

Flooding Resilience Future for the ABC Mega Region

Applying Nature-based solutions as a systematic approach

P5 Presentation

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November, 2022

TU Delft, Faculty of Architecture

CONCLUSION	CONTEXT
STRATEGY AND DESIGN	PROBLEM
ANALYSIS	CONCEPTUALIZATION

CONTEXT

THESIS LOCATION

CONTEXT

Lower Rhine River Basin / ABC (Amsterdam-Bruseel-Cologn) Mega Region

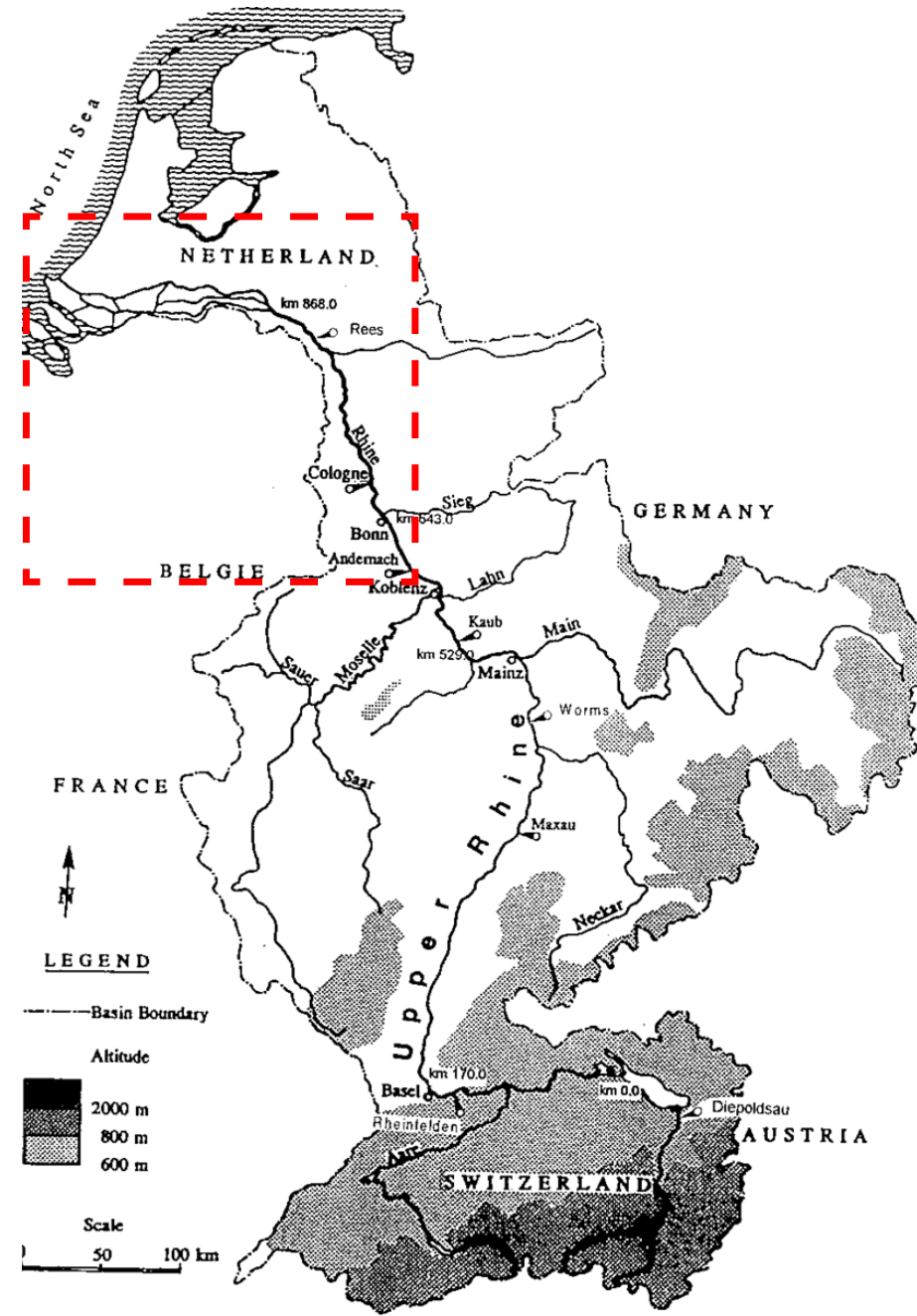


Figure: Rhine river basin
Source: illustrate by Huw C. Davies, 2000

PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION

Map of the ABC (Amsterdam-Bruseel-Cologn) Mega Region

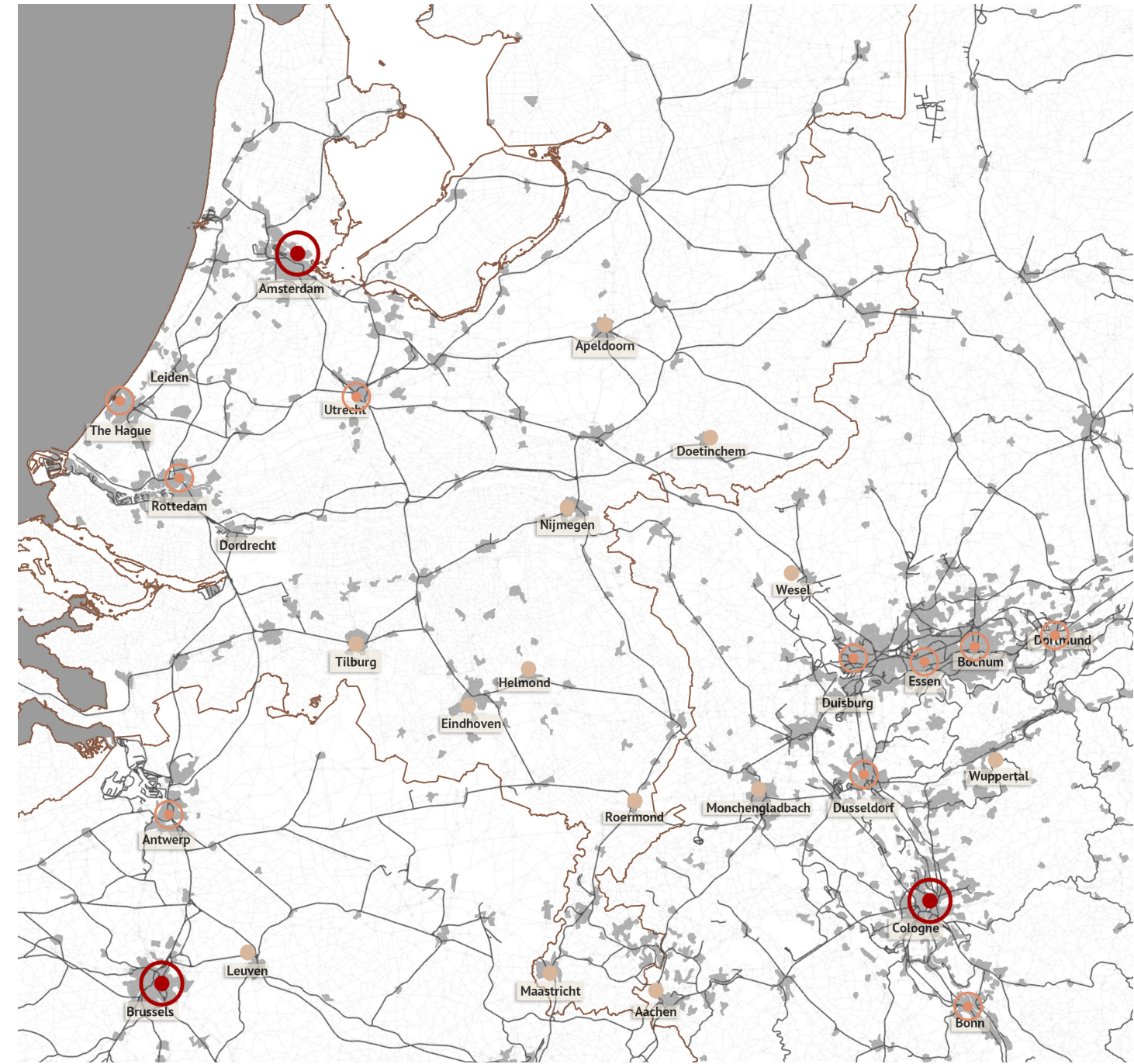


Figure: the ABC Mega region
Illustrate by the author
Source: Openstreetmap, 2018



- Major cities ●
- Big cities ●
- cities ●

CONCLUSION

STRATEGY
AND DESIGN

ANALYSIS

CONCEPTUALIZATION

PROBLEM

CONTEXT

PROBLEM

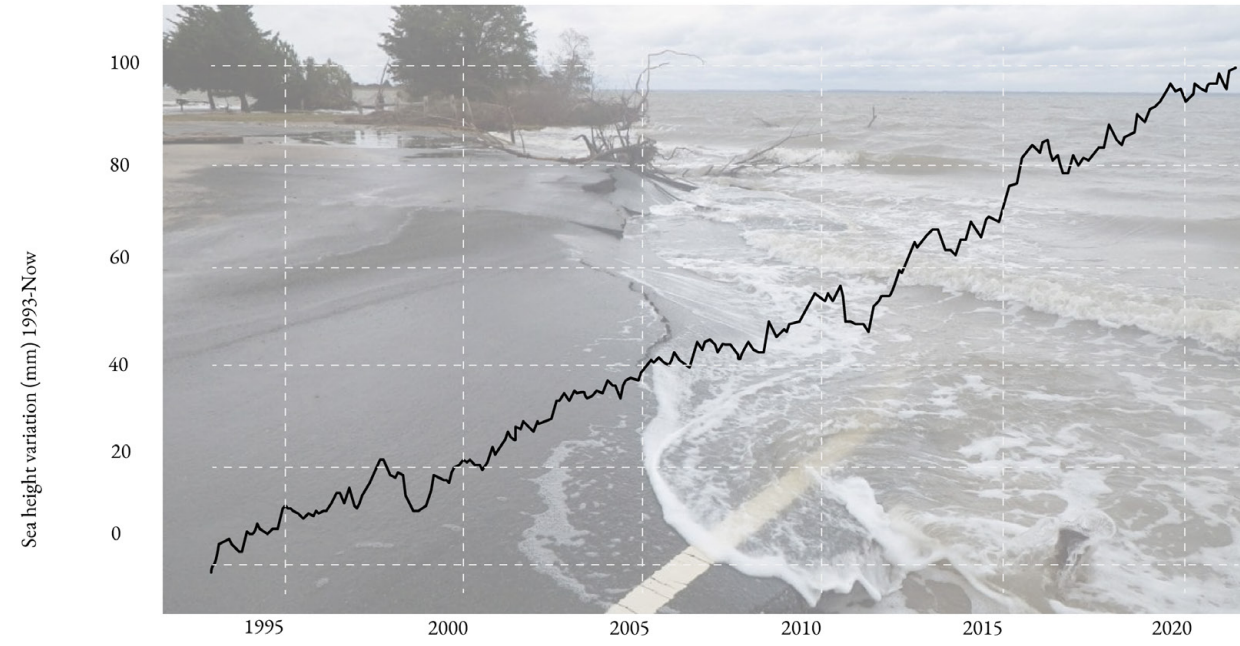
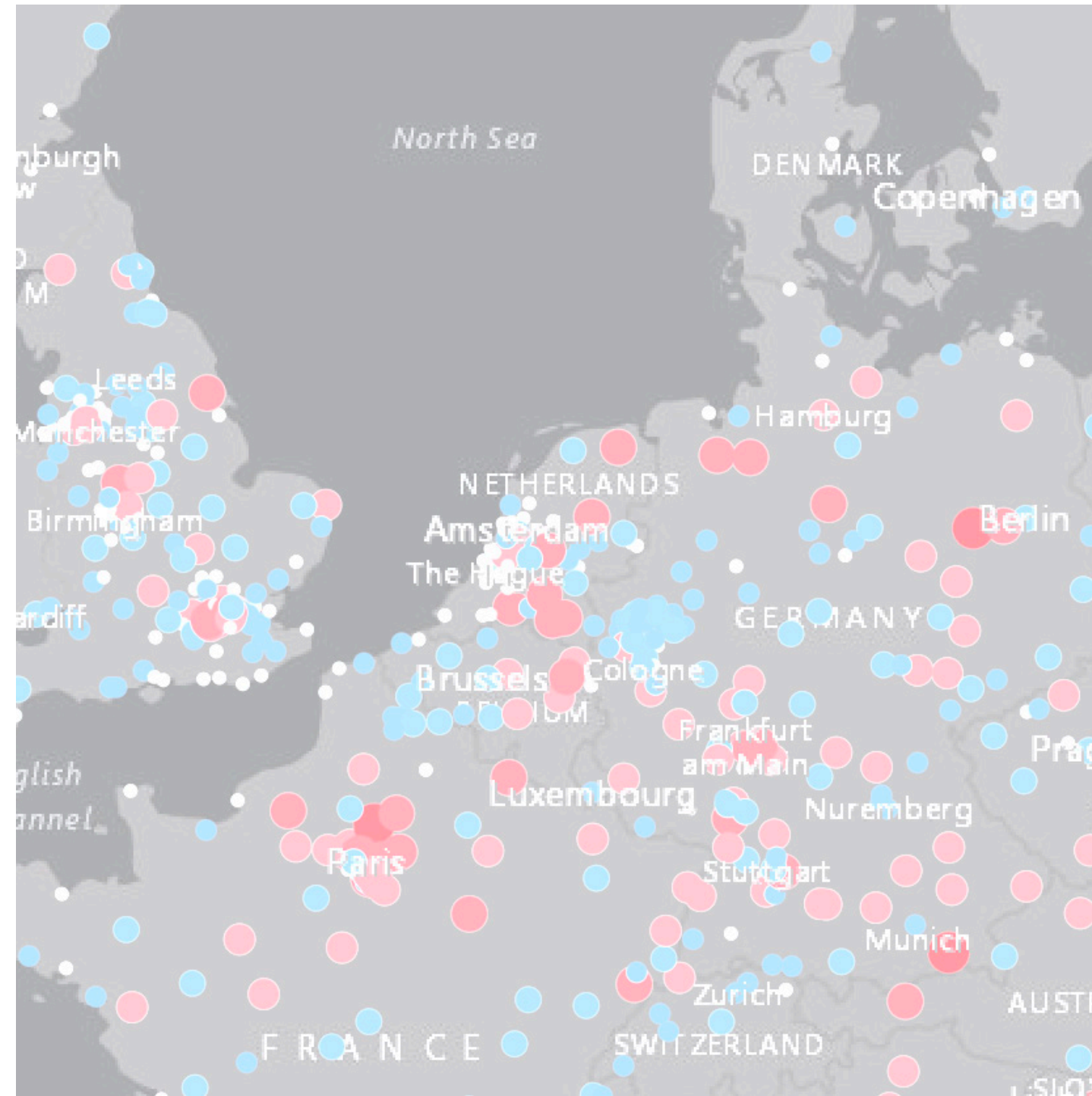


Figure: Sea level raise 1993-now
Illustrate by the author
Source: Climate.gov, 2020

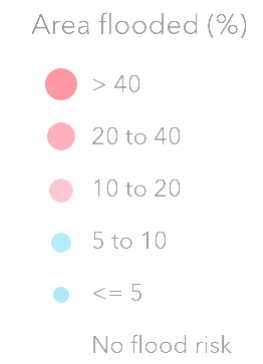


AP Photo/Michael Probst

Urban area potentially exposed to river flooding in 2071-2100 compared with 1961-1990



Source: Esri, HERE, Garmin, USGS | CReSIS (Centre for Remote Sensing of Ice Sheets) 2018



Flood risks in the ABC Mega region

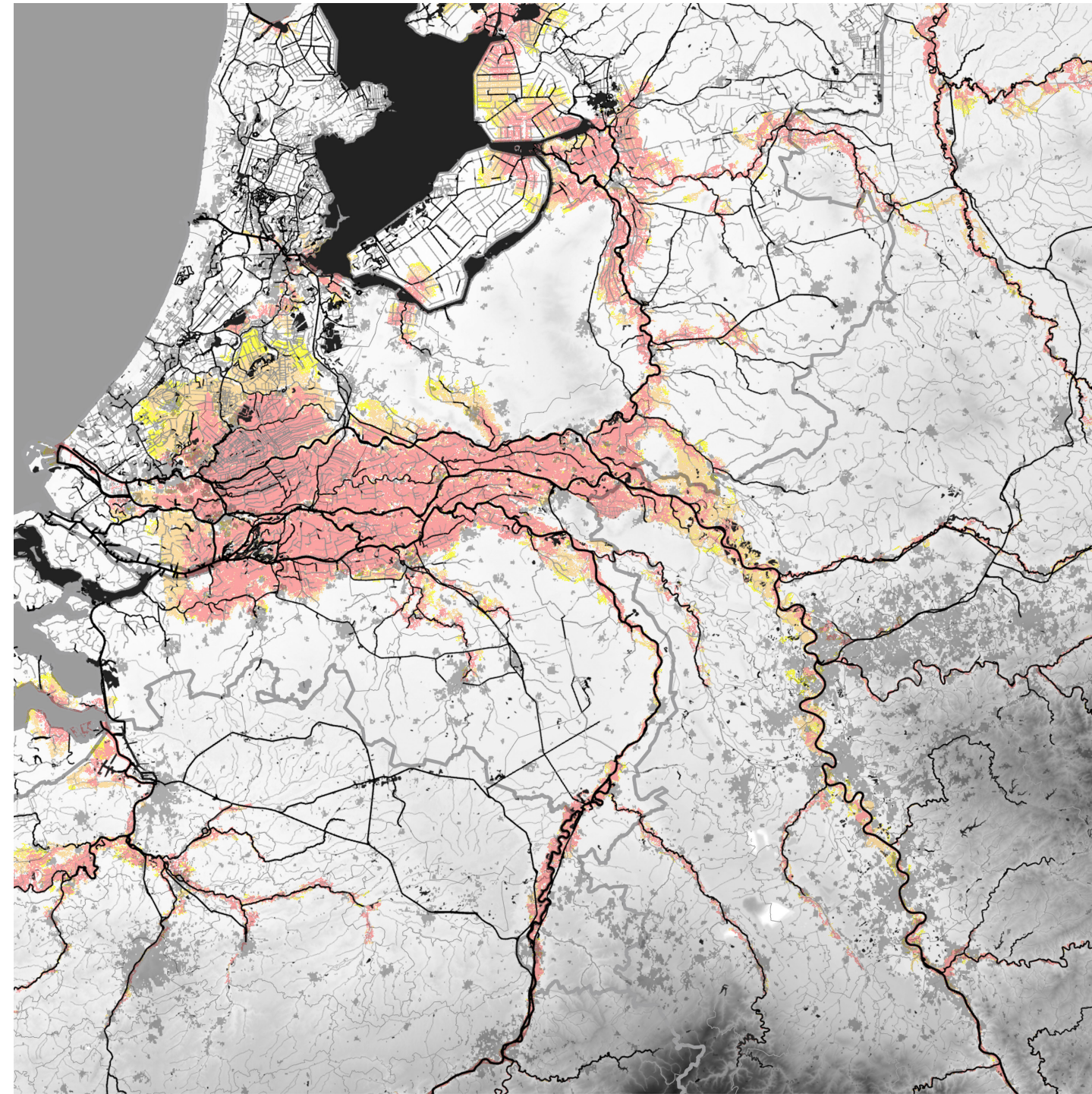
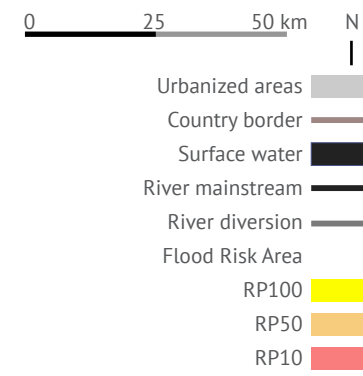


Figure: flood risks in the ABC Mega region
Illustrate by the author
Source: Joint Research Centre (JRC), 2016



Urban area change 1992-2019

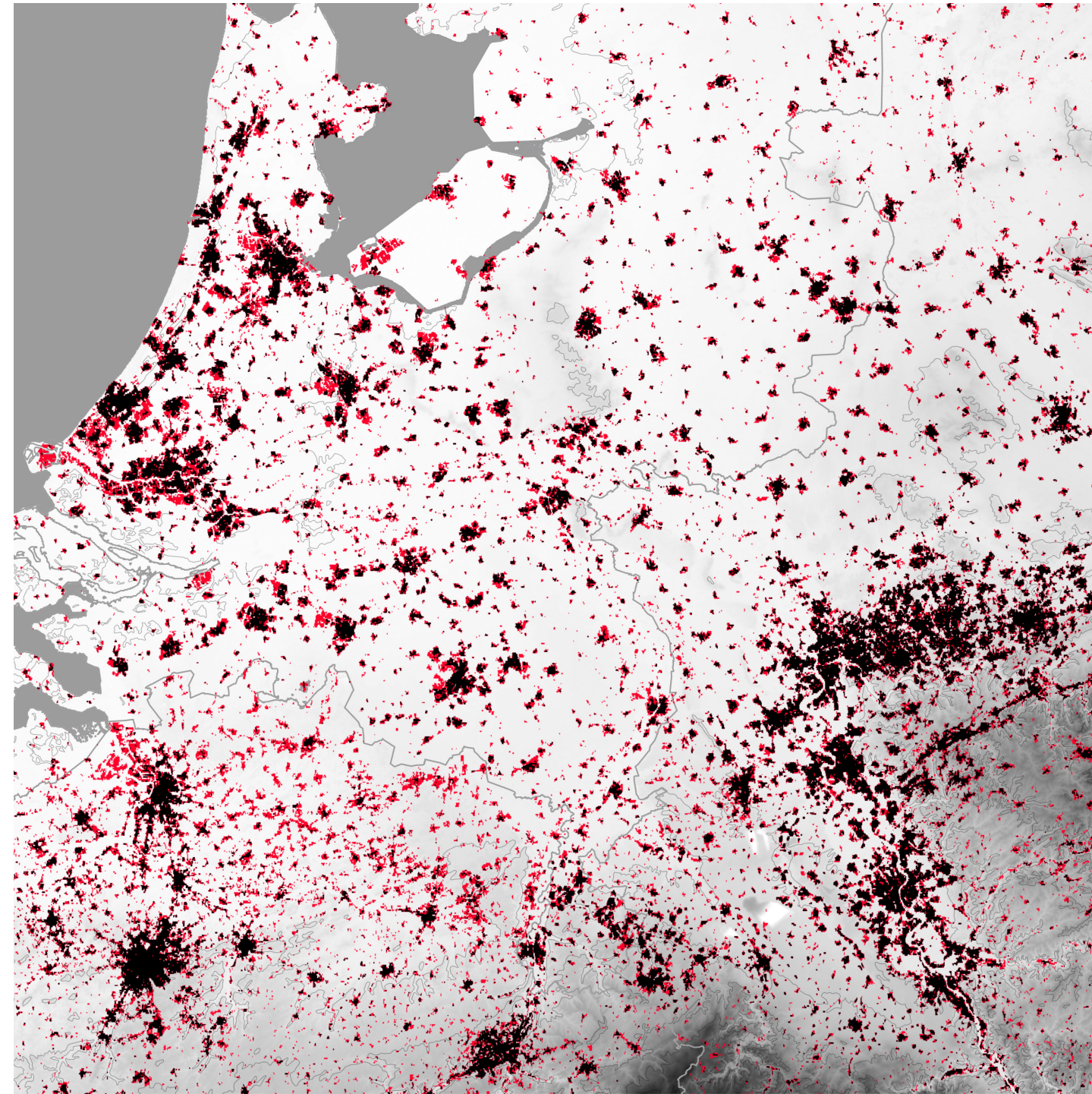
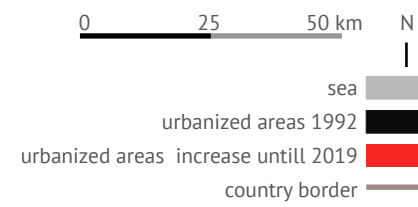


Figure: Urban area change 1992-2019
Illustrate by the author
Source: Corponicus , 2019



CONTEXT

PROBLEM

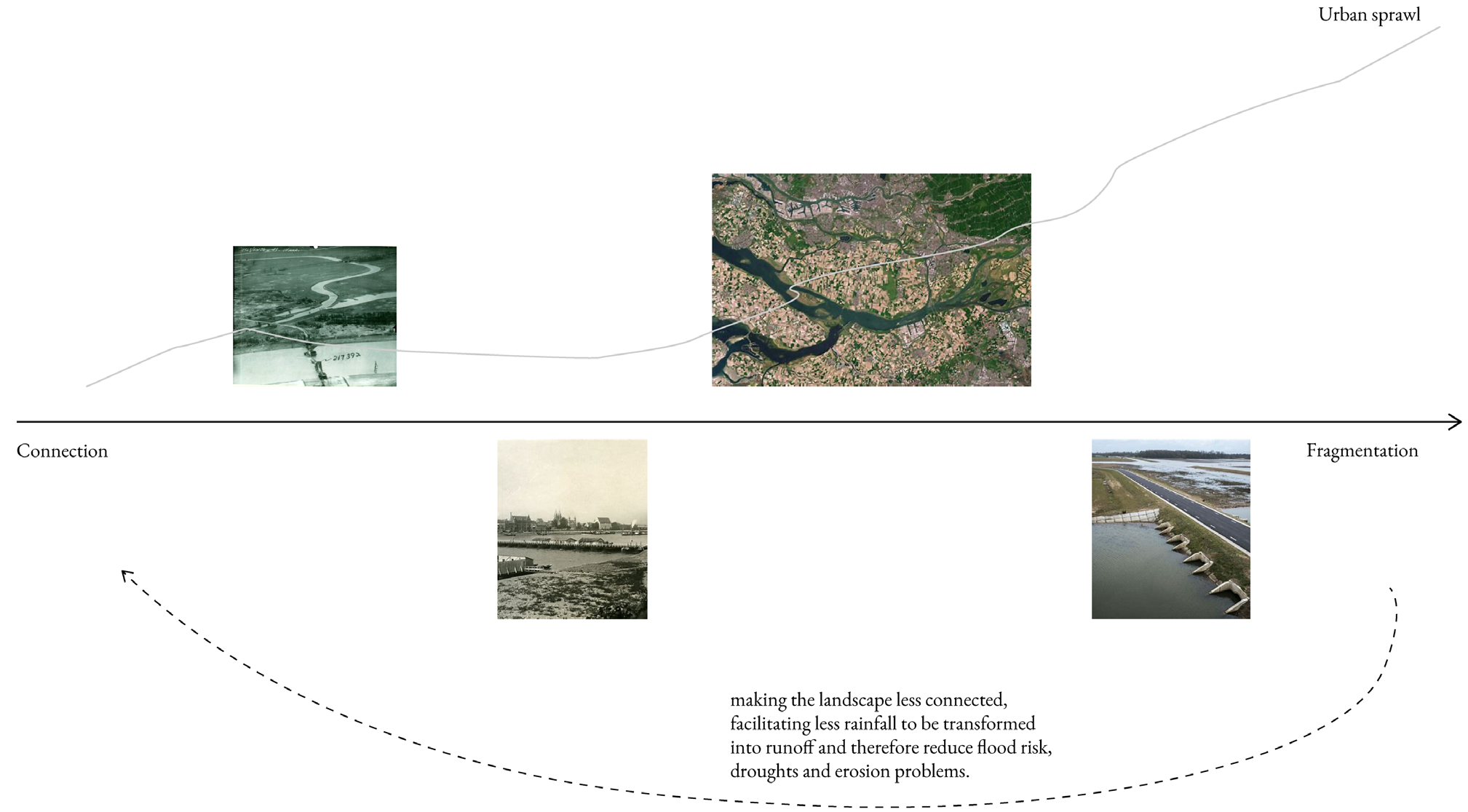
CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION

Landscape fragmentation caused by grey infrastructure



CONTEXT

PROBLEM

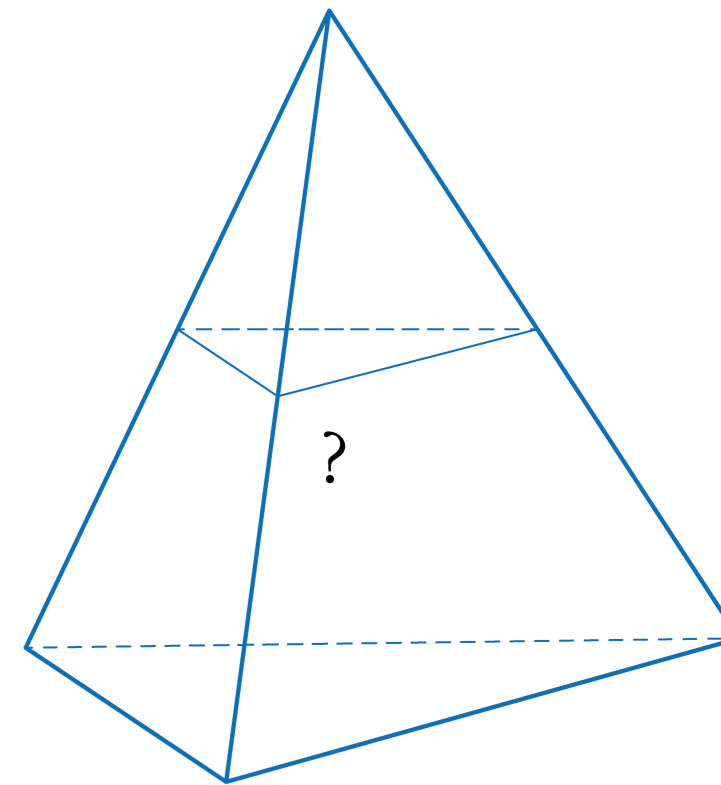
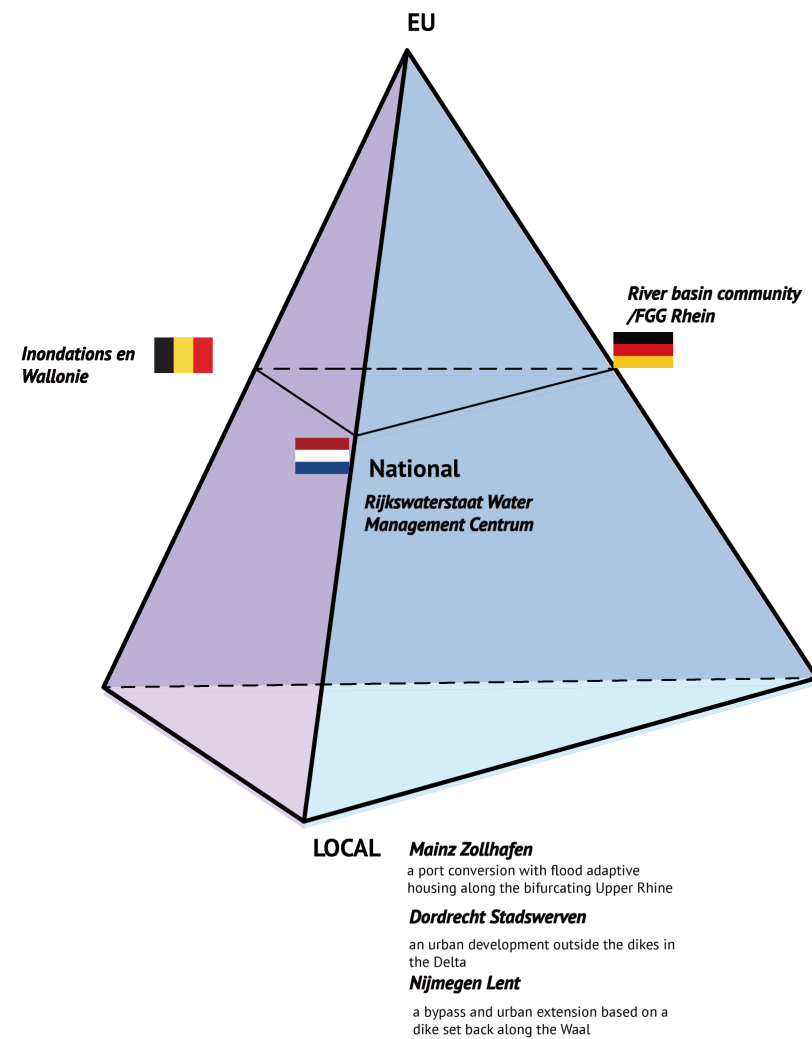
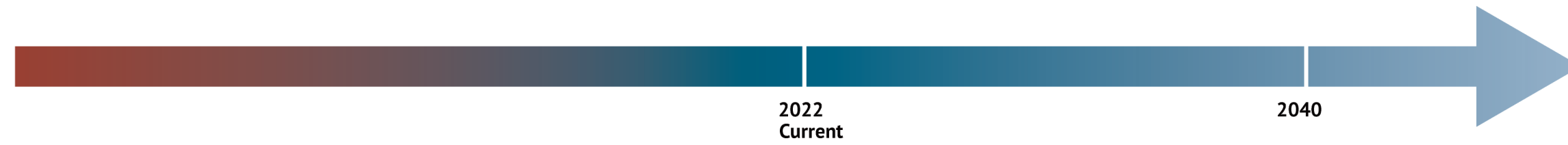
CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION

