Public Participation GIS for flood and stormwater resiliency

A study of Public Participation GIS as a tool in the design process for flood and stormwater resiliency in the Kävlinge river catchment.

Guerlouse Duterloo

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Swedish University of Agricultural Sciences, SLU
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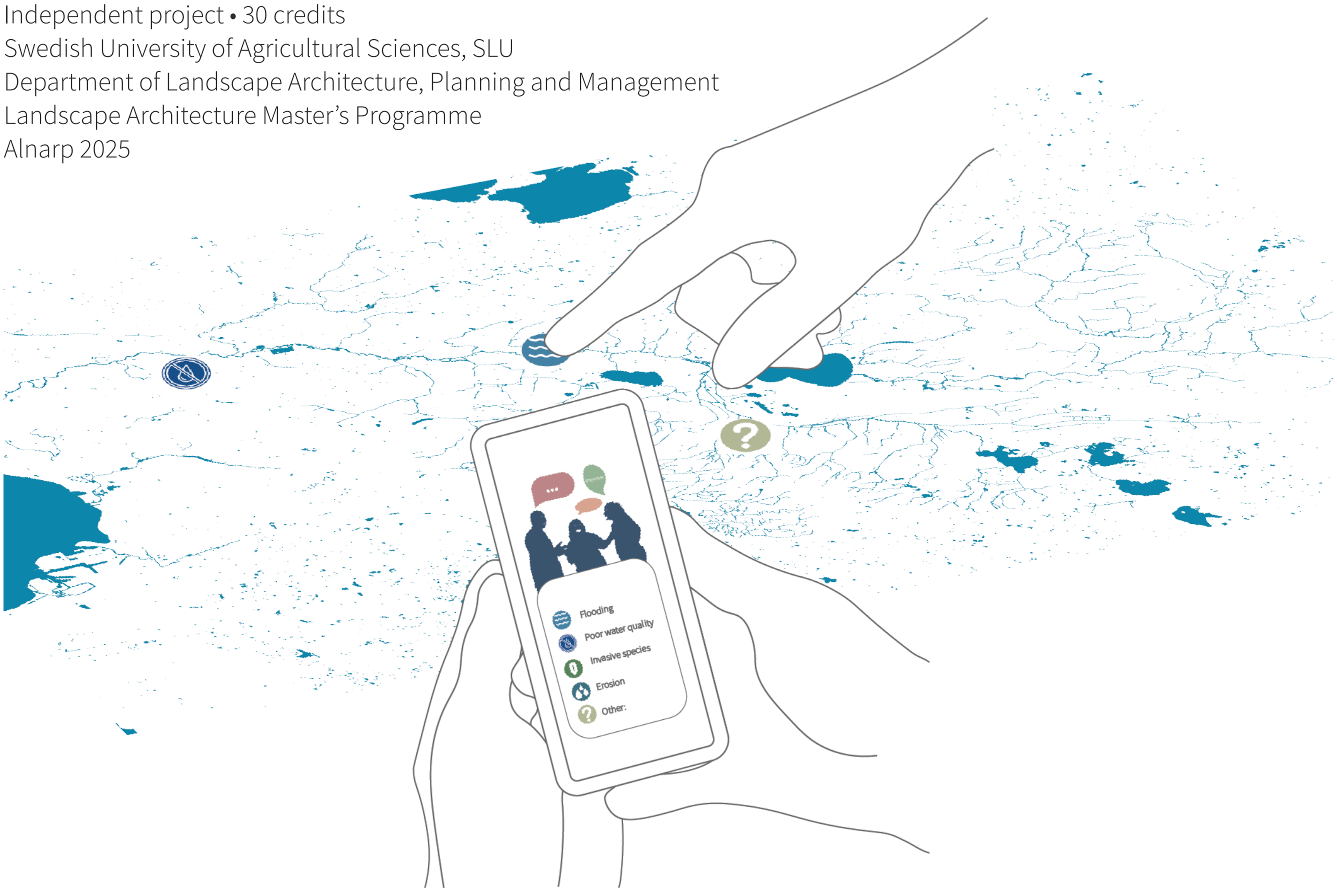

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Abstract

Rivers are the supporters of some of the most biodiverse ecosystems in the world. Yet, in Europe, they have been subjected to severe degradation over centuries which impacted not just the river itself but the whole catchment and floodplain. There has been argued that in order to steer river management towards more sustainable direction it will require transdisciplinary research with diverse stakeholders. This could prevent injustice in source and flood risk distribution and can contribute to a just distribution of ecosystem services. Public Participation Geographical Information Systems (PPGIS) present itself as an effective tool in revealing stakeholders' values and collecting local knowledge. This study applies and explores PPGIS as a tool in the design process of planning for flood and stormwater resiliency in the Kävlinge river catchment. The different methods used in this thesis study are literature, GIS site analyses, site visit, PPGIS survey and designing. The study found that PPGIS contributed to the design process by revealing local experiences, identifying a priority area, and generating new solutions to improve the environmental quality of the study area. This study shows that PPGIS is a promising tool in river catchment management if improvements are made to target more and a varied group of respondents.

Keywords: Public Participation GIS, PPGIS, river catchment management, river restoration, flooding, stormwater

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Abbreviations

PPGIS	Public Participation Geographical Information Systems
ES	Ecosystem services
SMHI	Swedish Meteorological and Hydrological Institute

1. Introduction

1.1. Background

Rivers are the supporters of some of the most biodiverse ecosystems in the world (Reid et al., 2019). They are supporters of many important ecosystem services including flood regulation (Tockner et al., 2010). Yet rivers in Europe have been subjected to severe degradation over centuries that has had an impact not just on the river itself but the whole catchment and floodplain (Feld et al., 2011). Alterations for purposes such as navigation and agriculture (Gilvear et al., 2013) have fragmented the rivers, altering flow and sediment. This has led to the degradation of rivers, and their loss in ecosystem services (Sabbion, 2017).

There has been argued that in order to steer river management towards more sustainable direction it will require transdisciplinary research with diverse stakeholders (Henze et al., 2018). Begg (2018) argues that involvement of local stakeholders is important because governments lack knowledge and funding to implement flood management measures such as property-level protection measures. Transdisciplinary research combines not only scientific knowledge but also other types of knowledge, as local knowledge (Henze et al., 2018). This participatory process could lead to higher collective capacity and an increased acceptance by society (Henze et al., 2018). Furthermore, the involvement of community perspectives can prevent injustice in the distribution of resources in flood risk management (Begg, 2018). Public Participation Geographical Information Systems GIS (PPGIS) presents itself as a successful method to reveal different stakeholders' values and local knowledge. This method where participants are asked to map place-based values (Brown et al., 2020) seems to be very useful in enhancing the democratic aim of planning process (Kahila-Tani et al., 2019). Among others because of the local based knowledge and the high number of participants that can be reached (Kahila-Tani et al., 2019).

The promising role of PPGIS in planning process is the reason for this study to apply this tool in a river catchment area in Sweden. This study will evolve around the Kävlinge river catchment, located in the south of Sweden, Skåne (Fig.1). The continuous goals from the Kävlinge Water Council mentioned in their Water Conservation Programme have been to mitigate flood and drought in the river, reduce nutrient transportation in water bodies, promote biodiversity and contribute to recreation (Om – Kävlingeån, n.d.).

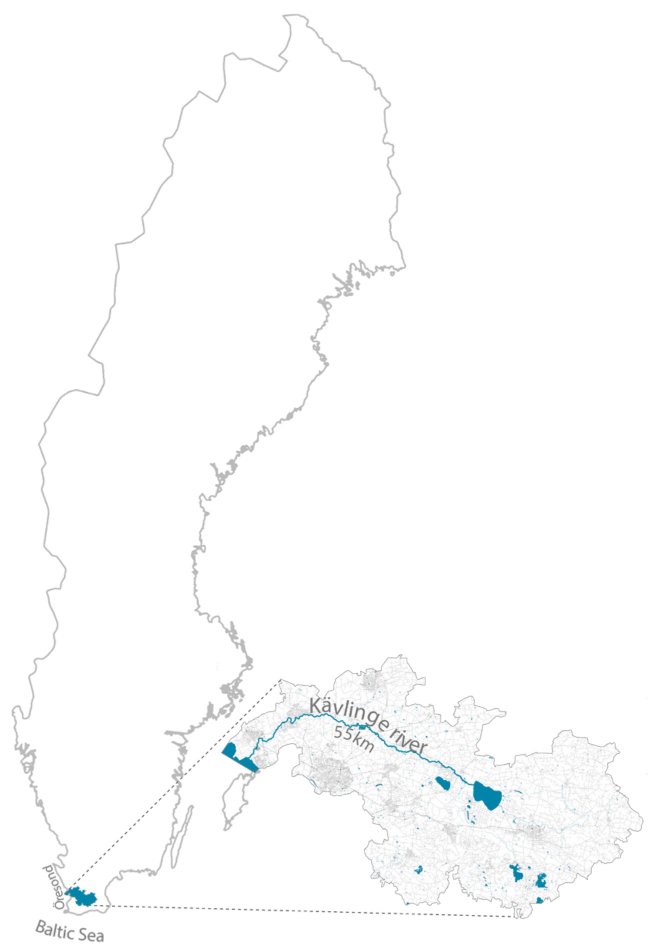


Fig.1. Location study area in Sweden

The PPGIS survey will be used to map landscape values and environmental and social challenges. Mapping landscape values which are derived from ecosystem services is a fitting method to identify the social and cultural benefits that residents from an area experience (Brown, 2012; Fagerholm et al., 2012). The study will focus on the flooding and recreation part of the goals from the Kävlinge Water Council. Therefore, the aim of this thesis is to apply and explore PPGIS as a tool in the design process of planning for flood and stormwater resiliency in the Kävlinge river catchment.

This thesis is structured in the following manner. Chapter 1 provides an overview about the potential and possible need for PPGIS in the planning process and river catchment management. Chapter 2 describes the different methods used in this thesis. Chapter 3 explains the theoretical framework that forms the basis for the PPGIS survey. Then chapter 4 talks about flood mitigations and river restoration techniques that can contribute to flood and stormwater resiliency. Chapter 5 analyses the landscape characteristics of the study area and the flood risks and accessibility of the river Kävlinge. In chapter 6 the results of the PPGIS survey are analysed. Chapter 7 describes the design process that made up for the conceptual plan. This thesis ends with the discussion in chapter 8 that talks about improvements for PPGIS in this design process. The conclusion of this thesis is presented in chapter 9.

1.2. PPGIS and reaching participants

Kahila-Tani et al. (2019) identified the advantages and disadvantages of online PPGIS by reviewing several PPGIS projects. The authors concluded that PPGIS can reach a broad spectrum of people and the silent majority. PPGIS has the potential of reaching the 'silent majority' better than in conventional participatory methods such as public meetings. Where most of the time organised interests' groups and the most vocal and active citizens are present (Innes & Booher, 2004). Though scholars have been critical about this potential of GIS saying that it should be a tool to be add to the existing toolbox of participatory planning rather than replacing existing participatory tools (Rall et al., 2019).

1.3. Research questions

The degradation of rivers and their ecosystem services ask for interdisciplinary management that include local based knowledge. There is a need to not only include scientific knowledge but also local experience in decision making of river management. PPGIS present itself as a useful method in revealing stakeholders' values and collecting local knowledge. Therefore, the aim of this thesis is to apply and explore PPGIS as a tool in the design process of planning for flood and stormwater resiliency in the Kävlinge river catchment. This study explores the contribution of PPGIS in a design process by applying the tool in the study area Kävlinge river catchment. Furthermore, by analysing its weaknesses and formulating improvements points this thesis hopes to contribute to and inspire future research on PPGIS for flood resilience in river catchments.

Research question (RQ): How can PPGIS contribute as a tool in a design process for flood and stormwater resiliency in a river catchment?
Sub research question 1 (SRQ1). What measurements can be applied to mitigate flood and stormwater in a river catchment?
Sub question research 2 (SRQ2): Which areas in the study area are vulnerable to future flooding.
Sub research question 3 (SRQ3). How accessible is the river by public transportation and by foot?
Sub research question 4 (SRQ4): What water related challenges does the project group perceive in the study area and what kind of solutions would they prefer?

2. Methodology

This study used literature, PPGIS survey, site analysis (GIS site analysis and site visit) and designing. These methods all contributed to answer the RQ and the conceptual plan of this thesis. Figure 2 show cases the methods used.

2.1. Study area

The selected area for this present thesis study is partly located in the Kävlinge river catchment (Figure 3). This river catchment is located in the South of Sweden, Skåne. The catchment area is about 1200 km2 (Om – Kävlingeån, n.d.)

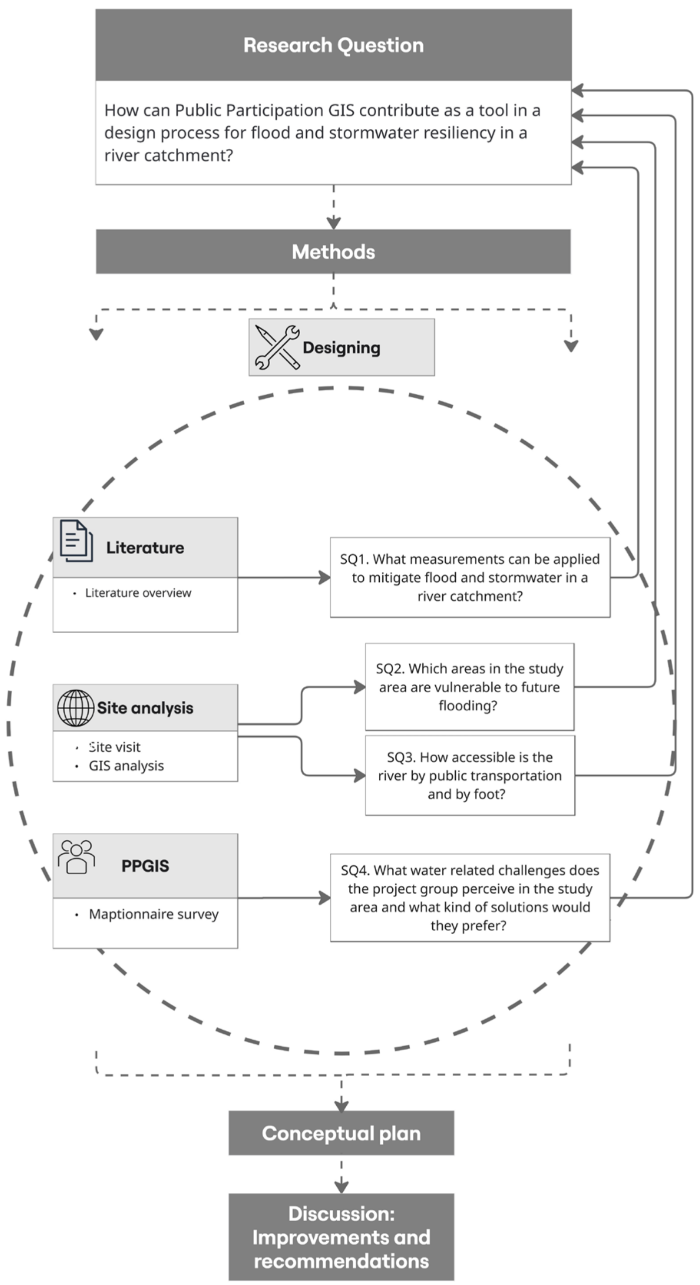


Fig.2. Thesis methods. Overview of methods used and how the sub research questions contribute to answering the research question.

The river is around 55km long and springs from the lake Vombsjön and ends in the Oresund sea. The largest side channels of this river are Bråån, Klingavälsån and Björkaån. Management of this catchment falls upon the Kävlinge Water Council. The continuous goals as described in their Water Conservation Programme have been to mitigate flood and drought in the river, reduce nutrient transportation in water bodies, promote biodiversity and promote recreation and outdoor activities (Om – Kävlingeån, n.d.). The latest by increasing the connectivity from cities and villages to nature areas and water environments with public transportation hubs and walking paths and trails.

The Kävlinge river catchment encompasses the municipalities Lund, Sjöbo and part of Eslöv municipality. Since 2024 these municipalities together applied for the UNESCO Biosphere candidacy under the name Storkriket(Biosfärområdet Storkriket, 2025).

The term biosphere refers to the layer of air, water and living organisms that surrounds our planet. UNESCO selects biospheres reserves around the world with the aim for them to lead in long-term sustainable social developments. Storkriket would be Sweden's 8th biosphere reserve. Having the title 'biosphere reserve' would increase the opportunities in this area for fundings that contribute to research, testing innovations, demonstration of projects and environmental monitoring (Biosfärområdet Storkriket, 2025). The organisation behind Storkriket was interested in the type of information that results from a PPGIS survey for their area and were willing to help distribute the survey. That is the main reason the study area of this thesis includes the landscape of this soon to be biosphere, Storkriket.

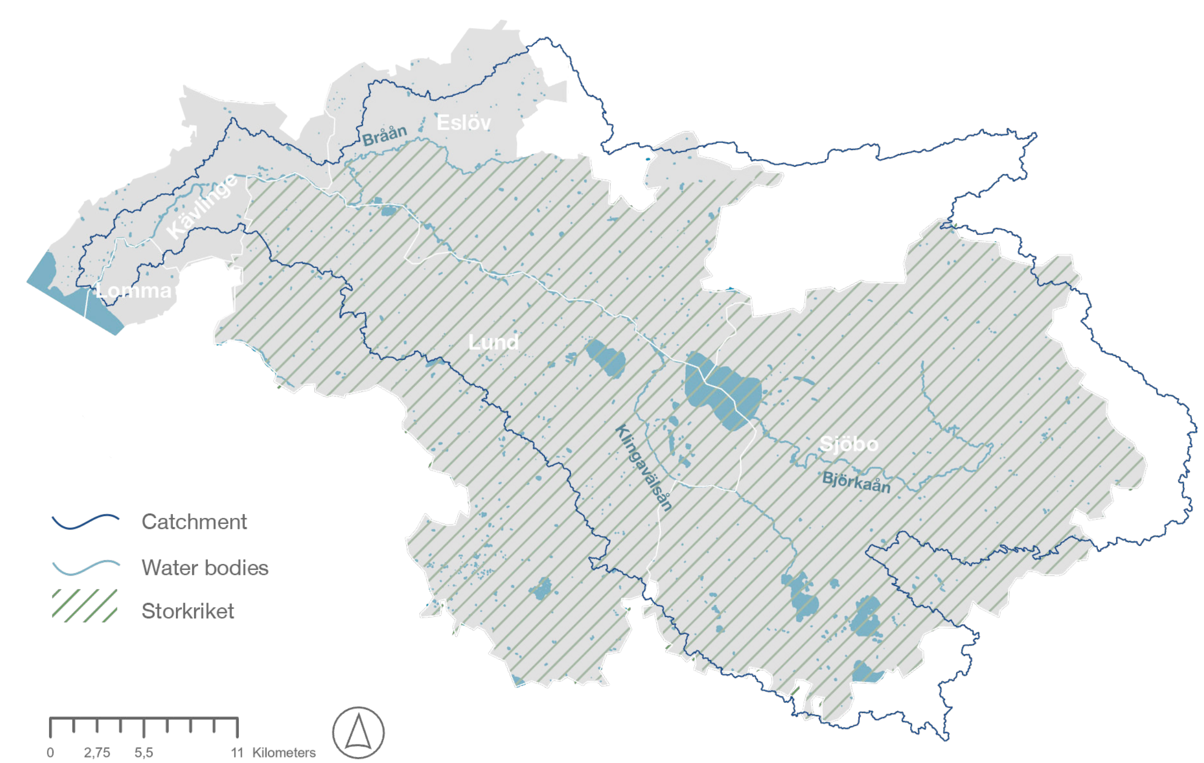


Fig.3. The study area includes the biosphere Storkriket and falls partly in the Kävlinge river catchment.

2.2. Literature

This thesis study searched for literature on two thematic aspects: (1) on practices in river catchments to mitigate flood; and (2) on PPGIS. Literature was found through the SLU library data base with an exception to a few on google scholar. Online and physical articles were used for this thesis study. A combination of different key words was used to search for literature including but not limited to river/stream, management/restoration, river catchment, flood, mitigation. Literature was also used to gather information on PPGIS and especially in the context of river catchment projects. These articles formed the basis for the theoretical framework and the survey. The questions were formulated after reading what other studies have researched. It was important to formulate similar questions so that results could be compared with existing research. A combination of key words was used for this including but not limited to PPGIS/public participation GIS, stakeholders, river, river catchment, ecosystem services, landscape values. After finding relevant literature a short thread search was used, sometimes called backwards chaining or chain searching.

2.3. Site Analysis

This included a site visit to the study area and GIS site analyses in ArcGIS.
The study visit was to experience how accessible the river is by bus and by walking. And to get an impression of the study area. I went three times to the study area on the 11th of February and the 22nd and 23 of April. On the first visit I went to Tolånga, Sjöbo, Flyinge and Kävlinge. On the second visit I went to Bjärred and Lund. On the third visit I went to Kävlinge again. At every stop I tried to walk to the river and made pictures and drawings. The second and third visit was combined with distributing the survey. A more in-depth landscape analysis is conducted in ArcGIS based on the following topics:

- Land use
- Future flood scenario
- Historical river course
- Transportation & accessibility.

According to Nijhuis (2016) and Liu and Nijhuis (2020) GIS provides spatial knowledge that is of value in the field of landscape architecture. GIS helps landscape architects see the hidden landscapes structures and compositions (Nijhuis, 2016). It can realistically simulate past, present, and future scenarios. And can provide designers with understanding the spatial connectivity and accessibility of a site (Liu & Nijhuis, 2020). GIS's various tools to transform information and data and visualise this into understandable maps makes it an important medium in this thesis.

Future flood scenario

A future scenario of flood risk was made in Scalgo. Scalgo is a software that analysis surface water in a landscape. By manipulating precipitation and sea-level rise, future flood scenarios can be visualized and calculated. In Sweden Scalgo uses data of the terrain and its infiltration capacity to make these calculations. I used Scalgo to map pluvial flooding due to cloudburst and coastal flooding due to sea level rise. The scenario that this study works with is a 2meter sea level rise and a cloudburst of 50mm rain based on future predictions of Swedish Meteorological and Hydrological Institute (SMHI) (Sjökvist et al., 2025) and IPCC (2021). These criteria scenarios entered into Scalgo reveals terrains that are potentially flooded at the Sea-Level Rise and the Flooded Areas with the Flow Accumulation. The Flooded Areas together with the flow accumulation display a static model and do not consider the duration of the rain event. The Flooded Areas show the water in depressions for the described cloudburst event. The Flow Accumulation layer shows how water flows on the surface of the terrain between depressions. Together with ArcGIS I could identify vulnerable areas and buildings in the study area during this scenario.

Historical river course

The historical river course of Kävlinge was analysed to determine where the river used to meander. The method for this analysis is georeferencing. This method made it possible to transform the historical maps I found and match them with the official Swedish coordinate system, SWEREF 99. It uses control points in scanned maps and aligns this to control points in digital maps. For each historical map I used at least five control points.

Transportation & accessibility

A buffer analysis was conducted for the transportation and accessibility analysis. The aim of this analysis was to investigate how accessible the river is by bus and by walking. A buffer is a set distance zone around a geographic object. The buffer analysis calculates the extent to which this object is available to another geographic object. In this case I analysed the extent to which the river is available to houses. And the extent to which bus stops are available to houses. The buffer criterium is set on 300m from the 3-30-300 advise by (Konijnendijk, 2023). This advice concerns green spaces in cities. I used this as a criterium in this thesis study because I am of opinion that a river has the potential to provide similar health and recreative services as green spaces. The buffer criteria for the bus stops are based on literature about comfortable walking distances to transit stops. A basic rule in this field describes a distance between 400 and 800m for residents to the nearest bus stop or transport node (Stojanovski, 2020; Mu & Jong, 2012). The distance worked with in this present study is the average, 600m. Different than the other analysis, the buffer analysis only includes the municipalities that intersect with the river Kävlinge. Since the river does only run through a few municipalities in the project area.

The sources for the GIS site analysis area presented in table 1. And the flow diagrams for the analysis can be found in appendix B, C and D.

2.4. PPGIS survey

The PPGIS survey was one of the main data sources for this thesis. The platform to make this map-based survey, Maptionnaire, was provided by my supervisor. This software is decided on because of its user friendliness.

The aim of the survey is to acquire an impression of the social and environmental challenges residents perceive, map landscape values and measure sense of place. Respondents were asked to fill out the questionnaire on Maptionnaire (Figure 4). The survey ran from the 1st of April till 31st of May. The survey was sent by mail to respondents and also handed out as a flyer with a QR code that led to the survey's website. Table 2 shows how the survey was distributed.
Respondents' results were extracted from Maptionnaire into an Excel spreadsheet and into ArcGIS to analyse. The results were analysed in a quantitative way in the form of a heatmap with the GIS kernel density tool and other maps. Kernel density is a GIS tool commonly used in PPGIS to analyse data (cf Korpilo et al., 2023; Czepkiewicz et al., 2018; Rall et al., 2019). The kernel density tool calculates the density around points in a neighbourhood. Showing a high density where there is a cluster of points and lower density further away from the cluster.

Table.1. Data and sources used for the analysis in ArcGIS

Dataset	Source	Criteria buffer/future scenario
Topographic Map	Lantmäteriet	
Property map Built-up areas	Lantmäteriet	
Property map Transport networks	Lantmäteriet	
Property map Hydrography	Lantmäteriet	Kävlinge river 300m
Flooded areas	SCALGO	50mm
Sea-level rise	SCALGO	2m
Flow accumulation	SCALGO	
History map	Stockholms universitetsbibliotek	
Bus stops	Lantmäteriet	600m
River Catchment	SMHI	
Historical wetlands	SMHI	

Table.2. Distribution survey

Survey distributed to:	Type of medium
Organisation Biosphere Storkrikket	Mail
Kävlinge Water Council	Mail
Kävlinge municipality	Mail
Lomma municipality	Mail
Eslöv municipality	Mail
Sjöbo municipality	Mail
Lund municipality	Mail
Lund Library	Flyer
Kävlinge library	Flyer
Bjärred Library	Flyer
Fishing association Kävlinge-Lödde (FVOF)	Mail
Landscape architecture students at SLU	Mail

The survey started with introduction questions where respondents were asked to answer questions about their age, sex, and education. Followed by questions where they had to: choose to which stakeholder group, they identified themselves, if they lived in the study area, and if so, where. This introduction part was followed by questions where participants were asked to map landscape values, and environmental and social challenges in the study area. An example of environmental challenges included flooding, poor water quality, and erosion. Follow up questions about the placed landscape values included how often they visited this place and what kind of recreational activity they undertake.

This part was followed by questions where participants could map areas that according to them need improvement concerning the environmental quality, recreational and cultural facilities and path and accessibility of the place. With environmental quality respondents could choose between a set of river restoration techniques but were also free to come up with own solutions. The last part of the survey asked about respondent's experience with flooding, involvement in flood management and their favourite place in the study area.

Fig.4. PPGIS survey on Maptionnaire

2.5. Design process

The design process in landscape architecture and different approaches.

This study follows the analytical design approach described by Milburn and Brown, (2003) to answer the RQ and design a conceptual plan for the study area. In this analytical approach as Jansson et al. (2019) explains research is central to design and informs the concept generation. In the field of landscape architecture research is incorporated at different phases in the design process Milburn and Brown (2003): Phase A before design (intrinsic research, literature research, review of examples and case studies and site analysis); phase B during the design where research helps to form the concept; phase C after designing where research helps to evaluate and justify the design.

Milburn and Brown (2003) identified different approaches practitioners have for using research during design, phase B. They have categorized these approaches in four models: (1) Artistic (2) Intuitive (3) Adaptive (4) Analytical and (5) Systematic. The analytical model is visualized in figure 5. The triangular forms visualise research and the circles visualise the concept. The site is the rectangle. The research done is adjusted and changed by the concept. Because the research has to fit the site and its challenges and might not be applicable in its traditional form Milburn and Brown (2003).

The emphasise in this approach is the process rather than the end product and differs in that way from the other models (Jansson et al., 2019; Milburn & Brown, 2003).

The analytical approach in this thesis

Based on the analytical design model of Milburn and Brown (2003) my own design process is visualized in figure 6. In phase A the literature read, *informs* this thesis with *flood mitigation and river restoration techniques* and knowledge on how to *formulate a PPGIS survey*. The run-up to phase B is *formulating general rules*. Here the site analysis and the goals of Kävlinge Water Council help formulate general rules that support the concept forming in phase B. These general rules are not strict but give direction to the following phases and support design decisions that are being made. Phase B starts with B1, the general rules formulated earlier give direction in visualizing and formulating the *conceptual strategies* and *allocate* them in the study area. In phase B2 the results of the survey provide additional research for the design process. The results are *evaluated and visualized* in the study area. New literature may be needed to formulate solutions for specific challenges that resulted from the survey. In phase B3 the allocation of the conceptual strategies and the PPGIS results are combined in a *conceptual plan*.

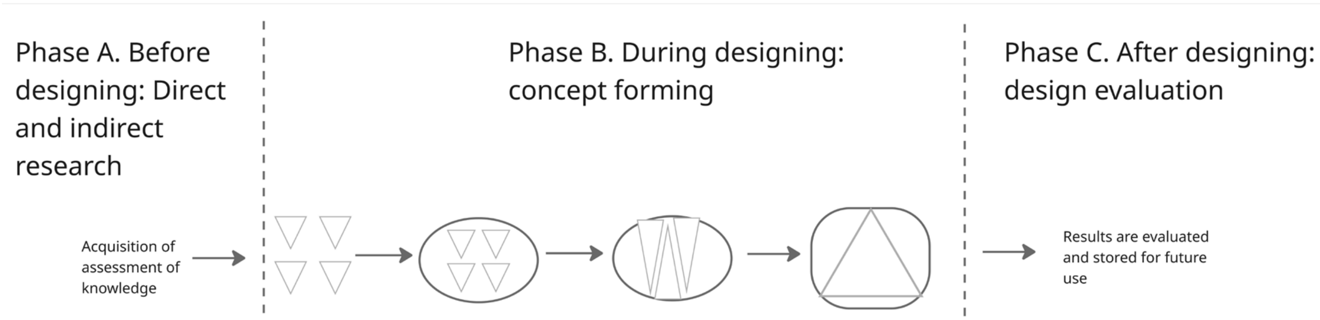


Fig.5. The analytical model modified from Milburn & Brown (2003).
In this design approach, research (triangle) informs the concept generation, and the concept (oval) modifies the research. Since the site (rectangle) needs the research to adapt to it specific issues.

