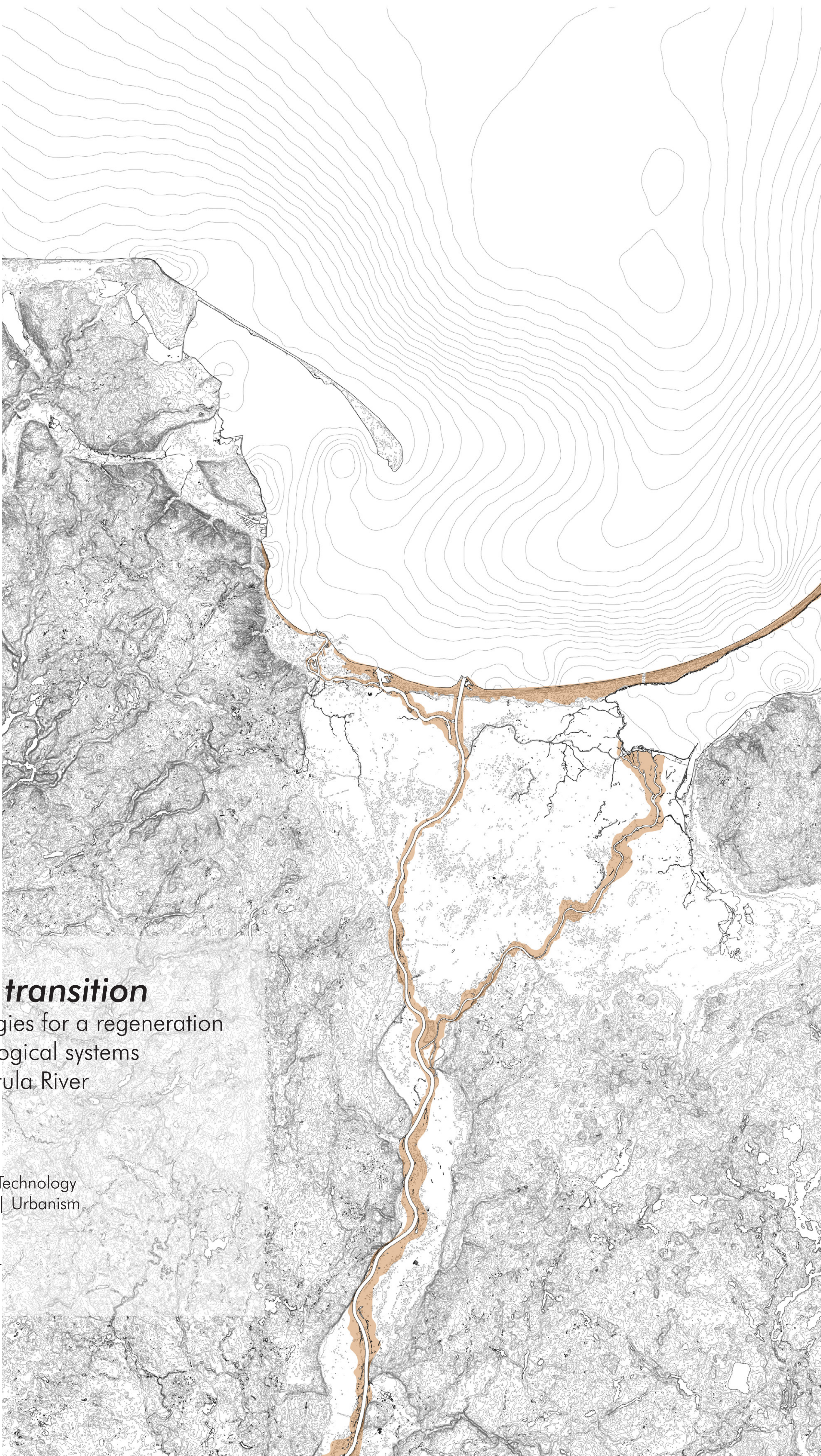

Edges in transition

Spatial strategies for a regeneration of socio-ecological systems along the Vistula River

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Transitional Territories
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Inland, seaward.
The trans-coastal project.
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keywords: regeneration | socio-ecological systems | landscape urbanism | water pollution | edge design | remediation |

Fig. 1. My parents wandering through the agricultural edge of the Vistula River
Source: author's own photograph | field trip February 2021

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especially the first half a year!
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Muchas gracias! Dziękuję bardzo!

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Thank you very much!

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Dzięki Wam tu jestem.
Dziękuję bardzo!

Contents

Abstract

The proximity of rivers stimulated the development of the economy and culture of civilizations throughout the ages. Consequently, the advancements in technology allowed people to influence the riverine systems. In riparian areas, such as the Vistula River Delta, the river was regulated and the land was reclaimed to accommodate agriculture, urbanization and industries. Besides the spatial changes, the anthropogenic alterations have also environmental consequences, namely increased risk of flooding and limited water and sediment retention capacity of the delta. Lowered ecological performance of the riverine edges lead to a higher amount of contaminants being discharged to the Vistula River and subsequently to the Baltic Sea. The pollution caused by human activities as well as severe changes in the climate profoundly affect the state of ecosystems and human health.

Designing for regeneration of socio-ecological systems along the Vistula River is based on understanding the relationships between the pollution flows, flooding and the performance of the riverine edges. The project suggests a systemic transition towards more regenerative riverine landscapes with a focus on the redefinition of the edge space by remodeling landscape topography and the use of specific vegetation. The landscape design provides ecosystem services, including improvement of water quality, flood management, biodiversity and recreation.

The proposal illustrates possible changes in the three exemplary riverine edges, namely an agricultural edge and an underutilized and post-industrial edge in the city of Gdansk. The choice of these types of edges was based on the fact that agriculture is the biggest factor that contributes to the eutrophication of the Baltic Sea (HELCOM, 2015), while the post-industrial edges in Gdansk face environmental and spatial challenges that might become potentialities for future changes.

The design and its possible expansion intend to enhance the ecological, social and economic performance of the Vistula River edges. Higher ecological performance is achieved through the implementation of remediation practices and creating space for flood accommodation. Whereas, social and economic performance is enhanced by new functions and an increase of accessibility and connectedness of the edges. The proposal might act as a model for transitions of the Vistula river tributaries as well as other riverine systems facing similar issues. That is thanks to the set of design principles established in the project. The ambition of the thesis is to contribute to the promotion of ecological awareness and advocacy in Poland.

Fig. 2. Confluence of the Dead Vistula River and the Vistula River
Source: author's own photograph | field trip February 2021

Chapter 1
Introduction

The following chapter reveals the motivation behind the thesis topic, provides the definition of an edge and explains what types of edges are considered throughout the project.
The section introduces the context of the Vistula River and its considerable environmental, social and economic importance.

Motivation

Throughout my life, I have moved a couple of times and the first thing I recall while thinking about each of the cities I lived in is that they were located by the water but the relationship between the city and the water was different in each of these places. The first two ones were located on the riverbank. One of them on a hill with a breath-taking view of the widest point of the Vistula river in Poland, the second one with rivers woven between the city tissue, composed of numerous islands creating an exciting structure connected by over one hundred bridges. In the first city, Plock, the river was perceived as a wild element and only the old river bed was used for recreational purposes. In Wroclaw, however, where the rivers are regulated, the city does not "fear" the element of water and encroaches on the riverbanks by creating waterfront public spaces.

What intrigues me is the relationship between the land and the water, the transition, the process where a city turns its face towards water.
I could observe that act of embracing the element of water while living in Copenhagen. I was fascinated by the changes that happened there, how the city treated water as a resource, how it changed its character from an industrial city to "a city for people". The transformations had not only spatial and social dimension but economic and environmental dimension. Improving the quality of water, soil and air, creating a network of public spaces and giving the harbor back to people triggered economic growth and counteracted the process of suburbanization.

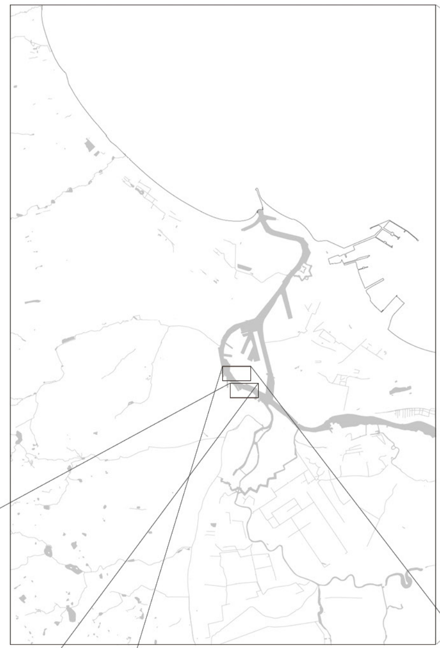
Throughout this year I would like to investigate the potentialities that are present in the post-industrial landscapes of the port city of Gdansk and to what extend the livability and vitality of the city could be changed.
There is a need to look at a bigger picture taking into consideration the fact that the quality of water and thus the condition of the urban edges in the city of Gdansk is shaped not only by the local pressures, but it depends on the condition of a larger riverine system. Therefore, I would like to carry out research on the past and present transitions of the edges along the Vistula River and their impact on various systems.
The desired outcome of the thesis is a proposal of possible future transitions improving the state those edges.

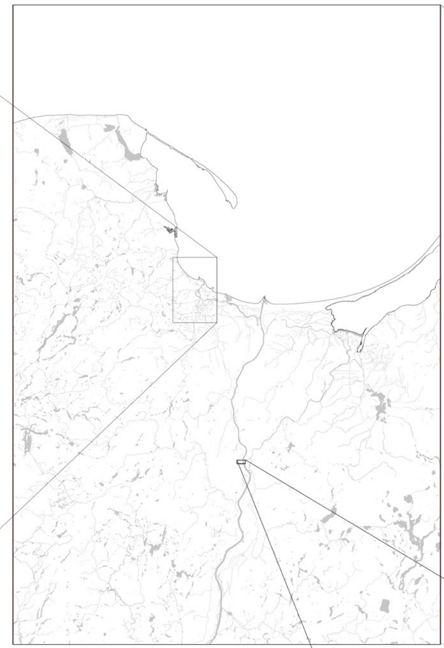
Fig. 3. Poniatówka Beach by the Vistula River in Warsaw
Source: Capital City of Warsaw

Edges | context

An edge was defined by Dramstad, Olson and Forman (1996) as the outer part of a habitat patch, which is distinct from the inner part or in other words an edge is "the key ecological transition zone between two types of habitat". The physical characteristics of the edges, including the width, structural diversity, abruptness or softness, determine the ecological condition of a place. Natural edges, such as river banks, have been and still are in transition due to anthropogenic pressures like urbanization and thus they become "critical points for interactions between human-made and natural habitats" (Dramstad et al., 1996). These transitions may have negative and positive outcomes.

The narrative of the thesis is based on the changing condition of edges along the Vistula River with a focus on the post-industrial and underutilized edges in the port city of Gdansk and the agricultural edges in the Vistula River Delta. As explained further in the problem field analysis chapter the transitions of the land uses along the edges and the transitions of the edges themselves have an impact on the social and economic performance in the riverine areas as well as the ecological performance of the riverine and marine environments. Considering the edge as a transition zone between land and water means that the edge may mediate between land and water and therefore a positive change of the edge conditions might influence both systems and reduce the pressures on them.





micro scale | post-industrial edge

micro scale | underutilized edge

micro scale | agricultural edge

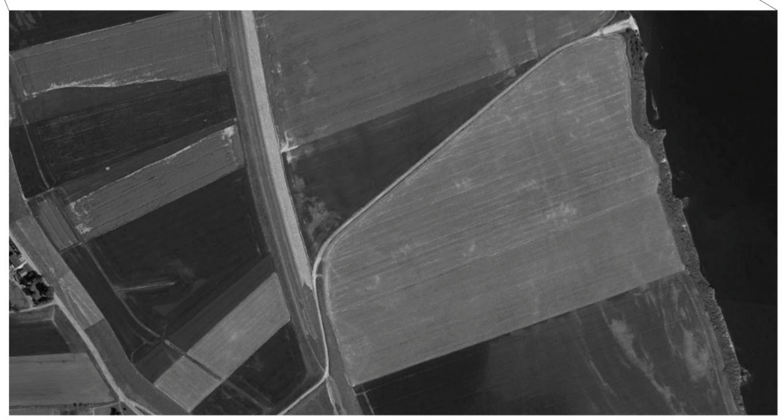


Fig. 4.
Source: OpenStreetMap, Google Earth

The Vistula River

The Vistula River is called "The Queen of Polish Rivers" thanks to its considerable environmental, social and economic importance. It is one of the longest European rivers with a length of 1,047 kilometers and a width of 300 to 1000 meters in its lower and middle course (Kajak, 1993). Its basin area covers 194,000 square kilometers, from which 87% lies within the borders of Poland (Szymkiewicz, 2017). The Vistula River runs from the Beskidy Mountains in the south to the Baltic Sea in the north and drains 54% of the country area bringing yearly around 32 cubic kilometers of water to the sea (Kajak, 1993). Around 22.9 million people, which comprises about 60% of the Polish population, live in the basin area (Buszewski et al., 2005). There are three macro-regions within the catchment area, The Upper Vistula with an intense concentration of industries, the Middle Vistula of predominantly agricultural character and The Lower Vistula with industries and agriculture (Buszewski et al., 2005). It is used as a source of water but it serves as a recipient of sewage (Kajak, 1993).

Environmental significance of the Vistula River

Originally the basin area of the Vistula River was almost entirely covered with forests, however, already in the 14th century, it was largely deforested due to the development of agriculture and settlements and since then the forest coverage occupies 26.5% of the area (Biakiewicz & Babinski, 1980, as cited in Kajak, 1993). The Vistula River is relatively natural, especially its middle course as well as part of the lower course since only some sections were a subject to regulation (Kajak, 1993). Rich semi-natural vegetation covers most of the Vistula River edges, that includes trees, shrubs and permanent meadows, besides the diversity and number of birds and fish is abundant (Backiel & Penczak, 1989). However pressure from anthropogenic activities, especially building a dam and reservoir in Wloclawek in the 1960s changed micro-climatic conditions, the hydrological system of the river and intensified the risk of accumulation of toxic substances in the bottom sediments of the reservoir (Buszewski et al., 2005). That led to an ecological catastrophe, namely an increase of fish mortality and eventually the disappearance of some migratory fish species due to damming and pollution (Backiel, 1985 as cited in Kajak, 1993).

Fig. 5. "Vistula landscape" by Józef Rapacki | 1901
Polish Parliament Building in Warsaw

Economic significance of the Vistula River

The Vistula River was of considerable significance to the Polish economy for many years. A substantial number of cities was located by the Vistula River, including Warsaw, Cracow and Gdansk. In the 17th century, it was one of the European waterways which was most used for the economic purposes and had one of the heaviest traffic in Europe (Cyberski & Kawinska, 1995; Babinski, 2010). The role of Vistula was indirectly affected by the economic regression of Poland which started in the 18th century (Szymkiewicz, 2017). The natural accumulation of the sediment load was enhanced by the hydraulic changes, such as dikes, driven by potential reclamation of land for agriculture, and thus the navigational role of the Vistula River decreased as the river became gradually shallower and more sandy bars occurred in its section (Cyberski & Kawinska, 1995). The plans to restore the international waterway importance were presented already in the 20th century (Ankiersztejn, 2013) and reintroduced in the second decade of the 21st century (Nowakowski et al., 2015).

Social significance of the Vistula River

The Vistula River is perceived by many as a symbol of the Polish nation. It is described in the Polish literature and portrayed in the paintings as a symbol of freedom, national pride and the Polish identity - Polishness - especially during the time after the Partitions of Poland (Warnke, 2017).
Oskar Flatt, a 19th century Polish author wrote in his publication “Brzegi Wisły” (literally “Banks of the Vistula”):

“Whose heart hasn’t been struck by the Vistula’s shores?
Aren’t these shores an open book of history?”

However, as stated in the final report of the research on the cultural change by the Vistula River (Pieniazek et al., 2016), in the second half of the 20th century the area of the Vistula River was neglected, both physically and symbolically.
Since the beginning of the 21st century the river is again recognized as a space for cultural and recreational activities.

Fig. 6. “Piaskarze” by Aleksander Gierymski | 1871
National Museum in Warsaw

Fig. 7. The industrial edge of the Ostrow Island in Gdansk
Source: author's own photograph | field trip February 2021

Chapter 2
Problem field and analysis

The chapter illustrates the changing edge conditions along the Vistula River.
It reveals the factors and processes than cause the change and shows the relations between those triggers.

Edges in transition
Changing condition of the edges

The current condition of the edges along the Vistula River is a result of processes transitioning those edges over time. The changes happened across different scales, from the local scale to the territorial scale. The chapter focuses on the forces shaping the vulnerability of the edges to flooding, the degree of pollution and the performance of them. They are not separate factors but there is a close interrelationship between them.
There are various reasons behind the changes in the landscape and thus the edge condition. That might be a reduction of the risk of flooding or improving the operational efficiency of the edges. However, as the environment is an interconnected system, the transitioning of one part of it may have an (often undesirable) effect on the rest of the system.

Fig. 8. View towards the Ostrow Island in Gdansk from the Young City
Source: author's own photograph | field trip February 2021

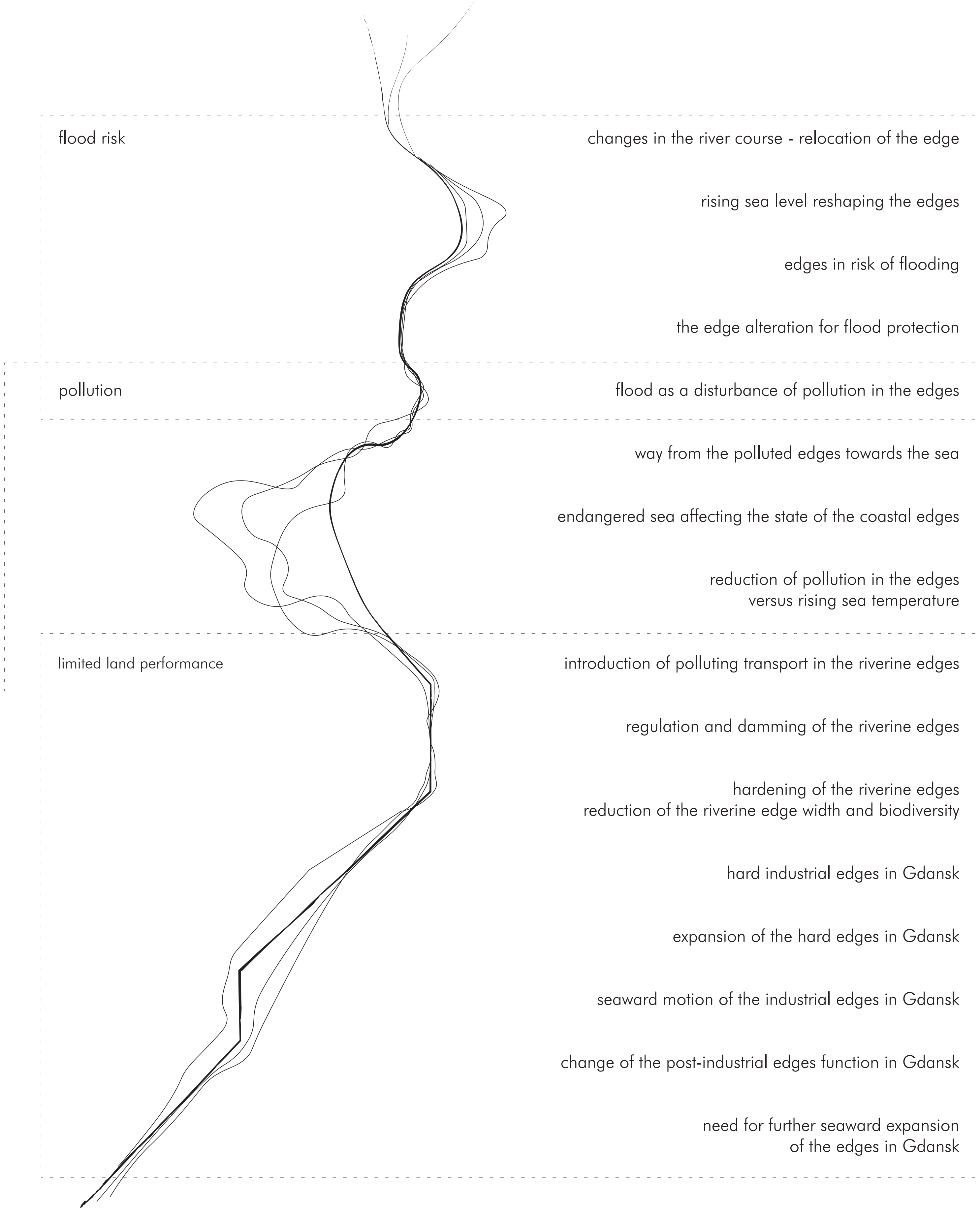
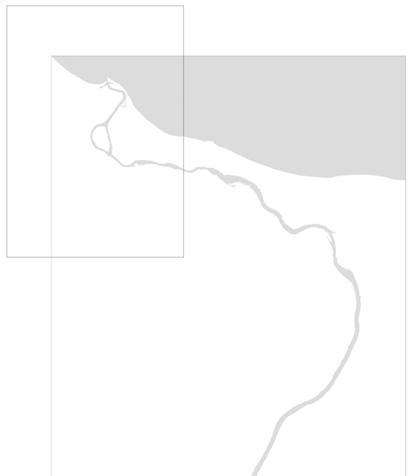


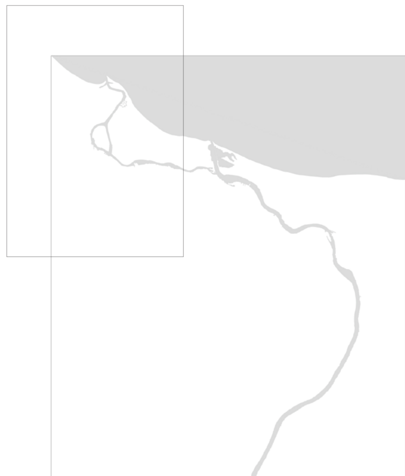
Fig. 9. A conceptual visualization of the processes transitioning the Vistula River edges
Source: author's own work

Edge condition x flood risk
changes in the river course

The changes which occurred in the landscape of the Vistula River Delta were caused by human interventions and natural phenomena. The landscape of the Vistula river had been developing naturally until the 13th century, afterwards, the landscape was shaped by anthropogenic activities (Makowski, 1993 as cited in Robakiewicz, 2010). The Vistula River Delta fens were reclaimed for agricultural purposes due to their fertile soil, besides hydraulic engineering practices, such as dikes, were introduced to minimize the flood risk in the area (Cyberski & Kawinska, 1995).
Not only the landscape along the river changed but the river itself, its course and the location of the estuary. Initially, the estuary of the Vistula River was located in Gdansk, which meant that the city was vulnerable to flooding both from the sea and the rivers. The situation changed in 1840, when an ice jam blocked the flow of the river and it flowed through the dunes to the Baltic Sea, creating a new mouth of the Vistula River, which was later called the Smiala Vistula (Brave Vistula). At the end of the 19th century an artificial channel - Przekop - was dug. During that time the other distributaries of the Vistula were partly closed (since then the branch flowing through Gdansk is called the Dead Vistula) and thus Przekop became the main estuary of the river (Robakiewicz, 2010). The project reduced the risk of flooding in the area.

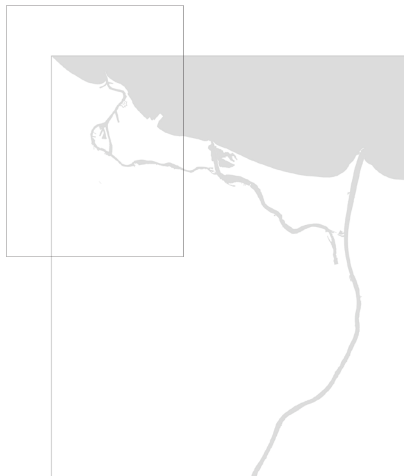


Gdansk Vistula estuary
currently called Dead Vistula
till 1840



Smiala (Brave) Vistula estuary

since 1840



Przekop Wisły
(Vistula Dug-through)
since 1895

Fig. 10., 11., 12. Vistula River mouth locations; the rectangles mark the current extent of Gdansk
Source: Adapted from Robakiewicz (2010)

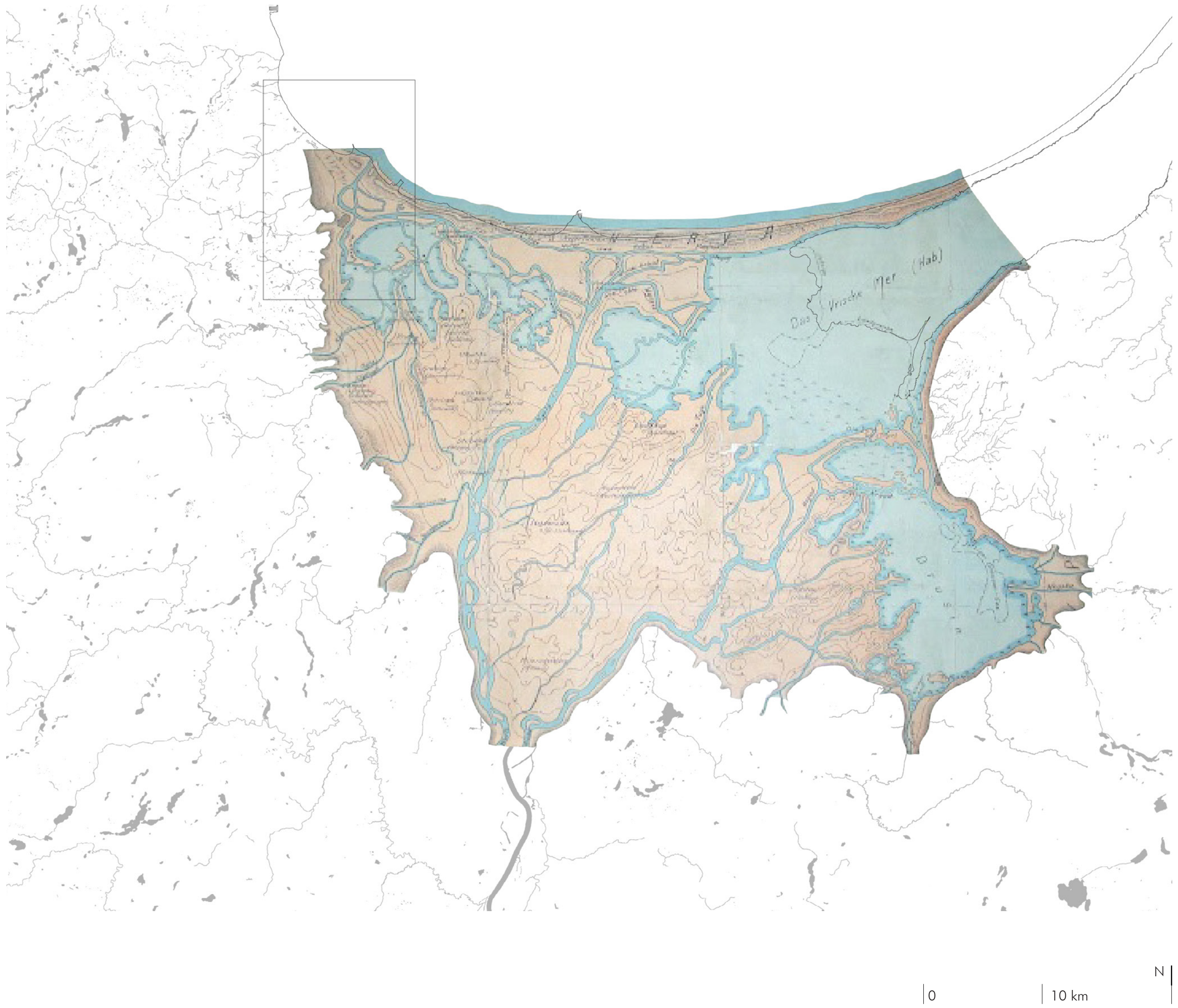


Fig. 13. Vistula River Delta fens | around 1300
Source: Das Weichsel-Nogat-Delta, Hugo Bertram

Edge condition x flood risk
rising sea level

The coastal flooding within the Baltic Sea basin originates from storm surges which mainly depend on the amount of water flowing into the Baltic Sea from the North Sea leading to variations in water level (Paprotny & Terefenko, 2017). The frequency of storm surges which exceed the cautionary level (around 0.7m above mean sea level) is currently rising, the annual number of storms escalated from two in the mid-twentieth century to six in the 2000s (Wisniewski & Wolski, 2009). Storm surges may affect not only coastal areas but landscapes inland, especially fluvial plains, as the seawater flows into the river system.
Additionally, the climate change triggers sea level rise which is another factor increasing the vulnerability of coastal areas to inundation. As stated by Hunter (2010) the rising sea level is a predominant agent of the increase in the frequency of storm surges. Paprotny and Terefenko (2017) assessed the relation between the sea level rise and the exposure of the land, population and buildings to inundation in the Polish coastal zone.
The diagram reflects the cumulative number as well as increments of exposed entities. The land would be endangered even with a small change in the sea level, whereas the number of endangered people and buildings noticeably soars when the mean sea level change is higher than one meter.

Fig. 14. Storm on the Baltic Sea | January 2019
Source: photograph by Marcin Bielecki | PAP | rmf24.pl

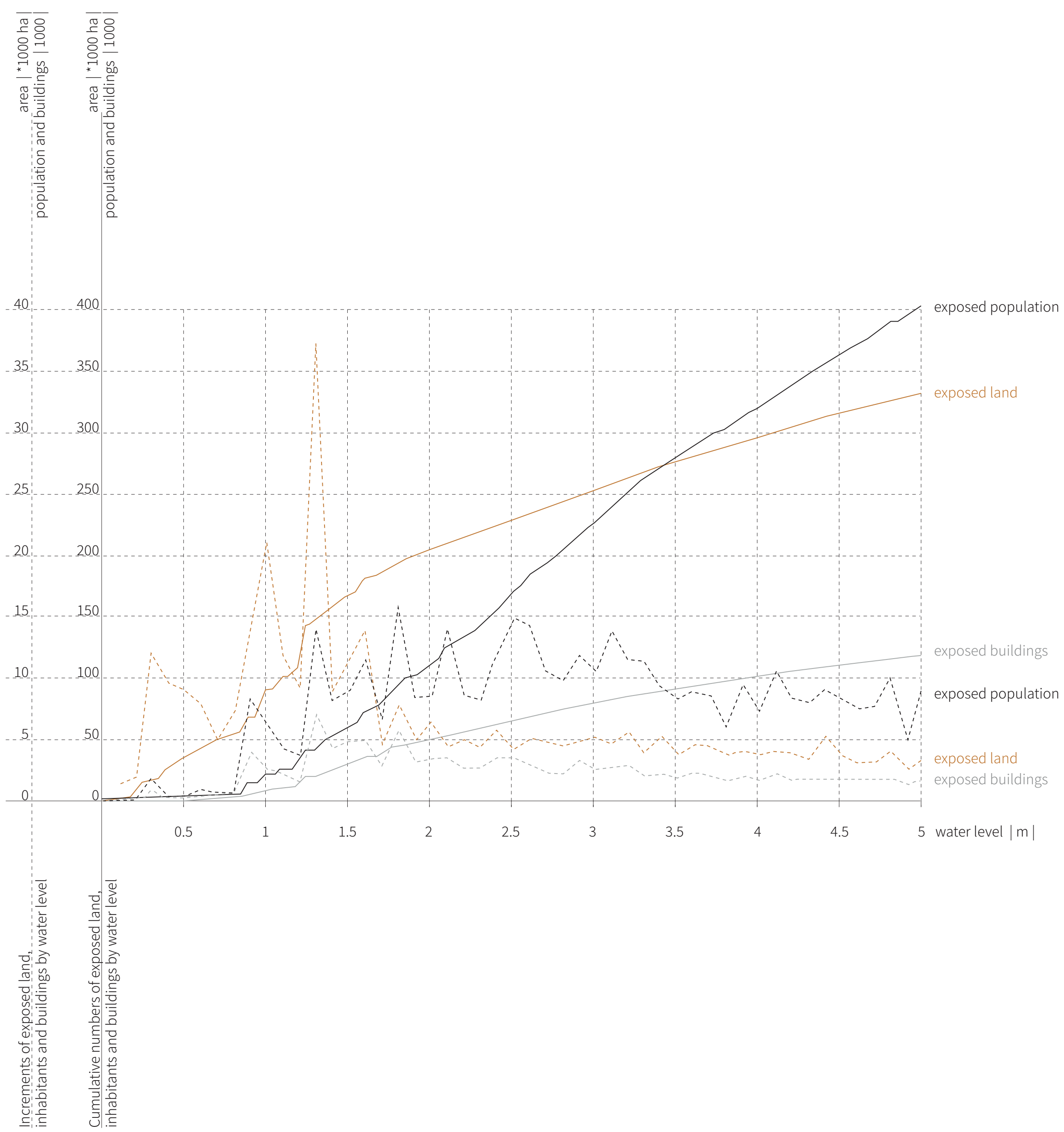


Fig. 15. Exposed land, inhabitants and buildings by water level
Source: adapted from Paprotny & Terefenko (2017)

Edge condition x flood risk
areas prone to flooding

The city of Gdansk is located in the Delta of the Vistula River by one of the river's mouth, in the coast of the Baltic Sea. Therefore the potential flooding event in the city can originate from three different directions, namely the sea, the Vistula River and the creeks in the moraine hills as Gdansk is situated on a hilly and on a low-lying terrace (Majewski et al., 2006).
In the past, the city experienced severe flood events mostly caused by ice jams on the Vistula River (Majewski, 2016). One of them, as explained in the section "Changes in the river course", triggered the creation of a new mouth of the Vistula River (Smiala Vistula) (Robakiewicz, 2010). Since the end of the 19th century, there were no ice jam floods in Gdansk because the Dead Vistula was separated from the main river by storm barriers and locks (Majewski, 2016).
Today the city is threatened by the events of high sea water level and storm surges in the Baltic Sea, which cause flooding due to backwater effect. Storm surges lead to extremely high sea water level at rivers mouths, which might be transmitted upstream via rivers by backwater effect (Ikeuchi et al., 2017).
In Gdansk, most of the land prone to flooding from the sea is used for industrial and port activities.

Fig. 16. Backwater effect in Gdansk after a storm on the Baltic Sea | January 2019
Source: photograph by Marcin Bielecki | PAP | rmf24.pl

Areas particularly prone to flooding

- From the rivers 1%
- From the rivers 10%
- From the sea 1%
- industrial and port areas

N
0 1 km

Fig. 17. Areas prone to flooding in Gdansk
Source: PGW Wody Polskie

Edge condition x flood risk
flood protection

Gdansk has one of the highest flood risks in Poland, however, it has one of the most developed flood protection systems in the country thanks to its long experience with living under the risk of flooding (Kaulbarsz et al., 2007).
The difference in elevation between the lower terrace and the upper moraine terrace exceeds 180 meters which poses a threat to low-lying landscape and therefore the city built a network of storage reservoirs on the creeks (Ministry of the Environment, 2018). The flood protection system comprise drainage pumping stations, emergency water discharges, sluice and storm gates. Besides that, the main tributaries of the Vistula River were embanked by fifteen kilometers of levees and the beach strip is nourished to combat erosion caused by coastal floods.

Fig. 18. Water storage reservoir Opacka - Oliwski creek
Source: www.gdmel.pl/zbiorniki-retencyjne

Existing and planned
flood protection | 2007

- storm water drainage
- existing/planned drainage pumping stations
- existing/planned storage reservoirs
- existing/planned emergency water discharges
- beach nourishment
- levees
- sluices/storm gates

N

0 1 km

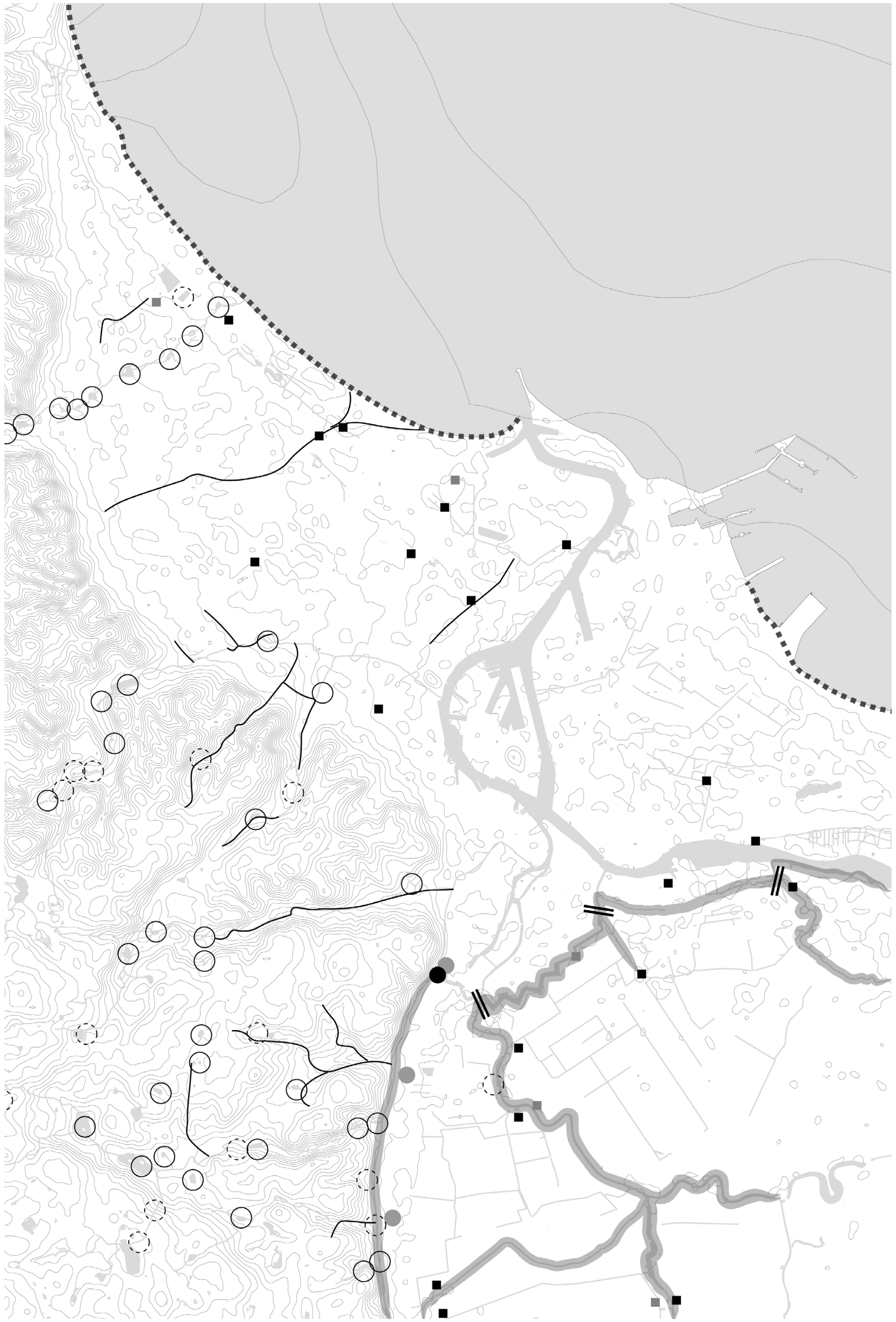


Fig. 19. Existing and planned flood protection in Gdansk
Source: adapted from the project of „Study on preconditions and directions of spatial development for Gdansk" | Gdansk Development Agency, 2007

Edge condition x flood risk x pollution
pollutants and sediments

The dynamics of rivers is strongly correlated with sediment transport, which, next to sedimentation and erosion, is an important factor shaping the riverine landscapes (Heininger & Cullmann, 2015). A substantial amount of sediment is concentrated in estuaries as the sediment load is transported from inland sources by rivers as well as from the sea by tidal currents (Hayter, 2013). The sediments in estuaries are often contaminated by pollution from the surrounding soil and ground, and thus they change the ecological quality of waterways (Kleisinger et al., 2015).
Flood events pose a real risk in the areas of high concentration of pollutants, such as industrial areas, as they can cause a release and spread of the compounds present in the sediment back to the water body (Cañellas-Boltà et al., 2005). To reduce the risk of flooding, waterways are maintained by dredging, which suspends deposited sediment and leads to siltation - an increased concentration of suspended sediment in the water body (Khan & Wu, 2013).

Fig. 20. Siltation | The Vistula River estuary after severe flood events | May 2010
Source: photograph taken by Michał Zurawiecki | trojmiasto.wyborcza.pl

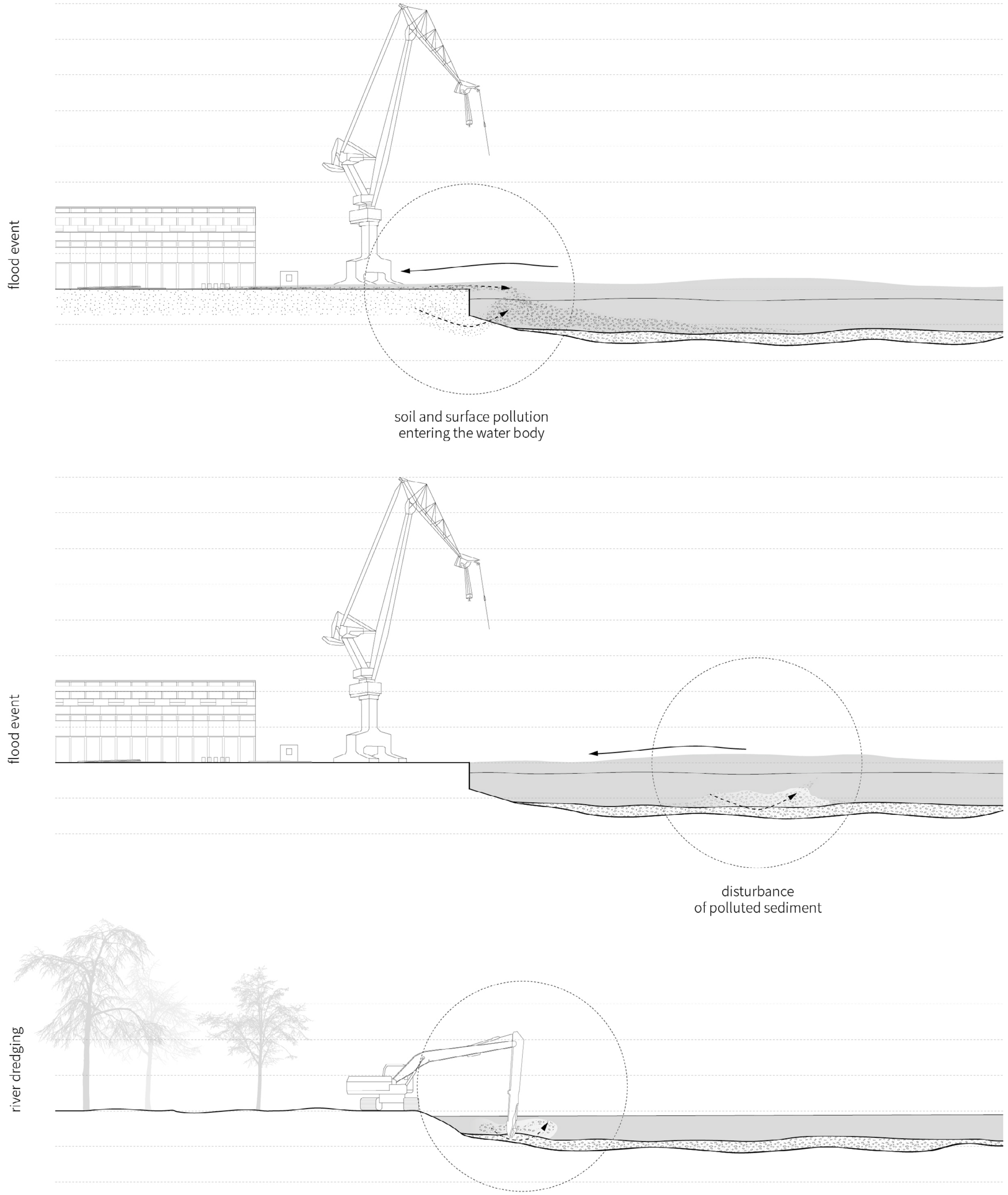


Fig. 21. Relationship between flooding and pollution
Source: author's own work

Edge condition x pollution
towards the sea

The Vistula River catchment area covers nearly 200,000 square kilometers and drains over half of Polish territory (Kajak, 1993). The amount of pollution entering the river varies along the course and depends on the use of landscape. The industrial pollutants from the Upper Vistula are partly retained in Goczalkowice Reservoir, similarly, the inputs from urban areas and agriculture in the middle course are processed and retained to some degree in reservoirs (Kannen et al., 2004). As shown in the section, the major inputs to the Gdansk Bay originate from the Vistula River basin, the additional load of nutrients and pollutants come from Tri-city effluents and atmosphere. Part of the load sinks in a process of sedimentation but might be re-suspended in the event of flooding or dredging (Cañellas-Boltà et al., 2005).
The Gdansk Deep is the final depository of fine particle, the organic pollution which originates mainly from the Vistula River basin leads to a permanent low oxygen condition - hypoxia - in the Gdansk Deep (Kannen et al., 2004).