Multi-level and crossing border governance



PROBLEM STATEMENT

CONTEXT

PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY
AND DESIGN

CONCLUSION

*In the lower Rhine basin, the ABC MEGA Region is faced with the increasing **risk of flooding** caused by climate changing and extreme weather. The repercussions of over-modifying nature due to the urban sprawl and decay causing the **land scarcity and landscape fragmentation**, seems to put it in a more dangerous conditions. Crossing border and multi-level governance seems to be difficult to carry out an coherent flood management strategies.*

*Spatial planning should be better involved in the process of flood management to **recognize the dynamics** and to **activate the capacity of the green and blue infrastructure of flood resilience** as well as **guide the expansion and form of the cities** in the ABC Mega Region.*

CONCLUSION

STRATEGY
AND DESIGN

ANALYSIS

CONCEPTUALIZATION

PROBLEM

CONTEXT

CONCEPTUALIZATION

FLOODING RESILIENCE FUTURE FOR THE ABC MEGA REGION

LOWER

LOWER FLOODING RISKS

LONGER

LONGER LIFE-SPAN

SUSTAINABLE

SUSTAINABLE URBAN
DEVELOPMENT

HEALTHY

HUMAN WELL BEING

ENGAGING

CATALYSTS OF LOCAL
INVOLVEMENT

COOPERATION

STRONGER CONNECTION

BROADER

BROADER RANGE OF
BENEFICIARIES

DYNAMIC

DYNAMIC AND
FLEXIBLE SYSTEM

A SYSTEMATIC APPROACH, NATURE-BASED SOLUTIONS (NBS)

CONTEXT

PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



Figure: Deep Forms of Nature-based Solutions
Source: Turenscape, 2018

A SYSTEMATIC APPROACH, NATURE-BASED SOLUTIONS (NBS)

CONTEXT

PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION

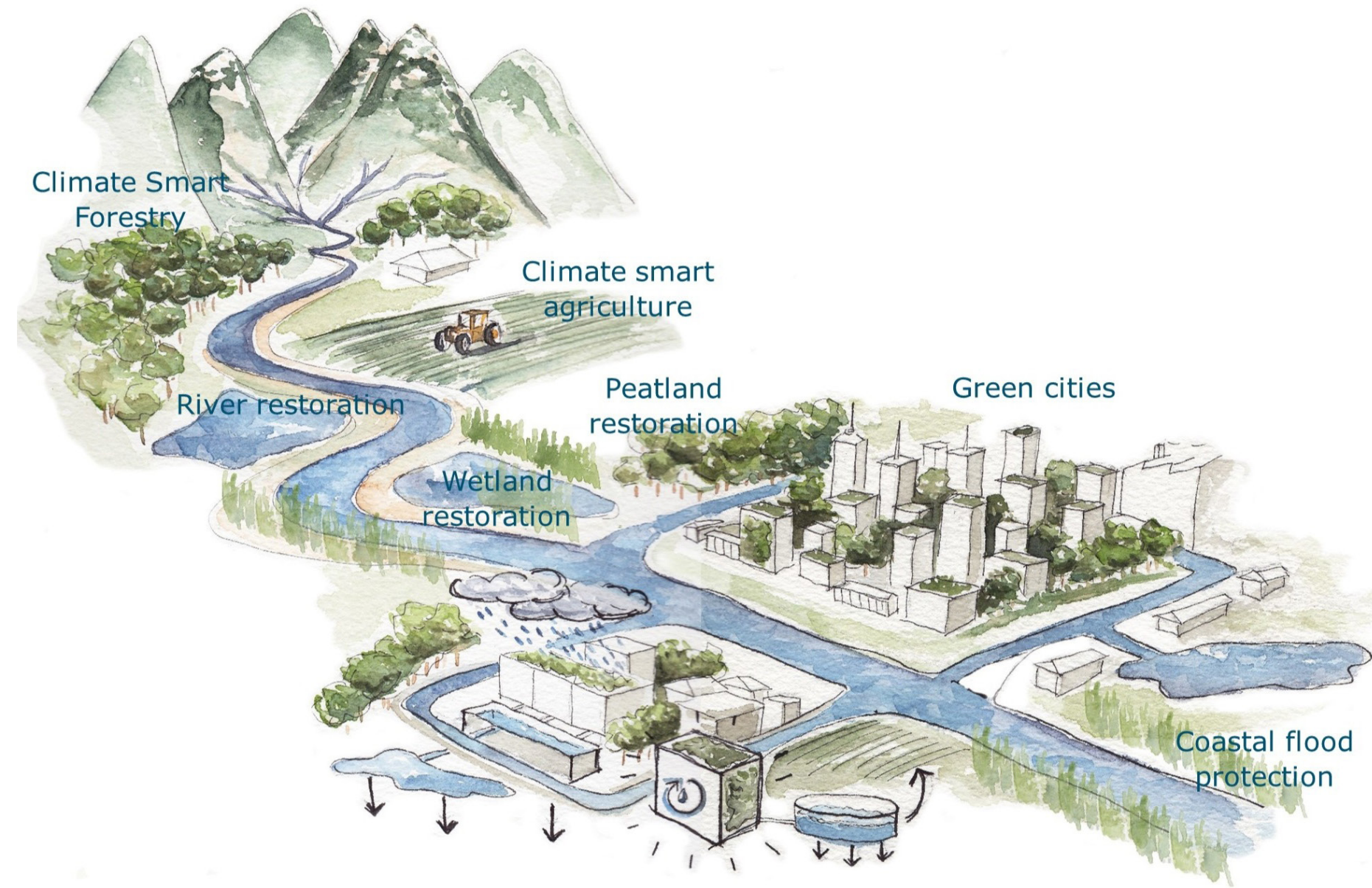


Figure: Nature-Based Solutions are a new focal point in the global effort to deal with climate change
Illustrate by Natasha de Sena, WER

THEORETICAL FRAMEWORK

CONTEXT

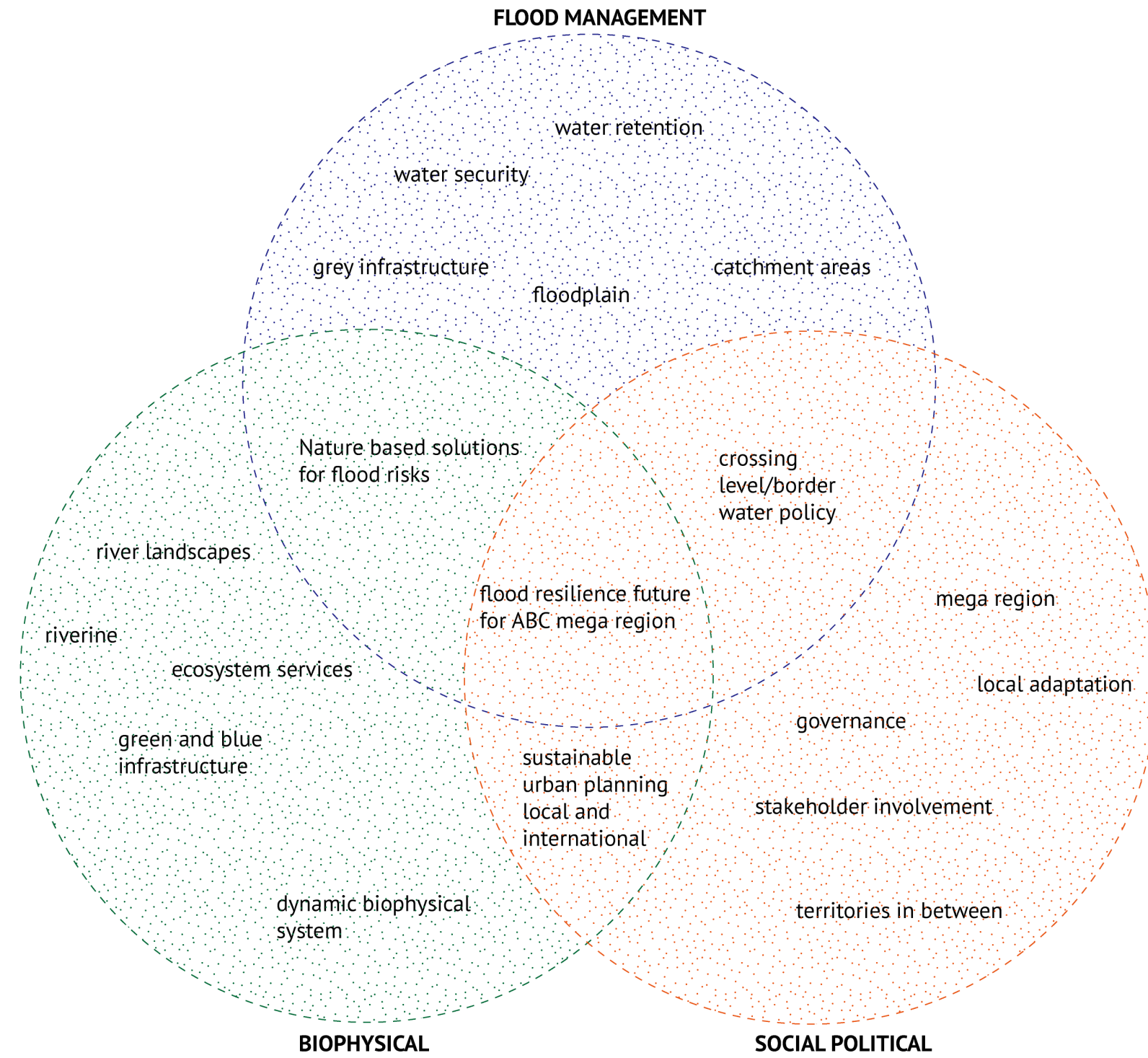
PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



CONTEXT

PROBLEM

CONCEPTUALIZATION

ANALYSIS

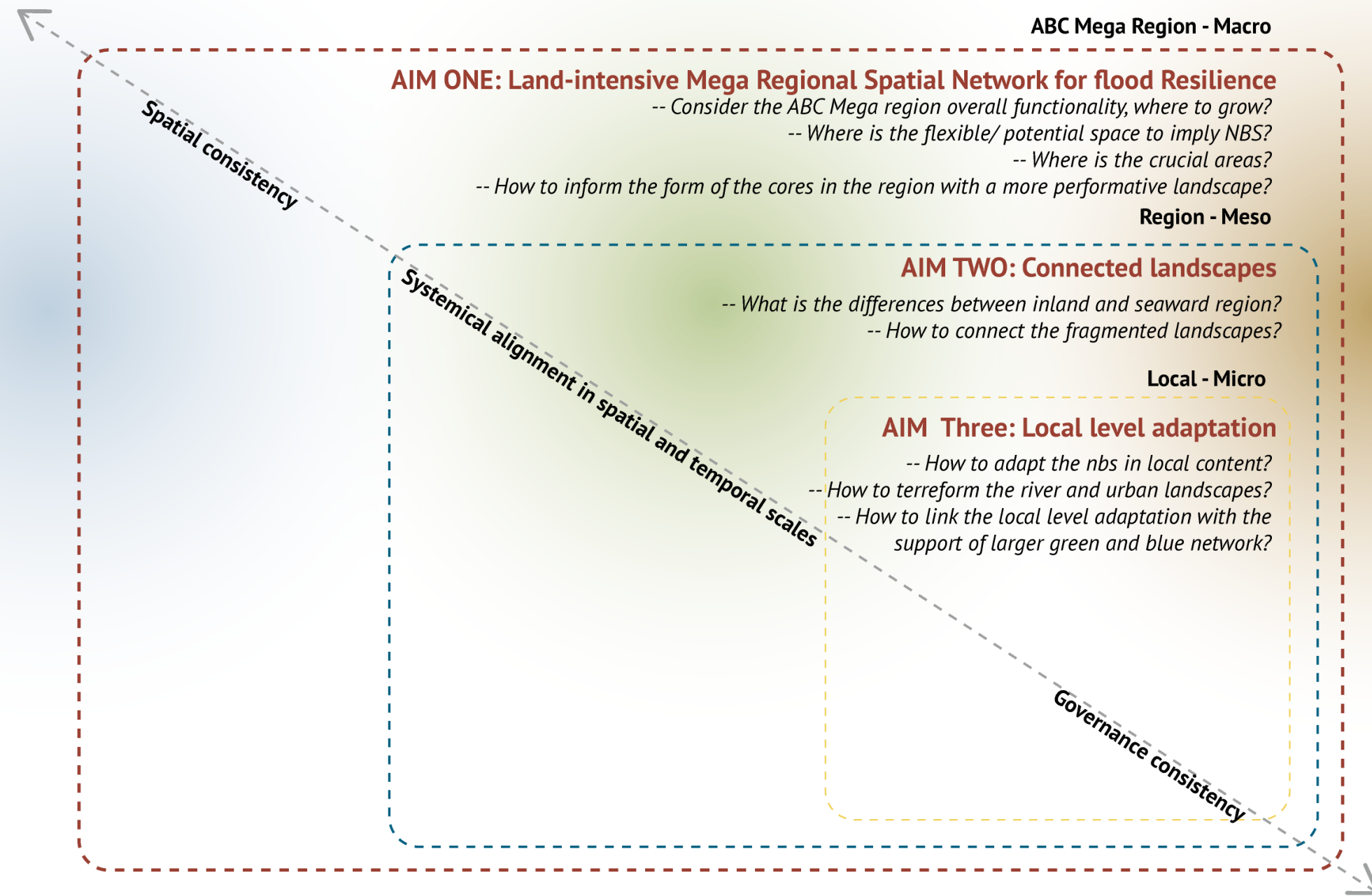
STRATEGY AND DESIGN

CONCLUSION

Flood Management

Nature-Based Solutions

Urban Development



CONCEPTUAL FRAMEWORK

CONTEXT

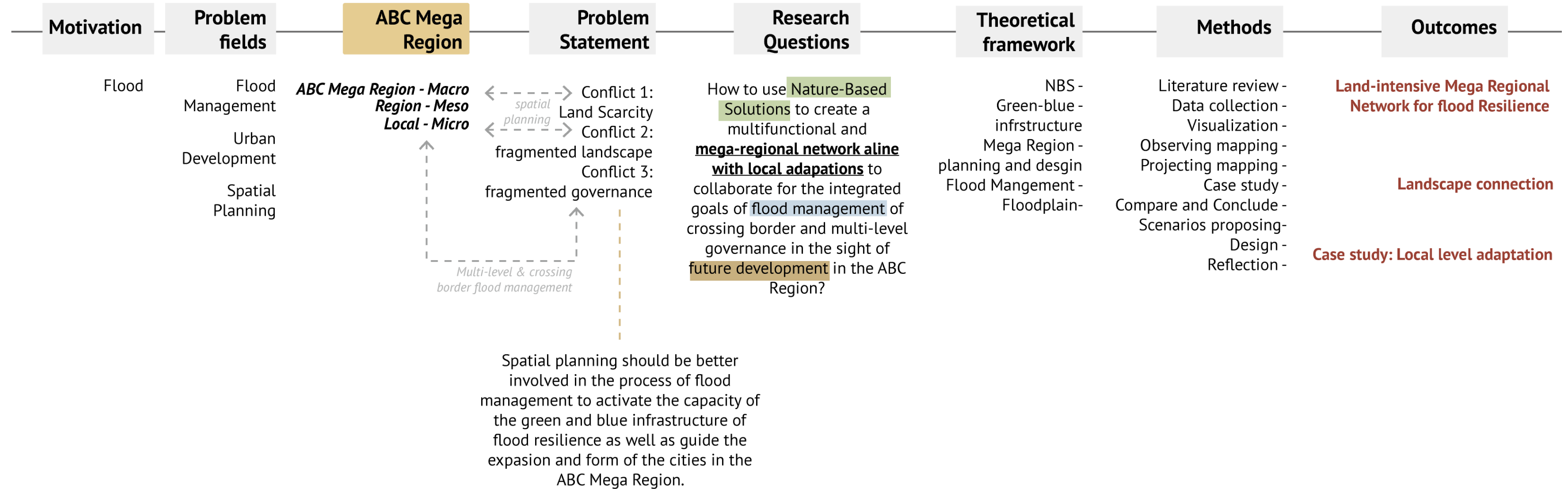
PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



CONCLUSION

STRATEGY
AND DESIGN

ANALYSIS

CONCEPTUALIZATION

PROBLEM

CONTEXT

ANALYSIS

SCALES

CONTEXT

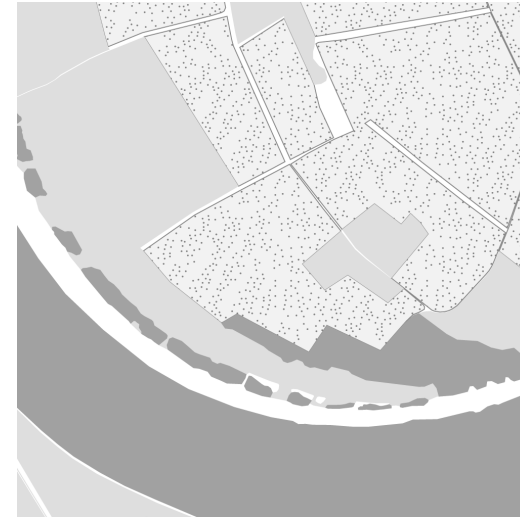
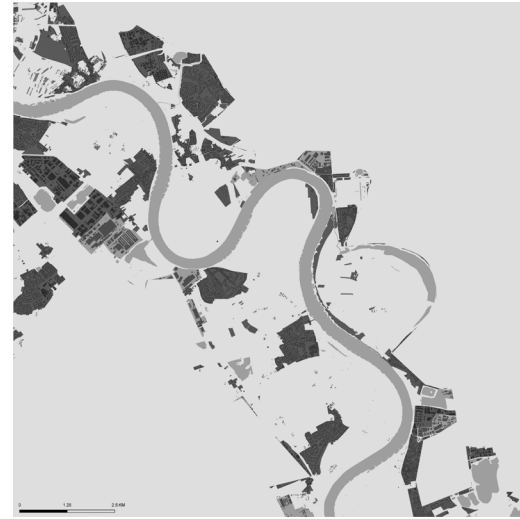
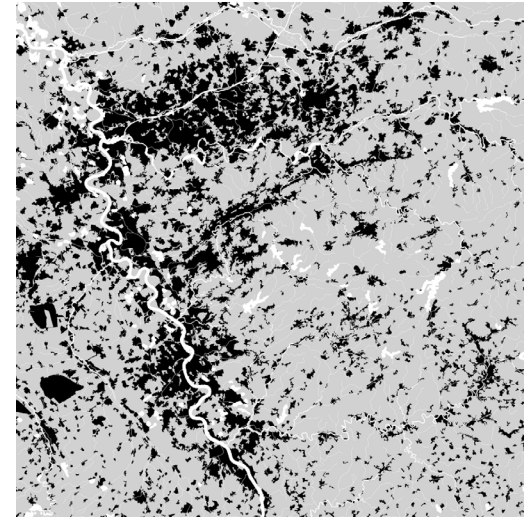
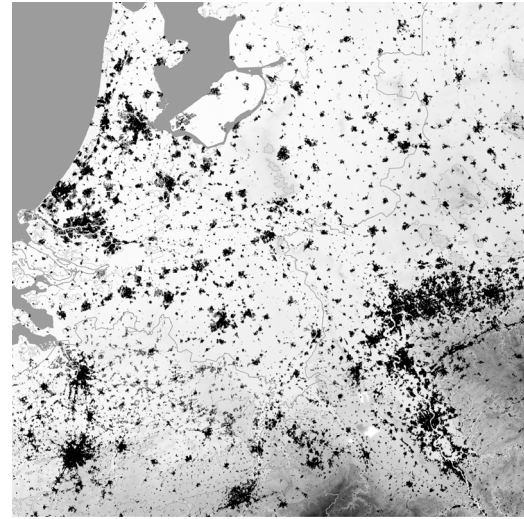
PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



**WHY?
OPPORTUNITY**

**WHICH?
SUITABILITY**

**WHERE?
AVAILABILITY**

**HOW?
APPLICABILITY**

**SCALE UP
IMPLEMENTATION**

<ul style="list-style-type: none"> → ABC Mega region → Nature based solutions → Territories in between 	<ul style="list-style-type: none"> → Inland → Seaward 	<ul style="list-style-type: none"> → Flooding risks → Other related systems → Typologies 	<ul style="list-style-type: none"> → Scenarios proposing → Case study 	<ul style="list-style-type: none"> → Scale up → Up to down
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OPPORTUNITY

Where to grow? Where to apply nature-based solutions for flood management?



- population decline (red dots)
- population growth (blue dots)
- urbanized areas (grey)
- country border (brown line)
- surface water (dark blue)
- River mainstream (medium blue)
- River diversion (light blue)
- Flood Risk Area
 - RP100 (yellow)
 - RP50 (orange)
 - RP10 (red)

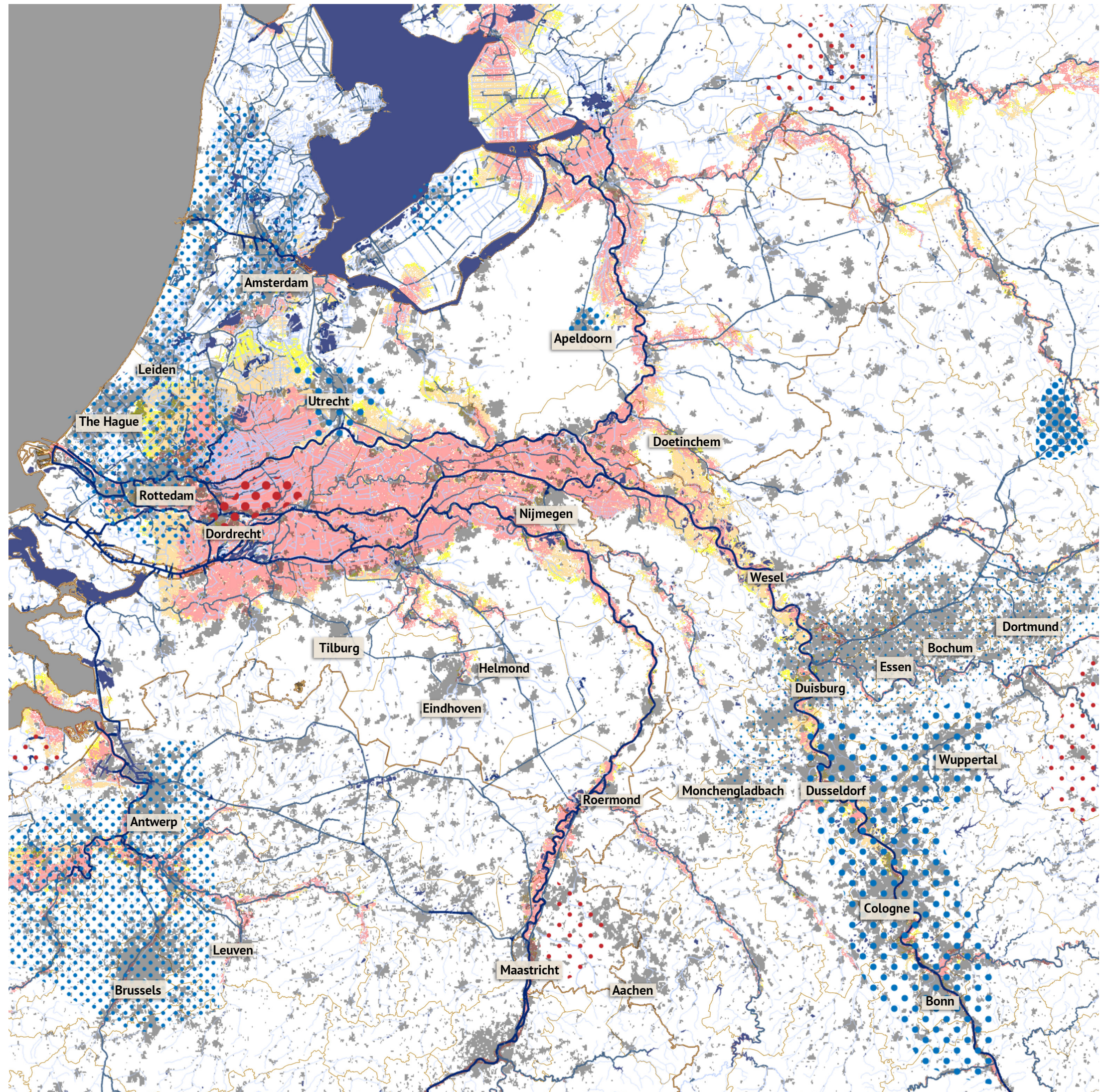


Figure: Areas to grow or to shrink and the flooding risks
Illustrate by the author
Source: Eurostat NTUS , 2018

CONTEXT

PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION

OPPORTUNITY

Territories in Between (TiB)

CONTEXT

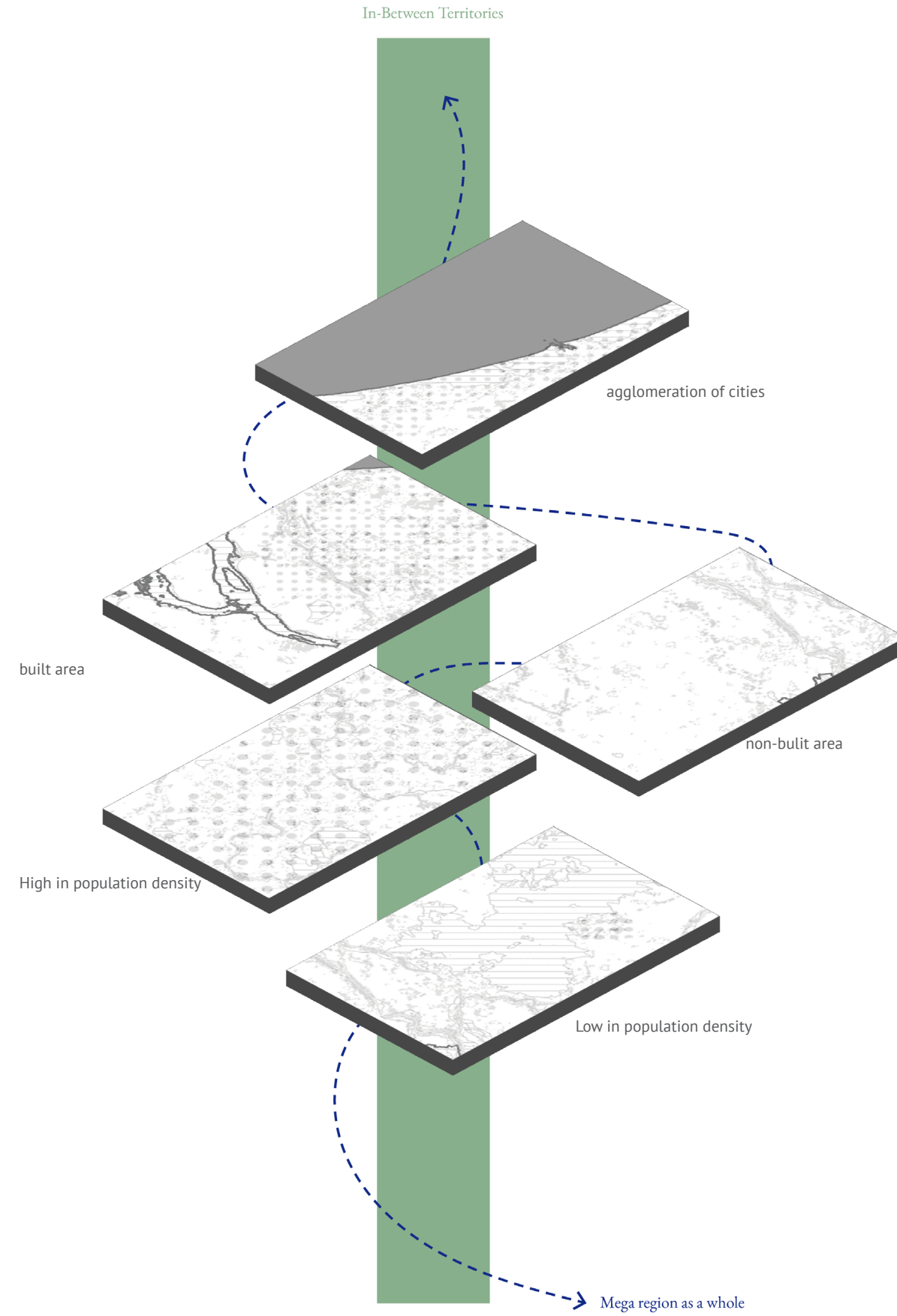
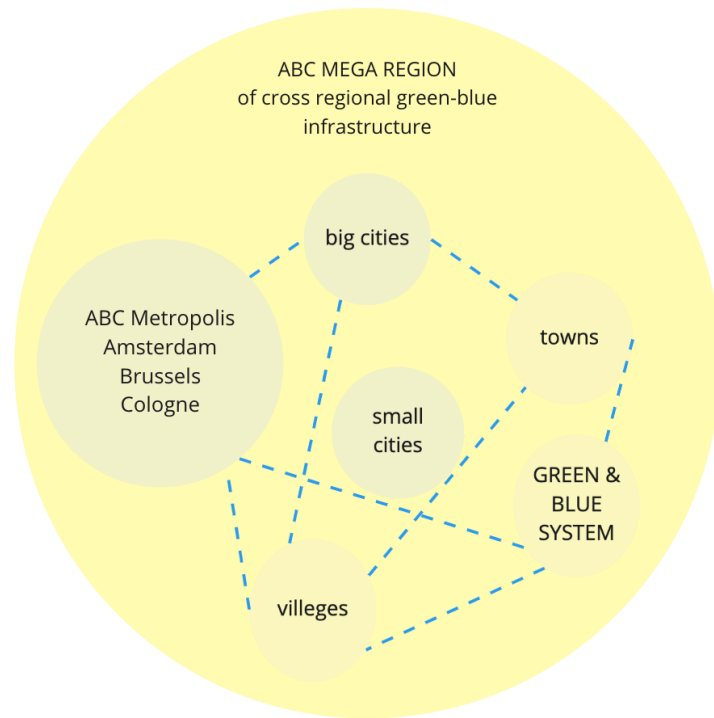
PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



OPPORTUNITY


CONTEXT

Potential areas to apply nature-based solutions for flood risks control

Territories in between

PROBLEM



potential area 

CONCEPTUALIZATION

- Randstad, the Netherlands
- Flanders, Belgium
- Ruhrgebiet, Germany

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION

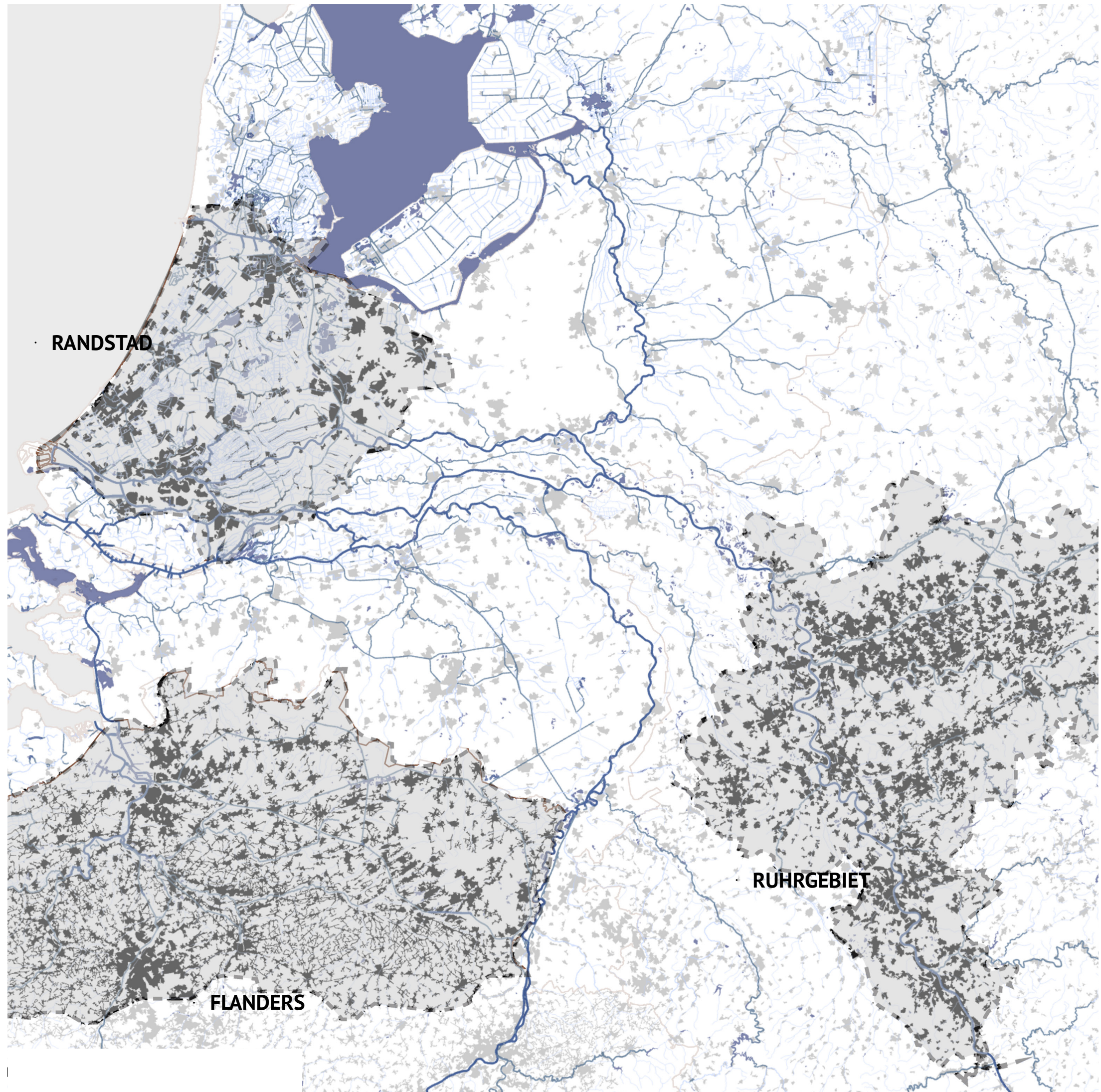


Figure: potential areas to apply nature-based solutions for flood risks control
Illustrate by the author
Source: Copernicus,2017