Phase C presents itself in the discussion of this report. Where the methods are discussed and recommendations for PPGIS in this thesis and further research are debated. This study examines how PPGIS can contribute to the design process and the added value of PPGIS will become clearer as the study progresses. Where exactly and how PPGIS contributed to the design process depends not only on how the PPGIS survey is formulated but also on how it is answered by the project group.

Comparing the analytical approach with the other approaches

A critique on the analytical approach is that it is less creative compared to the other approaches Jansson et al. (2019). For example, in the artistic and intuitive approach where research is sometimes set aside when generating the concept. Respondents in the study of Milburn and Brown (2003) have vocalized that research can be a limiting factor in designing and can negatively affect creativity. However, the analytical model is one of the models where research plays the most prominent role in the design process. And therefore, aligns best with this thesis that combines different knowledge types derived from different research methods. The local based knowledge derived from PPGIS, and scientific knowledge derived from the GIS site analysis, documents, and literature.

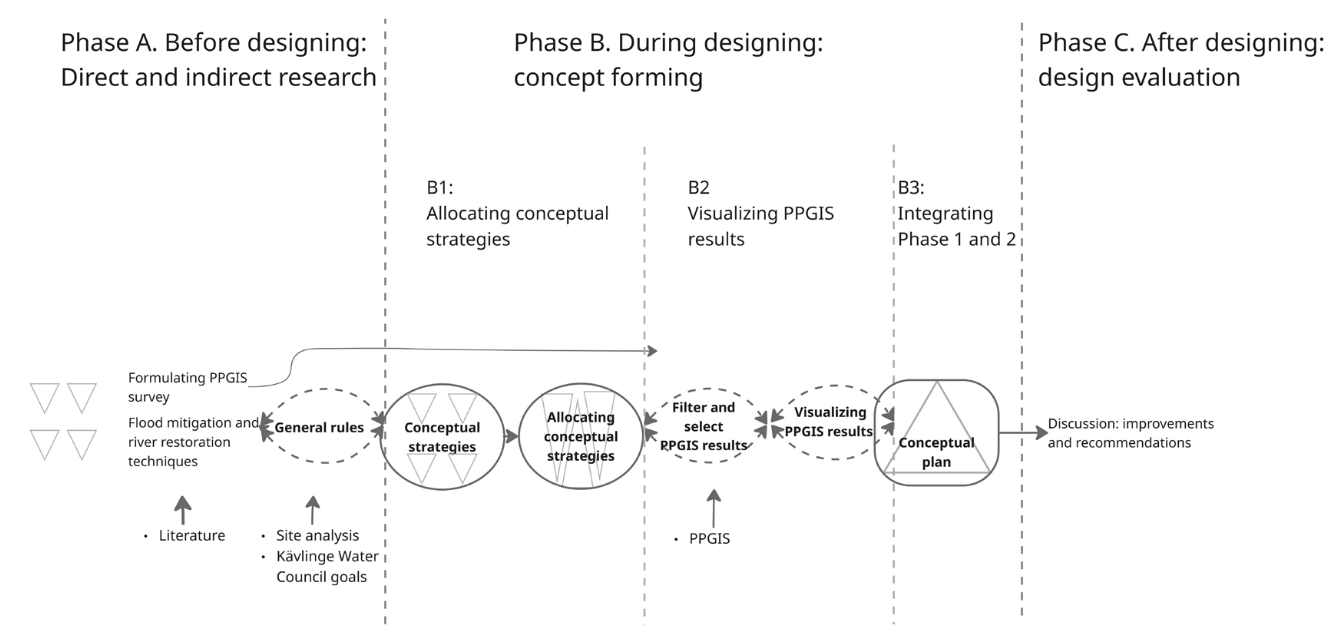


Fig.6. The analytical design approach in this thesis.
The analytical design approach in this thesis. The process seems linear, and phases seem to have a clear end and beginning. However, in practice I have worked at different steps and phases at the same time or came back to a step.

3. Theoretical framework

This chapter explains the theoretical framework that formed the basis of the PPGIS survey in Maptionnaire. The survey questions are based on the typology landscape values, sense of place theory and stakeholder categorization.

3.1. Landscape values

Since the early 2010's PPGIS has been more and more used as a tool to engage the public and stakeholders in identifying Ecosystem Services (ES) in the landscape (Brown & Fagerholm, 2015). ES are services from the ecosystem people direct or indirect benefit from (Brown et al., 2015). There are for example provisioning services such as food and fresh water but also cultural services such as recreation and education (Millennium Ecosystem Assessment, 2005). The study of (de Groot et al., 2010) on the connection between landscape values and landscape attachment concluded that mapping ES reveal the connection between landscape features and human wellbeing (de Groot et al., 2010). Using this method in PPGIS provides a complementary way to the mapping of ES based on experts (Brown & Fagerholm, 2015).

The need to evaluate nature's services in a place-based way is noticeable in participatory multifunctional management. It is crucial in planning for multifunctional management to include a variety of stakeholders and for them to be able to participate (Cowling et al., 2008; Potschin & Haines-Young, 2013).

There are different typologies to map ES but one of the common ones is 'Landscape values' also called social values for ecosystem services, formulated by (Brown & Reed, 2000; Sherrouse et al., 2011). An example of these landscape values is aesthetic/scenic, economic, and historic. The landscape values for the PPGIS survey are based but not restricted to this typology (Figure 7). The study of Garcia et al. (2017) also includes negative landscape values. An example of these negative LV is aesthetic unpleasantness, flood risk, and sense of insecurity. These Negative LV helped identifying how and where urban streams should be improved (Garcia et al., 2017). Schröter et al (2023) do something similar but names it social and environmental challenges. For example, restricted access to river and soil pollution. The survey questions in this study about environmental and social challenges are based on but not restricted to the typologies of Schröter et al. (2023) and Garcia et al. (2017).

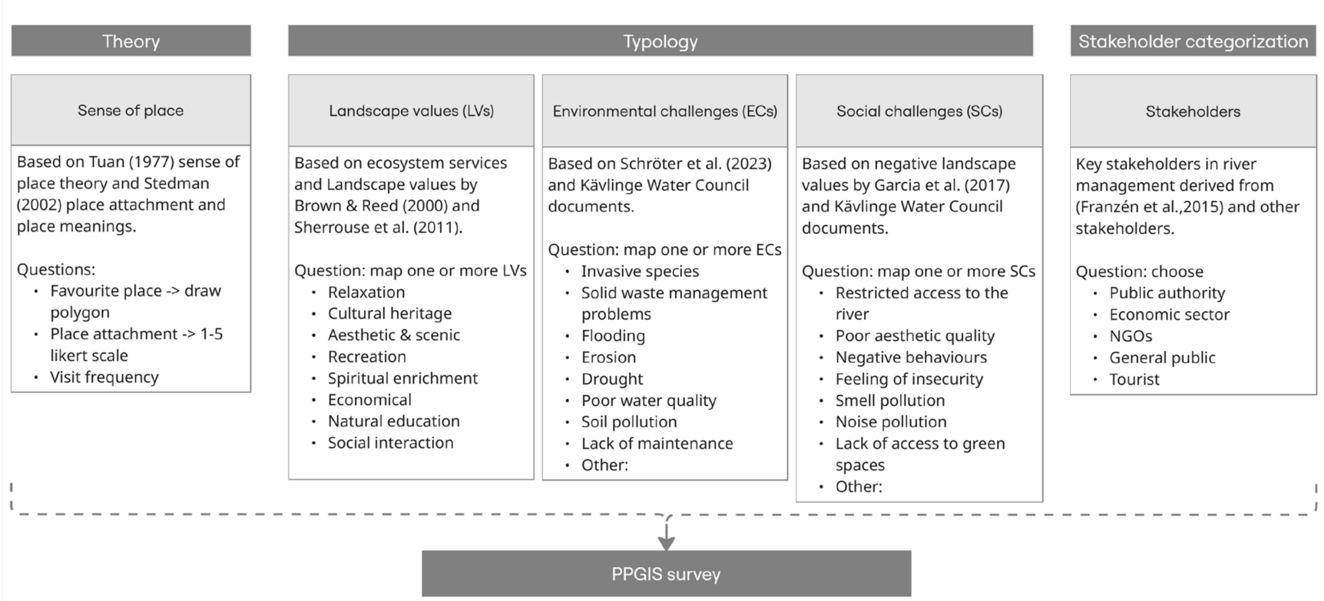


Fig.7. Theories and typologies that form the basis for the PPGIS survey in Maptionnaire.

3.2. Sense of place theory

Sense of place theory by (Tuan, 1977) is described as a person's value towards a place and their attachment to this place. This theory is an umbrella construct which includes place attachment and place meanings (Stedman, 2002) and is shown to be related to environmental stewardship. Environmental stewardship is defined as a person's pro-environmental behaviour and the extent to which someone cares for the environment and uses it in a responsible manner (Bennett et al., 2018). Stedman (2002) carefully concludes that place attachment is positively related to local stewardship. Explaining that a high place attachment and low place satisfaction, not inherently linked, results in a person's motivation to engage in place protective behaviour.

Someone's sense of place with PPGIS can be measured with a variety of combination of survey questions about mapping favourite/meaningful places, mapping landscape values, frequency of visit and scoring statements related to place attachment 'sense of place.' An example of the questions: "place X" is very special to me. and I identify strongly with "place X" (Williams & Vaske, 2003). Gottwald and Stedman, 2020) used this method in their study about environmental stewardship for riverine landscapes. In their study participants were asked to map their favourite places in the landscape and were asked to select values to that place. Gottwald and Stedman, 2020) believe that people who value a place for its multiple ecosystem services show pro environmental behaviour towards the place. Participants were also asked about their attachment to the place, frequency of use and willingness to show environmental favourable behaviour. Their study showed that a strong sense of place results in a higher level of local environmental stewardship. Furthermore, several authors agree that sense of place concept helps explain people's position in decision making processes (Hausmann et al., 2016; Masterson et al., 2017).

3.3. PPGIS and and stakeholder's categorization

Usage of 'public' in PPGIS may refer to the broad definition of stakeholders "those affected by planning decisions (Brown et al., 2015,pp 2)." This includes almost everybody from the general public to decision makers and everything in between. However, the traditionally analysis of stakeholders means the identification of key individuals and or representative figures and groups with a specific policy and domain (Reed et al., 2009). This is a narrower definition of stakeholders.

PPGIS studies that have categorized their stakeholders in the narrow definition have done this to show and analyse the differences between stakeholders and their type of knowledge (García-Nieto et al., 2015). This study includes key stakeholders of river management derived from (Franzén et al., 2015) and are defined as key water users and managers (farmers, suppliers of water and wastewater services, monitoring authorities, and nongovernmental organizations (NGOs) with an interest in recreation and environmental protection. As well as two new stakeholder groups, tourist, and the general public. These tourists and the general public might have little to no influence in the management of the river catchment but do use the river and it landscapes and will be affected by its management.

By asking respondents about their relationship with the study area it was possible to group them in categories. Respondents could describe their relationship as: A. I work on a national or local level on water issues and landscape management (Public authority), B. I work as a farmer or forester (Economic sector), C. I am involved at a non-governmental organization with an interest in recreation and environmental protection (NGO), D. I am a resident (General public) or E I am a tourist (Tourist). The participants who filled out the PPGIS survey will be referred to as the project group.

4. Literature overview

This chapter answers the SRQ1 What kind of measures can be applied to mitigate flood and stormwater in a river catchment. By assessing and understanding continues process that play a role in a catchment, the kind of floods that can occur and various solutions.

4.1. Coastal and inland flooding

Understanding the hydrological cycle in a river catchment is important in managing and protecting river catchments. In a broad context, hydrological processes in a river catchment can be described in the hydrology cycle see figure 8. With processes such as precipitation, interception and evapotranspiration water is being transported through rivers to the sea. Climate change affects this hydrology cycle and leads to condition changes in the catchment (Jiménez-Navarro et al., 2023). As an example, changes in precipitation can lead to alterations in catchment flows and surface runoff (Akter et al., 2018). In Sweden this can result in an increased streamflow (Graham et al., 2007).

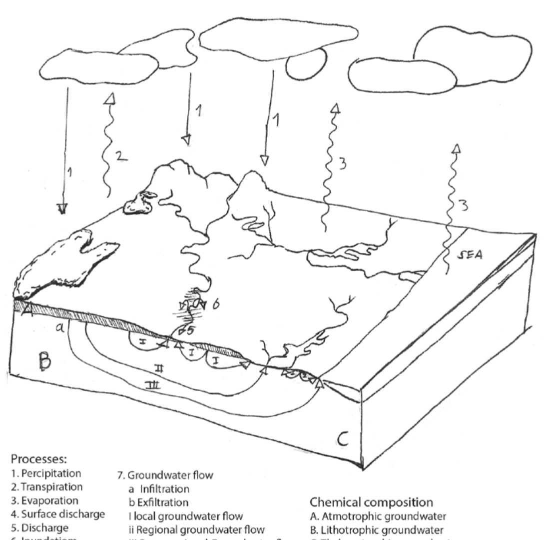


Fig.8. A simplified representation of the hydrological cycle modified from Buuren (1997). Kävlinge river catchment as a coastal river catchment has to deal with both coastal and inland flooding.

Predictions are that snowmelt-driven high flows in spring will become less severe with increasing temperatures caused by climate change (Rojas et al., 2012). Still, this can differ depending on where in Sweden.

Sea level rise is also a consequence by climate change and affects coastal catchments. A river catchment as Kävlinge that discharges in the sea is prone to inland flooding as well as coastal flooding. Due to higher sea levels, it will be more difficult for rivers to discharge in the sea. Resulting in a higher flood stage downstream than it would be upstream of the river mouth and along the flood plain (Garcia & Loáiciga, 2014).

Coastal protection can take multiple forms. Watson and Adams (2010) propose moving buildings upslope together with vertically elevating the new first row of buildings with posts. Another option they propose is still moving buildings upslope but together with creating a vegetative coastal buffer zone. The Kävlinge river discharges in the nature reserve Lödde therefore public authorities might prefer these solutions rather than hard engineering projects. Which will be in line with the EU project LIFE Coast Adapt. This project has implemented nature-based coastal adaptations in Skåne and activates for nature-based solutions because of its multifunctionality and cost effectiveness (LIFE Coast Adapt, 2024).

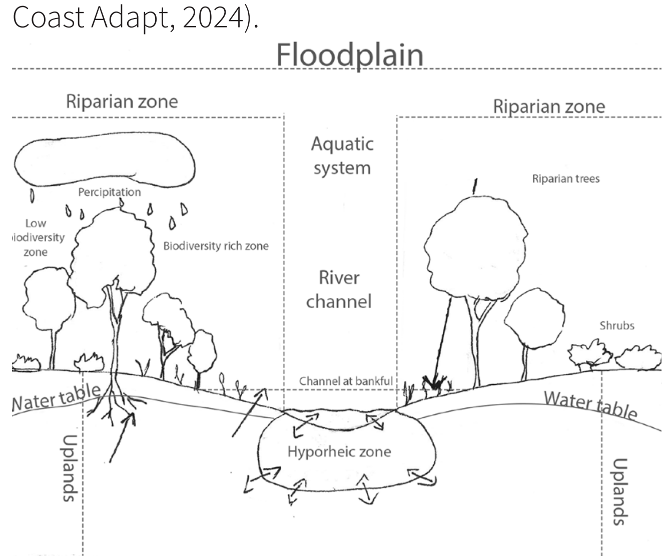


Fig.9. Riparian zone of a natural river modified from (Singh et al., 2021). The decrease of riparian zones along rivers have had a negative effect on the natural flood regulations of rivers.

4.2. Riparian zone

Riparian zones encompass the adjacent landscape of a river. They support river health and the ecosystem functions and services of a river (Singh et al., 2021). Managing this landscape is crucial for river health and its flood regulation. Figure 9 shows the riparian zone of a common river. The water knows various water levels, normal channel level, and channel at bankful. Due to agriculture intensification and urbanisation riparian zones along rivers and streams have been decreased (Singh et al., 2021). Resulting in less space for the river to flood. Management practices as riparian buffer strips return these landscapes back to the river. It regulates flooding and stabilizes stream banks (Singh et al., 2021).

4.3. River restoration

During the industrialization many rivers and their floodplains were heavily modified due to hard engineering projects (Brown et al., 2018). These projects included for example channelization, and construction of dikes and hydropower plants for different purposes (Logar et al., 2019). Rivers and their floodplains provide many ecosystem services including regulation of flood (Millennium Ecosystem Assessment (Program), 2005; Millennium Ecosystem Assessment, 2005; Tockner et al., 2010). But modifications have contributed to the degradation or loss of these services by drastically affecting the flow, quality, and structure of the watercourses (Sabbion, 2017). River restoration techniques have grown in interest to restore these lost or degraded ecosystem services (Feld et al., 2011) (Sabbion, 2017). River restoration can be defined as, "assisting the establishment of improved hydrologic, geomorphic, and ecological processes in a degraded watershed system and replacing lost, damaged, or compromised elements of the natural system." (Wohl et al., 2005, p. 2).

Close related to this is river rehabilitation. These strategies aim to restore lost ecosystem services on the river and focuses on biodiversity conservation, sustainable flood management, physical habitat quality restoration, fisheries enhancement, pollution control and cultural awareness (Gilvear et al., 2013). At last, there are connectivity strategies. The aim of these strategies is the reviving of transportation of organic material, sediment, and nutrients and connection of lateral habitats (ponds, backwater, and tributaries) (Sabbion, 2017).
The success and choice of river restoration techniques dependents on the context and the objectives. Table 3 presents techniques that contribute to the restoration of the ecosystem service flood regulation.

Table.3. Techniques that contribute to restoring rivers ecosystem service flood regulation

Rehabilitation measurements (Gilvear et al., 2013)	Restoration techniques	Restoring connectivity
Re-meandering	Road improvements to reduce impervious surfaces, the addition of cross drains, resurfacing, bank stabilization, removal or addition of culverts. Aim of all of this is to restore and reduce sediment supply, run-off and hydrology (Novotny et al., 2010).	Removal or modification of barriers and infrastructure (dams, culverts, bridges, levees) (Cowx & Van Zyll de Jong, 2004; Fullerton et al., 2010)
Buffer strip creation and riparian revegetation/woodland	Re-meandering (Vought & Lacoursière, 2010)	Levee lowering or setback (Roni et al., 2008)
Reconnecting old channels	Bioengineering technique, stabilise banks by the combination of natural materials and living plants (Cavaillé et al., 2013)	Side channel reconnection (Muhar et al., 2016)
Bank protection removal	Riparian habitat improvement by restoring the natural sinuosity and creating structures (i.e., pools, riffles, new floodplain habitats) (Sabbion, 2017).	Blue green infrastructure: Vegetated (detention, retention, basins or ponds; bioswales, rain gardens; wetlands) and unvegetated (rainwater cisterns; high flow bypass channels; porous paving or pervious pavers) systems. (Sabbion, 2017)
Restored floodplain forests	Naturalisation of riverbanks by eliminating hard structures and designing new vegetated banks and meanders with trees and bushes within channels (Sabbion, 2017).	Side channel reconnection (Muhar et al., 2016)
Removal of barriers (Flood embankment removal, culvert removal, weir removal)		

Channelized rivers transport water quickly having less retention capacity compared to a meandering river. This increases the flooding downstream. Re-meandering a river slows down the water flow, increasing its water retention capacity. It reduces the peak discharge of a rainfall and so reduces the risk of flooding further downstream.

In addition, a meandering river does not just transport matter downstream but also utilizes it by organisms and sediments it during a flood (Madsen, 2010) The different currents create and maintain habitats by sorting sediment. This creates opportunities for a variety feeding specialists (Madsen, 2010). Rivers with a steep gradient seldom have riffles.

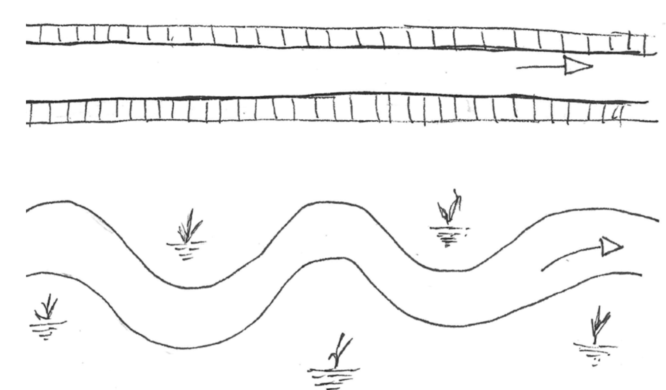


Fig.10. Difference between channelized river and meandering river modified from Madsen (2010).

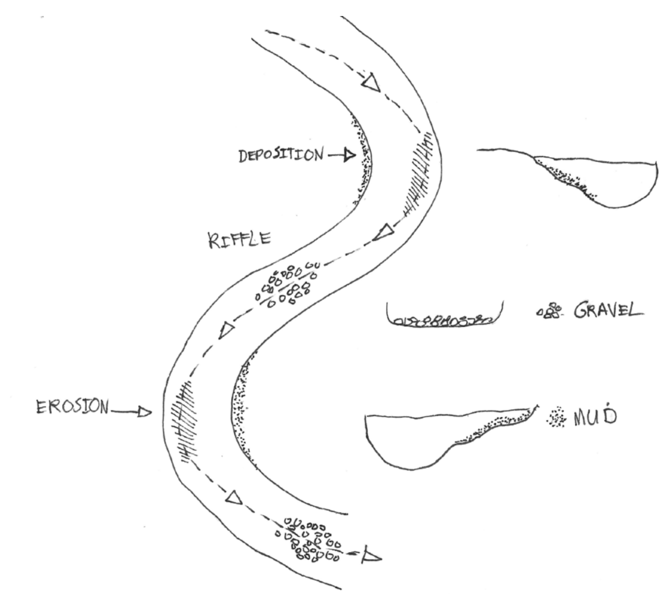
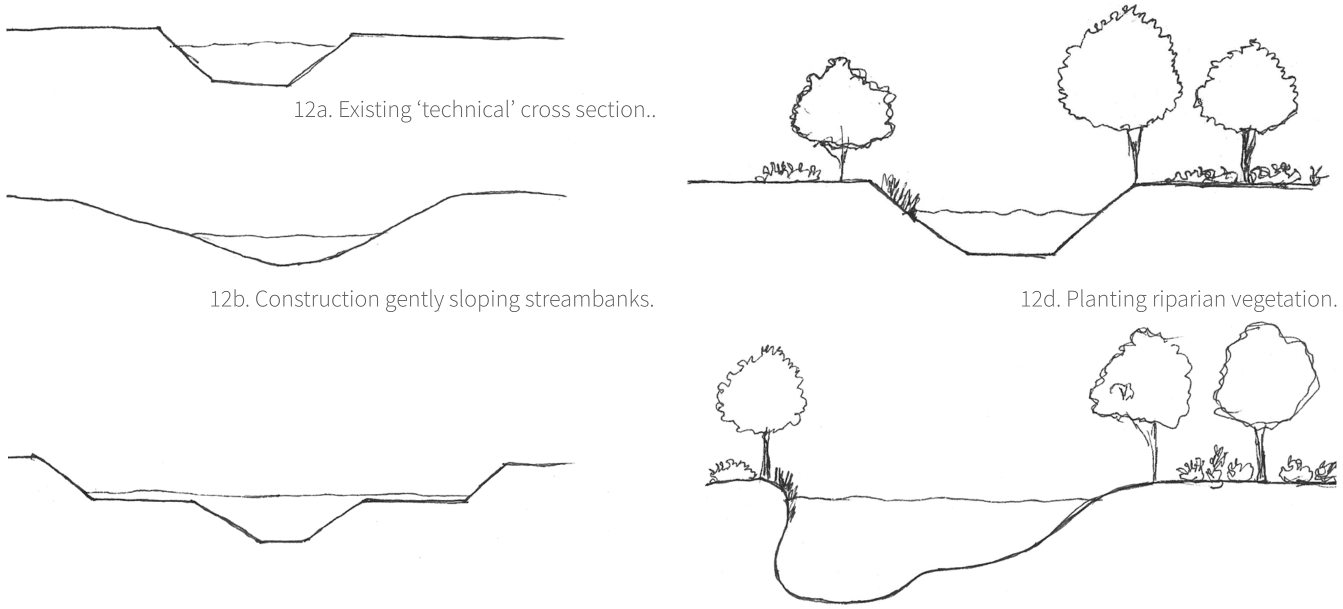


Fig.11. A meandering river stimulates different sedimentation which supports a variety of habitats modified from Madsen, (2010).



12a. Existing 'technical' cross section..

12b. Construction gently sloping streambanks.

12c. Constriction two or multiple-stage channels

12d. Planting riparian vegetation.

12e. Spontaneous development of riparian vegetation.

Fig.12. Restoring a channel to its former channel characteristics with the use of channel measures, b, c, d, or e. Modified from Buuren (1997).

Restoring a channel to its former channel characteristics and increasing it water retention capacity can be achieved with different channel measures (Fig. 12). A gently sloping bank, two multi stage channel or riparian vegetation can partly restore the origin channel characteristics (Buuren, 1997). These can be alternative techniques for re-meandering.

Levee removal, lowering or setback are techniques that give the river the opportunity to choose its own course and or to meander (Roni et al., 2008). The river will be able to connect to its floodplain, and their ecosystem services can be restored. Including retention and natural water exchange between the main streams and its floodplains.

Reducing impervious layers is a strategy for allowing more rainfall infiltration and less surface runoff (Watson & Adams, 2010). There are many strategies to reduce imperviousness in a catchment for example, rain gardens and retention basins (see Table 3, blue green infrastructure in Restoring connectivity). Other methods that focus on roads and streets can be narrowing streets and driveways or by implementing porous pavements. Watson and Adams (2010) explain that with porous pavements rainfall is temporarily stored into the voids of the pavement bed and slowly infiltrates the uncompacted fill underneath. The geotextile works as barrier and prevents the migration of soil into the bed. Porous asphalt or porous concrete work as suitable replacements for most roads and waking paths (Watson & Adams, 2010).

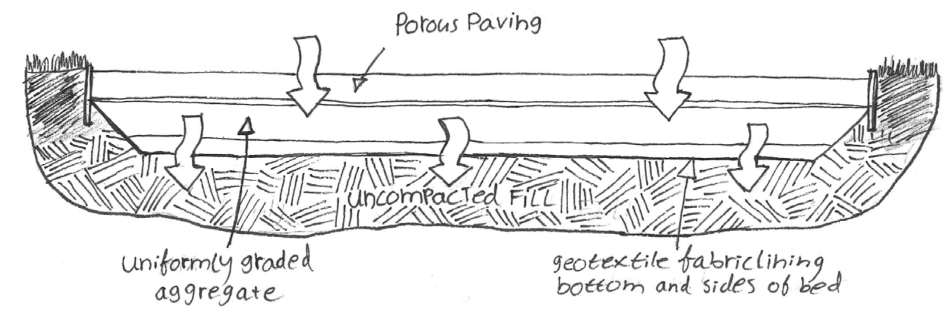


Fig.13. An example of porous paving. Modified from Watson and Adams (2010).

4.4. Agriculture stream restoration

Vought and Lacoursière (2010) provide a set of stream restoration techniques that are suitable in agriculture landscapes in Skäne. They clarify that with the start of tile drainage within the last 150 years; streams have drastically changed drainage. Resulting that the relatively low relief streams were incapable in lodging the increasing volume of water from the tile-drainage network. The streams were straightened and deepened to accommodate these new water volumes (Wolf, 1960). Together with the intensification of agriculture, riparian vegetation has been diminished. At the point where streams were merely seen as drainage and were put underground with the use of pipes.

The authors argue that this has led to the decoupling of streams to their floodplain. This resulted in a decrease in groundwater levels, local and sometimes regional. Including the following two negative effects that influence the ecosystem service flood regulation.

- Changes in the stream hydrography
- Changes in channel stability

The changes in hydrography have resulted in high peak flows and lower base flows. Changes in channel stability has increased peak flows in channelized streams. The steep banks in combination with the smooth bottoms has resulted in a shorter channel length (shorter channel length for the same vertical drop). This has caused an increase in bank erosion and sediment transport. Vought and Lacoursière (2010) have identified five key restoration measures that can counteract these negative effects and change the streams to a more functional and natural condition. Were and how these measures can be implemented is explained in table 4.

- Re-creation of buffer-strips (defined as the foundation-block)
- Alteration of tile-drainage
- In-channel modifications
- Creation of riparian wetlands/ponds
- Day lightening

Still the authors recognise that the drainage function in agriculture land use is particularly important therefore, only implementing buffer strips along the streams can already support the return of key ecosystem services. In addition to this implementing other measures on tactical places such as locations with high nutrient level, high runoff, high erosion can further contribute to reinstating of a river valley or stream.

Table.4. Agriculture stream restoration techniques (Vought & Lacoursière, 2010)

Techniques	How and where to implement
Re-creation of buffer-strips/riparian vegetation	Along streams. Minium width of 10m
Creation of riparian wetlands/ponds. Wetlands and ponds increase the retention time, hydraulic storage and sediment trapping. Also, the build-up of these organic material increases the denitrification. Another benefit is that wetlands/ ponds contribute to the biodiversity of the landscape.	Excavate an area along the stream where water can be split from an upstream area and can also return to the stream after it has spent some time in the pond. Close to the draining basin close to the sea is most effective place but along the stream is also already quite effective. Or current agricultural land that are seasonally wet, difficult to plough and or less valuable to farmland due to the mineralisation of peaty soils. These are signs that the land used to be a former wetlands or swamps and a good place to restore these wetlands.
Recreating Meanders This is one of the most stable stream configurations. It contributes to water velocity compared to straightened channels as well as adding to an increase of the friction area.	This is a big undertake and requires experts on hydrology and geomorphology. Roughly the wavelength should be 10-14 times the full bank of watercourse.

