs within flood risk zones.