OPPORTUNITY

CONTEXT

Policy related to flood management and nature landscapes protection

PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION

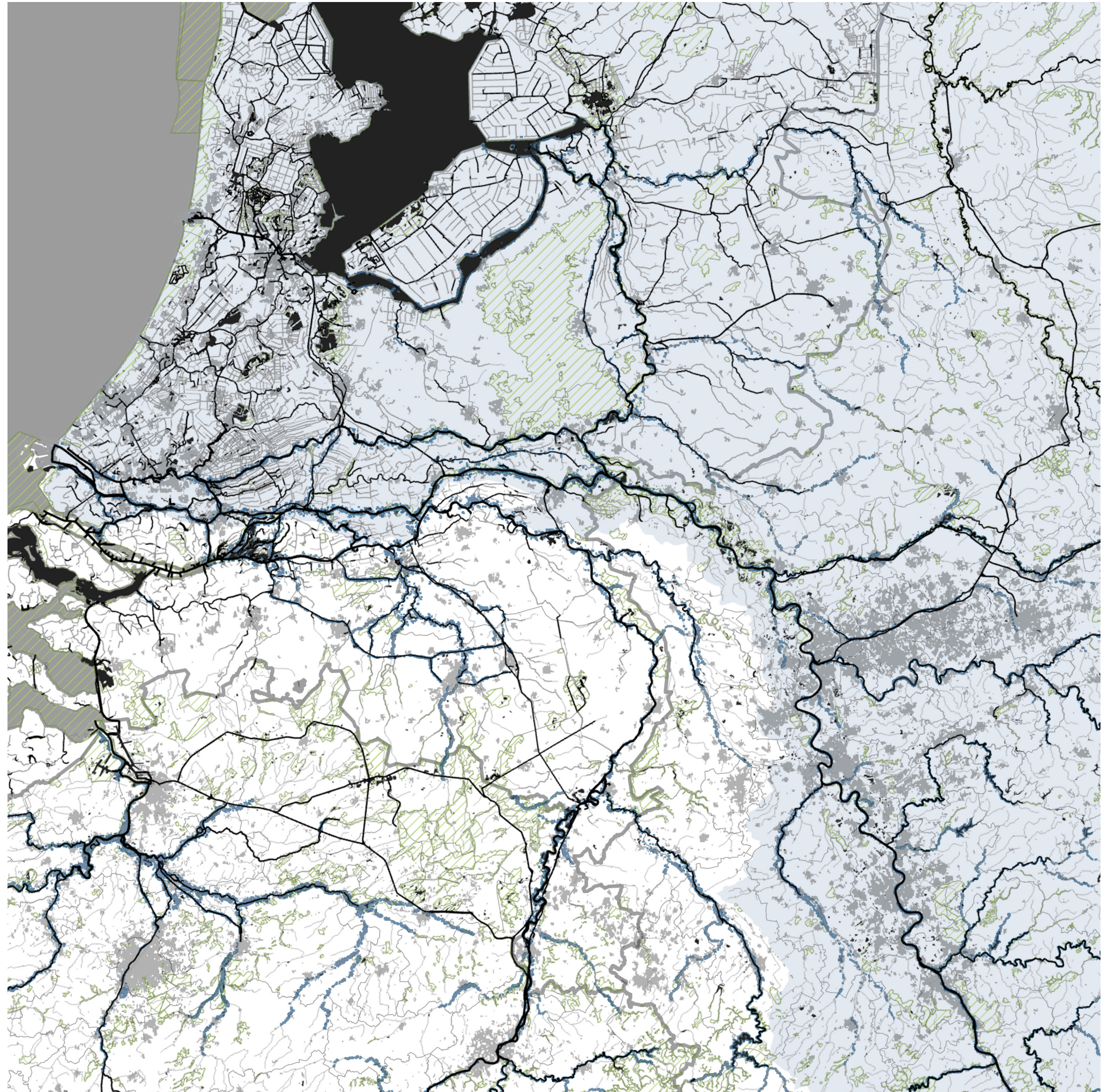
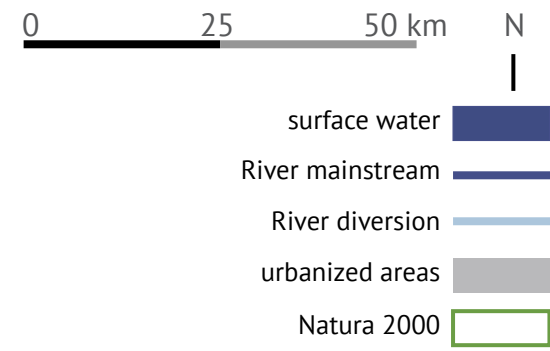


Figure: Policy related to flood management and nature landscapes protection
Illustrate by the author
Source: Copernicus,2017 and Natura 2000

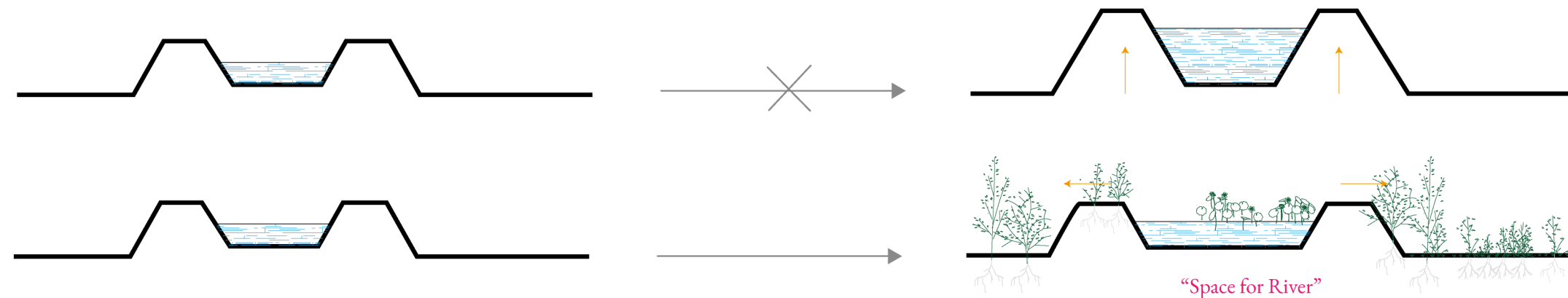
OPPORTUNITY

CONTEXT

“Space for river”

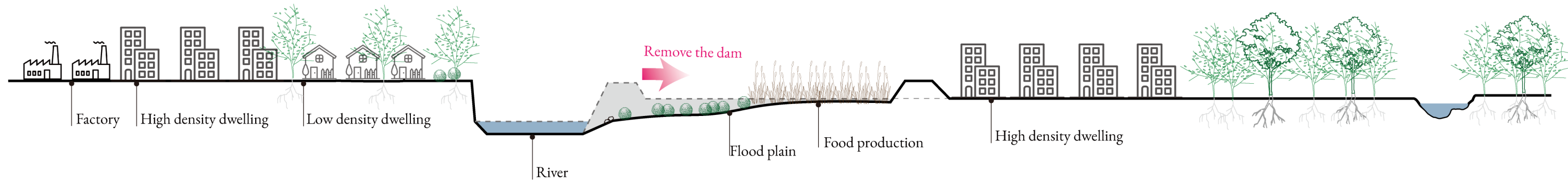
PROBLEM

CONCEPTUALIZATION



ANALYSIS

STRATEGY AND DESIGN



CONCLUSION

OPPORTUNITY

CONTEXT

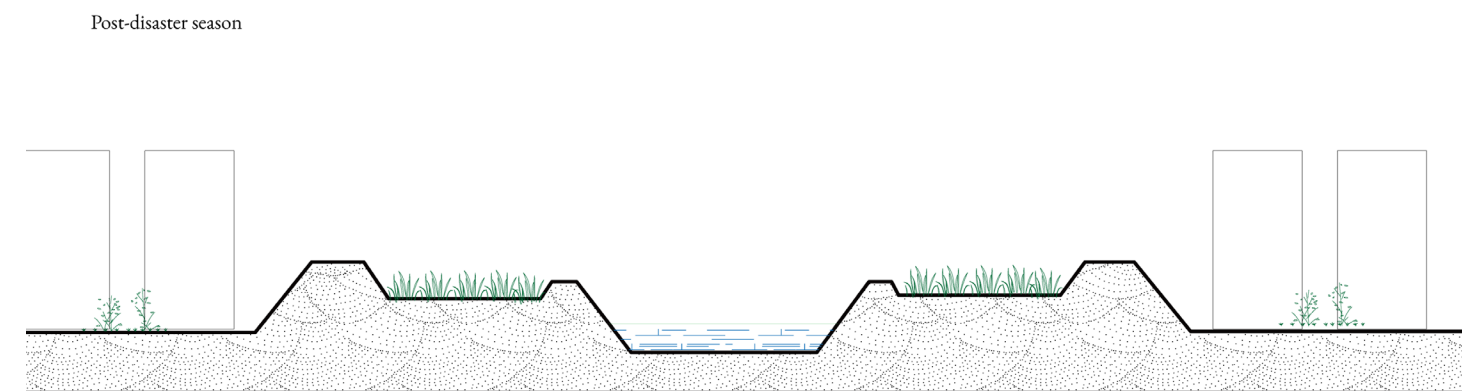
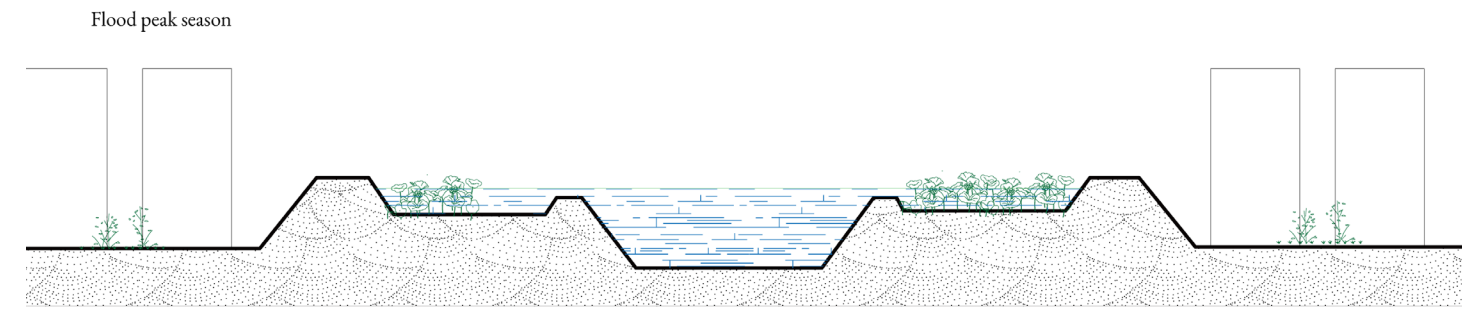
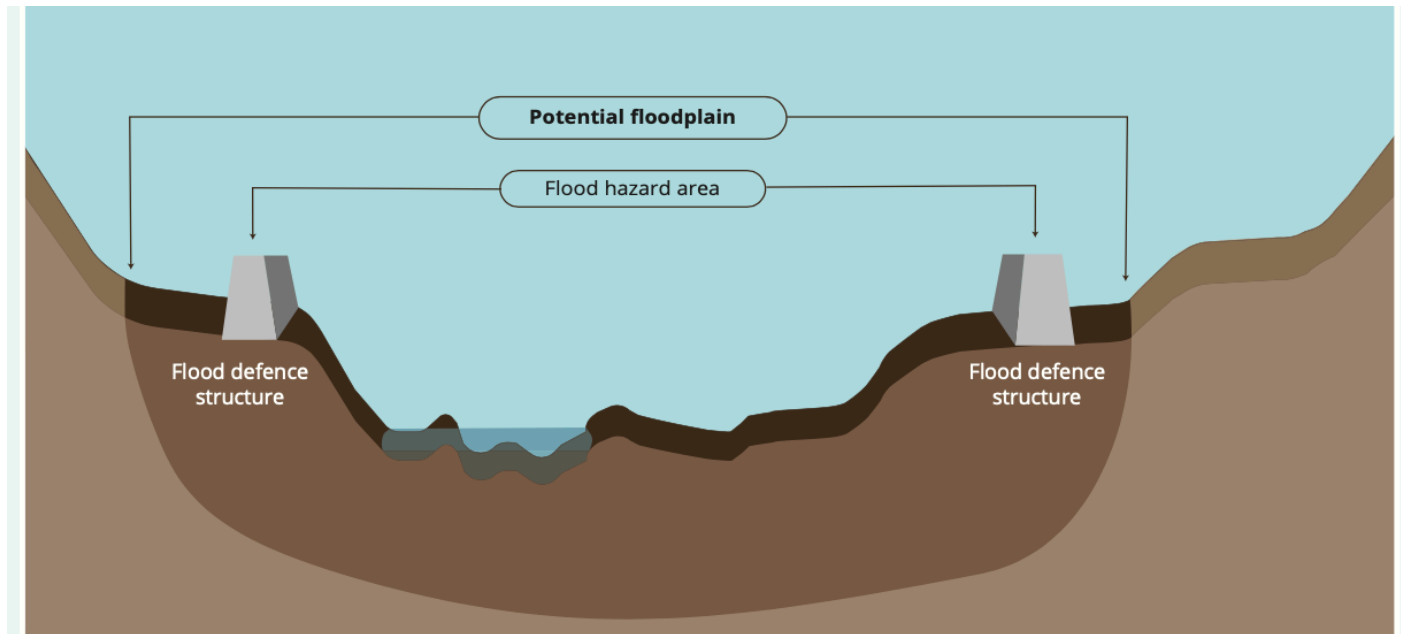
PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



SUITABILITY

CONTEXT

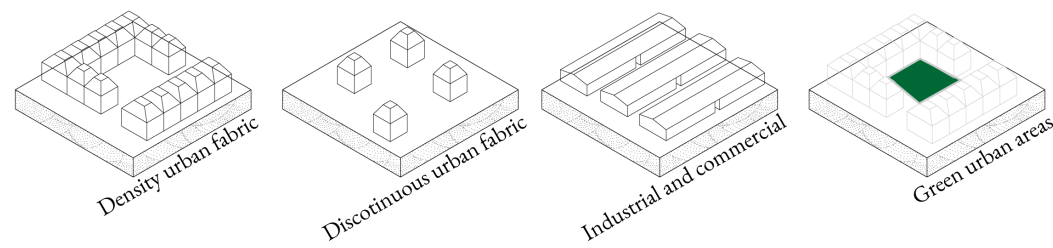
Landcover



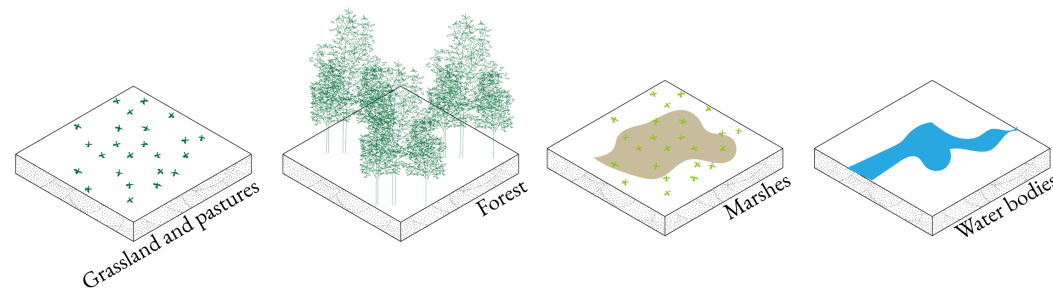
PROBLEM

- forest
- natural grassland
- moors
- burnt areas
- marshes
- green urban areas
- vineyards
- agriculture
- irrigated land
- crops

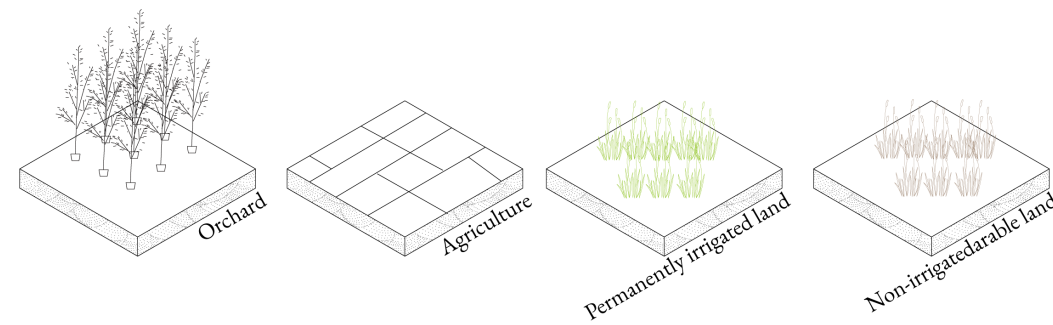
CONCEPTUALIZATION



ANALYSIS



STRATEGY AND DESIGN



CONCLUSION

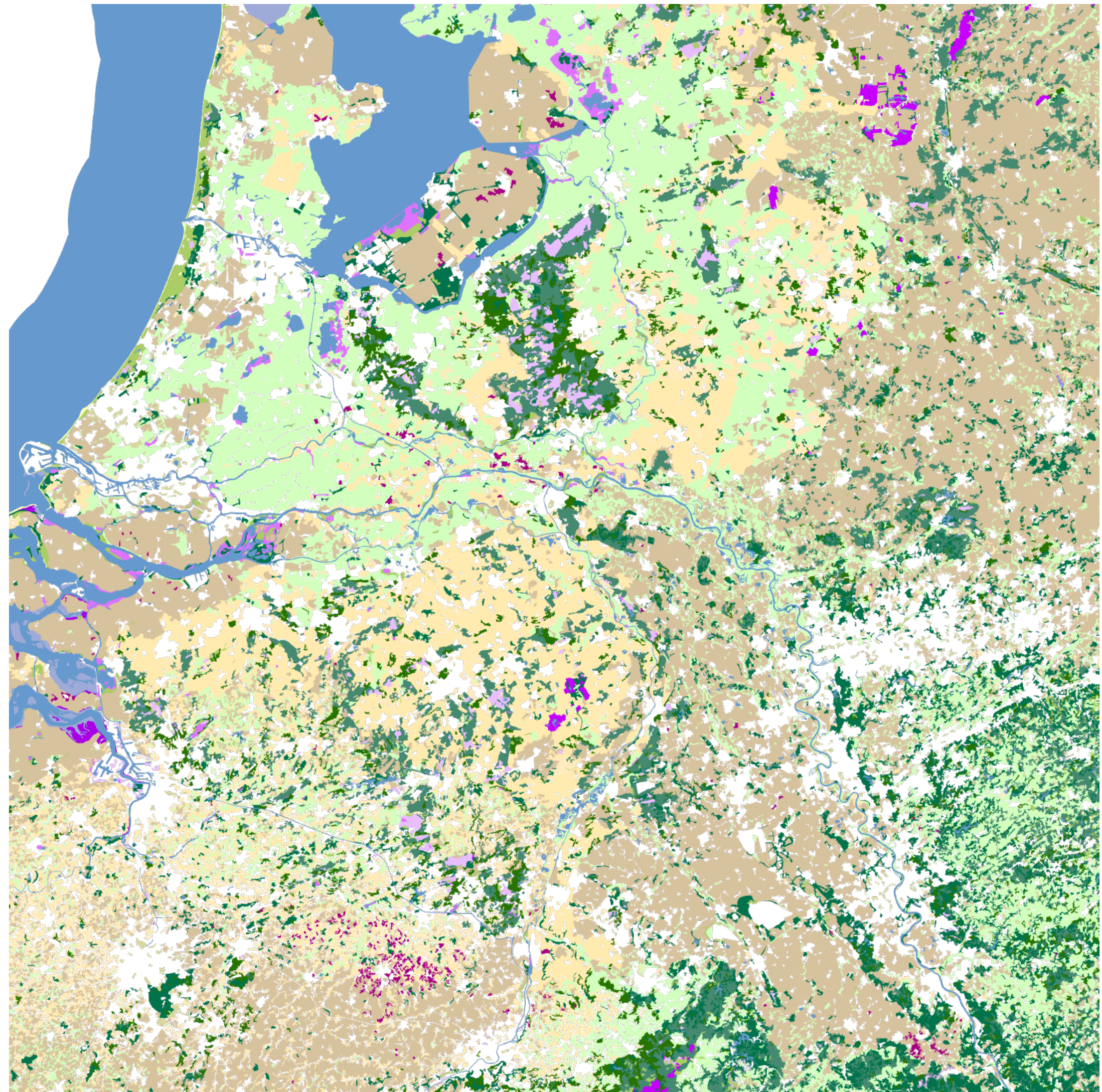


Figure: land cover in the ABC Mega region
 Illustrate by the author
 Source: Copernicus,2017

SUITABILITY

CONTEXT

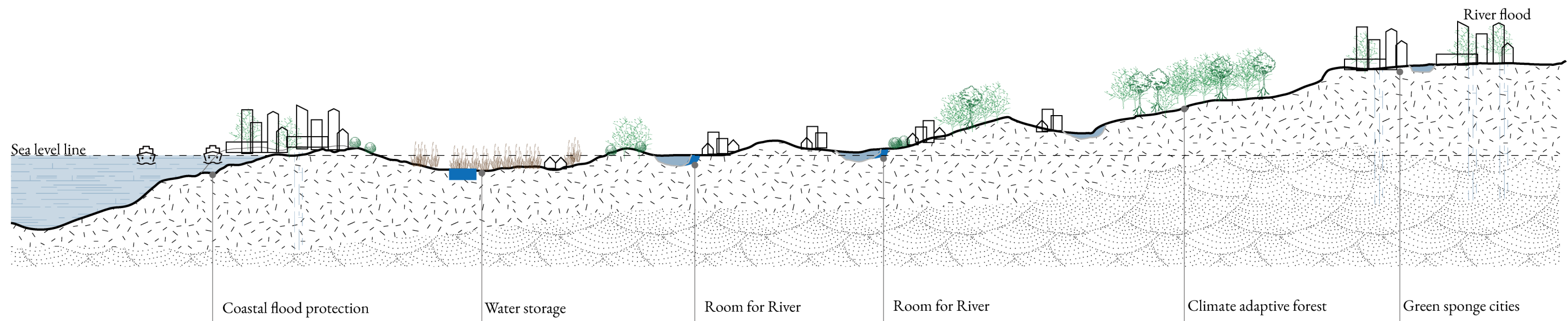
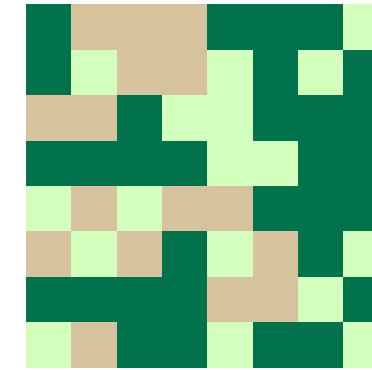
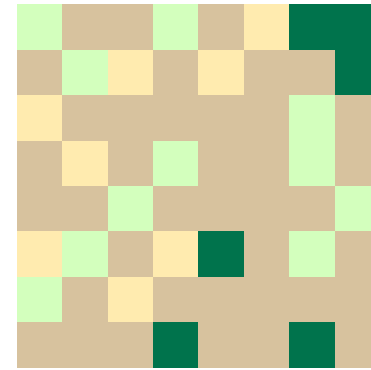
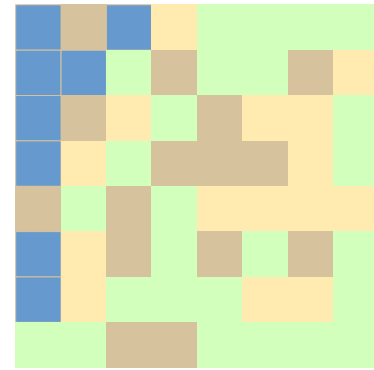
PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



SUITABILITY

CONTEXT

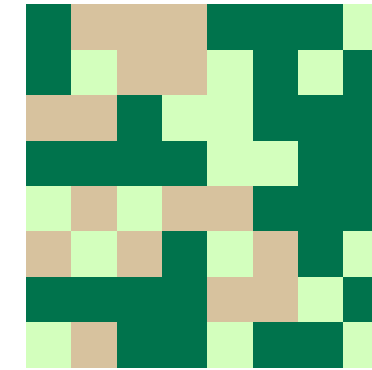
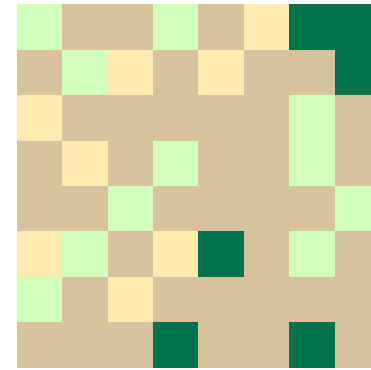
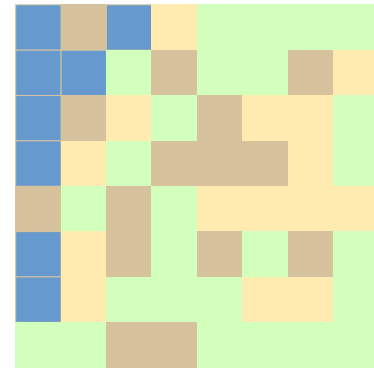
PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



Downstream
Seaward

Upstream
Inland



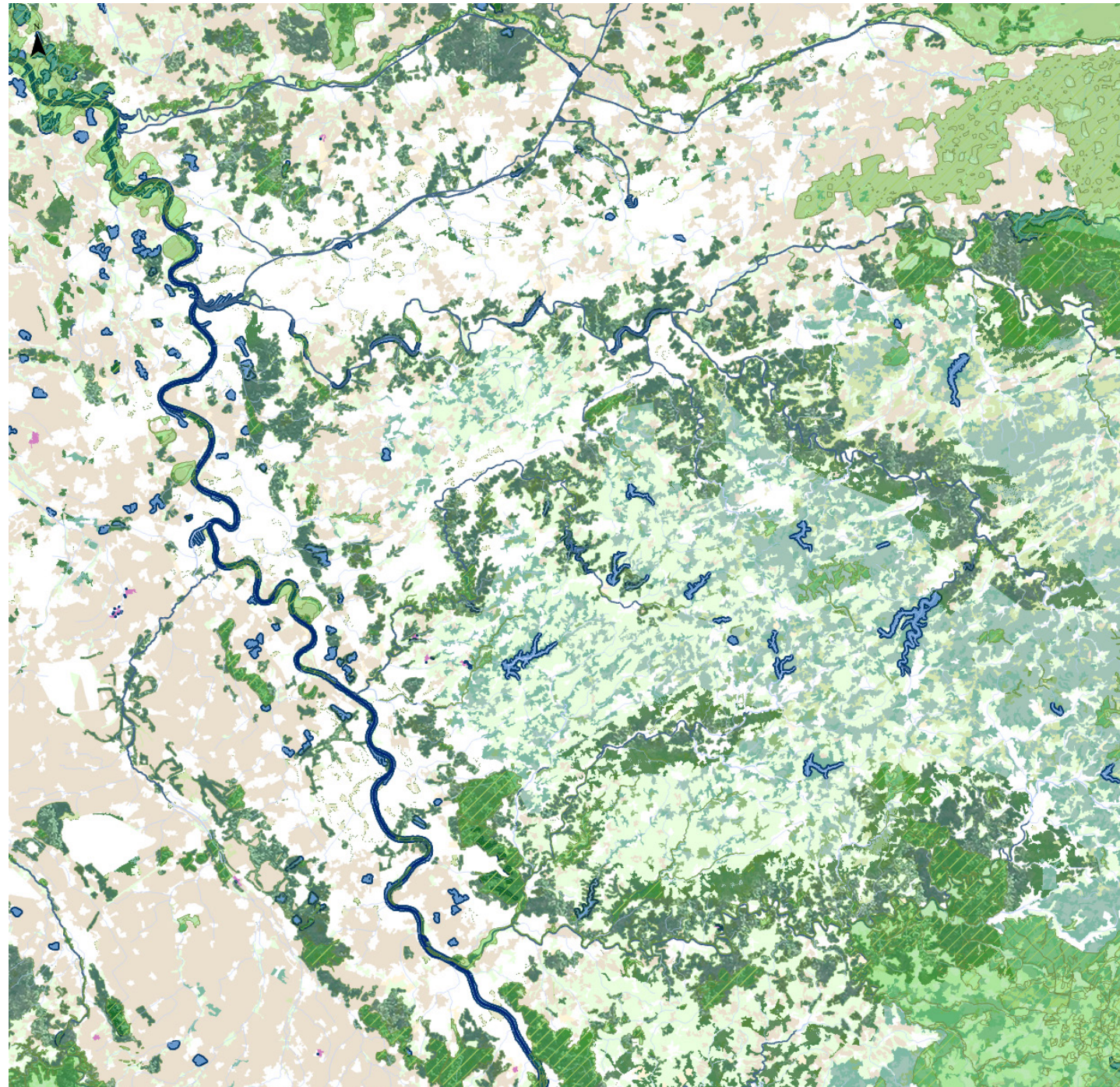
AVAILABILITY

CONTEXT



Green corridors alongside the rivers in Ruhrgebiet

PROBLEM



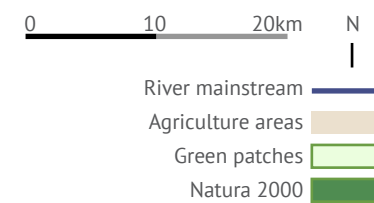
CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION

Figure: green corridors alongside the rivers in Ruhrgebiet
Illustrate by the author
Source: Copernicus, 2017