Buffer strips have the ability to delay flows by allowing infiltration therefore contributing to the decrease of flood risk downstream (Boardman & Vandaele, 2023). Still the extent of effectiveness depends on the size of the buffer. Buffer strips have mainly been tested for their ability of reducing nitrogen and nutrient leaching to streams and groundwater. Still in the most optimal situation buffer strips may decrease in the volume and timing runoff water entering a stream therefore lessens the peak flow. This is caused by evaporation; more amount of rain is caught by leaf litter and returned to the atmosphere and therefore not reaching the ground. In addition, ground roughness of plants and trees capture water in small topographic irregularities. This contributes to a slower runoff velocity.

5. Site Analysis

This chapter presents the GIS site analysis focussing on land use, future flood scenario, transportation & accessibility and the historical river course and the site visit. It answers SRQ2 'Which areas in the project area are vulnerable to flood and stormwater?', by analysing the vulnerable land use types and buildings in a future flood scenario. It also answers SRQ3 'How accessible is the river by public transportation and by walking?', by presenting an overview of the transport network in the study area, highlighting buildings that do not have access to the river and my own experience in the accessibility of the river.

5.1. The study area

Kävlinge river catchment includes the municipalities Lund, Kävlinge, Lomma, Sjöbo and part of Eslövs municipality. Kävlinge river starts in the lake Vombsjön and ends at the sea close to Bjärred and is around 55km long. In the lower part of the river the name changes to Lödde. The landscape is characterized by agriculture and most of the land is intensively cultivated. The share of the different land uses is shown in figure 14. Open space in the study area refers to spaces as squares, Deposition from the glacial periods led to the sedimentation of fertile soils in the catchment with the exception of the sandy soils around lake Vombsjön (Krug, 1993). The study area provides habitat for various species (see Figure 15). An important species is the stork that has been re-introduced in the area since 1980's through rewilding programmes (Kävlingeå-projektet, n.d.). Many wetland birds including the stork disappeared in the 1940's because of the drying out of wetlands and meadows. But the study area also has to deal with species that form a threat to the landscape.

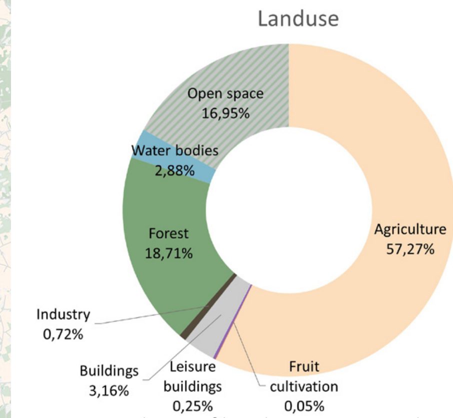


Fig.14. Share of land use types in the study area.

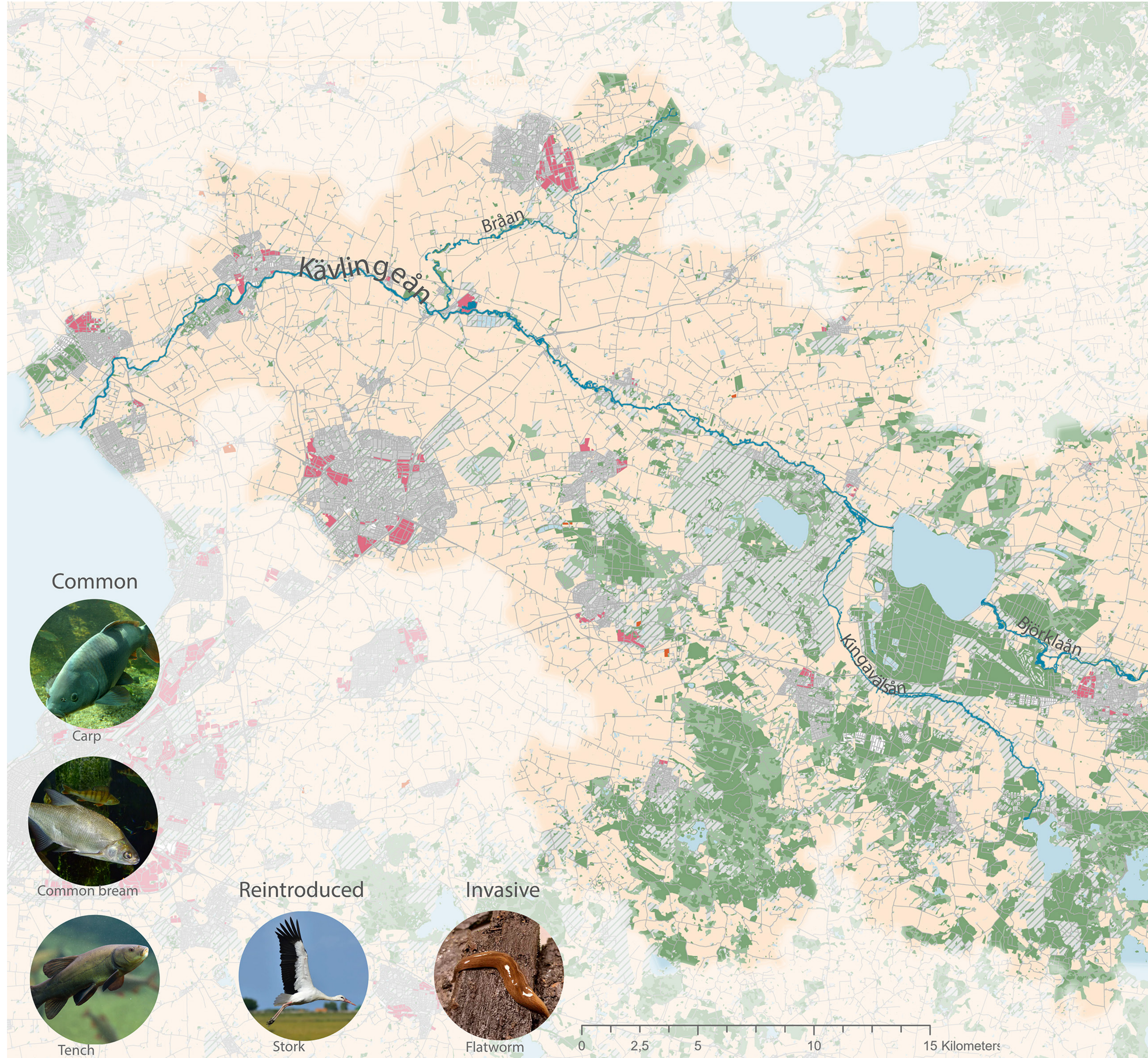


Fig.15. Study area with its main rivers and fauna.

For example, the weed ragwort (Jacobaea vulgaris), although not invasive still can form a threat due to its toxicity for varies animals such as cattle, sheep, and horses (Figure 16). The plant can cause liver failure to these animals, and The Swedish Veterinary Institute advises to ensure that animals do not have access to the plants (J | Skogensrost, n.d.). An invasive species that has been identified in the study area is the invasive flatworm. This species eats other worms thar are useful in loosening up the soil in agricultural land (Invasiv plattmask i Sverige – kontrollera importerade växter, 2024).

Fig.16. Ragwort weed with flowers (J | Skogensrost, n.d.)

Revingehed military field

Landscapes in the study area with different functions are of interests to this study's research question. An example of a landscape with different functions and maybe even controversial ones is Revinge field. Revinge field is a Nature 2000 area located about 20km east from Lund (Figure 17). The management and regulation concerning a Nature 2000 has as aim to prevent the extinction of animals and plants. This Nature 2000 area is about 4500 hectares and includes pastures, agricultural land, forests and is a popular recreation place for local residents (Länsstryrelsen Skåne, 2018). For various recreation activities as hiking, swimming, and horse riding. However, within this nature area the military training field of the Southern Skåne regiment P7 is situated. This regiment started training here in 1887. The heavy vehicles used for training have created sandbanks that are now habitats for several red listed animals and plant species (Stenberg et al., 2021). The training mainly takes place in agriculture fields and some forested areas (Figure 18). These forests are then subjected to technical training requirements to mitigate nature impacts as much as possible.

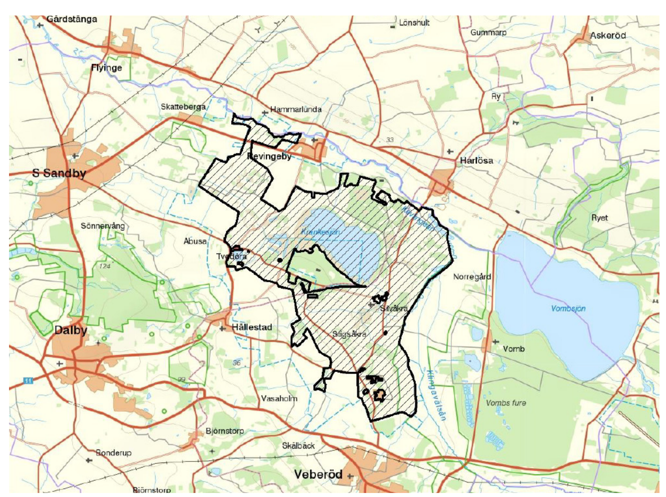


Fig.17. Revingehed military field (Länsstryrelsen Skåne, 2018).

Wetlands: The mouth of the river

The river Kävlinge changes name at the mouth of the river to Lödde. This nature reserve (Figure 19) is a valuable landscape for birds and has a rich fauna (Löddeåns Mynning (Norra Delen), n.d.). For example, the grebe and spoonbill breed here. In some years, the little tern and the greater sandpiper also breed here. In the autumn geese and ducks rest in the area. The landscape consists of well grazed coastal meadows. And the presence of salt in the landscape results in wet and dry meadows that alternate with each other.

Beneath the sea water surface, the flora also creates habitats for various species. Eelgrass (Zostera marina) is a type of seaweed that grows in dense patches and forms underwater meadows. Eelgrass is important because it provides a habitat for various fish and crustaceans. This grass grows between 1 and 10m deep and occurs on the entire west coast of the Baltic Sea. Since 1980's more than half of the eelgrass has disappeared, and it is now a threatened ecosystem. Eelgrass is important because it absorbs nutrients, absorbs and stores large amounts of carbon dioxide and helps counteract climate change. In addition, the roots stabilize soil, and the leaves dampen currents, which reduces turbidity and provides clearer water (Hellenberg, 2025).

Fig.18. Military training area (Länsstryrelsen Skåne, 2018).

Fig.19. Nature reserve Lödde.

5.2. Kävlinge future flood scenario

The most recent flood along the Kävlinge river occurred in February 2024. It took place in the municipality of Eslöv (Figure 20). The river overflowed and damaged multiple properties (Engstrom, 2024). Melting snow and precipitation contributed to the rapid increase in the river's water level, causing the flood (Nyheter, 2024). Though this flood occurred in February SMHI warns for more frequent intense rainfall events in the future especially during the summer as most intense rainfalls occur during these months (Nyberg et al., 2019). Research from 2009-2018 showed that Skåne was the second most severely affected region in Sweden by cloudbursts, in terms of economic and health damage (Nyberg et al., 2019). A cloudburst is defined as a rain event with at least 50mm rain in one hour or at least 1mm in one minute (Sjökvist et al., 2025).

This GIS analysis shows a future flood scenario in the study area. Based on a cloudburst event defined by SMHI and a sea level rise of 2m (Figure 21). IPCC (2021) predicts that a global mean sea level rise of nearly 2m could occur by the year 2100 under a scenario of remarkably high greenhouse gas emissions (SSP5-8.5).

Fig.20. Winter flood in Eslöv damages several properties (Engstrom, 2024).

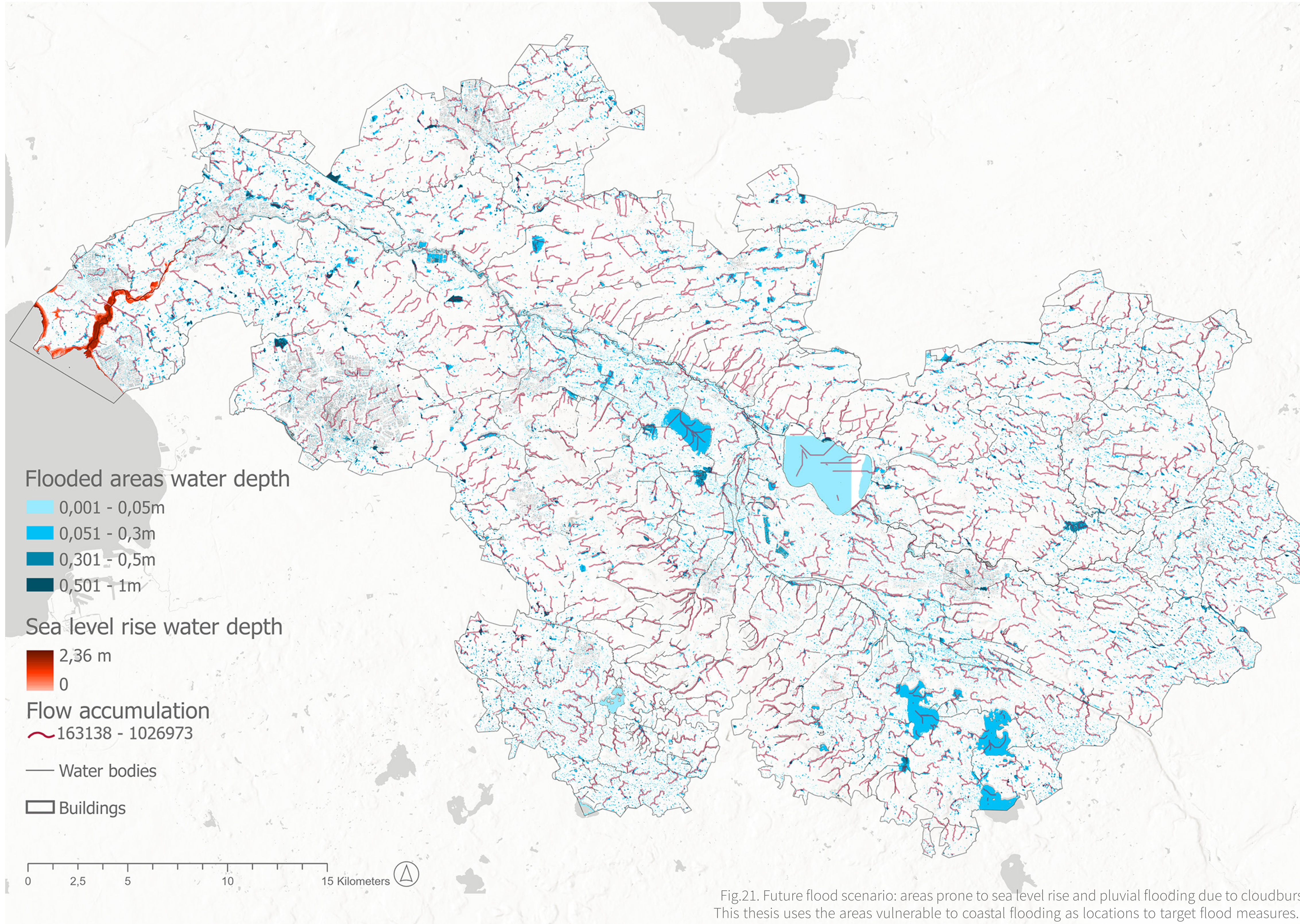


Fig.21. Future flood scenario: areas prone to sea level rise and pluvial flooding due to cloudburst. This thesis uses the areas vulnerable to coastal flooding as locations to target flood measures. It also uses the flow accumulation as places to target flood mitigations that can slow down the water flow in the catchment to depressions and the river. The flooded areas are seen as potential areas to hold water for a longer period of time in the landscape.

Flow accumulation shows how the water flows in an extreme weather event as this. The one shown on the maps are the flows with the highest accumulation. This means that these cells have the highest count of upstream cells that flow to that cell. A high flow accumulation can be explained by the land surface upstream from the cell., hard surfaces, lack of vegetation etc. and therefore contribute to a high flow accumulation to cells downstream. Upon analysing the flood map result most flooding occurs on and close to the river. Other areas of flooding are distributed along the cities and edges of the study area.

Vulnerability to stormwater and sea level rise
The impact on flooding can cause economic, cultural, and ecological damage. SMHI explains that stormwater can cause flooding, erosion and earth movements (Eklund et al., 2015). Economical losses include crop loses and damage on buildings, streets, and road trailways. Cultural damages include damage on health and cultural heritage. Figure 22 shows the vulnerable land use types during a storm water event at the scenario shown in the previous map (Figure 21). The open spaces include areas such as parks and squares; the leisure buildings include buildings as museums. Industry, open spaces, and agriculture are the most vulnerable in the project area. However, it should be explained that the extent of damage depends on the depth of the flooded area.

Figure 23 shows buildings that will be affected by a sea level rise of 2m. A distinction is made between residential buildings and other types of buildings. Figure 24 provides a closer look to the buildings that will be affected by this sea level rise. Spatially analysing vulnerable landscapes and buildings for a future flood scenario can help in allocating funds and flood protection.

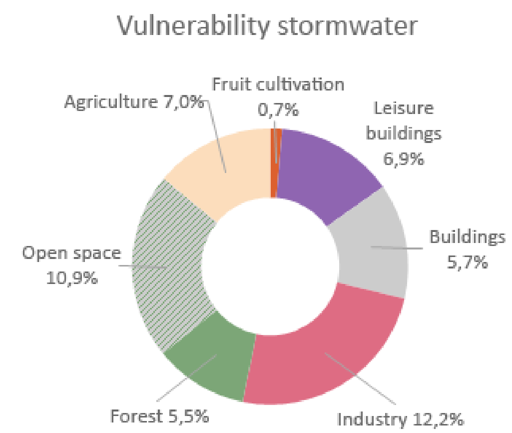


Fig.22. Vulnerability of land use types to stormwater.

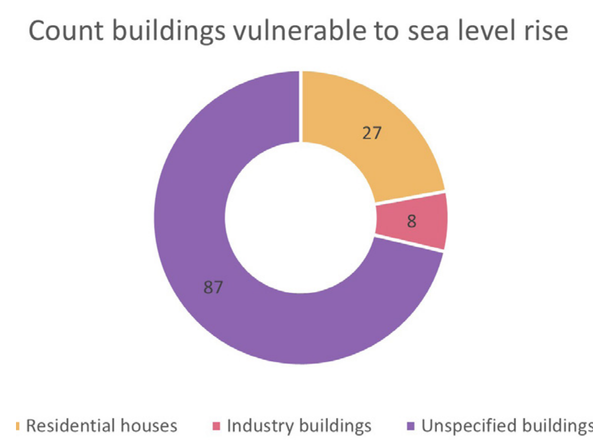


Fig.23. Vulnerability of buildings to coastal flooding.

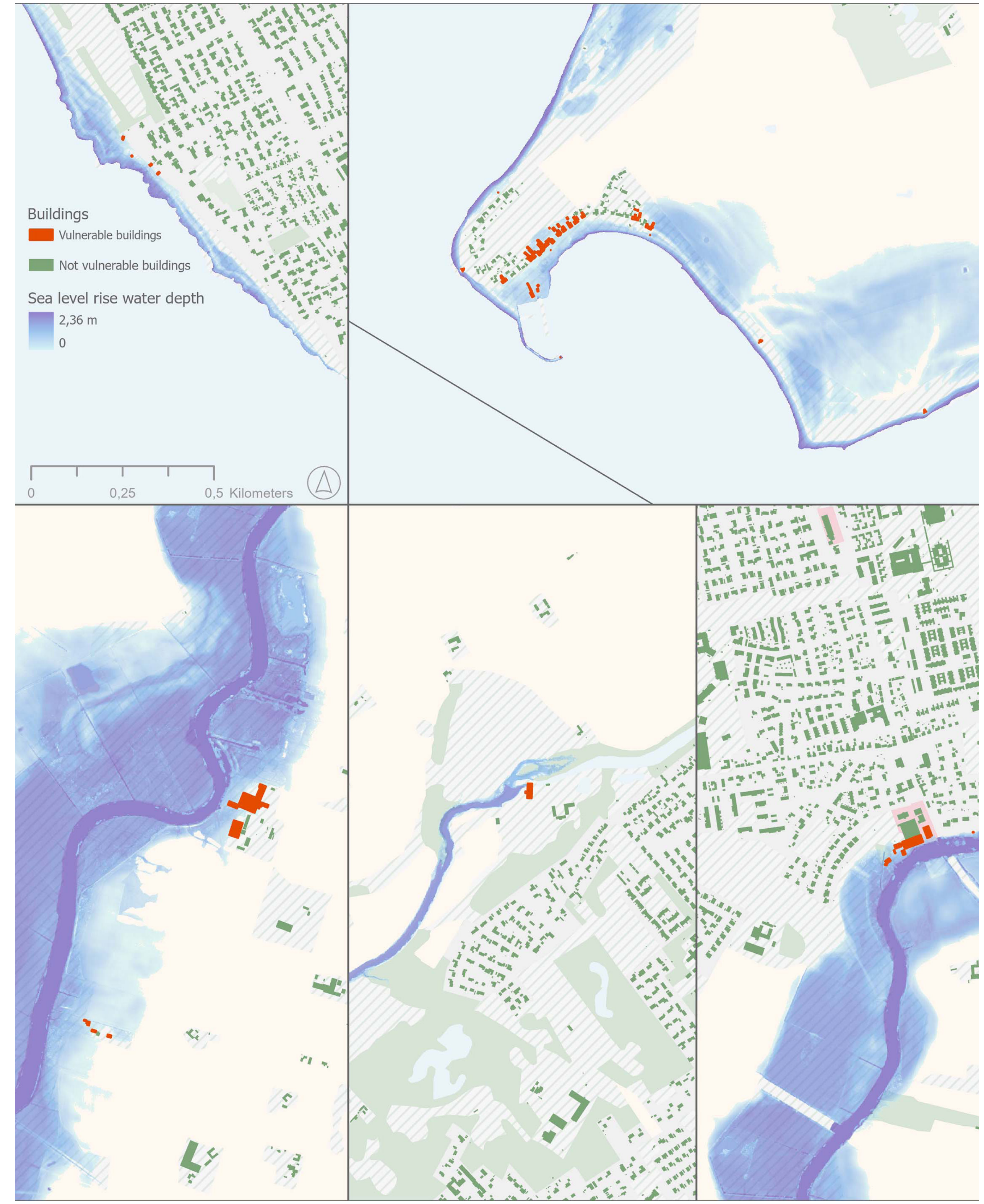


Fig.24. Close ups of the buildings affected by sea level rise.

5.3. Transportation and accessibility

Analysing the existing transport network in the study area provides insights into the accessibility of the river. It also helps identifying areas where accessibility could be improved. The goals from Kävlinge Water Council on recreation focusses on at least 3km walking paths alongside the river. And improving the connectivity between cities and bus stops to recreational areas. Figure 25 shows the accessibility from houses to the river by public transportation. This buffer analysis only includes the accessibility towards Kävlinge river therefore showing a smaller part of the study area. This part of the study area counts 147 bus stops, but the accessibility to the river for around half of the houses is still limited. Figure 26 shows multiple transportation networks in the whole study area car roads, cycling paths and pedestrian paths. It shows that there is potential to contribute to recreation by connecting the river to the existing Skåneleden route and the regional bike route.

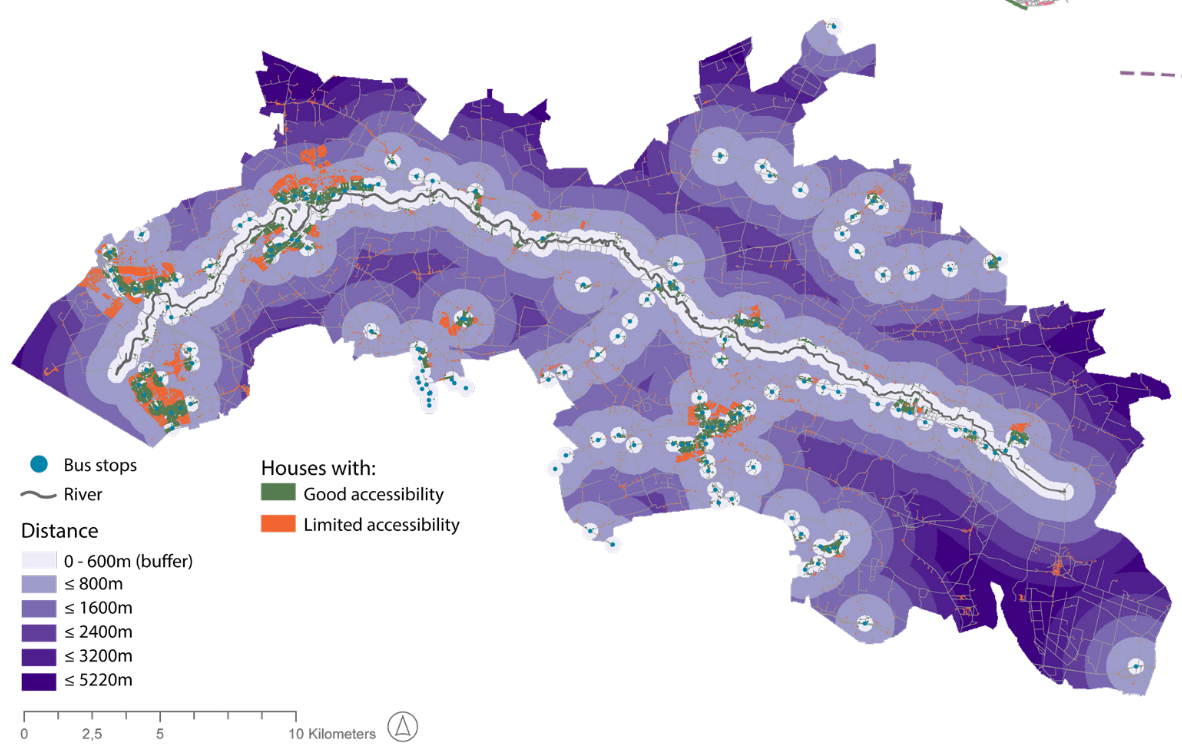


Fig.25. Buffer analysis.
The map shows the accessibility of houses in the study area to the river (dark grey) by public transportation (bus stops in blue) or by foot. Limited accessibility means if a house does not have a bus stop withing 600m and/or is further than 300m from the river. Accessibility at these houses should be improved with additional walking paths, cycling paths or bus stops.

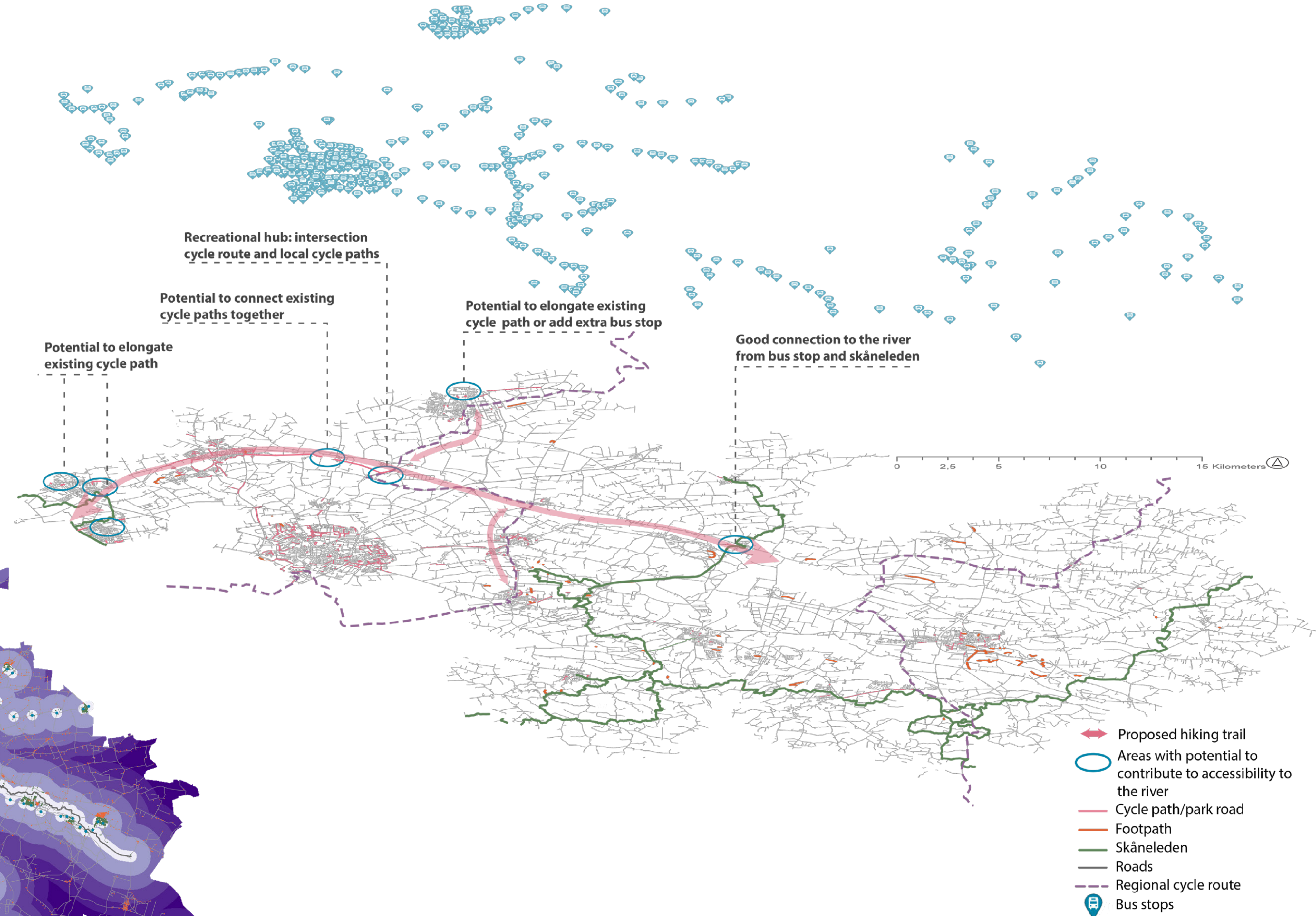


Fig.26. Transportation network in the study area.
Areas circled in blue are locations to improve the accessibility in the study area or are places with good connection and therefore proposed cycle paths and hiking trails should connect with these places.