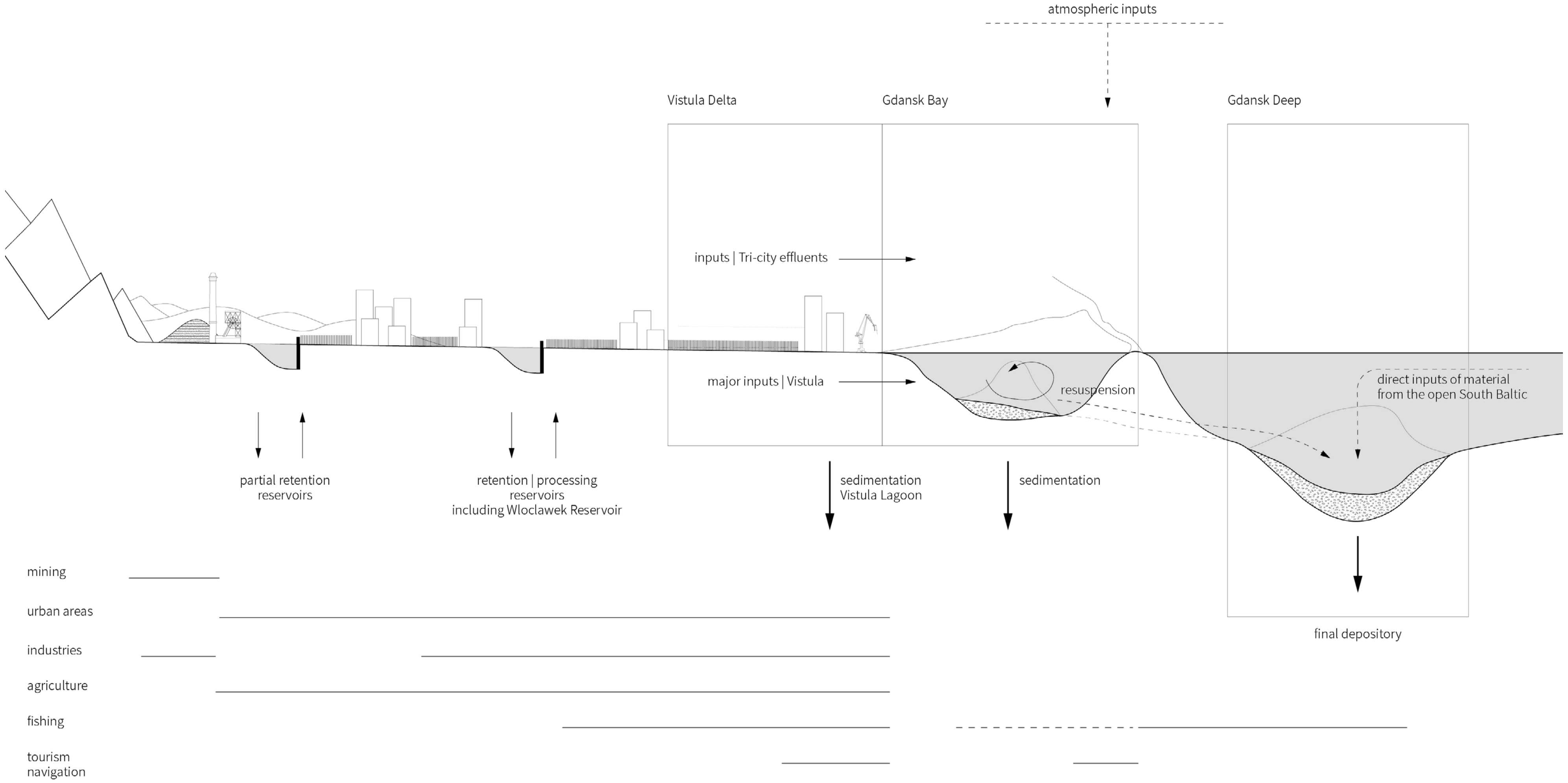


Fig. 22. Sewage leaking the Vistula River after a failure of the wastewater treatment in Warsaw | September 2019
Source: photograph taken by Maciej Jazwiecki | Agencja Gazeta | polityka.pl

Fig. 23. Schematic fluxes and connexions between the Vistula catchment and the coastal zone
Source: adapted from Kannen et al. (2004)

Edge condition x pollution
endangered sea

The Baltic Sea is one of the most polluted seas in the world and its critical issue is eutrophication, which is particularly visible in the coastal areas (European Environment Agency, 2019). Eutrophication is a process, caused by an excessive anthropogenic nutrients load, mainly phosphorus and nitrogen, into the sea waters (Gustafsson et al., 2012). It results in increased growth of potentially toxic algae and deep-water oxygen deficiency (Elmgren, 2001).
One of the reasons for eutrophication in the Baltic Sea is the fact that its natural capacity of processing the nutrients is exceeded by the amount of polluted water the Baltic Sea receives from its vast drainage area (fourfold the sea area) with nutrient accumulation in the sea over the last fifty to one hundred years (Andersen et al., 2017). Moreover, the retention of pollutants in the Baltic Sea takes a considerable amount of time and the process of stratification diminish ventilation of deep waters, leading to hypoxia, which then may cause loss of biodiversity in the sea waters (Elmgren, 2001).

Fig. 24. Oliwski creek estuary | brackish water of the Baltic Sea | 2019
Source: photograph taken by Wojciech Radwanski

Pollution by phosphorus and nitrogen

The map illustrates the relative distribution of phosphorus and nitrogen concentration in the Baltic Sea water. It presents the load of both nutrients in the sub-catchment areas.

Relative distribution of phosphorus concentration in the seawater
0
1

Relative distribution of nitrogen concentration in the seawater
0
1

Load of phosphorus from sub-catchments (kg/km²)
- less than 5.00
- 5.01 - 10.00
- 10.01 - 20.00
- 20.01 - 40.00
- 40.01 - 80.00
- more than 80.01

Load of nitrogen from sub-catchments (kg/km²)
- less than 110.00
- 110.01 - 250.00
- 250.01 - 500.00
- 500.01 - 1000.00
- 1000.01 - 1500.00
- 1500.01 - 2000.00
- more than 2000.01

N
0 100 km

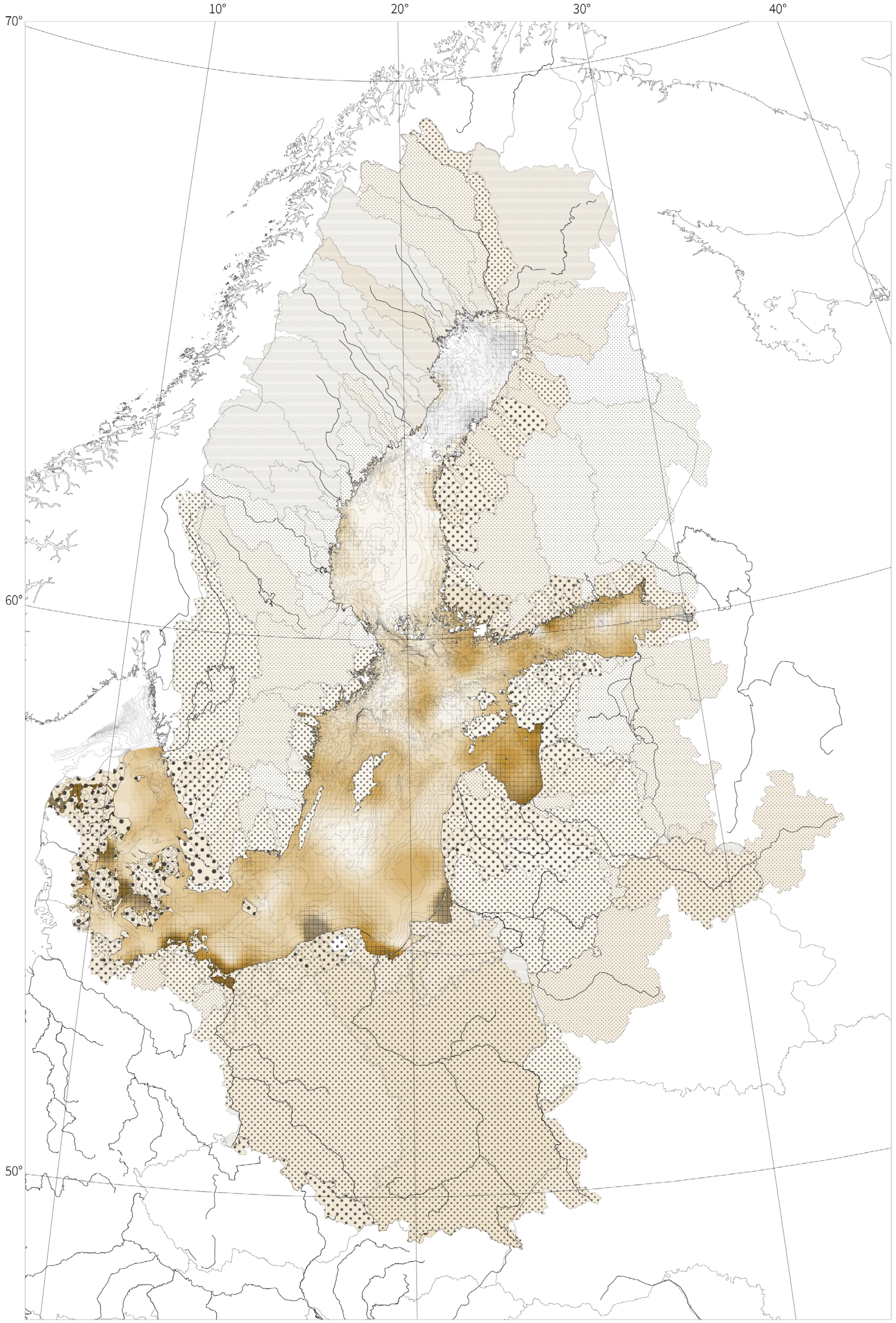


Fig. 25. Concentration of phosphorus and nitrogen in the Baltic Sea and its sub-catchment areas
Source: HELCOM Pollution Load Compilation, ICES's oceanographic database, SMHI, eionet

Edge condition x pollution
rising sea temperature

Eutrophication in the Baltic Sea exacerbated after the mid-twentieth century (Elmgren, 2001). The visible decrease in the nutrient input in the 1980s was caused by the use of efficient sewage treatment (Andersen et al., 2017). Later in 2009, The European Union Strategy for the Baltic Sea Region (EUSBSR) was adopted by the European Council. One of its objectives was to promote the protection of the marine environment by reducing the loads of nutrients entering the sea. Even though the adoption of the strategy led to a decrease in nutrient release to water bodies, the changing climate poses additional challenges. Rising sea surface temperature prolongs the growth period of algal blooms and creates more favorable conditions for the increase of algae population (European Court of Auditors, 2016). Secondly, as winters become shorter and wetter, the Baltic Sea ice cover significantly shrinks, and the amount of snow in the sea sub-catchment areas decreases throughout the years. That leads to a smaller water retention capacity of the sub-catchment areas and thus greater run-off of nutrients from there, which exacerbates the problem of eutrophication (Von Storch et al., 2015).

Fig. 26. A colorful summer marine phytoplankton bloom in the Baltic Sea | image captured by Envisat's MERIS | 13 July 2005
Source: European Space Agency

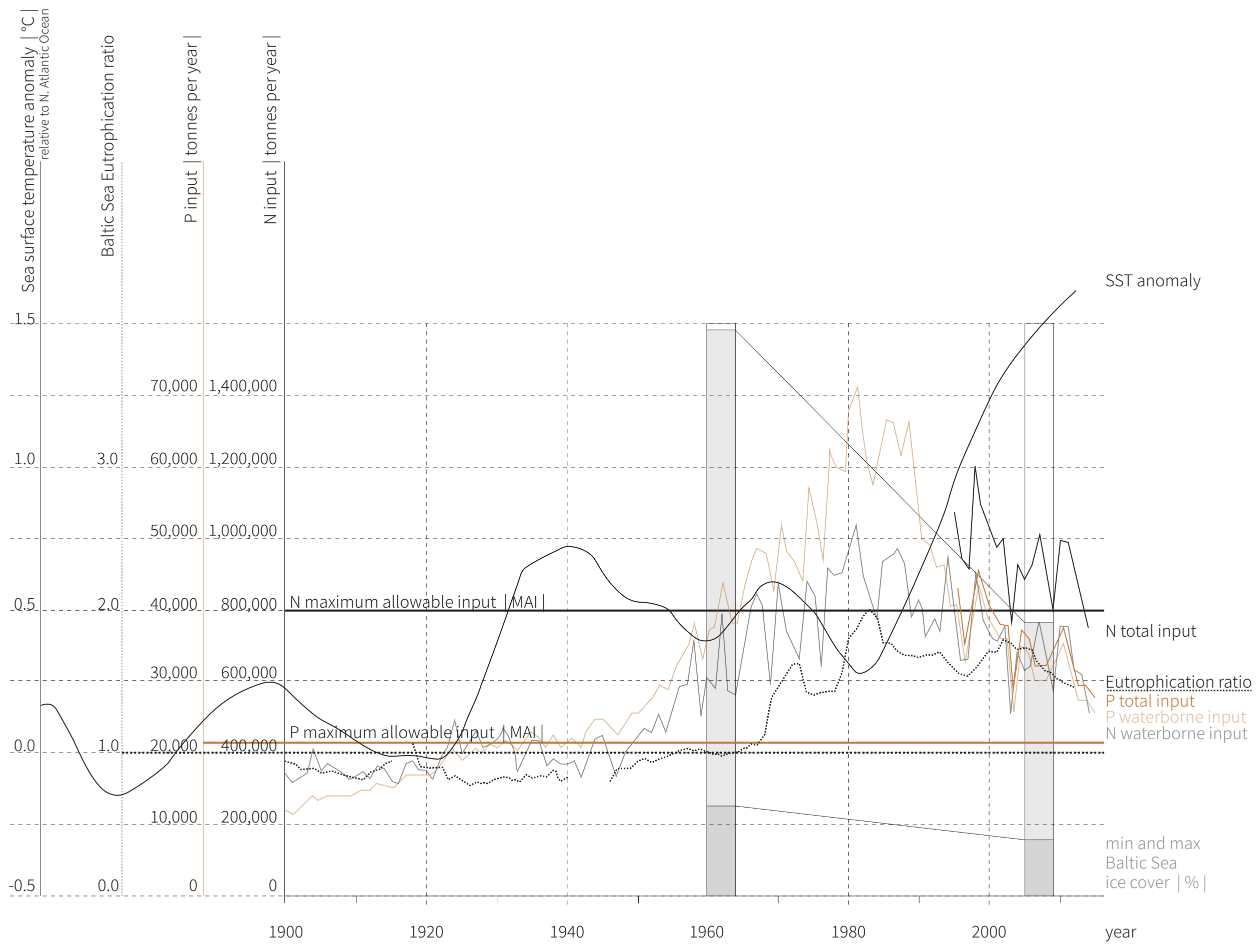


Fig. 27. Juxtaposition of factors increasing the severity of eutrophication in the Baltic Sea
Source: NOAA Extended Reconstructed Sea Surface Temperature (ERSST); Baltic Sea ice cover - Finnish Meteorological Institute, HELCOM; eutrophication ratio - Andersen et al. (2017); nitrogen and phosphorus input - Gustafsson et al. (2012), Savchuk et al. (2012), HELCOM (2015)

Edge condition x pollution x performance
shipping. sea and waterways

The pressure on the Baltic Sea ecosystems is exerted not only by the anthropogenic activities within the drainage area but by activities on the sea, namely shipping and dredging. The expansion of global maritime trade triggers an increase in shipping and port activities, which strongly influence the levels of water and air pollution within the sea basin and coastal areas due to oil leakage, leaching of toxic paint and exhaust emissions (Trozzi & Vaccaro, 2000). In addition to that, ports, as inter-modal trade hubs which allow for the transfer of cargo between ships and inland means of transport, are highly prone to contamination of soil (EPA, 2008).
The use of inland waterways for shipping constitutes an additional environmental stressor for the riverine network, water edges and eventually for the sea ecosystems (European Conference of Ministers of Transport, 2006).
Today the share of Polish rivers in total freight transport is negligible and accounts for around 0.1% (Nowakowski et al., 2015), despite their historical legacy of international waterways (Cyberski & Kawinska, 1995). However, the current Polish government has the ambition to restore the international importance of Polish inland waterways. Together with the governments of Belarus and Ukraine, it initiated a project of a waterway linking the Baltic Sea in Gdansk with the Black Sea in Kherson by connecting five rivers including the Vistula. The project would require dredging and widening the rivers and building cascade dams as well as a channel connecting the Vistula with the Mukhavets River in Belarus (Murphy, 2020).

Fig. 28. Deep-water Container Terminal in Gdansk
Source: gospodarkapolska.pl

Current and proposed shipping routes

The map illustrates the shipping density in the Baltic Sea in the years 2011-2015 as well as possible use of the Vistula River as a part of E70 and E40 waterways connecting the Baltic Sea with respectively the North Sea and the Black Sea.

- Port
- Planned waterway
- Shipping density
  - low
  - high

0 | 100 km | N

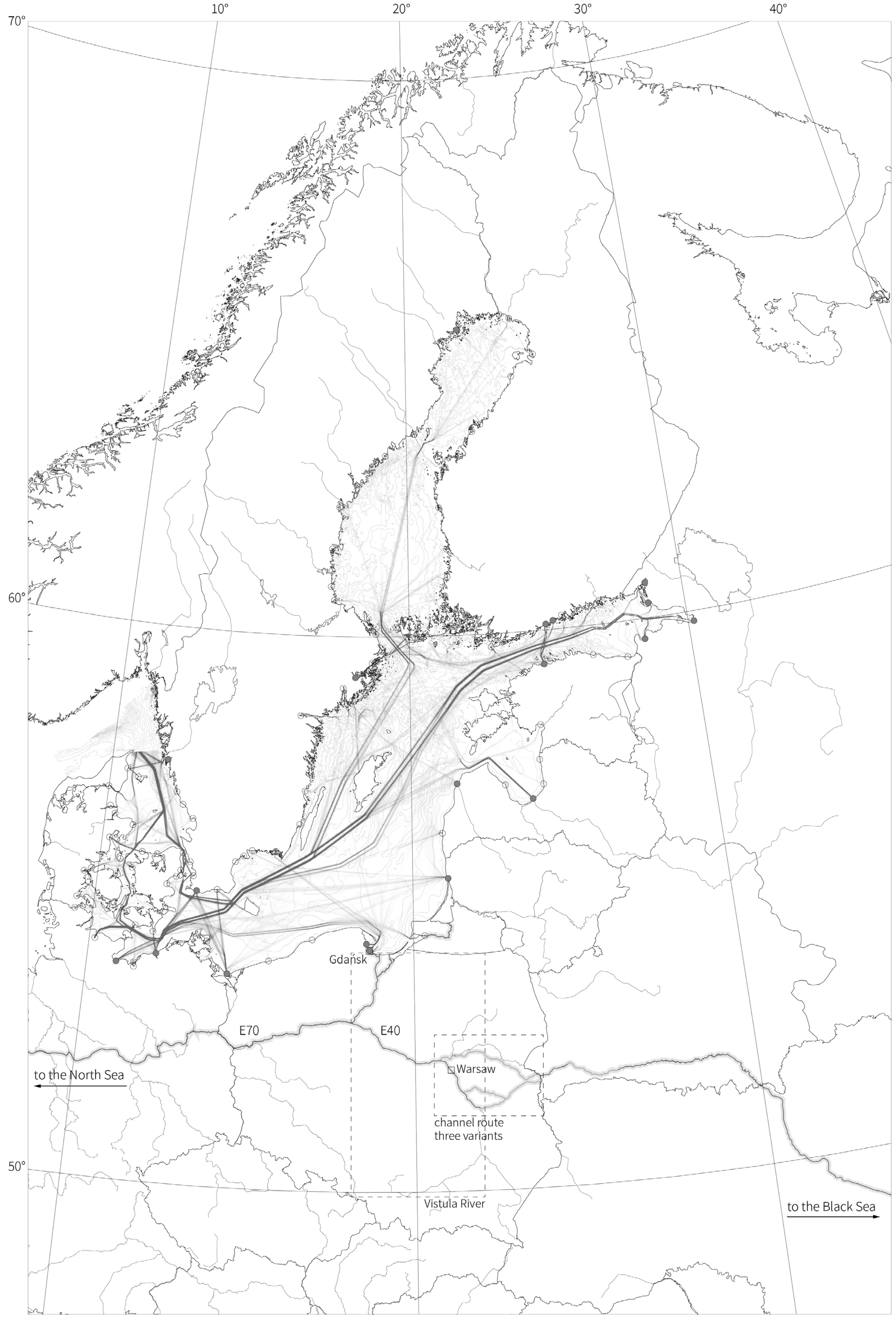


Fig. 29. Current and proposed shipping routes
Source: HELCOM HOLAS II Dataset: Shipping density 2011-2015

Edge condition x performance
cascade hydropower dams

Plans to make the Vistula River suitable for navigation emerged after Poland regained its independence in 1918, they were later interrupted by the Second World War, and after that continued until the mid-twentieth century (Ankiersztejn, 2013). In 1957 the Committee for Water Management established at the Polish Academy of Sciences developed a concept of regulation of the Lower Vistula course which provided for construction of hydropower barrages along the river (Szymkiewicz, 2017). Several variants of the cascade were proposed, the one with ten dams is illustrated in the section. Nonetheless, only one dam was built in Wloclawek and further development of the project did not take place due to economic issues (Szymkiewicz, 2017).
The proposal of the development of the Lower Vistula Cascade was reintroduced by the Polish government in 2016 (Council of Ministers, 14 June 2016). Moreover, in 2017 the Polish president ratified the European Agreement on Main Inland Waterways of International Importance (AGN, 1996 in United Nations, 2000) which requires the development of inland water infrastructure.
In order to meet the requirements, the Polish rivers will need to be narrowed to reach the necessary depth for navigation (Jurszo, 2017). That process might severely affect the environmental conditions of the river edges (Schoof, 1980).

Fig. 30. Wloclawek dam, view from the side of the upper reservoir
Source: Szymkiewicz (2017)

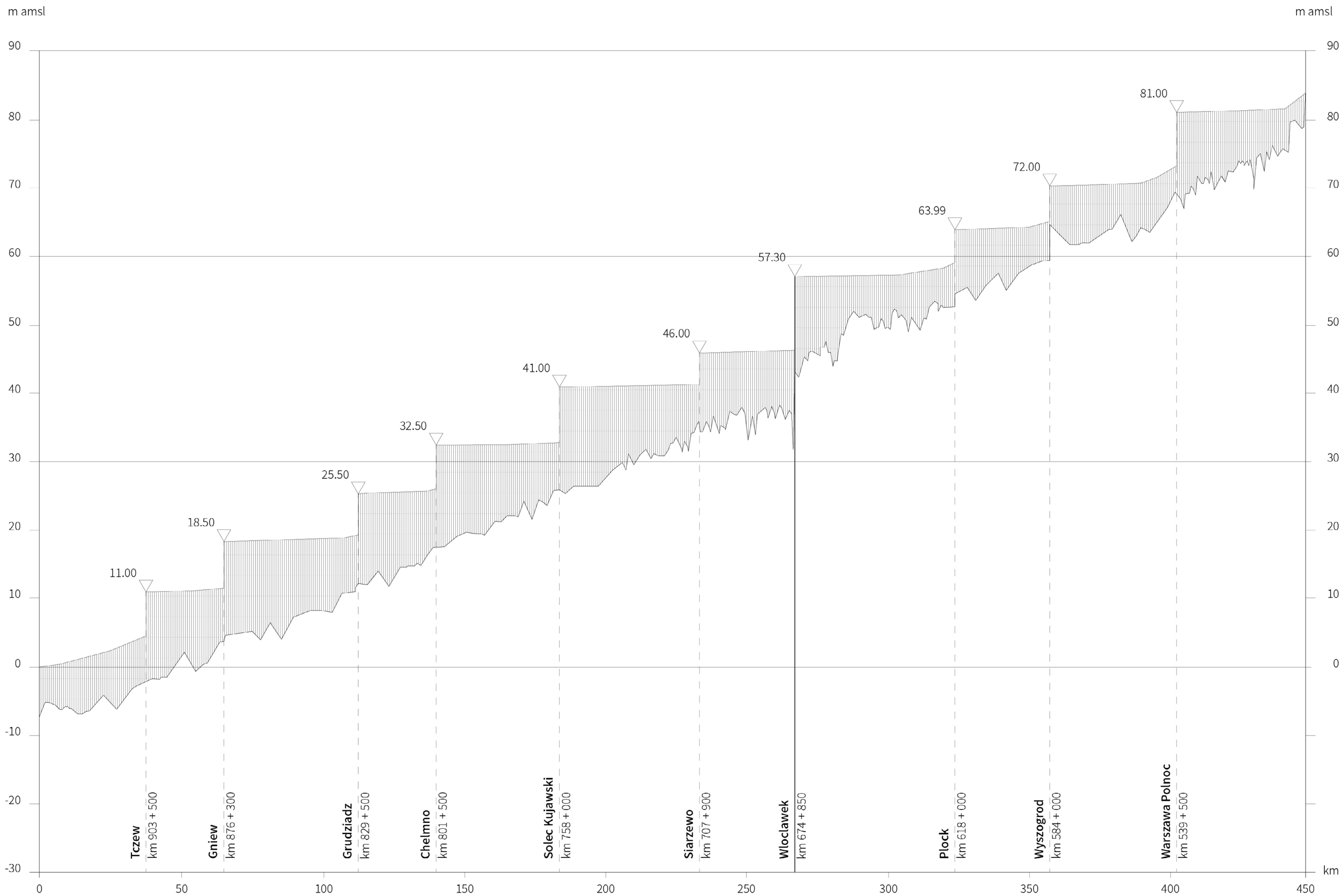


Fig. 31. One of the proposed variants of the Lower Vistula Cascade
Source: Maritime Institute in Gdansk (2015)

Edge condition x performance
environmental consequences

The growing interest in the environmental issues in the 1990s was, next to the economic issues, another reason which led to a rejection of the proposals to regulate and use the Vistula River for the commercial purposes in order to preserve its current condition and convert the landscapes to parks and protected areas (Natura 2000) (Ankiersztejn, 2013).

Nonetheless, the environmental consequences of the built Wloclawek Dam and Reservoir are catastrophic and constructing the rest of the Lower Vistula Cascade may aggravate the problems (Kajak, 1993). The mortality of fish increased and some migrating species disappeared due to pollution, reduced river flow velocity and constraints of migration through the dam (Backiel, 1985 as cited in Kajak, 1993). The Vistula River is partly regulated by perpendicular and longitudinal dams, which look natural, however, they cause greater environmental uniformity by eliminating temporary and permanent river islands (Kajak, 1993; Gierszewski et al., 2015). Channelization of a river to make it suitable for navigation requires changing the width of the river and its edge (Jurszo, 2017). That consequently affects islands and sandbanks in the riverbed, which constitute habitat for some bird species (Gertée, 2018).

Next to that, the sediment and pollutants carried by the river accumulate in the reservoirs and reduce the water retention capacity of the river valley simultaneously increasing the risk of flooding (Jurszo, 2017).

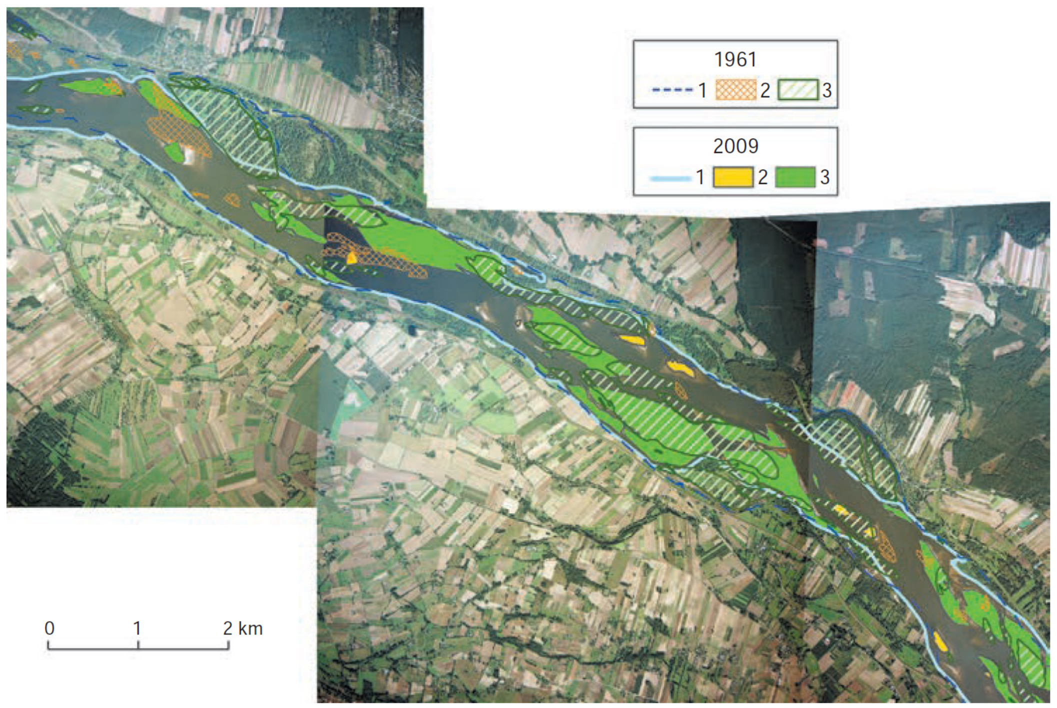


Fig. 32. Changes in the configuration of the Vistula channel near "Kepa Wykowo"after construction of the dam in Wloclawek
1 – river channel, 2 – unstable channel forms, 3 – stable inter-channel forms
Source: Center for Geodetic and Cartographic Documentation (CODGiK), Warsaw

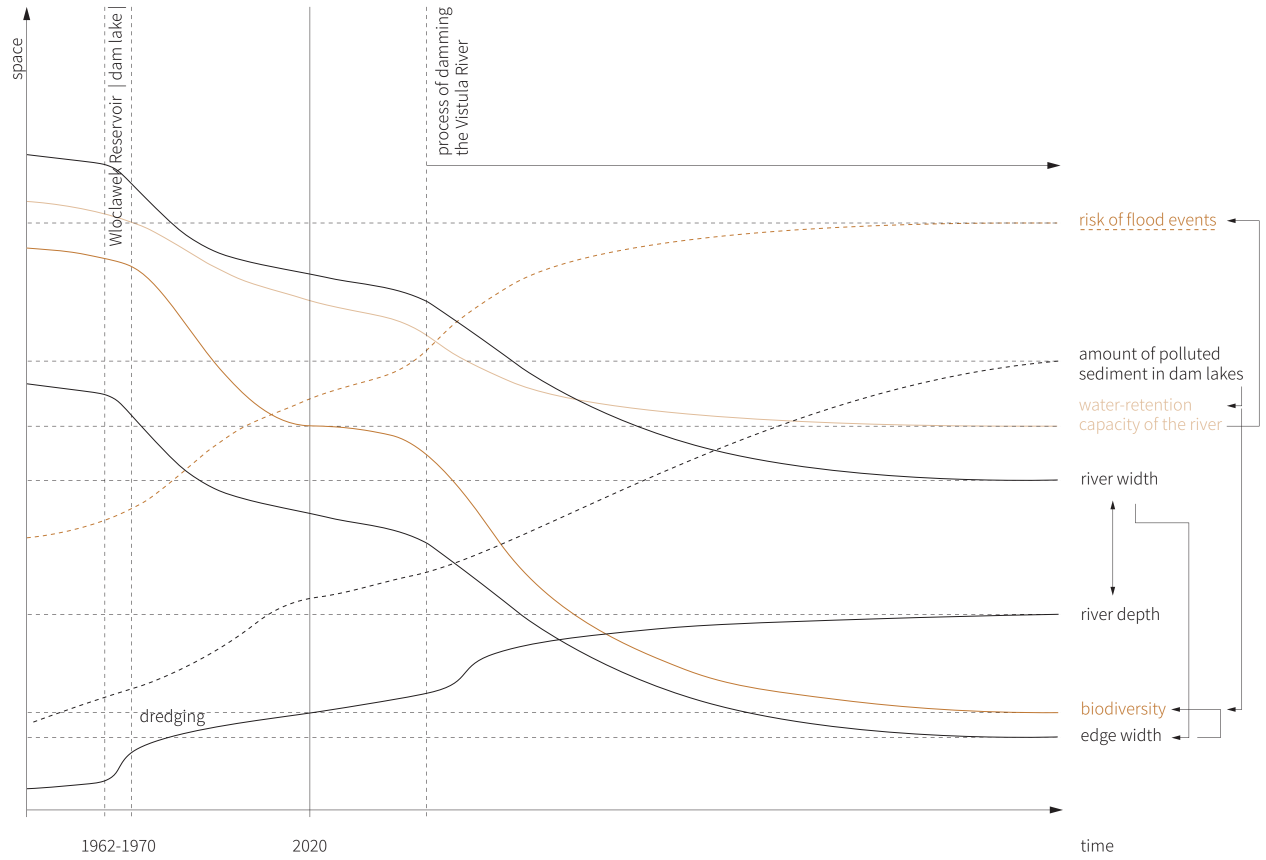


Fig. 33. Relations between various processes linked to damming and channelization of the Vistula river
Source: author's own work

Edge condition x performance
port and industries

The edges of the Vistula River in the urban areas have been altered throughout history in order to accommodate various functions and make the edge operational. In the case of the city of Gdansk, the proximity to the Vistula river and its (now former) estuary was a key driver in shaping the city character and boosting its growth. Gdansk became an important trading hub on the map of Europe and since the middle of the 14th century, it belonged to Hanseatic League, a supranational alliance of cities and ports located by the Baltic and the North Sea (Tölle, 2008).
The growth of the port stimulated the development of the industries, including the shipbuilding industry on the waterfronts of der Holm (today called the Ostrow Island) and the Young City (Lorens & Lewicki, 2018). Due to economic and technological changes both the port and the industrial activities are being moved seaward, requiring land reclamation and leaving behind underused and disused landscapes adjacent to the urban tissue.
The city of Gdansk proposed a strategy to regenerate the post-industrial area of the Young City and incorporate it into the Central Belt of Services which binds the Tricity metropolitan area (Gdansk-Gdynia-Sopot) (Biuro Rozwoju Gdanska, 2018). On the other side, the project of the Central Port would add extra 410 hectares of reclaimed land ("Tak bedzie wygladal Port Centralny," 2019), which may result in migration of some Inner Port activities seaward, and thus the emergence of 120 hectares of disused land on the left bank of the Dead Vistula River that could be gradually incorporated into the urban tissue (Kiewlicz, 2015).

Fig. 34. Industrial and port area in Gdansk
Source: trojmiasto.pl

Land use
in the city of Gdansk

- port areas
- future port area | Central Port
- port areas which might be abandoned
- industrial areas
- post-industrial areas | Young City
- urban tissue
- Central Belt of Services
- green areas
- agricultural land

N

0 1 km

Fig. 35. Current land use and potential future changes
Source: Geofabrik, Open Street Map, Port of Gdansk

Edge condition x performance
port and city growth

Fig. 36. Growth of Gdansk and its port
Source: www.gdansk.pl, www.planygdanska.pl

Edge condition x performance
port - city relationship

Throughout history, there was a close relationship between the ports and cities linked with them as the city's wealth was dependent on its capacity to adapt the port to emerging changes in economy and technology (Hein, 2014).
The city of Gdansk was first closely related to the port, which lay by Motława river (a tributary of the Dead Vistula River), and thus the waterfront had then both operational and urban function (Szmytkowska & Nowicka, 2015). Subsequently, some activities were moved to the new port in the mouth of the Vistula River, leaving space between the city and the estuary for industries and further expansion of the port.
In the mid-nineteenth century the Prussian authorities, as Gdansk was a part of Prussia at that time, saw an opportunity to build shipbuilding industry by the Vistula River (Lorens & Lewicki, 2018). Most of the development occurred in the Young City, an area adjacent to the city and close to the mouth of the river. Some buildings were located on the Ostrow Island. The shipyard developed rapidly thanks to its location and the national investment in navy (Wróbel & Frankowski, 2016). However, after the socio-economic transformation in 1989, the financial status of the institution drastically changed and it went bankrupt in 1996. The remaining activities were moved to the island and the process of spatial restructuring started in the Young City (Lorens & Lewicki, 2018).
The Inner Port by the Dead Vistula River grew alongside the city until the modernization of the maritime transport which took place in the twentieth century. The ambition of further growth and the need to receive a larger number of deep-water containers forced the port to reclaim land in the Outer Port and create the Deepwater Container Terminal (O DCT, n.d.). Further land reclamation is planned in order to increase the capacity of the port (Port of Gdansk, 2019).

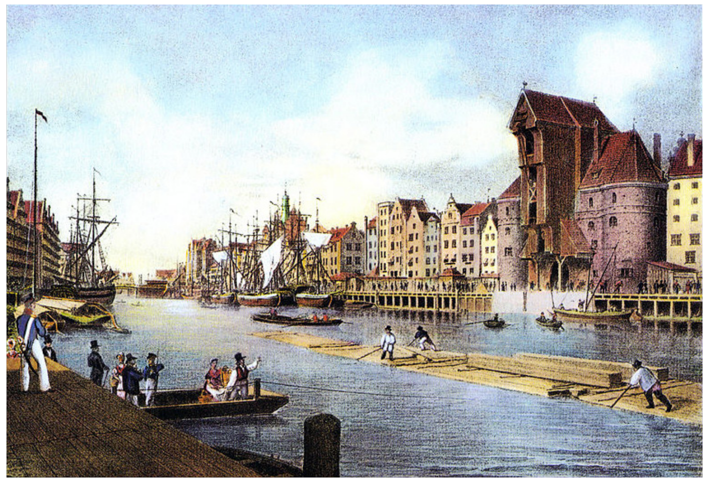


Fig. 37. "Zuraw Gate in Gdansk" by Friedrich Eduard Meyerheim | 1850
Source: Archiv "Deutschland und die Welt"

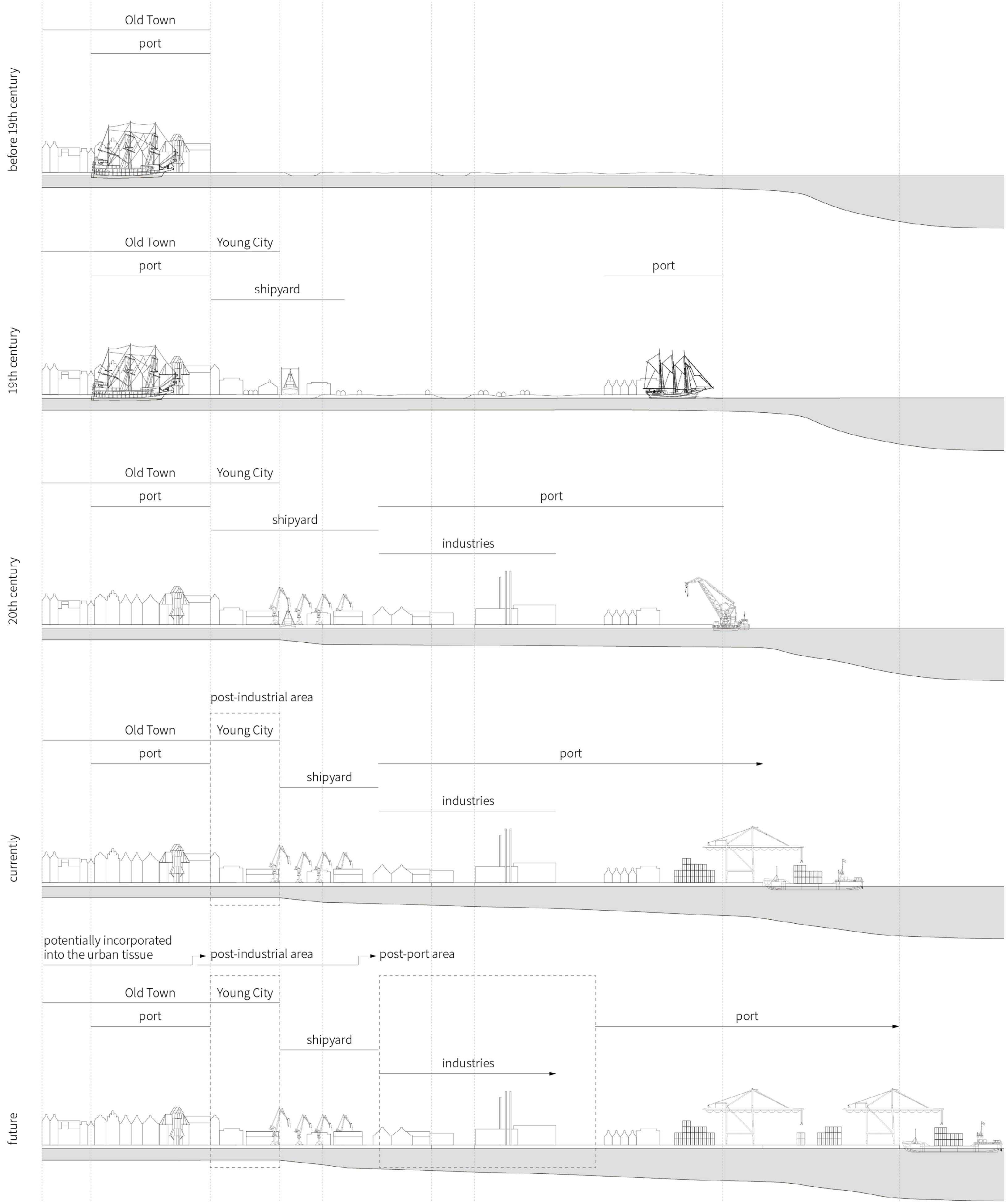


Fig. 38. Changing port-city relationship
Source: author's own work

The aforementioned proposal to incorporate the Young City in the urban tissue was first introduced in the 1990s when the area was no longer a part of Gdansk Shipyard. There were several competitions conducted addressing revitalization of this part of the city. The last one, from 2018, was won by Henning Larsen Architects.

The proposal aspires to create a mixed-use neighborhood by reusing post-industrial structures and constructing a few towers by the waterfront buzzing with public life. The project includes water and soil remediation, which would allow for the water to be used as a recreational space.

The idea of connecting the Young City with the city is in alignment with "The study of conditions and directions of spatial development in the City of Gdansk" (Biuro Rozwoju Gdanska, 2018) highlighting the crucial role of counteracting urban sprawl by increasing the density of the existing urban tissue.

Fig. 39. Photograph of the Young City by Wojciech Radwanski; Fig. 40. Henning Larsen Architects' proposal for revitalization of Gdansk Imperial Shipyard, visualization by Plankton Group; Source: Archdaily

Edge condition x performance
spatial limitations

Freeing the industrial and port landscapes for urban areas is possible because of changes in the economic system (shift towards service-based economy) and modernization of the maritime transport, namely containerization.
After the introduction of container ships in the second half of the twentieth century ports needed to meet new spatial requirements such as access to vast land and deep-water areas on the sea (Hoyle, 2000). Although the rivers were dredged to receive larger ships, eventually the cities and the ports grew apart because former harbor areas were not able to fulfill the needs of the modernized port technology (Hoyle, 2000). In many European cities located by rivers, port activities migrated towards the estuary, in some cases, including Gdansk, leading to land reclamation to increase the capacity of the port (Pinder, 1981, as cited in Hoyle, 2000).
The diagram illustrates a conceptualization of relations between various processes and spatial changes in the city of Gdansk in the twentieth and the twenty-first century.

Fig. 41. Visualization of The Central Port in Gdansk | 2019 |
Source: ZMPG SA, Port of Gdansk

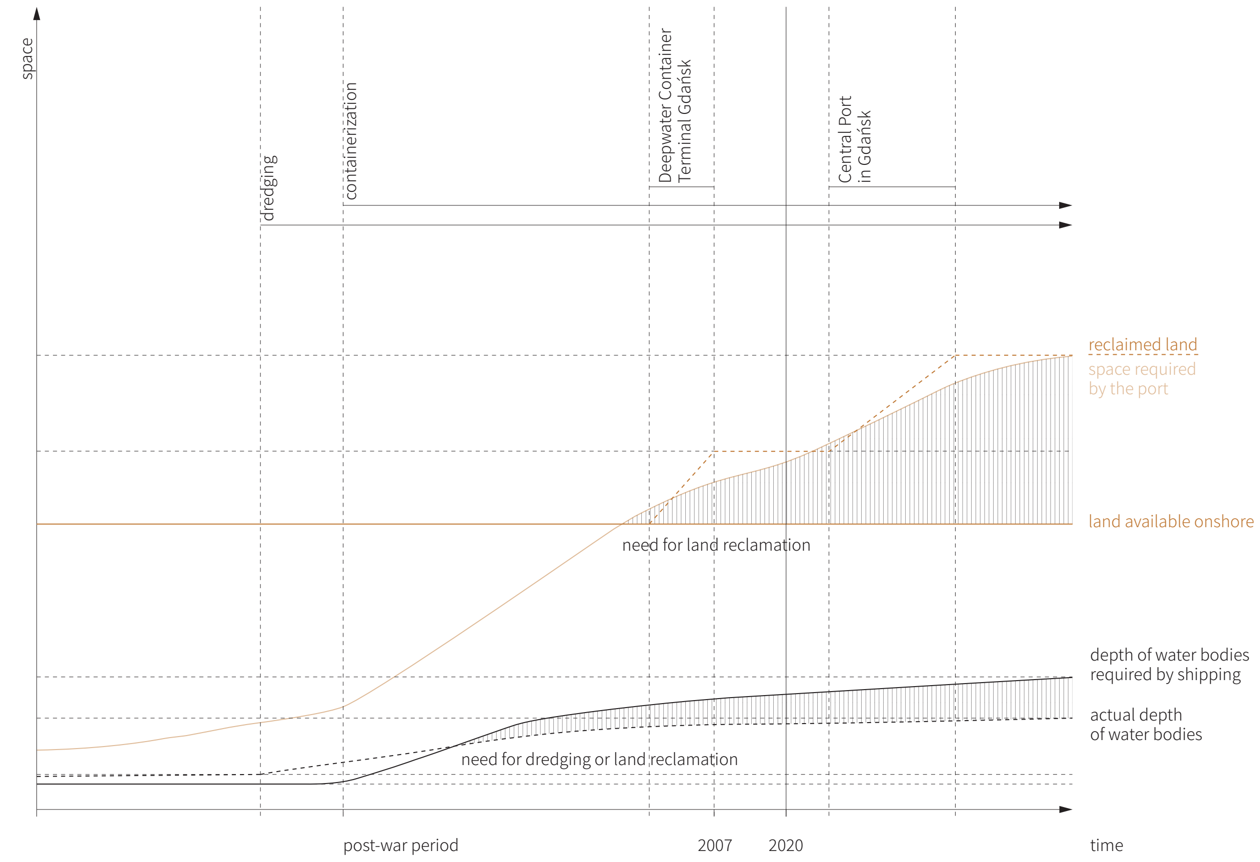


Fig. 42. Conceptual spatio-temporal diagram of the port of Gdansk development
Source: author's own work

Chapter 3
Methodology

The chapter illustrates and explains how different concepts, notions derived from the literature were applied in the research process and what methods were used to conduct the research.

Fig. 43. The agricultural edge of the Vistula River | floodplain separated by a dike | Małe Walichnowy
Source: author's own photograph | field trip February 2021

Introduction

The alteration in the edge condition between diverse ecological systems along the Vistula River originates from disturbances triggered by anthropogenic activities, such as agriculture, industrialization and land use (European Environment Agency, 2019).

Dramstad, Olson and Forman (1996) defined
an edge as a key ecological transition zone between two types of habitat

The degradation of soil, water and air is caused by various pollutants from fertilizers, industries and urban areas, which consequently impact the health of people and ecosystems (European Environment Agency, 2019). Additionally, the more frequent flood events and sea temperature rise increase the vulnerability of social and ecological systems (Altieri & Gedan, 2015; Staudt & Kordalski, 2005). There is a need to define the study approach as well as possible concepts, theories and methods that might be used to address this complex problem field and help structure the research in order to reveal potentialities to implement regenerative design scenarios in the Vistula River Delta, in particular in the urban area of Gdansk. The aim of this chapter is to establish a research, conceptual and methodological frameworks to achieve the desired outcome.

First, I briefly introduce the problem based on the literature review. The challenges described there concerning changing landscapes and edge condition are a basis to formulate the needs and thus aim of the research - regeneration of socio-ecological systems. The posed research question asks how the aim can be achieved and if landscape can be used as a medium to cope with the site-specific urgencies. The main research question is then split to extract four main concepts and issues. They are used to formulate sub-research questions, which help answer the main research question.
Thereafter, I present the expected outcome of the research, which represents dependencies between the phenomena of climate change and anthropogenic activities. Building scenarios is based on a matrix showing different degrees of climate change severity and the direction which the society's attitudes and values, and thus the practices, will take.
The next part presents a causal relationship between the processes - economic and technological change, anthropogenic activities and climate change - and environmental and spatial issues that occur as a consequence of these processes. Then, the aim of the research - regeneration of socio-ecological systems - is deconstructed by revealing concepts needed to achieve the goal, namely resilience, health and urban performance and diversity. The theories from which the concepts were derived are clarified and it is explained how they help to build the proposal aligned with the research aim.
I describe the methods I plan to use to answer the sub-research questions, namely literature review, data collection, critical mapping, site visit, scenario building, stakeholders analysis, research through design and spatio-temporal analysis. I introduce the limitations of the methods and the overall scope of the thesis.
Finally, ethical considerations of the project are presented and a timetable is outlined.