Flood risk area

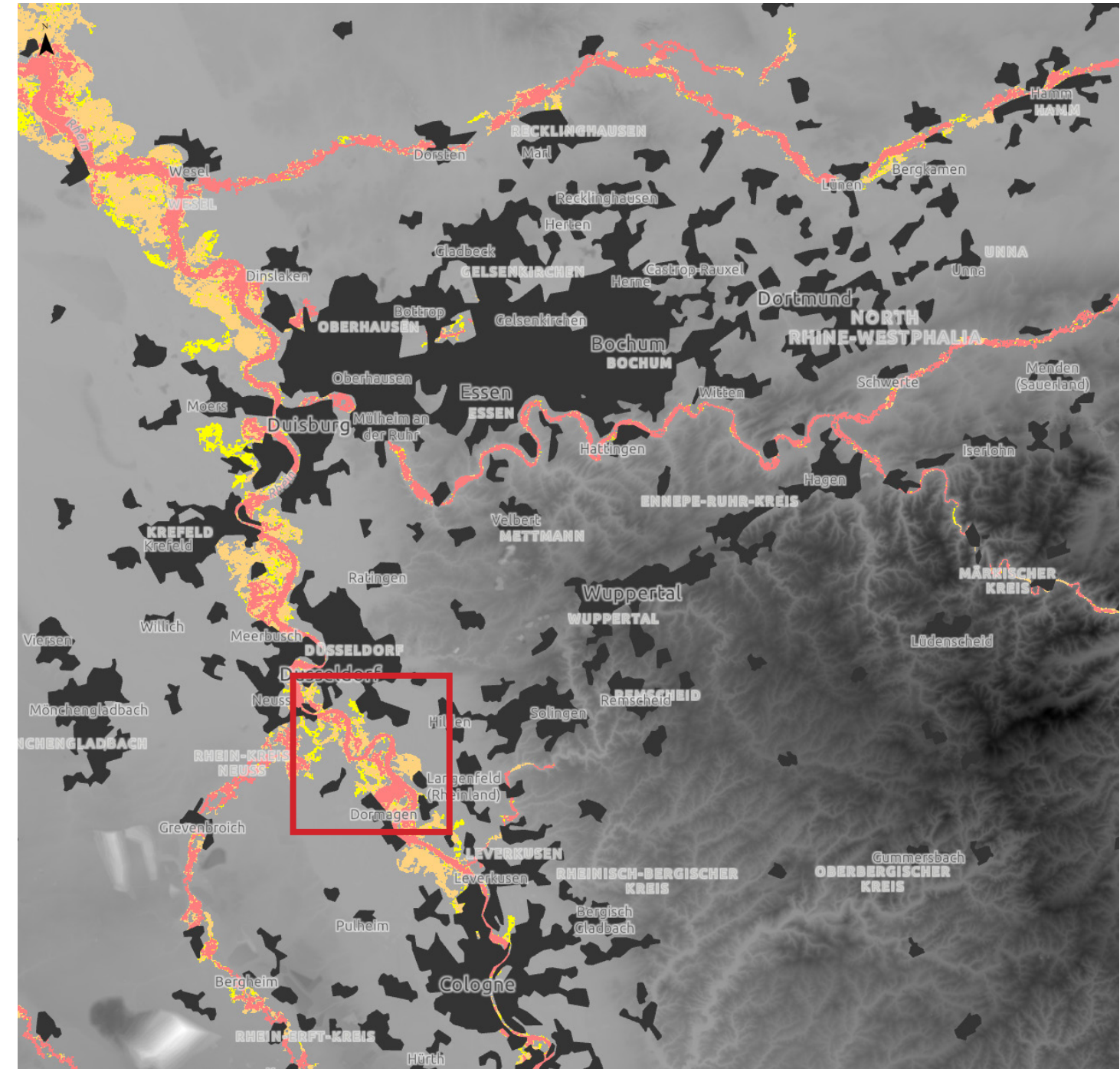
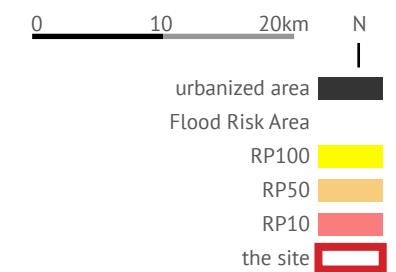


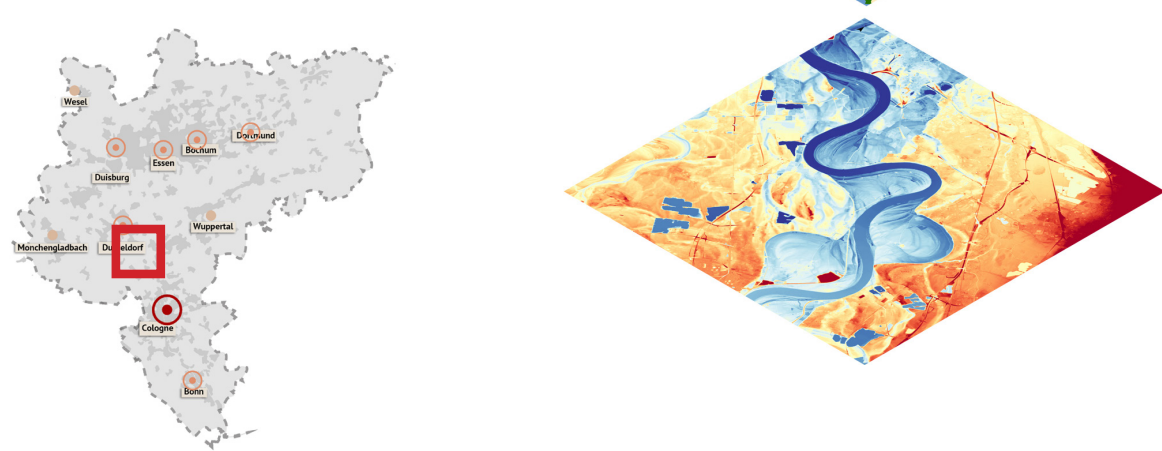
Figure: flood risk area
Illustrate by the author
Source: floodmap EFAS, 2019



AVAILABILITY

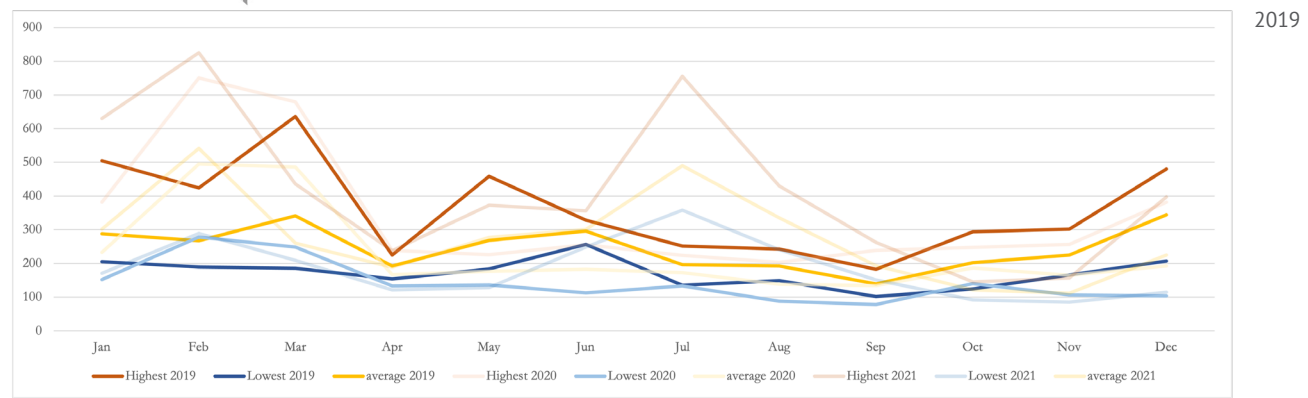
CONTEXT

Terrain and water level

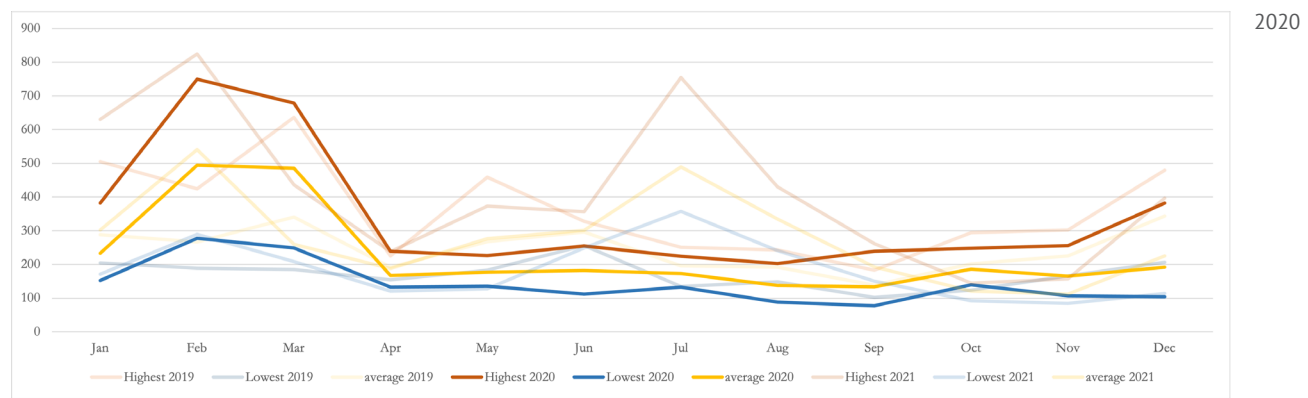


PROBLEM

CONCEPTUALIZATION



ANALYSIS



STRATEGY AND DESIGN

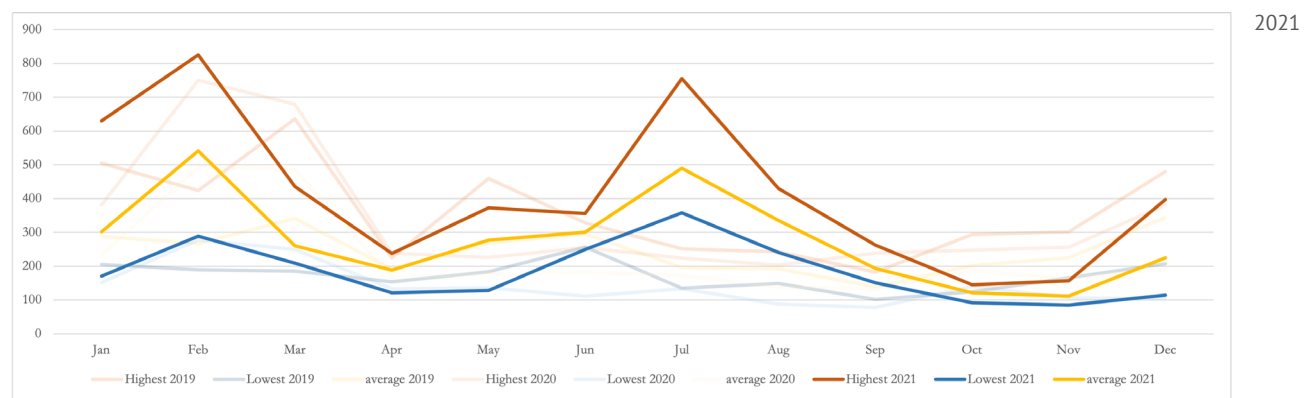
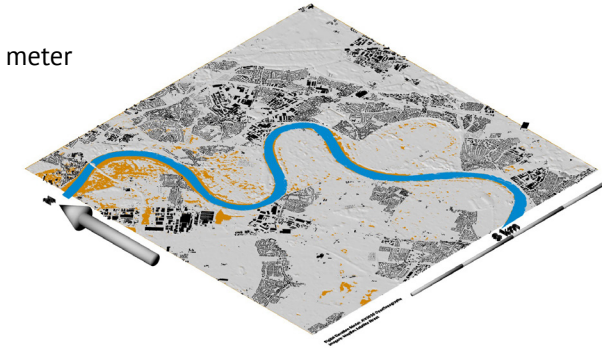


Figure: Rhine waterlevel monthly
Illustrate by the author
Source: OpenDataPortal Düsseldorf, 2022

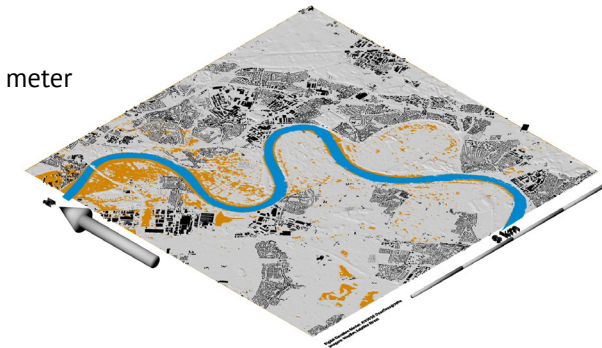
CONCLUSION

Terrain and scenarios of water level raising

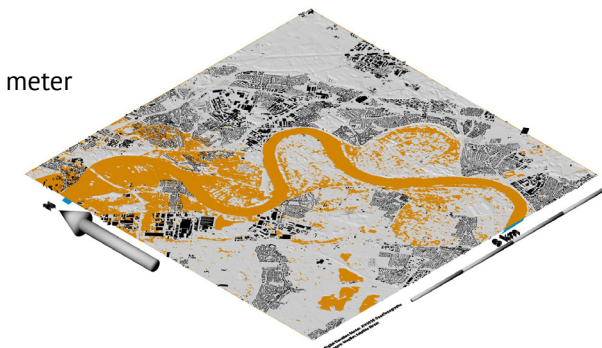
0.0 meter



0.3 meter



0.5 meter



1.0 meter

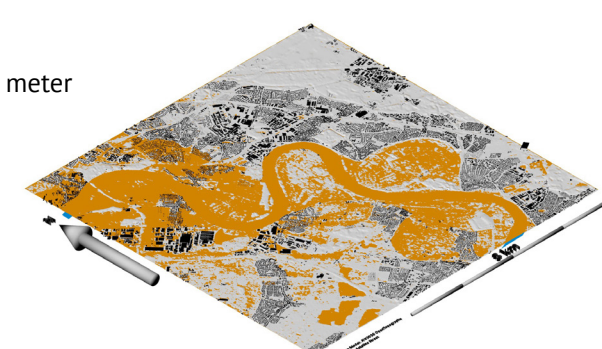


Figure: scenarios of water level raising
Illustrate by the author

AVAILABILITY

soil

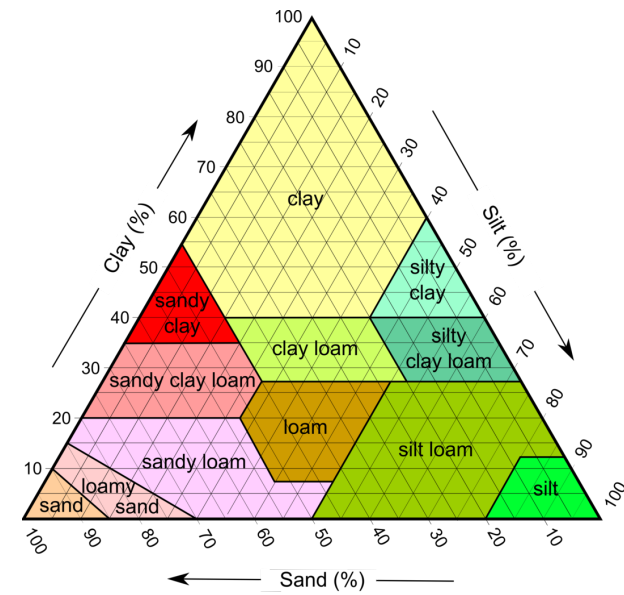
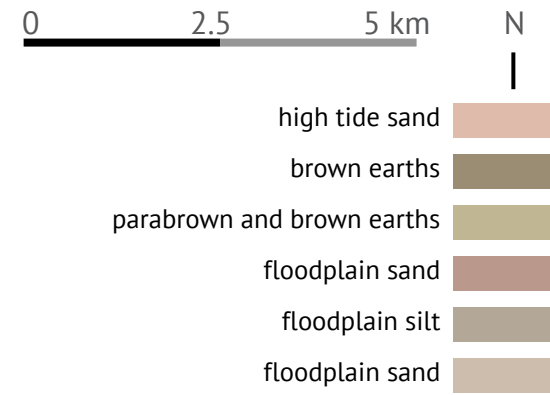


Figure: USDA Soil Texture
Source: Christopher Aragón, 2018

Soil Group	Description	Final Infiltration Rate (mm/h)
A	Lowest Runoff Potential. Includes deep sands with very little silt and clay, also deep, rapidly permeable loess.	8 - 12
B	Moderately Low Runoff Potential. Mostly sandy soils less deep than A, loess less deep or less aggregated than A, but the group as a whole has above-average infiltration after thorough wetting.	4 - 8
C	Moderately High Runoff Potential. Comprises shallow soils and soils containing considerable clay and colloids, though less than those of group D. The group has below-average infiltration after pre-saturation.	1 - 4
D	Highest Runoff Potential. Includes mostly clays of high swelling percent, but the group also includes some shallow soils with nearly impermeable sub-horizons near the surface.	0 - 1

Figure: The USDA-NRCS Hydrologic Soil Group Classification
Source: Reynold J. Stone, 2014

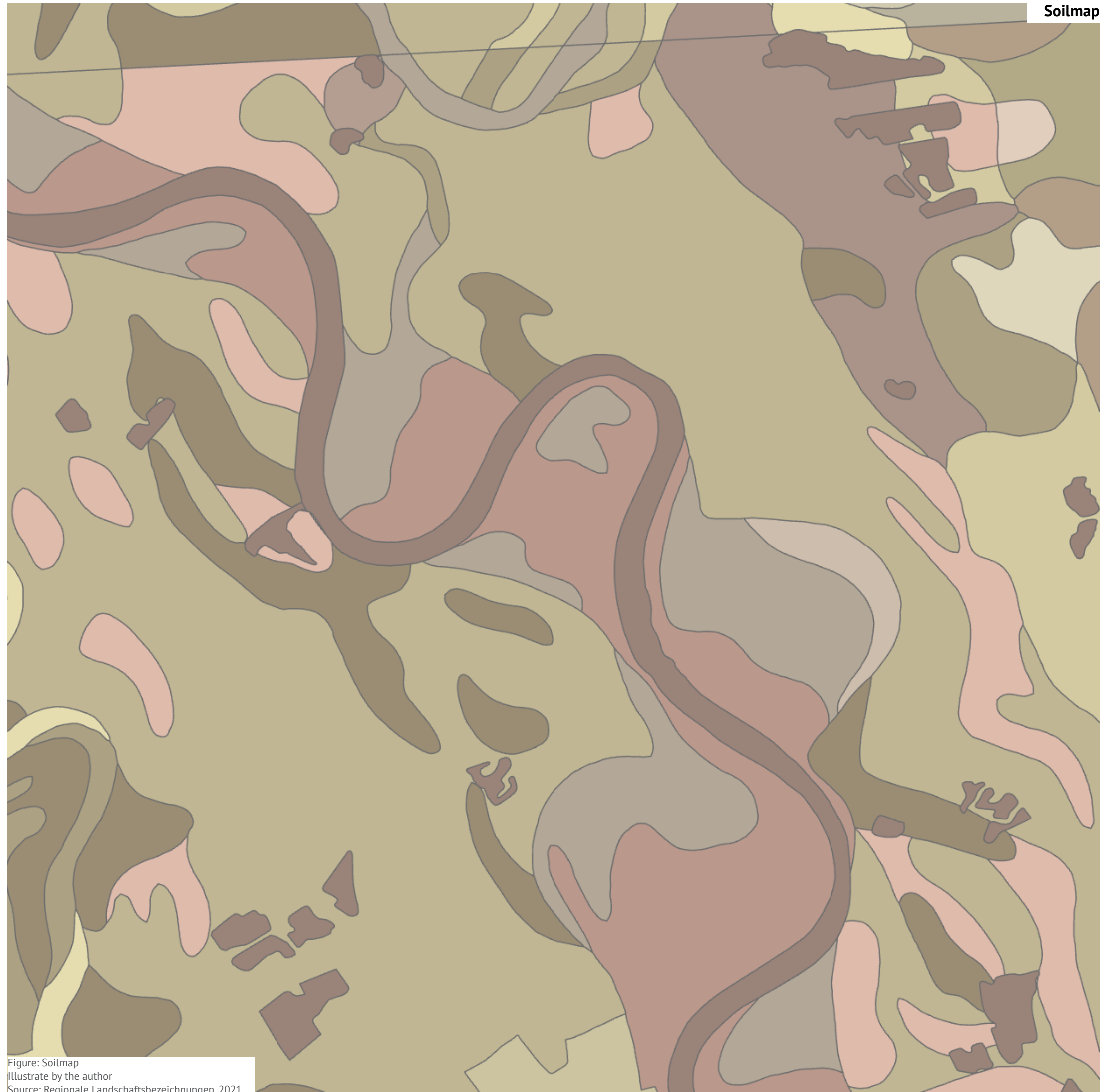
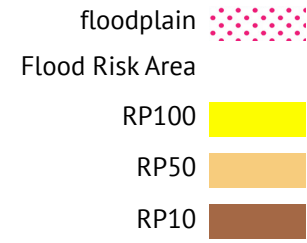


Figure: Soilmap
Illustrate by the author
Source: Regionale Landschaftsbezeichnungen, 2021

AVAILABILITY

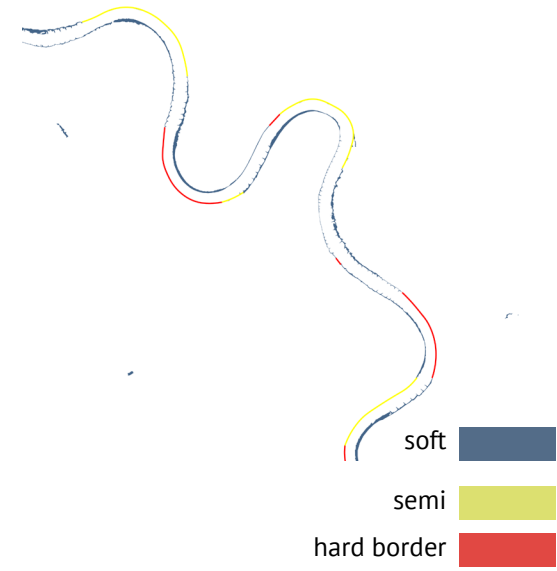
CONTEXT

spaces along side the river



PROBLEM

CONCEPTUALIZATION



ANALYSIS

1



3



STRATEGY AND DESIGN

2

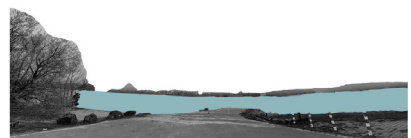


5



CONCLUSION

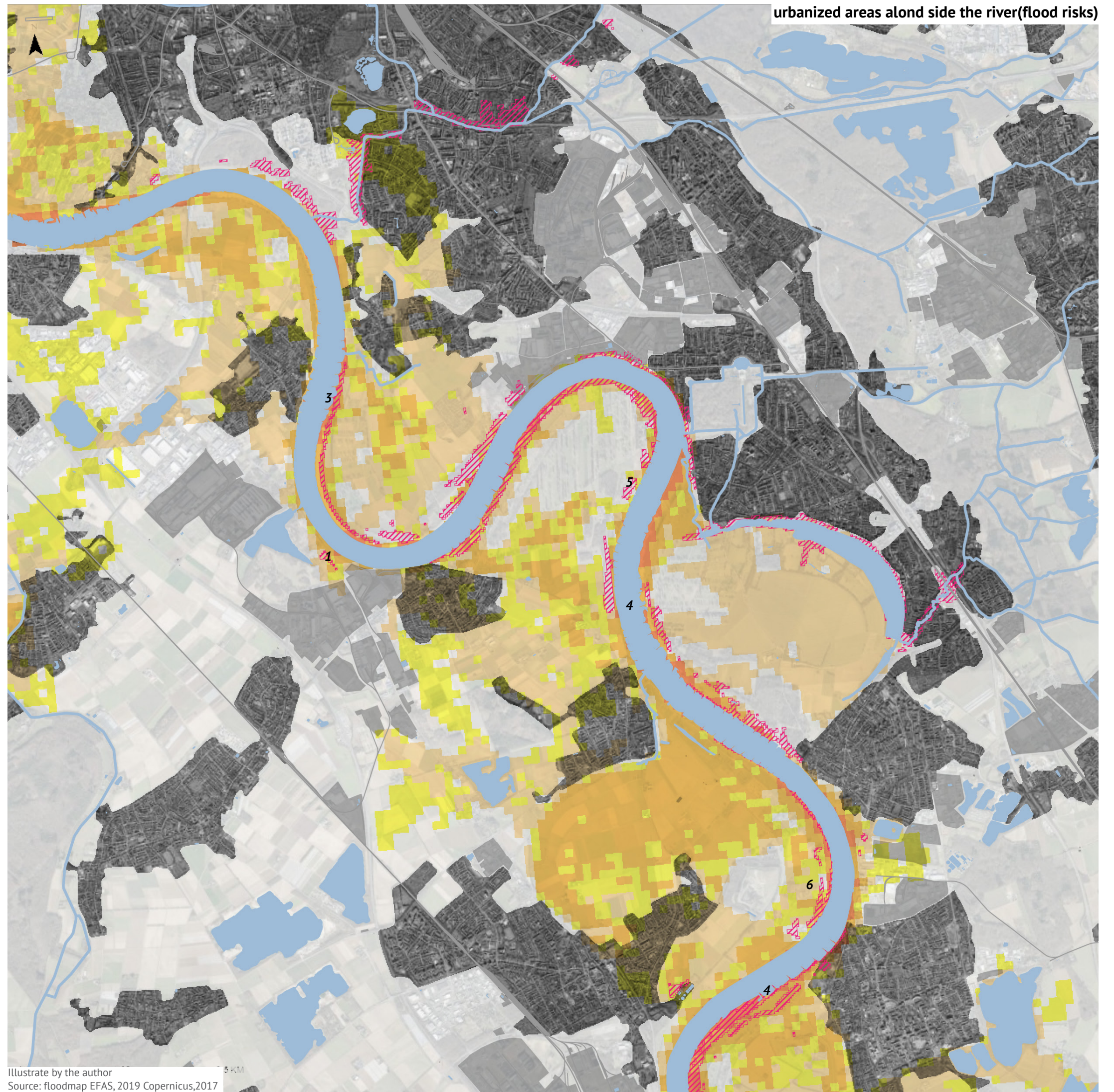
4



6



Figure: the spaces alongside the river
Illustrate by the author
Source: Google streetview, 2022



Illustrate by the author
Source: floodmap EFAS, 2019 Copernicus, 2017

AVAILABILITY

the flood protection system and floodable area



- In need of renovation —
- refurbished —
- High terrain —

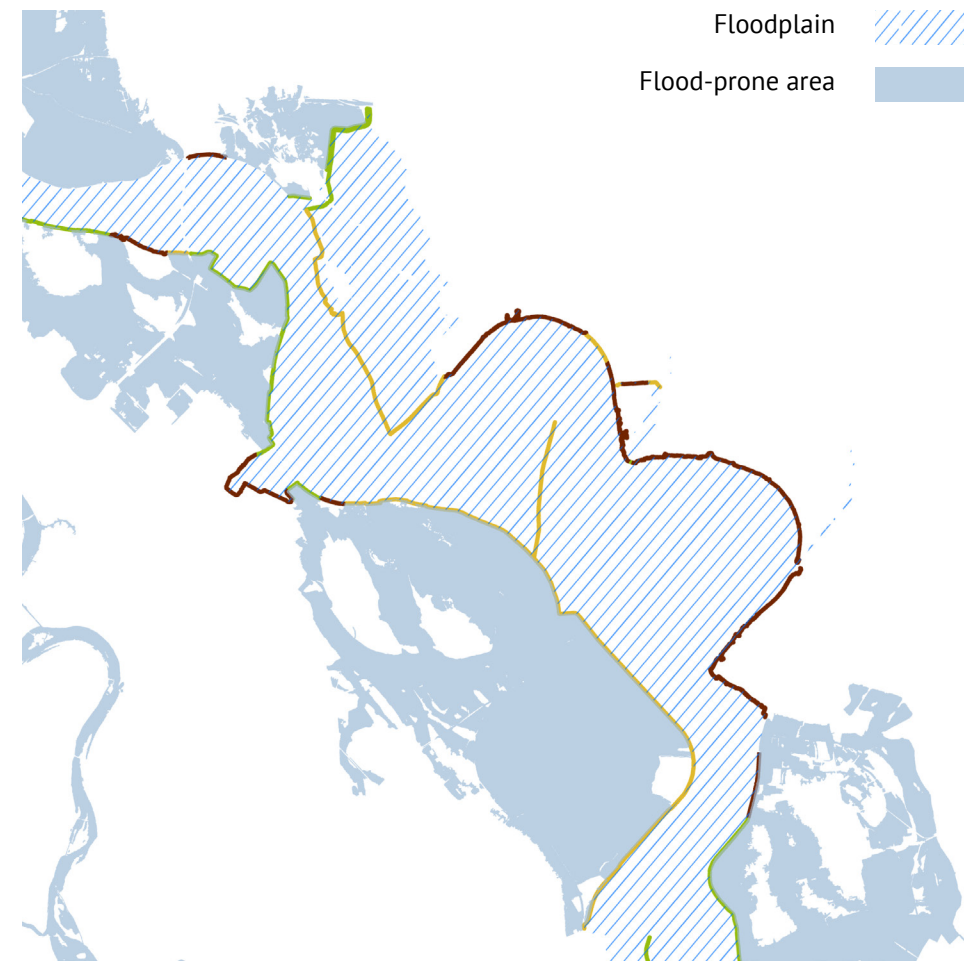


Figure: floodplain and flood-prone area
 Illustrate by the author
 Source: Bezirksregierung Düsseldorf Sachstand Maßnahmenumsetzung, 2022

status of the flood protection system



Figure: status of the flood protection system
 Illustrate by the author
 Source: Bezirksregierung Düsseldorf Sachstand Maßnahmenumsetzung, 2022

AVAILABILITY

Functional spaces along side the river

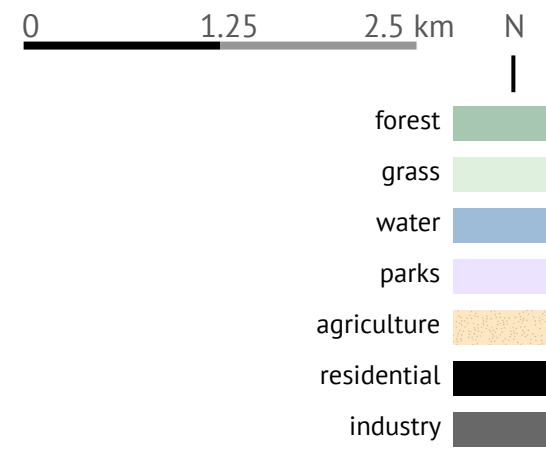


Figure: different spatial element in the satellite map
Illustrate by the author
Source: Googlemap, 2022

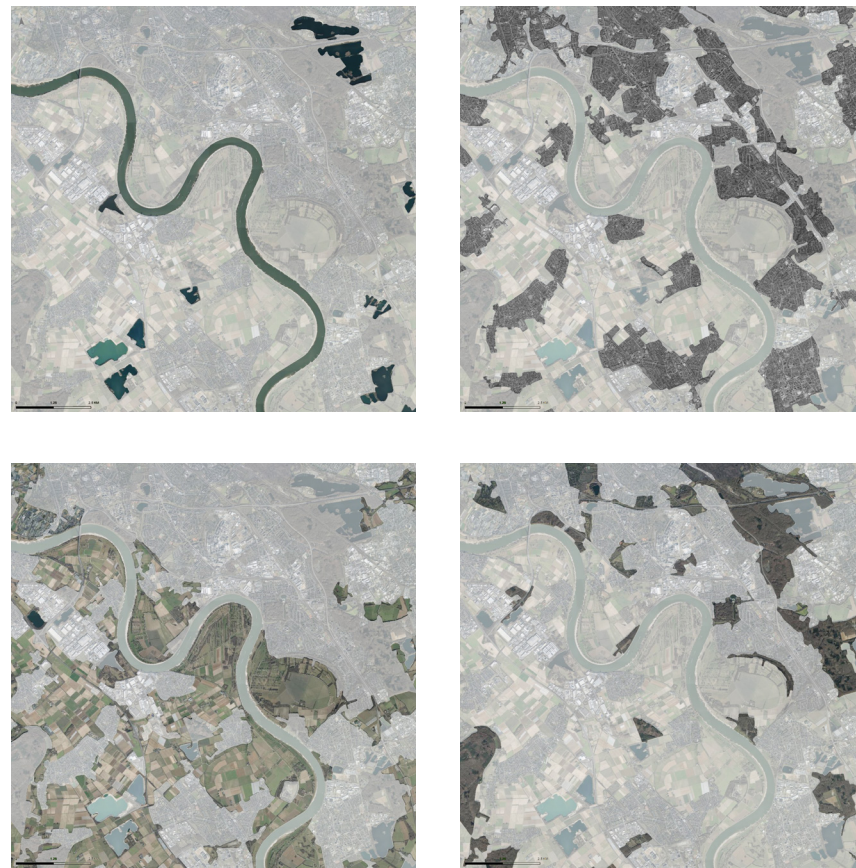
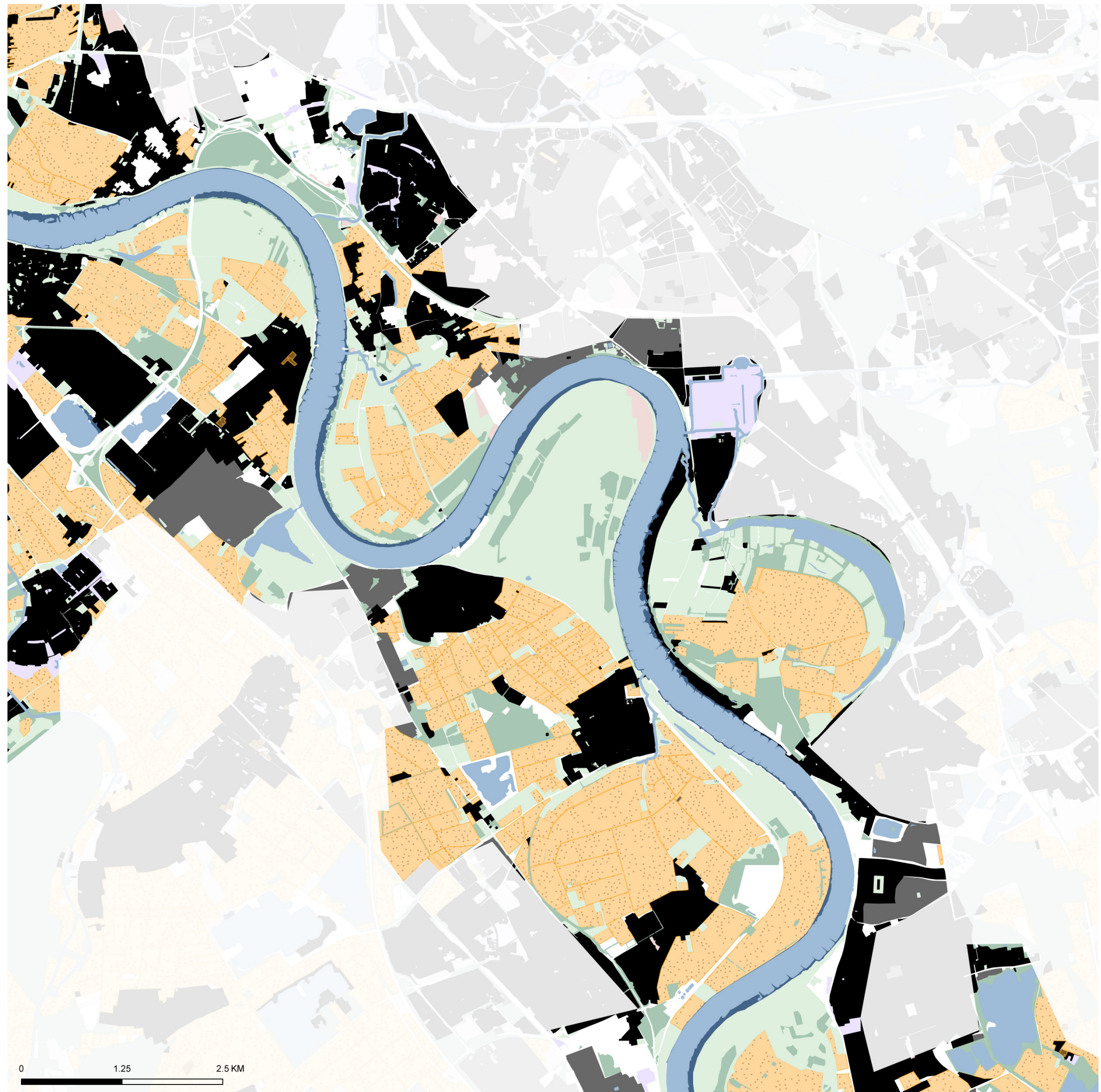