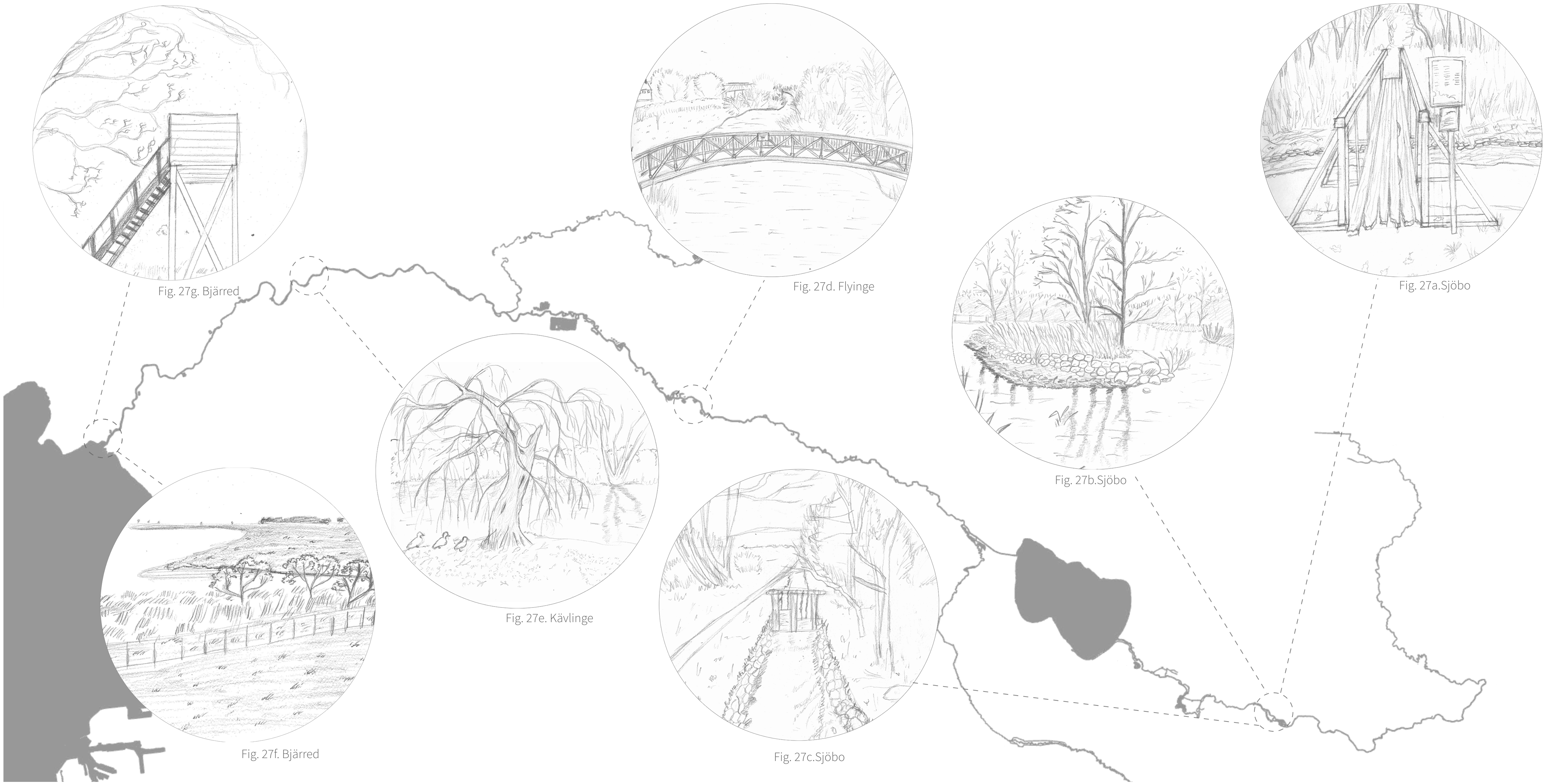


Fig. 27g. Bjärred
Fig. 27d. Flyinge
Fig. 27a.Sjöbo
Fig. 27b.Sjöbo
Fig. 27e. Kävlinge
Fig. 27f. Bjärred
Fig. 27c.Sjöbo

Fig.27. Stops I made during the site visit.

Site visit
The river Kävlinge flows through Skåne passing several cities. Some cities and villages are accessible by train or by bus. The map in figure 27 illustrates the cities and stops made during this site visit. When arriving at a transport hub it varies if the river is in walking distance.

The first stop of this site visit is Sjöbo. The tributary of Kävlinge river named Björkaån flows here and later changes its name upstream and becomes Åsumsån. River access is greatly restricted here by agricultural land. It takes some time to find the tributary. The path leading to the river is hidden and consists of gravel and mud. Here you find a weathered bridge (27.a). Crossing the bridge vegetation gets denser. The sign positioned next to the bridge provides visitors with information about the river and the fishing rules in the area. Walking along this tributary one finds a small island (Figure 27b). It is February and the water level seems high. But fluctuations in the water level due to precipitation or drought will leave more or less of the island exposed. Providing a dynamic landscape interesting for visitors as for flora and fauna. Continuing, a smaller side stream can be found (27.c). The water level seems to be managed with a little wooden dam. A side effect of this dam could be that it acts as a barrier for natural river flow and migration of fish.

In Flyinge a large bridge, accessible for cars and pedestrians, provides a broad view of the river Kävlinge (27.d). Trying to get even closer to the riverbank, one must cross a private land or an agriculture field. With some effort following a muddy trail close to the bridge piles it is possible to access the riverbank. The restricted access of the river by private owned land creates a challenge for visors to enjoy the river.

In Kävlinge, a public park provides access to Kävlinge river. This park Silverforsen Folkets originated in 1905 when local workers bought land along the river and designated it partly for cultivation and meetings and entertainment (Kävlinge Folkets Park, n.d.). The main entrances lead to the riverbank (27.e). Under the willow tree ducks rest. The grass is dry and filled with leaves. The path is part of the walking route in the park that provides information about the flora and fauna along this part of the river.

The river flows though the nature reserve Loddeåns before it discharges in the sea (27.f). Here you can hear several birds chirping. Although it was raining it was still pleasant to walk through this landscape and to go up to the birdwatch tower (27.g). The tower provides an even better view of the river mouth and the nature reserve.

5.4. Historical river course

Kävlinge river catchment has lost a substantial number of wetlands and surface waters during the 19th and first half of the 20th century. The area of wetlands and surface waters in the catchment decreased by around 300km2 during this period (Krug, 1993). Between 1880 and 1914 the drainage of wetlands was the most intensive. This development happened almost parallel with the increase in agricultural land (Krug, 1993). In the 19th century the Sweden's population increased rapididly. As a result farmers felt compelled to drain land to increase productivity and meet the demands of the growing population (Krug, 1993). Streams were straightened and deepened to improve farmland and accommodate high flow events. However, extreme water level fluctuations were more common as a result of these drainage activities. In general, the removal of upstream wetlands causes more frequent extreme high and low water discharge in a catchment (Mitsch & Gosselink, 1986). This was also the case in the Kävlinge catchment after the reduction of wetlands predominantly in the lower parts (Krug, 1993). From 1940's on more catchment drainage activities continued with advanced techniques as the tile and cover drainage (Krug, 1993).

Figure 28 combines two different historical time periods in the river catchment. Wetlands in the river catchment in the 1810s and the river course registered between 1910 and 1915. Comparing the old river course with the current river course makes it possible to identify where the river used to meander. The historical wetlands and lakes show areas where restoration could be possible and reduce the flow discharge of the catchment. This is particularly interesting, as these wetlands and lakes date back to the 1810s, predating the intensive drainage period between 1880 and 1914.

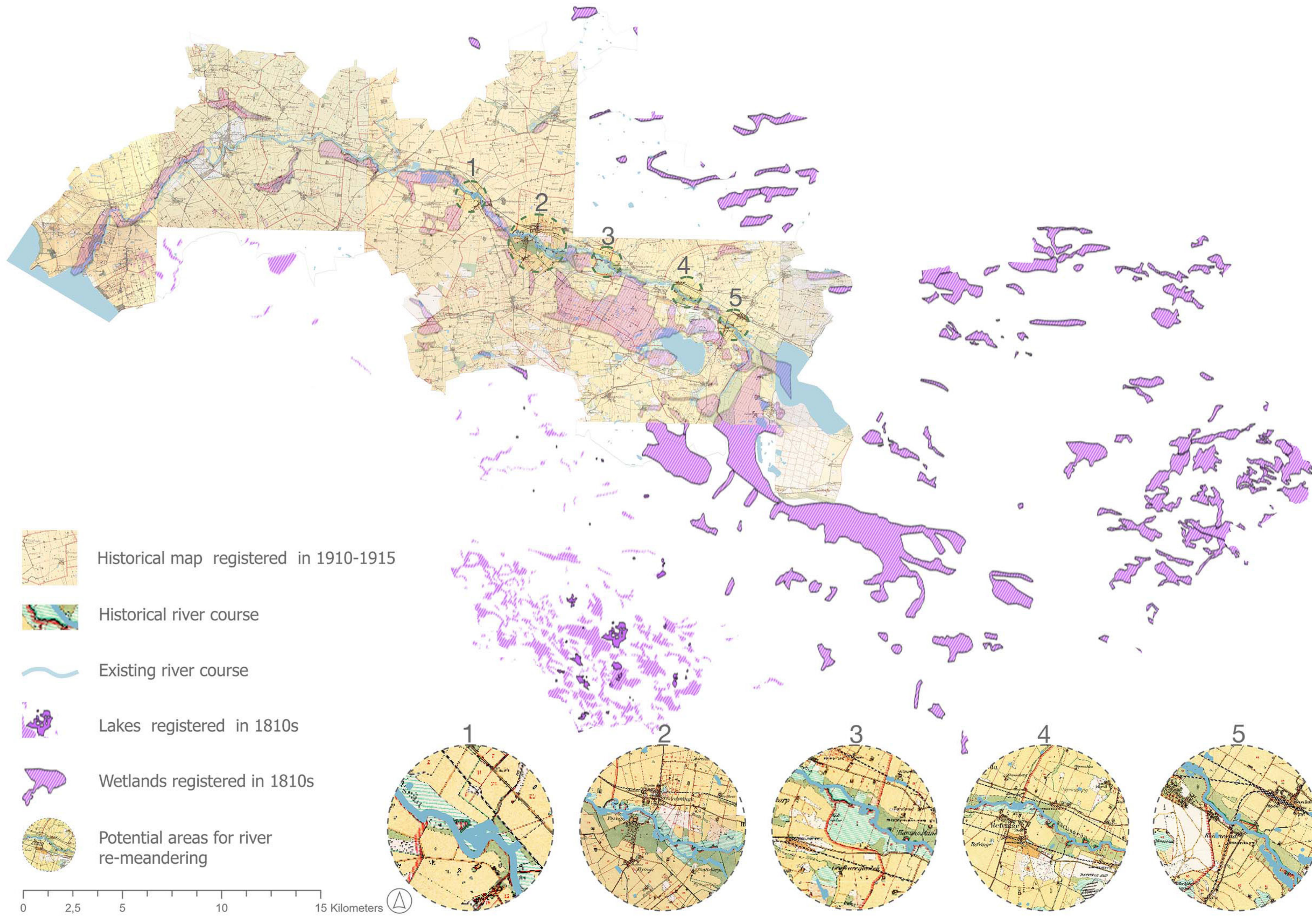


Fig.28. The figure shows the river course as measured in 1910-1915 and, lakes and wetlands measured in the 1810s. The five close ups show areas to re-meander the existing river back to its course from 1910-1915.

6. Results PPGIS

This chapter answers SRQ4 What water related challenges does the project group perceive in the study area and what kind of solutions do they prefer. SRQ4 is answered through analysing the PPGIS survey results that gathered information about the project group landscape values, challenges, preferred improvement actions, and favourite places in the study area.

In total 46 respondents filled out the survey. The most represented stakeholder group is the public authority (Figure 30). From the respondents who live in the study area it can be noticed that most of them have lived here either less than 5 years or over 30 years (Figure 32).

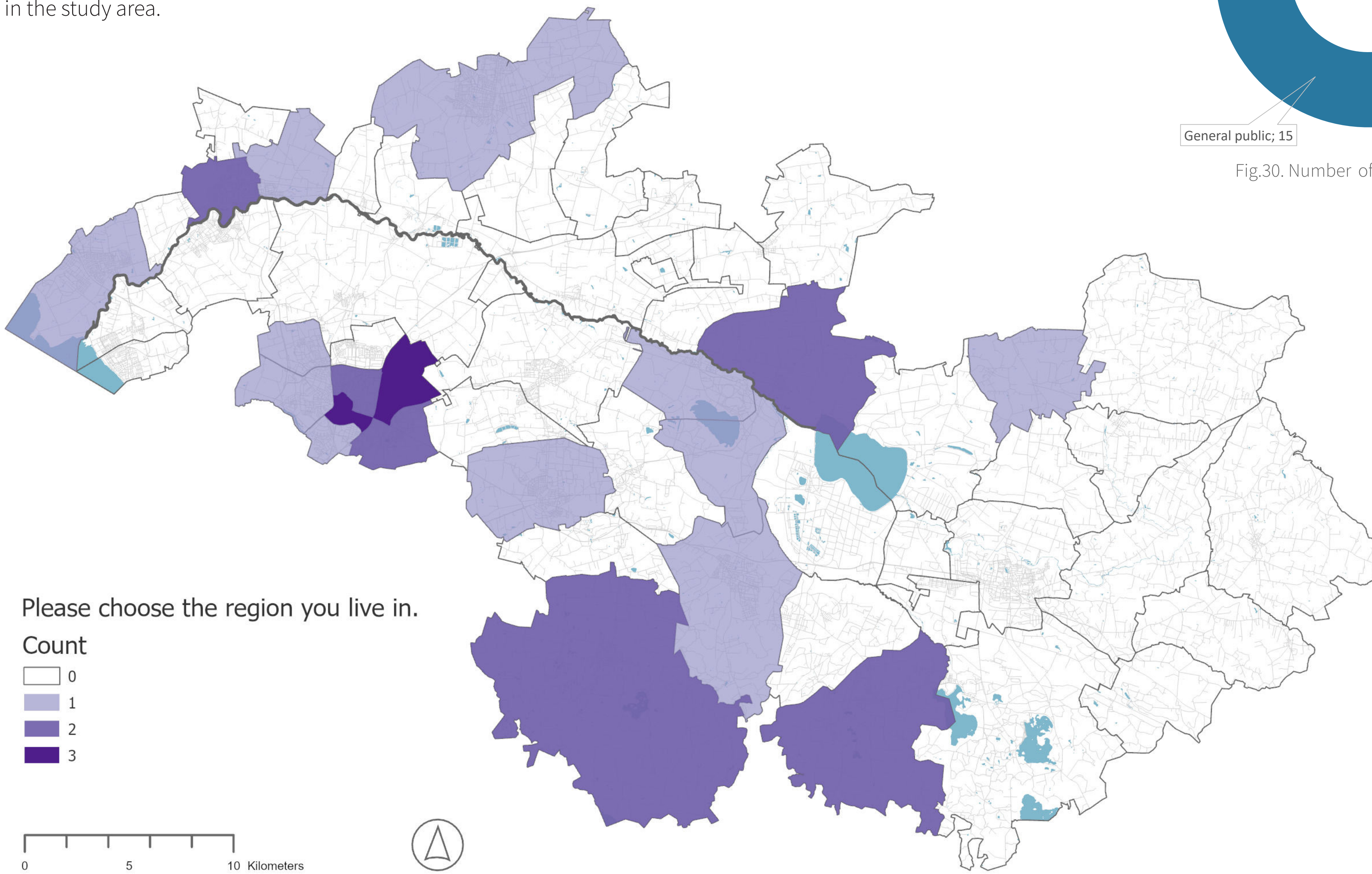


Fig.29. The regions the respondents live.

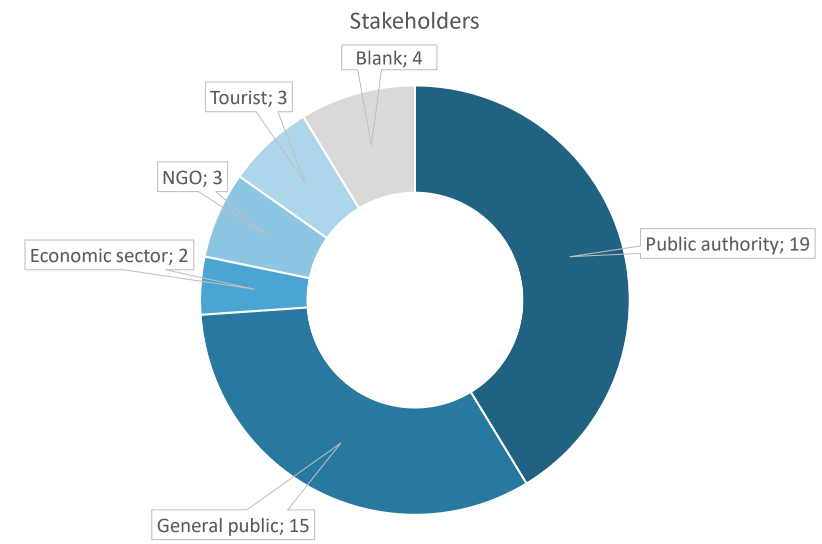


Fig.30. Number of stakeholders that filled in the survey.

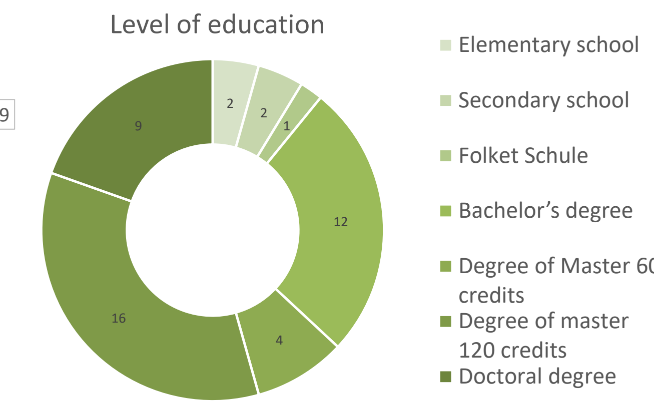


Fig.31. Respondents' highest education level.

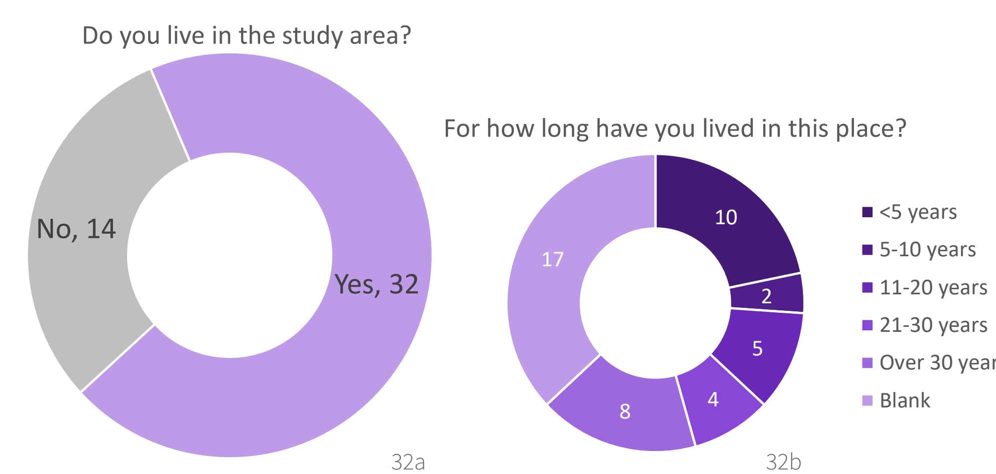


Fig.32. Respondents' answers to the question Do you live in the study area? (a) and follow up question for how long? (b).

6.1. landscape values

Figure 33 shows the spatial distribution of landscape values placed by the project group. In total 136 landscape values were marked. It displays that these are mostly clustered in the bigger cities in the study area and the centre of the study area. Figure 34 displays the number of landscape values mapped by each stakeholder's group. The top three most frequently placed values were recreation, natural education and aesthetic & scenic. This distribution is shared by both the public authorities as the general public. In addition to the list of activities that respondents could choose from, two new activities were identified: camping and going to the beach. The three least placed values were spiritual enrichment and social interaction. Economical, and relaxation together share the third place.
Table 5 shows respondents answers to the follow up question about their recreational activities.

Table.5. Respondents' recreational activities and visit frequency at that mapped location.

Other	Frequency
Walking	20
Walking your pet	5
Watching nature	14
Land sport	3
Water sport	8
Social activity	7
Photography	5
Camping	1
Going to the beach	2

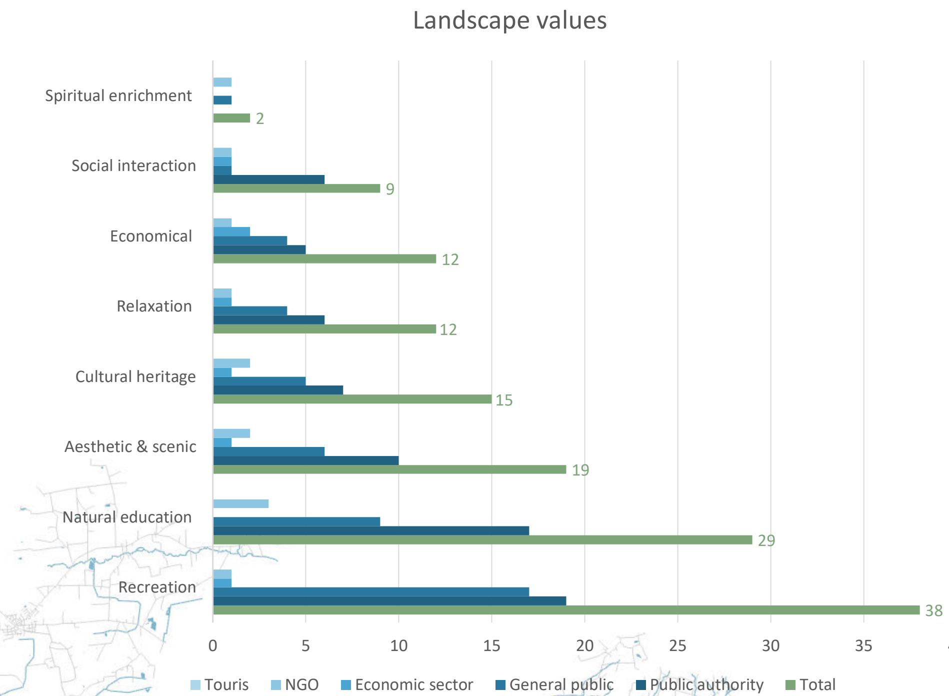


Fig.34. Number of landscape values by each stakeholder's group.

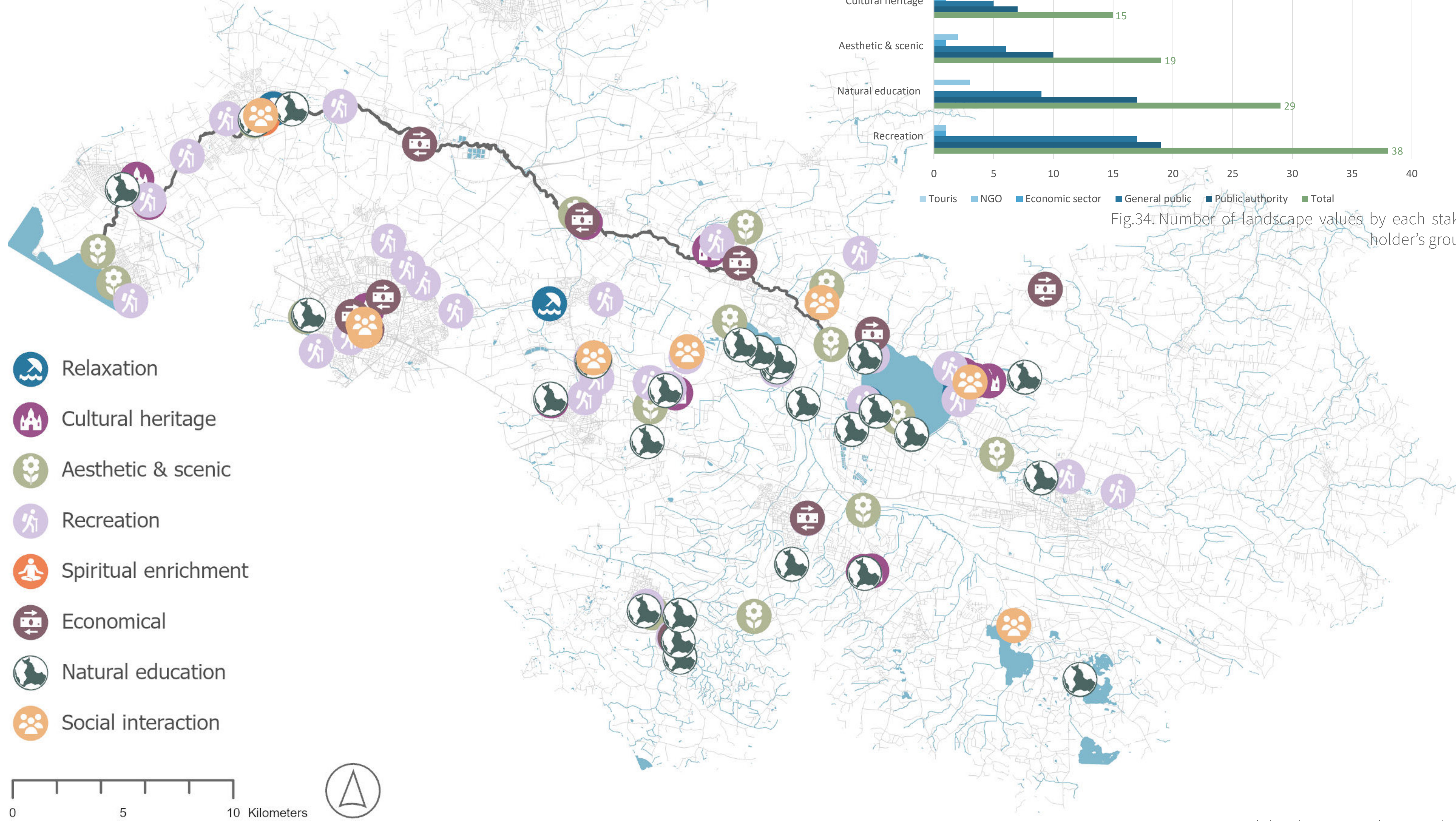


Fig.33. Spatial distribution Landscape values.

6.2. Environmental challenges

The distribution of the environmental challenges in the study area is shown in figure 35a. Respondents identified in total 59 environmental challenges in the study area. Flooding was the most frequent placed challenge overall (Figure 36). This was also the most often placed challenge by the economic sector. The public authority placed the challenge 'other' the most and the general public solid waste management problems. The least placed challenges were soil pollution and lack of maintenance together with poor water quality.

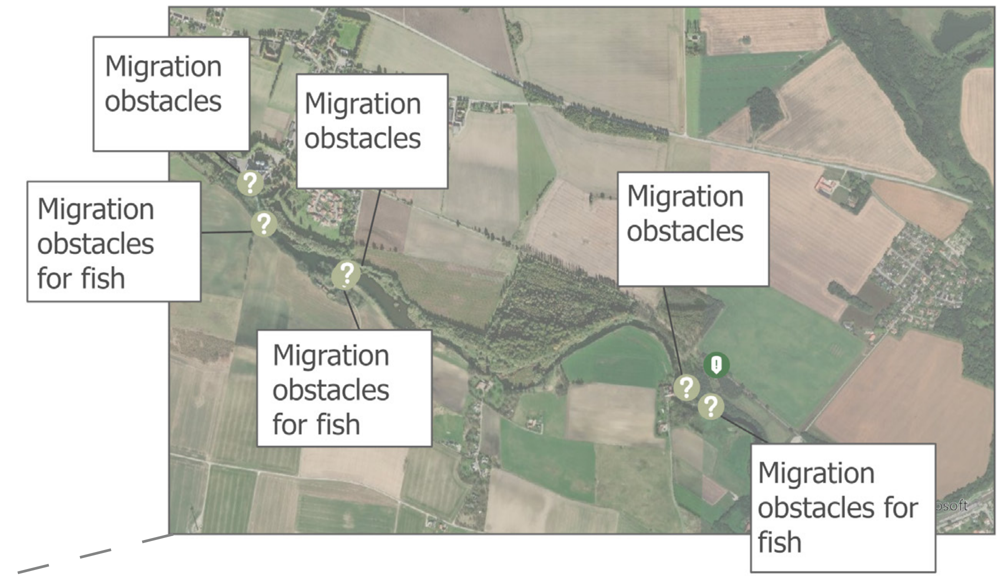


Fig. 35b. Respondents' answers to the option 'other'.