Research framework

Personal motivation and relevance of the research

	State of the environment in the edges of various systems	
Problem field	Changing edge condition. Environmental, social and spatial implications of changes in the landscape.	
	Keywords	socio-ecological systems | water pollution | edge condition | landscape urbanism | remediation | port city |
	Location	Gdansk | Vistula River Delta | Baltic Sea
	Statement	The changing condition of the edges between land and water, different water systems as well as between diverse land use along the Vistula River stems from anthropogenic activities, such as urbanization, industrialization and agriculture (European Environment Agency, 2019). The polluted environment is a threat to the health of people and ecosystems (EPA, 2008). The issue becomes more urgent due to a higher risk of flooding and economy-driven dredging activities which lead to a disturbance of contaminated soil and sediment and thus increases the vulnerability of socio-ecological systems (Cañellas-Boltà, 2005). Moreover, the water edges in the coastal cities, which were formerly occupied by industries or a port, face spatial issues, namely abandonment and degradation (Hoyle, 2000).
Research question	Can landscape be used as a medium to cope with socio-ecological and spatial urgencies along the edges of the Vistula River through a regenerative design? Aim of research To find ways (design and strategies) to achieve transition towards regeneration of socio-ecological systems in the edges of various landscapes	
Methodology	Mixed methods approach	
WHY?	Theoretical framework	socio-ecological systems | regenerative development and design | landscape urbanism | landscape ecology |
HOW?	Conceptual framework Analytical framework Empirical framework	
Methods	literature review | data collection | critical mapping | site visit | scenario building | research through design | stakeholders analysis | spatio-temporal analysis |	
Outcomes	Multi-scalar design and strategies Building scenarios Phasing of spatial strategies Strategy for engagement of potential stakeholders Design proposal and phasing (micro scale)	
Evaluation Reflections		

Problem statement

I started the research by using a multi-scalar approach to define the problem field. I looked at the relationships between phenomena and issues occurring in various scales in the edges between land and water, different water systems as well as between diverse land use along the Vistula River with a focus on environmental and spatial issues.
The changing condition of the edges between land and water, different water systems as well as between diverse land use along the Vistula River stems from anthropogenic pressures and climate change (European Environment Agency, 2019). The Vistula River basin holds a position of the second largest river basin within the Baltic Sea catchment area, which means that its condition strongly affects the state of the sea (Pastuszak et al., 2012). The semi-enclosed Baltic Sea has a limited water exchange through a very narrow connection to the North Sea, and thus it is particularly vulnerable to contaminated input from the rivers (Andersen et al., 2017). Be-sides that, the rising seawater temperature increases the vulnerability of the sea to eutrophication (European Environment Agency, 2019).
The pollution of the Vistula River originates from anthropogenic activities namely urbanization, agriculture and industrialization (Kannen et al., 2004). Various compounds and waste directly enter the waterways, whereas excessive nutrient input from agricultural runoff infiltrates the soil and is transferred through it to the water-ways. While a part of the pollution flows to the sea, the rest sinks to the riverbed (Kannen et al., 2004). Because of that, the cities located closer to the sea, such as Gdansk, have a limited opportunity for nutrient retention and therefore a bigger impact on the seawater than upstream cities. However, the contaminated sediment in the riverbed may be disturbed in the event of flooding or because of dredging activities and thus release the pollutants back to the water body (Cañellas-Boltà, 2005). The flood is a threat to the quality of water in places where the soil is polluted or hazardous waste is present on the ground, namely in the industrial areas (Trozzi & Vaccaro, 2000). A particularly advantageous location for industries is in the proximity of port cities (Fujita & Mori, 1996), which are therefore especially prone to water pollution. The port activities affect the quality of water, soil and air. These factors harm the health of people as well as the state of ecosystems (EPA, 2008). Another factor which poses a threat to the ecosystems is regulation and damming of the Vistula river, which would be in alignment with the Polish government ambition to create an inland waterway through the Vistula River as a part of E40 waterway connecting the Baltic Sea with the Black Sea (Maritime Institute, 2015).
Next to the environmental vulnerabilities in the edges along the Vistula River and health issues resulting from them, there are spatial urgencies in prominent locations such as waterfronts. Cities like Gdansk, located by the water, saw the potentiality in the waterfront and used it often for industrial and port purposes (Hein, 2014). The shift towards service-based economy induced deindustrialisation and caused the emergence of disused post-industrial landscapes (Marshall, 2001; Rachwal, 2011). Moreover, changing maritime transport requires vast, deep-water areas, and thus leads to migration of port activities seaward and reclamation of land, as projected for the city of Gdansk, and consequently raising an issue of abandoned landscapes adjacent to the city center (Hoyle, 2000).
In conclusion, it may be said that there is a strong link between anthropogenic activities and the state of the environment, which eventually affects human health. The edge condition is a reflection of that issue and hence there is a need to propose spatial strategies for change. The hypothesis is that the landscape and ecosystem services embedded in it can be used as a medium to cope with socio-ecological and spatial urgencies along the edges of the Vistula River.

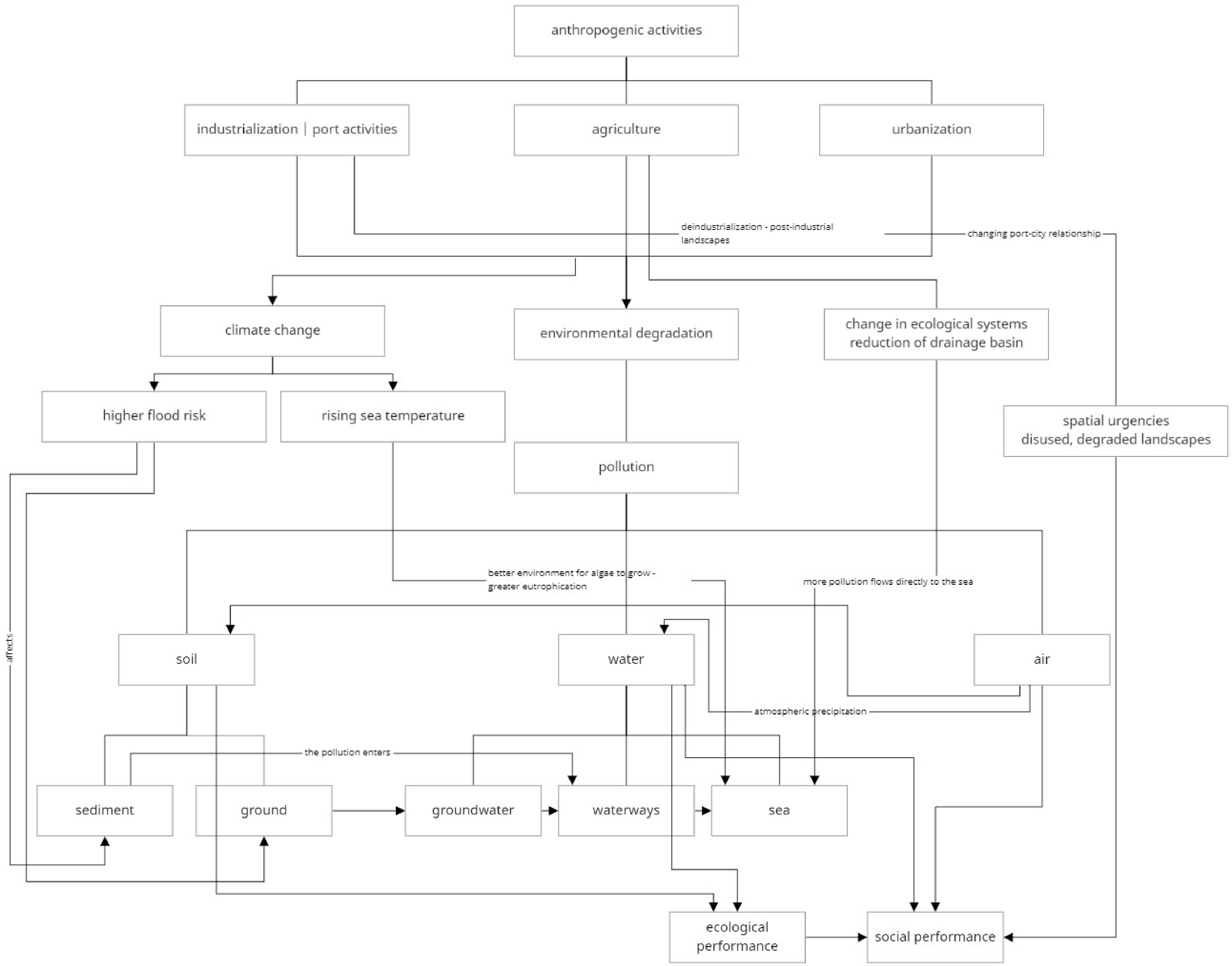


Fig. 44. Problem statement causal nexus
Source: author's own work

Research questions

Can landscape be used as a medium to cope with socio-ecological and spatial urgencies along the edges of the Vistula River through a regenerative design?

In order to answer the research question, I pose four sub-research questions, namely:

Sub-research question 1
What are the urgencies in the social and ecological systems along the Vistula River, what do they originate from and how are they interrelated?

Sub-research question 2
What are the potentialities of using landscape as a medium for regeneration?

Sub-research question 3
Can the presence of spatial urgencies along the edges become a potential to respond to environmental issues of a larger territory?

Sub-research question 4
What stakeholders could drive the transition towards regenerative practices?

Research aim

Regeneration of socio-ecological systems

The research aims at evaluating the prevailing condition of edges between land and water, different water systems as well as between diverse land use along the Vistula River. Moreover, the intent is to reveal variables of spatial, environmental and social vulnerabilities to expose the impact of externalities caused by climate change and anthropogenic activities, such as urbanization, industrialization and agriculture.
The goal is to find regenerative design practices and strategies for transitioning socio-ecological systems in the edges of agricultural landscape in The Vistula River Delta and in the post-industrial and underutilized edges in the city of Gdansk.

Expected research outcomes

The thesis is a form of spatial manifestation of transitions that might happen in the edges of the Vistula River due to climate change, the continuation of the current approach to landscape or shift towards the regenerative approach.
The ambition is to imagine, illustrate and describe those transitions in the matrix of four scenarios. Two of the projected scenarios show consequences of persisting with degenerative practices considering the high and low intensity of climate change. The other two scenarios project possible effects of regenerative practices, similarly regarding the climate change severity.
The final design outcome is a set of spatial configurations of strategies and design interventions for transitioning three types of edges along the Vistula River. The design proposal is based on the notion of using landscape, and ecosystem services embedded in it, as a medium to regenerate the edges. The design follows a set of principles regarding the increase of the remediation capacity, resilience and performance of the landscape, which further helps reach the scalability of the project.

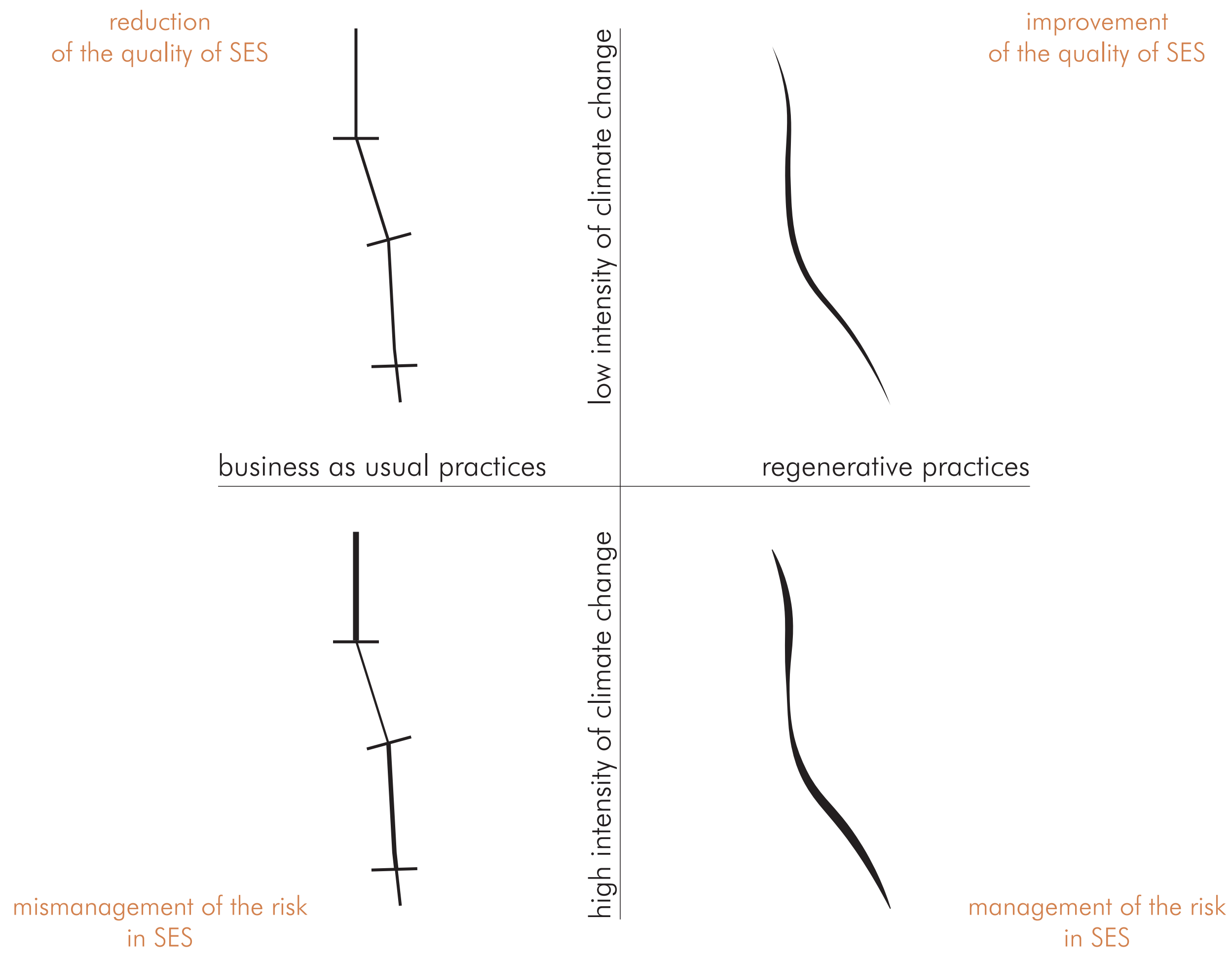


Fig. 45. Matrix of scenarios
Source: author's own work

Theoretical and conceptual framework

The thesis aims to propose design practices to reach the regeneration of socio-ecological systems. The focus is on transitioning edge condition with the use of landscape (and ecosystem services embedded in it) as a medium.
The terms and concepts used in the conceptual framework originate from various theories clarified below.

Resilience of socio-ecological systems
Crawford S. Holling (1973), Lance H. Gunderson (2000), Marina Alberti & John M. Marzluff (2004), Gilberto Gallopín (2006), Muriel Cote and Andrea J. Nightingsale (2012)

The socio-ecological systems (SES) represent the dynamics of relations between human and environment, as social and ecological systems are interdependent and cannot be conceived separately (Cote & Nightingale, 2012). The resilience of these systems can be defined as their ability to withstand disturbance without flipping into another state (Gunderson, 2000). The concept helps to propose strategies addressing the issue of flood risk in the context of water-land edges along the Vistula River.

Landscape urbanism
Charles Waldheim, James Corner and others (the 1990s)

Landscape urbanism is an ethos that covers the complexity of urban ecology (Corner, 2014). Within this framework, a city is seen as a dynamic matrix of layered systems, which cannot be operated with any degree of certainty what a design outcome will be. Use of landscape in reshaping the urban form allows for accommodation of new temporal functions. Time is used as an actor in the transformation processes of disused degraded areas, while the <u>landscape is a medium</u> to restore the ecological capacities of the site. This concept is used to give clear directions for designing the edge in the urban context - the post-industrial and underutilized waterfronts in Gdansk - to reach an objective of (urban) performance and diversity of uses.

Regenerative design
Steve Larrick (1997), Pamela Mang & Bill Reed (2012), Raymond J. Cole (2012)

Mang and Reed (2012) stated a premise that the regenerative design goes beyond the mitigation of consequences of human activities. It is intended as a reconnection of social systems with the evolving ecological systems in order to improve the condition of both social and ecological systems, including the health of people and environment (Larrick, 1997). This concept enables building the capacity of society and landscapes to regenerate themselves. It allows restoration of the landscape's inherent resilience.

Landscape ecology
James D. Olson, Richard T.T. Forman, and Wenche E. Dramstad (1996), Richard T.T. Forman (2008)

Landscape ecology principles help maximize the integrity of ecological systems and minimize land degradation and fragmentation when a new entity or structure is introduced in a landscape. They encourage long-term planning and cross-disciplinary design, especially connected with environmental design. The landscape ecology principles help shape the composition of landscape and bring forward transcalar proposals.

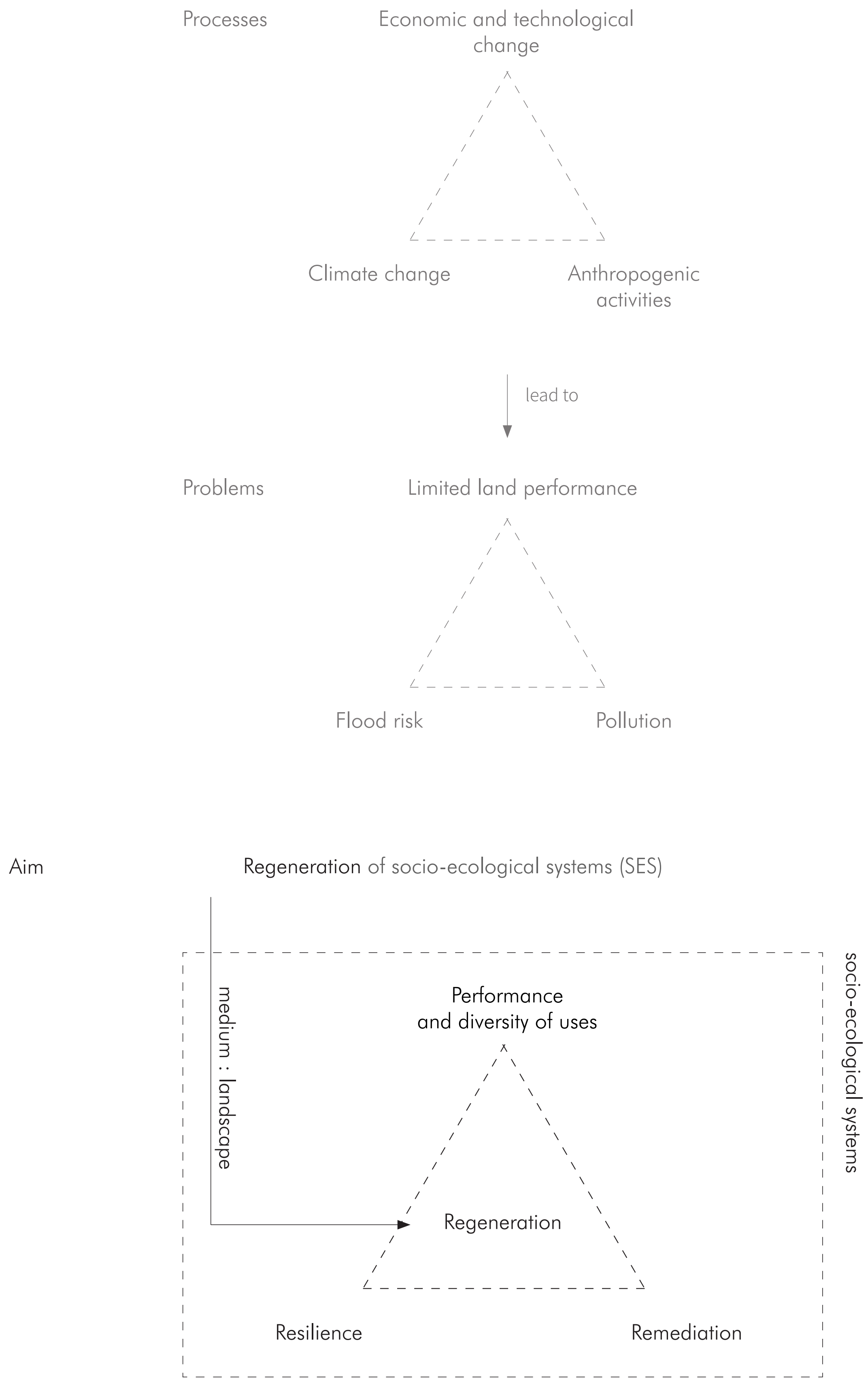


Fig. 46.
Source: author's own work

Research methods

This paragraph will elaborate on the methods which were used to answer the sub-research questions. The methodological framework of this research is built by theoretical, analytical and empirical frameworks.

Literature review is a method used in the theoretical framework. It allows evaluation of scientific literature, policies in place and professional reports about the state of the researched location. The main bodies of literature which were analyzed are landscape urbanism, landscape ecology, socio-ecological systems and regenerative design and development.
The location-based papers and reports concern primarily environmental conditions of systems in different scales, from the local to territorial.

Document analysis is used to back the research with evidence-based data derived from various reports, fact sheets and publications researched through the literature review. The qualitative information is collected through subjective-evidence-based sources such as media and websites forums.

Critical mapping aims at representing the relationships between the processes present in the territory through a juxtaposition of data collected via the literature review. It allows a better understanding of the dynamics of different systems and how they influence each other.

Site visit is a key method to understand better the researched phenomena through observation of the chosen context. Moreover, it is used to document the site through photographs, sketches and videos to back the arguments in the report and presentations.

Scenario building is used to explore possible future developments. It is based on a matrix of four different directions. The horizontal axis addresses a variety of practices, whereas the vertical axis talks about the intensity of climate change.

Stakeholders analysis is needed to examine the interest and power of various actors in the process of promotion and implementation of proposed strategies. It helps to establish what might be the possible collaboration of the stakeholders.

Research through design is used to test various spatial configurations of performative practices to manipulate the edge conditions. The method helps to develop strategies and design interventions to arrive at the projected regeneration scenarios (right side of the scenario matrix - ecology- health-driven practices).

Spatio-temporal analysis helps to imagine how the strategies and design would strengthen over time, what changes in policies are needed to support the development of the proposal and if the proposed design is capable of responding to the evolving socio-ecological systems.

Research question
Can landscape be used as a medium to cope with socio-ecological and spatial urgencies along the edges of the Vistula River through a regenerative design?

Sub-research question 1
What are the urgencies in the social and ecological systems along the Vistula River, what do they originate from and how are they interrelated?

Methods
literature review | document analysis | critical mapping | site visit

Sub-research question 2
What are the potentialities of using landscape as a medium for regeneration?

Methods
literature review | scenario building | research through design | spatio-temporal analysis

Sub-research question 3
Can the presence of spatial urgencies along the edges become a potential to respond to environmental issues of a larger territory?

Methods
literature review | document analysis | site visit | scenario building | research through design | spatio-temporal analysis

Sub-research question 4
What stakeholders could drive the transition towards regenerative practices?

Methods
stakeholder analysis | spatio-temporal analysis

Project framework

The taxonomy is used to represent the relationships between different dimensions of the project framework. The project focus which was derived from the analytical phase of the process provides a lens to examine the conditions of the landscapes throughout various scales. It creates an outline for transition parameters that are used to guide the design interventions. Using a multi-scalar approach in the analysis as well as the design allows understanding the complexity of problems and relations between them. In the design process, it reveals the possible scale of impact a design intervention might have on social and ecological systems and in the further part of the process, it helps determine how scalable and transferable the proposal might be.

The importance of incorporating temporal scales in the process is crucial especially in vulnerable landscapes like the Vistula River Delta. The edges experience flood events cyclically and therefore taking into consideration the seasonal dimension of the project is key to provide resilient landscapes. In the case of urban edges, the seasonality relates to the intensity of use and thus the social performance. Alongside cyclical changes, there are incremental changes, including the amount of agricultural runoff, future development and climate crisis. The issue of pollution is a matter of the utmost urgency in the riverine landscapes of the Vistula River Delta and that is why addressing this problem is the main objective of the initial phase of design

(short-term). The long term proposal must take into account the future possible changes affecting the riverine landscapes, namely the future development especially in the post-industrial areas as well as the uncertainty of the climate crisis. More frequent and more severe flood and drought events will require a remarkable degree of resilience of the design proposal to maintain the remediation capacity of the landscape and high social performance.

The proposed transitions of the edges, similarly to the past and current transitions, happen within both man-made and natural systems. The projected transitions materialize in the three design parameters, namely "character|function", "geometry|topography" and "vegetation diversity". They play a role in attaining the objectives of, respectively, increase of performance and diversity, resilience and remediation, which subsequently improve the social, ecological and economic performance of the edges. The design is evaluated by assessing these three dimensions of the proposal in all three samples of edges. By enhancing the social, ecological and economic performance of the riverine edges, the proposal fulfills the aim of the thesis, namely the regeneration of socio-ecological systems.

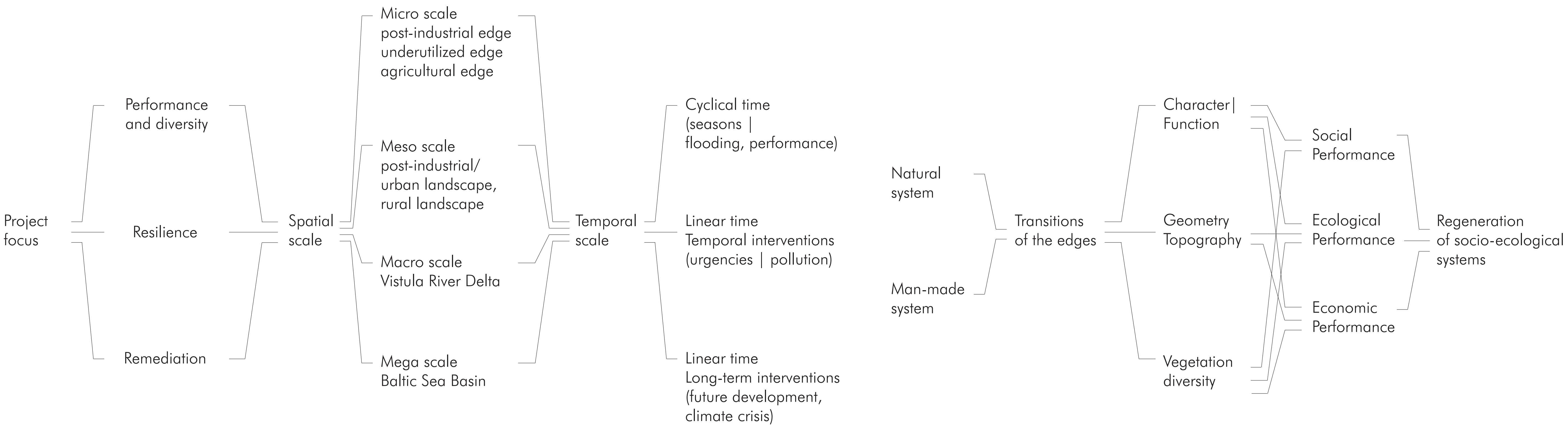


Fig. 47. Taxonomy | project framework
Source: author's own work

Chapter 4

Spatial strategies

The chapter illustrates proposal for further transition of the edges along the Vistula River with a focus on the agricultural edge in the Vistula River Delta, the underutilized and the post-industrial edge in the city of Gdansk.

Fig. 48. Marine yacht club by the Dead Vistula River in Gdansk
Source: author's own photograph | field trip February 2021

As the awareness on ecology increases, so does the desire to remediate polluted landscapes such as post-industrial landscapes, roadways, river corridors or agricultural fields. The possible ways to approach this problem vary in terms of disturbance to the site. The remediation practices may range from the use of plants (phytotechnology) or partial removal of the soil to large-scale engineering works. The choice of a method or a mix of methods depends on the type and severity of pollution present on site.

"Phytotechnology is the use of vegetation to remediate, contain or prevent contaminants in soils, sediments and groundwater, and/or add nutrients, porosity and organic matter.
It is a set of planning, engineering and design tools and cultural practices that can assist landscape architects, site designers, engineers and environmental planners in working on current and future individual sites, the urban fabric and regional landscapes."

definition by Kirkwood and Kennen (2015)
as an expansion of previous definitions
(Rock, 2000; ITRC, 2009)

The mechanisms of phytotechnology include:
(O - organic pollutants, N - inorganic pollutants)
Phytovolatilization (O, N) - a plant releases the contaminant as a gas through plant leaves and stems.
Phytodegradation (O) - a plant takes up the pollutant from the soil and breaks it down to smaller parts.
Phytometabolism (O, N) - a plant processes nutrients (inorganic contaminants) and turn them into plant parts (organic contaminants are first broken down in the process of phytodegradation).
Phytoextraction - (O, N) - a plant extracts the contaminant from soil and water and stores it in plant parts. A plant with inorganic pollutants must be harvested.
Rhizodegradation (O) - a plant or soil microbiology around the roots release root exudates which breaks down the pollutant.
Phytohydraulics - (O, N) - a plant pulls water upwards through roots to leaves and may pull contaminants together with water.
Phytostabilization - (O, N) - a plant holds the pollutant in place to prevent its spread.

Another advantage of phytotechnologies is that they are less expensive than conventional industry remediation practices and there is a potentiality to use the vegetation to temporarily change the character of an area undergoing remediation. This means that the designed landscape could have multiple functions, including next to purification of water and remediation of soil, increasing resilience to the extreme weather conditions as well as improving social performance of a space.

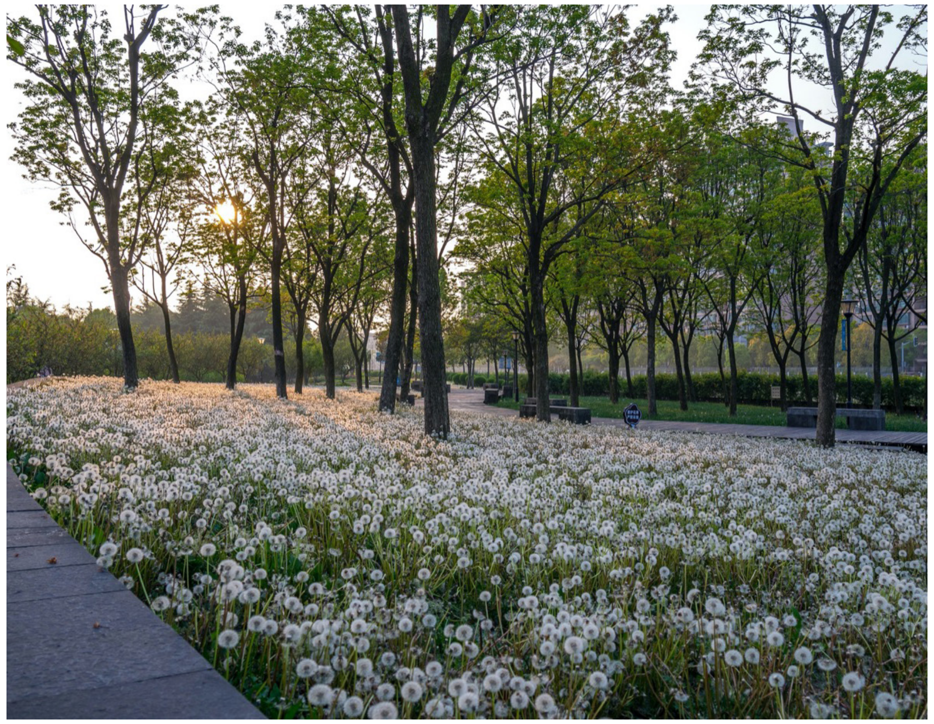


Fig. 49. Qingpu Nanjing Parkby Design Land Collaborative (DLC) | Source: landezine.com
Fig. 50. De Ceuvel by DELVA Landscape Architecture | Urbanism | Source: landezine.com
Fig. 51. Weiliu Wetland Park by Yifang Ecoscape | Source: landezine.com

Spatial scale
social and ecological impact of interventions

The issues and processes identified in the problem field are embedded in various scales, starting from a micro scale where a particular section of the river was altered to national projects and their consequences in larger scales of a region and eventually the state of the sea. The ambition of the proposal is to contribute to the improvement of the ecological, social and economic resilience locally and regionally by transitioning the riverine edges. The main design scale of the project is the micro scale. After defining the prevailing issues related to the past transitions of the edges, the choice was made to focus in the design assignment on the condition of agricultural edges in the Vistula River Delta and the post-industrial and underutilized edges in the city of Gdansk.
I chose the agricultural land edge as agriculture is the biggest factor that contributes to the eutrophication of the Baltic Sea (HELCOM, 2015), whereas the choice of Gdansk was made because the condition of the land-water edges in the city has been greatly transformed throughout years and is still in transition in order to meet the requirements of the industries and the port (Lorens & Lewicki, 2018).
The proposed design interventions could be transferred along the edges of the Vistula River and its distributaries leading to the ecological continuity of the riverine landscape. The strategies could be spread also through the tributaries of the Vistula River to further maximize the effects of the transitions.
Next to the positive impact on the riverine and marine ecosystems, the project is meant to influence the society inhabiting the riverine landscapes by increasing their resilience to environmental changes as well as providing them with access to the river edge and thus increase the human-nature connectedness.

Spatial scale
- Micro scale
  post-industrial edge
  underutilized edge
  agricultural edge
- Meso scale
  post-industrial/
  urban landscape,
  rural landscape
- Macro scale
  Vistula River Delta
- Mega scale
  Baltic Sea Basin

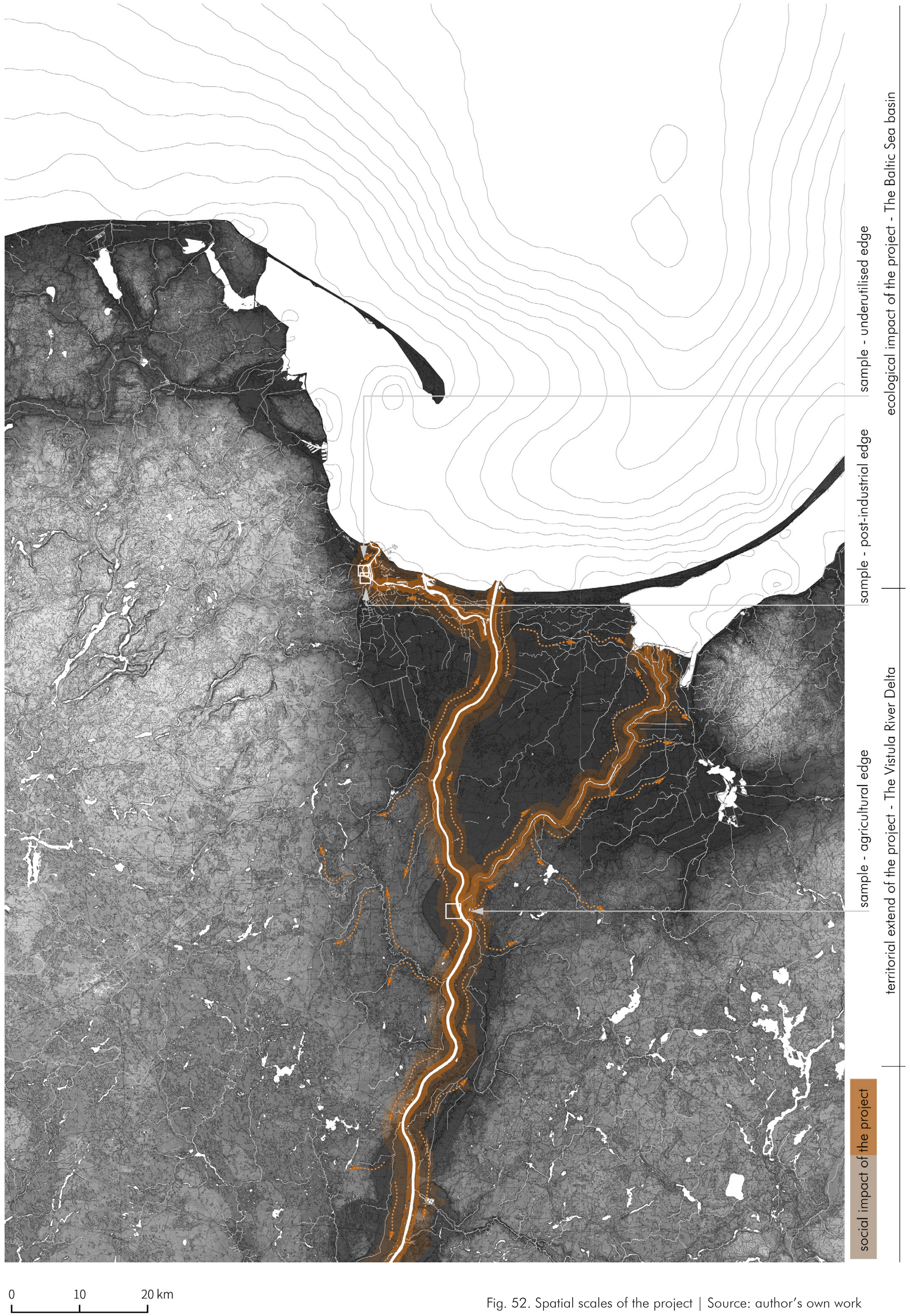


Fig. 52. Spatial scales of the project | Source: author's own work

Temporal scale
cyclical and incremental change

As transitioning of the edges is a process of a gradual alteration of the edge conditions, it requires looking at the temporal dimension of the current and future events affecting the state of the edges. They include the anthropogenic pressures such as future development in the city (Young City, Gdansk) and port area (The Central Port, Gdansk) as well as larger infrastructure projects (creation waterways and dams). Next to that, there is growing pressure from the climate crisis, namely more severe flood events and drought periods.
Recently observed and confirmed by scientific research water deficits and ever-smaller flows in rivers have become a pressing problem in Poland. They are mainly the result of the lack of snow cover in winter and prolonged rainless periods. In the case of the Vistula River, the water levels in the spring of 2020 at the water gauge in Warsaw were at an extremely low level. According to the data from the Institute of Meteorology and Water Management on May 28 2020, the Vistula River reached an unprecedentedly low water level of 64 cm.
The observed trend over the last 10 years is decreasing, which leads to water deficits, reduced flows and, consequently, raises concerns not only about the availability of water for water supply to people, agriculture, industry and water and sewage management but also decline the supply of groundwater resources. Currently, in Poland, only about 6-6.5 percent of the average annual runoff from the country is kept in retention reservoirs, whereas in neighboring countries with similar hydrological conditions this ratio is almost twice as high (more than 10%) (Zalewski et al., 2020).
Increasing resilience to extreme weather conditions is therefore a key, most notably in the polluted landscapes as the changes in the water flows would alter the flows of the pollution through the soil layers.
In the urban areas changes of use of the edges often require prior preparation of the site for further development, particularly in the post-industrial areas such as the Young City in Gdansk. The severe pollution present on site must be removed before the new development project is implemented. The pace of the remediation processes would be therefore different in the areas where there is a desire for future development and in the areas where those kinds of time constraints are not present.

Temporal scale
- Cyclical time (seasons | flooding, performance)
- Linear time Temporal interventions (urgencies | pollution)
- Linear time Long-term interventions (future development, climate crisis)

Fig. 53. Flood event, the Vistula River in Warsaw, May 2019 | Source: twojapogoda.pl
Fig. 54. Drought, the Vistula River in Warsaw, April 2020 | Source: picture from a video by Maciej Margas & Aleksandra Łogusz (Poland on air)
Fig. 55. Henning Larsen Architects' proposal for revitalization of Gdansk Imperial Shipyard, visualization by Plankton Group | Source: Archdaily

Edges
different characters along the river

The sections of the edges chosen for the design interventions are exemplary locations of landscapes that differ in character. Looking at their current state, we can say the edges of the Vistula River transition from the natural and soft in the deltaic agricultural land to the man-made and hard in the port city of Gdansk. Simultaneously, the more natural edge, the less diverse uses of the land.

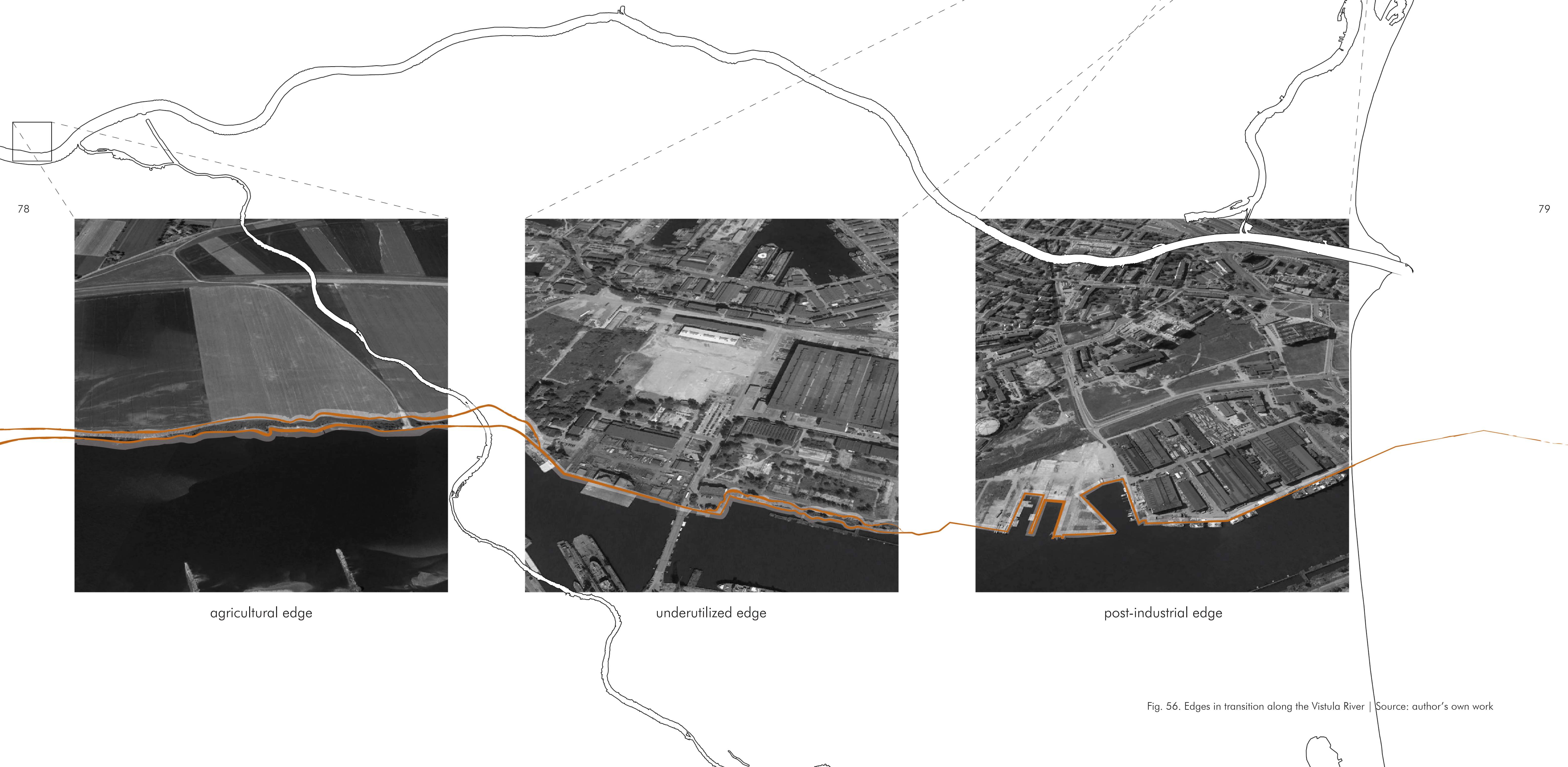
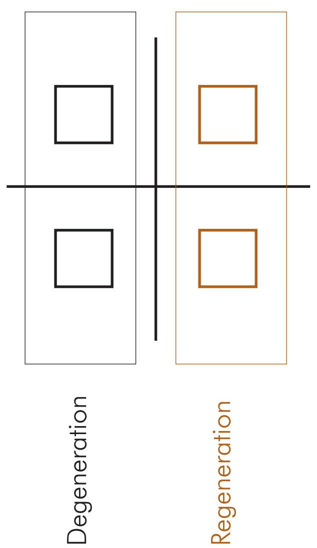
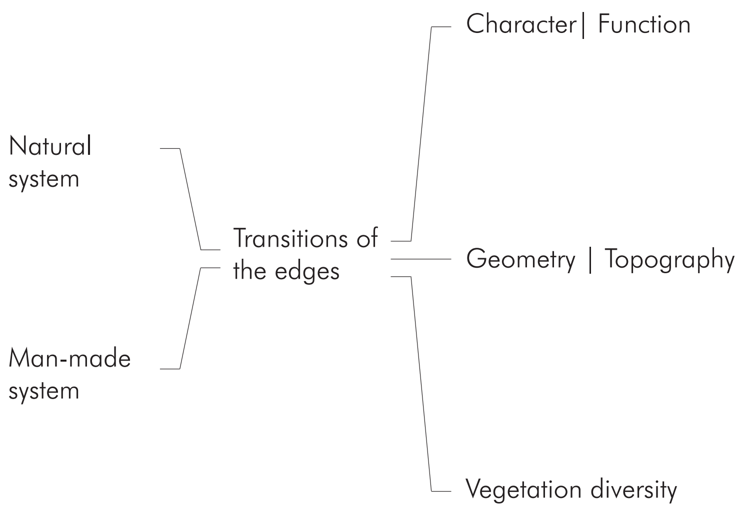


Fig. 56. Edges in transition along the Vistula River | Source: author's own work

Edges
current state

The current state of the riverine edges can be analyzed through lenses of character/function, geometry/topography and vegetation diversity. They influence respectively the performance of the edges, the resilience to extreme weather conditions and the remediation capacity. The schematic maps and sections juxtapose the conditions of the three types of edges within the aforementioned themes which influence the regeneration capacity of the landscapes.
The social performance of the edges depends on their accessibility and the diversity of functions of the landscape. Therefore it gradually increases in the spectrum from the agricultural to the post-industrial edge. On the other hand, the ecological performance of the edges depends on their abruptness and softness, and thus it gradually decreases seaward as the edge becomes hard in the city of Gdansk.
Topography, as well as the permeability of the edge, determines the possible accommodation of the ecological processes such as flooding, storm water management and habitat diversification.
The latter improves the remediation capacity of the edges as diverse, connected and densely distributed patches of vegetation process the pollution coming from the agricultural runoff and industrial activities as well as during flood events from the contaminated water and sediment.