Figure: Functional map alongside the river
Illustrate by the author
Source: Openstreetmap, 2022



AVAILABILITY

Functional spaces: Natura 2000 and green spaces

0 1.25 2.5 km N

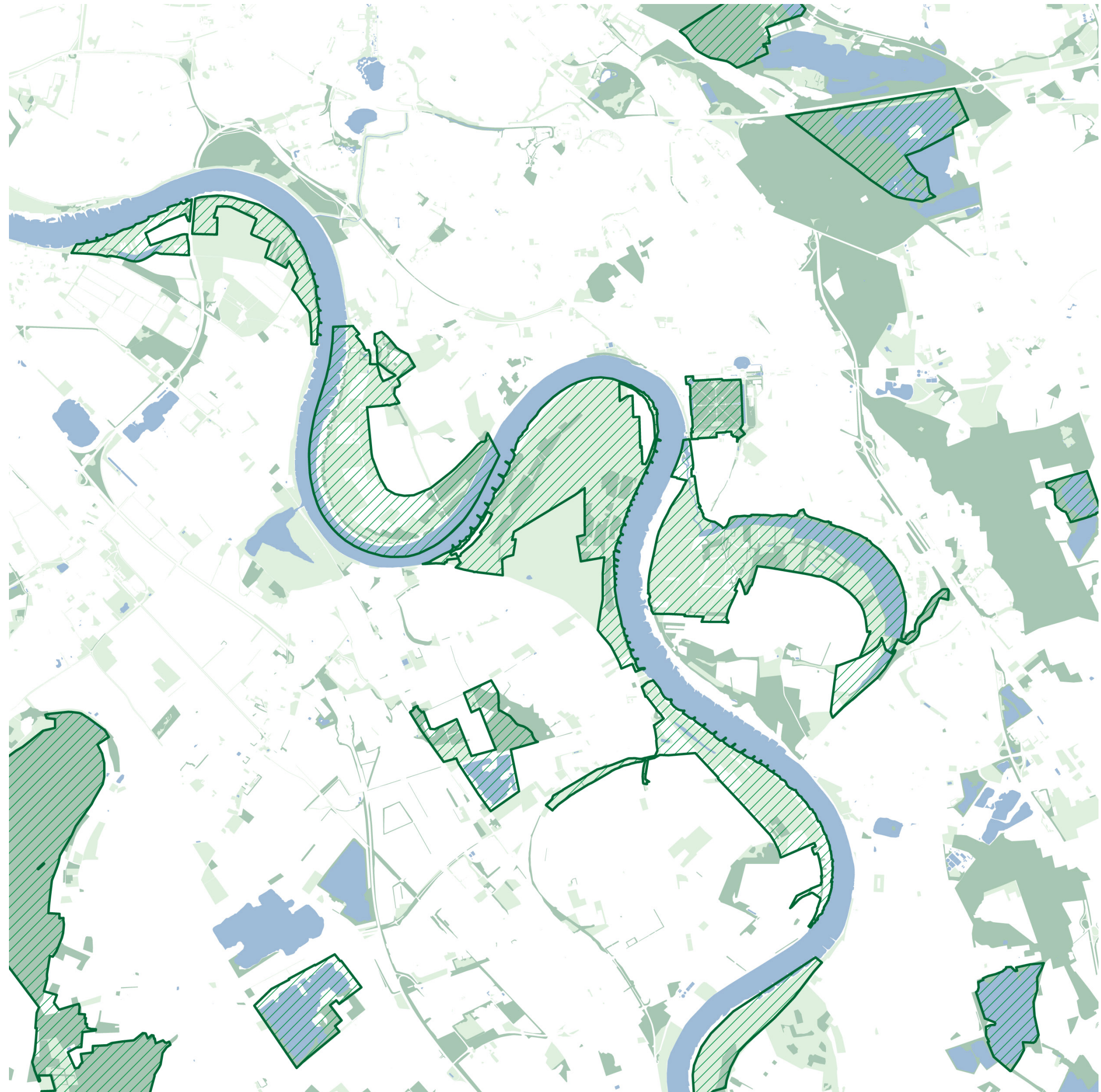
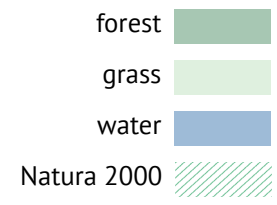










Figure: Natura 2000 and green spaces
Illustrate by the author
Source: Openstreetmap, 2022

CONTEXT

AVAILABILITY

Functional spaces: Farmland and agriculture

0 1.25 2.5 km N

- Winter rapeseed 
- Sugar beet 
- Peas 
- Beans 
- Maize 
- Winter wheat triticale 
- Sunflowers 
- Summer cereals 



Winter rapeseed



Sugar beet



Summer cereals



Sunflowers



Peas



Beans

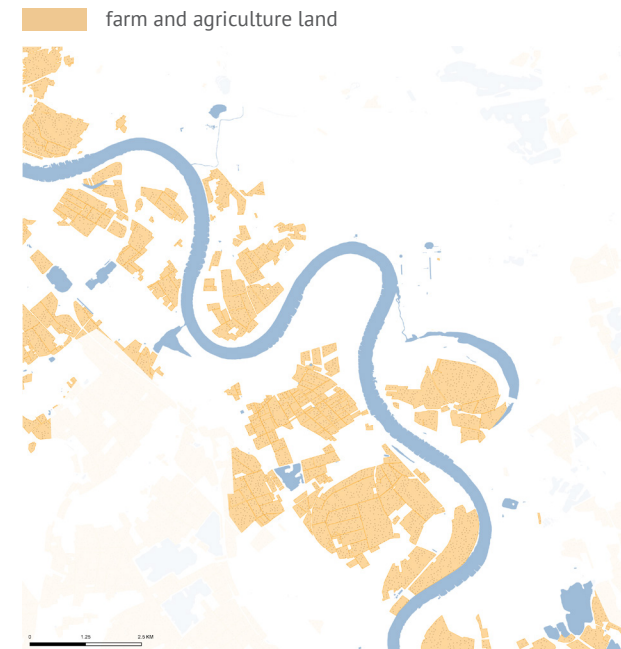


Maize



Winter wheat & triticale

Figure: farmland and agriculture landscapes
Illustrate by the author
Source: Openstreetmap, 2022



CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION

Figure: farmland and agriculture landscapes
Illustrate by the author
Source: Copernicus and Humboldt University Berlin - P.Griffiths, 2016



AVAILABILITY

Functional spaces: urbanized area and recreation spaces

0 1.25 2.5 km N

- park
- recreational
- residential
- industry

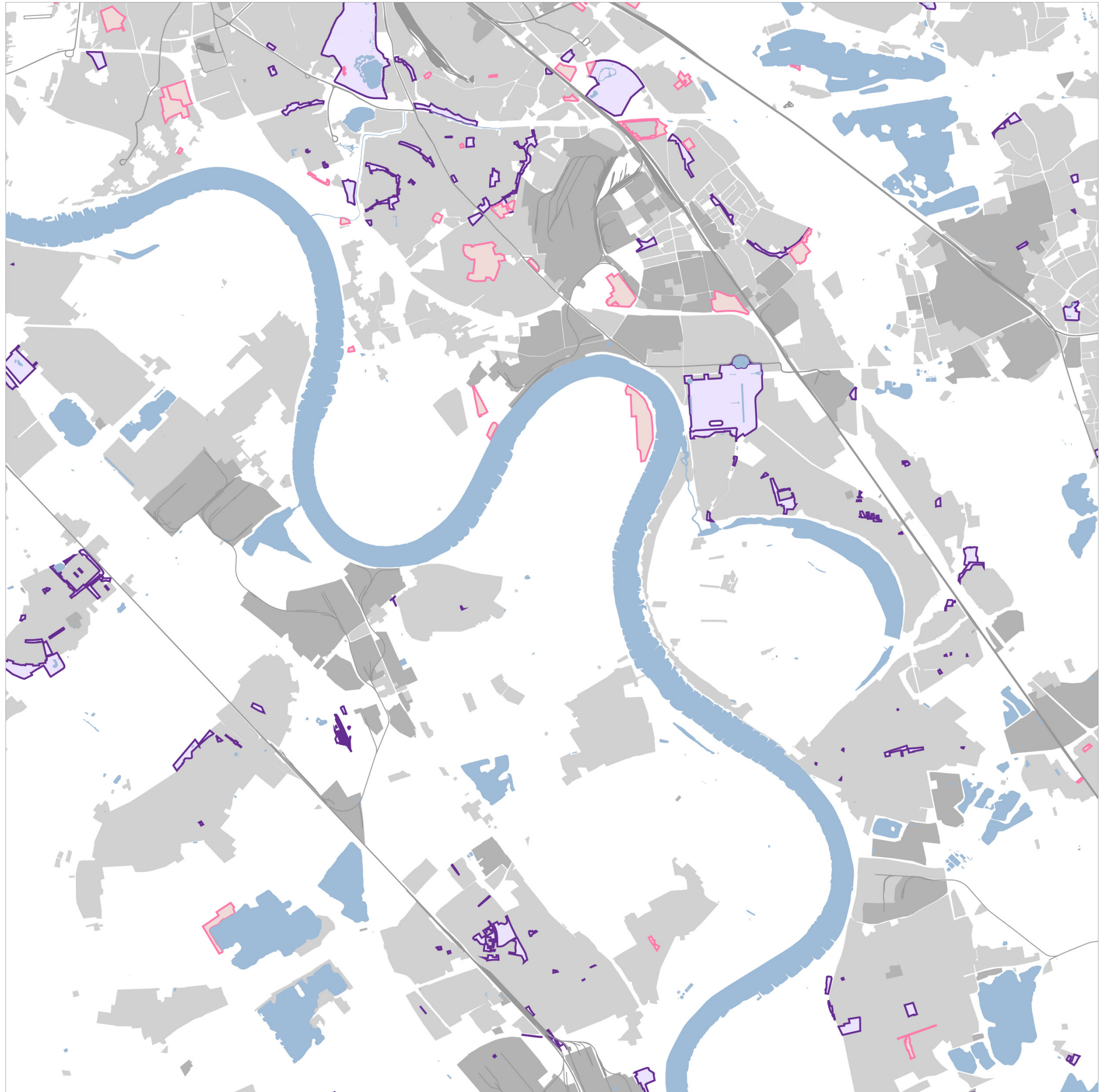


Figure: urbanized area and urban parks
 Illustrate by the author
 Source: Openstreetmap, 2022

AVAILABILITY

policy support

CONTEXT

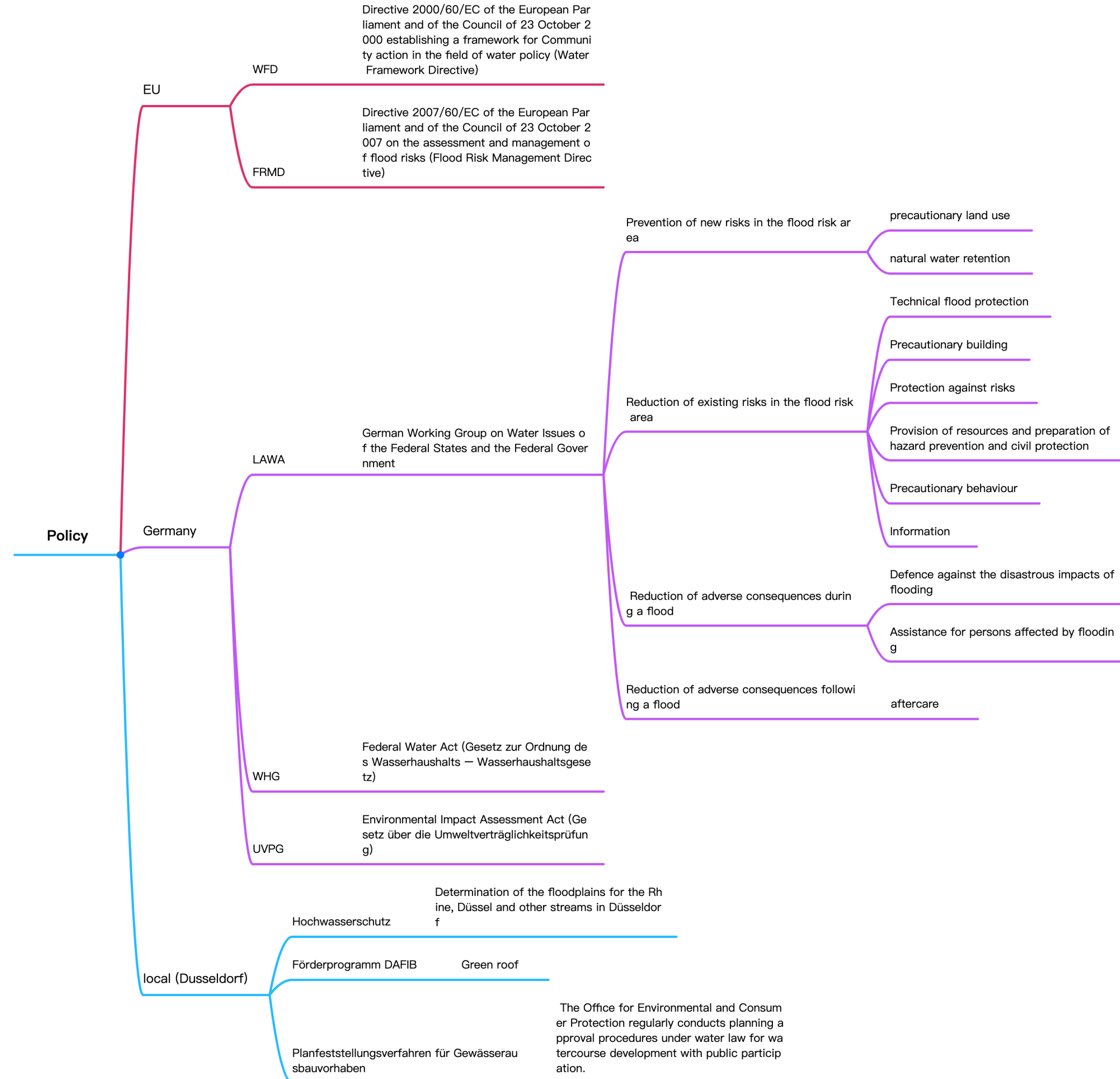
PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



CONCLUSION

STRATEGY
AND DESIGN

ANALYSIS

CONCEPTUALIZATION

PROBLEM

CONTEXT

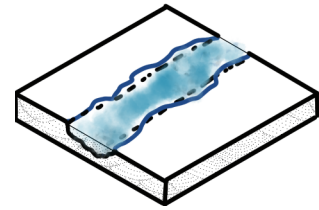
STRATEGY AND DESIGN

IMPLEMENTATION

CONTEXT

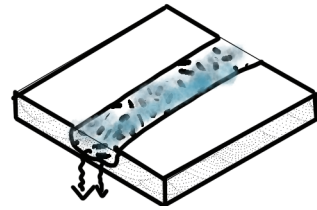
Find the suitable NBS strategy for the design

PROBLEM



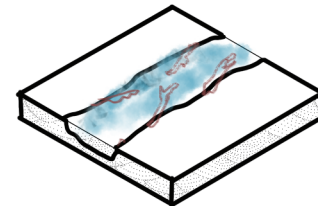
Riverbank softening

1



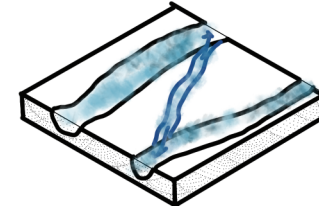
River bed infiltration

2



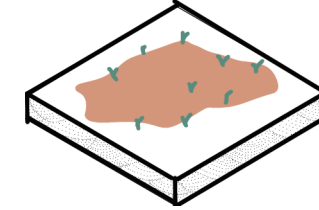
Deadwood and roots runoff control

3



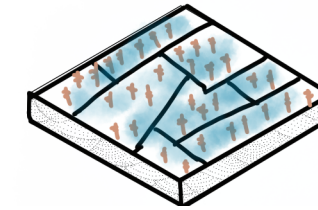
streams connection

4



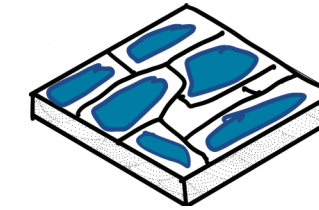
wetland rentention

13



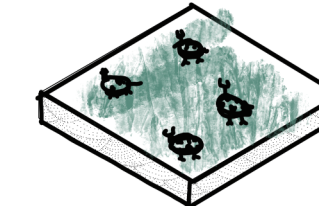
aqua agriculture

14



fishing pond with aqua agriculture

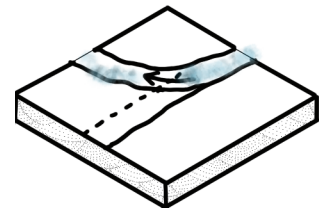
15



Pastoral in floodplain

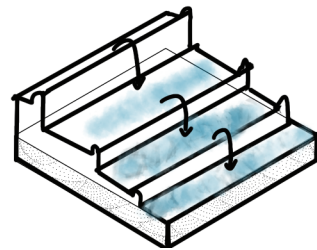
16

CONCEPTUALIZATION



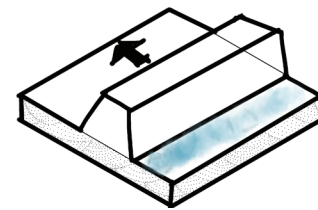
Redirecting

5



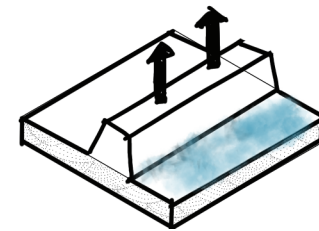
terraces and slopes

6



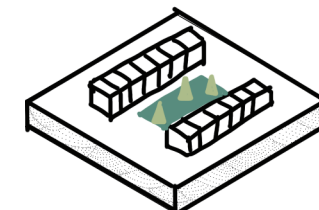
Remove the dam for bigger floodplain

7



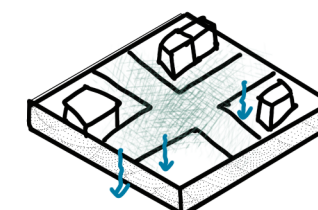
Highten up the dam for bigger floodplain

8



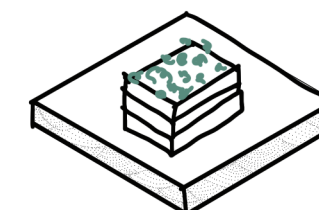
urban farming

17



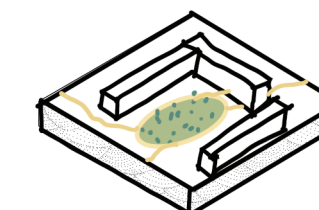
desealing cities

18



green roof

19

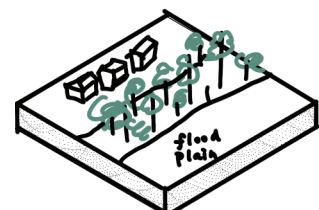


urban parks

20

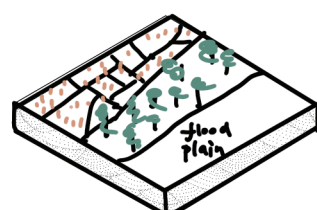
ANALYSIS

STRATEGY AND DESIGN



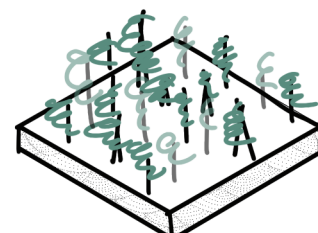
buffer belt for city

9



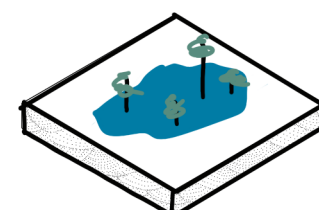
buffer belt for agriculture

10



forest restoration

11



mangrove forest

12

CONCLUSION

IMPLEMENTATION

CONTEXT

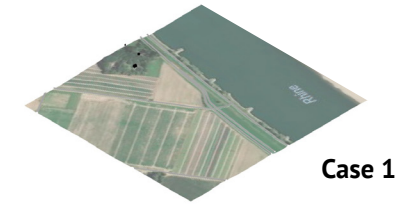
PROBLEM

CONCEPTUALIZATION

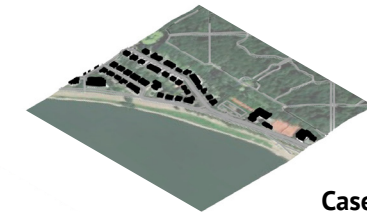
ANALYSIS

STRATEGY AND DESIGN

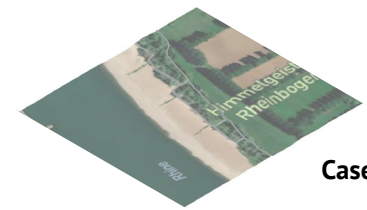
CONCLUSION



Case 1



Case 2



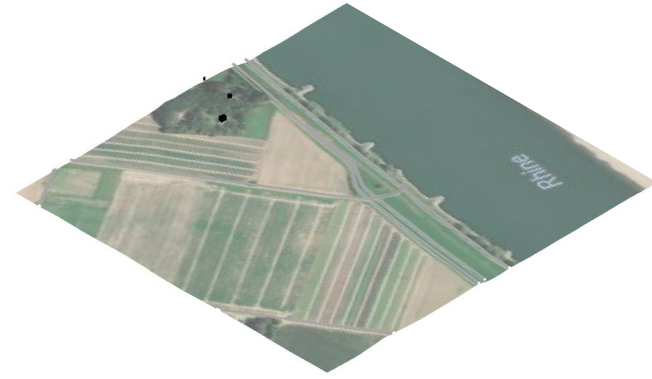
Case 3

Source: Googlemap, 2022

IMPLEMENTATION

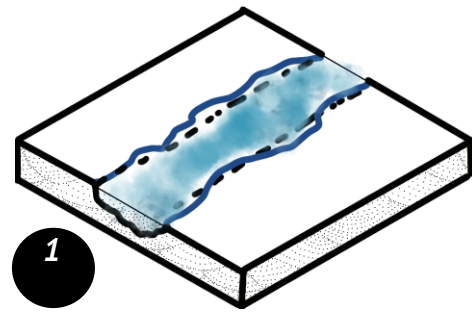
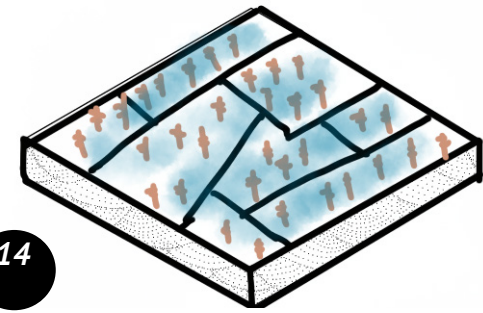
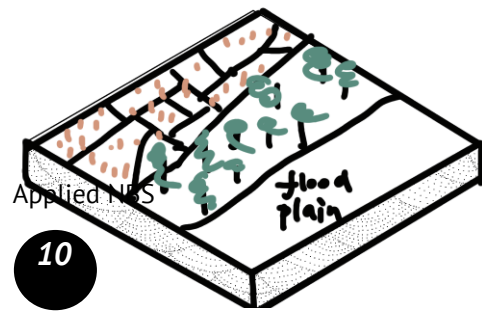
CONTEXT

Case 1

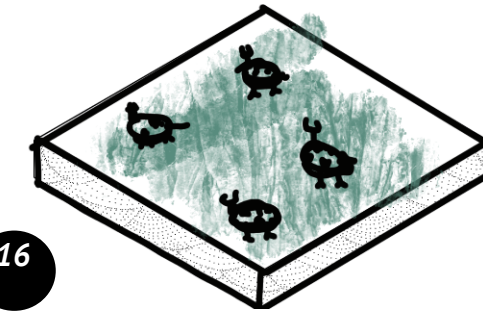
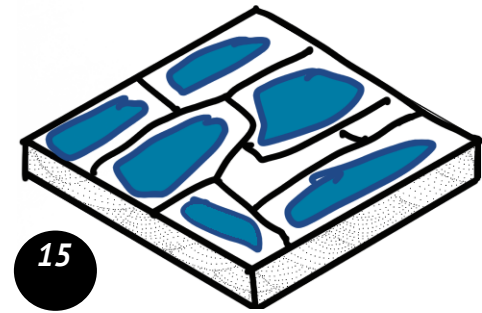


PROBLEM

CONCEPTUALIZATION



ANALYSIS



STRATEGY AND DESIGN

CONCLUSION



before

after

CONTEXT

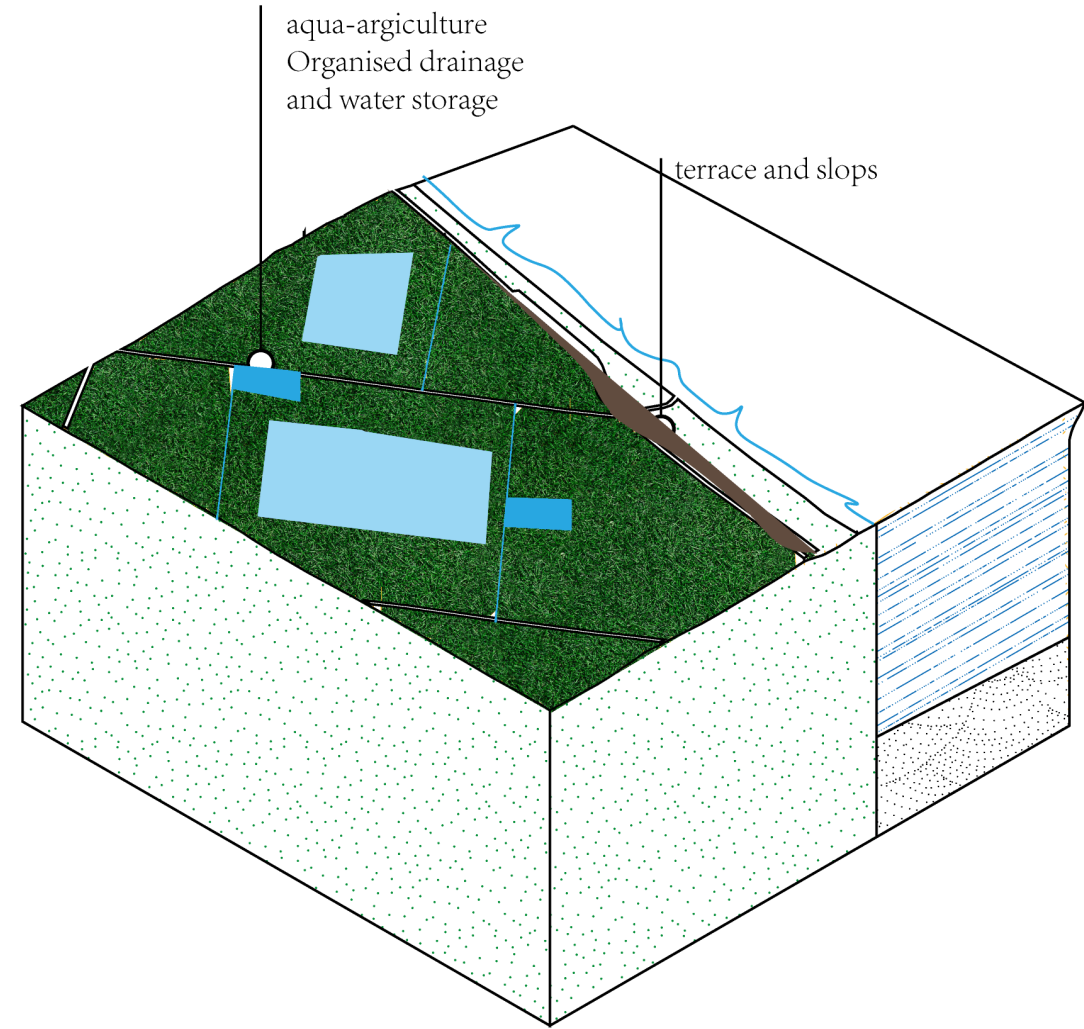
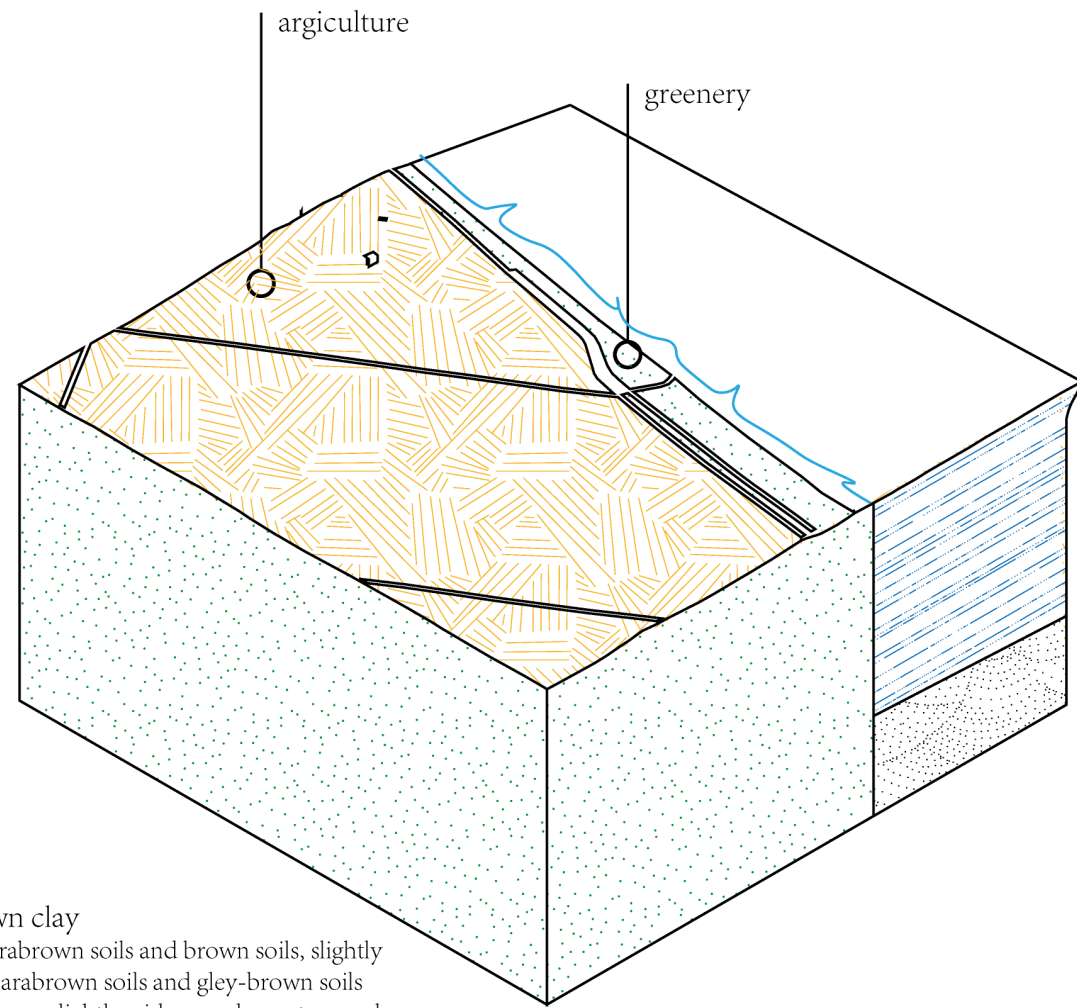
PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



flood soil Brown clay
 predominantly parabrown soils and brown soils, slightly
 widespread gley-parabrown soils and gley-brown soils
 from high-flood loam, slightly widespread over terraced
 sand or over deep terraced sand