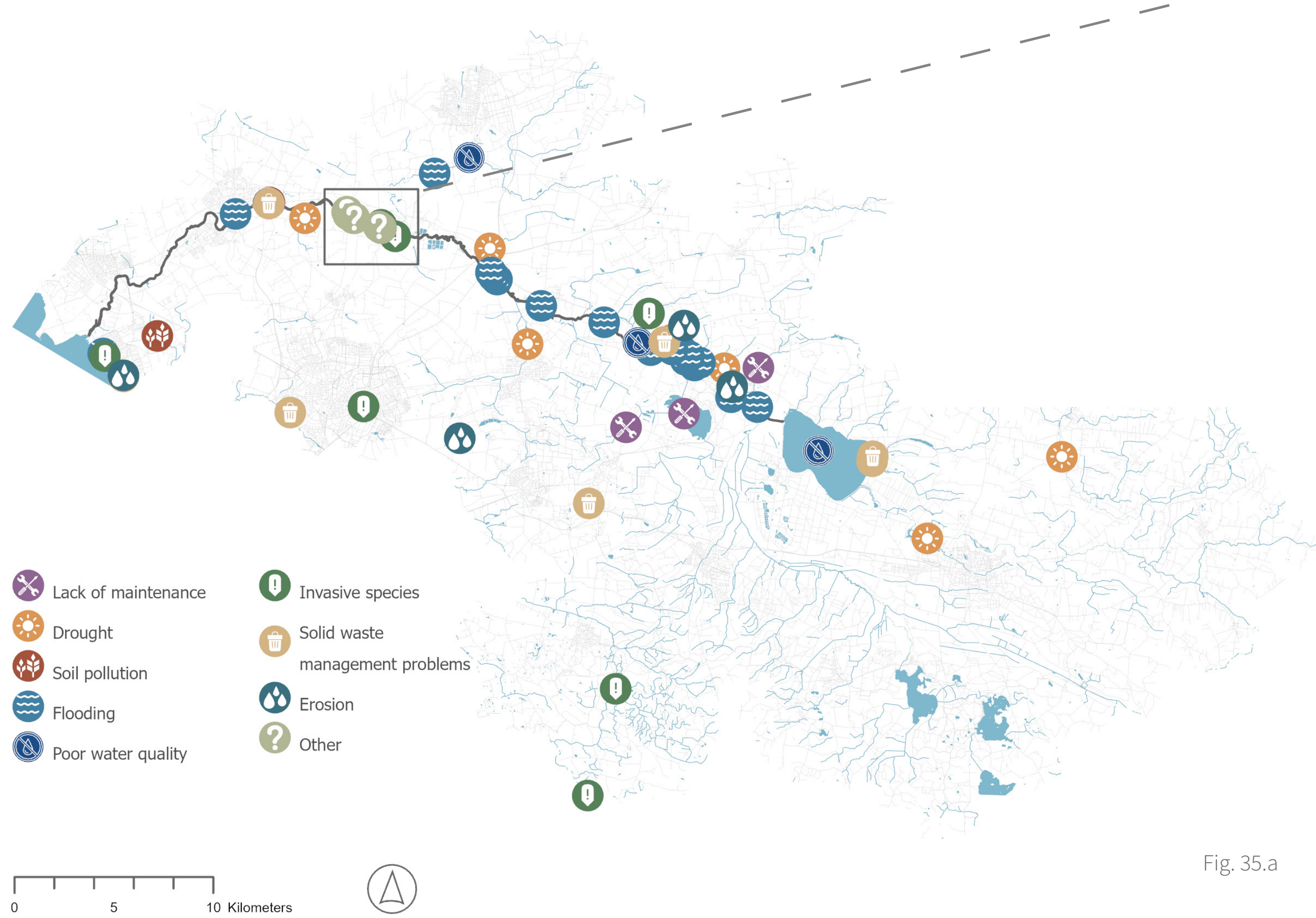


Fig. 35.a

Fig.35. Spatial distribution of the environmental challenges (a). Respondents' answers to the option 'other' (b).

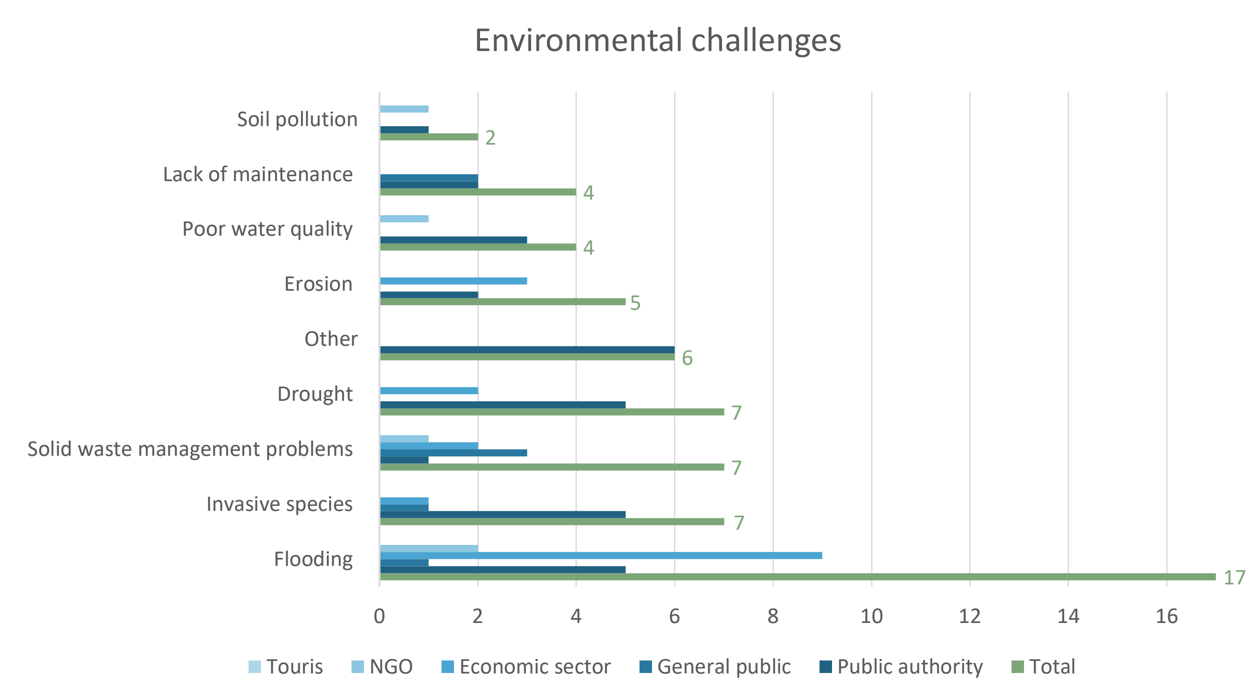
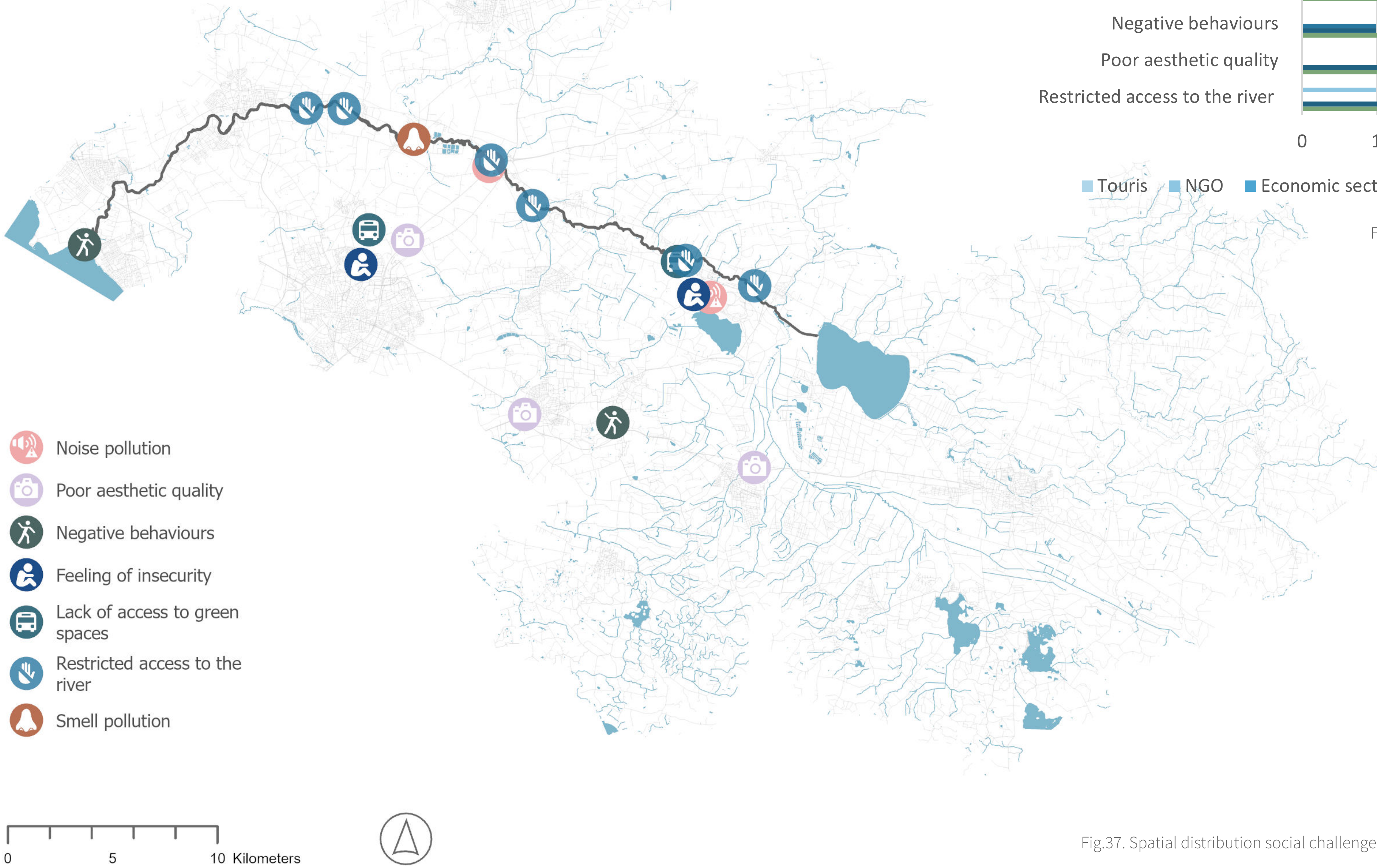


Fig.36. Number of mapped environmental challenges by each stakeholder's group.

6.3. Social challenges

Figure 37 shows the spatial distribution of the mapped social challenges experienced by respondents. Restricted access to the river was the most placed (Figure 38). The public authority mostly placed this. Negative behaviours were the most placed by the general public. The option 'other 'was not filled in by the respondents here. The least placed challenge was smell pollution.



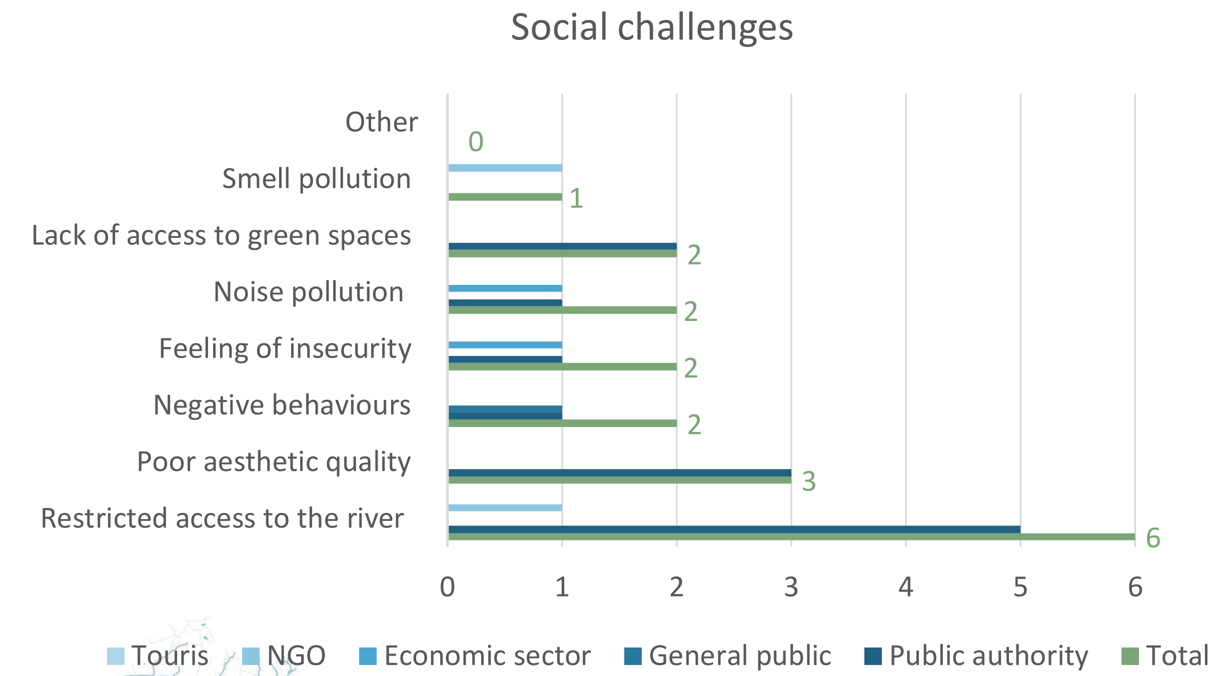


Fig.38. Number of social challenges mapped by each stakeholder's group.

Fig.37. Spatial distribution social challenges.

6.4. Landscape values and challenges along the river course

The landscape values and environmental challenges along the river course are visualized within a 300m distance from the river (Figure 39). Most landscape values are concentrated close to and in the lower course of the river, only a few challenges are placed here. The distribution of environmental challenges and social challenges are stretched over almost the whole river length but are scarce along the lower course of the river.

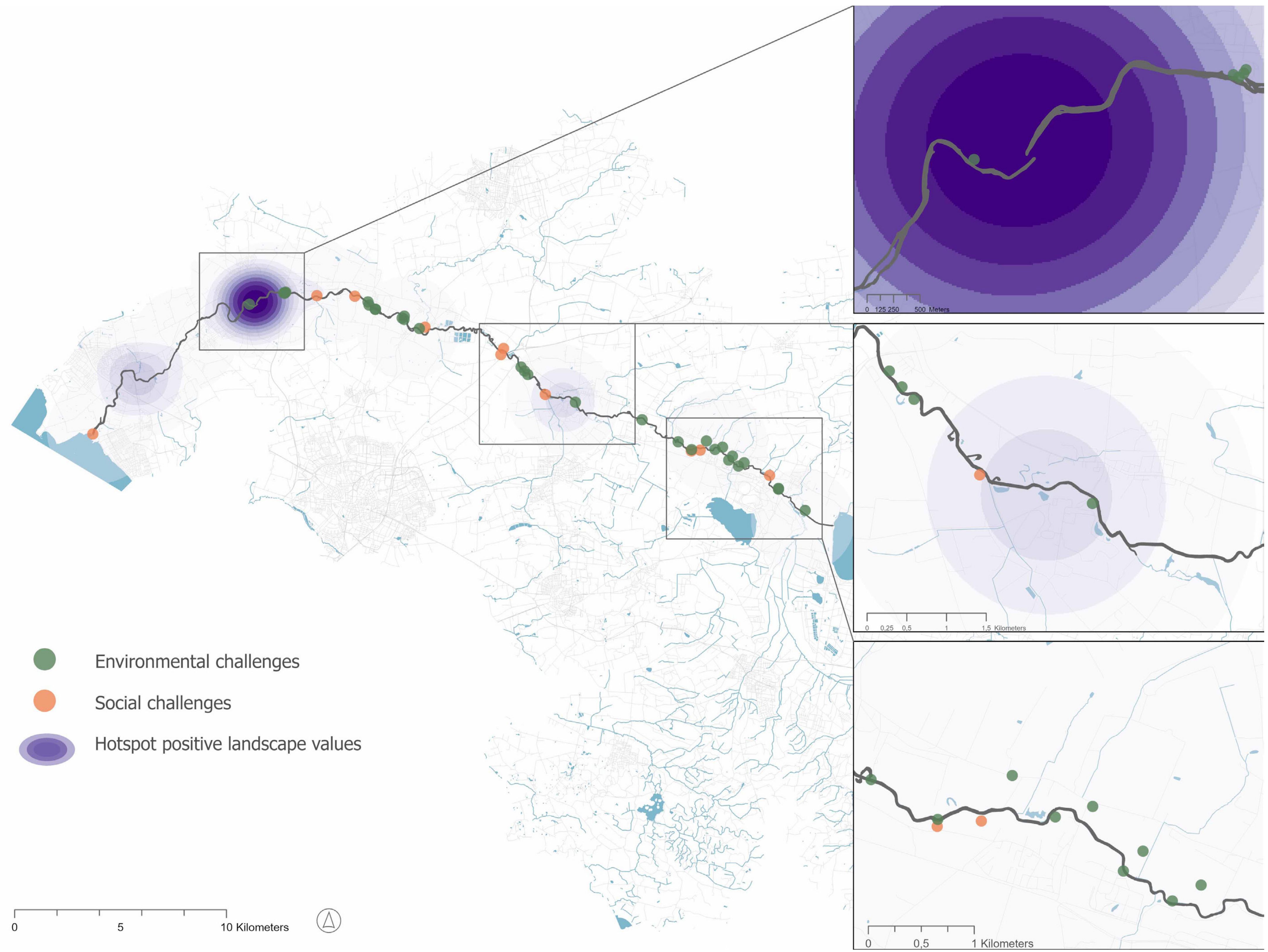


Fig.39. Spatial distribution of social and environmental challenges together with kernel density analysis of landscape values.

6.5. Improvement actions

In total 23 improvement actions were placed in the study area. The spatial distribution is shown in figure 41. The most often placed improvement action was environmental quality (Figure 40). Mostly placed by the public authority and the general public. The economical sector placed paths and accessibility the most. This map also shows that the social and environmental challenges have the highest concentration closer to the upper course of the river. The placed improvement actions do not show much overlap with the placed challenges, with an exception to a few of the improvement action paths and accessibility. Figure 41 also includes two close ups, these had the highest concentration on challenges. The close ups show the respondents preferred river restoration technique and own solutions they think the site needs.

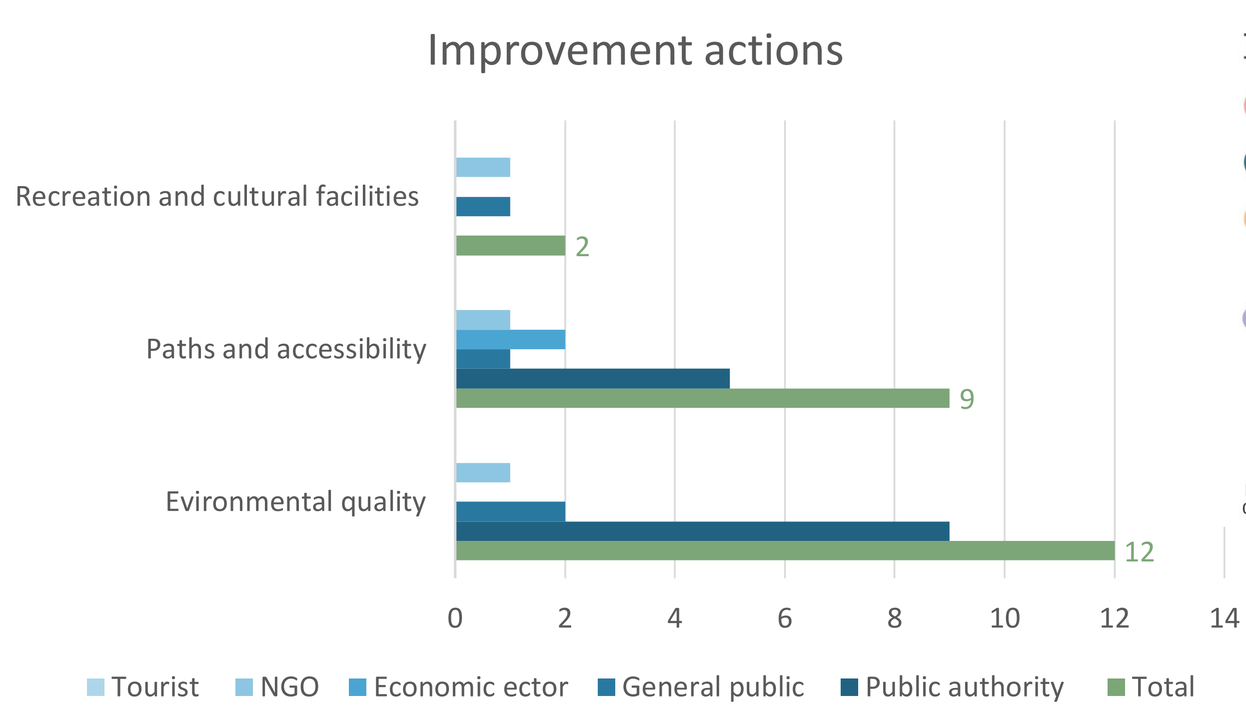


Fig.40. Number of improvements actions mapped by each stakeholder's group.

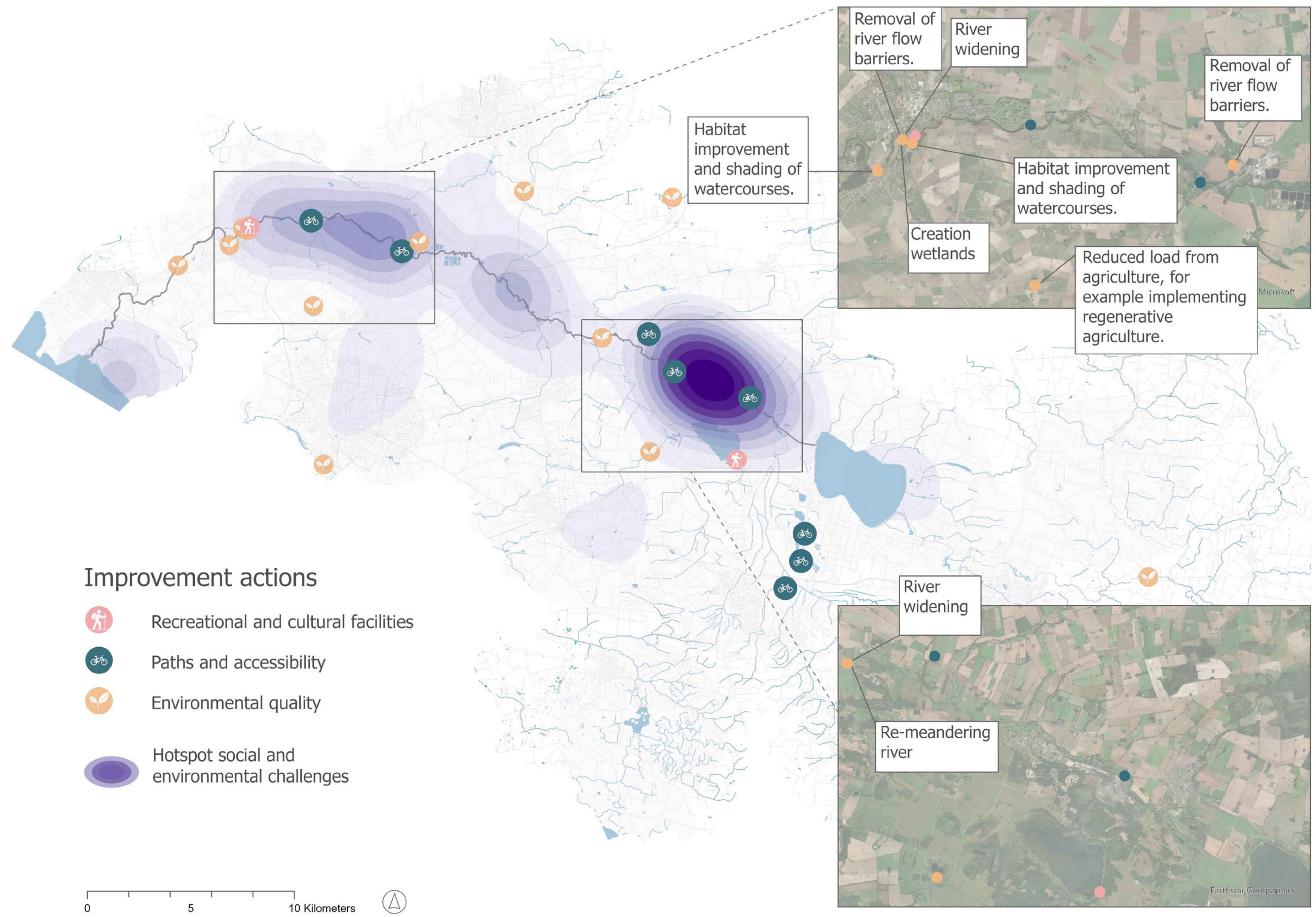


Fig.41. Spatial distribution of improvement actions together with kernel density analysis of social and environmental challenges.

6.6. Favourite places

In total 21 favourite places were marked by the project group. The spatial distribution of these places is shown in figure 43. Most of these places are clustered along the upper course of the river, with a few exceptions. Most respondents described their favourite place as a large coherent area (e.g. forest or nature area) or an elongated course (e.g. path or stretch along the river). The three most marked overlapping areas are shown in the zoom ins. These areas are partly forested with water features. Respondents gave their favourite place on average the highest scores on the sense of place statements about attachment and lower scores to the statements about activity (see Table 6).

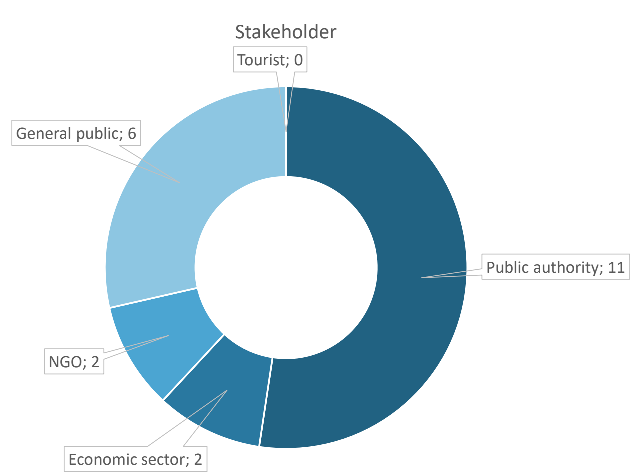


Fig.42. Stakeholders who marked their favourite place .

Fig.43. Markers of respondent's favourite place in the study area.

Conclusion PGGIS

These are the most prominent results from the PPGIS survey.

- The project group identified a new environmental challenge in the study area: Migration obstacles (for fish). This was mentioned five times.
- The results show that the landscapes along the upper and middle course of the river where more frequently mapped with the environmental challenge flooding compared to the other areas.
- The environmental and social challenges are the most concentrated close to the upper course of the river.
- Most preferred improvement actions were environmental quality and path and accessibility.
- The project group suggested new solutions for the improvement action 'environmental quality'. These were removal of flow barriers, habitat improvement and shading along river course and reduce nutrients flooding from agriculture land.

Table.6. Place attachment results for each favourite place a respondents drew. Statements were scored on a one to five scale. The table also shows the results of the follow up question, how often respondents visit their favourite place.

Place attachment		Visit frequency	
I am very attached to the place.	4,2	I do not visit the site	0%
This place means a lot to me.	4,2	Yearly or less than once a year	10%
I identify strongly with this place.	3,3	Semi-annually	30%
I feel this place is part of me.	3,2	Monthly	40%
No other places could compare to this one.	2,55	Weekly	15%
I wouldn't substitute any other place for doing the type of things I do here.	2,65	Daily	5%
The place is the best for what I like to do.	2,9	Total	
I get more satisfaction out of being here than at any other places.	2,9		
I am happiest when I´m at this place.	2,9		

7. Design process

This chapter presents the design process of this thesis. In phase A general rules are formulated. These rules are flood mitigations and techniques found in the literature overview suitable for specific land use type. In phase B1 the general rules together with the recreation goals from Kävlinge Water Council form four conceptual strategies. These are presented in the 'allocation of conceptual strategies' map. In Phase B2 the PPGIS results are evaluated and visualized in the 'PPGIS result' map. Phase B3 presents the integration of the conceptual strategies and PPGIS results in a conceptual plan.

7.1. Phase A: General rules

Overlaying the GIS site analysis maps revealed opportunities in the landscape where best to apply flood mitigation and river restoration techniques (Figure 44). For example, the land use underneath a high flow accumulation might reveal a stream in an agricultural plot. A fitting solution found in the literature to reduce flood along a stream in an agricultural plot is creating a riparian buffer along the stream. This than became a general rule for this type of land use. The starting points for these general rules were 1. the flow accumulation map and 2 the future flood scenario map.

1. Flow accumulation

High flow accumulations that are relatively long and are attached to Kävlinge river or one of the three main side channels (Bråån, Klinavälsån or Björklaån) were observed. These are the general rules for the following land use types:

Agriculture
- If underground stream in plot -> Daylighting
- If above ground stream in plot -> Riparian buffer

Transportation
- Porous paving

Stream
- Close proximity to another stream -> Reconnect side channel
- If underground -> Daylighting
- If in agriculture land -> Riparian buffer

2. Future flood map.

Flood areas that are relatively large and connected to the flow accumulation were observed. Here it also counts that the flow accumulations had to be attached to the river Kävlinge or one of the main channels.
- If in old wetland -> Restoring wetland
- If in old meander area -> Re-meandering river meander.