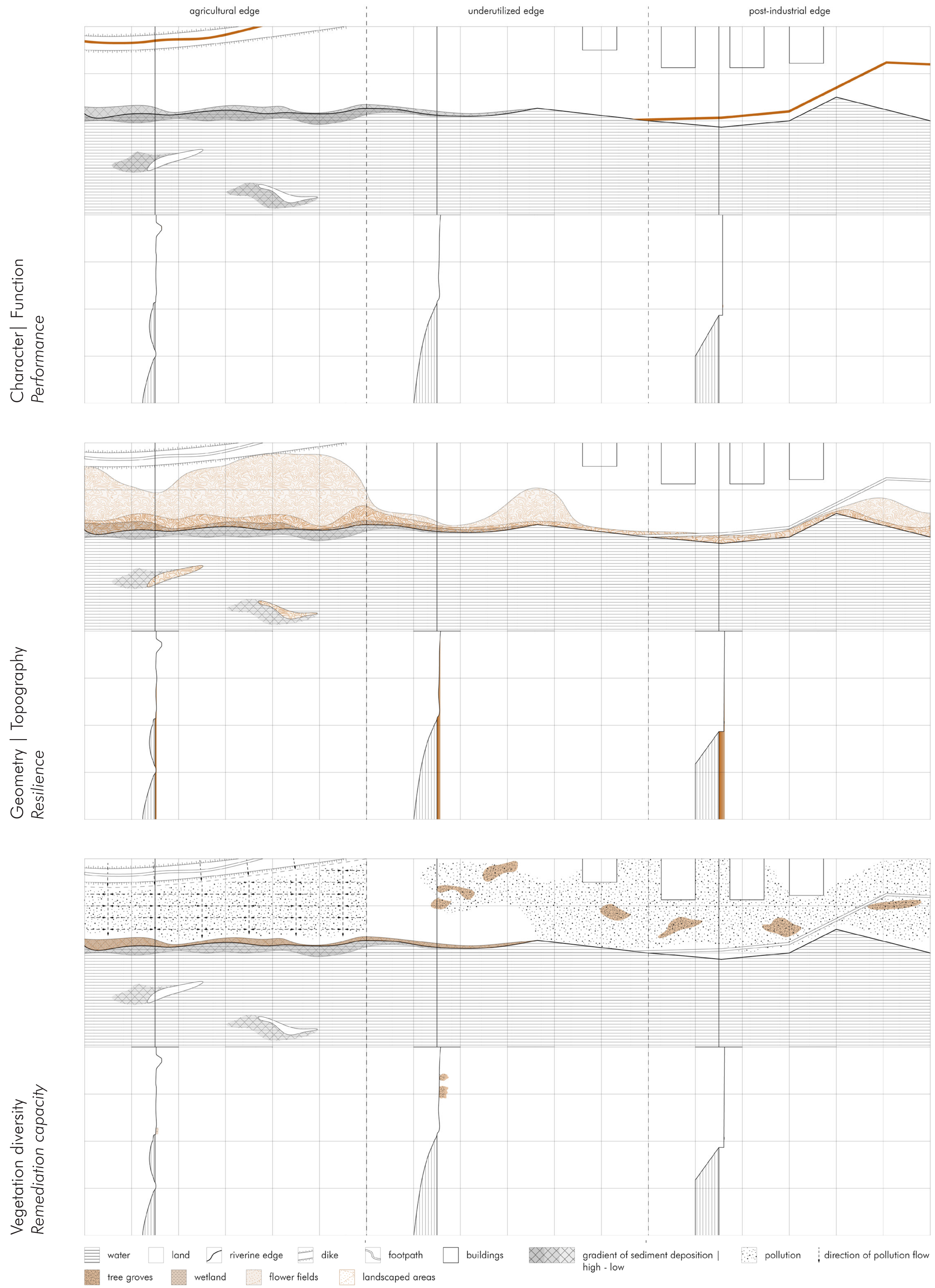


Fig. 57. Current state of the edges | Source: author's own work

Transitions of edge conditions
towards degeneration

The continuation of business as usual practices may lead to further degeneration of the socio-ecological systems along the Vistula River. Transitioning the river into an inland waterway would require constructing dams that would lead to reduced water retention capacity, higher amount of pollution and higher risk of flooding. Whereas, using the waterfronts in Gdansk for industrial activities would further contaminate the water and soil in the edges.

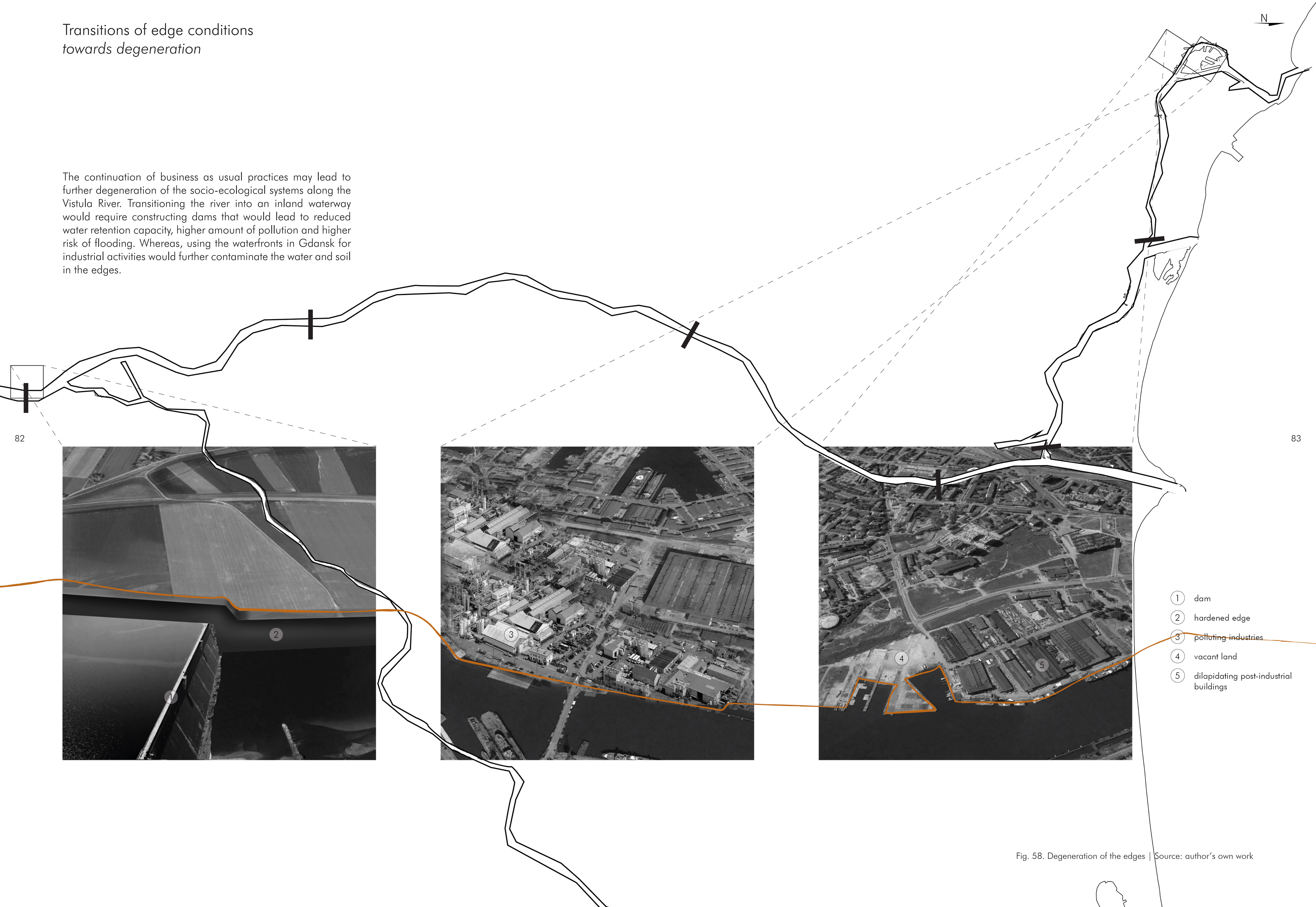


Fig. 58. Degeneration of the edges | Source: author's own work

Transitions of edge conditions
towards regeneration

In the strategy for regenerative riverine edges, landscape is used as a medium to transition the functions, the topography as well as to increase the diversity and amount of vegetation in the edges. The edge design is scalable and transferable as it spreads and transitions along the Vistula River as the landscape and the conditions change.

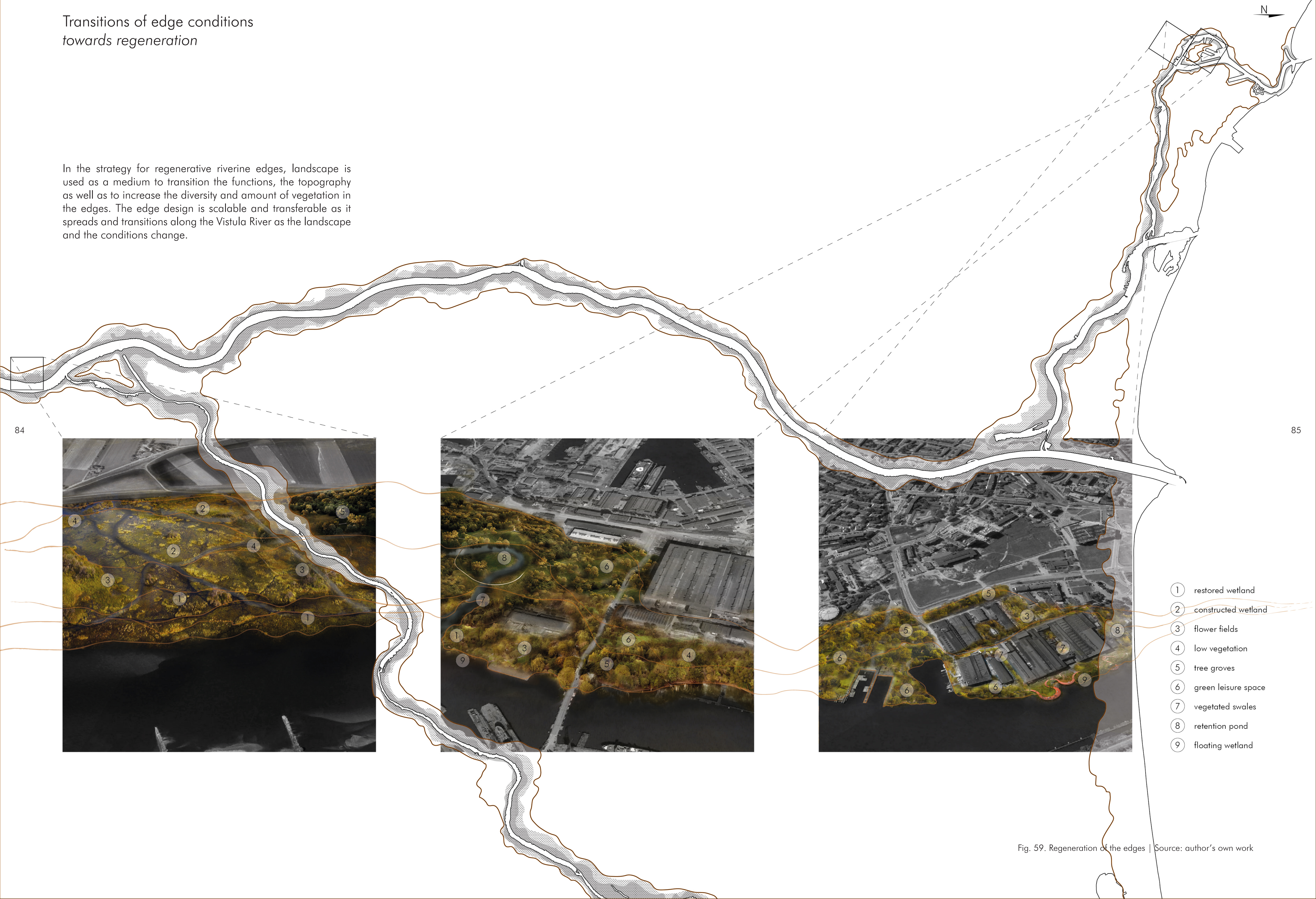


Fig. 59. Regeneration of the edges | Source: author's own work

Regeneration
performance and diversity of uses

The objective of an increase in performance and diversity of uses relates primarily to the social and economic dimensions of the project. Today, the social performance of the riverine landscapes of the Vistula River is limited because often the accessibility to the edges is restricted to land owners or employees of the industries occupying the waterfronts. In recent years the post-industrial edge was in large part made accessible to the public and there can be seen a rising interest of the residents in this area and thus a higher social performance of it as some permanent and temporal functions occur along the edges.
Expanding the accessibility of the post-industrial edge and allowing access to the surrounding underutilized edge as well as to the agricultural edge in the Vistula River Delta would enhance the connectedness of the riverscape. The creation of a network of quality open spaces with various uses would foster entrepreneurs and spark economic development of the riverine landscape.
Simultaneously, the higher structural diversity of the vegetative edges would provide higher resilience to water fluctuations and thus increase biodiversity (Dramstad et al., 1996). These transitions would therefore improve the environmental performance of the riverine systems.

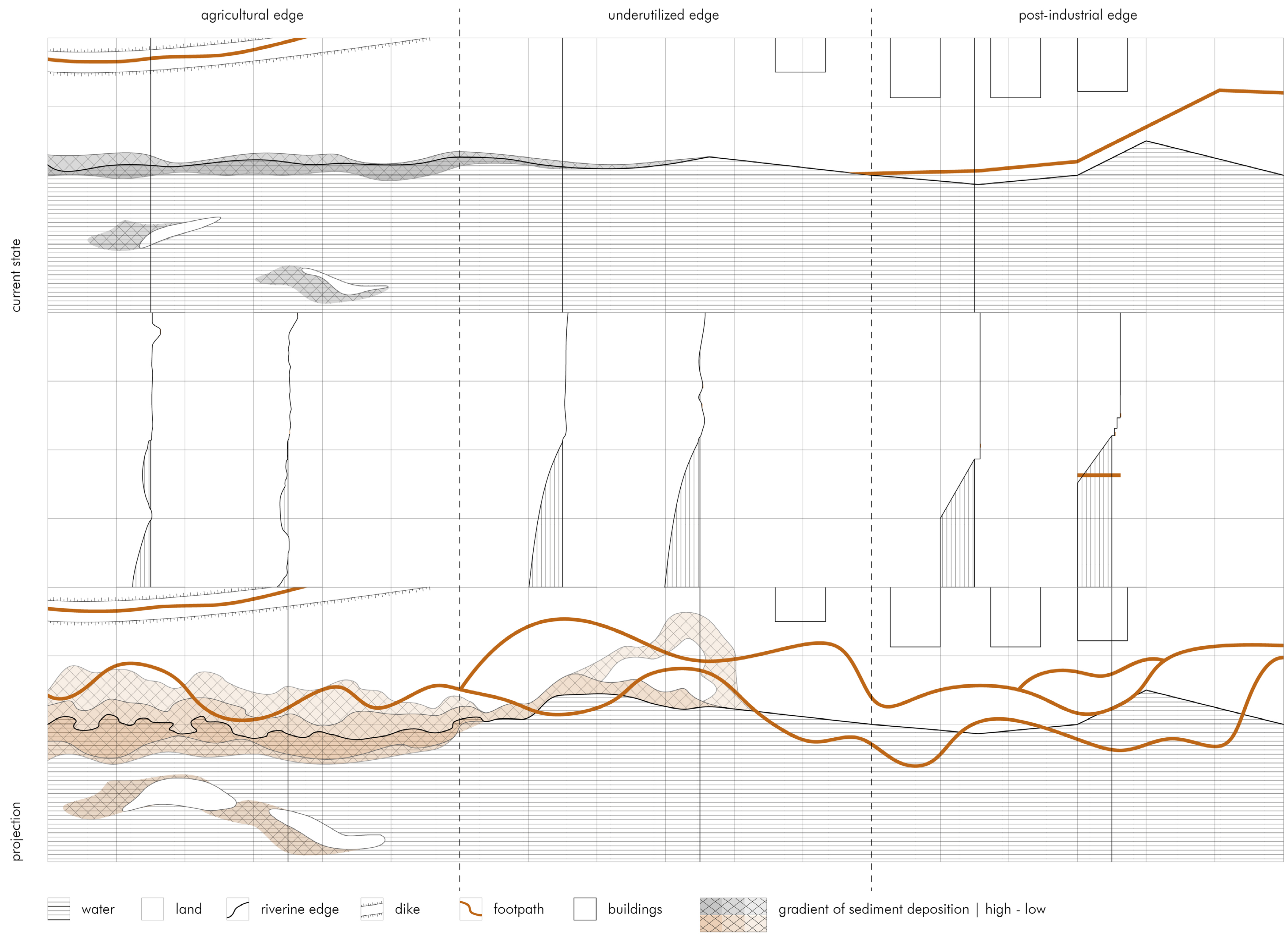


Fig. 60. Transition towards higher performance of the edges | Source: author's own work

The Vistula River is facing more frequent and severe flood events and periods of drought due to the climate crisis. The river edges are therefore the most risk-prone sections of the riverine landscapes. The current spatial conditions of the edges, namely the flat terrain and relatively straight boundaries between water and land lead to uncontrolled inundation of considerable land area during flood events as well as a rapid runoff of the floodwater to the river caused by limited permeability of the ground. Increasing topographic diversity and curvilinearity of the edges would allow for directing the flow of water through the landscape. Moreover, soil unsealing would result in a higher water storage potential of the riverine areas. The network of green and blue spaces would provide a wide range of ecosystems services, including water regulation. In this way, the edge would become an agent of transition towards the resilience of the landscape and thus the regeneration of it.

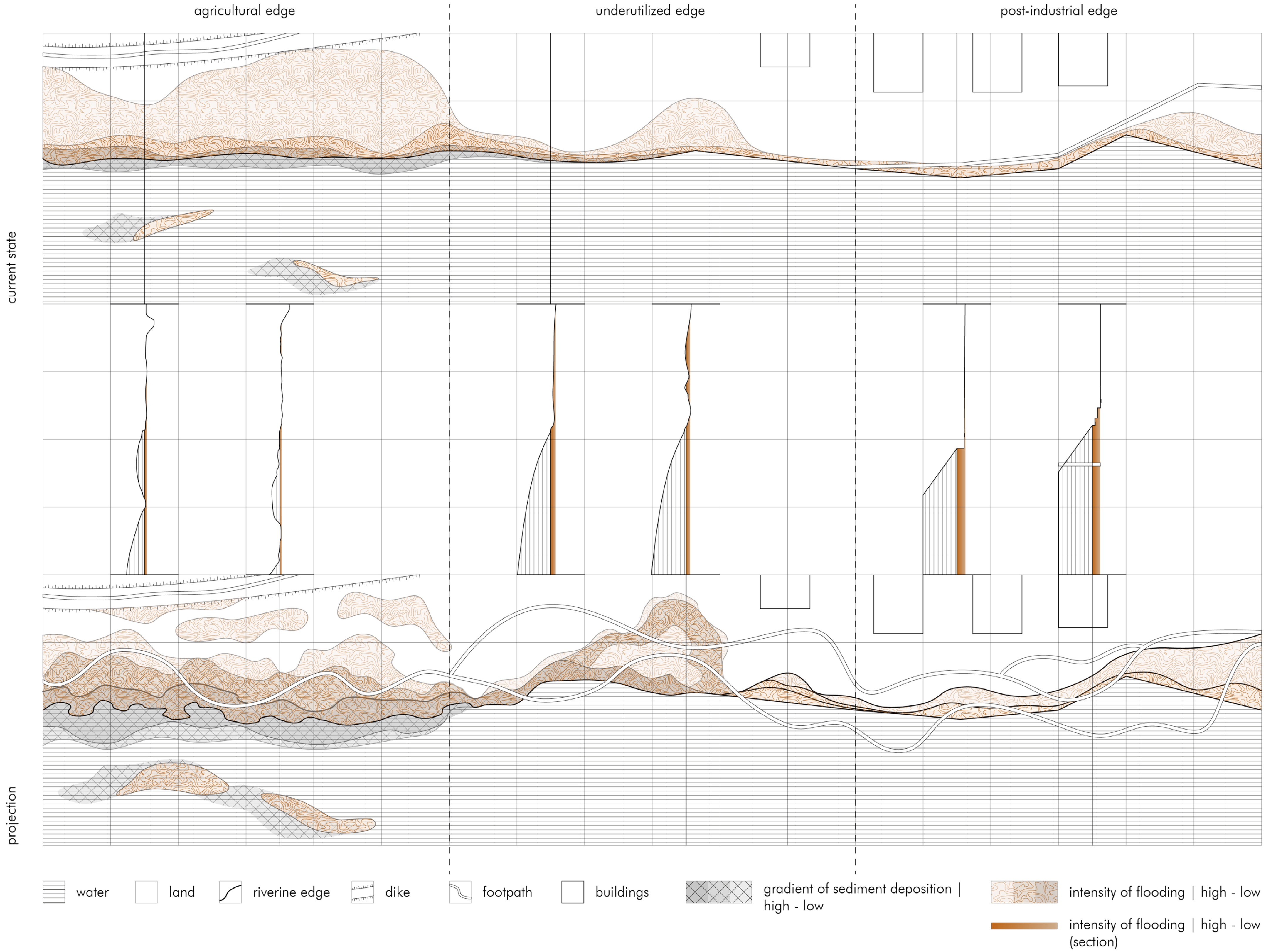


Fig. 61. Transition towards higher resilience of the edges | Source: author's own work

Regeneration
remediation

The pollution present in the edges of the Vistula River has its sources primarily in agriculture and industries. In the case of the post-industrial edges, the amount of industrial pollution present on site is not increasing at the same pace as in the past, since most of the industrial activities have been terminated. Whereas in the rural areas the agricultural runoff remains a dynamic process and therefore the river constantly receives the contaminants from the agricultural fields. Moreover, all three types of edges are brought under pressure because of storm water runoff and the floodwater which carries pollutants in the suspended sediment. Increasing the amount of space available for vegetation would be a significant trigger for remediation of the edges by means of phytotechnologies. Alterations in the topography allow the use of a wide spectrum of vegetation ranging from permanent and semi-permanent wetlands to ephemeral wetlands. Thanks to the higher topographic diversity and biodiversity the polluted water is directed through the landscape, gradually decontaminated and slowly discharged to the river.

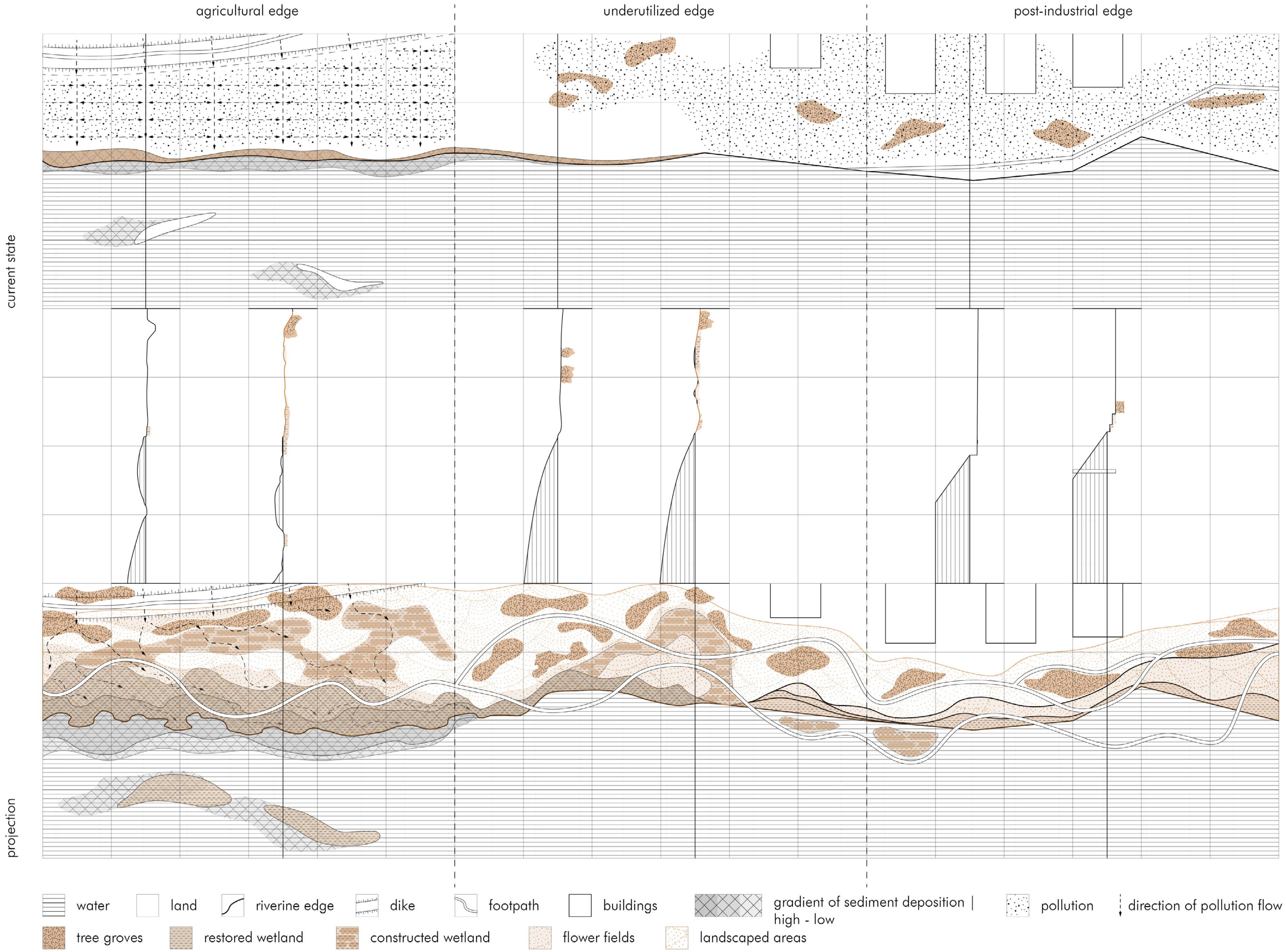


Fig. 62. Transition towards higher remediation capacity of the edges | Source: author's own work

Stakeholders
analysis

Transitioning the edges influences not only its physical appearance but also the performance of riverine ecosystems as well as society. Edges are the space where matter, topos and habitat meet. Therefore the proposal needs to address the complexity of those systems and lead to dynamic equilibrium between them. The systems of matter, topos and habitat function throughout different scales, which gives the project a multiscalar dimension, where a change in the micro scale may have an impact on the mega scale. Consequently, the project stimulates the interest of institutions, organizations and groups working with matter, topos and habitat on various scales.
As the aim of the proposal is to regenerate the socio-ecological systems along the Vistula River, the project has an ecological and social dimension and next to that also an economic dimension.
The ecological dimension is present from the micro scale of edge ecosystems to the mega scale of the Baltic Sea ecosystems. That is why the project may attract both the local organizations that focus on improving the quality of degraded ecosystems in a particular section of the riverine landscape as well as international organizations focusing primarily on the state of the Baltic Sea. They include HELCOM (Baltic Marine Environment Protection Commission) which cooperates with the governments of the Baltic Sea States to protect the Baltic Sea's ecosystems from all sources of pollution. Similarly, the Baltic Sea Action Group (Foundation for a Living Baltic Sea) works with the public and private sector to restore the ecological equilibrium of the Baltic Sea. Poland based organizations, such as EKO-UNIA address both the issues of the Baltic Sea and the Vistula River.
The social and economic dimension of transitioning the riverine edges would draw the attention of the local communities and especially the land owners. Possible diversification of functions would be beneficial for the economy of the place and thus its economic resilience. Moreover, the national water management institutions (e.g. Polish Waters) that work with the causes and consequences of flooding and droughts should find the proposal intriguing as it is a sustainable alternative to the currently proposed degenerative practices, such as regulating the rivers. Furthermore, making the edge accessible and simultaneously resilient to flood events would lead to an improvement of the people's quality of life.
Next to the interest dimension, there is the power dimension which influences whether the project is realizable. In order to achieve the aim of regeneration of SES, the values of the stakeholders with the most power need to be aligned with the values of the project. It is therefore important to reach that alignment by the cooperation of decision-makers with the environmental organizations and the society.

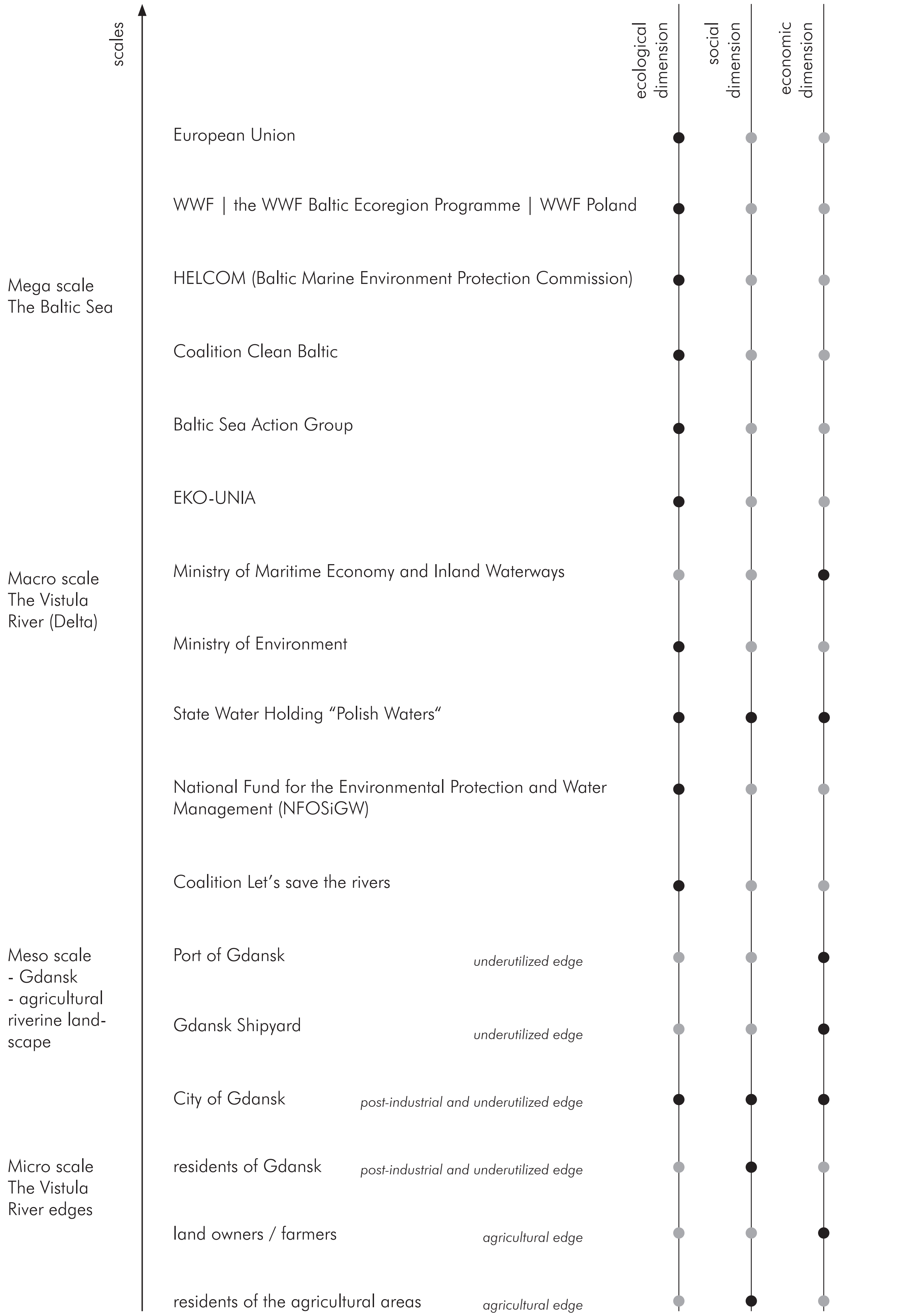


Fig. 63. Stakeholders' interests | Source: author's own work

Stakeholders
engagement

The current government's plans related to the future of the riverine edges are, however, opposite to the postulates of the environmental organizations. In 2016 the Ministry of Maritime Economy and Inland Waterways drafted a plan to develop inland waterways by diverting Polish rivers. The government narrative about the benefits of such actions is questionable. On March 12th 2021 the State Water Holding "Polish Waters" published a contract notice for the development of documentation for the construction of another barrage on the Vistula River (in Siarzewo, to the north from the Włocławek dam). The proposed barrage is communicated as an environmentally friendly project which will limit the consequences of droughts and flooding. However, as mentioned in the problem field chapter, the construction of the Włocławek dam had adverse effects on the ecosystems and resilience to extreme weather conditions. The environmental organizations, including WWF Poland, give counterarguments regarding not only the impact the project would have on the environment, but they also question the cost-effectiveness of the barrage. There is a need for a debate between the decision makers and pro-environmental stakeholders as the approaches represented by these two groups are conflicting. Moreover, the public has to be provided with reliable information about the consequences of both business-as-usual practices and regenerative practices. By engaging in the discussion with NGO's and society, the authorities would see the benefits of an opposite take on the matter and eventually could be convinced to withdraw from the proposed project and start cooperation with the environmental organizations towards the future regeneration of the riverine system.
The changes that would happen in the micro scale during the riverine edges transitions would be particularly important to the land owners in the agricultural landscapes, namely the farmers who use the edges as croplands. Currently, their agricultural activity on the edges is a source of their income. When proposing changes in the use of the edges it is essential to provide another source of income within the design as part of the compensation for the farmers' community. One of the ways to do that is to use the plant biomass originated that from phytotechnologies.
Next to the financial benefits of the project for the local communities (economic resilience), it would also increase the ecological resilience and social resilience by minimizing the negative consequences of the extreme weather events.
In the case of underutilized edge on the Ostrow Island in Gdansk, there is a need to convince Port of Gdansk and Gdansk Shipyard to collaborate with the city of Gdansk in order to move the remaining industrial activities from the island to the future Central Port and allow the city to develop on the island. That would be beneficial not only for the city residents and the city itself but also for the port authorities since the depth of the Dead Vistula River is shallower than of the planned Central Port which means that moving the activities seaward would reduce the amount of work related to deepening of the Dead Vistula River.

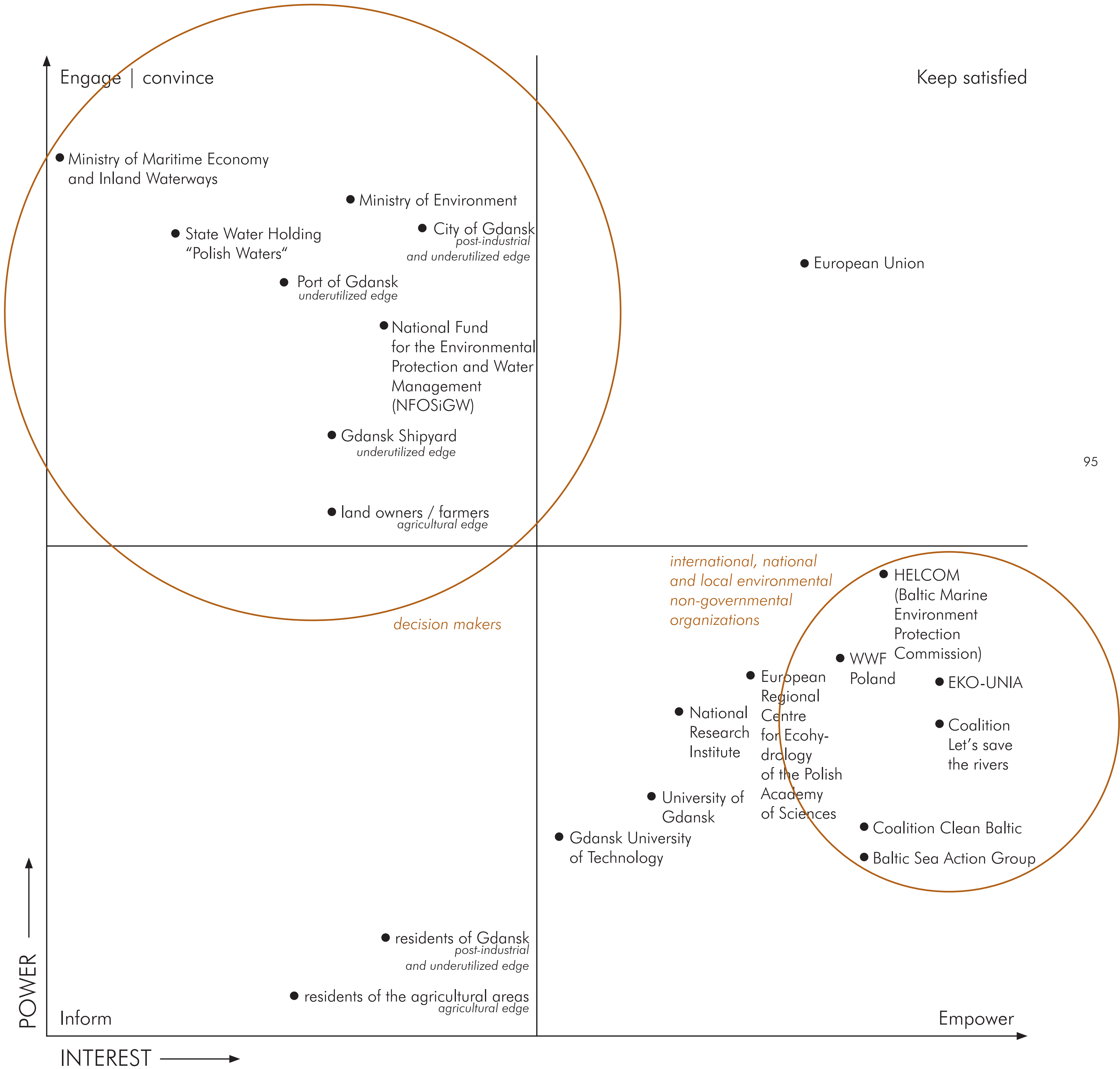


Fig. 64. Stakeholders' power interest matrix | Source: author's own work

Stakeholders
ownership and maintenance

The transitioning of the edges requires specific management actions. There are different ways to lead the process of regeneration. They depend on who owns and who maintains the site.

In the agricultural edges, the farmers own and manage the land. If this remains, then in order to shift the land use, the farmers could get subsidies from the government and EU to implement more regenerative landscape uses. As mentioned before, they could receive revenue from biomass from harvested vegetation. If the land became publicly owned, the landowners would need to receive compensation from the government for their land. If the maintenance was on the public side the governmental water management institution would need to collaborate with municipalities to coordinate the implementation of the strategies on a local scale.
However, if the land became publicly owned but privately maintained, the compensation for landowners could be lower since they would be able to gain profit from the maintenance of the land, including biomass production from the vegetation used for bioremediation.

In the post-industrial and underutilized edges in the city of Gdansk, similarly to the agricultural edge, there must be a dialogue between different groups of stakeholders, namely the city, the port, the shipyard, future developers and city residents. Some of the post-industrial edges are already included in the city development plans, however, the issue of pollution and remaining activities needs to be addressed first in order to further develop the sites. The remaining industries in the areas such as the Young City could receive tax remission to move their activities to the underutilized areas in the inland port, or later on also to the outer port.
The funding of the remediation projects could be granted by various stakeholders. One of them could be industries that polluted the landscape in the past. They could get tax remission for investing in decontamination of the land which they formerly used. The second option is that the city itself would pay for these kinds of projects since they would improve the social, ecological and economic performance of the city. And lastly, future developers could manage the remediation of the sites with subsidies from the city.

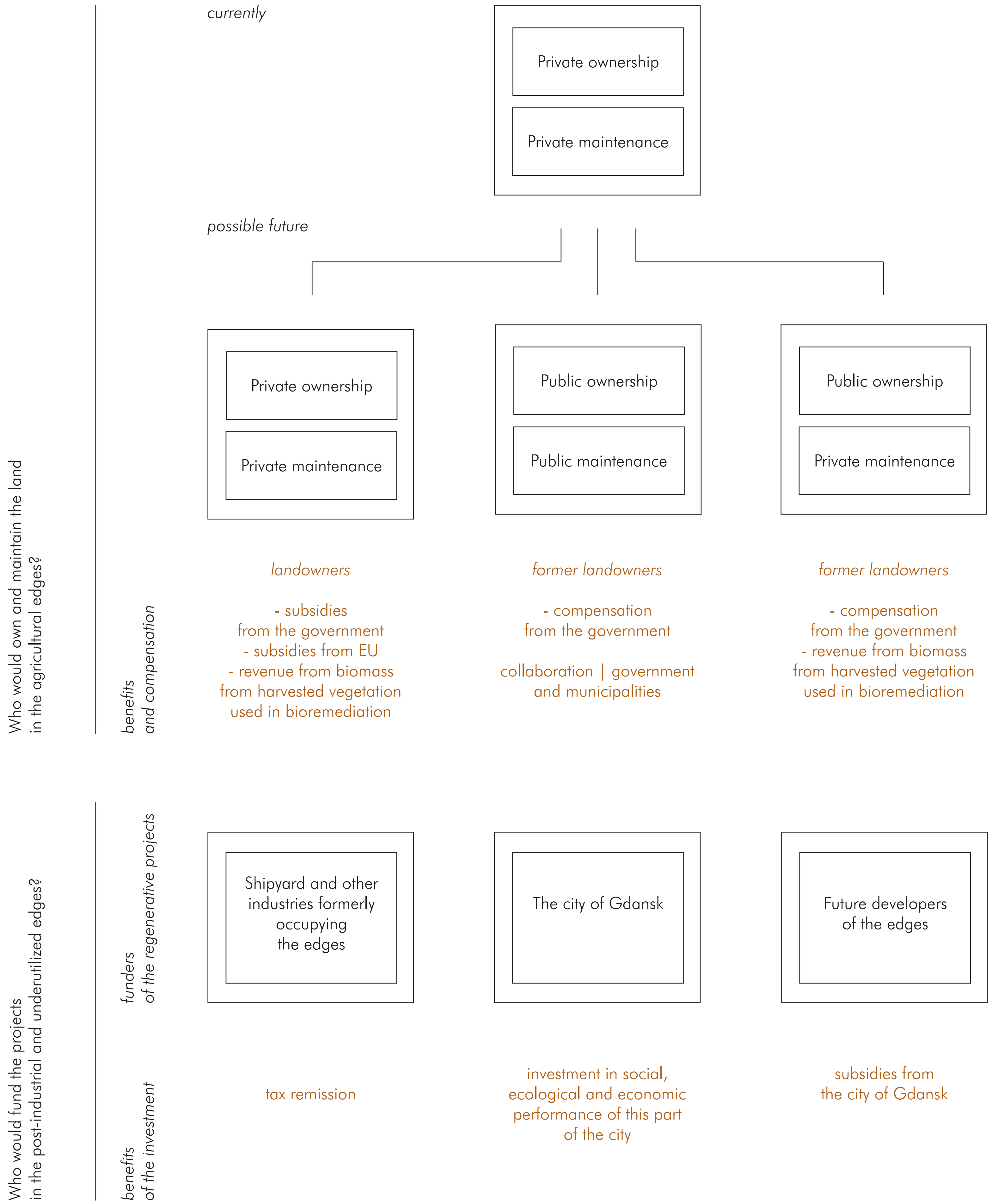


Fig. 65. Stakeholders' power interest matrix | Source: author's own work

Fig. 66. The Dead Vistula River | view towards the Ostrow Island and the Young City
Source: author's own photograph | field trip February 2021

Chapter 5
Regenerative design

The chapter illustrates design interventions in the chosen sites within the post-industrial and agricultural edges.
The section explains the process of implementation of the design principles in the space and time following the short-term and long-term goals.

Regenerative interventions
micro scale

For each type of the edges, I have chosen a site to indicate the visible and non-visible differences between the three defined edges types using a specific location. The conditions of each site vary and therefore each of them is provided with a particular approach to reach the aim of regeneration of socio-ecological systems. And thus a particular set of design interventions. Transitioning of each site has diverse objectives in terms of social, ecological and economic performance.