CONTEXT

PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY
AND DESIGN

CONCLUSION

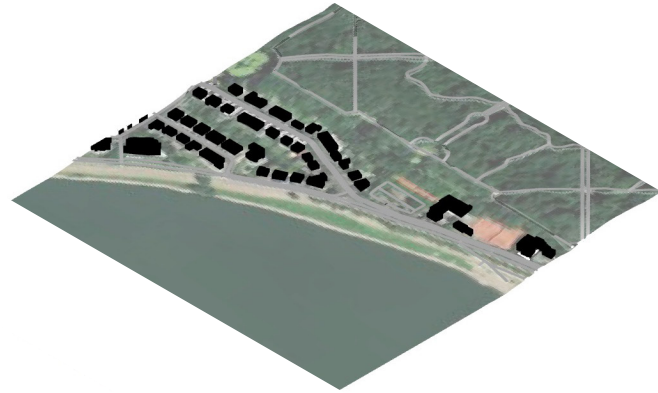


IMPLEMENTATION

CONTEXT

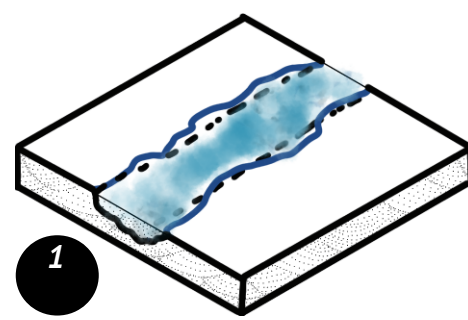
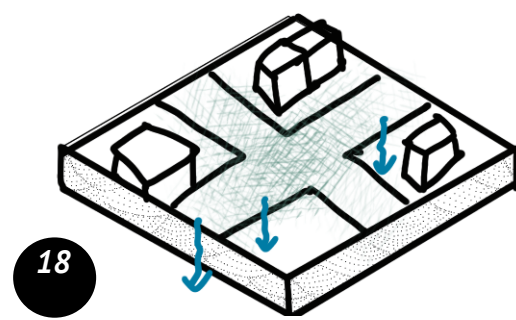
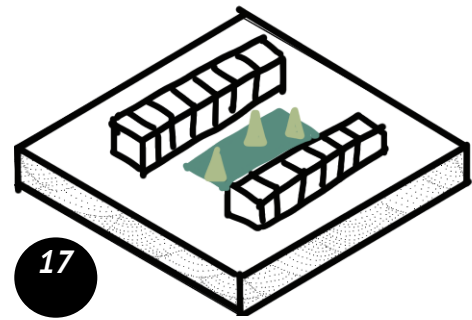
Case 2

PROBLEM

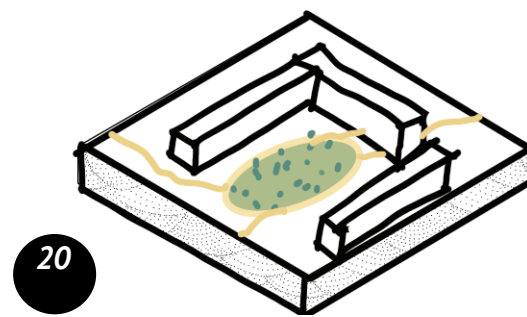
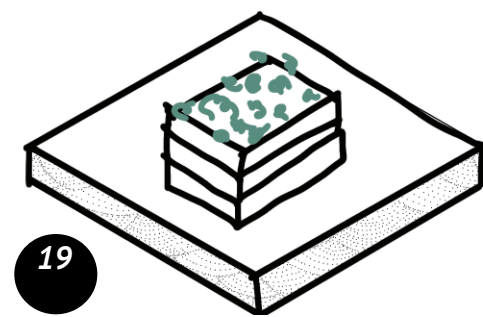


CONCEPTUALIZATION

Applied NBS



STRATEGY AND DESIGN



CONCLUSION



before

after

CONTEXT

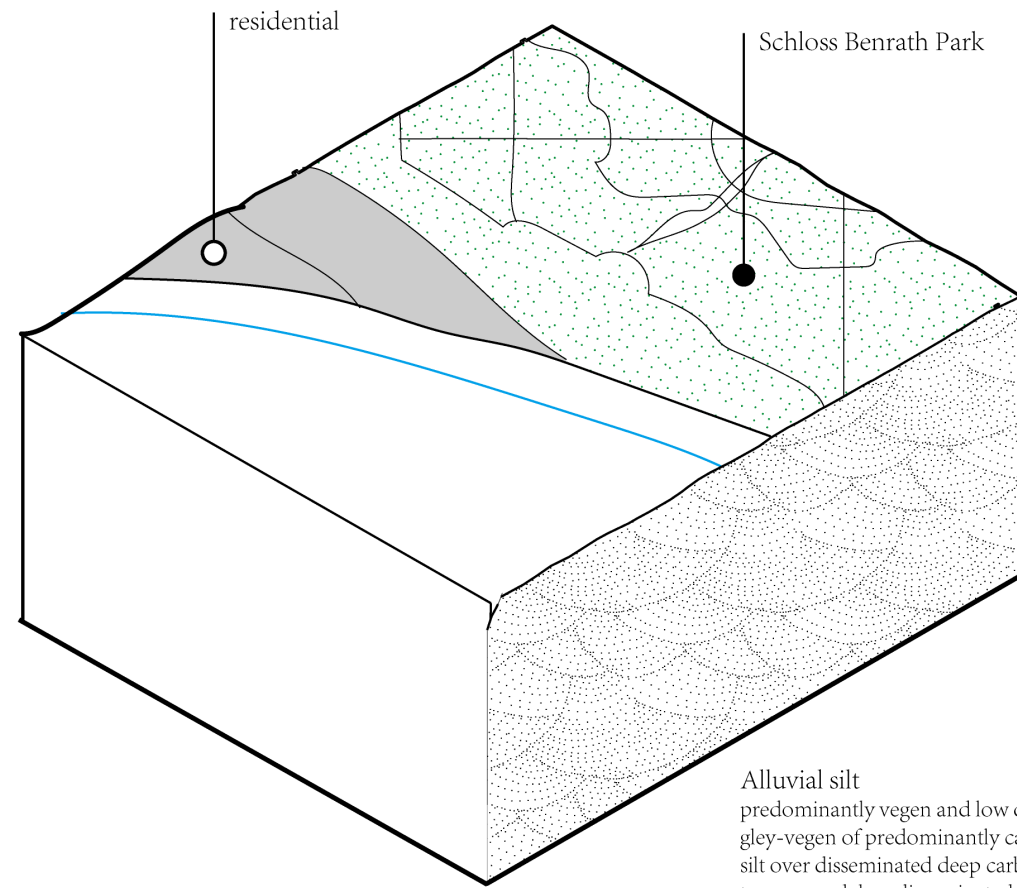
PROBLEM

CONCEPTUALIZATION

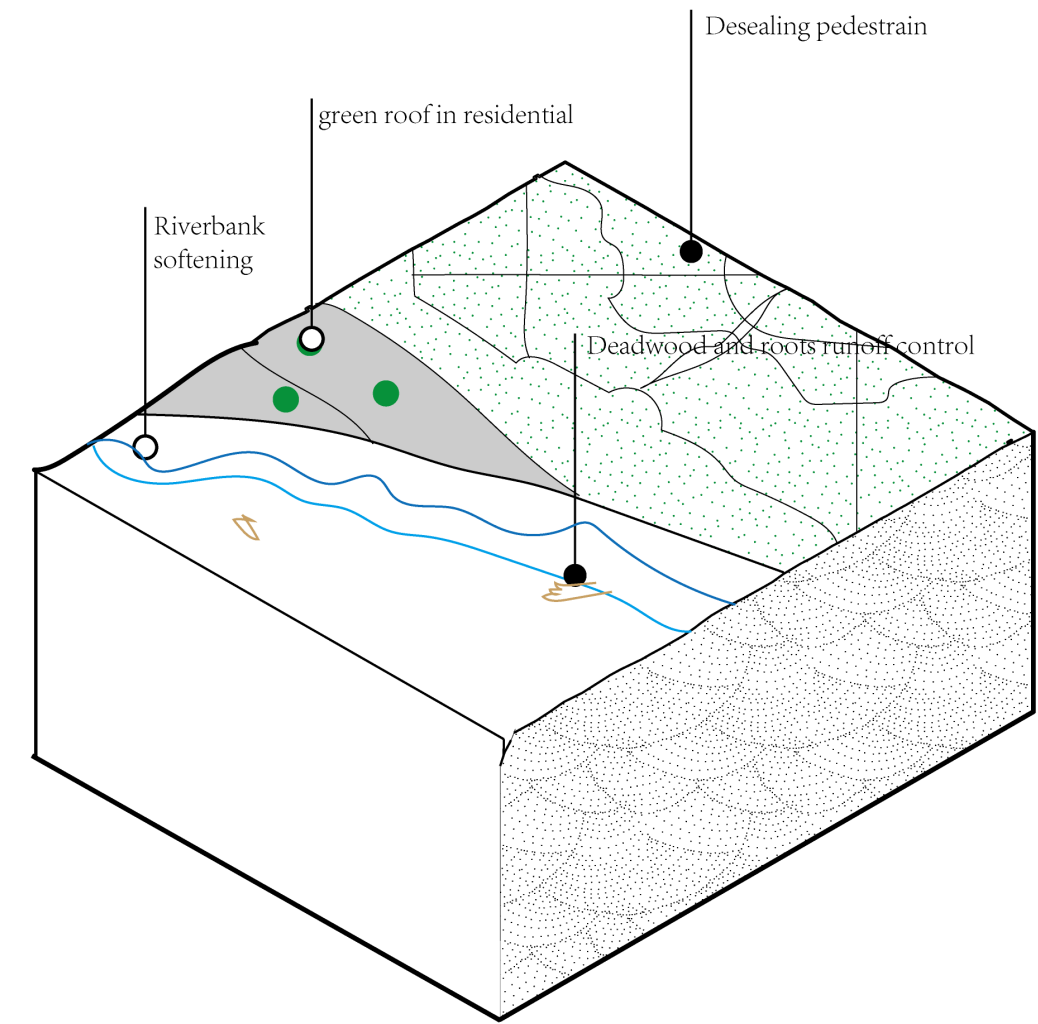
ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



Alluvial silt
 predominantly vege and low disseminated
 gley-vegen of predominantly carbonate floodplain
 silt over disseminated deep carbonate floodplain or
 terrace sand, low disseminated gley-vegen of
 carbonate floodplain silt over deep carbonate
 floodplain clay



CONTEXT

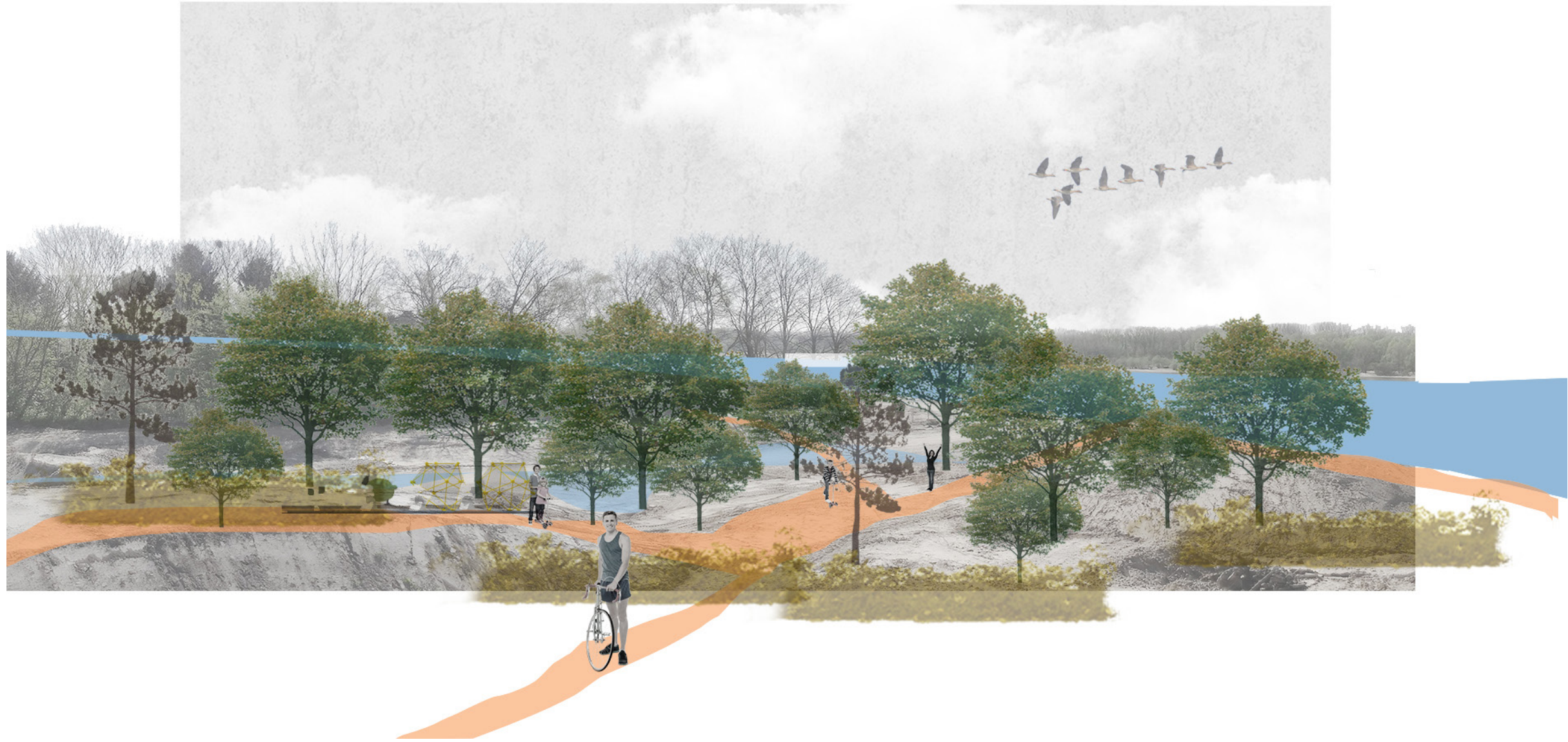
PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY
AND DESIGN

CONCLUSION

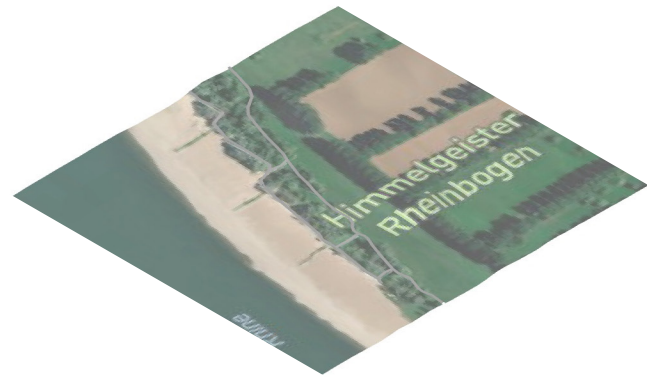


IMPLEMENTATION

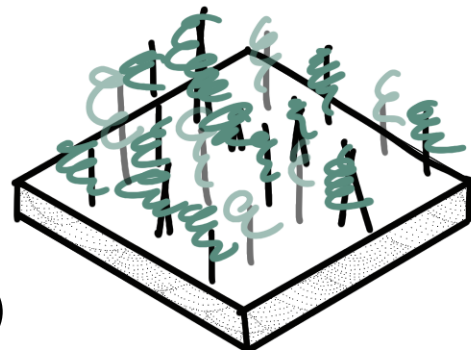
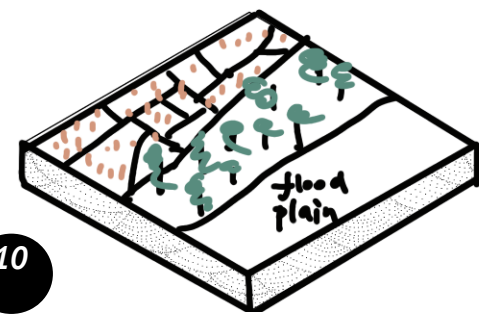
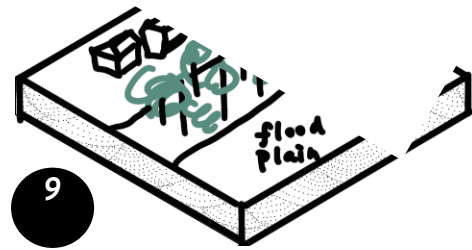
CONTEXT

Case 3

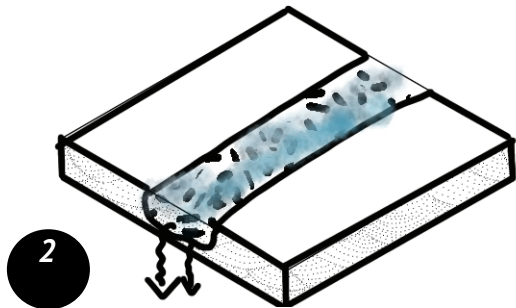
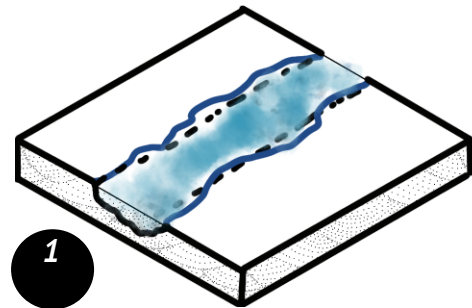
PROBLEM



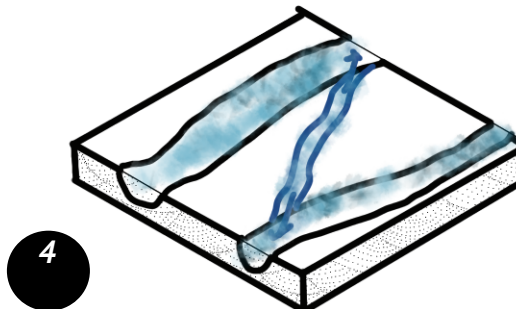
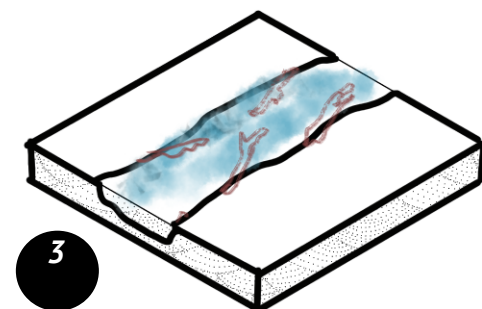
CONCEPTUALIZATION



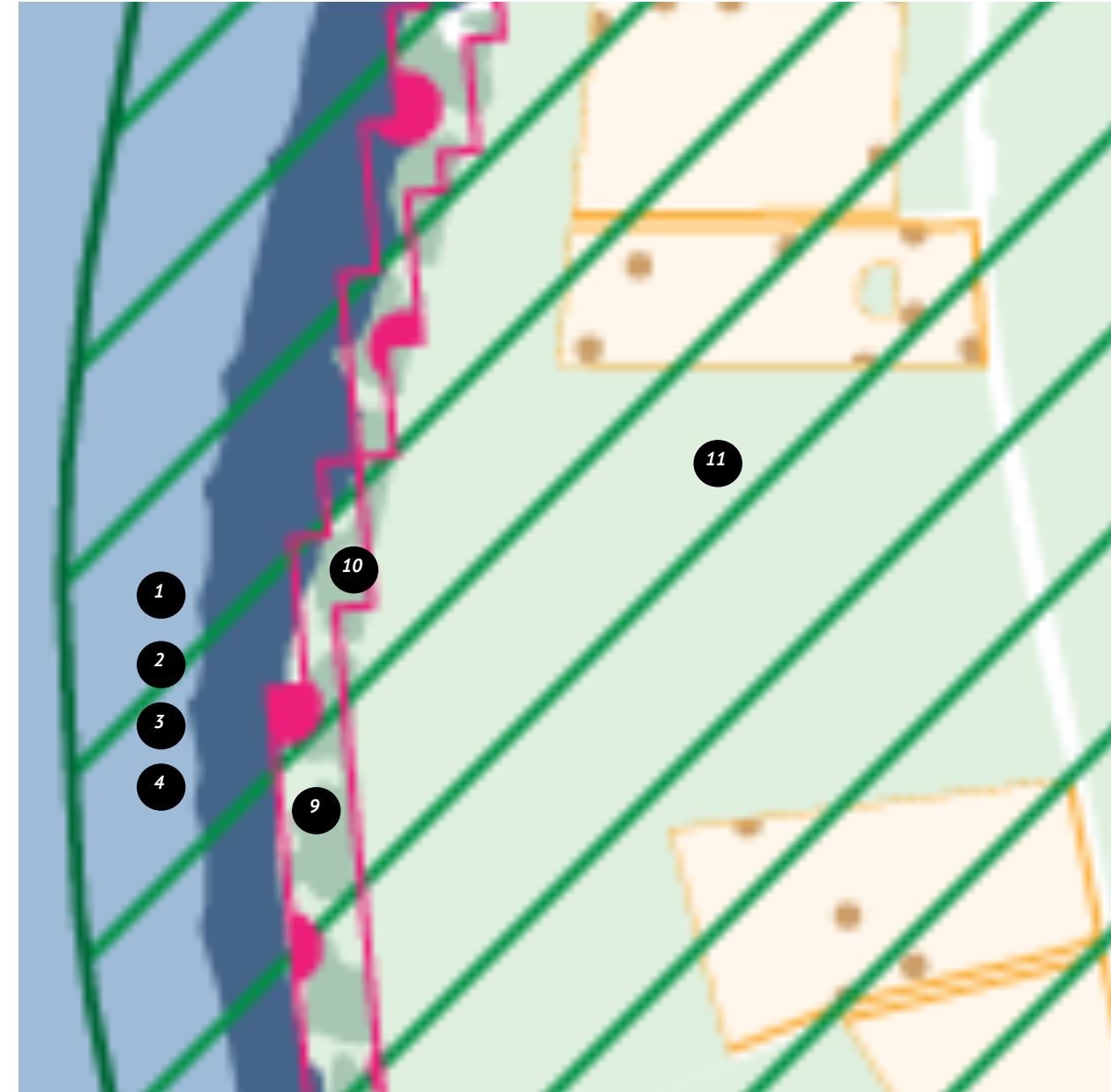
ANALYSIS



STRATEGY AND DESIGN



CONCLUSION



before

after

CONTEXT

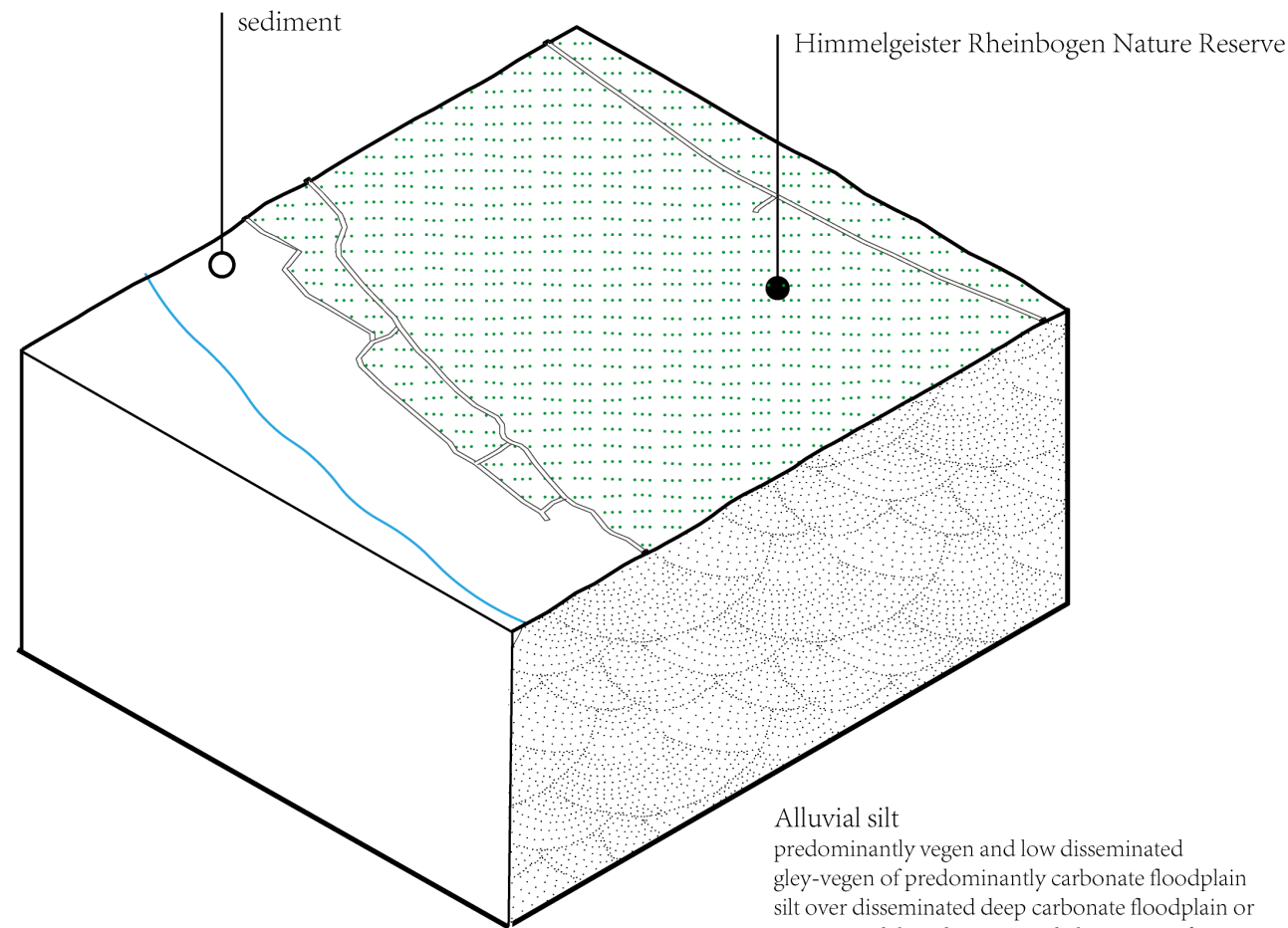
PROBLEM

CONCEPTUALIZATION

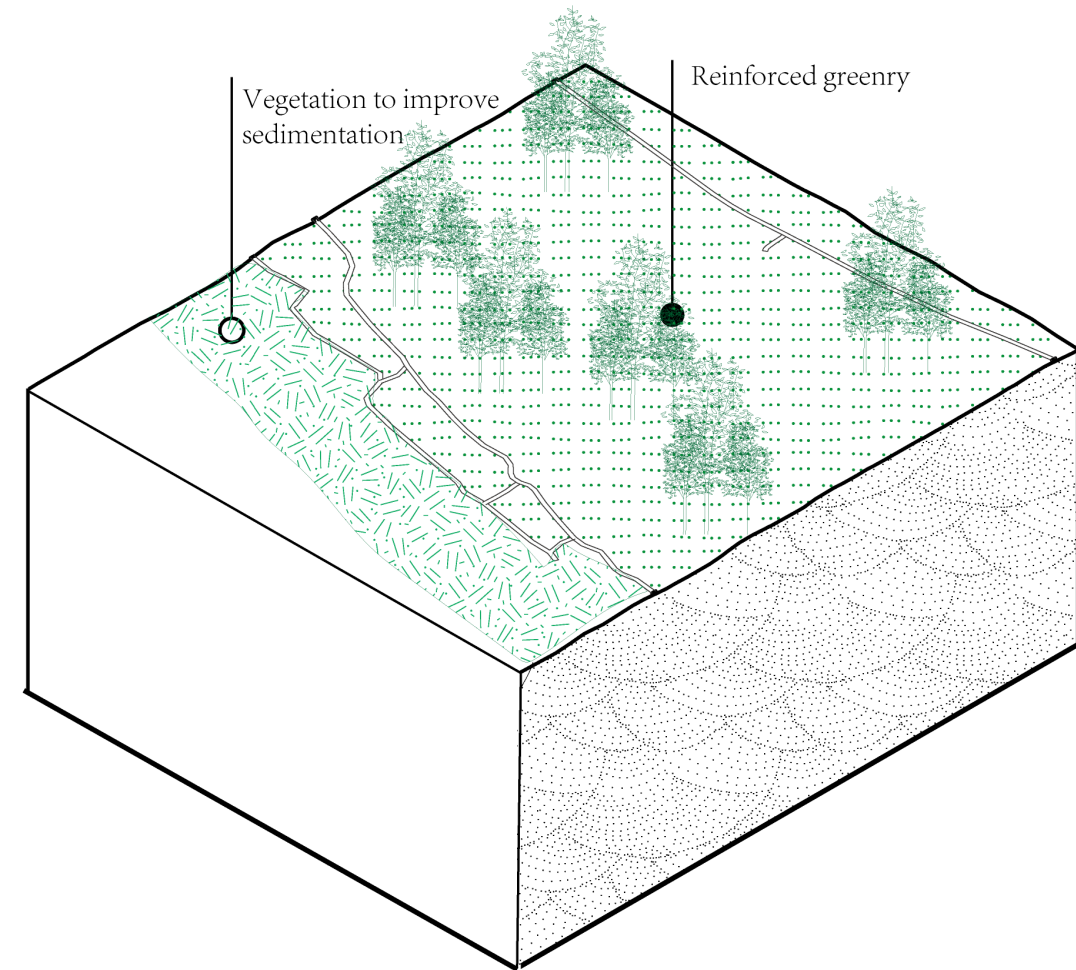
ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



Alluvial silt
 predominantly vege and low disseminated
 gley-vege of predominantly carbonate floodplain
 silt over disseminated deep carbonate floodplain or
 terrace sand, low disseminated gley-vege of
 carbonate floodplain silt over deep carbonate
 floodplain clay