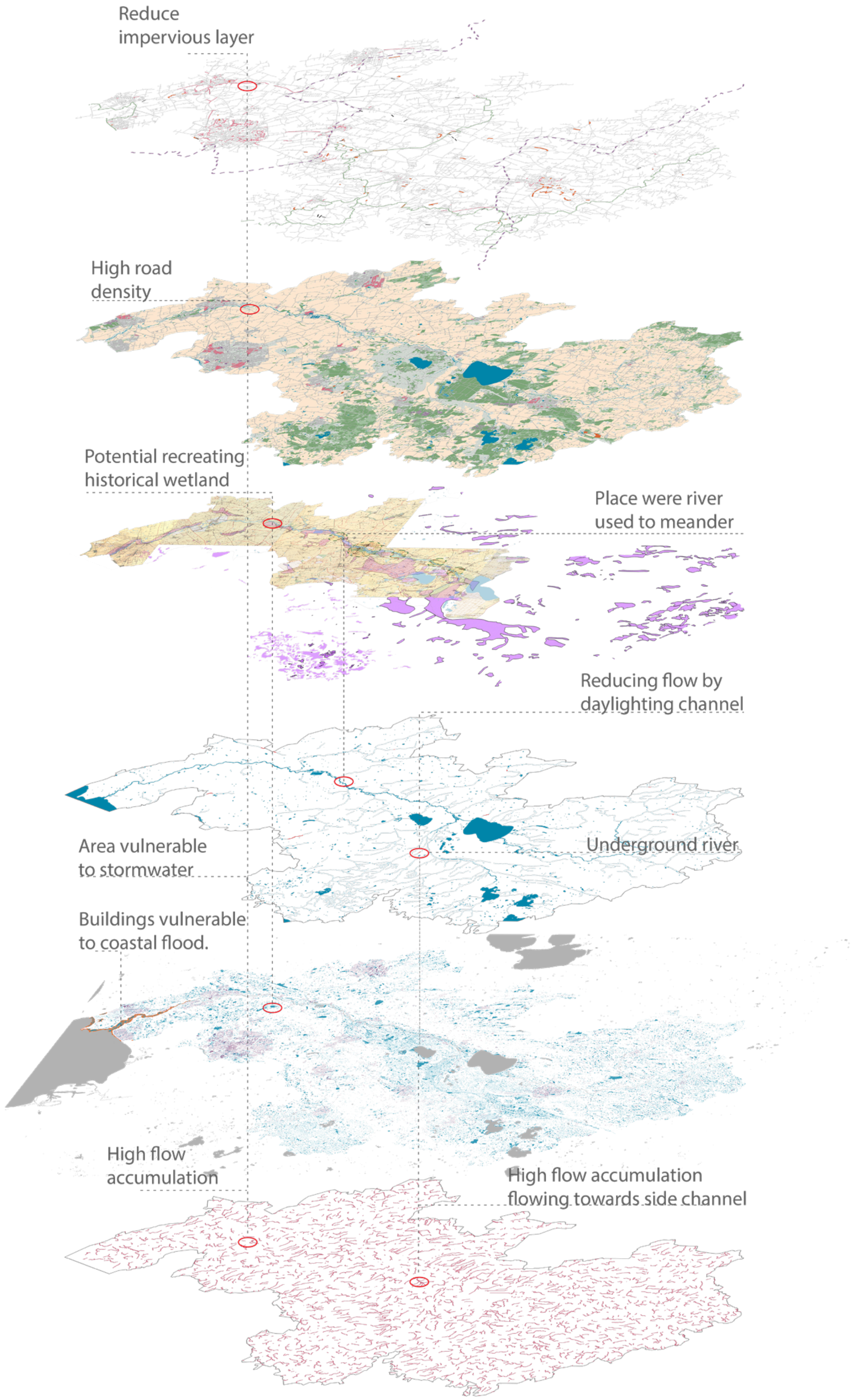


Fig.44. An example of my design process. The picture shows how by overlaying the GIS maps general rules were formulated. The aim for these general rules is to guide the design choices I had to make. Overlaying the maps was done by drawing on physical maps with pen and paper.

7.2. Phase B1. Allocating conceptual strategies

Based on the general rules and the recreation goals from the Kävlinge Water council four conceptual strategies are formulated and visualized (see figure 45). The general rules can be divided into three themes based on the purpose of the strategies. These are Natural River, Slow River, and Controlled flood. The strategy re-meandering has the aim to convert the river back to its historical river course that aligns more with the river natural geomorphology than it is now.

The strategies side channel connection, reduce impervious layer, riparian buffer, restoring wetland, and daylighting has as main purpose to slow down the water flow to the river. The strategy vegetative coastal buffer and elevated homes have as aim to safely accommodate flooding when it occurs and limit flood damage on buildings. In addition, the fourth conceptual strategy is directed towards Kävlinge water Council recreation goals. The Council has the aim to improve connectivity from cities to recreational areas and establish hiking trails along water ways.

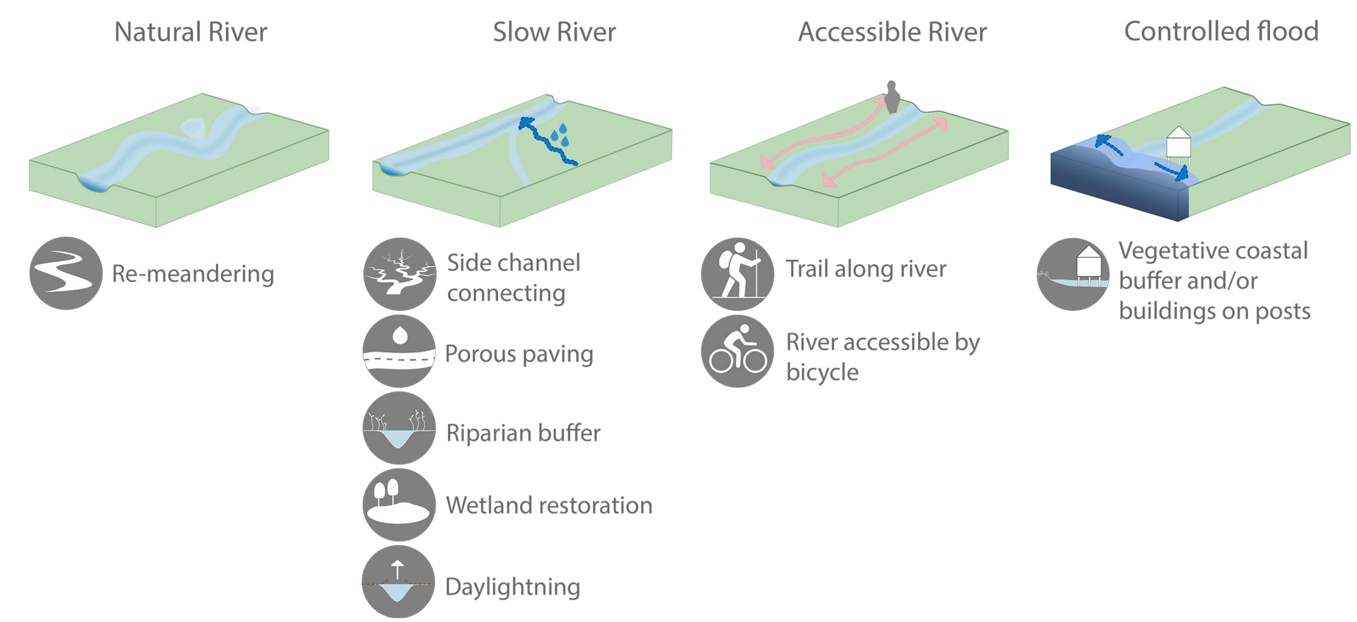


Fig.45. The conceptual strategies. Natural River, Slow River and Controlled Flood contribute to restoring the historical river course of the river, slowing down the water flow towards the river, and controlled coastal flooding, respectively. Accessible river values rivers accessibility and experience.

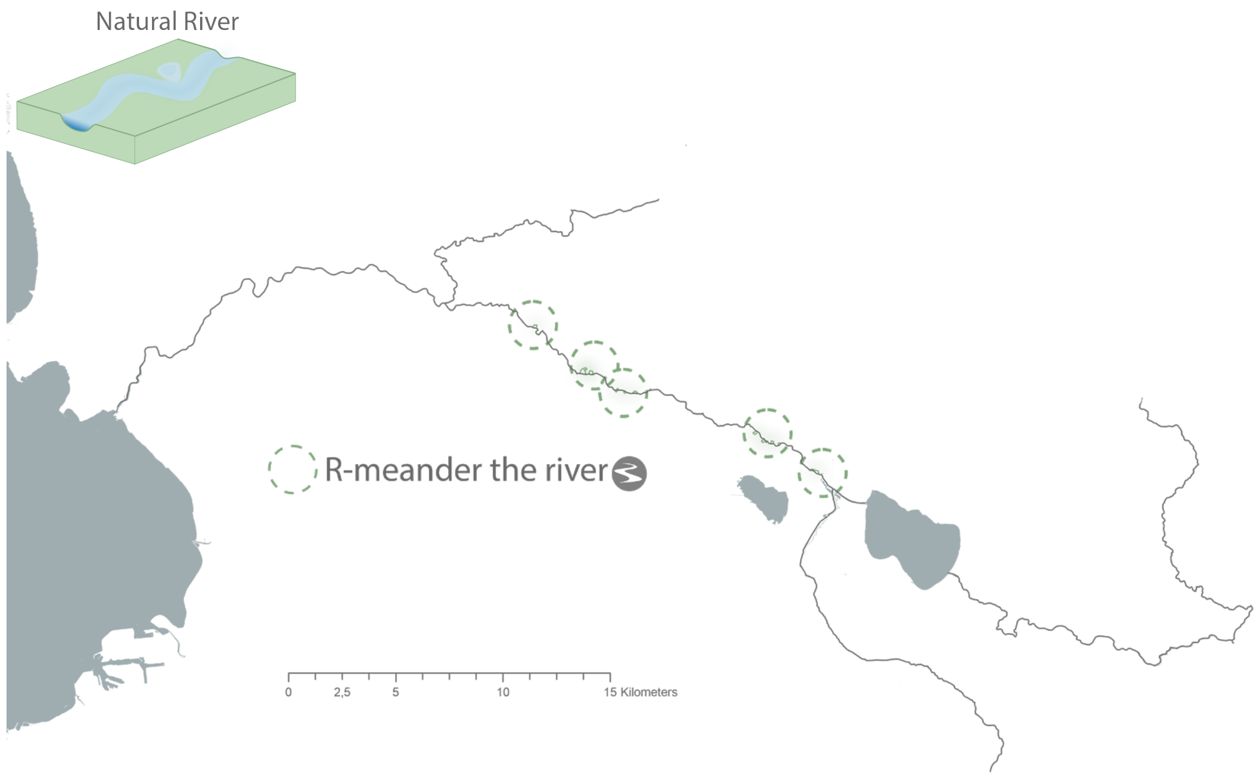


Fig.46. Natural Rive

Restoring the historical river course contributes to the rivers natural flood control. This is achieved by re-meandering the river where it historically meandered. Re-meandering a river contributes to flood mitigation as it slows down the water flow, increasing its water retention capacity. It reduces the peak discharge of a rainfall and so reduces the risk of flooding further downstream.

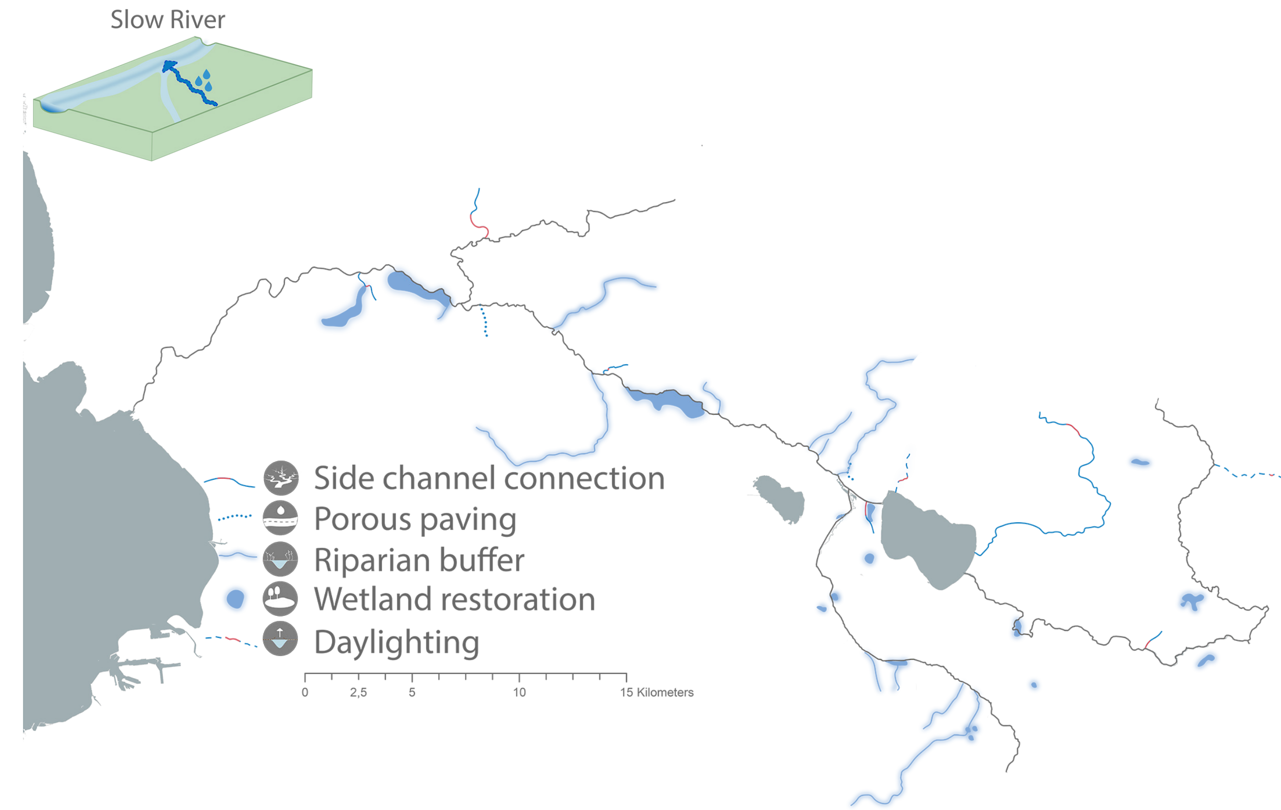


Fig.47. Slow River

Several strategies are formulated to decrease the change of flooding in the study area. Side channel reconnection, daylighting of channels, porous paving and restoring of wetlands are allocated at the most effective places. These measurements slow down the flow towards and in the main river resulting to lower flood risk further downstream. The new wetlands are located on places were there used to be a wetland and where the wetland connects to a stream.

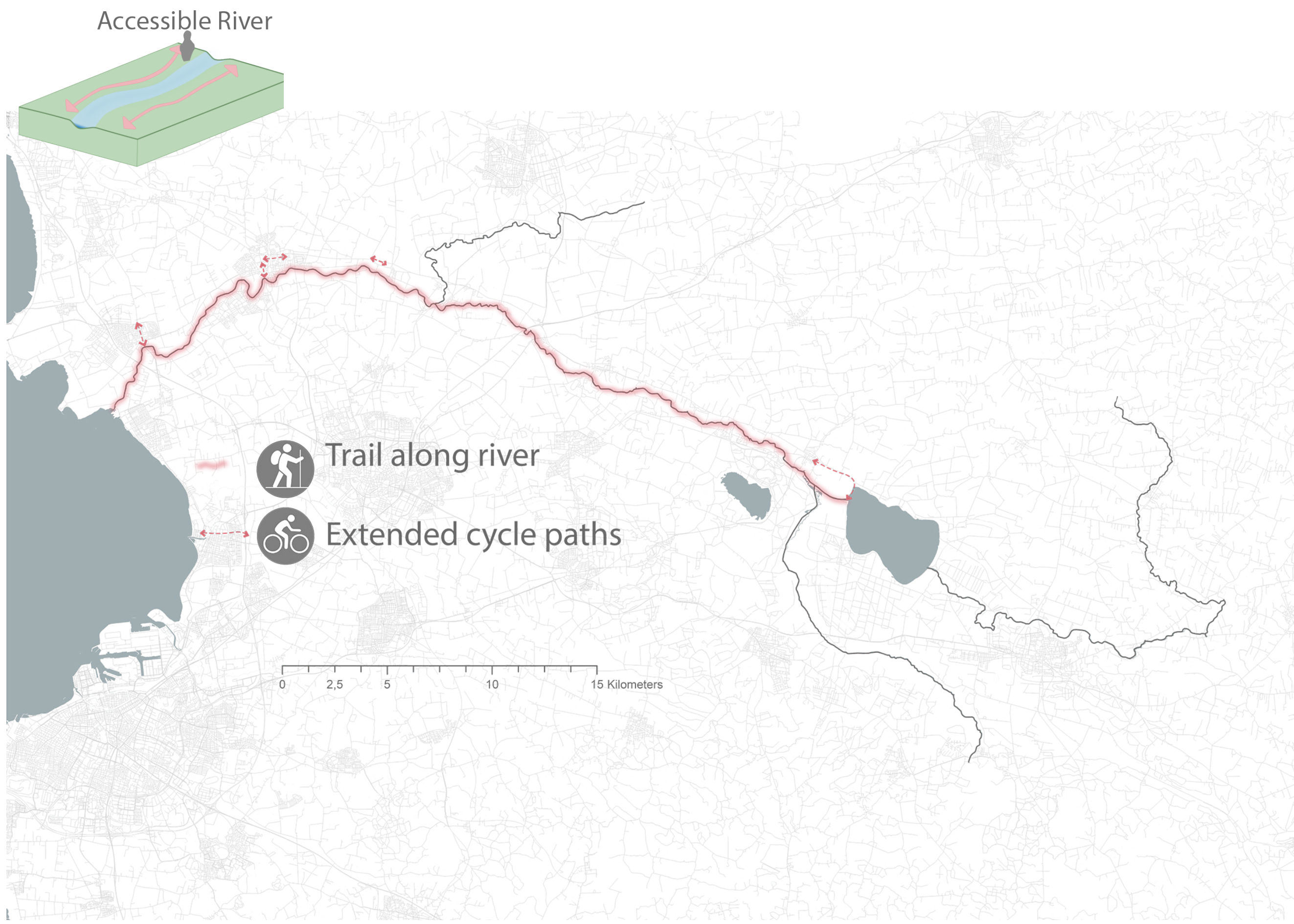


Fig.48. Accessible River

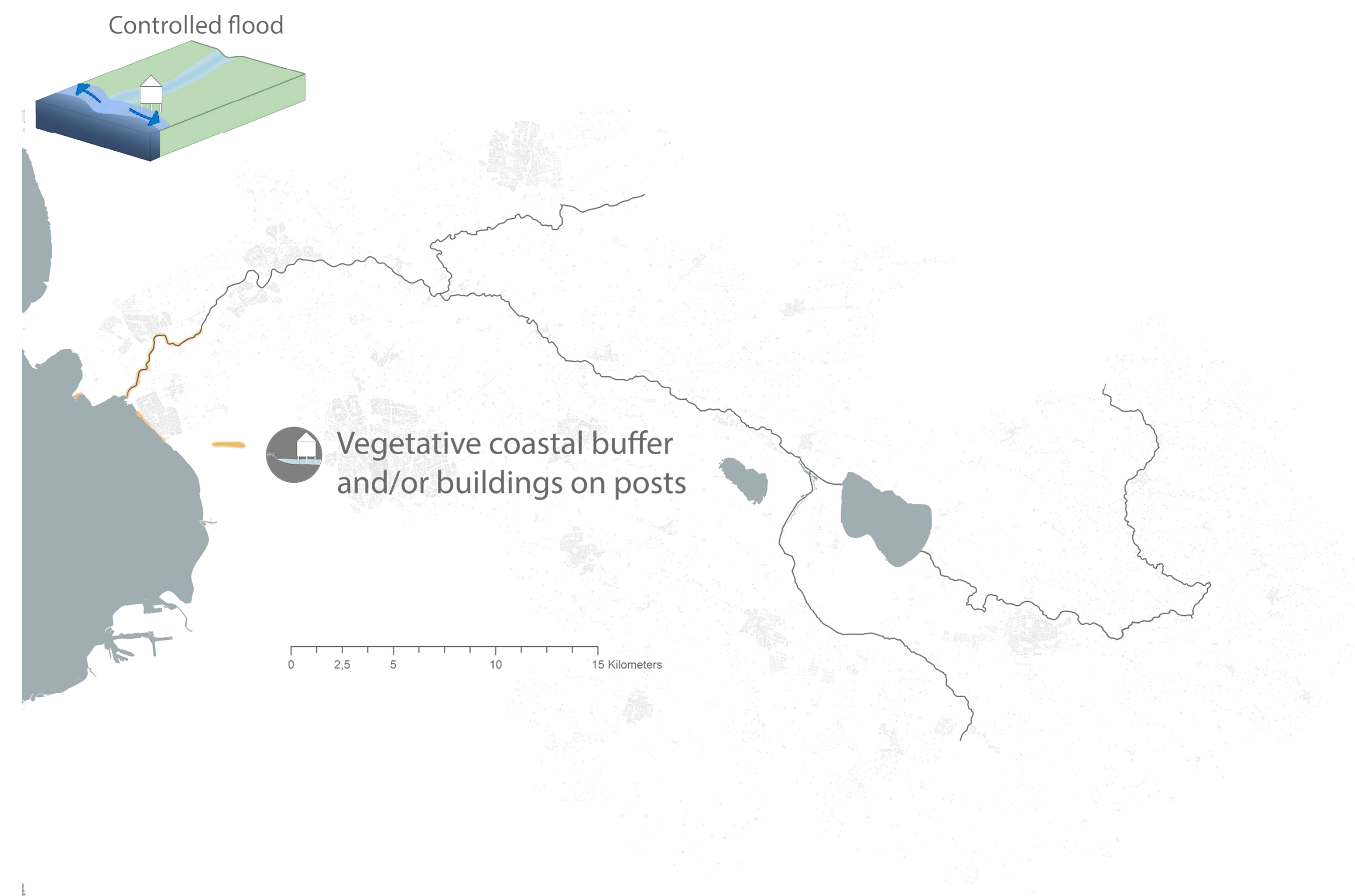


Fig.49. Controlled Food

The accessibility strategies are aimed to extent the existing infrastructure with bike lanes and trails to the river resulting in making the river more accessible. The extended cycle paths connect the buildings that have limited access to the river. The trail along the river connects the river to the existing recreational paths in the area the Skåneleden. And promotes the river as a recreational area.

Coastal flooding results that inland water from rivers will be more difficult to discharge in the sea. Therefore, the strategies vegetative coastal buffer and buildings on posts adapts the coast to future flood scenarios. By protecting the coast for higher sea levels (vegetative buffer) and preventing building damage (buildings on posts). These two strategies are combined as they function as a starting point for further discussion. As decision should be made based on the available space and or budget.

Allocation conceptual strategies

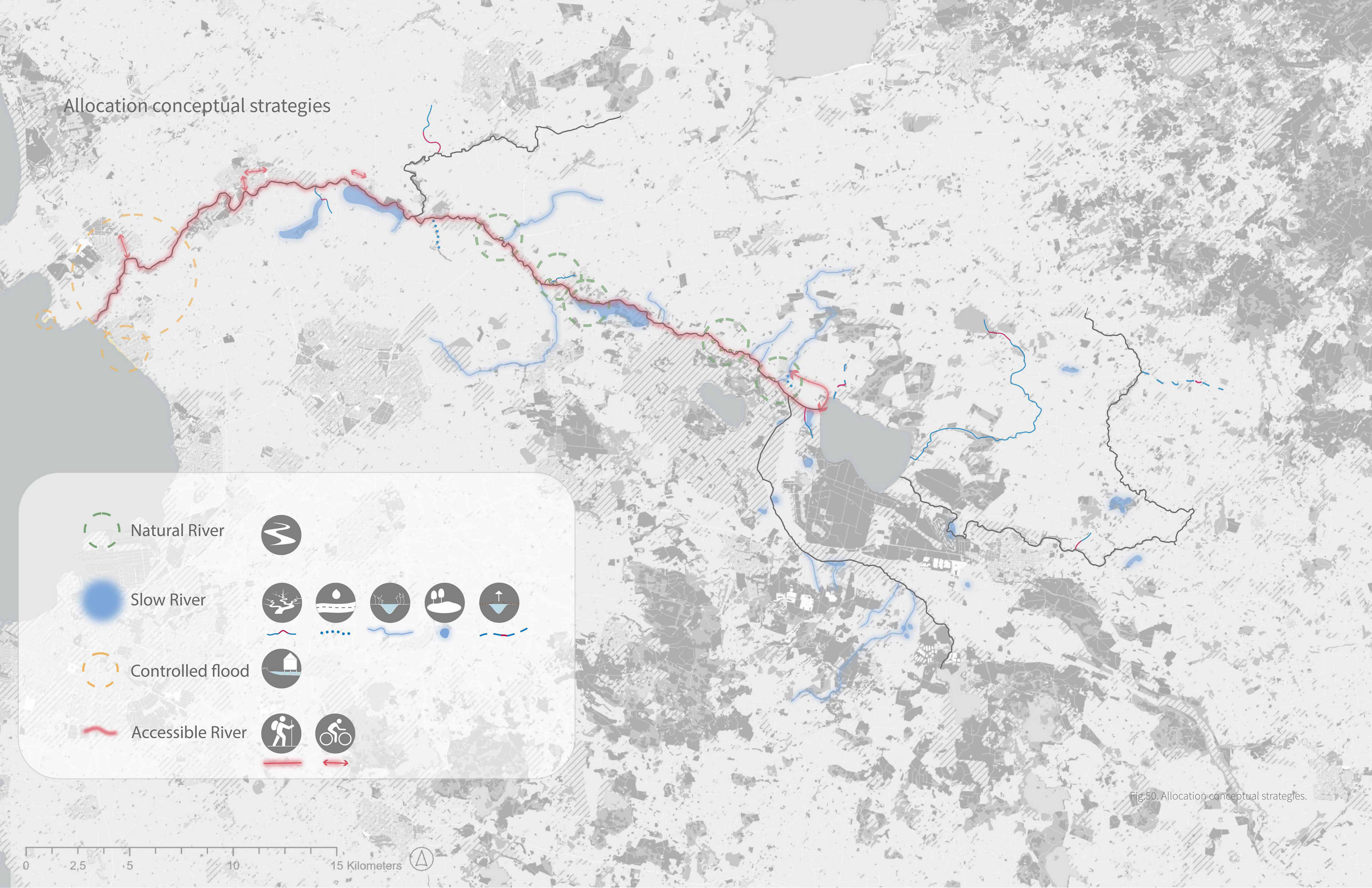


Fig.50. Allocation conceptual strategies.

7.3. Phase B2: Visualizing PPGIS results

The PPGIS survey collected various results and to get an overview of the results it was of importance to filter the results and determine how to include these results in the end product, the conceptual plan. I did this based on the following points.

1. Visualizing respondents' preferred improvement actions.
2. Translating challenges into a priority area.
3. Identification of key challenges

1. Visualizing respondents' preferred improvement actions

In the PPGIS survey respondents were asked what they would like to see improved in the study area concerning environmental quality, paths and accessibility and recreation facilities. As follow up question for environmental quality, respondents were able to vote for specific river restoration techniques that mitigate flood. In addition to this, respondents were also allowed to suggest their own solutions. All these answers are visualized along the river course. The results from the improvement action 'paths and accessibility' are also visualized in the map, as this was the second highest placed improvement action. The improvement action recreation was only placed 2 times. And therefore, is not seen as a priority (Figure 51).

Fig.51. Word Cloud. The figure shows the preferred improvement actions of the project group. The bigger the improvement action the more often it was mapped in the study area.

2 Identify priority area

The kernel density analysis in chapter 6 helped understand the spatial distribution of environmental and social challenges and their importance in the study area. It can be assumed that those more frequently mapped challenges and the areas with the highest density are of more importance to the project group and should therefore be a priority for managing the landscape. The PPGIS results show a significant higher concentration of environmental challenges, including flooding, and social challenges closer to the upper course of the river and should therefore be a priority area in this design process.

3. Identification of key challenges

New environmental challenges mentioned by the respondents are also visualized along the river course in this phase of the design process. Furthermore, extra attention is given to the environmental challenge 'erosion' and the social challenge 'restricted access to the river.' If too much erosion occurs in a riverbank, it might be a good idea to take actions to control this and prevent impact from future flood. The social challenge restricted access to the river was the most placed social challenge. And therefore, also worth addressing. It might be too ambitious and a waist of management and budget to organize a trail along the whole river course, around 55km. Instead, these markers give an indication where river access will be appreciated and where the hiking trail should go.

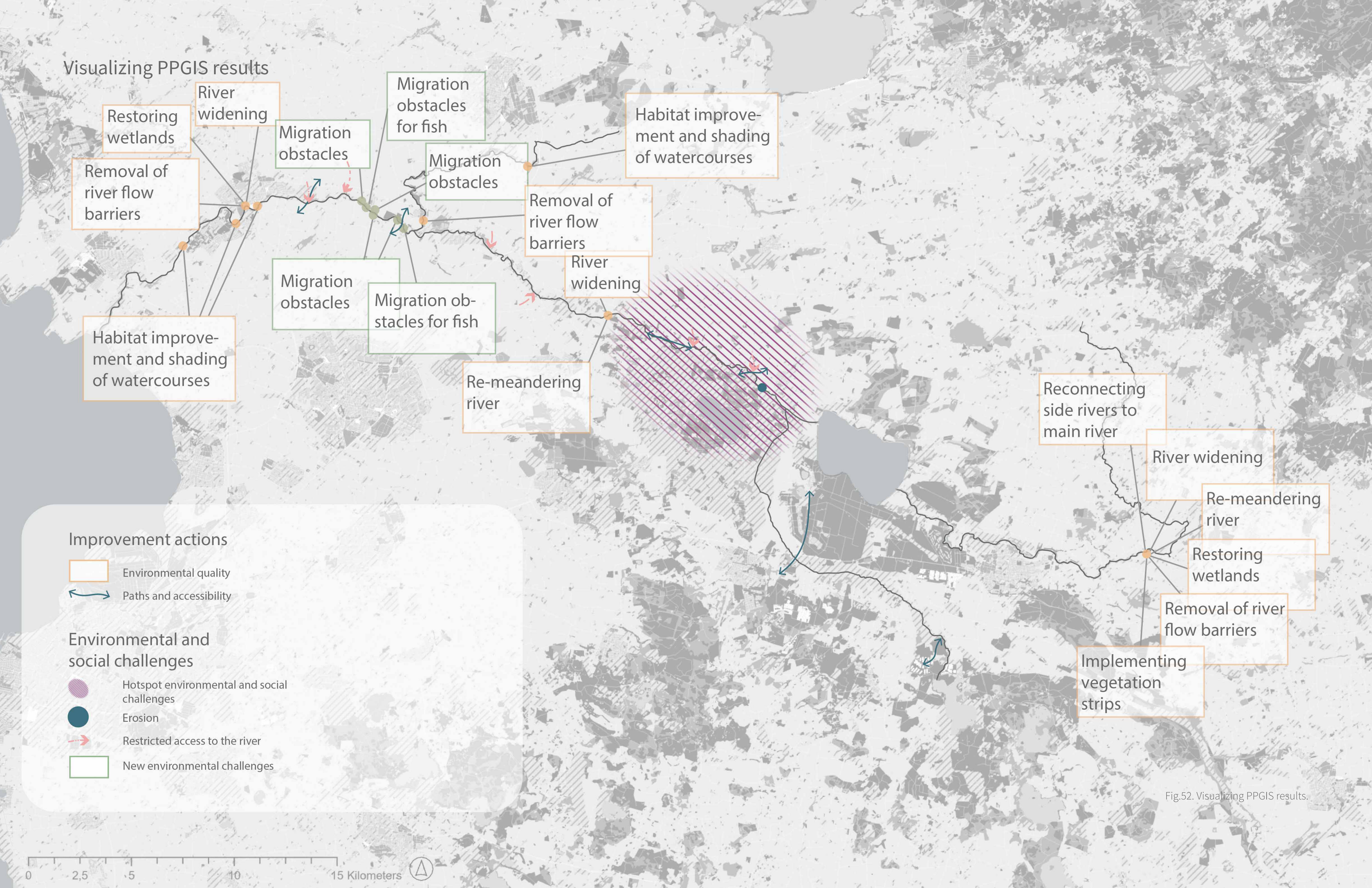


Fig.52. Visualizing PPGIS results.