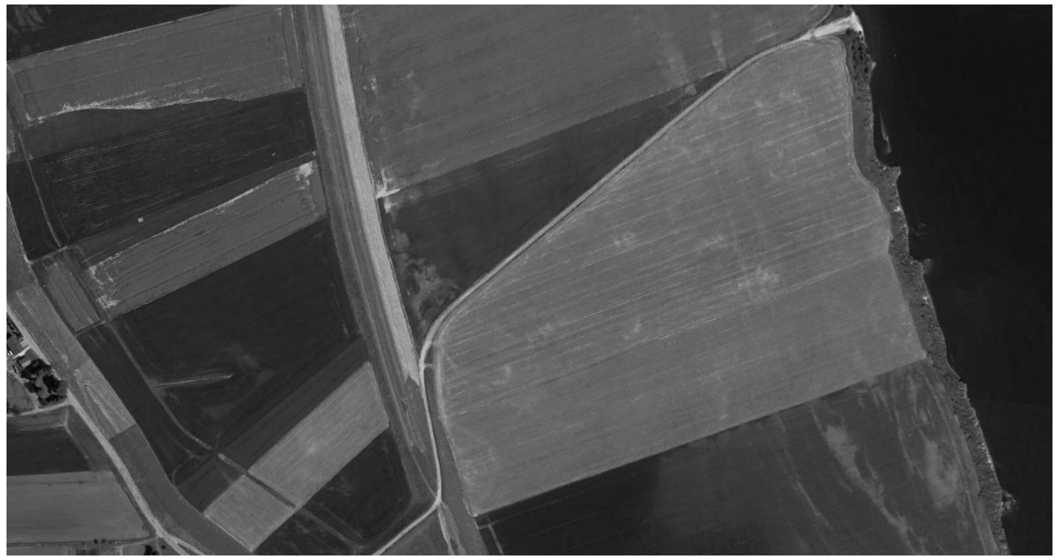
To understand the current condition of the edges I defined nine parameters that describe the sites. I then grouped them according to impact on the state of performance, resilience and remediation (see the next page). They are natural/man-made system, future change of a function (development plans etc.), the proposed change of a function (design proposal) under the performance and diversity; topography, soil types and water fluctuations under the resilience; and kind and flow of pollution, connectivity of vegetation patches and land availability for vegetation under remediation. From this matrix, I derived three parameters that could be altered using design. They are namely future uses of the edges, the topography and the amount of land for vegetation as well as the kind of vegetation present in the riverine edges.

underutilized edge

300 m

570 m

agricultural edge



600 m

1140 m

post-industrial edge

300 m

570 m

Fig. 67-69. The Vistula River edges
Source: Google Earth

Regenerative interventions
design parameters

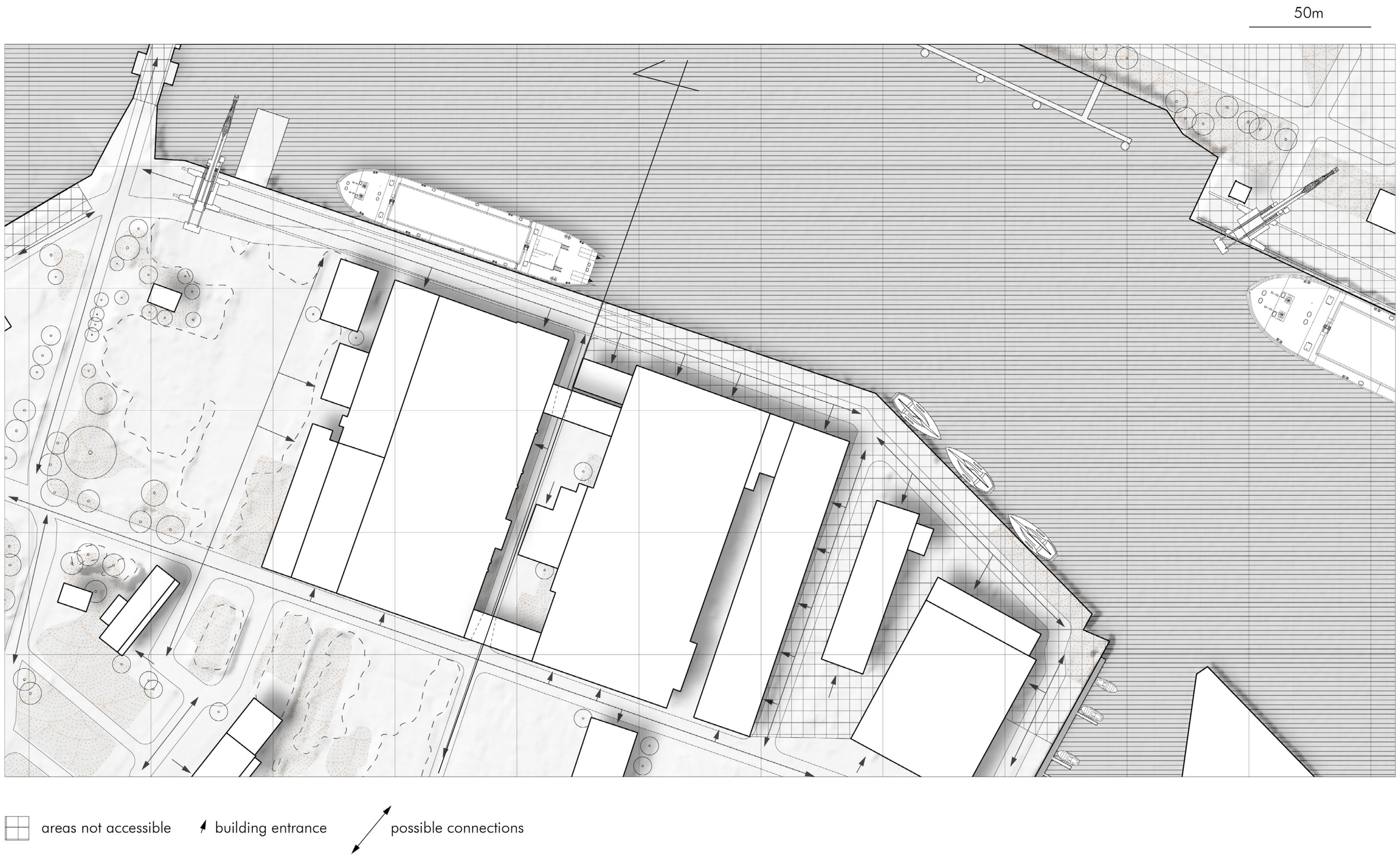
		agricultural edge	underutilized edge	post-industrial edge
performance / diversity (biodiversity, diversity of uses)	system	natural (soft edge)	man-made (hard and soft edge)	man-made (hard edge)
	future change of function	not known	possible lower industrial performance seaward movement of the industry	urban function
	proposed change of function	wetland high ecological performance	port-city transition landscape intermediate social and ecological performance	urban function high social performance
resilience	topography	floodplain	flat slopes	flat slopes
	soil type	fluvisoil	fluvisoil (partly sealed)	fluvisoil (sealed)
	water fluctuations	cyclical flooding	occasional flooding	occasional flooding
remediation	kind and flow of pollution	agricultural fertilizers | constant flow	industrial pollutants | occasional flow	industrial pollutants | occasional flow
	connectivity of vegetation patches	high	medium	low
	land availability for vegetation	wide edge	changing width of the edge	narrow edge

Fig. 70. Design parameters
Source: author's own work

Fig. 71. The Dead Vistula River | view towards the Young City
Source: author's own photograph | field trip February 2021

Post-industrial edge
spatial conditions
and potentialities

The chosen post-industrial edge is a part of the Young City in Gdansk, an area formerly occupied by shipbuilding industries. Since the shipyard bankruptcy in the 1990's the site was not accessible and only recently it has been opened to the public. The section of the site which is shown on the map as not accessible is still used for industrial activities. The rest of the built fabric is not occupied by any functions. However other parts of the Young City are already going through an urban activation process. The impact interventions in this area include an outdoor cinema, restaurants, concert venues and a dancing school.
Currently, the chosen site serves an educational function as it informs, with a help of info points, about the Gdansk shipyard heritage. Even though the area is in close proximity to the city center the social performance is limited since the roads and the pathways dead-end on the bridge leading to the Ostrow Island. There is a potentiality of opening the entire site to the public to ensure an undisturbed movement of people along the river edge. Next to that the access to the island from the Young City side would allow the flow of people through the island, as for now only one out of two bridge connections can be crossed by the public.
The riverine edge in the post-industrial landscape is characterized by its hardness which separates the land from the water. However, during flood events, the limited resilience capacity of the hard edge is prominent. Alteration of the edge section would make the edge more accommodating of flooding and storm water management. It would allow for water and land to blend and be ecologically sustainable, contrary to the channelized river.



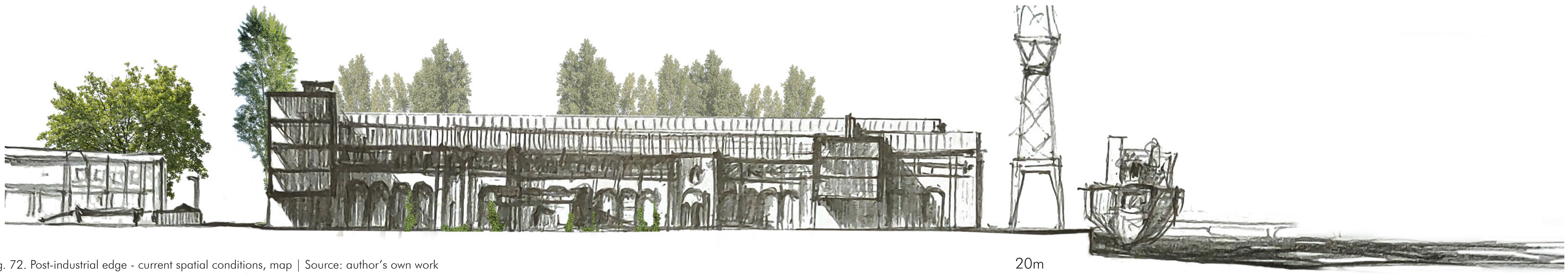
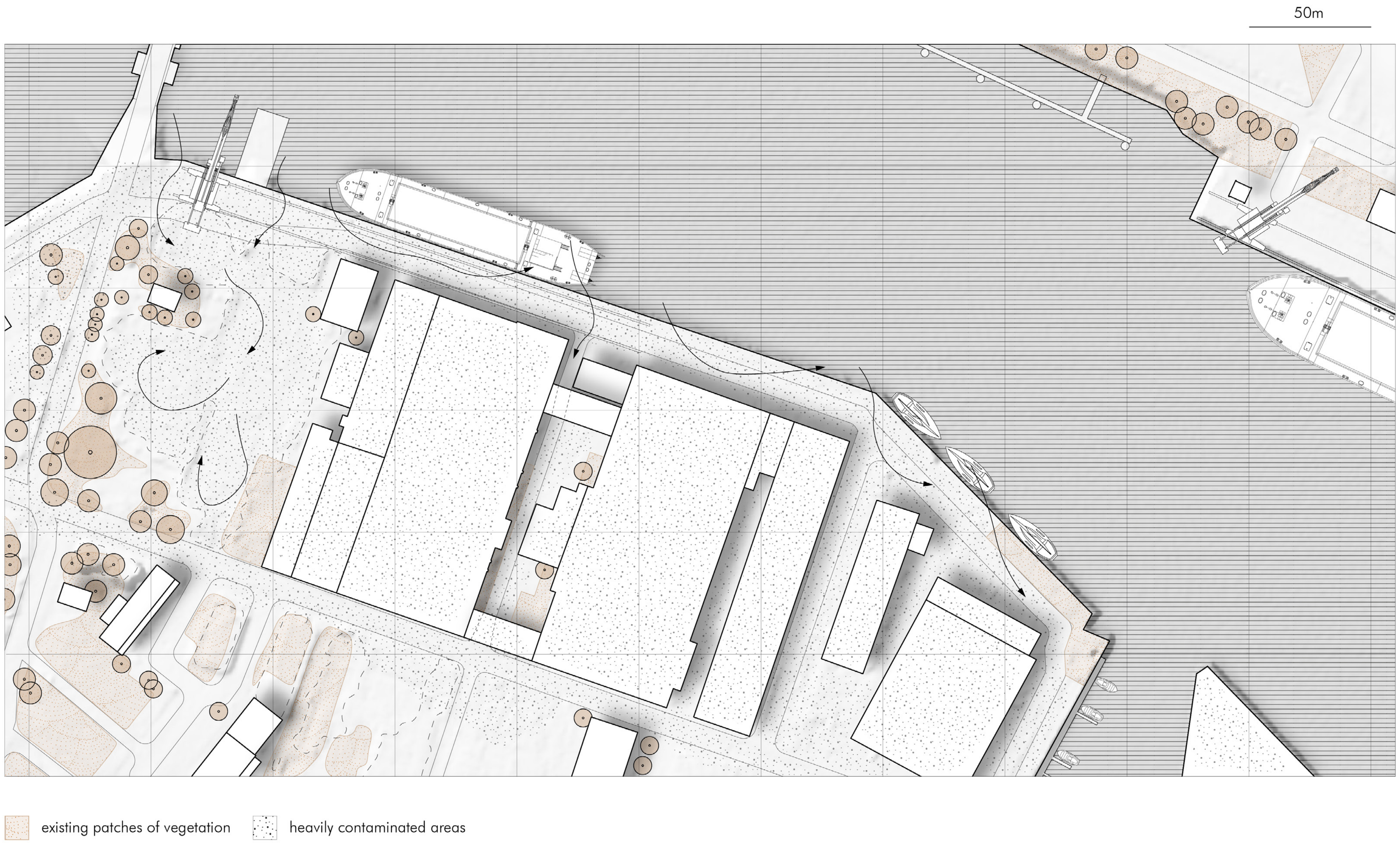


Fig. 72. Post-industrial edge - current spatial conditions, map | Source: author's own work
Fig. 73. Post-industrial edge - current state, section | Source: author's own work

Post-industrial edge
environmental conditions and potentialities

The current ecological performance of the post-industrial site is limited as most of the area is sealed or not covered by vegetation. The only green patches are present in the southern part of the site and along the road leading to the Ostrow island.
The water edge was shaped to meet the requirements of the port and industries, namely to be a space where ships can dock to load and unload. It is, therefore, a hard edge and currently, only the eastern part of it has a short stretch of low vegetation.
The shipbuilding activities formerly present on the site contributed to a high degree of soil, water and air pollution in the area (Zaborska et al., 2019). The shipbuilding processes took place both indoors and outdoors because of the size of the ships. Therefore the oil and heavy metals including lead, which are present in the paints, lubricants and solvents contaminated the soil and water more severely because of the exposure to the weather phenomena (EPA, 2008). The proximity of the water body increases the effect the industry has on the quality of the environment as the contamination flows through the site and enters a water body that acts as a carrier of toxins.
The opportunity of using phytotechnologies depends on the kind of pollution present on the site. As shown in the diagram below the phytotechnologies are more likely to be applied in an area with organic contaminants, whereas the inorganic contaminants require much more time to be treated. That is why it is important to take into consideration the future programming of the site to apply adequate remediation techniques.
As the chosen post-industrial edge is located close to the city center of Gdansk, there is a plan put in place to reuse the former shipyard buildings to increase the urban density and counteract the urban sprawl. It can be concluded that in order to accelerate the remediation processes there is a need to use a mix of remediation techniques, especially in the sections which are programmed to be used by people in the near future.



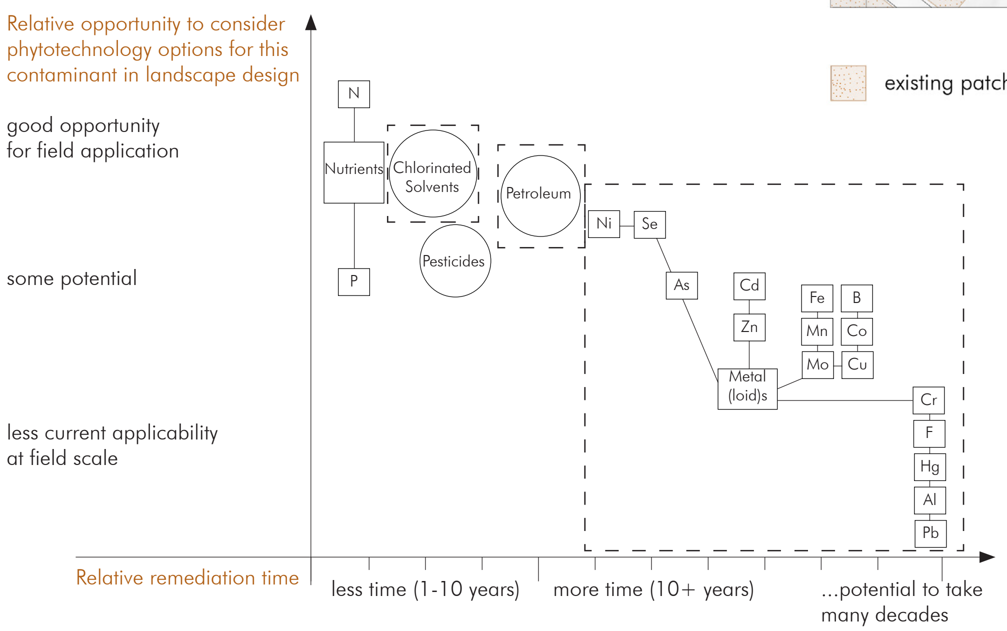


Fig. 74. Post-industrial edge - current environmental conditions, map | Source: author's own work
Fig. 75. Phytotechnologies - potential use x time matrix | Source: Kennen & Kirkwood (2015)

Post-industrial edge

transition | phase 1

remediation + resilience

The first step in the process of transitioning the post-industrial edge concerns soil works in order to prepare the site for the further superimposing of vegetation and a network of open spaces. The proposal consists of the addition and removal of soil. The soil would be removed from the sections of the edges which require more urgent decontamination action. Namely from the indoor spaces because of the potential future development and thus a direct contact with the soil. Furthermore, removal of part of the soil and soil washing is essential because of the limitations of phytotechnologies in the areas where heavy metals are present.

The landscape outdoors is shaped in a way to allow the floodwater to enter the site and be directed through it to eventually reach the water storage reservoirs. The controlled flow of the water through the landscape ensures better flood management. The resilience of the edge is additionally enhanced by the creation of a hilly landscape parallel to the water edge. The lower points of this landscape are where the water can flow and be further conveyed via shallow depressions like swales, which could additionally filter the water.

The elevation of the proposed hills depends on the severity of surges and the sea-level rise. The current elevation of the edge varies between 1 and 2 meters above mean sea level. The maximum storm surge of 1.5m would therefore require the height of the hills to be at least 0.5m. This height is proposed for the dikes in the immediate river edge.

According to the SEAREG programme (Sea Level Change Affecting the Spatial Development in the Baltic Sea Region, 2000-2006), the area of the Young City would be entirely inundated in the worst sea-level rise scenario (+0.98m) in an event of flooding with a storm surge of 1.5m. Considering that prediction, another group of hills behind the buildings is proposed to be 1.5m height to keep the area resilient to severe flood events. Next to that, the water storage reservoirs would need to be deepened to accommodate the increased amount of water coming from the river fluctuations.

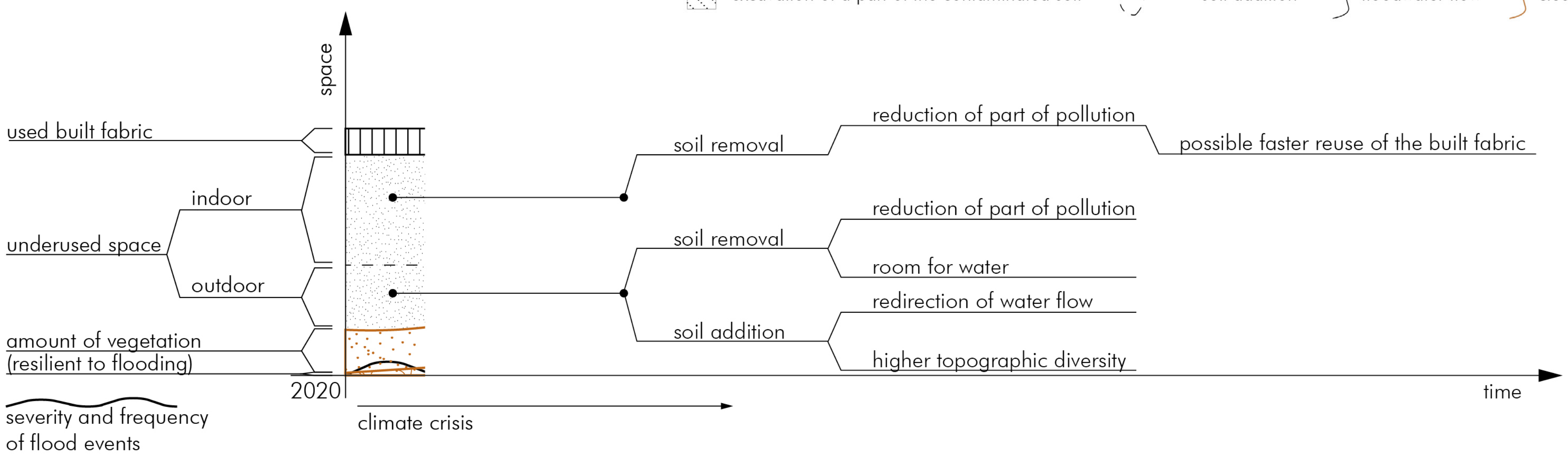


Fig. 76. Post-industrial edge - phase 1, map | Source: author's own work

Fig. 77. Post-industrial edge - phase 1, spatio-temporal diagram | Source: author's own work

Post-industrial edge

transition | phase 2

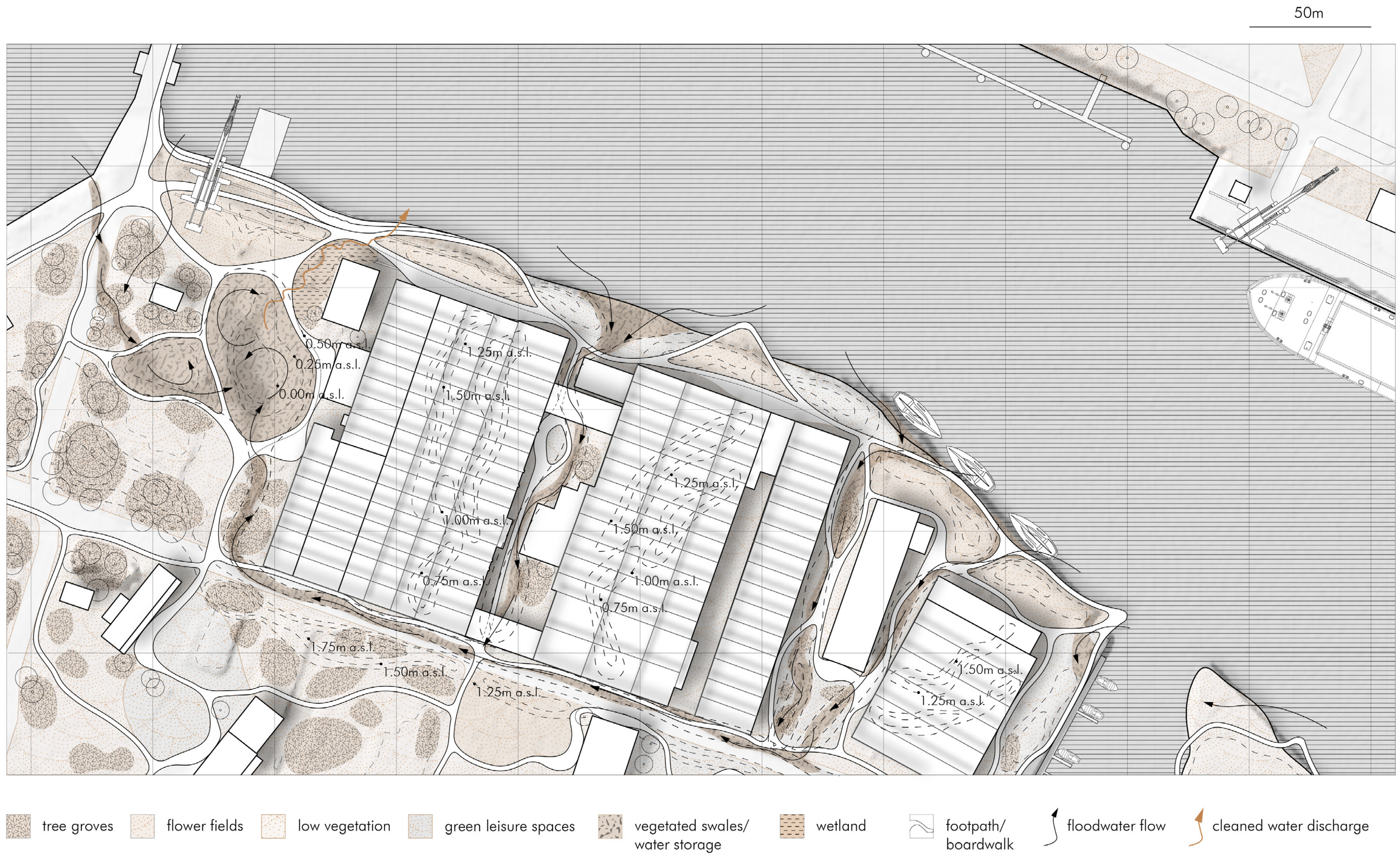
remediation + resilience + performance

The next layer of the design proposal for the post-industrial edge consists of vegetation in the landscape surrounding the built fabric. The specific planting is employed to help decontaminate the polluted soil and purify water by using plants ability to uptake, remove and mitigate pollutants. The use of vegetation is not only a low-cost and sustainable method to address the issue of pollution of matter, but it enhances the attractiveness of the site and provides safer landscapes for people (Kennen & Kirkwood, 2015).

The design proposes a gradient of wetness of the edge by the use of semi-permanent wetlands usually inundated every year, ephemeral wetlands with long dry periods and not regular flood events and hilly landscapes not experiencing flooding. As mentioned before, the alteration of the topography gives a chance to steer the floodwater via designed swales and filter strips which allow for the implementation of sedges species able to clean up the polluted water. The network of shallow depressions is designed in a way to prolong the flow of floodwater through the site, and thus the process of remediation. This measure adds to the soil permeability expanding the water storage capacity of the landscape.

The wooden boardwalks meander in between the buildings and the water improving the accessibility and connectedness of the edge. The paths are elevated to limit contact with the pollution and guarantee safety during flood events.

In order to create more space for vegetation in the edge, the buildings are considered in the design for the remediation. To ensure good conditions for planting indoors, such as access to fresh air and sun, the roof cladding and windows are temporarily removed.



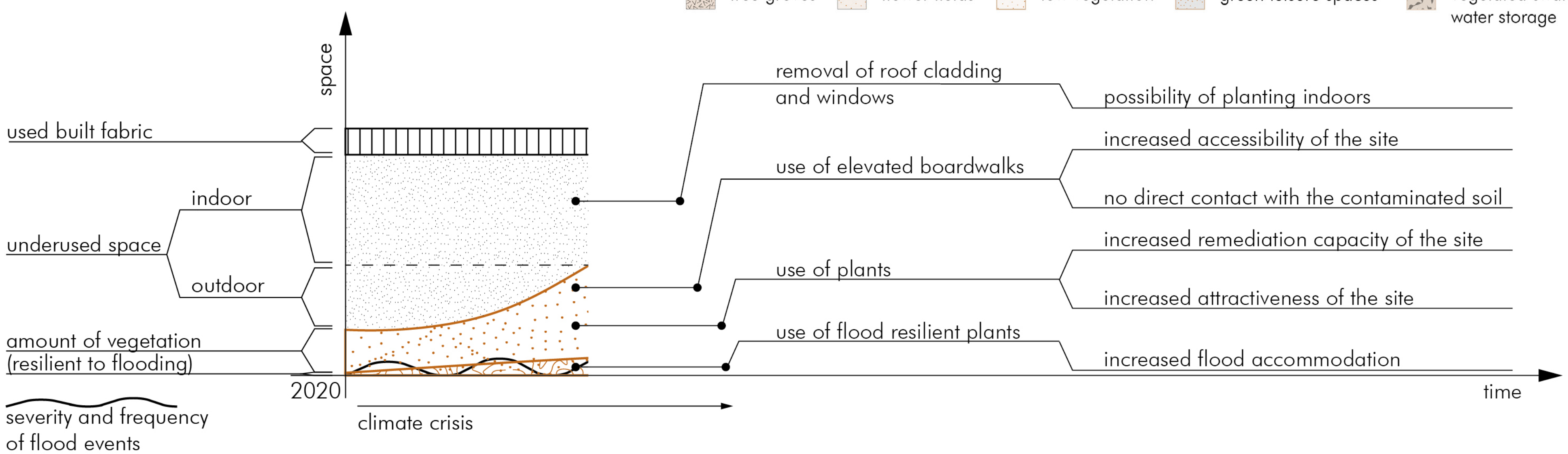


Fig. 78. Post-industrial edge - phase 2, map | Source: author's own work

Fig. 79. Post-industrial edge - phase 2, spatio-temporal diagram | Source: author's own work

Post-industrial edge
transition | phase 3
remediation + performance

Subsequently, the vegetation is planted within the buildings to maximize the remediation capacity of the edge. The floodwater is then allowed in the newly created landscape. As more space for water is ensured, the edge becomes more absorptive and accommodating of the water quality improvement process and flood management.
The blue and green network introduced within the post-industrial architecture gives the place a unique character which might be a trigger for a higher social performance of the area. Continuation of the use of the boardwalks in the buildings allows better connectedness of the different parts of the edge. Moreover, it makes the buildings accessible and gives an opportunity to create an educational space, where the visitors get to know about the process of bioremediation.
The edge design uses topography, vegetation and water as a medium to create a wide spectrum of experiences, including undulating flower fields by the river, shallow green swales surrounded by high walls of the post-shipyard fabric and a purifying water reservoir enclosed by a variety of vegetation.

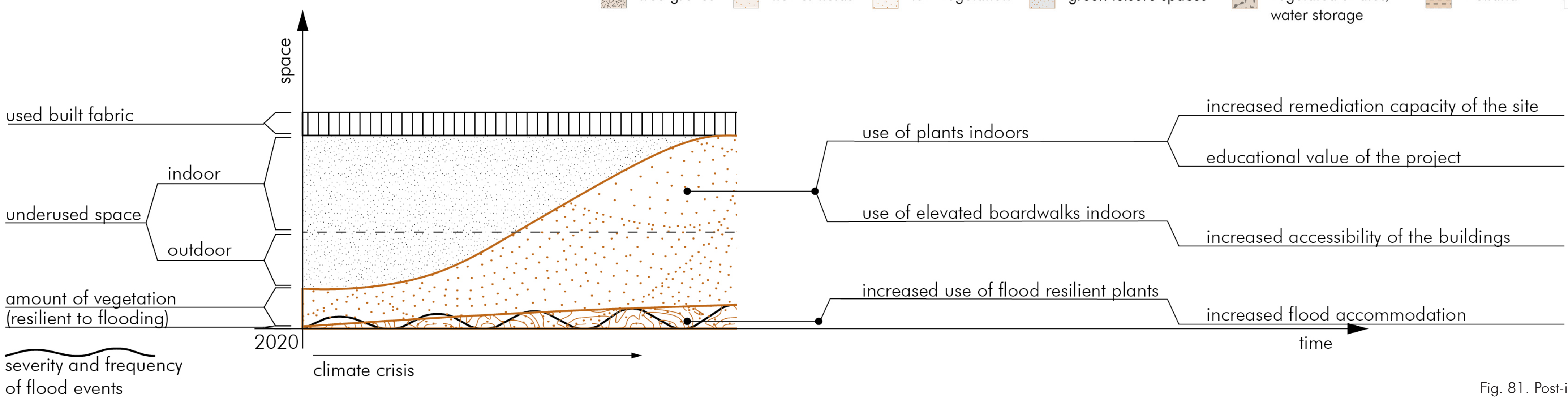
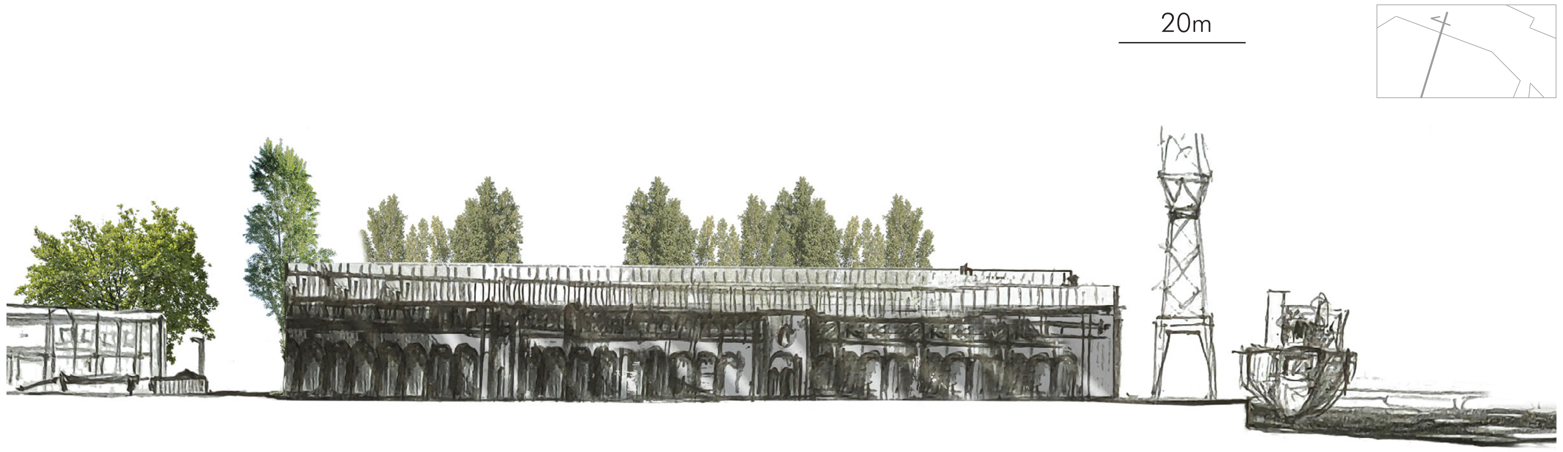
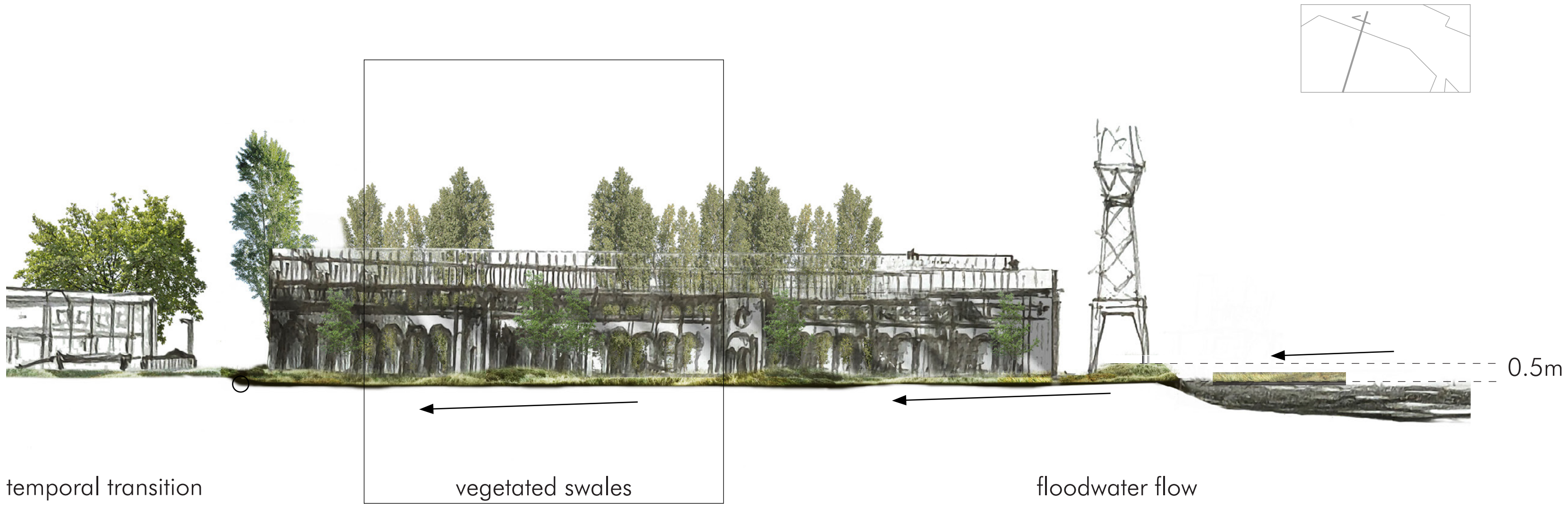


Fig. 80. Post-industrial edge - phase 3, map | Source: author's own work
Fig. 81. Post-industrial edge - phase 3, spatio-temporal diagram | Source: author's own work

Post-industrial edge
temporal transition | indoor space





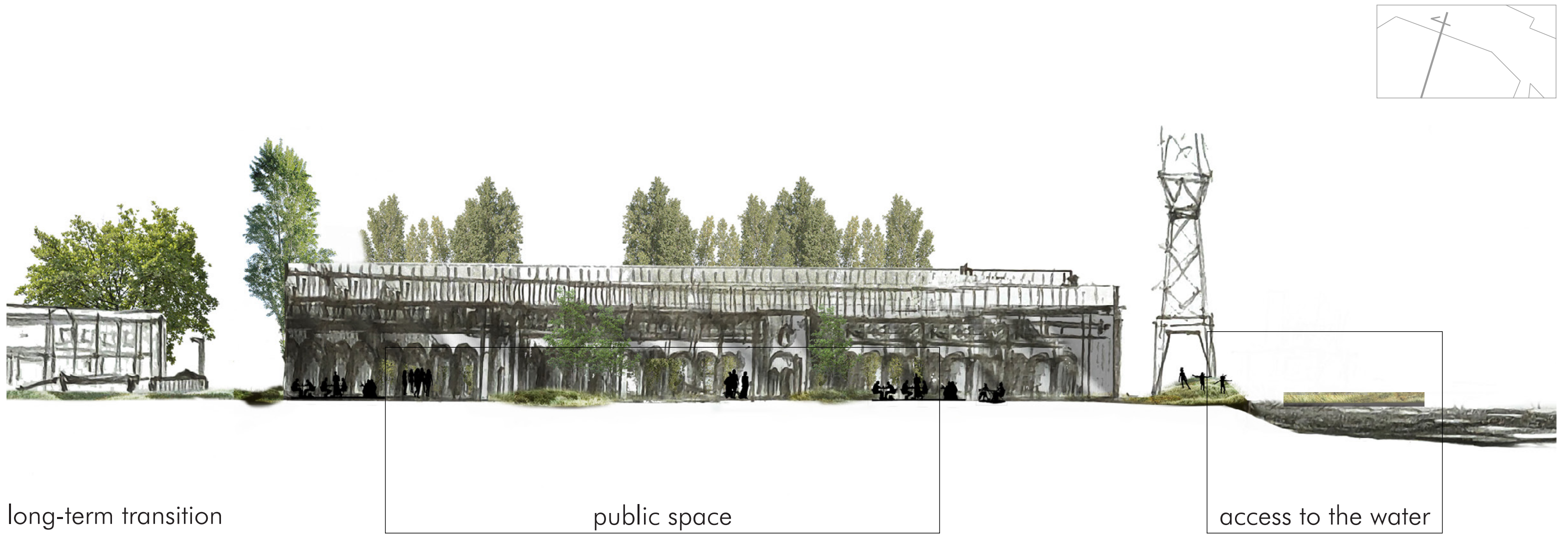


Fig. 82-84. Post-industrial edge - indoor space transition, sections | Source: author's own work
Fig. 85. Post-industrial edge - indoor space - temporal transition, visualization | Source: author's own work

Post-industrial edge
transition | phase 4
resilience + remediation + performance

In the previous phases of the design, the purification of water flowing in the river was only possible during a flood event, when the water entered the site and was cleaned while being conveyed through the vegetated swales. To ensure continuous decontamination of the river the edge is widened more vegetation is added. This layer of the edge design consists of floating wetlands and boardwalks meandering over the water. It softens the edge and enhances the smooth transition from water to land. The floating treatment wetlands are artificial floating platforms with aquatic plants. The contaminated water with nutrients and toxic metals is taken up by the plant roots that are submerged in the river, while organic pollutants are degraded by microorganisms present on the roots and the surface of the floating platform (Shahid et al., 2018).
The extension of the boardwalk over the water adds to the spectrum of the experiences as people can be surrounded by water and "feel" the flow of the river under their feet.

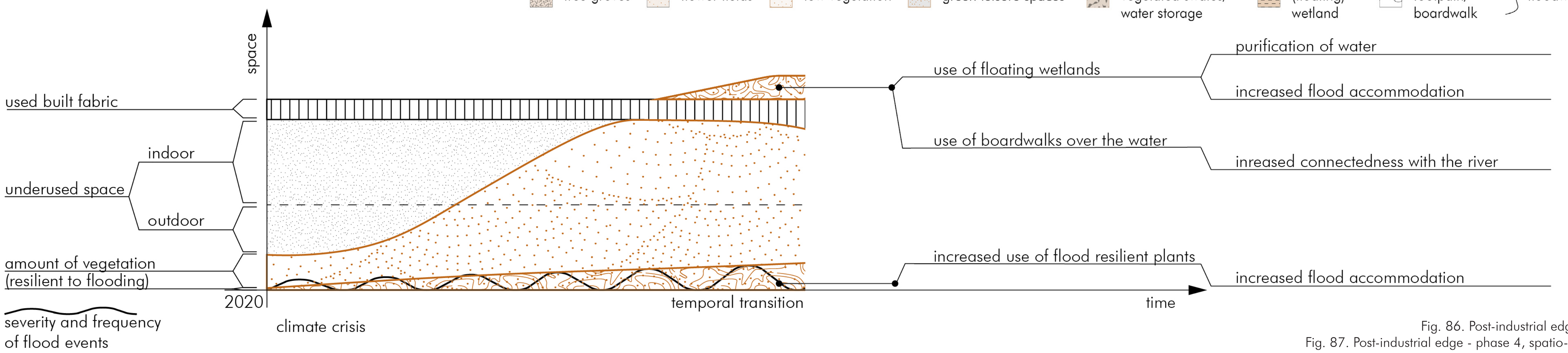
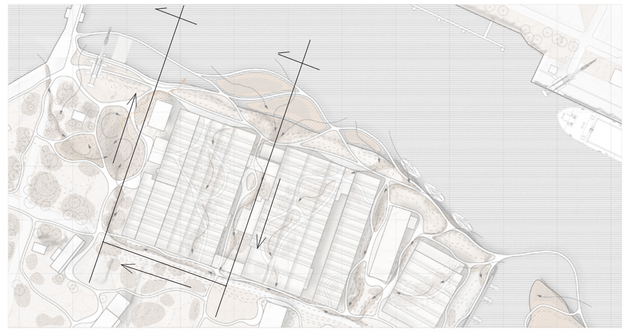


Fig. 86. Post-industrial edge - phase 4, map | Source: author's own work
Fig. 87. Post-industrial edge - phase 4, spatio-temporal diagram | Source: author's own work

Post-industrial edge
remediation process



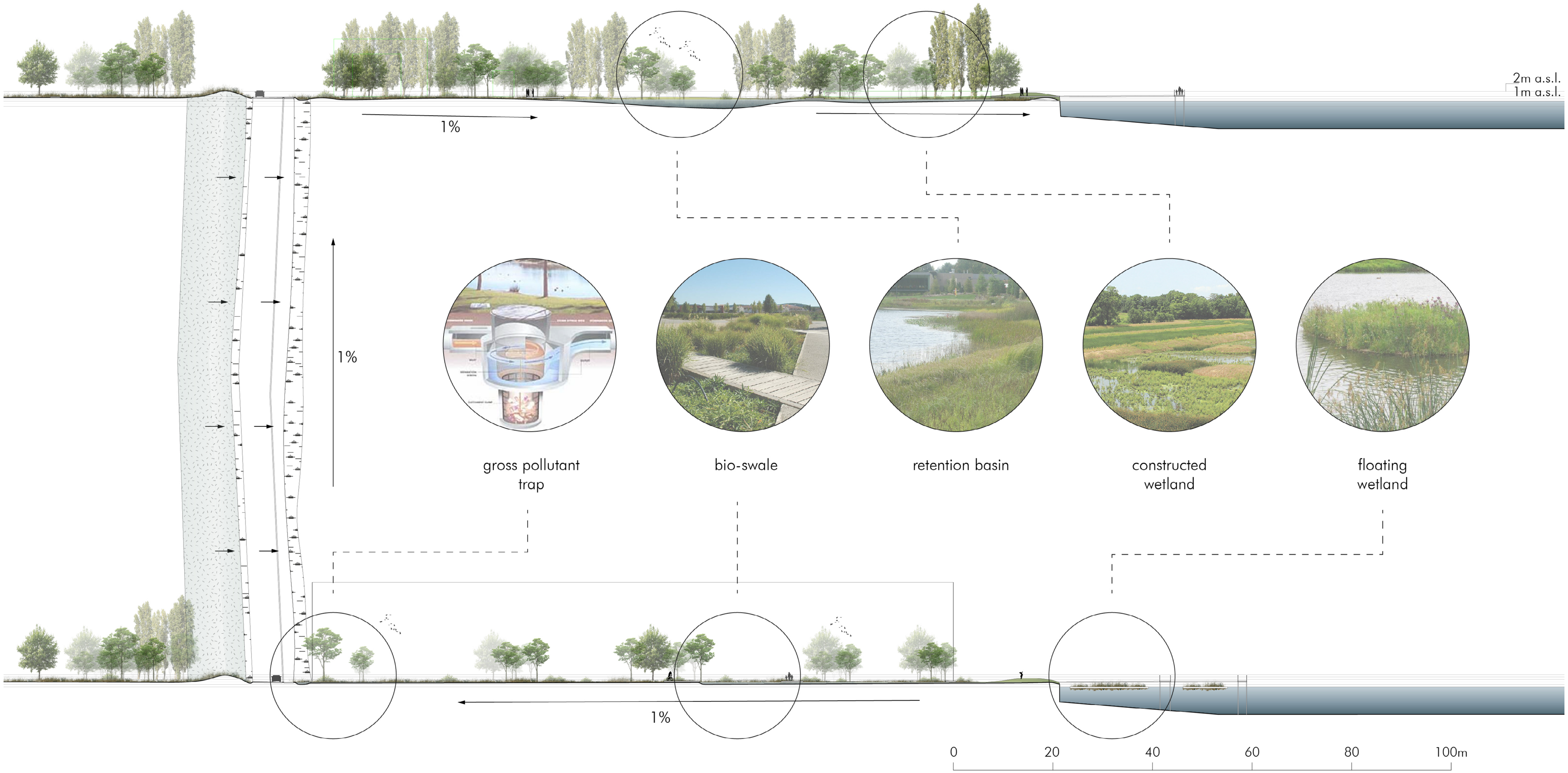
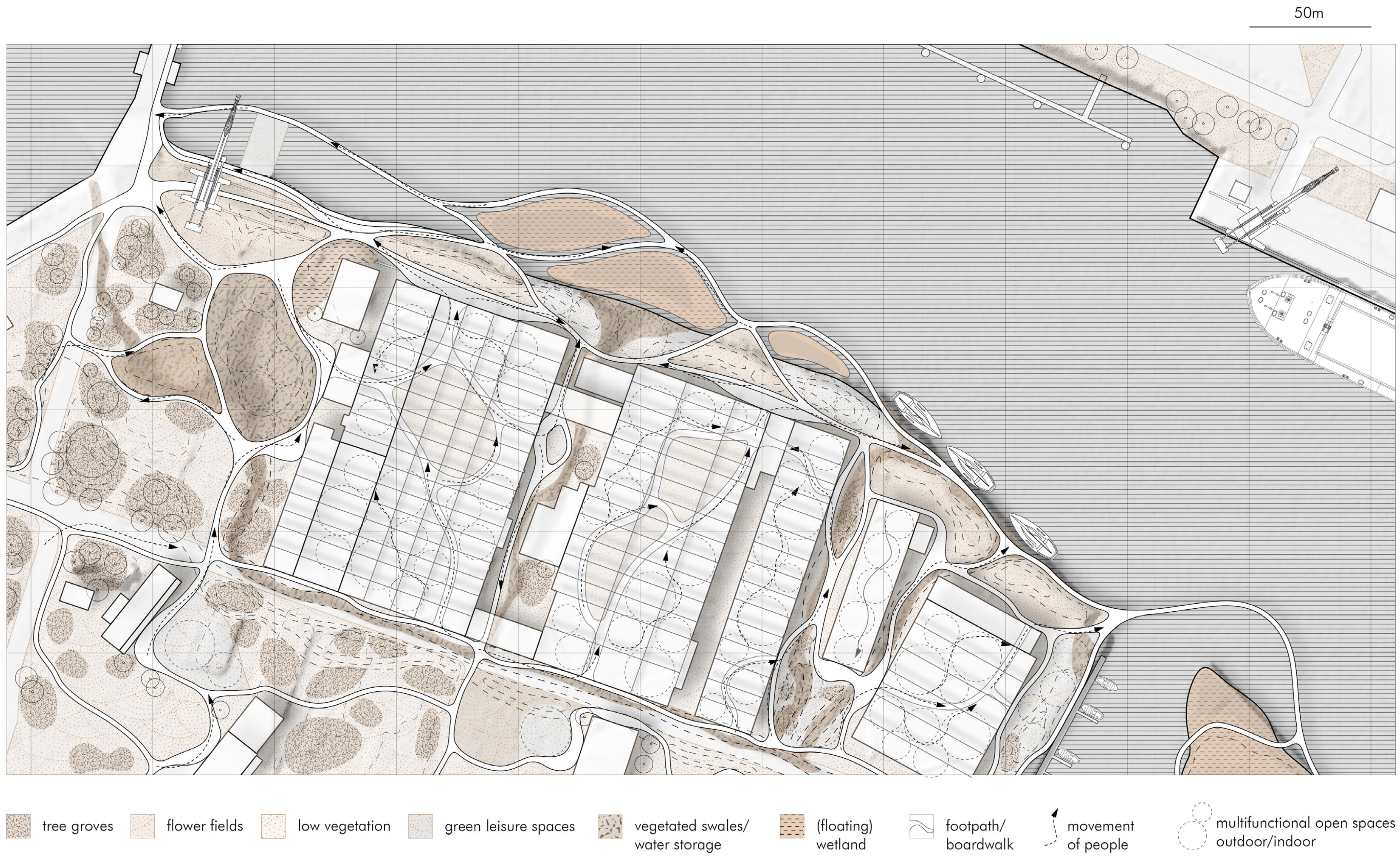


Fig. 88. Remediation process | Source: author's own work

Post-industrial edge
transition | phase 5
performance

The process of decontamination of the soil within the built fabric is accelerated by the initial phase of partial soil removal. The reason behind that is the future reuse of the buildings for a mix of uses to improve the social performance of the edge landscape. Most of the vegetation present within the walls is removed, the remaining patches would be a reminiscence of the former unique character and function of the buildings. The restoration of the post-industrial buildings would allow using them in various weather conditions. Connectedness and enhanced accessibility provide more room for creating a network of outdoor and indoor open spaces. The program of uses of the site is meant to be mixed and temporal as the proposal is a transitional phase from the current state of the edge to the decontaminated edge prepared for further development.
To make the proposal feasible a collaboration must be established between the city of Gdansk and the future developer to lead the project through phases and to maintain it. Next to that, prior to the start of the project, there should be consultations with the residents of the city, who would later feel more connected to the project itself.