CONTEXT

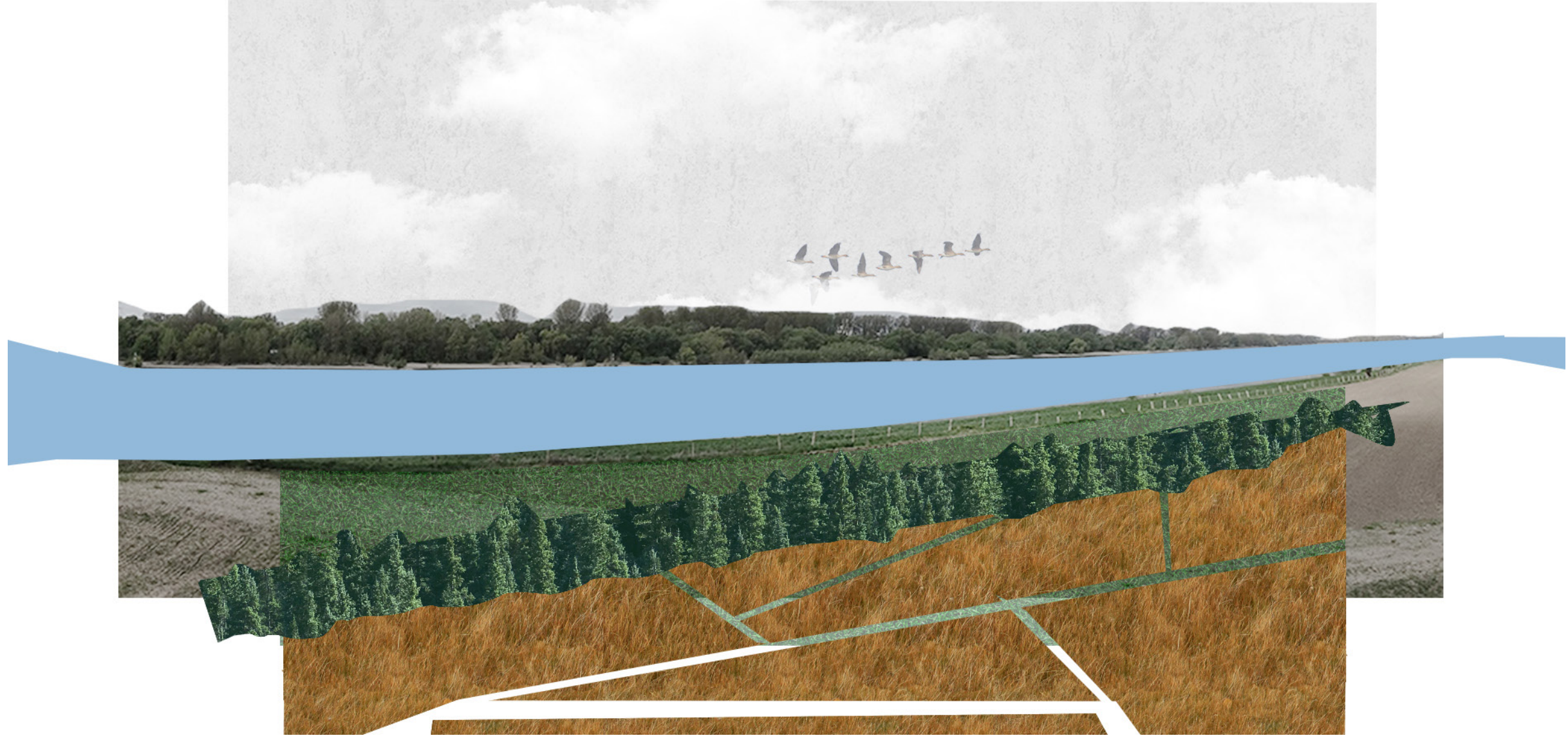
PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY
AND DESIGN

CONCLUSION



IMPLEMENTATION

CONTEXT

Strategy in agriculture land




PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION

water 
agriculture 
new seasonal cultivation 

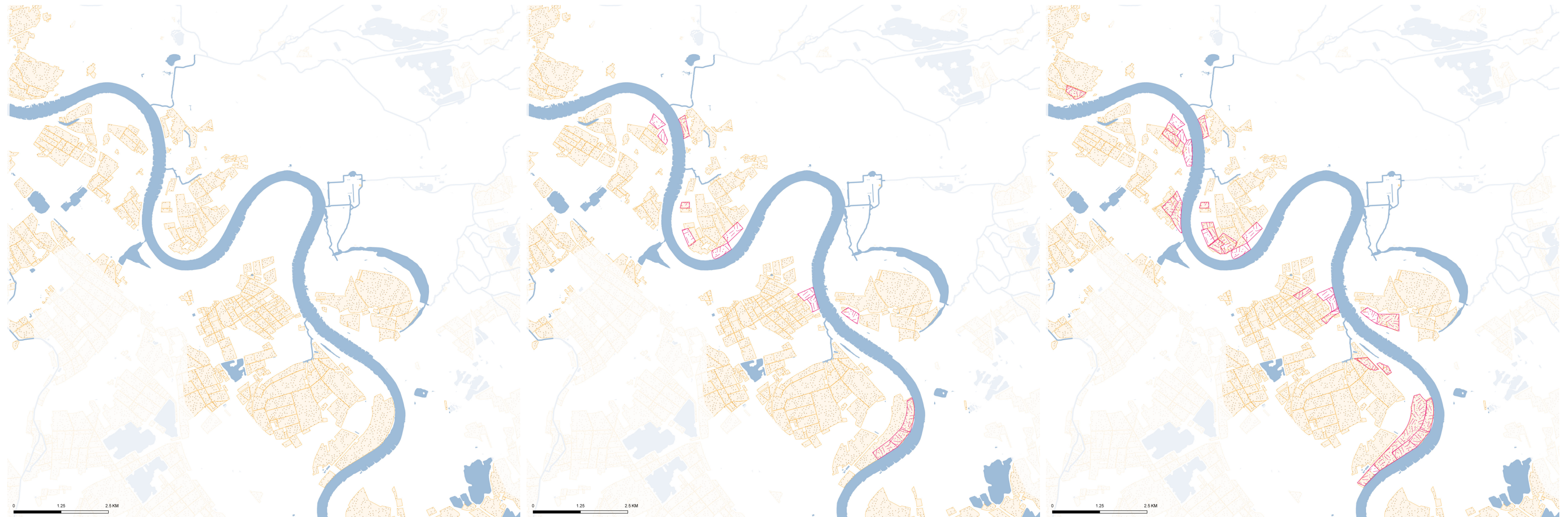


Figure: Strategy in agriculture land
Illustrate by the author
Source: Openstreetmap, 2022

IMPLEMENTATION

CONTEXT

Strategy in urban parks

PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION

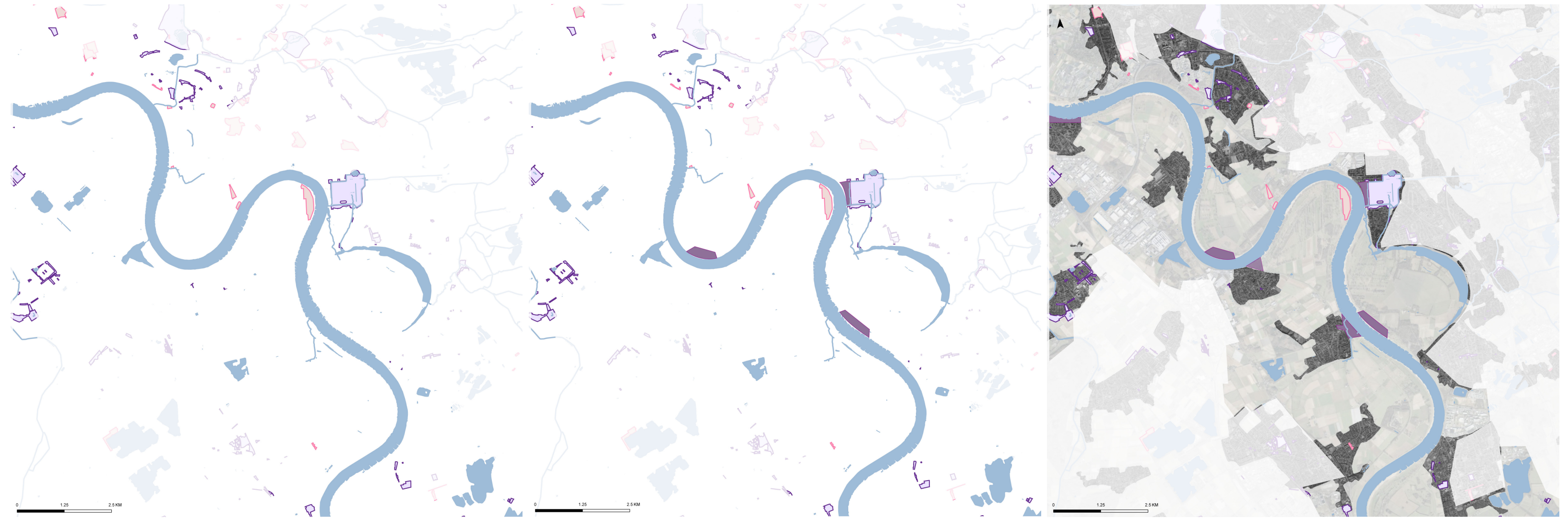


Figure: Strategy in urban parks
Illustrate by the author
Source: Openstreetmap, 2022

IMPLEMENTATION

CONTEXT

Strategy in green spaces

PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION




new forest 
new meadow 
new water 



Figure: Strategy in green spaces
Illustrate by the author
Source: Openstreetmap, 2022

IMPLEMENTATION

2022



CONTEXT

PROBLEM

CONCEPTUALIZATION

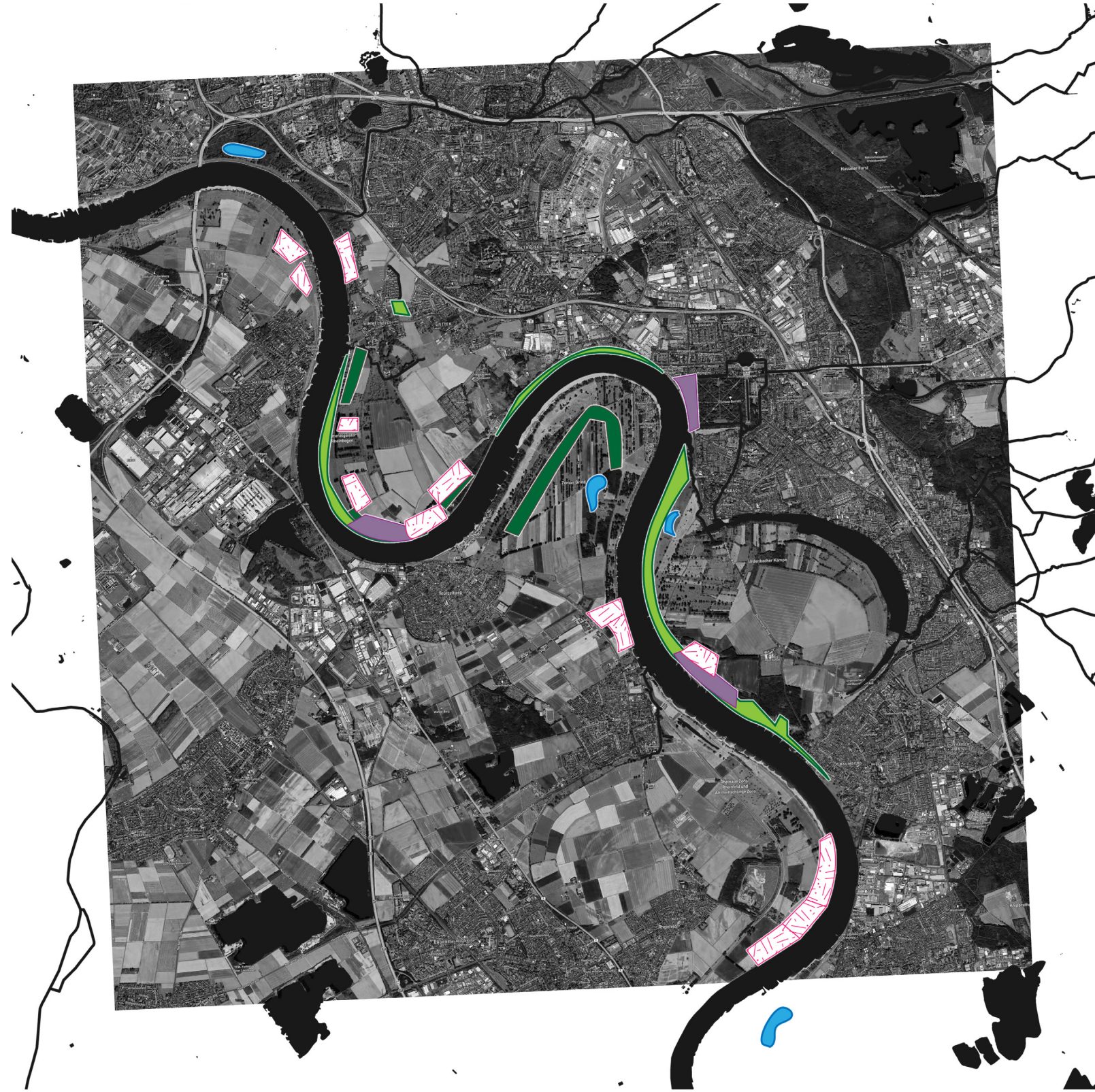
ANALYSIS

STRATEGY
AND DESIGN

CONCLUSION

IMPLEMENTATION

2030



CONTEXT

PROBLEM

CONCEPTUALIZATION

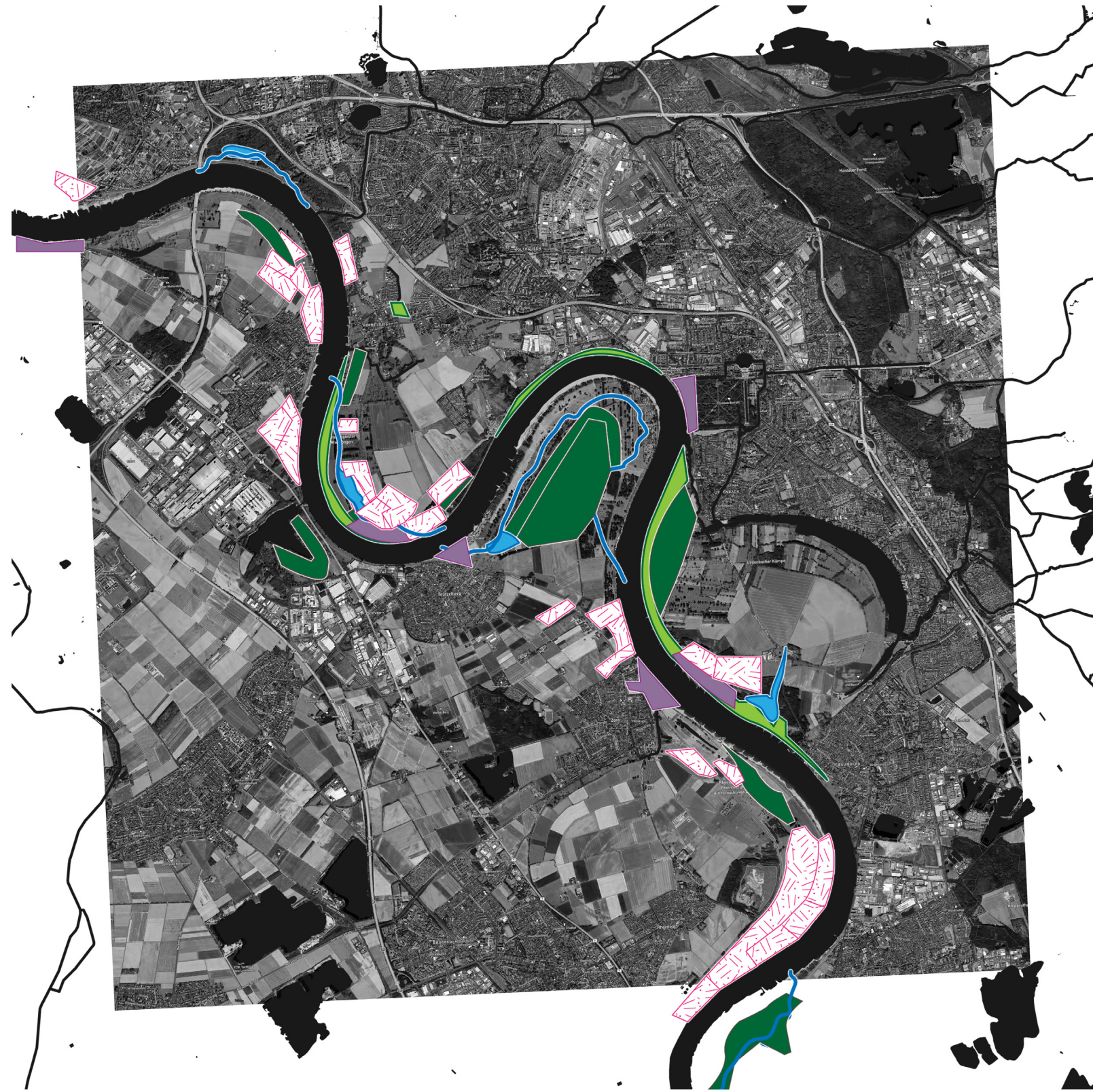
ANALYSIS

STRATEGY AND DESIGN

CONCLUSION

IMPLEMENTATION

2040



CONTEXT

PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY
AND DESIGN

CONCLUSION

FROM LOCAL TO MEGA REGION

CONTEXT

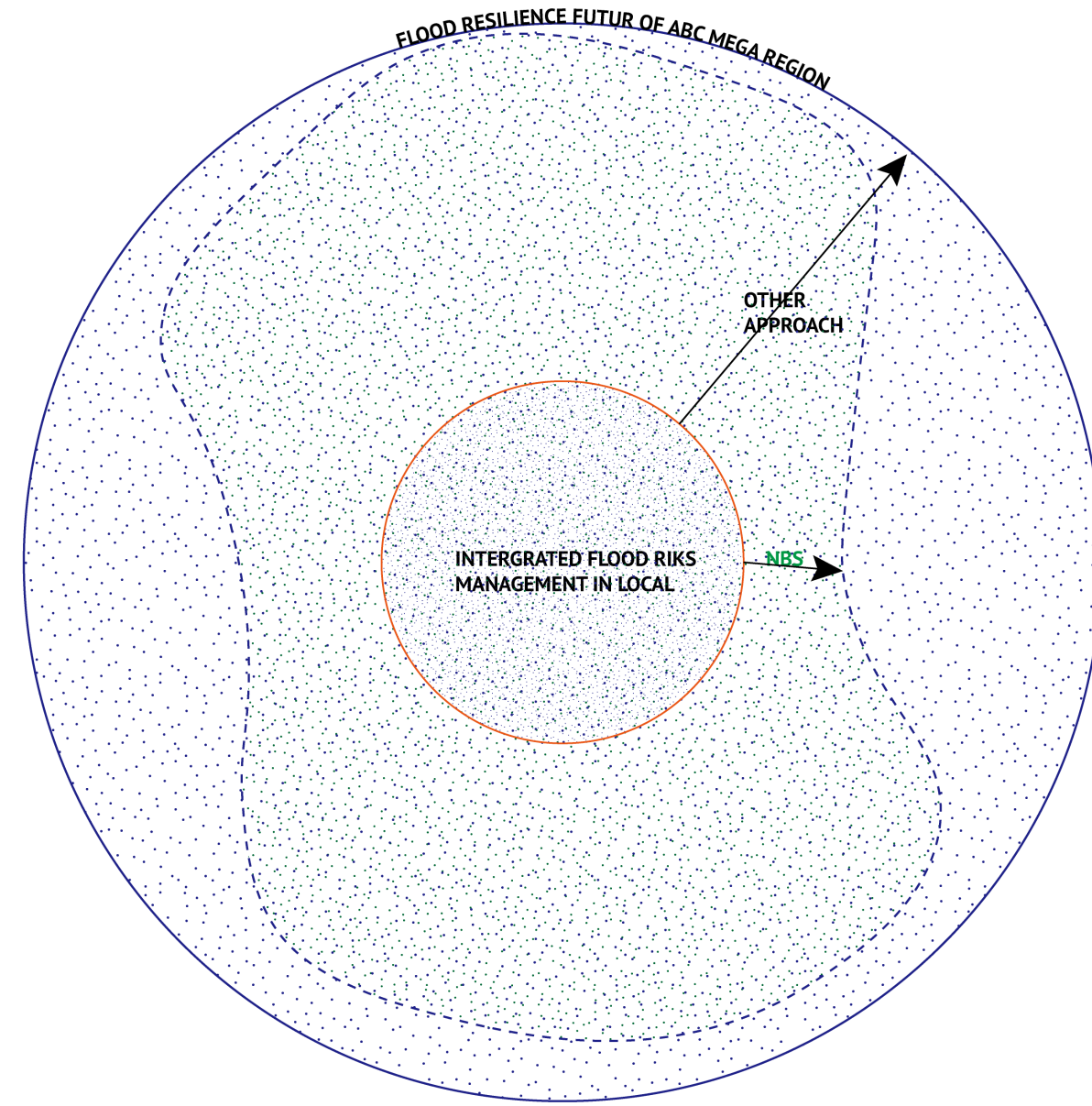
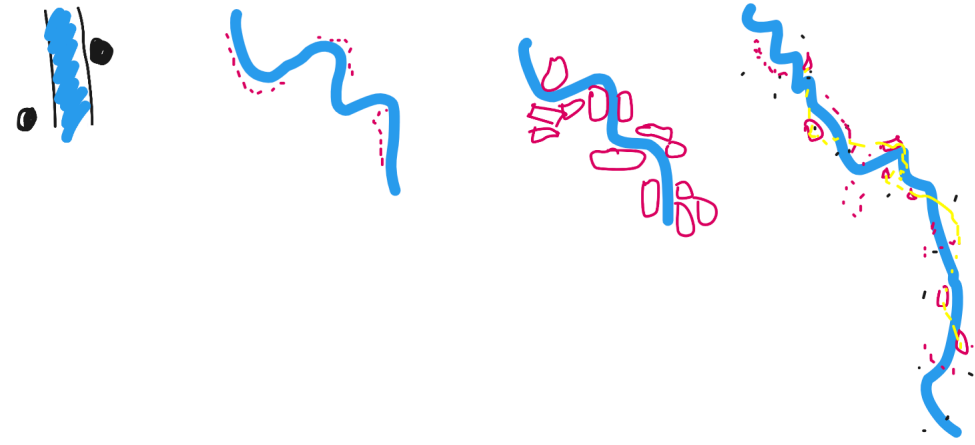
PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



STAKEHOLDERS

CONTEXT

PROBLEM

CONCEPTUALIZATION

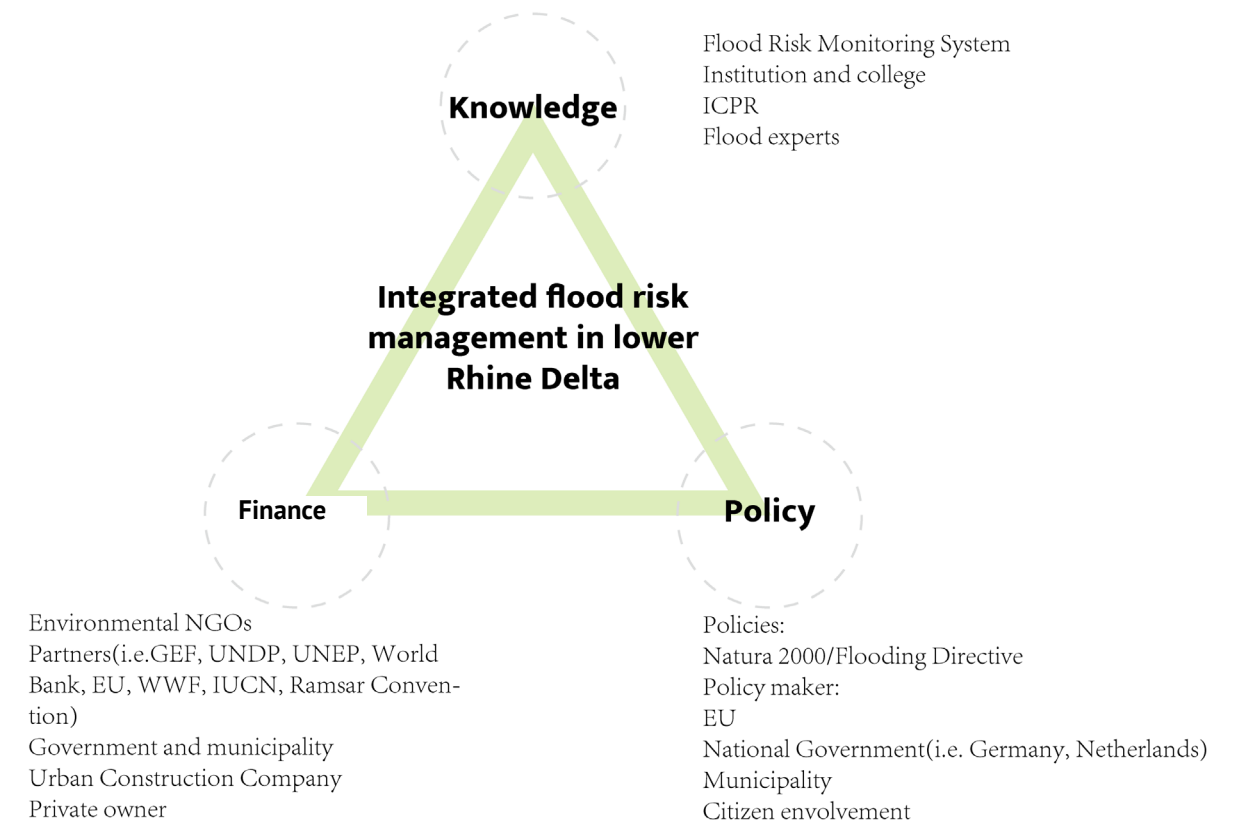
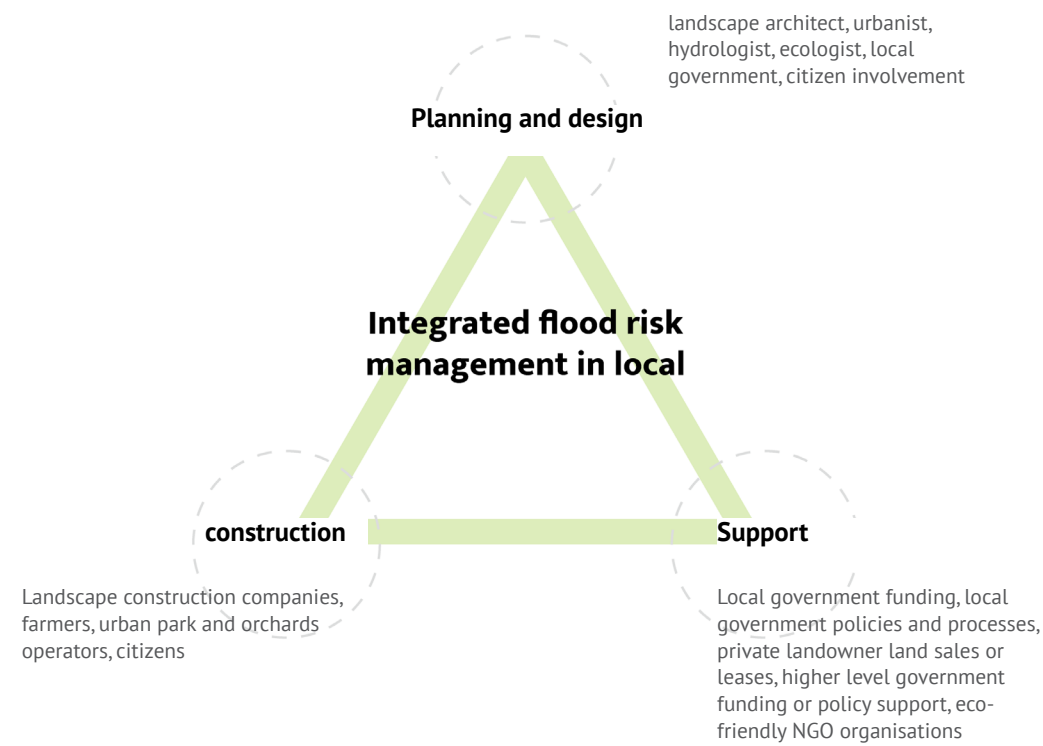
ANALYSIS

STRATEGY AND DESIGN

CONCLUSION

local - execution

mega regional - cooperation and support



CONTEXT

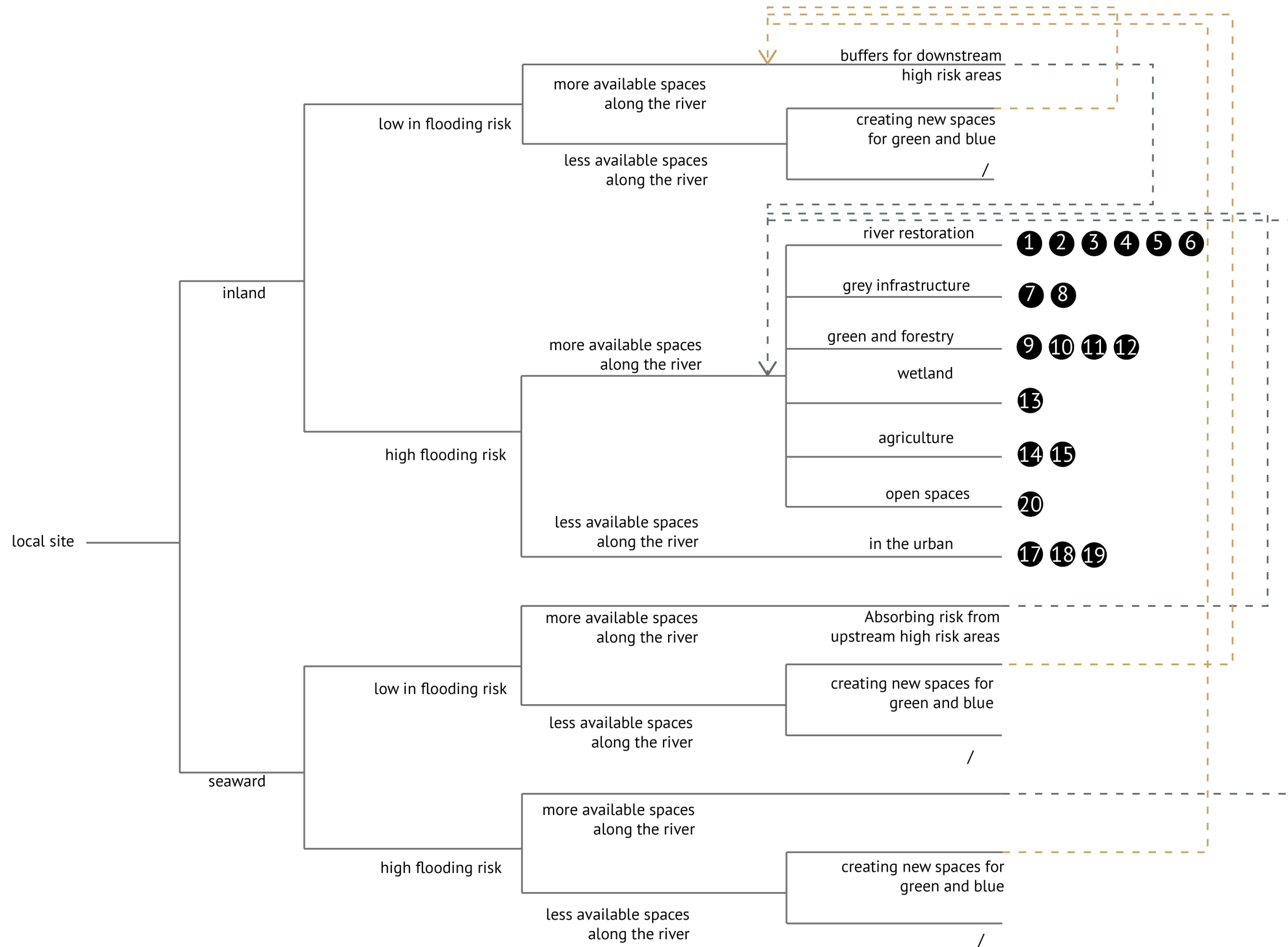
PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