7.4. Phase B3: Integrating conceptual strategies and PPGIS results into a conceptual plan

The conceptual plan integrates the PPGIS results with the four conceptual strategies to improve these conceptual strategies. Figure 53 shows how the conceptual plan integrates respondents' preferred solutions concerning environmental quality, environmental challenges, and social challenges. The improvement actions: environmental quality' from phase B2 are categorized into one of the four conceptual strategies that they align best with (Figure 54). The conceptual plan also visualizes places where multiple solutions were suggested for the improvement action 'environmental quality' and therefore discussion and negotiation are needed to agree on the most suitable measure. The new environmental challenge 'erosion' mentioned by respondents is categorized into the conceptual strategy 'controlled flood.' Erosion can be controlled with riverbank stabilization. This can strengthen the river and prevent impact from future floods. The markers where access to the river was restricted function as priority areas where the trail along the river should pass by. Since here access to the river is most wanted. This together with constructions that promote river experience such as a wooden deck, can contribute to making the river more accessible and a recreative water environment.

Fig.53. Integrating PPGIS results, improvement actions and social and environmental challenges.
The projects group own solutions and preferred measures for the improvement action 'environmental quality. The conceptual plan integrates these responses. And finds new solutions to integrate the projects group experience of erosion and the social challenge restricted access to the river.

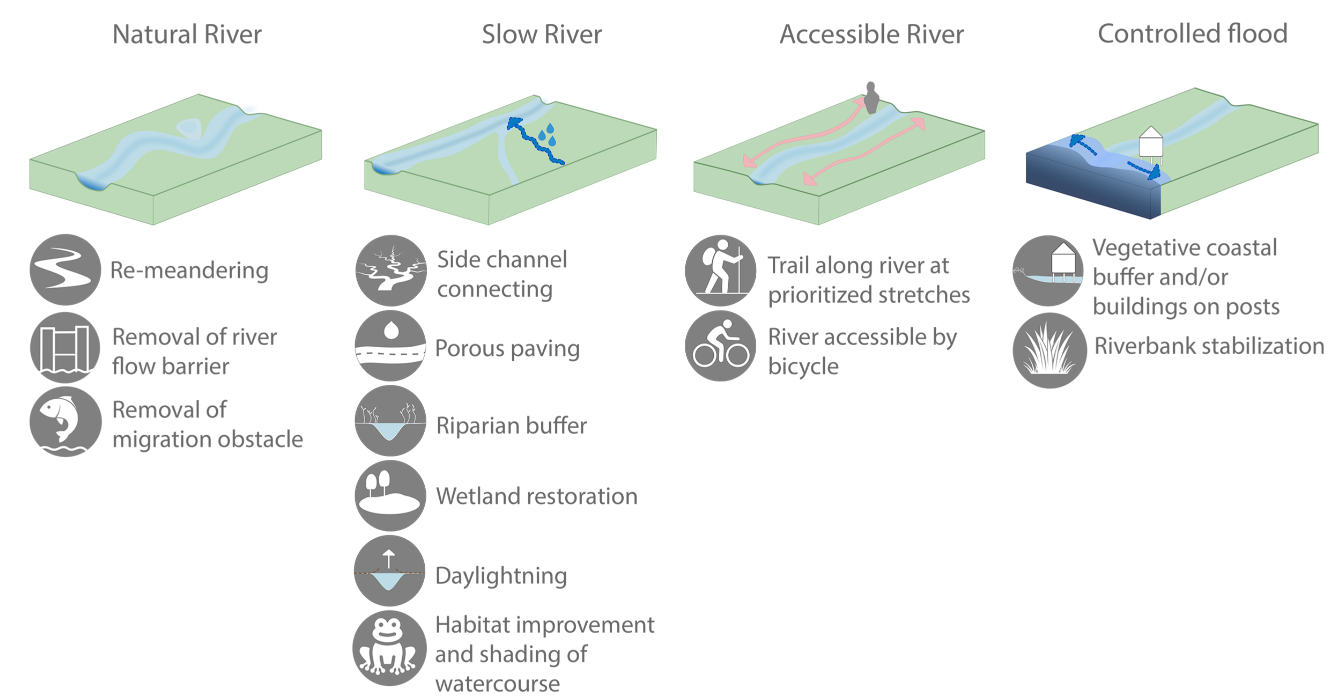


Fig.54. Improved conceptual strategies based on the PPGIS results.

Conceptual plan

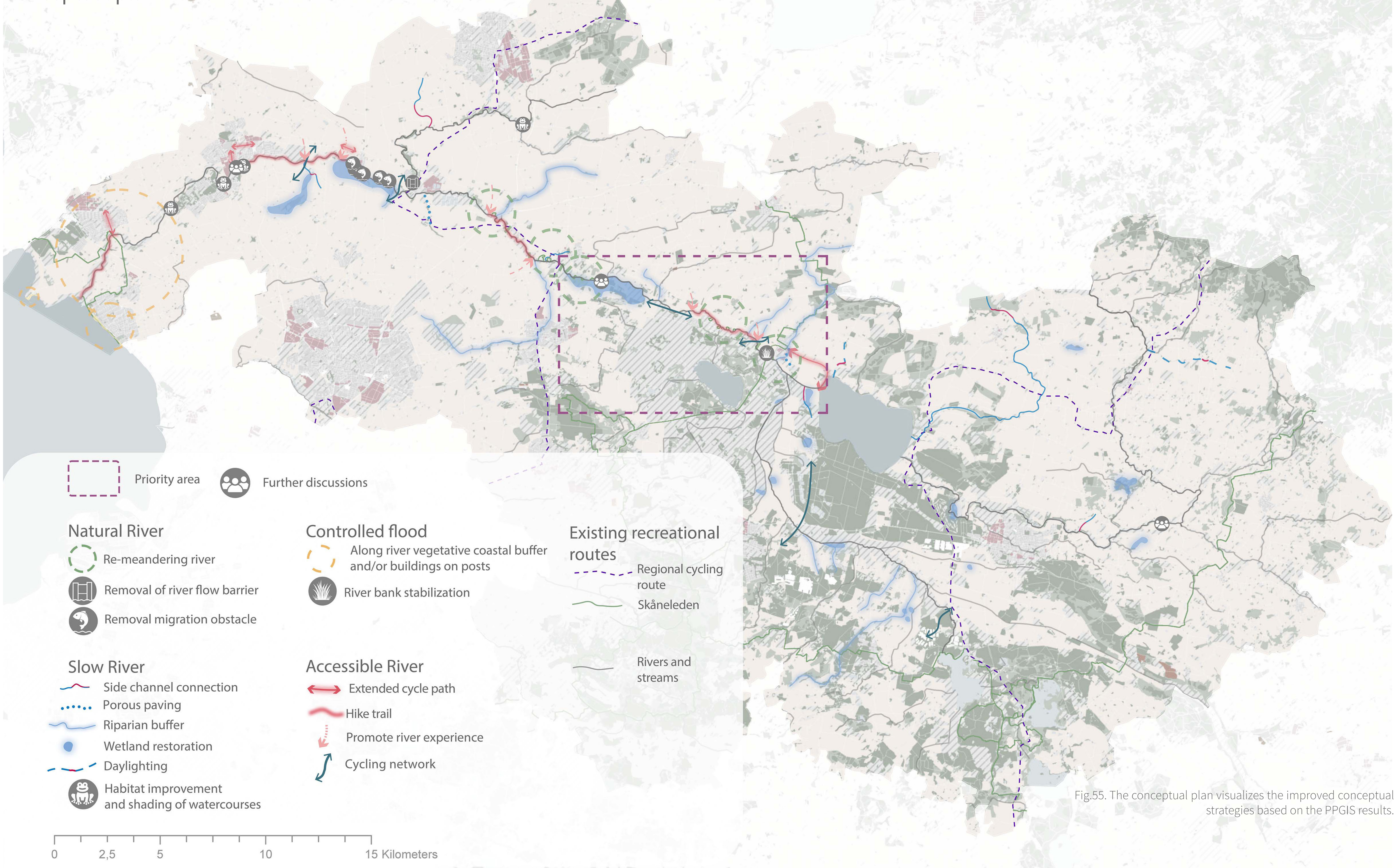


Fig.55. The conceptual plan visualizes the improved conceptual strategies based on the PPGIS results.

The priority area provides a closer look to the improved conceptual strategies. This area showed the most experienced environmental and social challenges in the study area. It should therefore be a priority when executing the proposal and plans mentioned in the conceptual plan. The following pictures give an idea how some of the strategies could look like.

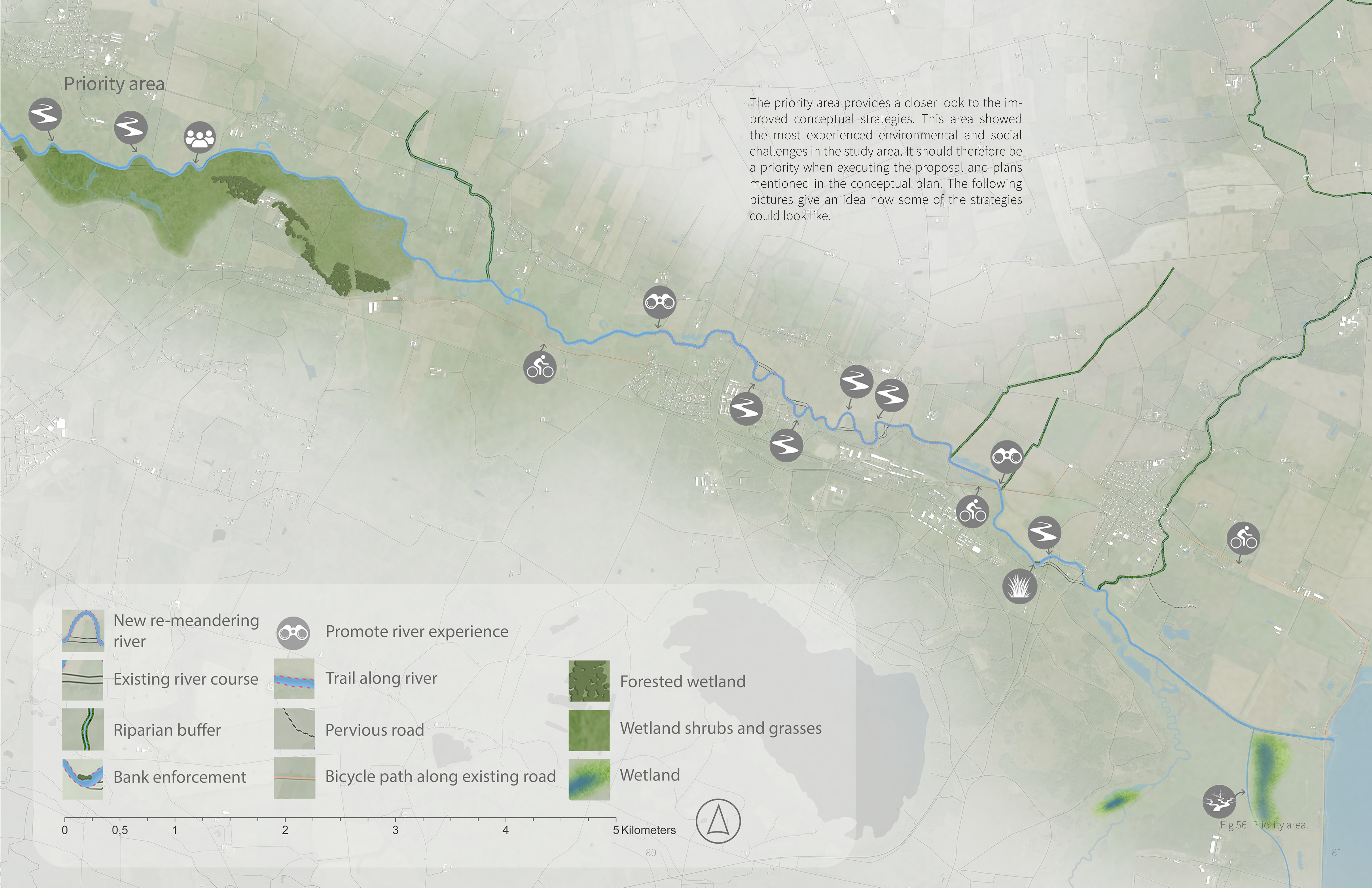


Fig.56. Priority area.

Re-meandering river

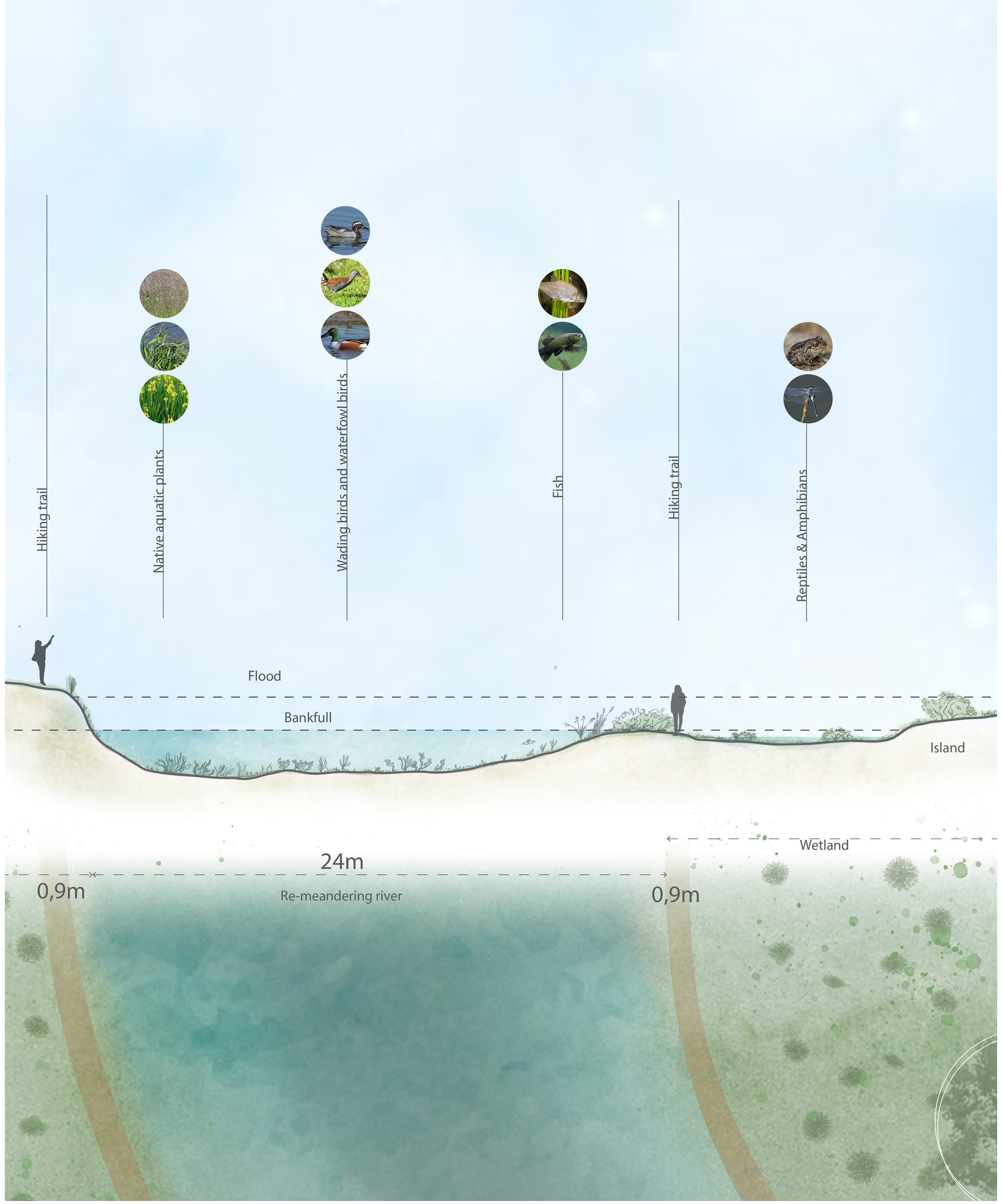


Fig.57. Re-meandering river.

Promote river experience

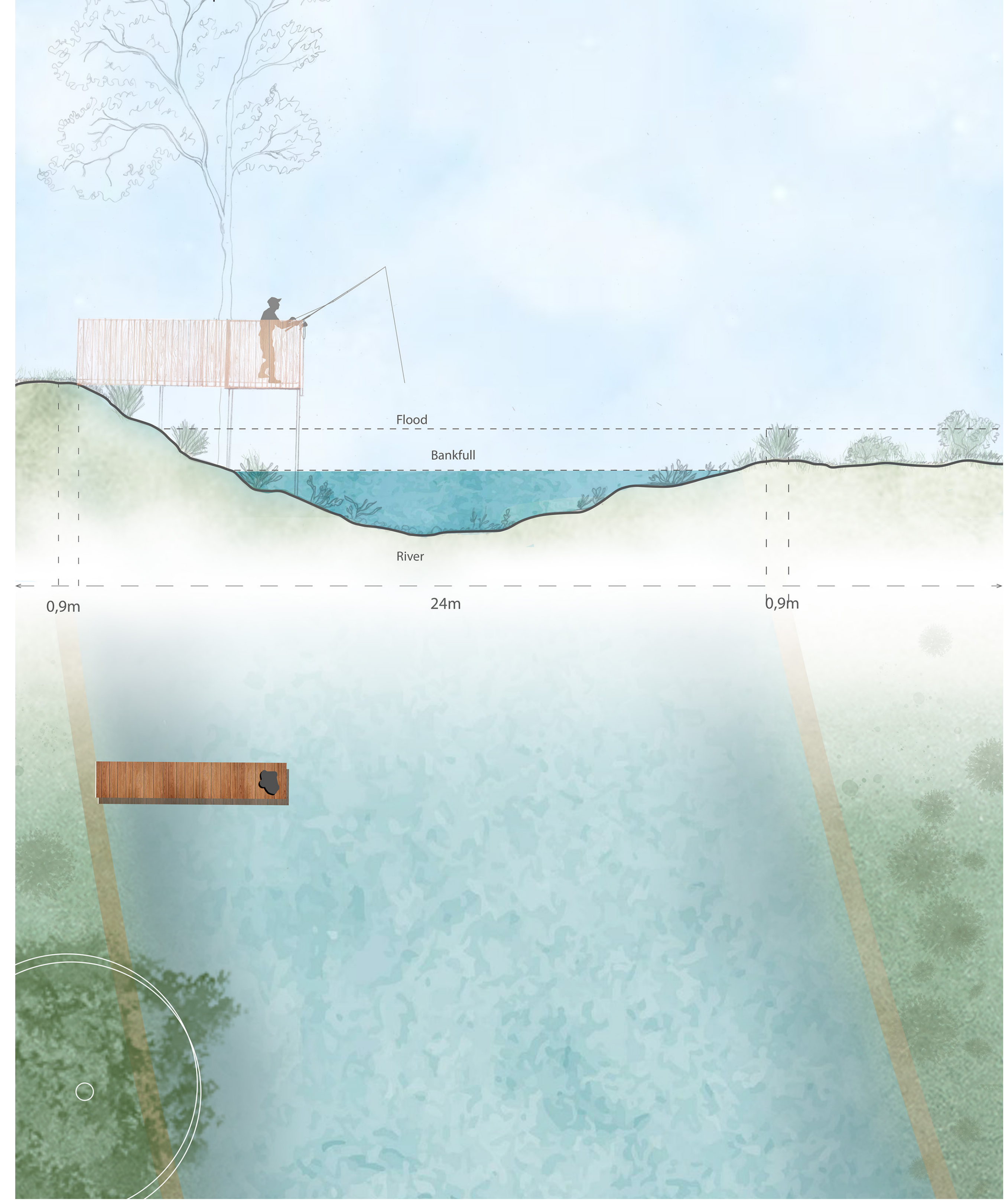


Fig.58. Promote river experience.

Riverbank enforcement: bioengineering

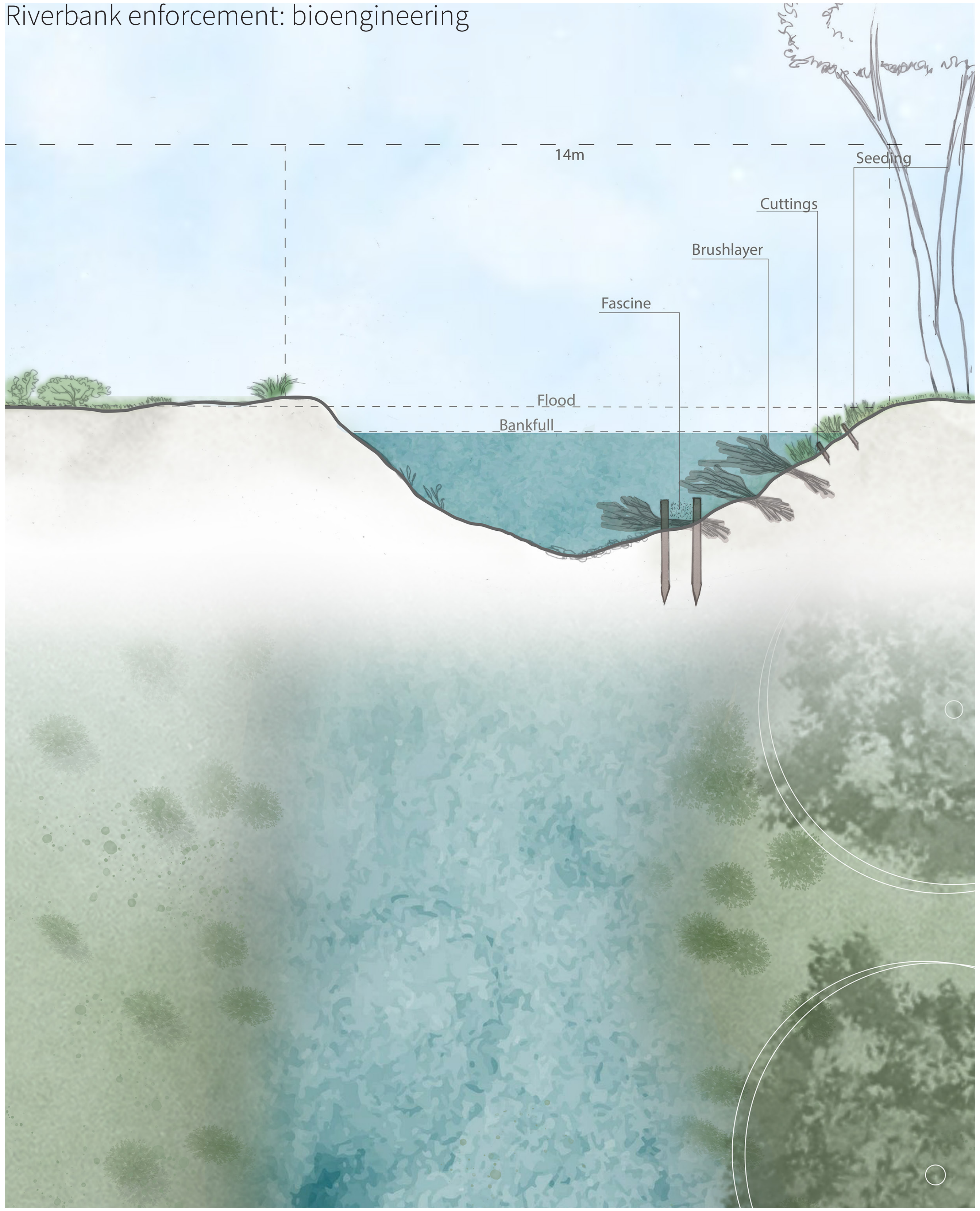


Fig.59. Riverbank enforcement: bioengineering.

Porous paving and riparian buffer

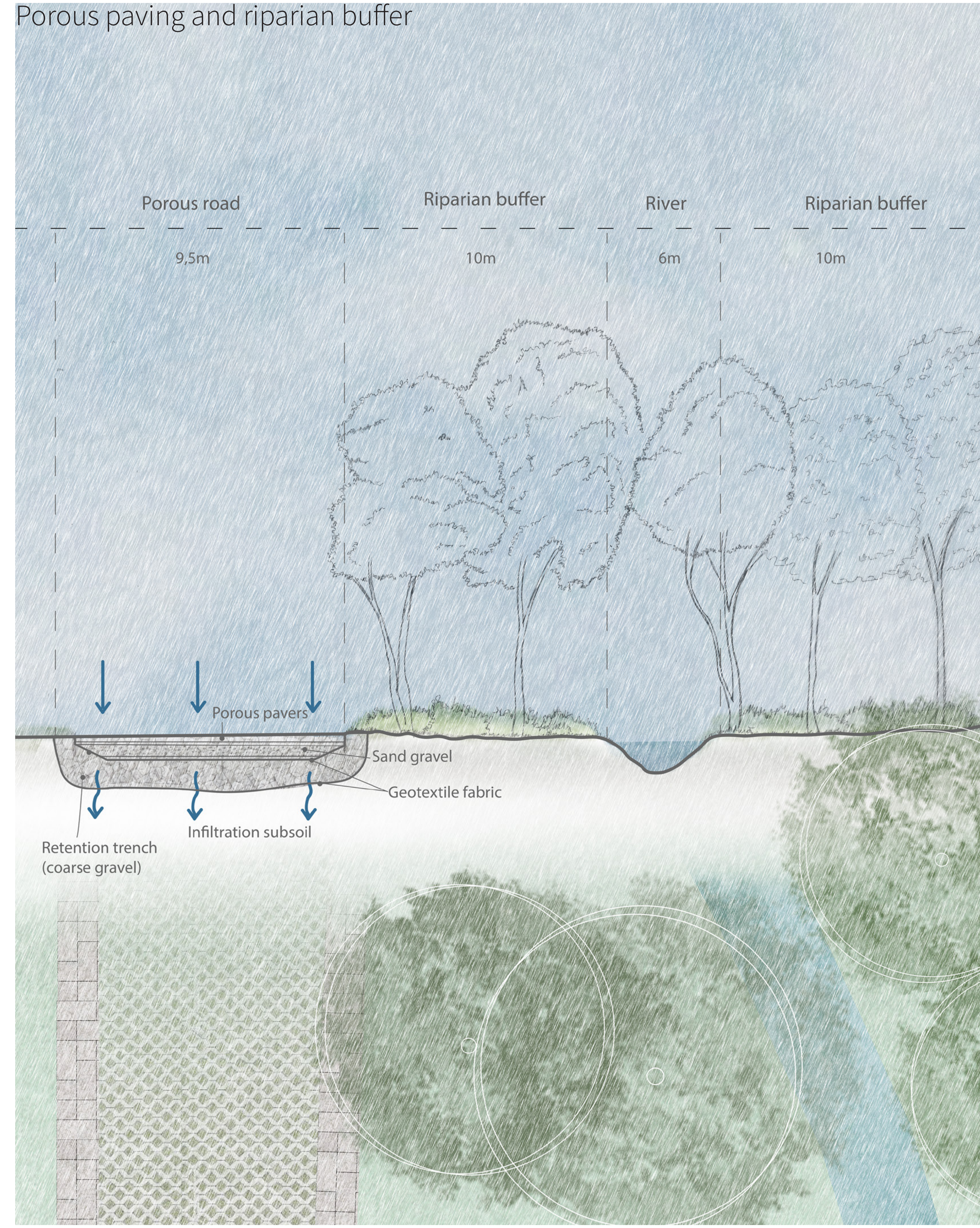


Fig.60. Porous paving and riparian buffer.

8. Discussion

This study applied and explored PPGIS as a tool in the design process for flood and stormwater resiliency in the Kävlinge river catchment. With the RQ How can PPGIS contribute as a tool in a design process for flood and stormwater resiliency in a river catchment? Different methods are used in this thesis to answer the research question: literature, site analysis (GIS site analysis and site visit), PPGIS and designing.

8.1. Methods

PPGIS complements the research in the designing process

The design process in this thesis followed the analytical approach. In my design process I went through different phases. Phase A, before designing (literature research, site visit and site analysis), phase B during designing were literature and the PPGIS results helped to form the conceptual strategies and conceptual plan. Phase C, after designing, is the last phase. In this phase research helps to evaluate and justify the design. In phase B, the analytical approach was applied in this thesis.

Phase A: versatility of knowledge and diversity of opinions and experiences.

Based on my experience going through the design processes I can say that PPGIS contributed to the design process in phase A by producing versatile knowledge and the diversity of opinions and experiences. The methods literature overview and the ArcGIS site analysis provided this study with scientific knowledge while PPGIS provided this thesis with local knowledge from various stakeholders. By asking different questions PPGIS was able to collect soft place-based information that revealed values (landscape values and sense of place), experience (also landscape values and challenges), behaviours (visiting frequency and recreational activity) and preferences (improvement actions). This was especially valuable for complementing the ArcGIS site analysis and site visit. In line with the research of Kahlia et al (2019) ''One unique possibility that the PPGIS approach provides is the simultaneous analysis of the 'soft', experiential place-based datasets with the 'hard', traditional GIS datasets.'' The ArcGIS site analysis provided large-scale maps showing areas that would be prone to flooding in a future flood scenario and calculated buildings that were vulnerable in this future scenario. PPGIS complemented this information by visualizing where respondents have experienced flooding by mapping it out themselves. PPGIS also revealed new knowledge that I could not analyse with GIS datasets available to me such as aesthetic and scenic landscape values but also environmental challenges, such as drought and erosion, which my GIS analysis did not focus on. Moreover, the PPGIS results complemented the information I collected during the site visit. During my site visit I was limited by time and could not investigate the accessibility of the whole river. The PPGIS results showed additional areas where respondents experienced restriction of river accessibility.