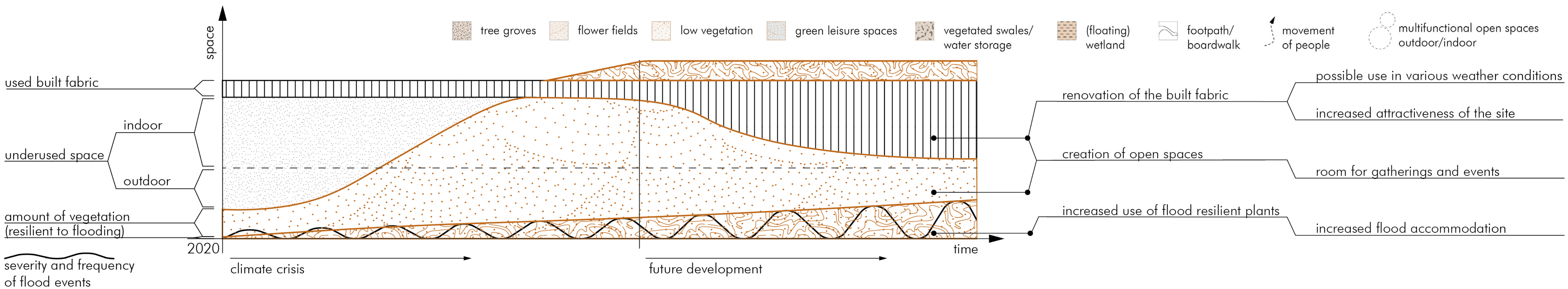


Fig. 89. Post-industrial edge - phase 5, map | Source: author's own work
Fig. 90. Post-industrial edge - phase 5, spatio-temporal diagram | Source: author's own work

Underutilized edge

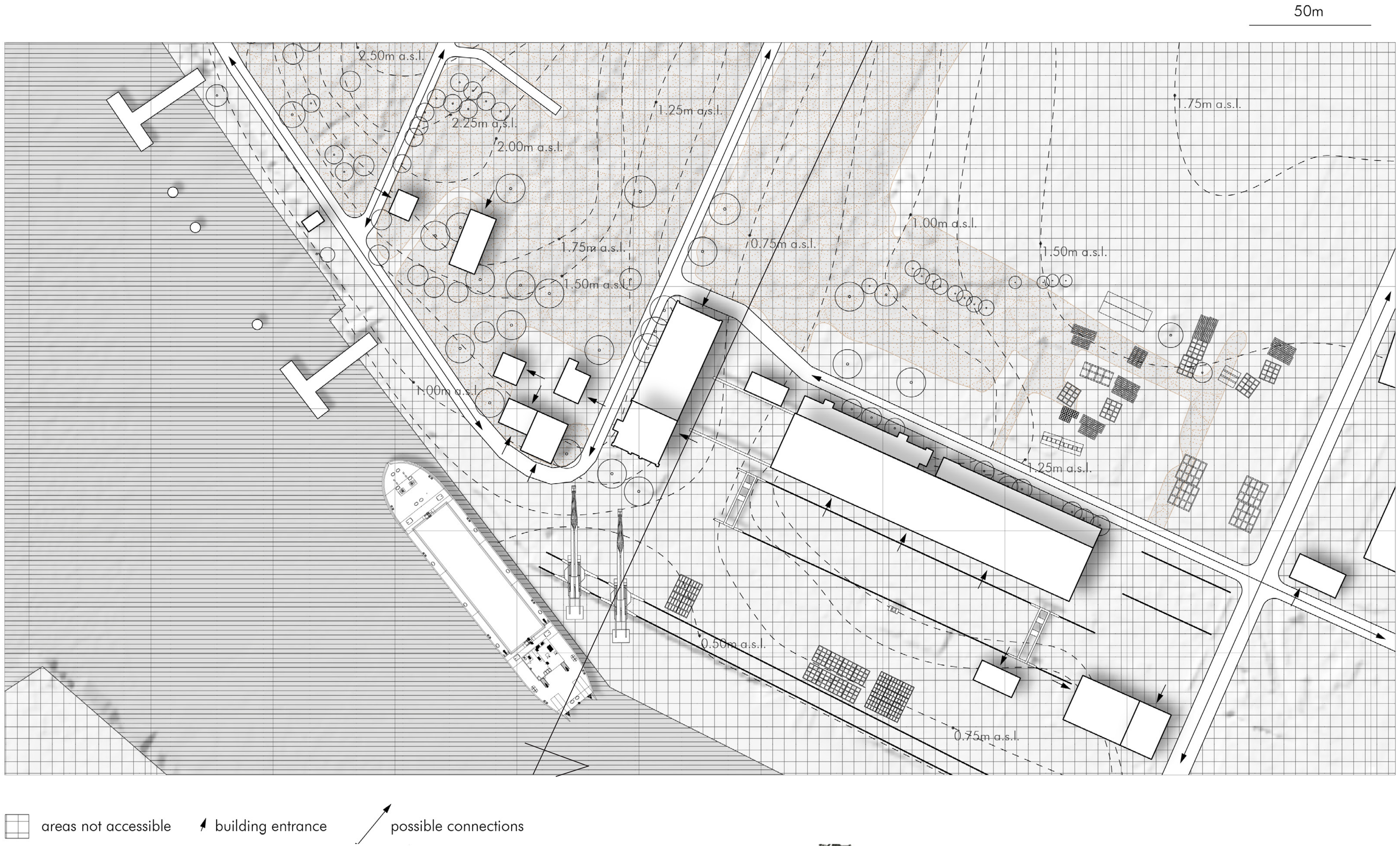
Fig. 91. The Dead Vistula River | view towards the Ostrow Island, Gdansk
Source: author's own photograph | field trip February 2021

Underutilized edge
spatial conditions
and potentialities

The underutilized site lies in the southern part of the Ostrow Island in Gdansk. The island is currently occupied by industries, including shipbuilding industries, and its northern part consists of several docks. Two bridges are connecting the island with the mainland, on the western side and in the southern part. The latter is an extension of the road crossing the Young City. Today, the island can only be accessed by the bridge in the western part, since the entire southern edge is occupied by industries and thus the entrance via the southern bridge is restricted. Even though the island is accessible via the western bridge, the edges of the island can not be reached. The main road on the island meanders between industries surrounded by fences and gates.

Looking at the current occupation of the land in this area, it can be said that the island, especially its southern part, is underutilized. The ratio of open space to the built area is substantially higher than in the area of the Young City. The immediate edge is occupied by shipyard infrastructure, namely rails and cranes. Behind the buildings, there is a disused outdoor square and a vast section of abandoned green area. The edges of the island could be made accessible by opening the bridge crossing to the public. With the use of the existing infrastructure the two bridges could be connected and would allow for crossing the island. In this way, the island would be better connected with the rest of the city and thus would become more attractive and vibrant.

The remaining industrial activities could be moved to the other parts of the island using the land more efficiently. The chosen edge could then become a recreational area with post-industrial character thanks to remnants of the shipyard. The industries could be gradually moved out of the island to the newly constructed Central Port. Freeing up space in the proximity of the city center would help counteract the process of urban sprawl. This process would provide room for further urban development.



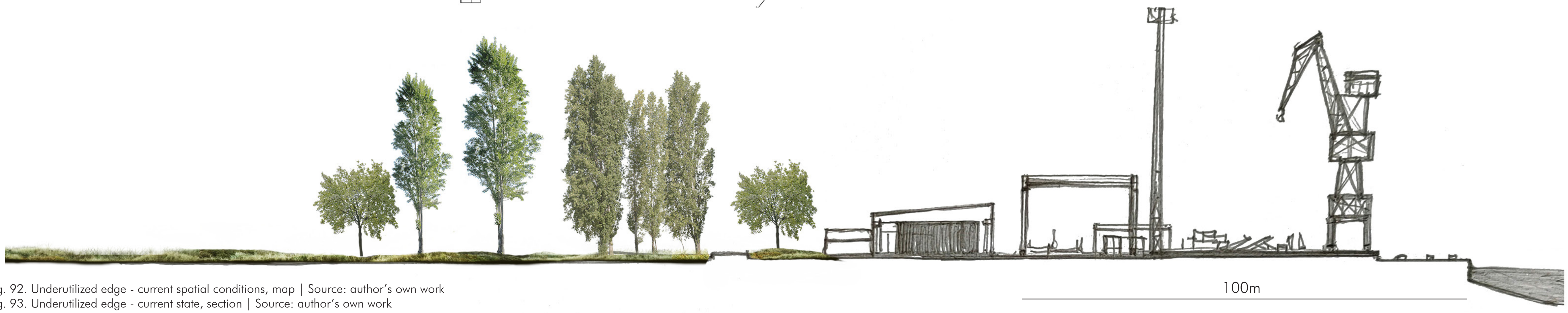
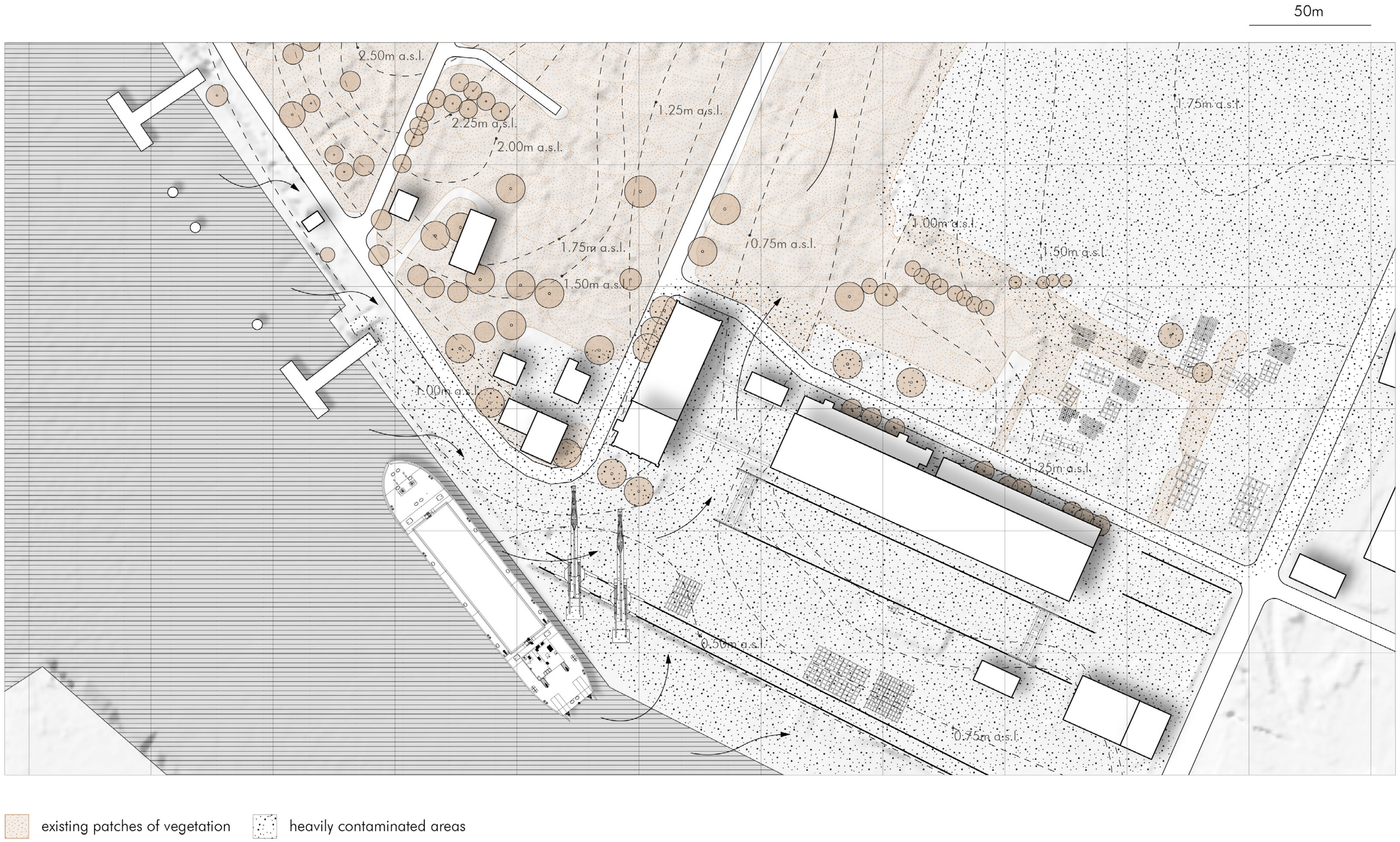


Fig. 92. Underutilized edge - current spatial conditions, map | Source: author's own work
Fig. 93. Underutilized edge - current state, section | Source: author's own work

Underutilized edge
environmental conditions
and potentialities

The ecological performance of the chosen section of the Ostrow Island is higher than that of the chosen site in the Young City. Here around half of the area is covered by vegetation, mostly grass and trees. There are various tree species present on the site, including poplar trees. Poplar trees are one of the most commonly used species in bioremediation practices (Kennen & Kirkwood, 2015).
The rest of the area is covered by pavement or gravel ground. Similarly to the Young City area, the southern part of the Ostrow Island is still partially used for the shipbuilding industries. That is why the soil present on the site and the water surrounding the island is contaminated by industrial pollutants. The underutilized part of the site could be used for further implementation of remediation practices in order to minimize the degree of pollution.
As the Ostrow Island has currently an industrial function and there is no proposal to change the functional programming in the near future, there is no time pressure regarding the decontamination process. This means that phytotechnologies may become the main remediation method in this area despite the time required for the process.
The use of plants is beneficial not only for the ecological performance of the site but also the social and economic performance. The vegetation would change the character of the island and substantially increase its attractiveness. As the existing terrain is not completely flat, the floodwater and rainwater flow follow the topography. This phenomenon constitutes a potentiality for diversified characters of the area.



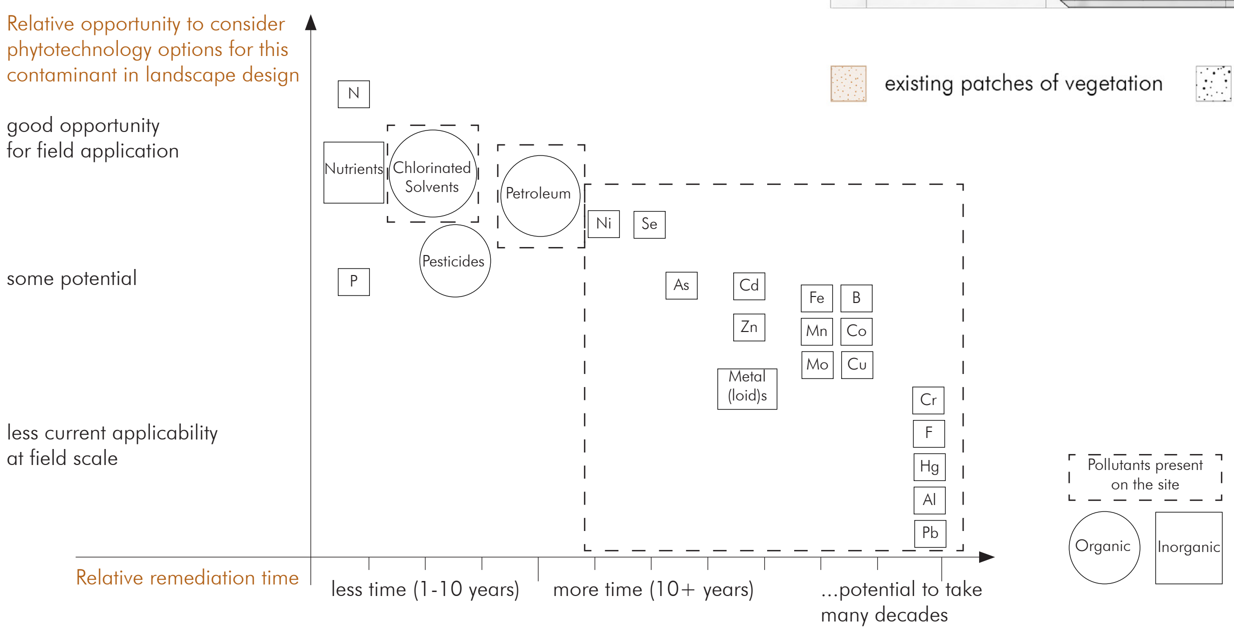


Fig. 94. Underutilized edge - current environmental conditions, map | Source: author's own work
Fig. 95. Phytotechnologies - potential use x time matrix | Source: Kennen & Kirkwood (2015)

Underutilized edge

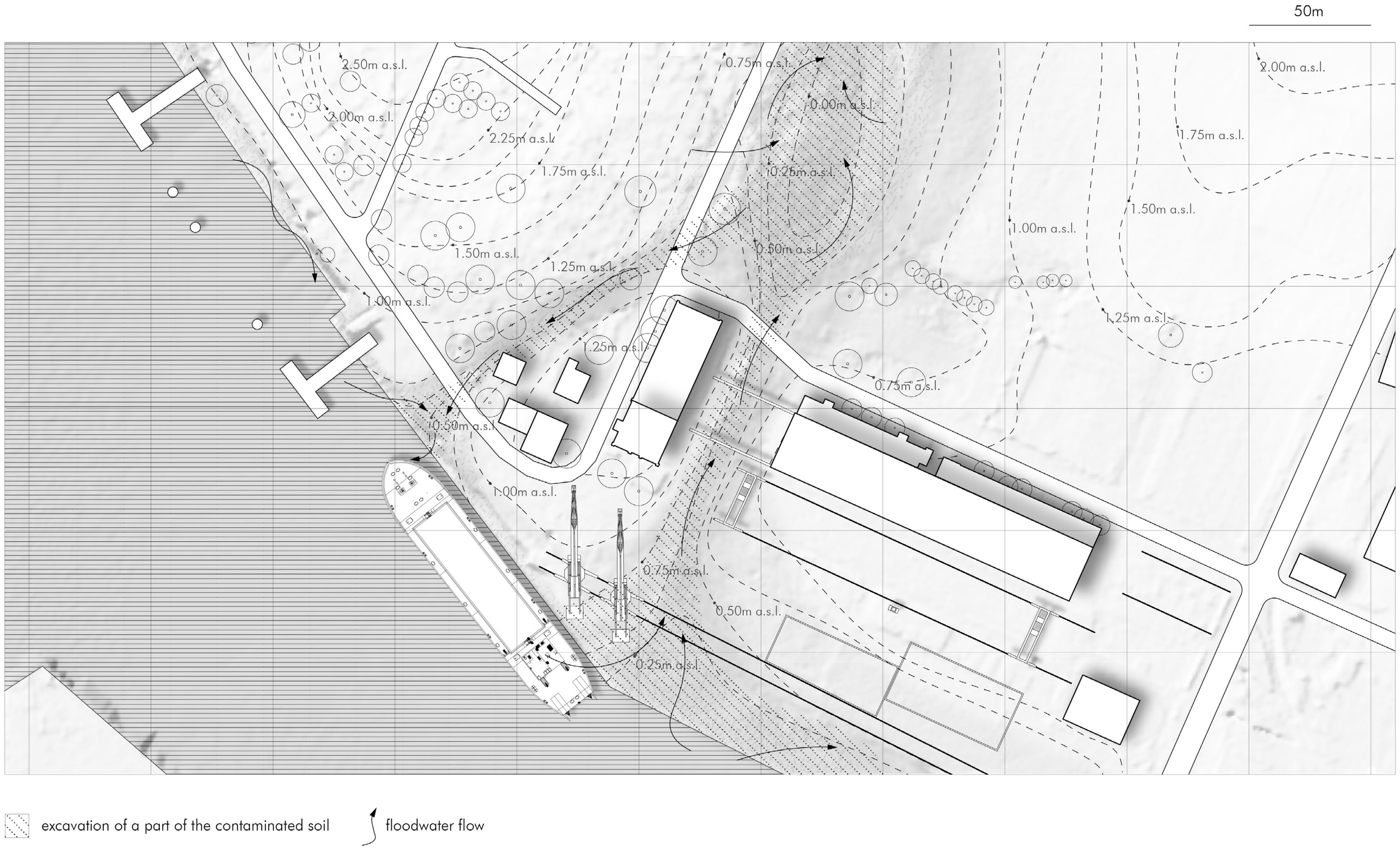
transition | phase 1

resilience + remediation

The transition of the underutilized edge on the Ostrow Island starts from changing the topography of the site. This process aims to increase the resilience of the site as well as its remediation capacity. The site would become more resilient to flood events thanks to the creation of low-lying areas, namely swales and a retention pond. That would allow for directing the water flow and better control over it. The low-lying landscape would increase the flood accommodation as the floodwater could be temporarily stored there and later slowly released back to the river.

The excavated soil would be temporarily moved outside the site to be cleaned from pollutants employing soil washing. Subsequently, the cleaned soil would be used to create a hilly landscape in the northern part of the site amplifying its topographic diversity.

In the paved area, located in proximity to the bridge, the surface would be capped to isolate the contaminated soil and prevent the spread of pollution. The capping remediation method is used to save the time needed to prepare the site for further uses. Thanks to that and possible further urban activation, this part of the site could become a first anchor point on the island, connecting it with the Young City and the rest of Gdansk.



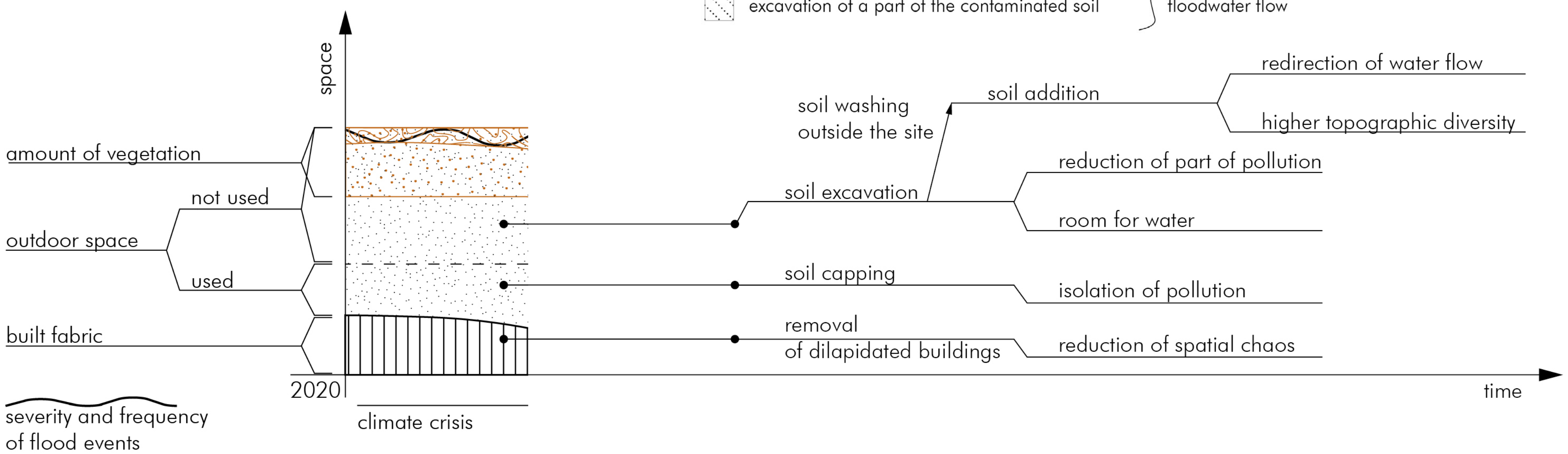
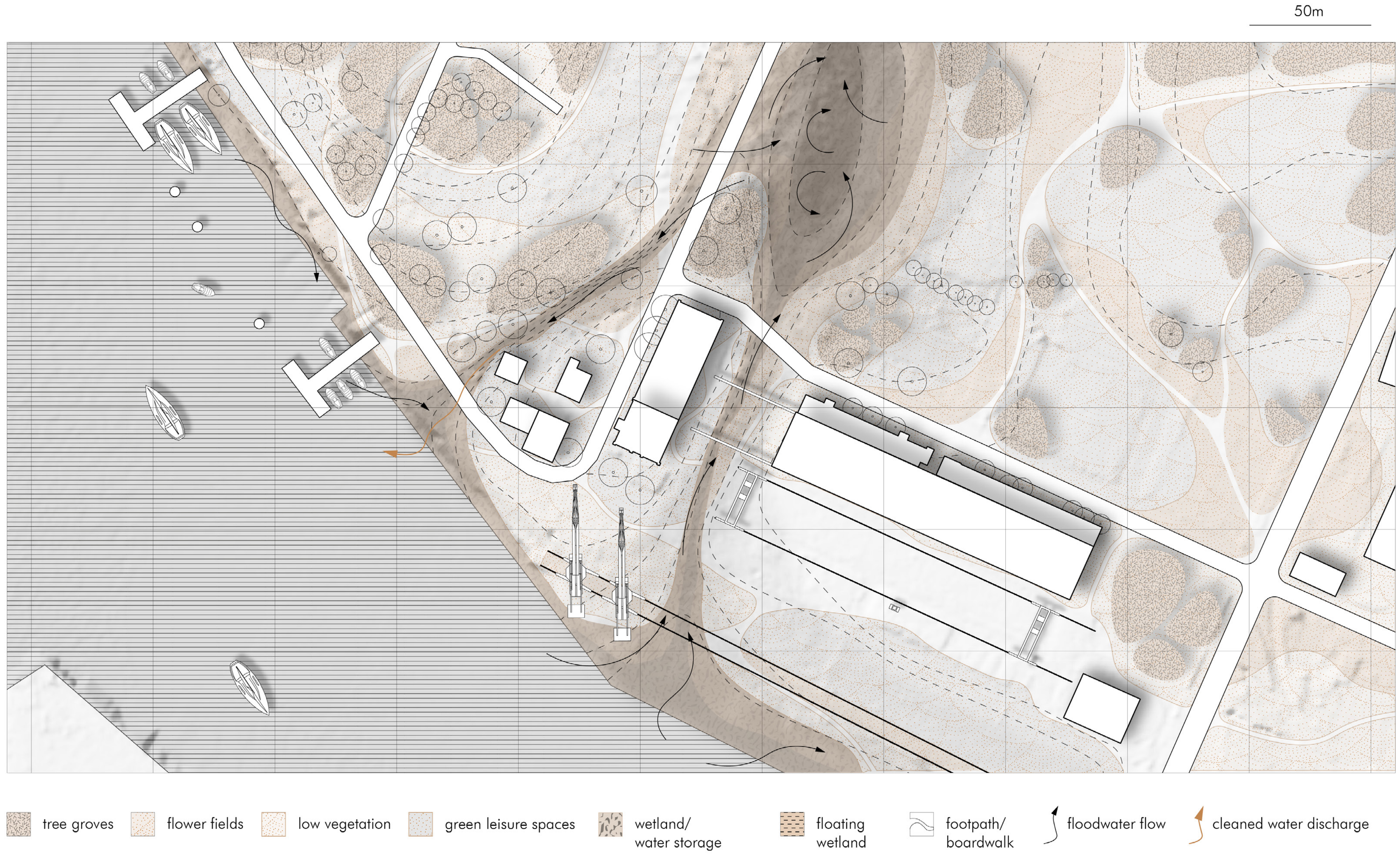


Fig. 96. Underutilized edge - phase 1, map | Source: author's own work

Fig. 97. Underutilized edge - phase 1, spatio-temporal diagram | Source: author's own work

Underutilized edge
transition | phase 2
resilience + remediation + performance

Superimposition of various layers of vegetation allows for the creation of different characters in the area. The transition from the urban character to a more natural character happens from the immediate edge towards the inland. The vegetation in the southern part of the site, namely flower fields and green leisure spaces, are used to improve the attractiveness of the area and to correspond with the transformed post-industrial area of the Young City. In this way, the design of the Ostrow island continues the patterns used in the other river edge and smoothly transitions towards a more tranquil green area.
The inland part of the island is a place where a hilly landscape with recreational spaces makes a descent to meet a low-lying area with wetland vegetation purifying the water and soil. The eastern side is mostly used for flower fields and leisure spaces as the soil used in this area were cleaned during the soil washing process. Whereas, the western part is filled with tree groves and that is where phytoremediation is the only used remediation method. The changing topography of the site and periodically present water naturally divide the area giving it a variety of characters.



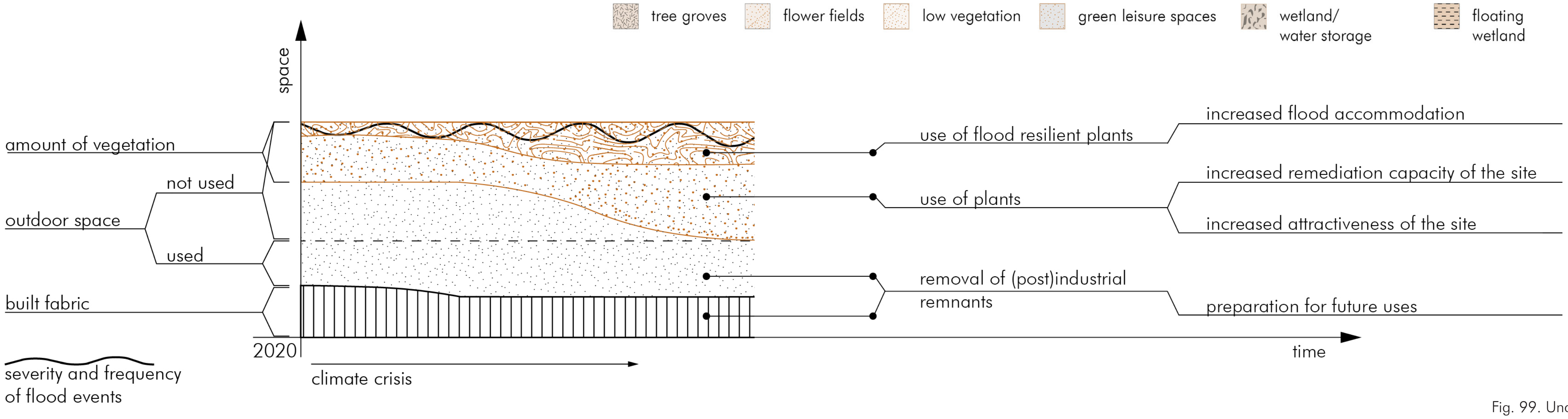
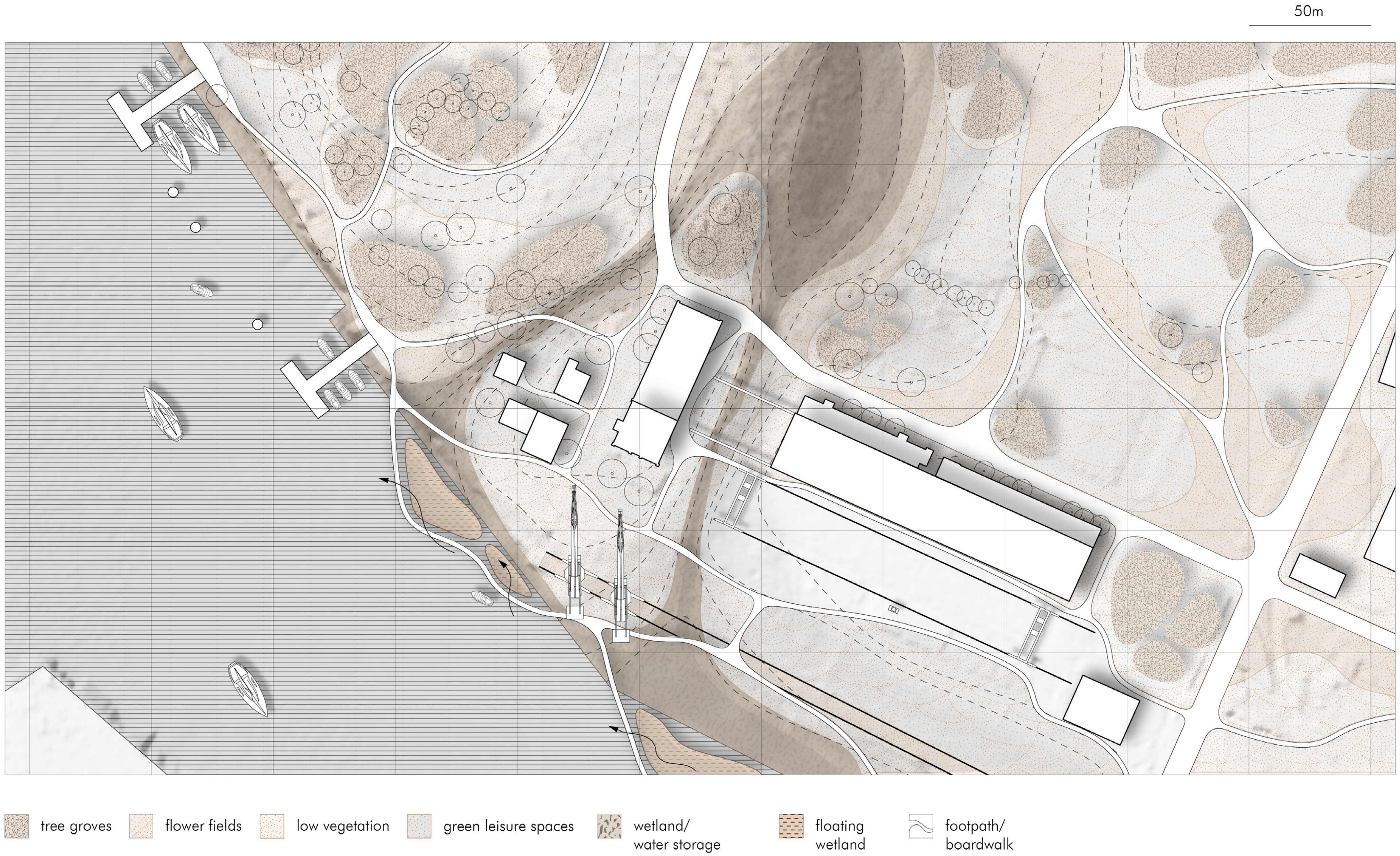


Fig. 98. Underutilized edge - phase 2, map | Source: author's own work
Fig. 99. Underutilized edge - phase 2, spatio-temporal diagram | Source: author's own work

Underutilized edge
transition | phase 3
remediation + performance

Two main roads, including the continuation of the bridge, are left and constitute the main communication axes of the area. Connected to them, a network of pathways is interwoven in the landscape and responds to the programmed intensity of uses. The boardwalks continue over the river providing better access to the waterscape. They can be used as docks for small boats or kayaks and in this way improve the social performance of the edge.
The pathways elevated over the water allow also to implement the floating wetlands on the river surface. That would improve the quality of water flowing in the Vistula River. Similarly to the topography and infrastructure, the post-industrial elements, such as rails and cranes, could be used to mark different projected functional zones.



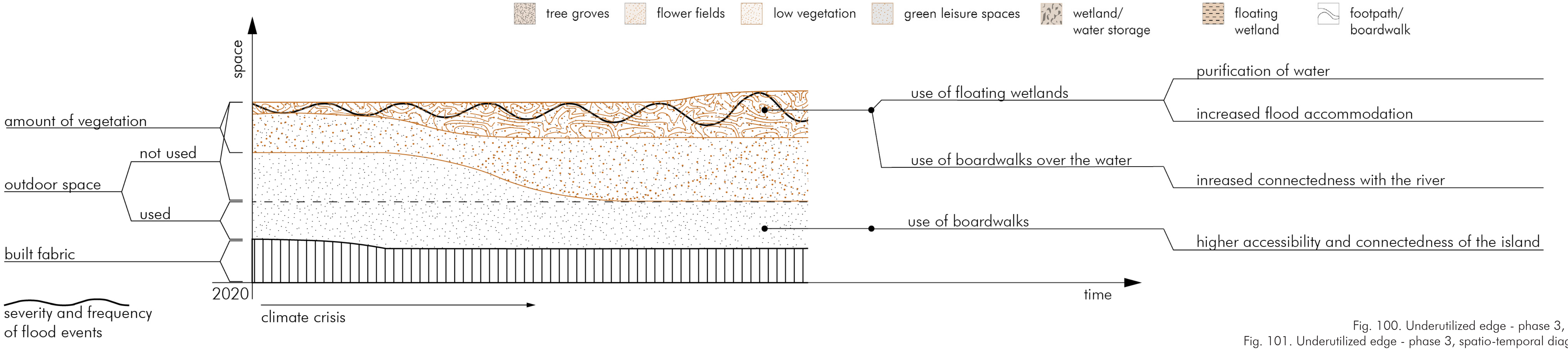
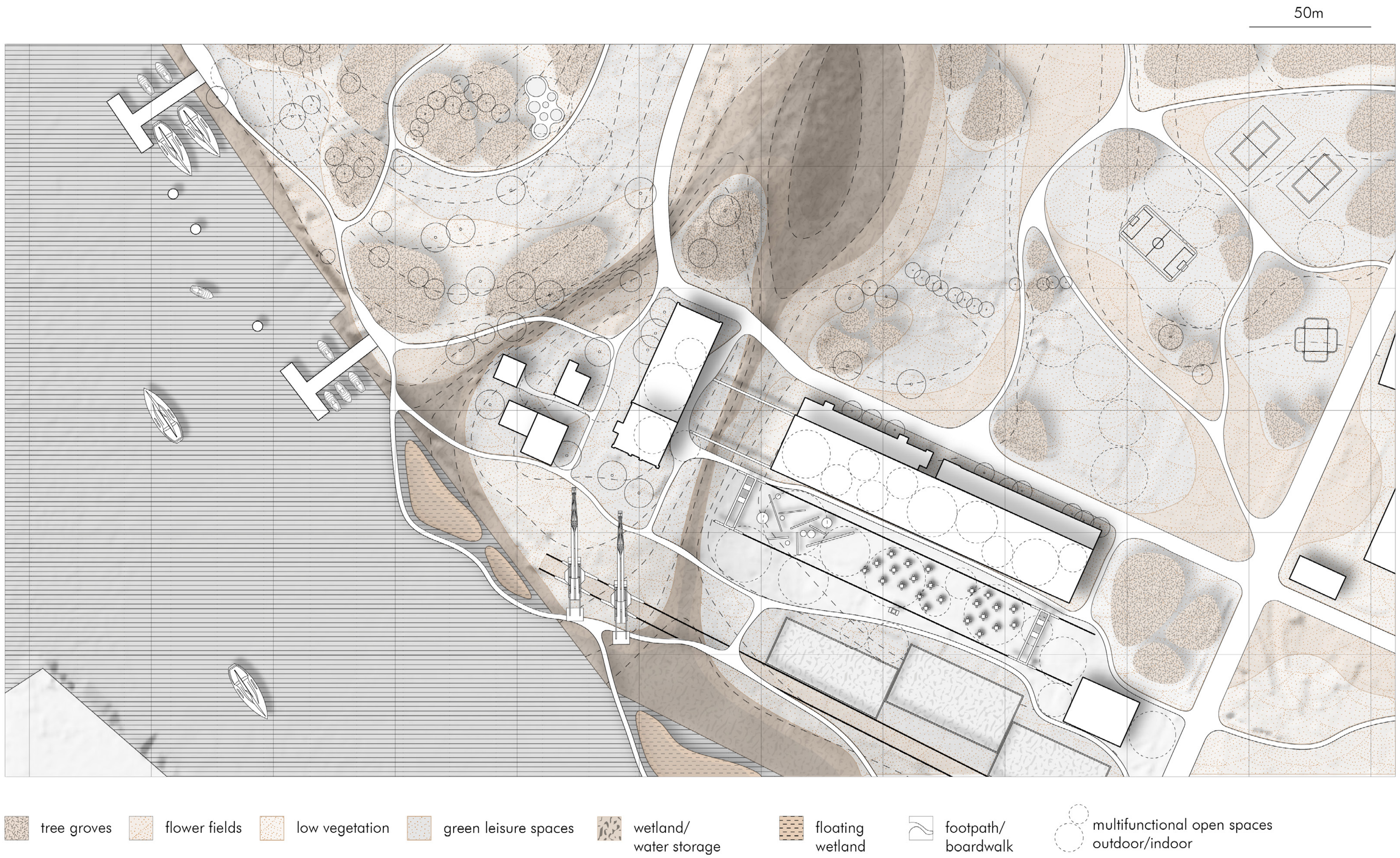


Fig. 100. Underutilized edge - phase 3, map | Source: author's own work
Fig. 101. Underutilized edge - phase 3, spatio-temporal diagram | Source: author's own work

Underutilized edge
transition | phase 4
performance

The last phase of the transition relates to the programming of the site in terms of social performance. The projected functional character of the area addresses not only the health of the environment but also the health of people. The proposal includes the implementation of sports facilities such as pitches and playgrounds in the green areas.
The southern part of the site is projected to experience a higher intensity of uses. The post-industrial buildings would serve as a multi-functional space with restaurants and a museum. These functions could be extended outdoors with the use of the space defined by the rails and two gantry cranes.
The next zone is designed to be another point on the map of sports facilities on the island. It is used for three outdoor swimming pools. Similarly to the rest of this part of the island, the soil surrounding the pools is capped which prevents the pollution from entering the pool water.
The transition is meant to be a temporal step between the current state and the possible future developments. It adds on a blue and a green network and together with the existing gray network, namely infrastructure, can be used as a base structure for future transitions. The design interventions are projected as a trigger for activation of the area and thus an increase of its social and economic performance.



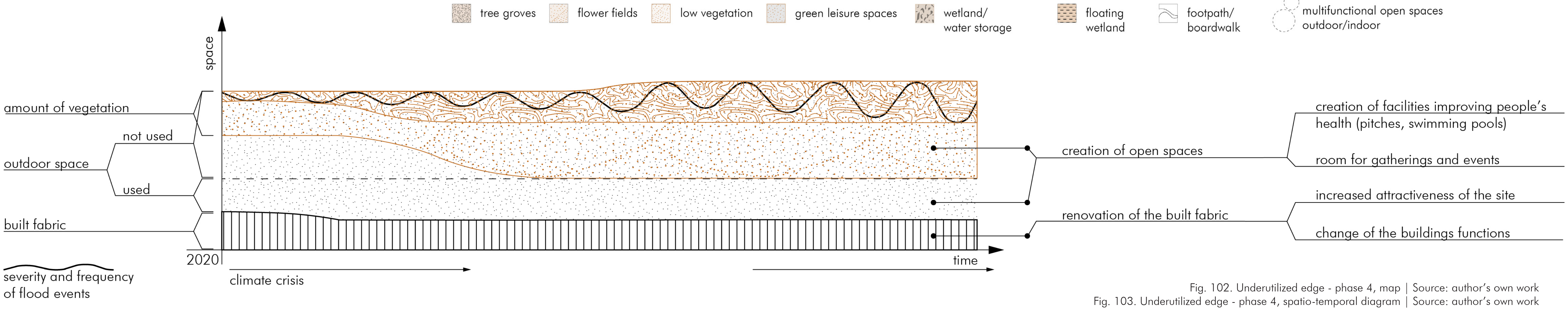


Fig. 102. Underutilized edge - phase 4, map | Source: author's own work
Fig. 103. Underutilized edge - phase 4, spatio-temporal diagram | Source: author's own work

Underutilized edge
regeneration

Fig. 104. The projection of the transition of the underutilized edge
Source: author's own work

Fig. 105. The Vistula River | agricultural edge
Source: author's own photograph | field trip February 2021

Agricultural edge
spatial conditions and potentialities

Despite hostile conditions and recurrent threats to property and life, the Vistula River Delta, similarly to other deltas, was colonized early in history due to the remarkable fertility of the soil. The shift from forests and pastures into agricultural fields was triggered by the economic reasons concerning a great demand for grain in Europe from the sixteenth to the eighteenth century (Cyberski, 1995). This led to an intensification of denudation and erosion processes and thus an increase of the transported load that made the river shallower and caused the creation of sandy bars (Cyberski, 1995). Additionally, the construction of dikes to protect the surrounding area from flooding limited the accumulation of the sediment within the floodplain.

In the section of the agricultural edge chosen as an exemplary site for the design assignment, there are two dikes that separate the existing village from the river. They do not only separate them physically but also visually. The Vistula River is not visible from the level of the village and vice versa.

The transition of the edge by spatial interventions has the potentiality to reconnect both sides of the dike and give the residents and visitors an opportunity to access and explore the restored natural riparian area. There is a possibility of reconnecting both sides of the river by reactivation of the former ferry crossing. The chosen site is located in the southern part of the Vistula River Delta close to the origin of Nogat (a distributary of the Vistula River and one of its delta branches), where the connectedness of both river edges is limited.