CONTEXT

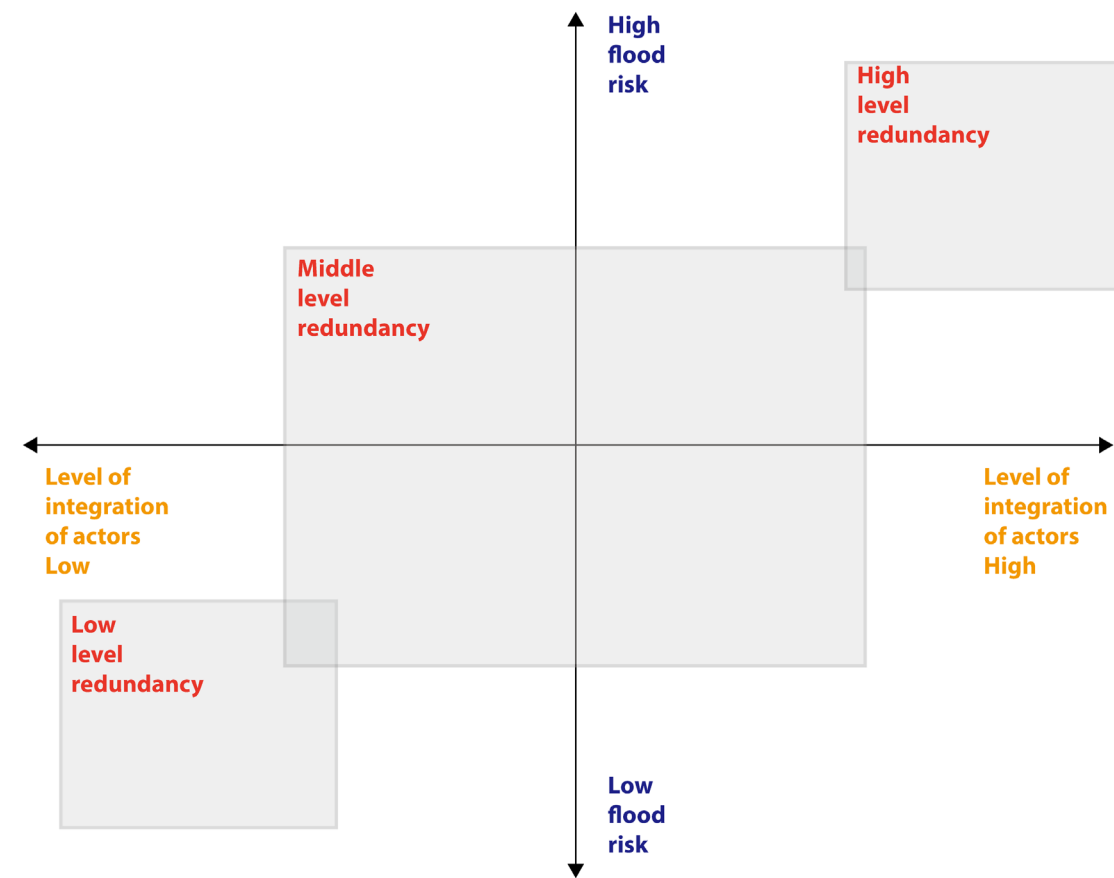
PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



The representative cities morphology of river landscapes and city landscapes

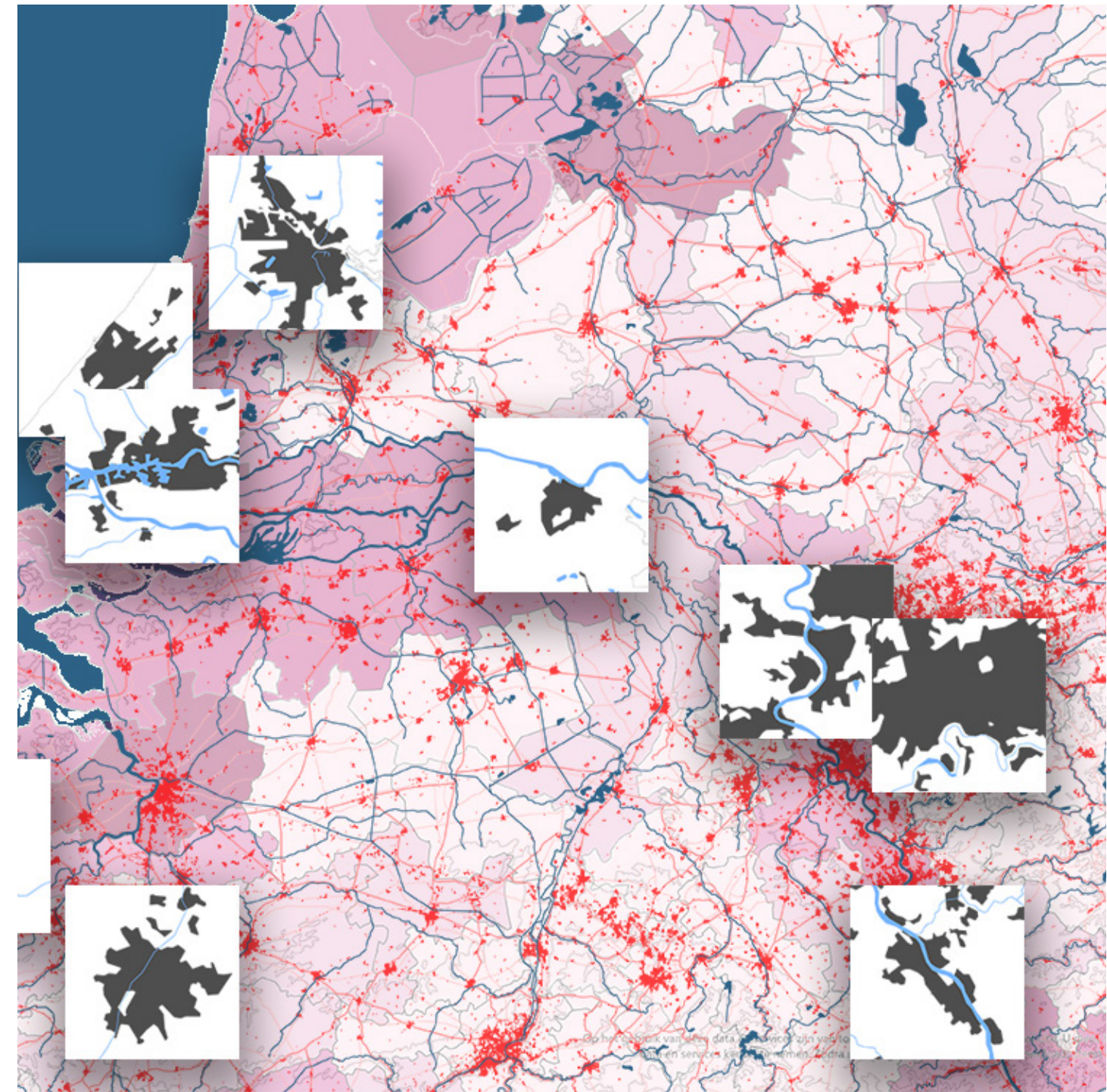
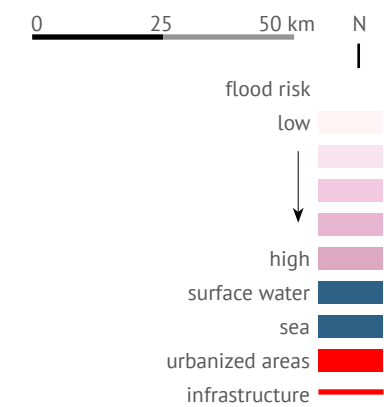


Figure: The representative cities morphology of river landscapes and city landscapes
Illustrate by the author
Source: Flooding atlas of Rhine River, 2020 and Corponicus , 2019



CONTEXT

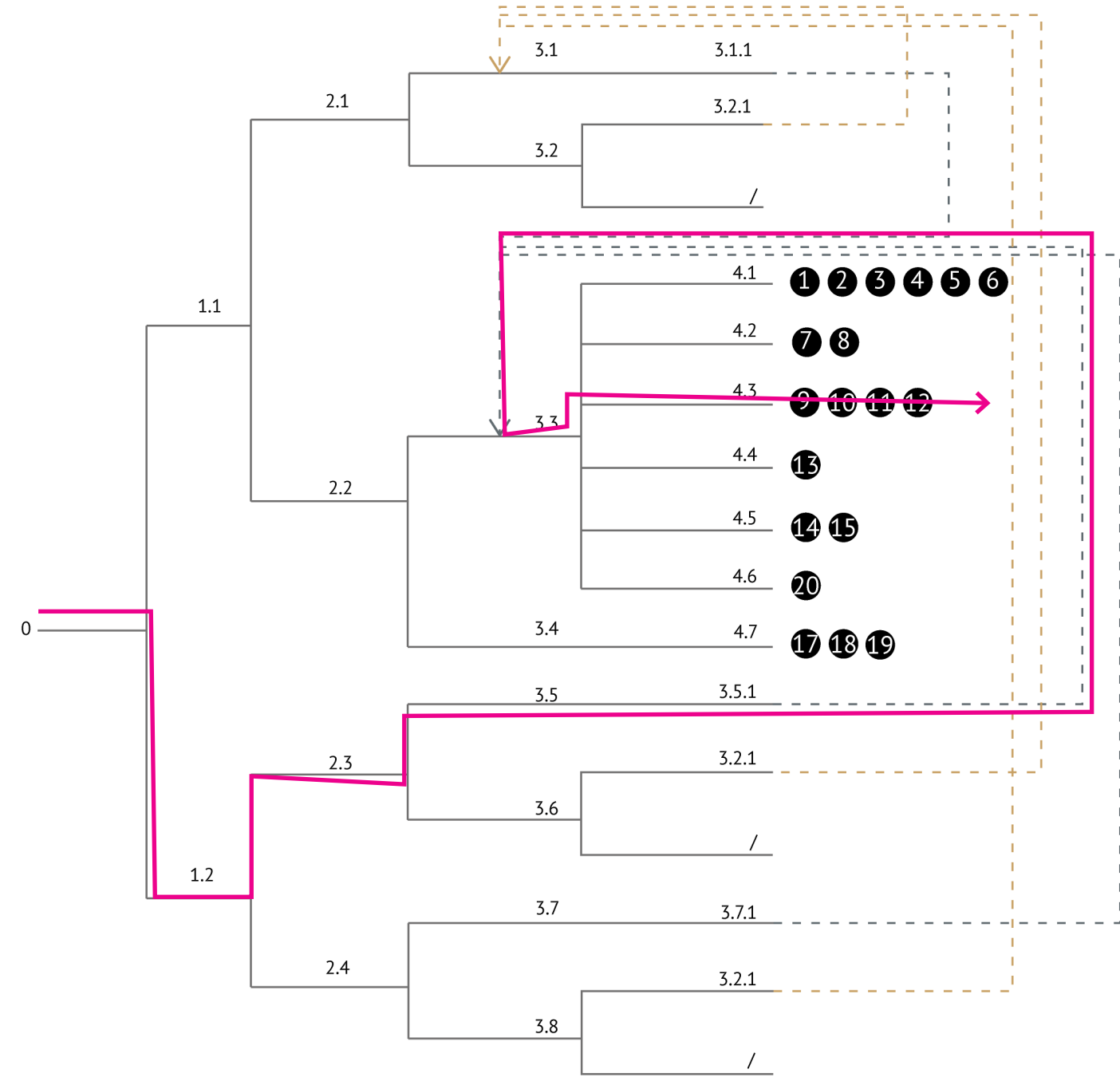
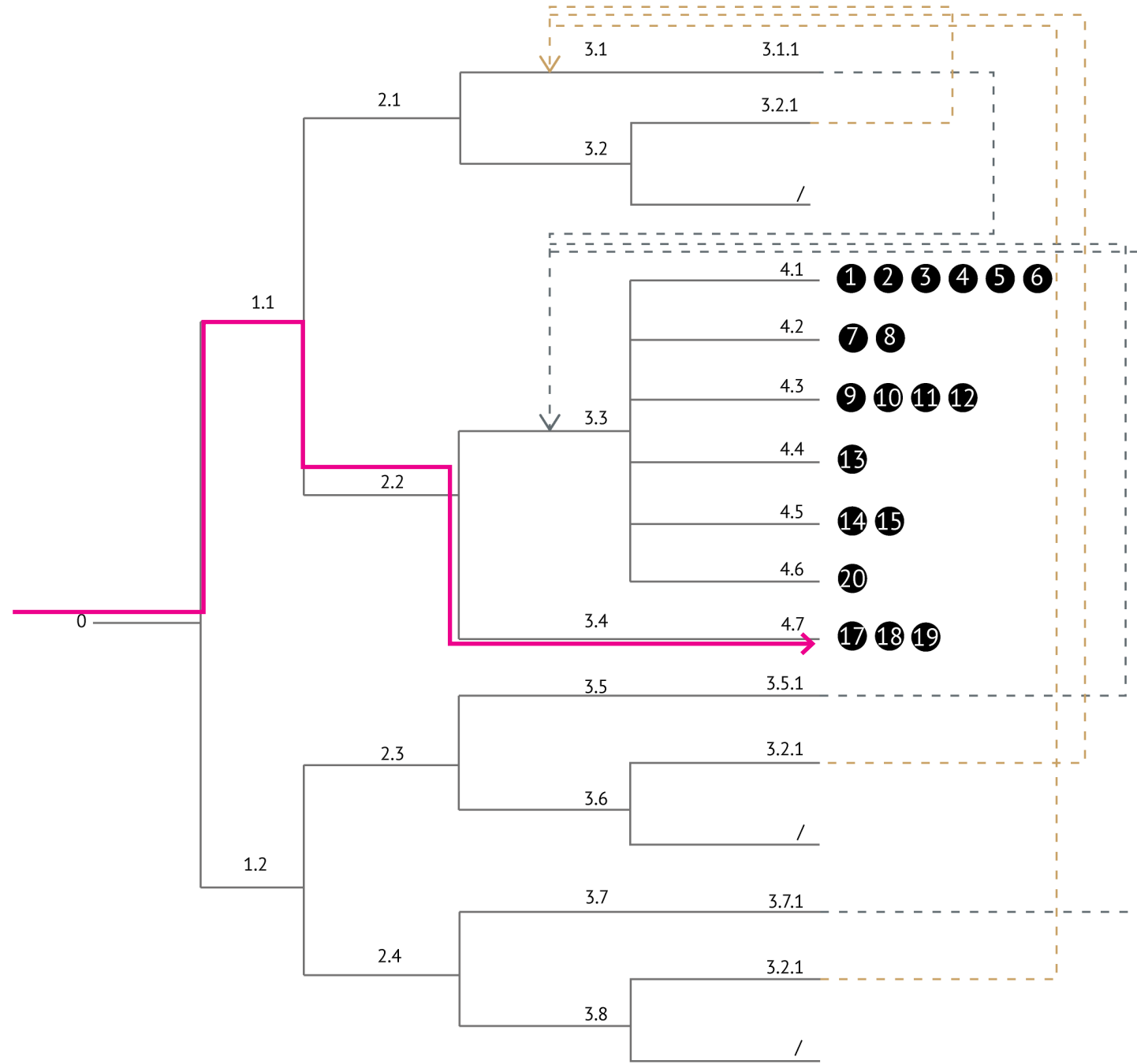
PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



SCHEDULE

CONTEXT

PROBLEM

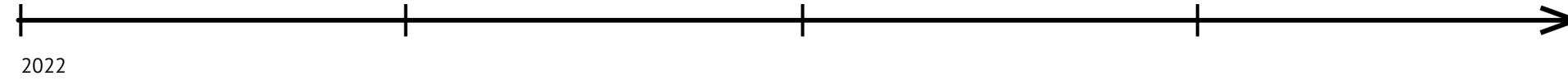
CONCEPTUALIZATION

ANALYSIS

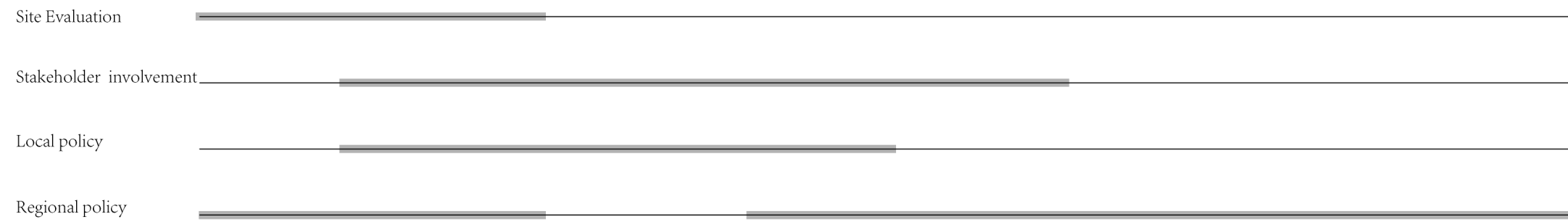
STRATEGY AND DESIGN

CONCLUSION

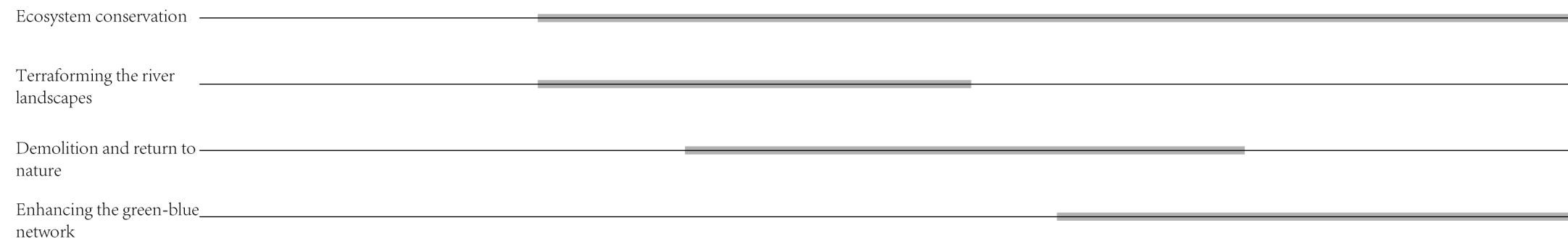
PREPARATION LOCAL EXPERIMENTATION REGIONAL INTEGRATION SYSTEMICAL EFFECTION



Planning and governance



Apply NBS



Values and outcomes



CONCLUSION

STRATEGY
AND DESIGN

ANALYSIS

CONCEPTUALIZATION

PROBLEM

CONTEXT

CONCLUSION

SYSTEMICAL INTERRELATIONS

CONTEXT

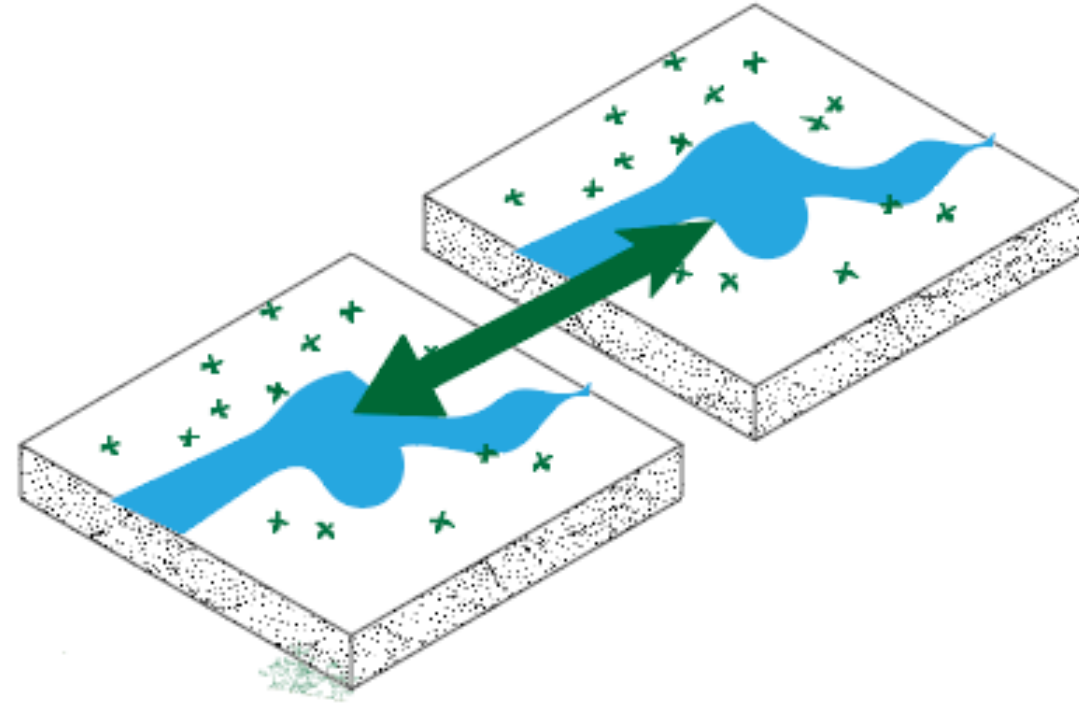
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AND DESIGN

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SYSTEMICAL INTERELATIONS

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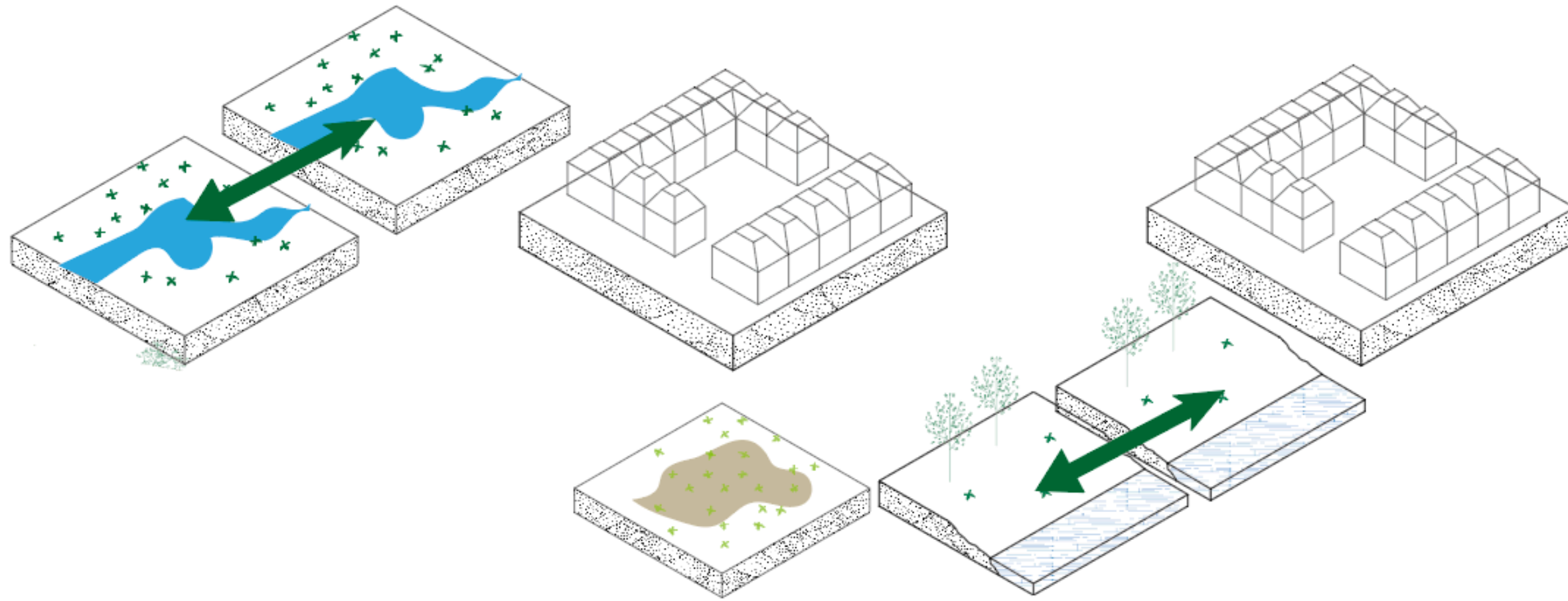
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SYSTEMICAL INTERRELATIONS

CONTEXT

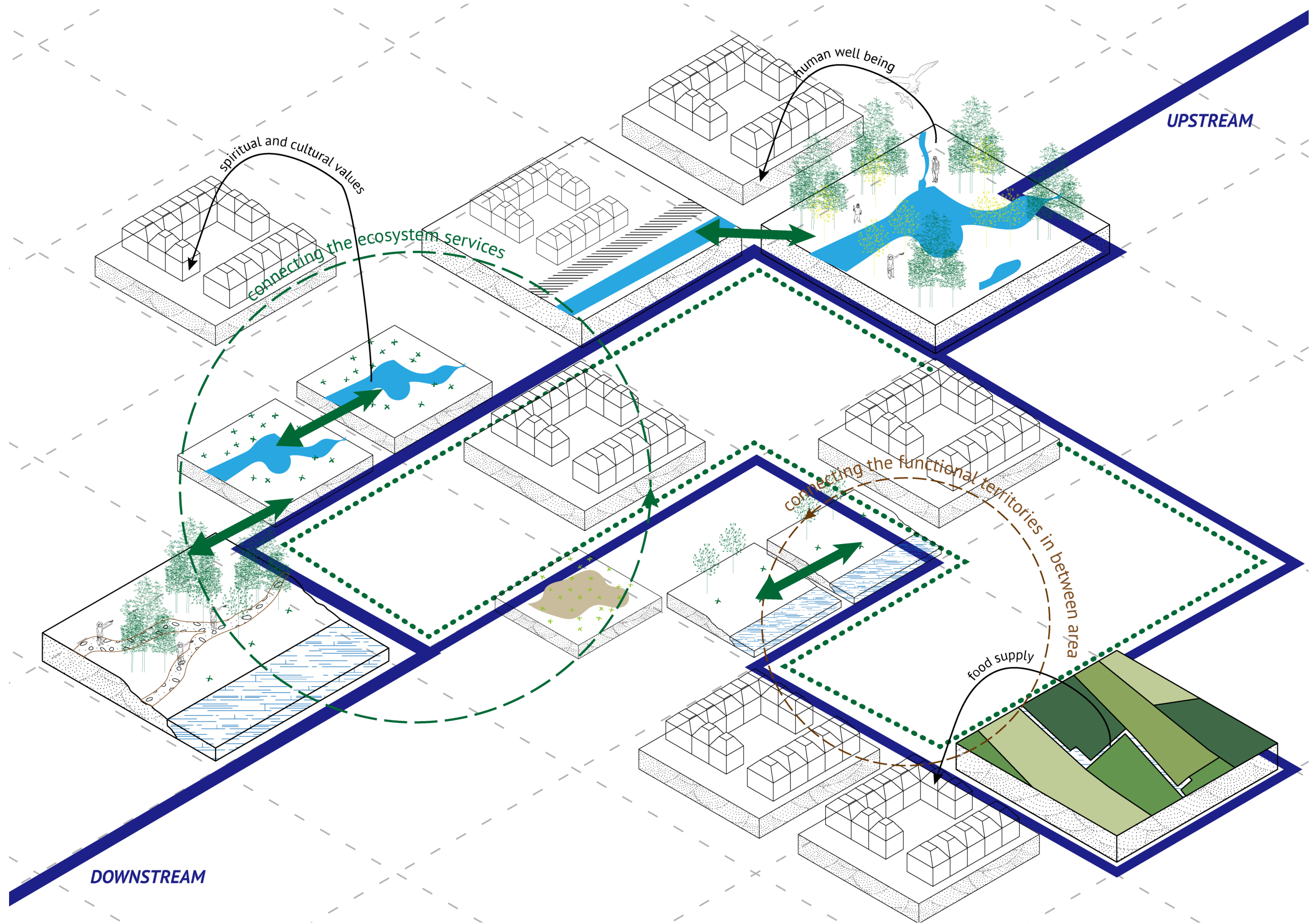
PROBLEM

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ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



POLICY

CONTEXT

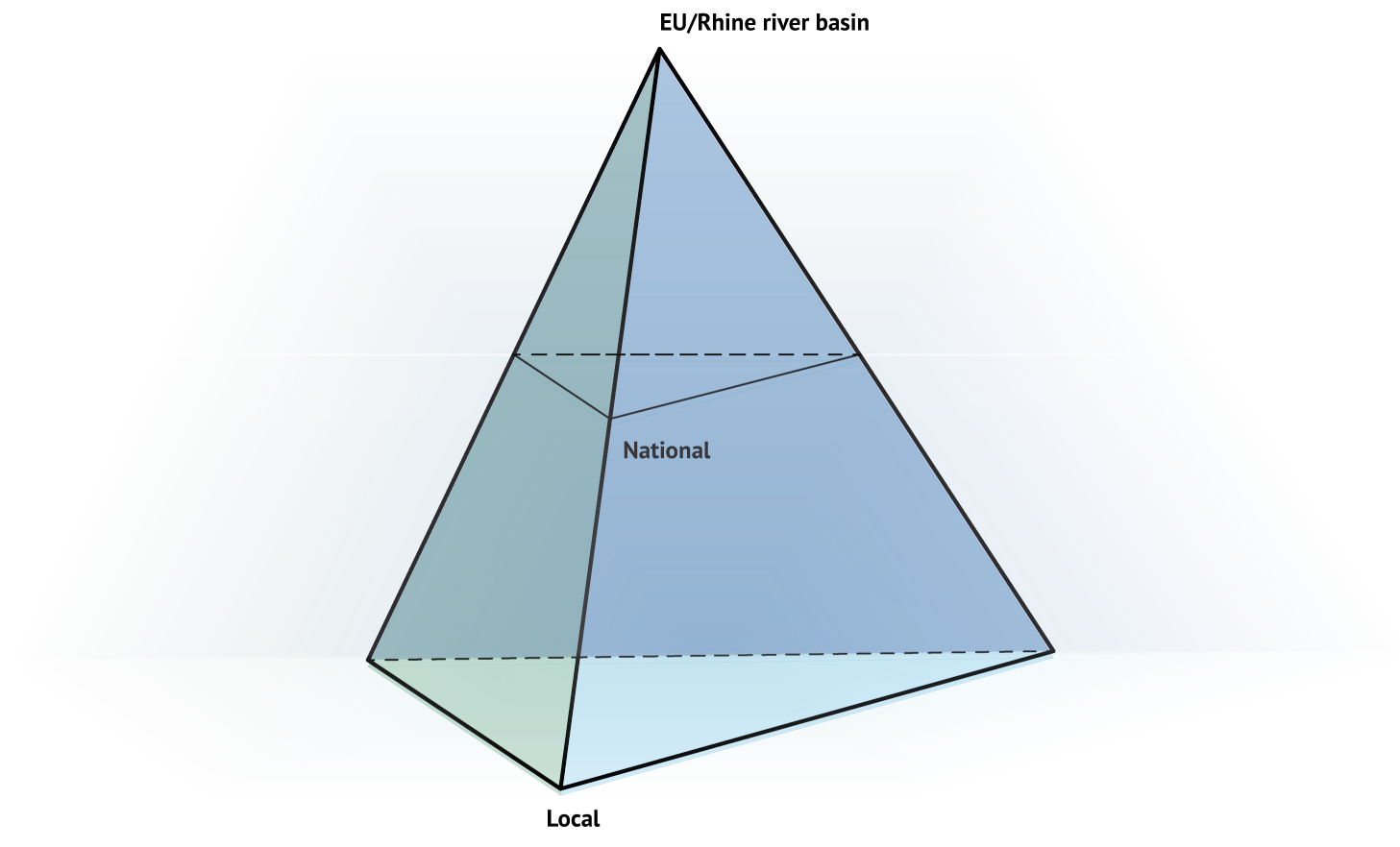
PROBLEM

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CONCLUSION



FLOODING RESILIENCE FUTURE FOR THE ABC MEGA REGION

LOWER

LOWER FLOODING RISKS

NBS can effectively control the risks and hazards posed by flooding.

LONGER

LONGER LIFE-SPAN

Eco-systems have a longer life span than grey infrastructure and can have longer term benefits and effects.

SUSTAINABLE

SUSTAINABLE URBAN DEVELOPMENT

In the case of urban development, the longer duration and life cycle of nature-based solutions means that urban construction and development based on this perspective also has a longer life cycle and more sustainable.

HEALTHY

HUMAN WELL BEING

The improved blue-green space provides residents with more natural spaces for public activities and recreation and is conducive to human-well-being

ENGAGING

CATALYSTS OF LOCAL INVOLVEMENT

Promoting local involvement and the improvement of local projects.

COOPERATION

STRONGER CONNECTION

Closer links and communication between other economic activities, such as the production and trading of agricultural products, etc.

BROADER

BROADER RANGE OF BENEFICIARIES

Extending the benefits of flood risk control measures from the local to the broader mega region from upstream to downstream.

DYNAMIC

DYNAMIC AND FLEXIBLE SYSTEM

Whereas previously the bearers of flood pressure may not have been directly related to the beneficiaries of flood risk control, this blue-green network adds even more connectivity at the system level. The whole system is also more flexible and dynamic.

FROM LOCAL TO MEGA REGION

CONTEXT

PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION

Systems involved

Urban planning

the trend and potential

the policy boundary

Spaces for expansion

City functions

Landuse and landprice

Local interventions and design

NBS for Flood management

Water/ blue infrastructure

Flooding risks

Green infrastructure

Opportunity

Suitibility

Availability

Adapability

Implementation

Nature based solutions for flood risk management

2022

Current

2040

Programme "Rhine 2040"



- Connected habitats
- More biodiversity
- Good water quality
- Mitigation of flood risks
- Cope with low water

Goal of Urban Flood Integration (UFI)

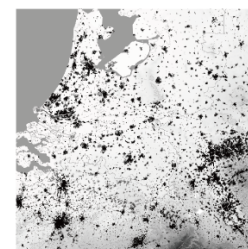
urban development, flood management, as well as navigation and environmental protection are negotiating the border between the river and the urban realm.

2100

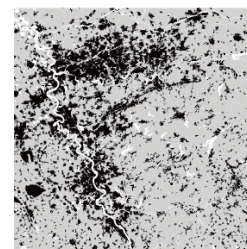
Flood resilience future

Urban spaces configurations and development

Mega regional



Regional



City



Local



VISION MAP

CONTEXT

PROBLEM

CONCEPTUALIZATION

ANALYSIS

STRATEGY AND DESIGN

CONCLUSION



VISION MAP

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