PPGIS also contributed to the diversity of opinions and experiences in the design process by targeting different stakeholders: public authorities, economic sector, general public, NGOs, and tourists. Targeting tourists was difficult in this study. Nevertheless, the results show where stakeholders had different opinions and where they agreed with each other.

Phase B (during designing): agency

In this phase, PPGIS contributed to the design process by making the conceptual plan more inclusive. During the design process I formulated the conceptual strategies based on flood mitigation and river restoration strategies found in the literature. But the results from PPGIS enriched this by generating new solutions that represented the respondents' choices. Examples of new solutions participants mentioned were the removal of river flow barriers and habitat improvement and shading of watercourses. Furthermore, based on respondents' experiences of social and environmental challenges a priority area could be identified. Assuming that areas with a high density of social and environmental challenges are areas where mitigation of these challenges are most needed. In summary, PPGIS proofs to broaden the participatory process when participants can map their landscape experience and are able to come up with their own solutions. This allows participants to have more agency in the design process not only in the early stage, when information and knowledge are collected, but also when decisions are made.

Phase C (after designing): follow up surveys

An effective way to evaluate the role of PPGIS in this study would be to both conduct a follow up survey as well as a post design intervention survey. A follow up survey would be helpful for respondents to voice their opinion on the conceptual plan and vote again for river restoration techniques that where not agreed on yet. This way there is a mutual understanding in what participants contribution was on the conceptual plan and measure their satisfaction with the final plan. In addition, a follow up survey should include respondents' opinion about the question asked in the survey and their thoughts on this map-based survey as a participation tool. In a situation where the plans would be implemented a post-evaluation survey could be useful in gathering information how the project group experiences the landscape now (a few years after design interventions). Both of these surveys are however beyond the scope of this thesis. Therefore, the strength, weaknesses, and improvements of PPGIS in this design process, concerning targeting more and a diverse group of respondents, translating accuracy and the length of the survey will be discussed more in depth in 8.2 and 8.3, from my own perspective and relevant literature.

GIS site analysis and limitations

Limitations of the GIS analysis

GIS was a helpful tool in conducting site analyses and a future flood scenario because of its ability to visualize complex and large spatial data. Still potential limitations of the conducted GIS analysis include, the choice of the future flood scenario, the type of flow accumulation analysis, the amount of data used for the historical river course analysis, and the lack of calculations on the effect of flood mitigation. More detailed GIS analysis does take more time as well as more expertise and therefore fall beyond the scope of this thesis. Still, these topics area discussed for the learning process of this thesis.

GIS data availability, scenario and calculations

The historical map I used dates from the years 1910-1915. From the literature overview it can be concluded that rivers and channels in the study area have been channelised earlier than 1910. Therefore, the historical river course analysis map does not show the original river course. As a result, the areas that I identified as potential areas to re-meander the river are not complete. Using several historical maps from different time periods and a geomorphological map could have contributed to a more precise picture of the historical river course. Furthermore, the appearance of meanders varies on the spatial scale at which the river is being viewed. The scale that I analysed the river course, 1:160000 on a A3, might have resulted in mistaking certain bends in the river for meanders.

Secondly, the scenarios presented in the flood map. The flood analysis map shows a scenario that is quite extreme concerning the sea level rise. A different scenario would expose less buildings as vulnerable to sea level rise. Also worth discussing is the flow accumulation in this map. Flow accumulation analysis are static flows that do not show the changes that happen during a real rain event (Persson et al., 2024). It does not show how a depression reacts when a cell is saturated by precipitation. In a real time event, flows will make new routes as they react to this. A dynamic flow model could show a more realistic map of the flows during a rain event (Persson et al., 2024). When using this in the thesis the allocation of the conceptual strategies would have been different because it could have showcased a more realistic flow of the study area. Integrating dynamic flood modelling in future research could enhance the GIS component of PPGIS. It strengthens the accuracy of a flood risk analysis measured with Scalgo and GIS and could show a clearer distinction with the experienced flooding results measured with PPGIS.

Lastly, this study does not include calculations on the exact effect the conceptual strategies have on mitigating flood. Since I used Scalgo in combination with GIS for the flood scenario, it would be possible to manipulate the terrain and, for example calculate how much water a new wetland can store. Instead, this study trusts that the proposed strategies based on literature, at least contribute to flood mitigation and therefore make the study area more flood and stormwater resilience.

8.2. PPGIS Results

Though PPGIS was a useful tool in this thesis there are still matters that could be improved to make the results more useful for local authorities like the Kävlinge Water Council.

Response rate and representation

Representation in the project group.

The results of the PPGIS survey show a total of 46 respondents and 93 visitors on the website. This could be regarded as a response rate of 46,5%. But only 20 respondents finished the survey. Still the answers of respondents who did not finish the survey are also included in the data analysis since not all questions were mandatory and the last question was 'submitting the survey.' Maptionnaire makes it easy to include these results since the answers are saved automatically. Still, as predicted, the survey is not a representation of the population in the study area, which has around 156.000 inhabitants ('Karta', n.d.). Additionally, not all municipalities were represented in the survey results. It was a challenge to target respondents from particular municipalities. Among the respondents, it can be noticed that there was an over representation of public authorities in the project group and an under representation of the economic sector, tourists, and NGOs. It is important that the response group represent the wider population. This will show a more realistic spatial distribution of landscape values, challenges and improvement actions in the stud area. In addition, it would contribute to a more equal distribution of strategies and plans that are proposed in the conceptual plan.

Overrepresentation high educated group

The results of the project group show an overrepresentation of people with a high level of education. Most participants had as highest degree a master's degree. This result is in line with the study of Brown (2012). The author concludes, after evaluating multiple PPGIS studies, that in general PPGIS responses contain bias towards social demographic groups with a relative high average age, high formal education, are male dominated and an underrepresentation of racial-ethnic groups.

Landscape values

The results showed that recreation, natural education and aesthetic & scenic were the most placed landscape values. This complements existing literature on PPGIS in a riverine landscape. In García-Nieto et al. (2015) where the categories recreation/tourism together with cultural heritage and aesthetic/scenic were as well the most mapped categories. However, natural education was not in the list of most mapped landscape values. This can be explained by the over representation of public authorities in this study who might value natural education and relaxation more than the residents

and tourists.

Discrepancy between challenges and improvement actions

Comparing the improvement actions with the social and environmental challenges. It could be expected that these would be located at the same place but looking at the map, they do not overlap much (Figure 42). A similar discrepancy is noticeable in the study of Schröter et al. (2023) were the dominance mapped challenges do not bring up actions that target these problems. In their study respondents mapped out waste problem as the dominance problem in the area but only a few environmental solutions were mapped at the same place. Schröter et al, (2023) argue that this might be due to recent political agendas of the management. The categorization of the improvement actions of this thesis are broader, recreation & cultural facilities, paths & accessibility, and environmental quality. It is still remarkable that the challenges and improvement actions are not complementing each other much. And the same conclusion could be drawn as in Schröter et al. (2023), that the current goals and policies of Kävlinge Water Council focus on specific areas and topics in the river catchment. Still the frequency of the mapped improvement actions environmental quality and path & acessibility show an appreciation of improving the study area on these topics rather than on recreation facilities.

Different values between stakeholders

The categorization of respondents was a useful way in visualizing difference experiences between stakeholders. The general public and the public authority had quite similar thoughts on the landscape values in the study area. However, the study showed different perspectives with regard to environmental challenges. Where the public authority identified a lot of new environmental challenges the general public found solid waste management problems the most prevalent challenge. Furthermore, restricted access to the river was the most dominant social challenge by the public authority and negative behaviours among the general public. These differences are probably a result of the stakeholder's personal interests driven by their use of the landscape and or responsibility in managing the landscape.

8.3. PPGIS improvements

Identify barriers for public participation

Nguyen et al. (2024) argue that it is important that researchers and decision makers identify barriers for certain stakeholders for participating in participatory process such as PPGIS. In order to reach those stakeholders groups and increase the participatory rate. An explanation given by Nguyen et al. (2024) that could exclude participation is access to technology. One approach to overcome this barrier as well as limit the bias in this thesis study towards respondents with a high level of education, would be to run in-person workshops as suggested by Schröter et al. (2023). This study showed that the socio demographic characteristics of the respondents in the workshops were slightly more balanced compared to the online surveys. Additionally, the study demonstrates that a workshop in the form of an in-person survey was helpful for reaching participants who encountered difficulties with the online survey and increasing the PPGIS response rate in general.

Improvements: distributing the survey

Offering different language adaptions of the online survey would be an effective way to reach the non-Swedish speakers. Maptionnaire has a tool to translate a survey to different languages. Immigrants and people speaking a minority language are often not well presented in conventional public participation processes and some PPGIS surveys using the multi-language tool have been successful in reaching these groups (Kahila-Tani et al., 2019). However, for this study I did not use these settings because I already saw a few translation mistakes when trying this setting. Another way of increasing the response rate would have been to mail the survey to more people. However, this was limited because of the lack of contacts I had of people living in the study area. If I would have lived in the study area, I predict that it would have been easier to distribute the survey. I would have been more comfortable going from door to door and address people personally. Also asking friends and relatives to help distribute the survey would have been an option in that scenario.

Weakness survey: length and repetitiveness

Certain questions used in PPGIS surveys have caused misunderstandings in other studies. From other research it is stated that the questions about landscape attachment are difficult to communicate to non-experts (Verbrugge et al., 2019). As far as can be said this was not the issue with this survey. From the beginning of these statements only two respondents stopped with the survey. In Maptionnaire I saw that most respondents dropped out after or during the mapping of landscape values and challenges. The number of respondents in the survey decreased here till half. This was probably because of the amount of landscape values and challenges or the repetitiveness of the questions. This might have made the survey too long for respondents to finish it.

Strength survey: open questions

In the study of Nguyen et al. (2024), the authors found that most answers in a survey are predetermined and can therefore interrupt the flow of idea generating and the spontaneous and out of the box inputs. Contributing to that these types of answers therefore limit the extent to which participants have an active role in the Co-production/ co-creation/ co-design process. The option to freely write answers at a few questions in this thesis survey tried to overcome this limitation. The thesis survey had the option 'other' for the questions on environmental and social challenges, improvement actions for environmental quality and the follow up question for Landscape values for the option recreation. In all cases this option was used by the respondents except for the social challenges question.

Translation improvements: data analysing

The survey was first written in English and with the help of my supervisor, online translation websites and friends, translated to Swedish. This might have caused some translation errors as I am not a native Swedish speaker. This has also influenced the analysis of the results. For example, when I had the stakeholder category 'resident' in mind I translated it to 'Jag är bosatt på landet' which means I live on the countryside. This might have confused the respondents because many of them chose the option 'Annat' (other) for this question. After asking a friend who lives in the study area, he said that he would have chosen 'Jag är bosatt på landet' if 'Annat' was not an option. Because of this I made the decision to combine these two categories when analysing the results.

Incorporating PPGIS in participatory processes and future projects

This thesis had an explorative nature of applying PPGIS. The sample size was limited and primarily consisted of the stakeholder group public authority. By describing the strengths and improvements of PPGIS in this design process it can inspire and help future research and institutions to use PPGIS as a participatory tool in their planning processes. With rules such as the European Landscape Convention the need to learn from different participation tools and how to improve these might become more relevant. The European Landscape Convention (ELC) has rules for European countries to integrate stakeholders' participation into landscape management and evaluation (Sandström & Hedfors, 2018). Sweden is since 2011 obliged by it. More research from this kind of nature can help institutes as the Kävlinge Water Council and Storkriket how they can best incorporate PPGIS and use it as an (additional) participation tool in their planning processes.

The Kävlinge Water Council already succeeds quite well in including different stakeholders in their planning processes. In the board different organisations and practices are voiced such as landowners, industries and concerned organizations (e.g. nature organizations) (Kävlinge River Water Council, 2013). Still PPGIS could be valuable for the Kävlinge water Council or Storkriket because it is a tool that includes residents as an extra stakeholder group, has the potential to reach the less vocal and active citizens and groups, and non-Swedish speakers. Hereby contributing to diversifying the stakeholder group and the democratising of the planning process. To reach these different groups it is advisable that the survey is translated into different languages and combined with workshops for people who are less equipped in technology. PPGIS should therefore be seen as an additional tool in their planning process and not a replacement. Furthermore, the number of contacts an organisation like this has with the locals could help with the distribution of the survey and can increase the response rate in general. PPGIS can also contribute as a way to draw inspiration from respondents. For example, to pole what places residents value the most and why. It could also be used as a voting platform to decide on plans and as a starting point for negotiations and discussions. It would be advisable to include a second survey round when doing a PPGIS survey to give participants the opportunity to comment on a final plan and measure their satisfaction in the use of PPGIS as a participatory tool.

9. Conclusion

This thesis answered the research question: How can PPGIS contribute as a tool in a design process for flood and stormwater resiliency in a river catchment? It explored the contribution of PPGIS in different design phases.

In phase A of the design process, before designing, PPGIS complemented 'hard,' traditional GIS datasets with 'soft,' experiential place-based data from various stakeholders. In phase B, during designing, PPGIS helped improve the conceptual strategies with measures that are based on the stakeholder's input. New solutions stakeholders mentioned that directly influenced the conceptual strategies and the conceptual plan are removal of river flow barriers, and habitat improvement and shading of watercourses. PPGIS also made it possible to identify a priority area. This area reflected stakeholders' experiences of environmental and social challenges as well as experiences of flooding. In addition, PPGIS helped highlight stretches along the river the hiking trail should follow, and where river experience should be prioritized. This was based on respondents' answers about places where they experienced restricted access to the river. Furthermore, PPGIS helped point out places for further discussion and negotiation between stakeholders to agree on the most suitable river restoration measures. In phase C, after designing, PPGIS improvements in the design process should focus mostly on reaching more and a more varied group of respondents. Since it is important that the results reflect the experiences of the broader public of a study area. Furthermore, this thesis recommends follow up surveys that measure respondents' satisfaction of the conceptual plan but also their opinion on PPGIS as a participatory tool.

Based on the results, PPGIS can contribute to the design process by formulating and targeting flood and stormwater measures and recreational landscape proposals that reflect stakeholders' landscape experiences and preferences. This study also advises practitioners to focus on methods that increase the participatory rate of PPGIS and limit biases in the results.

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Appendix A
PPGIS Survey

Survey translated to English

Let's get to know each other

1. Please select your gender (Multiple choice, one option possible)
    - Woman
    - Man
    - Non-binary
    - Don't want to answer.
2. In which year where you born?

Let's get to know each other

3. What is your highest level of education? (Multiple choice, one option possible)
    - Elementary school
    - Secondary school
    - Folket Schule
    - Bachelor's degree
    - Degree of Master 60 credits
    - Degree of Master 120 credits
    - Doctoral degree

Study area

4. Do you live in the study area? (Choose one)
    - Yes
    - No

My region (Follow up question q4 option 'yes')

5. Please choose the region you live in. (Click on predetermined regions on map)

My Region (Follow up question q5)

6. For how long have you lived in this place? (Multiple choice, one option possible)
    - <5 years
    - 5-10 years
    - 11-20 years
    - 21-30 years
    - Over 30 years

My region (Follow up question q4 option 'no)

7. Where do you live? (open question)
8. How long have you lived in this place? (Choose one)
    - <5 years
    - 5–10 years
    - 11–20 years

    - 21–30 years
    - More than 30 years

The landscape and I

9. In what way are you involved in the landscape?
    - I work at a national/municipality level with water issues and/or landscape management. (Public authority)
    - I work as a farmer or forester. (Economical sector)
    - I am involved at a non-governmental organization with an interest in recreation and environmental protection. (NGO)
    - I am a resident. (General public)
    - I am a tourist. (Tourist)
10. How far do you live from the river Kävlinge? (multiple choice, one option possible)
    - less than 500m
    - between 500m – 1km
    - more than 1 km

Landscape values

11. Please choose one or more positive landscape values and map this to a location you experience this. (click and drop pin)
    - Recreation
    - Cultural heritage
    - Aesthetic & scenic
    - Relaxation
    - Social interaction
    - Spiritual enrichment
    - Natural education
    - Economical
12. How often do you visit this place? (Pop-up question after each pin q12)
    - I do not visit the place.
    - Daily
    - Weekly
    - Monthly
    - Twice a year
    - Once a year or less
13. Please choose one or more of the following recreational activities you undertake and map this to the specific location. (Pop-up q12 after option 'recreation')
    - Walking
    - Walking your pet
    - Watching nature
    - Land sport
    - Water sport
    - Social activity

- Photography
- Other:

Environmental challenges

14. Please choose one or more of the following environmental challenges and map it to the place you experienced it? (click and drop pin OR draw polygons)
    - Invasive species
    - Solid waste management problems
    - Flooding
    - Erosion
    - Drought
    - Poor water quality
    - Soil pollution
    - Lack of maintenance
    - Other
15. Please write an example. (pop up open question, q15 answer 'other')

Social challenges

16. Please choose one or more of the following social challenges and map it to the place you experienced it? (click and drop pin)
    - Restricted access to the river
    - Poor aesthetic quality
    - Negative behaviours
    - Feeling of insecurity
    - Smell pollution
    - Noise pollution
    - Lack of access to green spaces
    - Other
17. Please write an example. (pop up open question, q17 answer 'other')
    Please map one or more.

What is your opinion?

18. Please choose one or more of the improvement actions that you believe should be implemented and map them to a specific location. (click and drop pin)

    - Paths and accessibility

Actions aimed at connecting attractive areas with walking paths that are accessible directly from urban areas/villages or public transport stops.

- Environmental quality

Actions aimed at improving the environmental characteristics of the landscape, e.g. flood mitigation, reduction water erosion, water purification.

- Recreational and cultural facilities

Actions aimed at promoting recreation and outdoor activities, e.g. improve or establish nature parks, cultural facilities and recovery of heritage.

19. What kind of measures? (Pop up question q19, option 'environmental quality')
    - Creation of wetlands
    - Re-meandering river
    - River widening
    - Removal of river flow barriers (dams, culverts and weirs)
    - Creation of vegetation strips
    - Reconnecting side rivers to main river
    - None of the above
    - Other

Your priorities

20. What kind of improvements do you think are most important to implement in the study area? Drag and drop the themes and rank them from one to five, from 1 to 5, with 1 being the most important.

- Recreation and culture
- Flood measurement and biodiversity
- Trails and accessibility
- Pollution and drought

Experience with flooding

	Yes	No
21. I have experience of flooding along Kävlinge river?	☐	☐
22. I have heard stories about flooding along Kävlinge river?	☐	☐
23. I have experience of flooding elsewhere?	☐	☐

Floods (Follow up question q23 option 'yes)

24. In what other places have you experienced flooding?

Involved in flood measurements

25. Have you been involved in any flood measurements in the study area (e.g. construction of wetlands, etc.)? (Choose one)
    - Yes
    - No

My favourite place

26. Please map out your favourite place in the area. (Draw polygon)

27. How often do you visit this place?

- Daily
- Weekly
- Monthly
- Twice a year
- Once a year or less

My favourite place

28. To what extent do you agree with the following statements?

a. I am very attached to the place.	Disagree	1	2	3	4	5	Agree
b. This place means a lot to me.	Disagree	1	2	3	4	5	Agree
c. I identify strongly with this place.	Disagree	1	2	3	4	5	Agree
d. I feel this place is part of me.	Disagree	1	2	3	4	5	Agree
e. No other places could compare to this one.	Disagree	1	2	3	4	5	Agree
f. I wouldn't substitute any other place for doing the type of things I do here.	Disagree	1	2	3	4	5	Agree
g. The place is the best for what I like to do.	Disagree	1	2	3	4	5	Agree
h. I get more satisfaction out of being here than at any other places	Disagree	1	2	3	4	5	Agree
i. I am happiest when I´m at this place.	Disagree	1	2	3	4	5	Agree

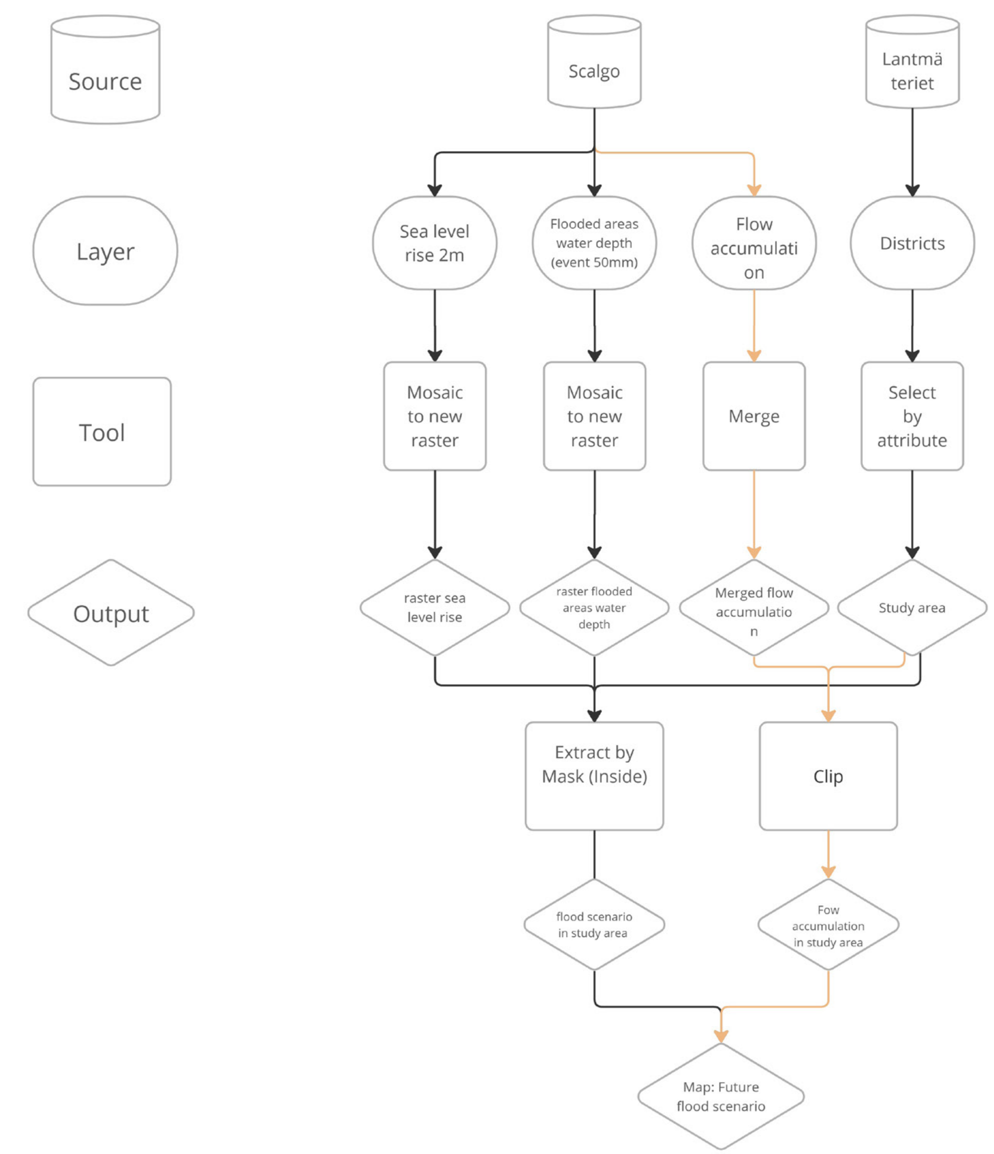
My favourite place

29. How would you describe this place?

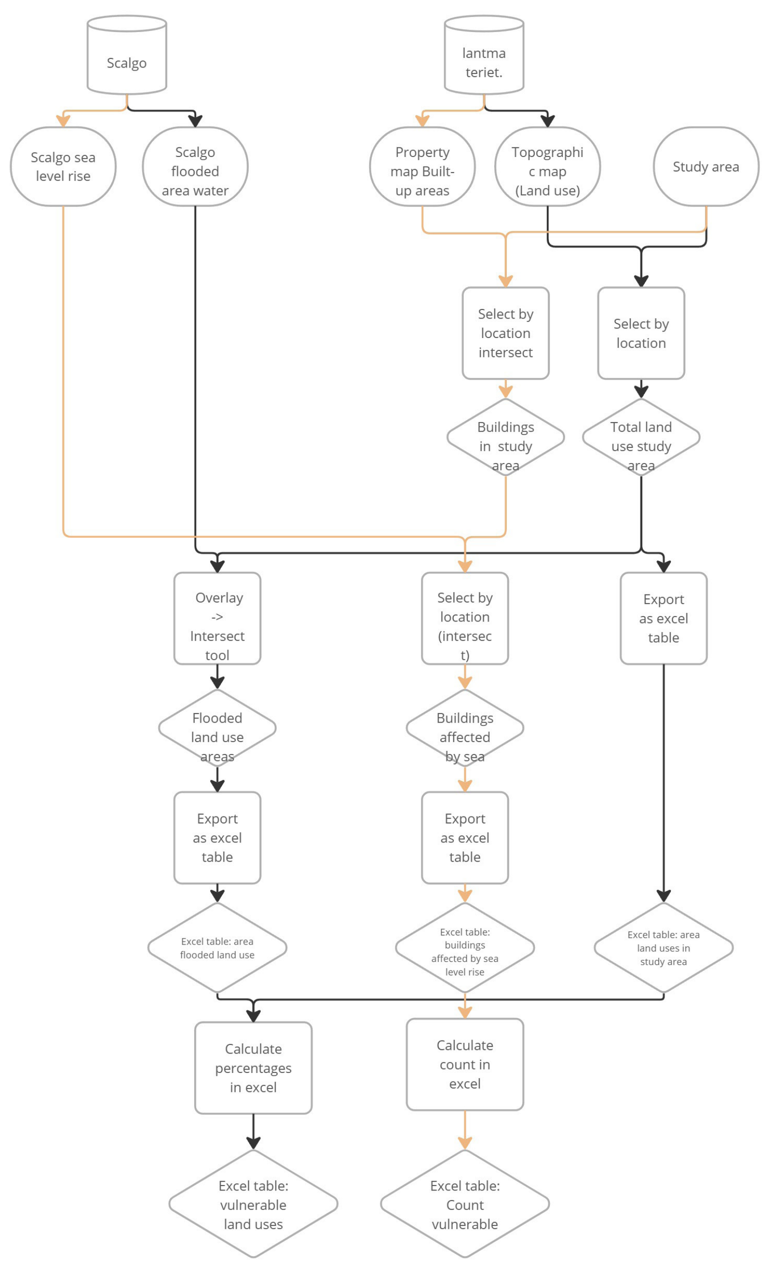
- A limited place (e.g. playground or a viewing point)
- A larger coherent area (e.g. forest or nature area)
- An elongated course (e.g. path or stretch along the river)

Appendix B

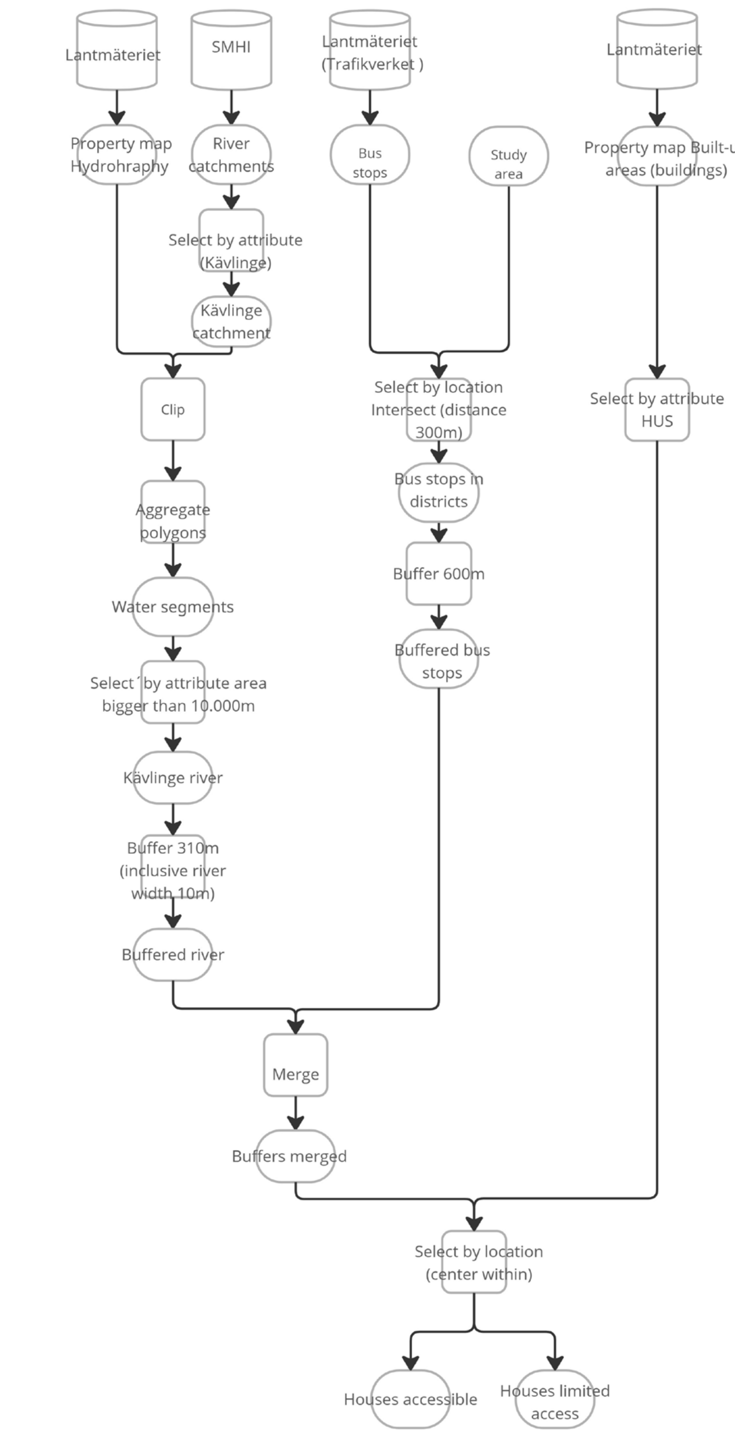
Flow diagram: Future flood scenario



Appendix C
Flow diagram: Vulnerability land use types and buildings



Appendix D
Flow diagram: Transportation and accessibility



Appendix E
Flow diagram: PPGIS kernel density