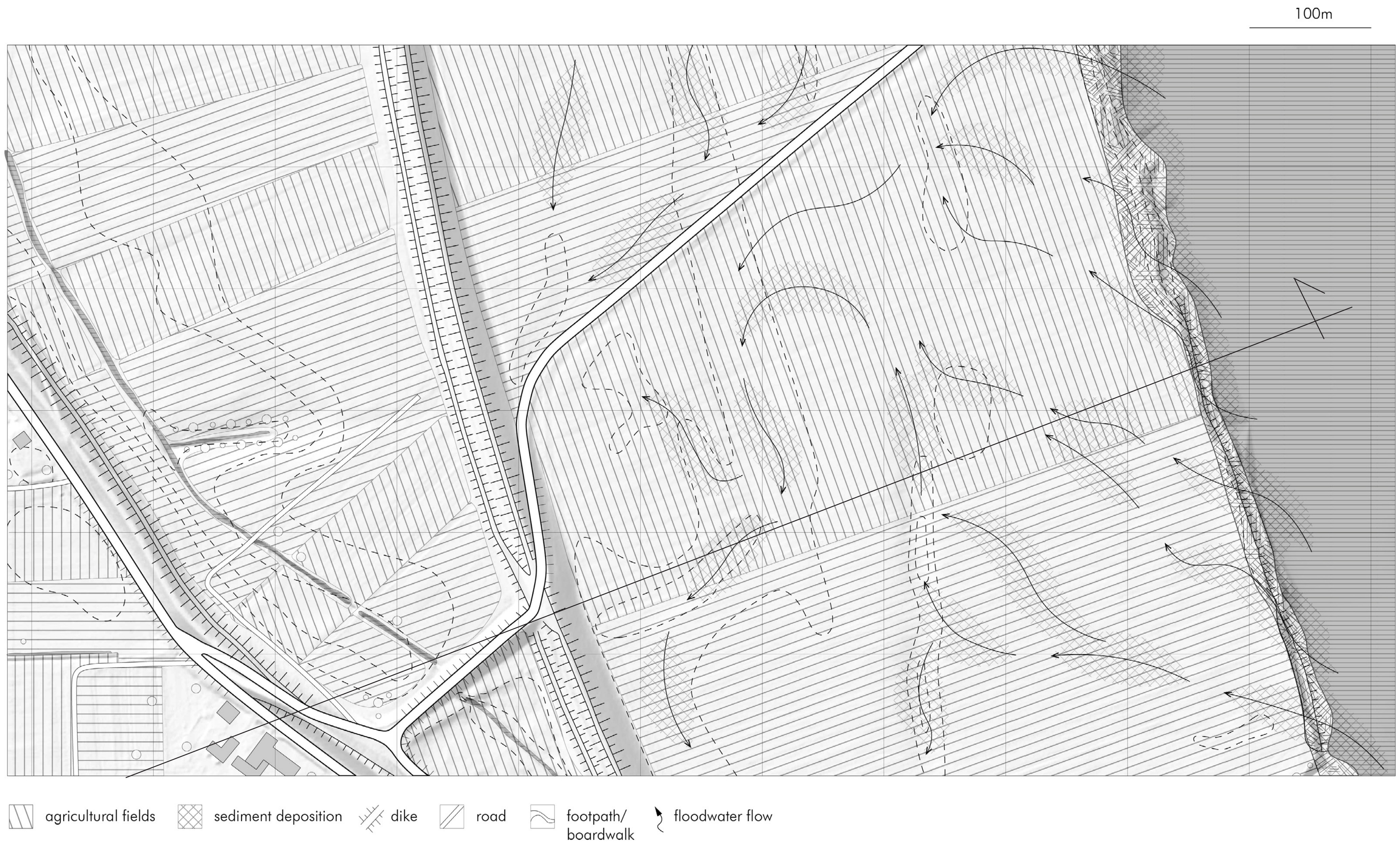


Fig. 106. Agricultural edge - current spatial conditions, map | Source: author's own work
Fig. 107. Agricultural edge - current state, section | Source: author's own work

Agricultural edge
environmental conditions and potentialities

The fertility of the soil led to creation of a mono-functional agricultural landscape. The fields occupy a vast part of the delta. Although the river bank is less abrupt than in the urban areas, it is a very narrow linear section with a limited amount of vegetation. The edge, therefore, does not have much agency in ensuring the resilience of the landscape, neither does it decontaminate the soil and water. Currently, the dike is a measure of flood protection, however, the land between the dike and the river consists of agricultural fields which act as floodplain during flood events.
Agriculture is a source of a variety of pollutants, such as pesticides, nutrients (nitrogen and phosphorus), composts (including animal manure) and petroleum as well as solvents used for heavy machinery (Kennen & Kirkwood, 2015). The presence of contaminants in the agricultural land is widespread because of the technological improvements which lead to an increase in yields. The pollution is discharged to the waterways through the ditches parallel to the fields and, as shown in the problem field section, the rivers play a role in channeling pollution downstream.
The objective of the design is to regenerate the deltaic landscape through the agency of the edges. The edges would then play a role of a buffer that process the pollution discharged from the fields and accommodate the flooding from the river.

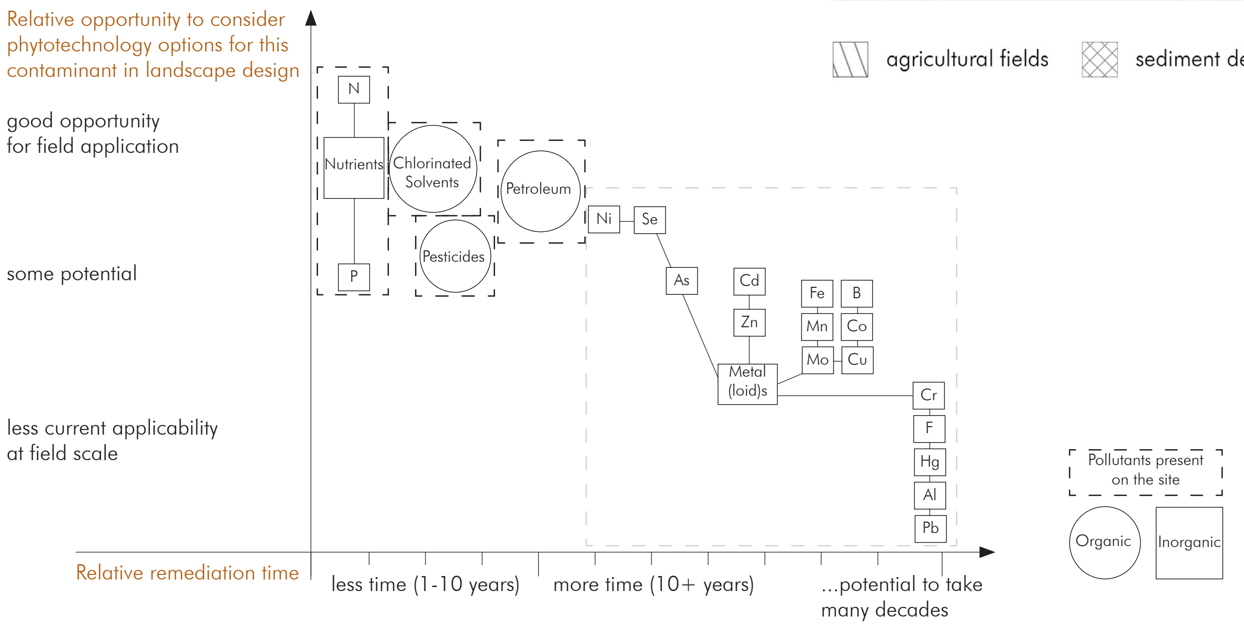


Fig. 108. Agricultural edge - current environmental conditions, map | Source: author's own work
Fig. 109. Phytotechnologies - potential use x time matrix | Source: Kennen & Kirkwood (2015)

Agricultural edge
transition | phase 1
resilience

To adapt the land for agricultural purposes, the low-lying wet zones of the riverine landscape in the Vistula River Delta were filled and drained. In order to restore the initial flood resilience of the edges, space for water needs to be provided. Changes in the currently flat topography would create an adaptive landscape with various degrees of wetness. Moreover, this measure would increase the water retention capacity of the site. The immediate water edge is designed to be the lowest section of the edge and therefore nearly always flooded. Further inland the presence of floodwater is ephemeral. The landscape is reshaped with the use of soil present on site, namely the soil is removed in the areas meant for permanent wetlands and used to elevate the landscape close to the existing dike. Higher topographic diversity of the edge ensures various conditions and thus higher biodiversity, including shallow foraging habitat for fish, deeper water for ducks and nesting islands for birds. By allowing water inland, the riverine edges become a theater of water fluctuations, a landscape in transition determined by rhythms of flooding and sediment transport.

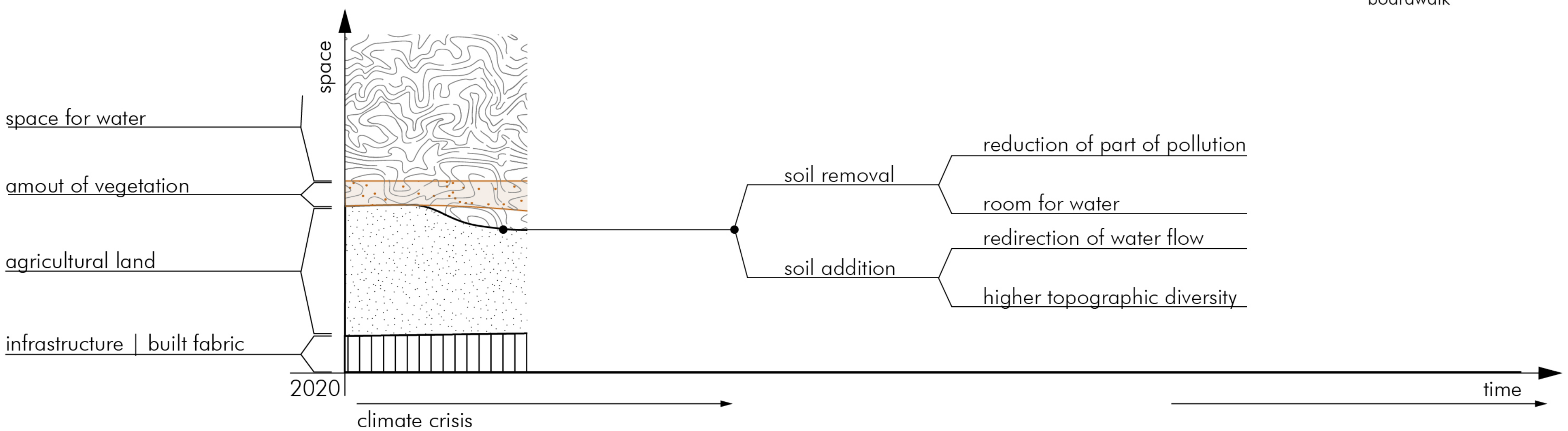
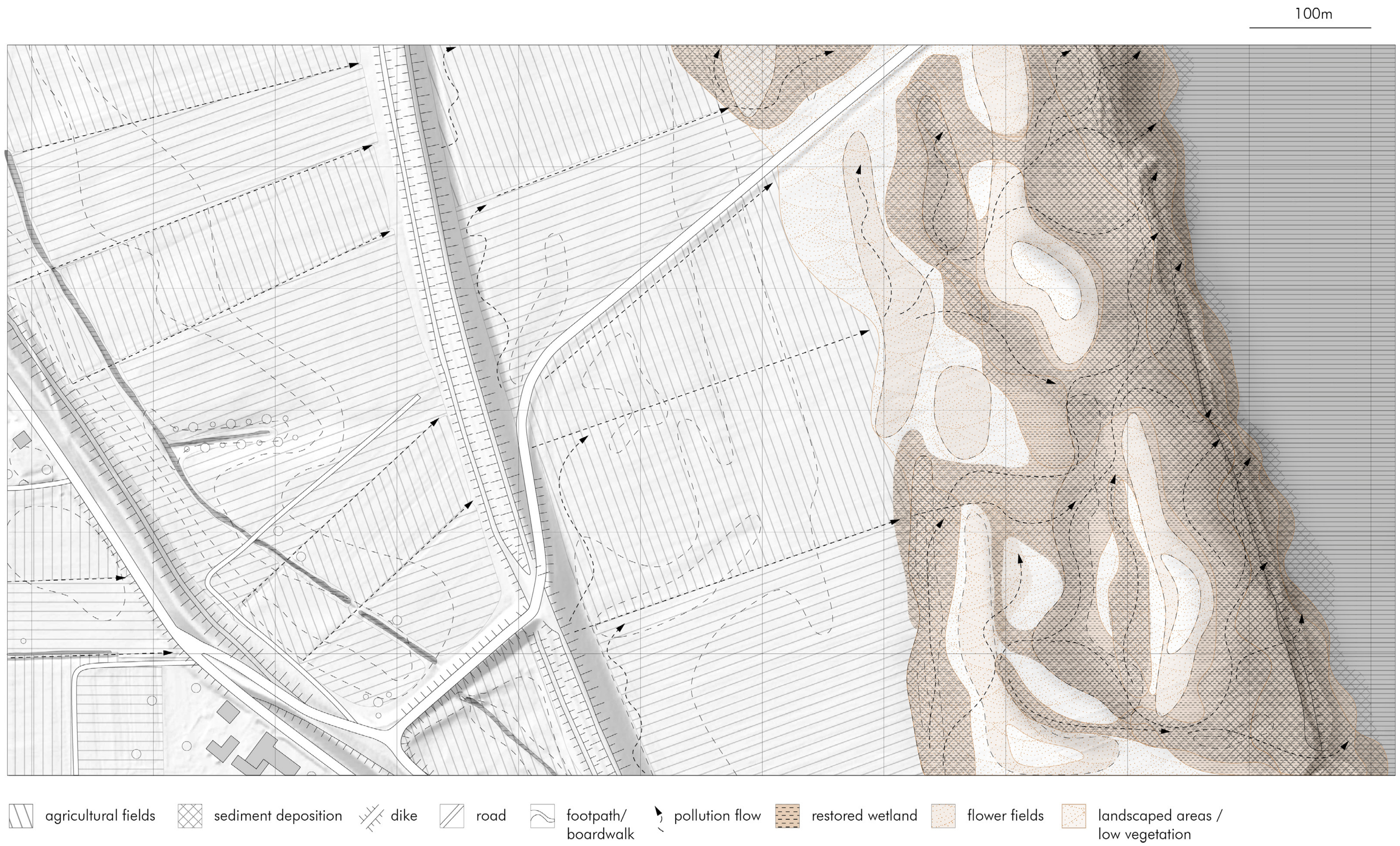


Fig. 110. Agricultural edge - phase 1, map | Source: author's own work
Fig. 111. Agricultural edge - phase 1, spatio-temporal diagram | Source: author's own work

Agricultural edge
transition | phase 2
remediation + resilience

Ecological restoration is a process that triggers or stimulates the recovery of an ecosystem in terms of its sustainability, integrity and health (Society for Ecological Restoration).
The deltaic landscape of the Vistula River used to abound in wetlands and marshes before it was drained for agricultural uses. The aim of this proposal is to regenerate the edges by improving their ecological and social performance. In the first phase of the project, the soil works would be conducted which would allow for a restoration of wetlands in the low-lying immediate water edge. Next to the necessity of specific physical conditions, the wetland restoration would require reintroducing absent vegetation and animals species (Gwin et al., 1999).
Wetlands provide a range of important ecosystem services, including improvement of water quality, flood management and biodiversity (Clarkson et al., 2013). Thanks to the restoration of wetlands in the agricultural edges of the Vistula River, the pollution of the river would be reduced. Firstly, the water overflowing through the wetlands would be filtered by the aquatic vegetation. Secondly, the agricultural and storm water runoff coming from inland would be processed by the wetland before entering the river, therefore the discharged water would be cleaner.



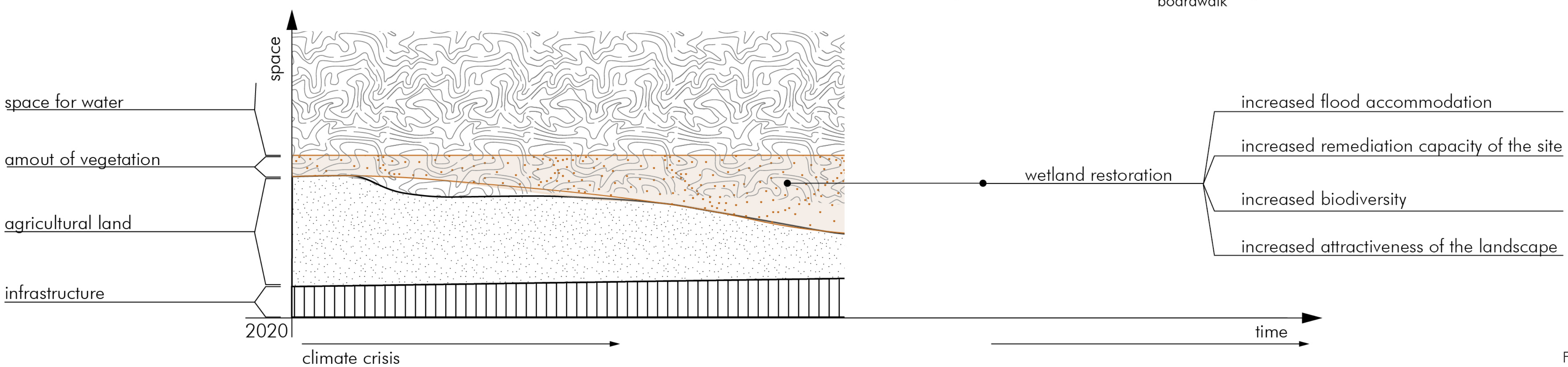


Fig. 112. Agricultural edge - phase 2, map | Source: author's own work
Fig. 113. Agricultural edge - phase 2, spatio-temporal diagram | Source: author's own work

Agricultural edge
transition | phase 3
performance

Today, access to the Vistula River edge in the rural part of the delta is restricted. The dikes constitute a significant barrier. The inconvenience of crossing the embankments led to an abandonment of some river crossing services, as in the case of the chosen side. The levees limit not only the movement in the direction perpendicular to the river but also parallel to the river. The infrastructure is moved away from the riverbed and therefore the movement of people happens only behind the dikes. The design proposal includes improving connectedness along the river edges as well as across them. The ferry crossing is reintroduced to improve accessibility and thus the economic value of the area. Next to that, a network of elevated boardwalks is proposed to provide an opportunity to experience the riverine landscape and discover the nature of the river dynamics. The network of paths allows the local communities and tourists to be more connected to the river both literally and emotionally by helping develop a place attachment.

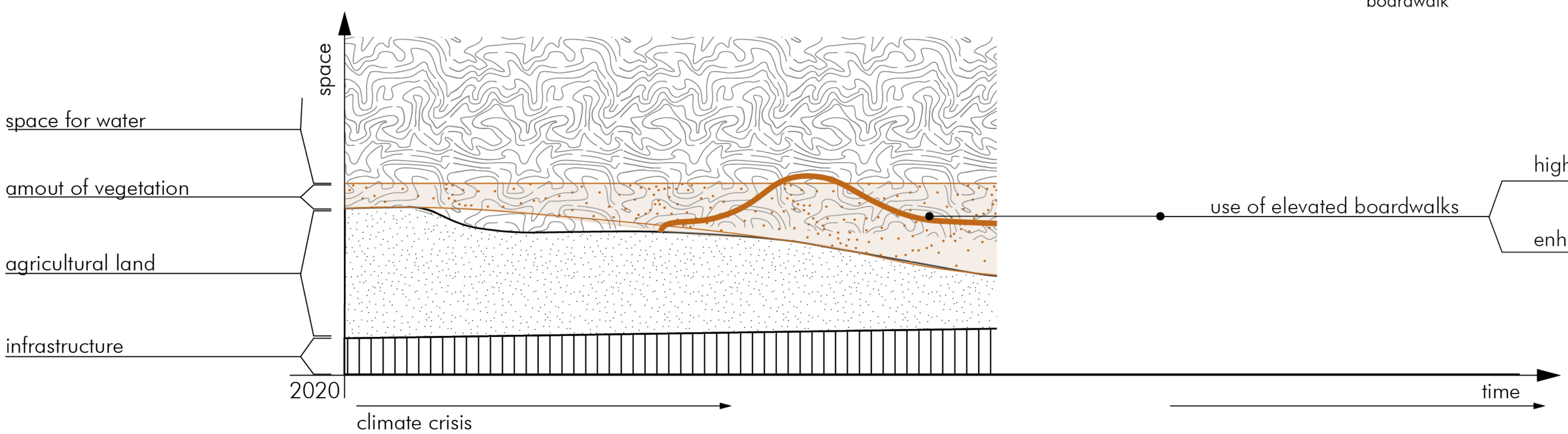
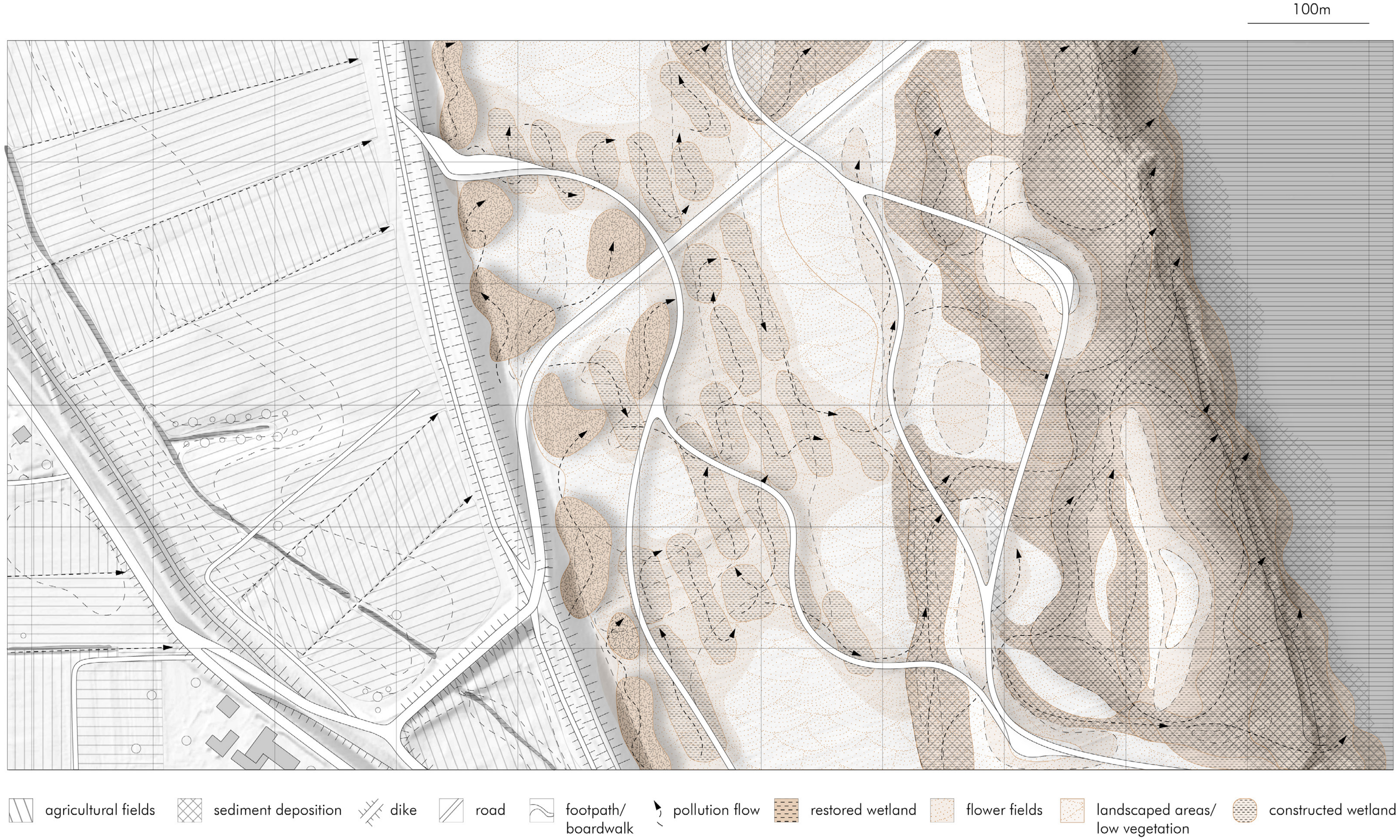


Fig. 114. Agricultural edge - phase 3, map | Source: author's own work
Fig. 115. Agricultural edge - phase 3, spatio-temporal diagram | Source: author's own work

Agricultural edge
transition | phase 4
remediation + resilience

The edge with a width of five hundred meters allows for various gradients of wetness and thus a variety of types of vegetation and remediation methods. The lowest-lying sections of the edge are used for wetland restoration. As wetlands are highly effective at removing contamination from water, the concept was reused in the man-made systems, namely constructed wetlands. In this proposal, the engineered wetlands are constructed further from the river, in the areas with ephemeral flooding. The constructed wetlands can achieve a high removal of nutrients from contaminated water (Vymazal, 2007). As stated in the problem field, nutrients, namely nitrogen and phosphorus, constitute the main pollutants of the riverine systems and the Baltic Sea. There are various types of constructed wetlands based on hydrology (subsurface and surface flow), the vegetation types and the flow direction (horizontal and vertical) (Vymazal, 2010). Using a hybrid of the various systems could provide a better treatment performance (Vymazal, 2005). One of the phytotechnologies used in the constructed wetlands is the phytoextraction of inorganic pollutants that require the subsequent harvest of the plants (Kennen & Kirkwood, 2015). The harvested biomass could constitute a source of income for the landowners and in this way increase the economic resilience of the area.



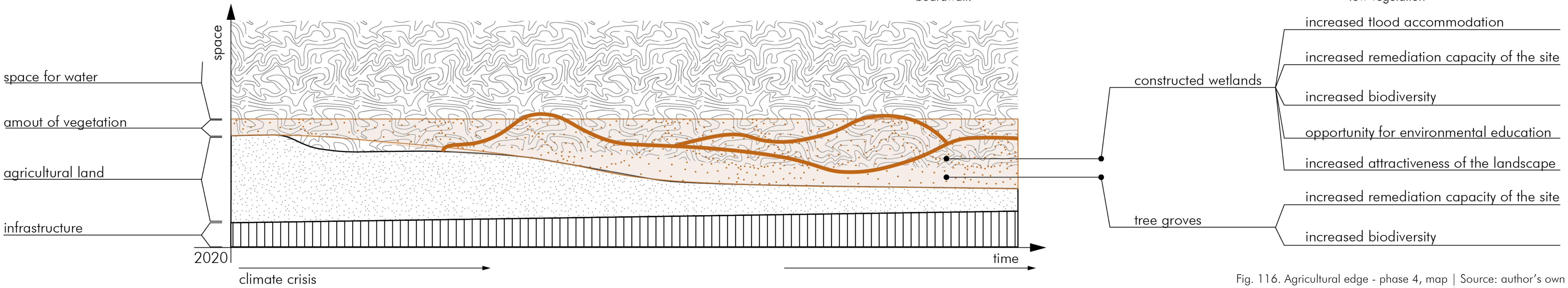


Fig. 116. Agricultural edge - phase 4, map | Source: author's own work
Fig. 117. Agricultural edge - phase 4, spatio-temporal diagram | Source: author's own work

Agricultural edge
transition

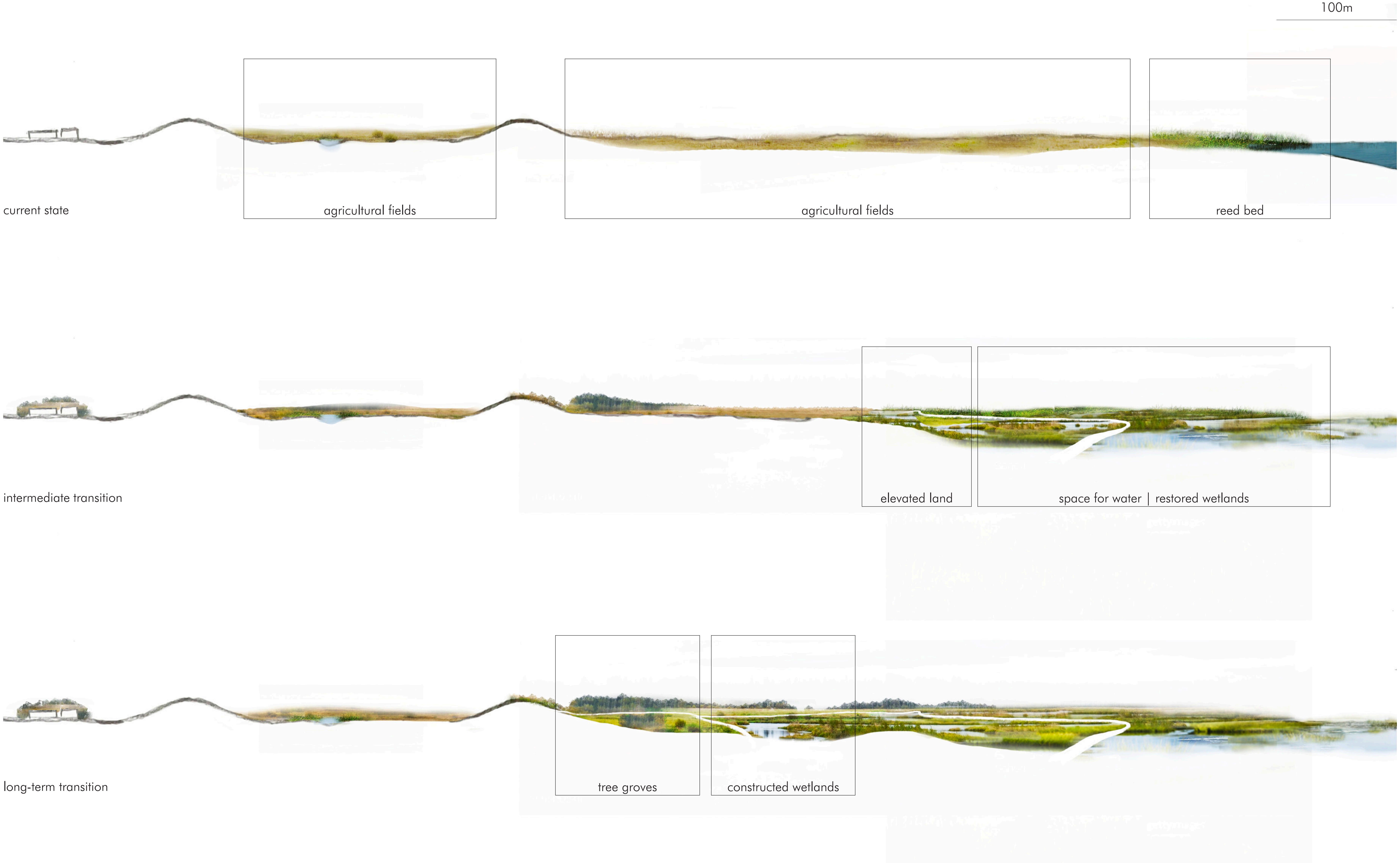


Fig. 118-120. Agricultural edge - transitions, sections | Source: author's own work

Agricultural edge
regeneration

Fig. 121. The projection of the transition of the agricultural edge
Source: author's own work

Chapter 6

Evaluation

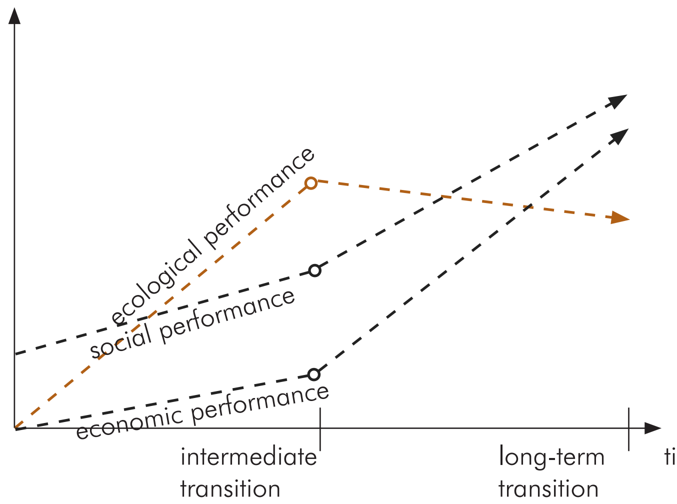
This chapter evaluates the transitions of the edges caused by superimposition of the design interventions. It illustrates how the social, ecological and economic performance change over time because of the transitions in the land use, land management and ownership.

Fig. 122. The Vistula River close to its estuary | Swibno
Source: author's own photograph | field trip February 2021

Transitioning of the edges
Post-industrial edge

The suggested systemic transition towards more regenerative riverine landscapes that is mainly focused on the remodeling landscape topography and use of specific vegetation providing ecosystem services will enhance the ecological, social and economic performance of the Vistula River edges and might act as an example for transitions of the Vistula river tributaries as well as other riverine systems.

Former occupation of the site, namely the shipbuilding industries, was a source of contamination, including solvents, petroleum and heavy metals. The pollution accumulated in the soil and water, causing degradation of the natural environment. The shipyards, similarly to other industries were gated and the access to the area was restricted. After the bankruptcy of the shipyard, the economic performance of the site was substantially reduced. Recently the area was opened to the public in order to improve the social performance of the site. However, the ecological and economic performance of the edge is not being addressed. The future development of the area proposed by the current landowners aims to improve the economic and social dimension of the Young City. To make it possible, the site requires remediation, which would improve the ecological performance of the site.
The design proposes changing the topography of the site to direct the floodwater flow and create space for water storage. In this way, the transition would improve the resilience of the landscape which has an impact on all three types of performance. The excavated soil would be washed outside the area and reused to create a hilly landscape that would additionally improve the resilience. Next to the soil washing, the design uses phytotechnologies to decontaminate the soil and water and thus make the environment healthy. Thanks to that, future development may take place and the economic and social performance of the edge would considerably improve. The temporal transition indoors, namely the use of space for vegetation, is replaced by multi-functional areas which create a network together with outdoor public spaces and are a trigger for a higher social and economic performance of the Young City.



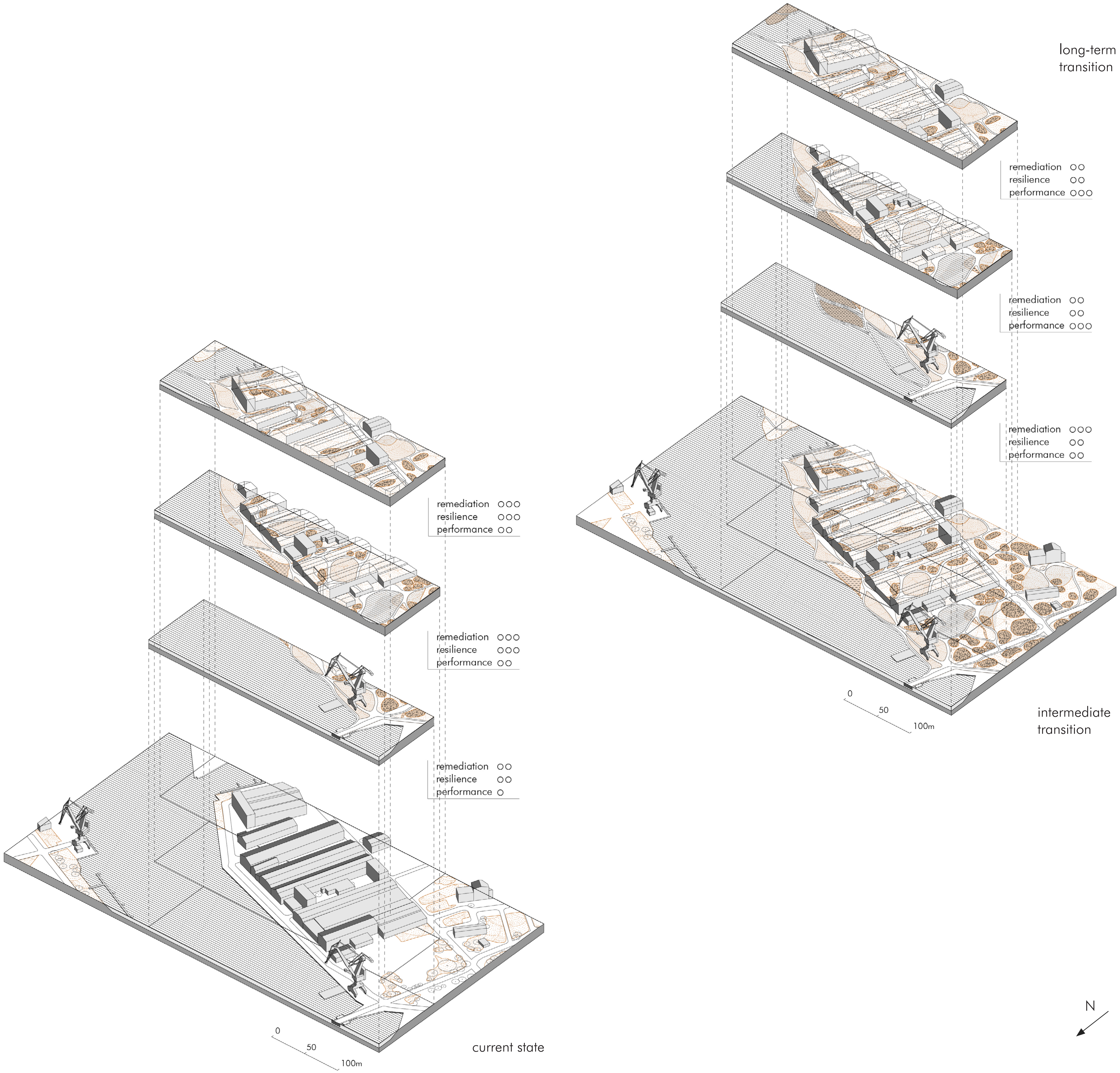
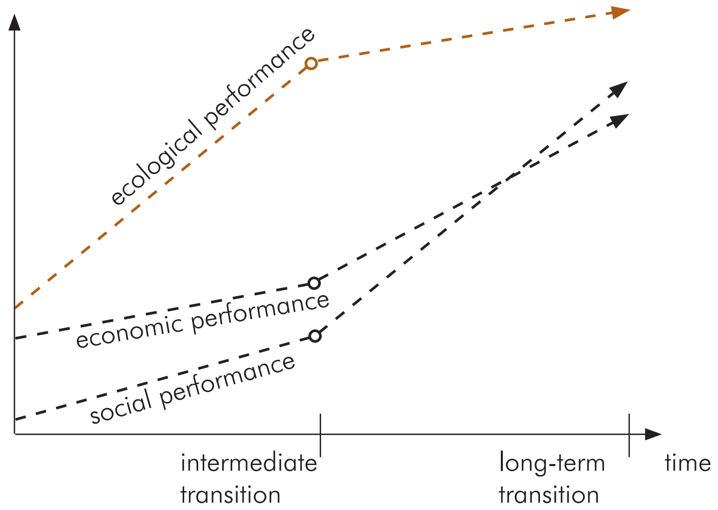
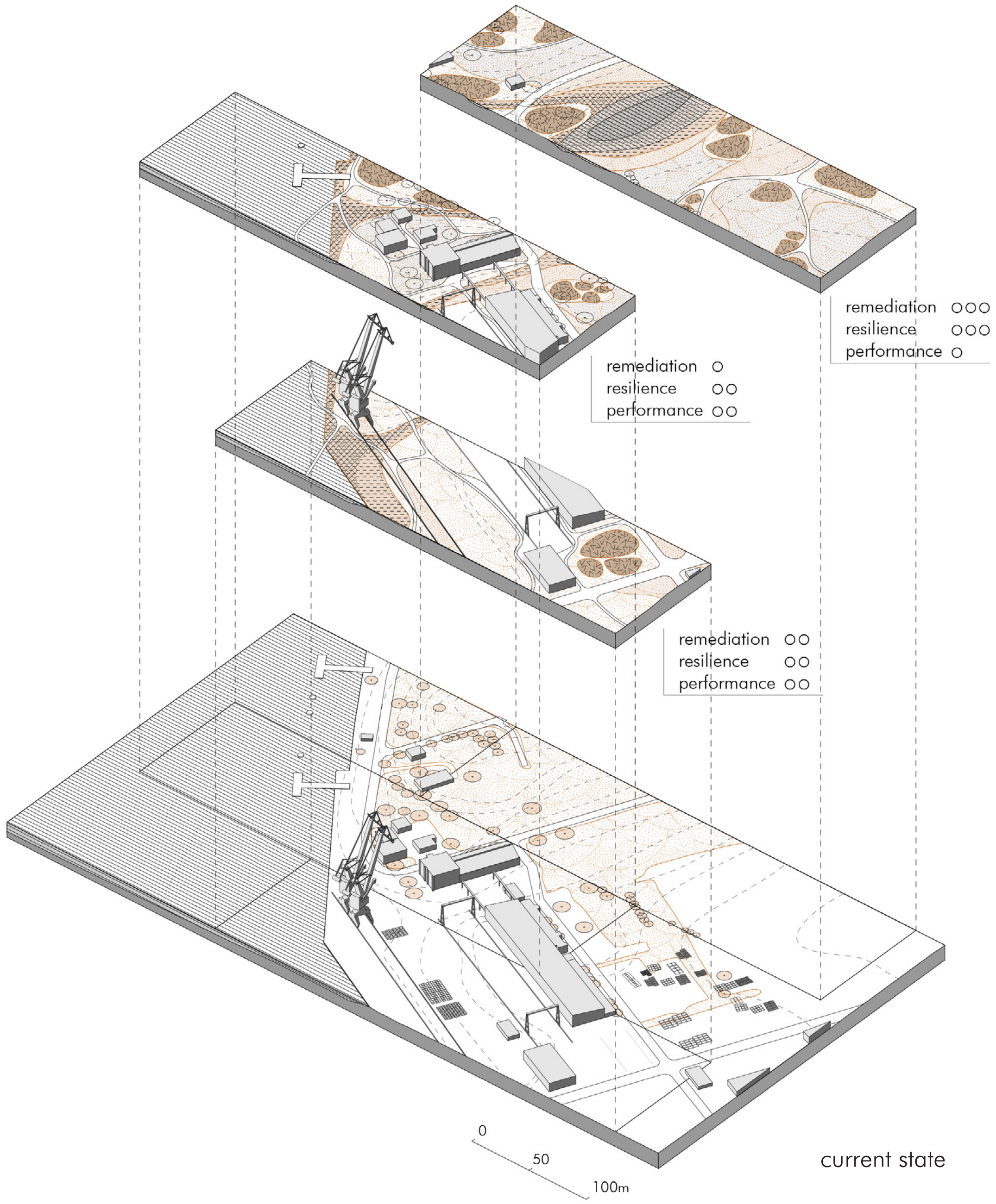


Fig. 123. Post-industrial edge - ecological, social and economic performance transition | Source: author's own work
Fig. 124. Post-industrial edge - assessment of remediation capacity, resilience and performance in the intermediate and transition | Source: author's own work
Fig. 125. Post-industrial edge - assessment of remediation capacity, resilience and performance in the long-term transition | Source: author's own work

Transitioning of the edges
Underutilized edge

The Ostrow island accommodated various functions throughout ages. Today it is a part of an industrial area of Gdansk. However, the land is underutilized, especially in the southwestern section of the island. The economic performance of the section is, therefore, lower than in the other parts of the island. The restricted access to the site profoundly influences social performance. In terms of ecological performance, the underutilized edge demonstrates higher biodiversity and amount of vegetation than the post-industrial edge.
The vast open space allows shaping the landscape more freely than in the post-industrial edge. Therefore the design proposes a transition that focuses on the use of outdoor spaces to improve the performance of the site. To ensure enhancement of the social and economic performance the area is made accessible through the bridge connecting it with the Young City.
Higher ecological performance is reached by providing more flood accommodation thanks to changes in the topography use of vegetation. Wetlands, flower fields and trees strengthen the remediation capacity of the area and its attractiveness, providing better conditions for improvement of social and ecological performance.
The economic and social dimension is enhanced by the introduction of multi-functional spaces outdoors and indoors, namely restaurants, museums and recreational areas.





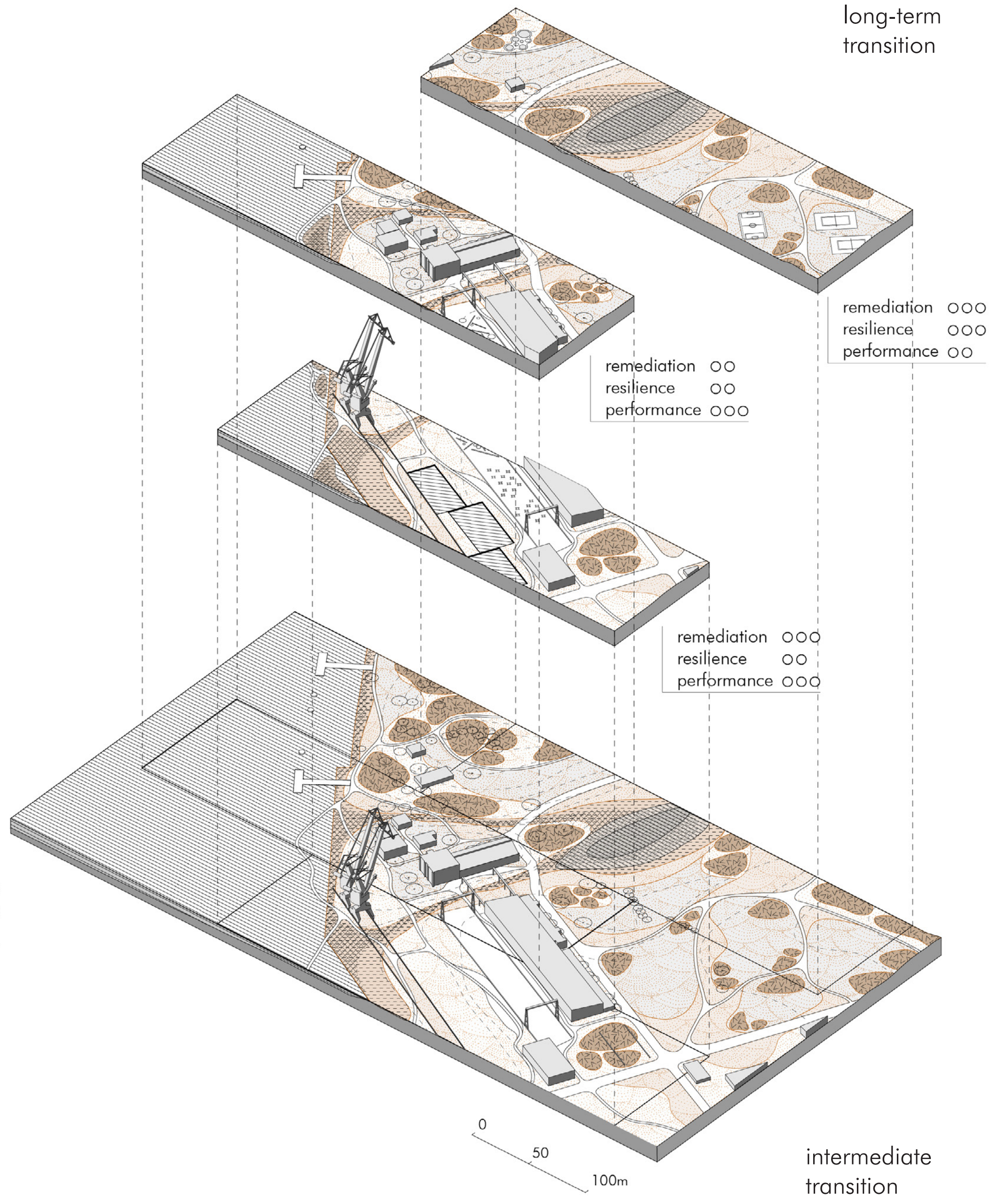
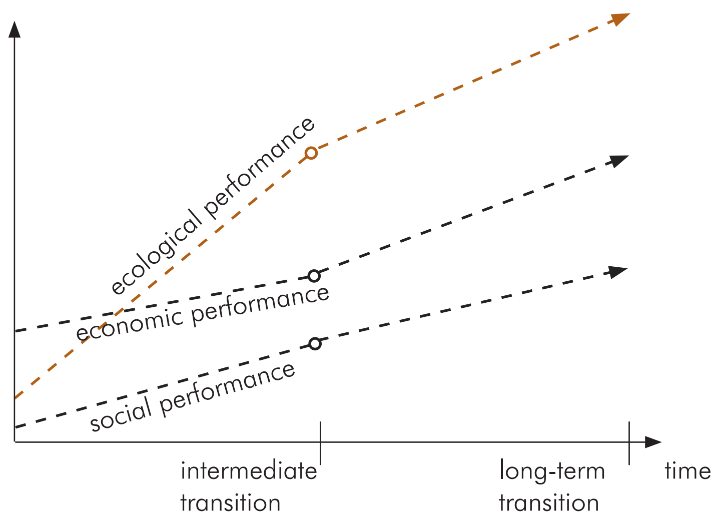


Fig. 126. Underutilized edge - ecological, social and economic performance transition | Source: author's own work
Fig. 127. Underutilized edge - assessment of remediation capacity, resilience and performance in the intermediate and transition | Source: author's own work
Fig. 128. Underutilized edge - assessment of remediation capacity, resilience and performance in the long-term transition | Source: author's own work

Transitioning of the edges
Agricultural edge

Mismanagement of the land in this part of the Vistula River, namely using floodplain only for agricultural land, leads to an insufficient resilience and remediation capacity of the site. Vast agricultural fields do not allow the water to flow freely through the site and be retained in the edge. Limited vegetation and abrupt land edge additionally affect the ecological performance of the landscape. The proposal envisions a shift to a more performative land, namely to a re-naturalized riverine edge with a wide spectrum of vegetation that gives room for the water and sediment and filters it. The change of land use would additionally reduce the amount of pollution discharged to the river as the edge itself would not be occupied by polluting activities, but by purifying the landscape.
Currently, the increased risk of flooding due to narrowed watercourse has an impact on the economic situation of the area as floodwater may substantially reduce crop yields. Moreover, the floods, as well as the pollution of soil and water, affect communities and their performance. The design uses aquatic and semi-aquatic vegetation that is resilient to extreme weather conditions. The introduction of natural and artificial wetlands increases biodiversity and thus ecological performance. The possible use of biomass from the vegetation resilient to flooding would increase the economic performance of the edge.
The limited accessibility of the edge strongly influences its social performance. As the land has multiple owners, the accessibility of the edge is restricted. Shifting the ownership to the municipalities would allow for the employment of a coherent strategy, increase in the connectedness and therefore higher social performance as well as possible implementation of new functions and thus further improvement of economic performance.



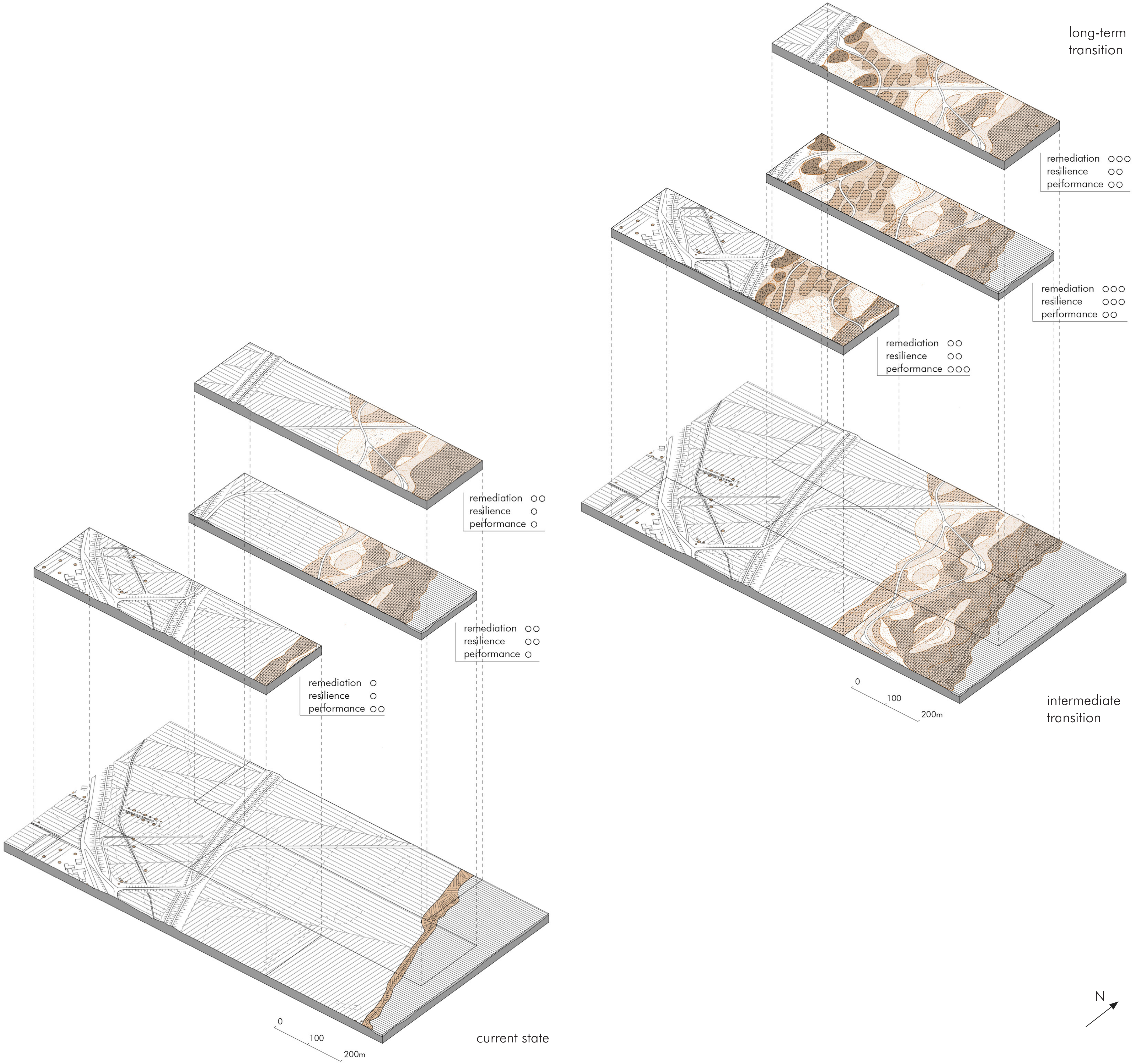


Fig. 129. Agricultural edge - ecological, social and economic performance transition | Source: author's own work
Fig. 130. Agricultural edge - assessment of remediation capacity, resilience and performance in the intermediate and transition | Source: author's own work
Fig. 131. Agricultural edge - assessment of remediation capacity, resilience and performance in the long-term transition | Source: author's own work

Fig. 132. The agricultural edge of the Vistula River | Małe Walichnowy
Source: author's own photograph | field trip February 2021

Chapter 7
Reflection

Project motivation, process and alignments

At the very beginning of the process I had an unclear picture of what I wanted to work on throughout this year. My previous plans regarding the Master's thesis topic changed due to the travel restrictions imposed during covid-19 pandemic. Thus, I decided to conduct a research in my own country and right now reflecting on that decision, I can say that this year allowed me to see and understand the complexity of the problem field I was addressing. My initial fascination that helped outline the topic of the thesis regarded post-industrial landscapes in the port city of Gdansk, however I also wanted to look at a bigger scale of the riverine system. Thanks to the mapping exercises in the collective phase of the journey as well as the conversations with my mentors the focus of the thesis was crystallized. Looking at the problem field through a lens of the transitions of the riverine edges helped establish an alignment of the issues discussed in the problem statement and the design assignment.

The choice of the Transitional Territories Studio was motivated by my desire to work with a multi-scalar approach to the project and to address anthropogenic pressures on the ecological systems.

The topic of my graduation project regards transitioning of the edge condition along the Vistula River with the focus on the pollution, flooding and performance. Examining those transitions through the four lines of inquiry of the TT Studio, namely Matter, Topos, Habitat and (Geo)politics demonstrated that the processes happening within the analyzed systems are interrelated, e.g. the pollution from the anthropogenic activities is transported seaward by the rivers and affects marine ecosystems. On the other hand, the phenomena, like rising sea level and more frequent storm surge, increase the flood risk inland. The relation to the topic of the studio "Inland, seaward. The trans-coastal project" can be seen more literally in the analyzed urban context of Gdansk, where the port moving seaward causes spatial urgencies in the edges of the city and the waterfronts.

My graduation project, similarly to other projects developed in the Urbanism track, has a multidisciplinary approach since it draws from disciplines such as spatial planning, urban design and landscape architecture. Besides, in formulating the problem statement and the research aim, I tried to integrate social, economic and cultural aspects with the condition of the landscape and the ecological systems. Furthermore, the research objective shows the relation between the project and the master program as it reveals an ambition to propose regenerative design practices and strategies for the built environment.

Relationship between research and design

Design for improvement of social, ecological and economic performance of the riverine edges in an area vulnerable to pollution and flooding like The Vistula River Delta requires an understanding of the relationships between the processes influencing the social and ecological systems. Taking into account the future developments and the possible severity of climate crisis, it is necessary to employ a medium which, next to being used for remediation, would be resilient to future changes and eventually contribute to the regeneration of socio-ecological systems in the study area. In the initial part of the project, the landscape ecology principles (Dramstad et al., 1996) are used to analyze the edges and derive design parameters. Thereafter, the research on landscape urbanism (Waldheim et al., the 1990s) helps design the process of transitioning the edges with the medium of landscape.

Scientific relevance and transferability

The thesis builds on the understanding of the concepts of regeneration and socio-ecological systems (SES). The concepts are based on extensive research, however, the practical implementation of them is limited. The project is an attempt to translate the concepts into practice by proposing design interventions and strategies for the regeneration of the socio-ecological systems. In this way, the thesis aims to bridge the gap between the theoretical and practical knowledge of the functioning of SES.

Besides that, the proposed transition of the edge condition and regeneration of the socio-ecological systems builds on the notion of using landscape, and ecosystem services embedded in it, as a medium to restore the ecological capacities of a site.

The ambition of the thesis is to contribute to the promotion of ecological awareness and advocacy in Poland. The spatial strategies and design interventions proposed for three types of edges in the Vistula River Delta, namely the agricultural, the underutilized and the post-industrial edges, may be applied in other riverine landscapes which face similar issues. That is thanks to the set of design principles established in the project.

Societal relevance

The thesis aims to benefit society and contribute to their mental and physical health by improving safety in the edges along the Vistula River, namely by the reduction of environmental pollution and the risk of flooding. The proposal for transitioning the edge conditions through regenerative design practices focuses on enhancing the social performance of the agricultural, post-industrial and underutilized edges and increasing the diversity of uses in these landscapes. The creation of a network of open spaces promotes the livability of these areas.
Furthermore, the intention behind the use of the matrix of scenarios is to manifest possible consequences of continuing the current practices and thus to increase the public awareness of relations between anthropogenic pressures and the severity of disturbances in socio-ecological systems.

Ethical considerations

While investigating the transitions of the edge conditions along the Vistula River there is a need to consider what systems are vulnerable and may be at risk. Anthropogenic activities including engineered solutions and profit-driven practices affect the existing landscapes and in consequence lead to environmental degradation, which impact ecosystems and humans' physical and mental health.
Taking the systems approach to ecology which defines it as "the study of the complex webs of interdependent relationships in ecosystems" (Metzner, 1999) requires exploration of multiple factors transforming the natural environment to understand the complexity of the systems. As stated earlier, the aim of the research is to find practices for a regeneration of socio-ecological systems. In order to do that the attitudes and values which drive the destructive practices need to be re-examined. What poses a challenge in the project is to define what is the minimal intervention that may alter the edge condition in a positive way and to what extent it might impact the social, ecological and economic performance of the edges.

Limitations

<u>Limitations of the methods</u>
First of all, the availability of data and access to it is restricted. For example, a wide range of environmental assessment datasets for the Baltic Sea is open-access and compiled by intergovernmental organizations, such as HELCOM, whereas the data on the state of the Vistula River is limited.
The analysis of urban performance carried out during the site visit were distorted due to restrictions imposed during the covid-19 pandemic.
There are limitations concerning scenario building and research through design. The exploration of possible future developments requires analysis of solutions in various case studies and it is challenging to generalize the findings and use them to make proposals. Additionally, there is a risk of unconscious bias in the proposal because of limitations related to personal communication with the stakeholders.

<u>Limitations of the project</u>
Climate change and anthropogenic activities influence the state of the environment in the Baltic Sea region in various ways ranging from pollution to increased risk of flooding (Andersen et al., 2017; Wolski et al., 2014). In this project, I focus on the condition of the edges along the Vistula River. I limited the scope of the thesis to the agricultural land edge in the Vistula River Delta and to the waterfronts in the port city of Gdansk. I chose the agricultural land edge as agriculture is the biggest factor that contributes to the eutrophication of the Baltic Sea (HELCOM, 2015), whereas the choice of Gdansk was made because the condition of the land-water edges in the city has been greatly transformed throughout years and is still in transition in order to meet the requirements of the industries and the port (Lorens & Lewicki, 2018).
Because of the limitations related to the access to data, including data about location, depth and intensity of pollution, the solutions proposed in the design interventions might not be sufficient in highly contaminated areas.
There might be limitations on scalability and transferability of the proposal as I project that some proposed strategies and design will address specific local context and thus, similarly to the aforementioned limitations of the case study analysis, it might be difficult to transfer the detailed proposal to different locations, however, the design principles might be used in the transitions of riverine landscapes elsewhere.

Conclusions

The research aimed to discover what factors influence the condition of the socio-ecological systems in the riverine edges of the Vistula River Delta and how they are related, in order to propose strategies improving the current state of the edges. First, the research discussed the environmental and spatial urgencies looking at the past and present processes taking place along the river. The analysis pointed to the conclusion that anthropogenic pressures and climate change lead to degeneration of the socio-ecological systems in the delta.

The formulated hypothesis concerned using landscape and ecosystem services embedded in it to improve the resilience, remediation capacity and performance of the edges. The hypothesis was tested by means of design in the riverine edges with diverse characteristics, namely in the post-industrial, underutilized and agricultural edge. The project proposes the alteration of topography, change of programming and implementation of vegetation in order to address the issue of pollution, flooding and limited performance. The main aim of the design is to decontaminate the riverine landscapes and thus limit the amount of pollution entering the Baltic Sea.

The proposal is based on the landscape urbanism framework and principles of landscape ecology as well as on case studies where plants were used to decontaminate the site and increase flood accommodation. However, there are limitations related to the accessibility of data about the amount and location of pollution. Therefore, the possible implementation of the suggested design would require an examination of the conditions of the specific site and possible adjustment of the proposal. The feasibility of the project ultimately depends on the stakeholders' involvement and awareness of the consequences of both degenerative and regenerative practices.

Further research is needed on methods and strategies necessary to promote the knowledge of the benefits of landscape design for transitioning the riverine areas. Lastly, to increase the probability of implementation of regenerative practices, a shift in the decision-makers stance on the employment of strategies is essential, namely, there needs to be a long-sightedness in decision making.

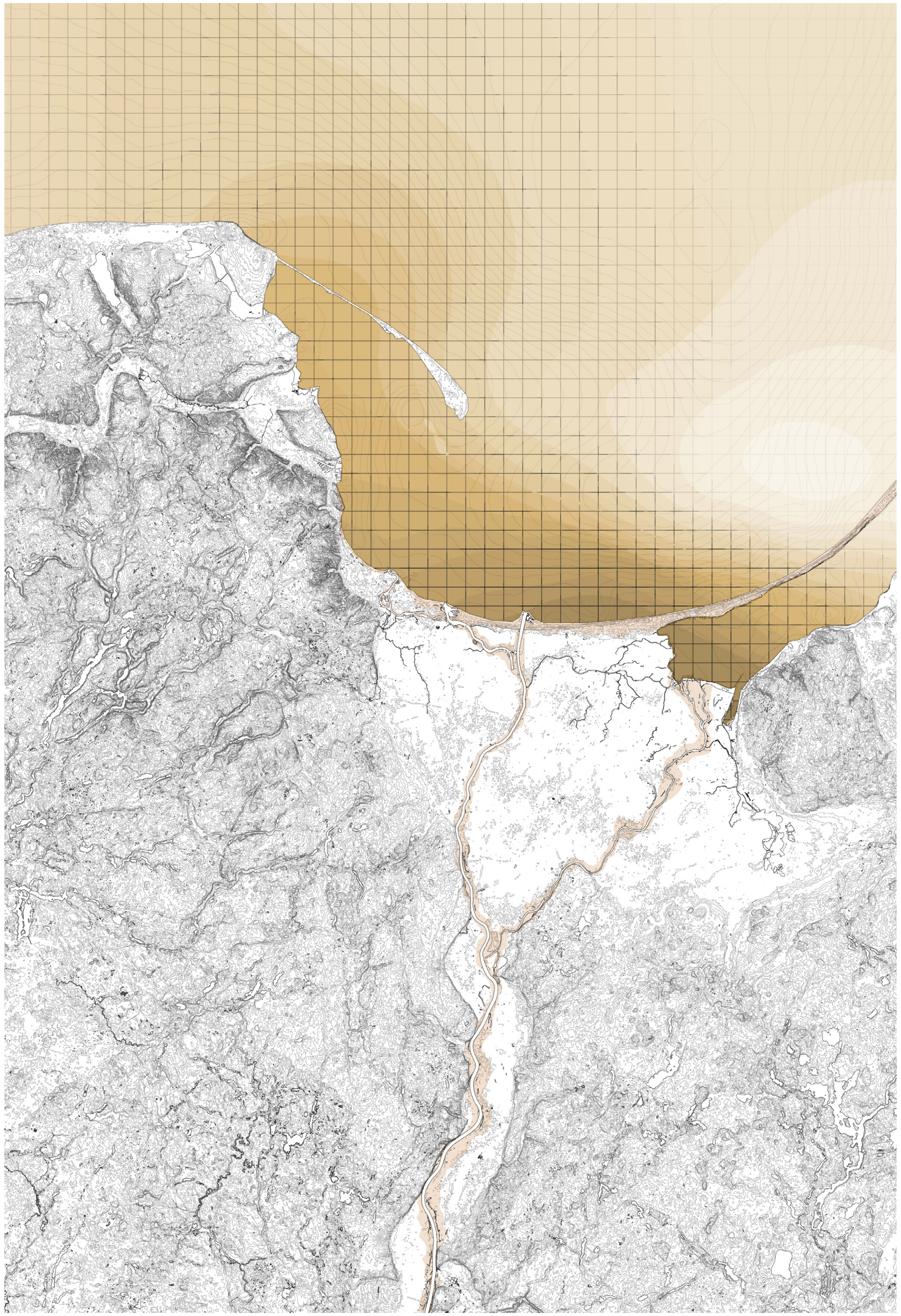


Fig. 133. Reduction of pollution in the Vistula River Delta and the Batic Sea | Source: author's own work

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Fig. 134. The Baltic Sea coast | Stogi beach | view towards the Deep-water Container Terminal in Gdansk
Source: author's own photograph | field trip February 2021

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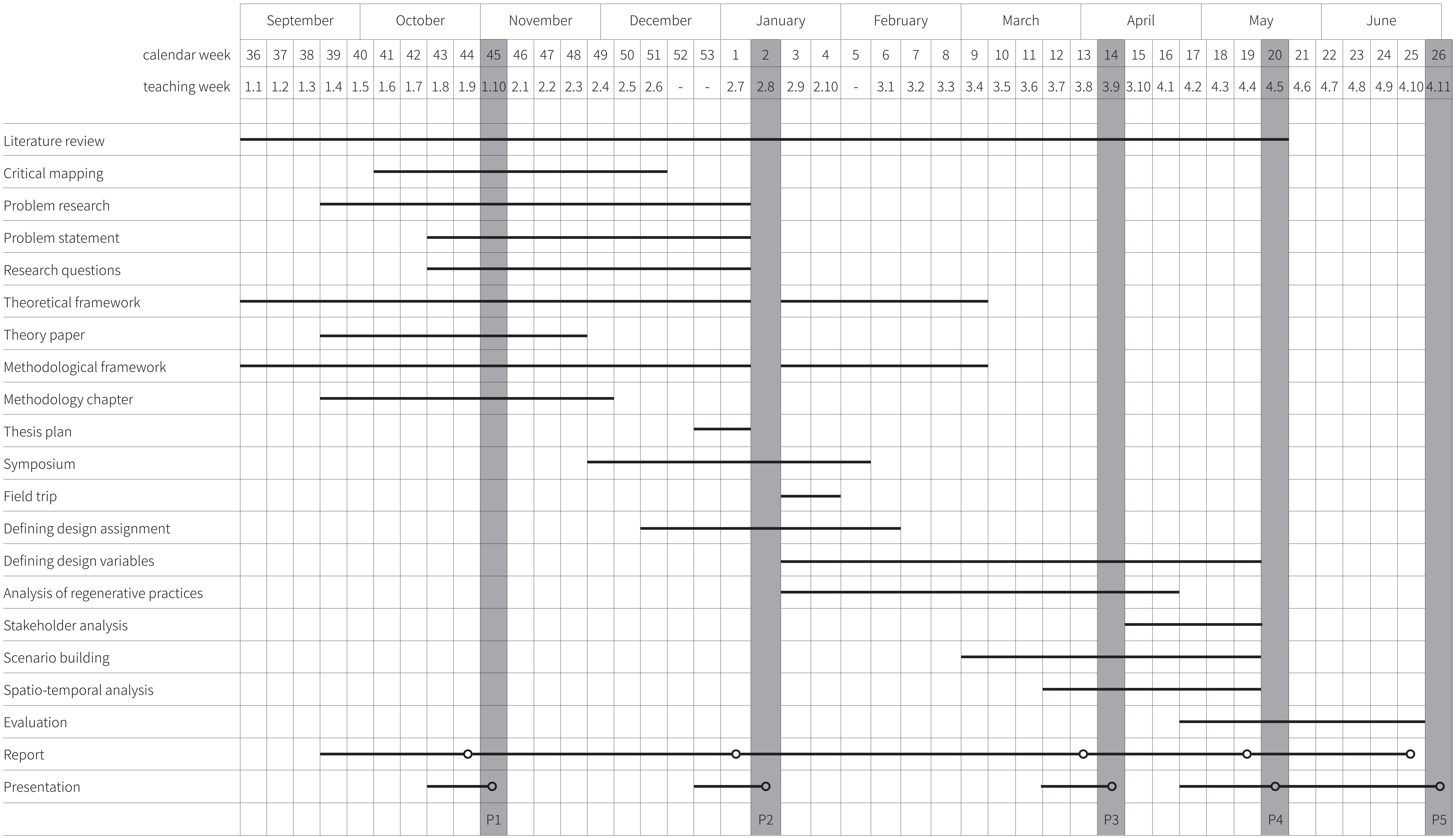
Appendix

Thesis planning
Theory paper

Thesis planning



Landscape as a Medium for a Regeneration of Socio-ecological Systems

Identifying environmental and spatial urgencies and potentialities of the abandoned landscapes in Gdańsk, Poland.

The current shift towards a service economy and advancement in maritime transport stimulate processes that influence the land use pattern in the port cities. The processes of deindustrialisation and seaward movement of the port lead to the emergence of disused areas often located between the water bodies and the dense urban tissue. Furthermore, the port cities face the issue of pollution of water, soil and air which originate from the port and industrial activities in the area and which impact the state of human health.

In order to counteract the degenerative effects of industries and port the paper proposes a concept of regeneration of socio-ecological systems. The framework of Larrick (1997) is used to understand the interrelations between different components within the socio-ecological systems and Mang and Reed (2012) understanding of regenerative development and design helps to imagine the spatial implementation of the concept of regeneration.

Taking into consideration the complexity of the urgencies in the port cities, the proposed framework for the spatial transition needs to allow flexibility and let time be an actor in the process of regeneration, which aligns with the tenets of landscape urbanism (North & Waldheim, 2013). Therefore the paper explores how the notion of landscape and ecosystem services could be used to rehabilitate the environment and join inaccessible abandoned areas to the urban tissue and thus reconnect the evolving ecological systems with social systems. A port city of Gdańsk is taken as a case study to analyse the spatial and environmental urgencies in place and prove the alignment with the issues addressed by landscape urbanism projects in which landscape is used to reach the aforementioned objectives.

Keywords socio-ecological systems, post-industrial area, regenerative design, landscape urbanism, urban performance, pollution

1. Introduction

Global and local processes influence the way cities function and how their territory is shaped. It is visible especially in the coastal regions, where the proximity of a body of water triggers the development of ports and vast industrial areas. However, with the shift towards a service economy, the process of deindustrialization takes place and raises an issue of disused, degraded landscapes. Gdańsk, a Polish port city, is a striking example of that phenomenon since the country's socio-economic transformation in 1989, which led to a shift from overindustrialisation to market economy and services became a leading economic sector. Further abandonment of land in port cities happens due to the modernization of maritime transport and thus the seaward migration of port activities motivated by the need for vast deep-water locations. Except for the spatial urgencies, the port and the industries cause environmental urgencies, including pollution of water, air and soil. Consequently, they lead to a degeneration of socio-ecological systems, namely disturbances in ecosystems and human health problems. There is, therefore, a critical need to address the abovementioned issues and stimulate

regenerative development and design in the city of Gdańsk. The paper explores the possibility of using landscape as a medium to reach the aim of regeneration of socio-ecological systems.

The two following sections of the paper cover the problem statement. Section 2 explores the changes in economy and technology, their emergence and spatial implications in the context of Gdańsk. Section 3 identifies the degenerative impact of port and industrial activities. Following the examination of spatial, environmental and health urgencies, the need for regeneration of socio-ecological systems is expressed. Thereafter, regenerative development and design framework is described. Finally, the last subsection reveals design principles of landscape urbanism, which could be used in the process of regeneration of the disused and degraded landscapes of Gdańsk.

2. Spatial urgencies and potentialities

Transitions that occur in space due to the changing land uses are triggered by shifts in various systems, including economy and transport. This section examines worldwide phenomena which have an impact on space in urban environments. The effects of these processes are presented more comprehensively in the case of the city of Gdańsk. Then the potential use of the concept of landscape is suggested as a medium to address the spatial urgencies.

2.1. Changing the city-port relationship

Throughout history, there was a close relationship between the ports and cities linked with them as the city's wealth was dependent on its capacity to adapt the port to emerging changes in economy and technology (Hein, 2014).
After the introduction of larger ships and changes in maritime transport in the second half of the twentieth century, ports needed to meet new spatial requirements such as access to vast land and deep-water areas on the sea (Hoyle, 2000). The cities and the ports grew apart because former harbour areas were not able to fulfil the needs of the modernised port technology (Hoyle, 2000). In many European cities located by rivers, port activities migrated towards the estuary, in some cases leading to land reclamation to increase the capacity of the port (Pinder, 1981, as cited in Hoyle, 2000). The separation of port and city results in emerging spatial urgencies in the cities. Former port areas often located in close proximity to the urban core undergo a transition from lively centres of trade to derelict wastescapes as they are left behind due to the port migration process (Hoyle, 2000). On one hand, they pose new planning challenges because of the vastness, the neglected structures as well as the environmental issues, described further in the paper. On the other hand, the brownfield areas may be seen as a potential new direction of development, giving the waterfront back to city residents. The revitalisation of the waterfront is a process that interests many, from local authorities and developers to city residents, it is due to the high visibility of these sites (Hoyle, 2000). Changing port landscape has therefore become a worldwide phenomenon.

2.2. Gdańsk and its port

The city of Gdańsk followed the abovementioned path of redevelopment. It was first closely related to the port, which lay by Motława river, and thus the waterfront had then both operational and urban function (Szmytkowska & Nowicka, 2015). Subsequently, some activities were moved to the new port in the mouth of the Vistula River, leaving space between the city and the estuary for industries and further expansion of the port. Both the city and the port grew alongside each other until the changes in maritime technology appeared, namely containerization. The ambition of further growth and the need to receive a larger number of deep-water containers forced the port to reclaim land in the Outer Port (O DCT, n.d.). There is a plan in place to continue the trend and build the Central Port (Figure 1), which would add extra 410 hectares of reclaimed land ("Tak będzie wyglądał Port Centralny," 2019). It may result in migration of some Inner Port activities seaward, and thus the emergence of 120 hectares of disused land on the left bank of the Dead Vistula River, which gradually could be incorporated into the urban tissue (Kiewlicz, 2015).

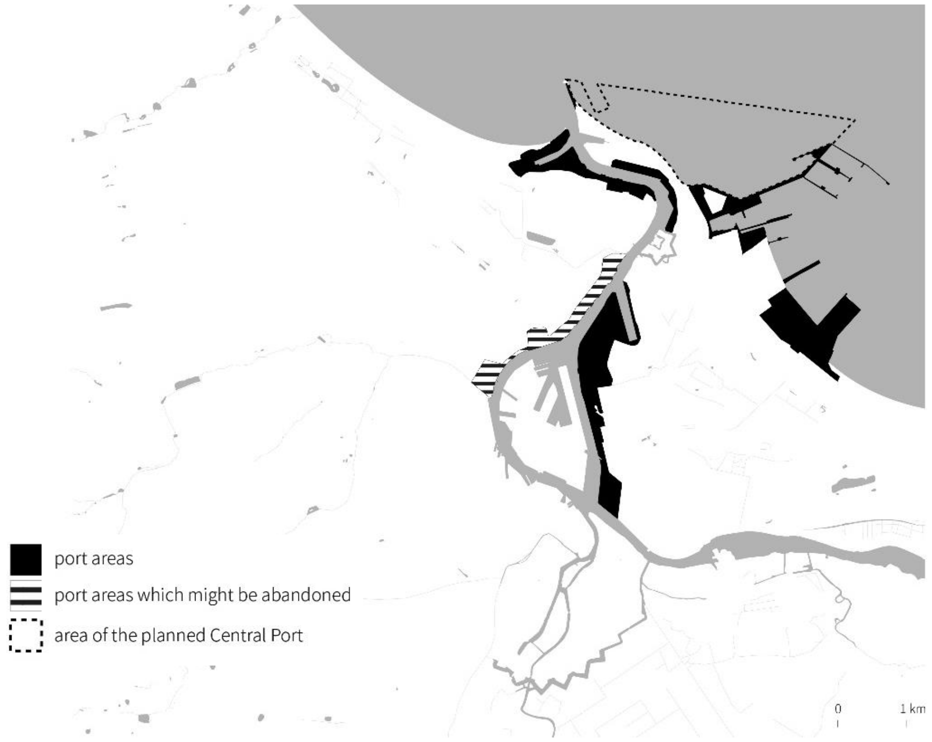


Fig. 1.
Changing port-city relationship in Gdańsk. Source: Author's own work

2.3. Deindustrialisation – phenomenon and spatial implications

Another phenomenon leading to spatial urgencies in cities is deindustrialisation, which can be defined as a process of decline in the manufacturing sector concurrent with a shift to services (Cairncross, 1982). As Clark forecasted (Clark, 1940, as cited in Schettkat & Yocarini, 2003) rising income would be followed by higher demand for services and thus an increase in employment in this economic sector. By the end of the twentieth century, the transition took place in all highly industrialised nations (Schettkat & Yocarini, 2003). The drop in employment in industries across Europe stemmed from the reduction of human labour in the manufacturing process due to the introduction of machines and moving the production to low-cost countries (Rachwał, 2011). In Poland, the transition to a market economy and hence deindustrialisation began in 1989 with market reforms introduced by the new democratic government (Gorzelak, 1995). Beforehand Poland was a member of the Socialist Bloc whose economic structure reflected the belief that industries were key to economic growth and building up military power, and thus the countries within the Soviet Union were industrialized to an excessive degree (Mickiewicz & Zalewska, 2002). The marginalisation

of service and agricultural sectors led both to poverty and limited availability of resources, only the liberation from the communist rule showed the importance of the previously neglected economic sectors and the real needs of the society (Mickiewicz & Zalewska, 2002). The changes in the system caused a shift in the employment pattern. At the beginning of the 1980s in Poland, 30.3 per cent of workers were employed in industry, by 1989 the rate decreased by 1.5 per cent and in 1995 it reached 24.9 per cent (Socha & Weisberg, 1999). The shift is reflected in the changing degree of land occupation, namely the emergence of disused post-industrial landscapes.

2.4. Rise and decline of industries in the mouth of the Vistula River

The location by the Vistula river close to the Baltic Sea gave the city of Gdańsk a chance to become an important trade hub in Europe (Tölle, 2008). Next to that in the mid-nineteenth century the Prussian authorities, as Gdańsk was a part of Prussia at that time, saw an opportunity to build the shipbuilding industry by the Vistula River (Lorens & Lewicki, 2018). Most of the development occurred in Young City (Figure 2), an area adjacent to the city and close to the mouth of the river. Some buildings were also located on der Holm, today called Ostrów Island. The shipyard developed rapidly thanks to its location and the national investment in the navy (Wróbel & Frankowski, 2016). First, it served mainly as a ship repair yard for small naval vessels, to soon become a leading place in the shipbuilding industry in Prussia. Since 1871 Gdańsk was under the German Empire rule, however, the importance of the place remained and it was then one of the largest shipyards in Germany (Januszajtis, as cited in Lorens & Lewicki, 2018).

Reorganization of the space happened at the end of the nineteenth century when most of the buildings were demolished and replaced by spacious production halls (Lorens & Lewicki, 2018). Later, after the Second World War, the Imperial Shipyard was connected with neighbouring Schichau Shipyard and named after Lenin, former head of government of the Soviet Union.

The aforementioned supremacy of the industrial sector in the Socialist Bloc was reflected in further growth of the shipyard and introduction of new structures in the landscape such as cranes, which became a symbol of the city. Gdańsk Shipyard was recognisable worldwide after the workers' protests which started Poland's way out of the communist regime (Tölle, 2008). After the socio-economic transformation, the financial status of the institution drastically changed and it went bankrupt in 1996. The remaining activities were moved to Ostrów Island and the process of spatial restructuring started in Young City. Several competitions for a transformation of the area were organised throughout the years. The submitted proposals included the reuse of the abandoned post-shipyard buildings as remnants of the industrial times. Moreover, the current development strategy of the city of Gdańsk proposes regeneration of the area as well as incorporating it into the Central Belt of Services of the Metropolitan Area Gdańsk-Gdynia-Sopot (Biuro Rozwoju Gdańska, 2019).

Fig. 2.
Post-industrial landscapes in Gdańsk. Source: Author's own work

2.5. Landscape as a medium to address the spatial urgencies

The land previously used for industries and port may be seemingly hard to access because of physical barriers such as a railway connecting the port with the inland area. Additionally, the urban form of the post-industrial and post-port areas is distinct from the rest of the city, and hence the visual connections between them are limited. The plans to incorporate the disused areas into the urban tissue must therefore address both the physical and the visual connectedness. Using landscape as a medium in the design process may help seamlessly link the abandoned waterfronts with the inland part of the city.

3. Environmental urgencies

The complexity of the human environment is based on various physical and non-physical elements which allow a diversity of human activities, however, they lead to pollution of air, water and soil (Lawrence, 2011). This part of the essay will explore the environmental impact of three significant entities in Gdańsk area, namely the port, the shipyards and the refinery, as well as the health consequences of pollution that originated from them. Thereafter, the last subsection will examine the possibility of using ecosystem services embedded in the landscape to address the issue of pollution.

3.1. Impact of port activities

The expansion of global maritime trade strongly influences the levels of air, water and soil pollution in port areas due to increased shipping and various port activities (Trozzi & Vaccaro, 2000). Ports, as intermodal trade hubs allow for the transfer of cargo between ships and inland means of transport (EPA, 2008). The use of diesel engines in ships, trains and trucks is the largest factor impacting the quality of air in harbours as these engines emit particulate matter (PM), ozone, sulphur and nitrogen oxides (SO_x, NO_x) as well as greenhouse gases (EPA, 2008). There are also various sources of water pollution in port areas. Trozzi and

Vaccaro (2000) listed origins of contamination including eutrophication, oil leakage and leaching of antifouling paint, which prevents the growth of organisms on underwater ship hull (WWF, 2006). The paint which was in use since the 1960s consisted of tributyltin (TBT), a toxic chemical compound, widely distributed in water, biota and sediment, especially in the harbour areas and shipyards (Lee et al., 2006, WWF, 2006). Although the ban on the use of tributyltin was adopted in 2008 (The AFS Convention, 2001), the time needed to reduce by half the concentration of it in the deep sediment is estimated at 87 ± 17 years (Viglino et al., 2004). Dredging activities, as well as flood events, pose a real risk in the areas of high concentration of pollutants as those processes can cause a release and spread of the compound present in the sediment back to the water body (Cañellas-Boltà et al., 2005; Viglino et al., 2004). Likewise, soil polluted by spills of oil and chemicals might affect the quality of water in flood-prone areas (Trozzi & Vaccaro, 2000).

3.2. Polluting shipbuilding industry

The presence of port is always associated with industries that benefit from the proximity to the transportation hub, however, they constitute another significant source of pollution (Trozzi & Vaccaro, 2000). In Gdańsk, the shipbuilding industry causes, next to the aforementioned spatial urgencies, environmental degradation (Zaborska et al., 2019).
The modern shipbuilding industry is based on collaboration between shipyards and global producers of prefabricated elements and thus the processes taking place in shipyards consist mainly of working with metal elements, treating the surfaces, installing various parts and systems as well as repairing and maintaining ships (OECD, 2010). These activities largely pollute the environment, at the same time the proximity of water increases the impact of the industry, as water becomes a carrier of toxins (OECD, 2010).
Besides that a great amount of work must be carried outdoor, considering the size of the ships. That condition increases the levels of air emissions contributing to climate change and air quality (Pulli et al., 2013). Air pollutants discharged during shipbuilding processes, such as welding or painting metal elements, include greenhouse gases, particulate matter (PM), sulphur dioxide (SO_2), lead (Pb), nitrogen oxides (NO_x) (EPA, 1994; EPA, 2008; OECD, 2010). Lead compounds are widely used in marine paint, which is a means of protection against corrosion (OECD, 2010). In some paints, heavy metals constitute up to one-third of ingredients (OSHA, 2006).
Apart from that, as mentioned in the report from the Organisation for Economic Co-operation and Development (2010) surface treatment and metalwork might also cause discharges of pollutants to soil and produce large quantities of residual waste and wastewater contaminated with oil and solvents. Moreover, during the process of abrasive blasting, in which ship surfaces are being prepared for further operations, a great amount of paint chips, oil and other pollutants is produced and might enter the adjacent water bodies in the event of flooding (OSHA, 2006).

3.3. Hazardous petroleum industry

Similarly to shipyards, oil refinery, located further from the Dead Vistula estuary, affects the quality of air, soil and water (Stepnowski et al., 2010).
Oil refineries are considered a dominant source of contamination in regions in which they are situated. Particulate matter (PM), sulphur dioxide (SO_2), nitrogen oxides (NO_x) and carbon monoxide (CO) are released in several processes including the burning of fuels and heating of steam as well as through accidental leaks from various devices (Hazardous Substance Research Centers, 2003). Besides that, the hydrocarbons which evaporate from water in the

refinery wastewater treatment facilities contaminate the air (Damian, 2013). Another serious air pollutant, ozone, is formed when nitrogen oxides combine with volatile hydrocarbons. The petroleum industry is also responsible for water pollution. A considerable amount of wastewater contaminated with crude oil and salt is discharged during refinery operations (Damian, 2013). The petrochemical industry in Gdańsk discharges its effluents to the Bay of Gdańsk close to the Dead Vistula River mouth (Kannen et al., 2004).

3.4. Relationship between the state of the environment and human health

Numerous time-series studies have proved a link between air pollution and health damage (Ulfvarson et al., 1991; Rudell et al., 1996; Bhatia et al., 1998; Peters et al., 2001; Boffetta et al., 2001; Pandya et al., 2002). As mentioned before, diesel exhaust is the primary source of air pollution in port areas (EPA, 2008). It contains about forty toxic compounds, which affect the environment and people's health (Mauderly, 1992, as cited in Bailey & Solomon, 2004). Exposure to diesel exhaust causes a decline in lung function as well as nose and eye irritation (Ulfvarson et al., 1991; Rudell et al, 1996). Moreover, similarly to nitrogen dioxide, sulphur dioxide and ozone, diesel exhaust particles may be a trigger for allergic and respiratory diseases such as asthma (Pandya et al., 2002). Significantly higher risk of cancers, mainly lung cancer, has also been linked to long-term exposure to diesel exhaust (Bhatia et al., 1998; Boffetta et al., 2001). Various port activities are related to particulate matter (PM) emissions, whose smallest particles are especially hazardous, causing lung and heart diseases (Peters et al., 2001). Moreover, toxic chemical compounds polluting water concentrate in fish muscles and if the residue level is too high the consumption of fish might affect human health (Lee et al., 2006).
Besides the impact on the physical health of people, pollution may influence their mental health. Lynch (1981) in his theory of good city form stressed the interrelation between a degree of air and water pollution and a feeling of safety, which is associated with the lack of fear of encountering hazards. He stated that safety is a crucial feature of the environment, which influences the vitality of habitats (Lynch, 1981).

3.5. Ecosystem services embedded in the landscape

Access to clean water and air is one of the factors determining the state of human health, which is a constituent of well-being (Millennium Ecosystem Assessment, 2015). That relation is noticeable especially in the port cities like Gdańsk, where land use development and linked to it anthropogenic activities have an adverse impact on ecosystem services. The recent growing interest in the concept of ecosystem services is stimulated by the aim to better communicate the linkage between human well-being and nature, that is to say, the landscape might positively influence the state of human health by providing ecosystem services (von Haaren et al., 2019). Landscape next to its recreational benefits has a capacity to remediate soil or purify water by use of special types of vegetation. Therefore the use of landscape in the post-industrial areas of Gdańsk could have both aesthetic and environmental profits.

4. Need for the regeneration of socio-ecological systems

The environmental degradation and spatial urgencies present in Gdańsk result from degenerative practices linked to port and industrial land use. There is a need to address those issues and change the current state of socio-ecological systems. As shown in the previous sections landscape and ecosystem services embedded in it could be used as a medium to regenerate socio-ecological systems, to improve both the state of nature and human health.

Regenerative development goes beyond the mitigation of consequences of human activities and it is intended as a reconnection of social systems with the evolving ecological systems (Mang & Reed, 2012). According to Larrick (1997), excessive pollution and consumption of resources would lead to a breakdown of the ecological systems (Figure 3), however, the evolution of the ecological and social system towards more complex coexistence enables the attainment of regeneration of both systems. In his framework, Larrick (1997) used the "principle of circular cumulative causation", which underpins the interrelationship of different parts within the framework, namely if one component of the system declines, it often affects the other components and if there is a positive change in one of the elements, it is likely to have a beneficial impact on the overall functioning of the system. That evolving complex interrelationship must be acknowledged for the shift towards regenerative practices to happen (Cole, 2013).

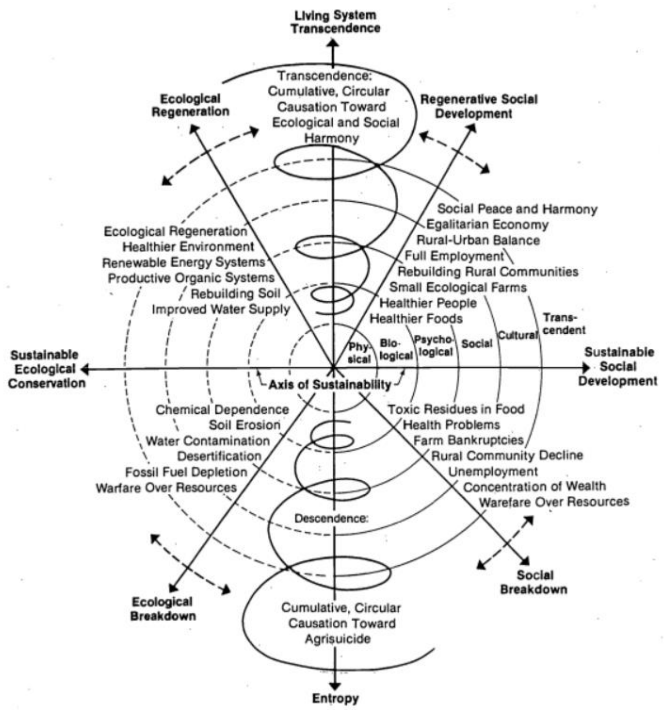


Fig. 3.
A Living Systems Model of Community Development. Source: Larrick, 1997

The health of social and ecological systems can be reached and sustained on the premise that the designer understands the complexity of the processes in place and envisions the integration of both systems; if there is a lack of understanding, the intervention might harm the systems (Mang & Reed, 2012). The design must also recognize and take into account the diverse characteristics of the project area and the stakeholders present there to guarantee the desired outcomes of the proposal (Cole, 2012). In the case of Gdańsk the residents and numerous entities, such as port or industries, would be the ones with a vested interest. Mang and Reed (2012) stated that regenerative development builds the stakeholders' capacity to co-design and take care of the project. Moreover, it defines the right processes to work on to direct the design towards the greatest potential for system's evolution, however, the possibility to use the natural potential of systems' is determined by their level of integration and state of health (Mang & Reed, 2012). Mang and Reed (2012) argued that a regenerative design aims to unveil the potential of a particular entity in order to use it and thus strengthen the viability and vitality of the systems, in which the entity is embedded. In the urban context, the urban landscape can serve as ecological infrastructure, which is a key factor in providing for the health and well-being of city residents (Corner, 2006).

4.2. Landscape as a medium

Since the end of the twentieth century, the landscape has become a medium for the creation of urban form, especially in a complex context, including post-industrial areas (Waldheim, 2006). Rising interest in the landscape discipline was triggered by heightened environmental awareness. That led to an emergence of landscape urbanism, which, as Waldheim (2006) pointed out, criticises the inability of architecture and urban design to logically explain conditions of the contemporary city, therefore the landscape is recommended as a framework for a temporal change, adaptation and transformation. Allen (2001) holds the position that „landscape is not only a formal model for urbanism today, but perhaps more importantly, a model for process". In one of the first exemplary projects of landscape urbanism, Park de la Villette, the landscape is used to arrange the process of social and programmatic change over time in the transformation of the post-industrial area (Waldheim, 2006). The project shows the flexibility of landscape urbanism allowing various kinds of planned and not planned activities to happen.

Besides that, the use of landscape in the remediation process of the post-industrial areas have beneficial effects on the ecological systems in place as it facilitates the functioning of ecosystem services (Woodruff, 2016). Next to the environmental urgencies, the landscape might also address the spatial urgencies by integrating transportation infrastructure and urban tissue. A good example is the city of Barcelona, where the peripheral infrastructure was built simultaneously with public parks creating a space in which none of these functions is more dominant than the other (Waldheim, 2006).

Looking at the advantages of using landscape in regenerative development and design, it may be said that the post-industrial and post-port areas in Gdańsk would greatly benefit from this medium in the spatial, environmental and social dimension.

5. Conclusion

As shown in the paper the process of deindustrialisation and advances in maritime technology lead to an abandonment of waterfronts in the port cities. Next to that, the industrial and port activities affect the quality of the water, soil and air and hence the state of human health. The city of Gdańsk is a striking example of a port city that experienced a transition from overindustrialisation to deindustrialisation and as a result, it was left with a vast post-industrial area. Besides that, the port of Gdańsk is expanding seaward, which may drive a further abandonment of land adjacent to the urban tissue. Even though the scale of the industrial activity in Gdańsk is reduced, the remaining industries and the port still pollute the environment.

The city of Gdańsk faces both spatial and environmental urgencies. Nevertheless, the abandoned sites may be seen also as potential areas for interventions that would help regenerate the socio-ecological systems, namely address the issue of pollution and at the same time improve the performance of the disused sites and connect them with the urban tissue.

Based on the literature review and analysis of case studies, it can be concluded that the landscape is a favourable framework for the process of urban regeneration, especially in the context of post-industrial areas as in the case of Gdańsk. Landscapes provide a wide variety of ecosystem services, including soil remediation, water purification as well as recreational

ecosystem services and therefore may be used as a model for urban processes addressing environmental and spatial issues.

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