REDESIGNING FLOODSCAPES

Integrated Flood Defence Infrastructures towards a sustainable and adaptive approach within the land and seascapes of Harlingen, NL

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Integrated Flood Defence Infrastructures towards a sustainable and adaptive approach within the land and seascapes of Harlingen, NL

Master thesis of Architecture For Sustainability Design

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» *Eventually, all things merge into one,*
and a river runs through it.
The river was cut by the world's great flood
and runs over rocks from the basement of time.
On some of the rocks are timeless raindrops.
Under the rocks are the words,
and some of the words are theirs.
I am haunted by waters. «

NORMAN MACLEAN
A RIVER RUNS THROUGH IT AND OTHER STORIES

ABSTRACT

Coastal regions are a transition zone between land and sea movements. It is exposed to many disasters such as floods because it is a transition zone. In the absence of co-relation between urban development and flood defense systems, it has led to separation in cities. This thesis works on studying nature-based solutions as an integrated flood defense system into the shrinkage urban developments.

This research aims to create a more nature-based flood defense system in the city of Harlingen, using the city center as a pilot area. The main idea is not only solving the flood risks and shrinkinage risks but also thinking the city much more efficient in an economical way and responsible to the coastline, the transition zone area can actually help for the adaptivity and the city itself can also be more resilient. In the first part of thesis, analyzes the current situation of coastal areas and which kind of solutions had been made since today. Then it continues what kind of problems are faced by climate change effects. Secondly, based on the literature review, nature-based solutions were applied to this research area. According to that, the thesis is arguing that coastal areas specifically being threatened by flood risk and shrinkage risk are the key problems to solve with nature-based solutions. The final part examines the application of all principles methods as a tool to integrate the overall evaluation. The thesis outlines that applying nature-based solutions in coastal areas which has both at risk of flooding and shrinkage, offers a new outlook on the future research.

Key Words: Nature-Based Solutions, flood defense system, Ecosystem-Based Services, Coastal Regions

MOTIVATION

The first time when I was in Venice, I realized the power of water and how it is impacted the city and how affects people`s daily lives. I was especially impressed when I saw that people were playing with the waters coming from the canals and overflowing into the square during the autumn frost and they were meeting it normally. This image was a great inspiration for me on the issues of water and floods. After that, I started researching flood-prone and flood-prone cities and tried to find traces of what impact this has on cities and human lives. At the same time, considering that we are currently facing climate change issues as well, it was also brought to my attention what impacts this could have on these issues in the future. These questions have led me to countries that have been dealing with flood issues for many years and have found alternative solutions to these flood issues. One of them was in the Netherlands. The fact that it is a country whose territory has already been called `low-lands` has kept me studying here. After that, I decided to write my thesis on this topic in the Netherlands. I contacted Assoc. Prof. Fransje Hooijemier, who is an expert on this topic from Delft Technical University. Thanks to Adj. Prof. Michele Cerruti, I had the opportunity to meet Dr.Luca Iurio, who is doing post-doctoral research on this topic at Tu Delft. It was a very useful experience for me to combine this knowledge from my main supervisors from Politecnico Di Torino and my co-supervisors from Tu Delft with different perspectives and conduct this thesis with both universities.

These are other alleviations for choosing a case study area from nature and metropolises;

Coastal territories and their significance for the diversity

What's the effect of littoral changes on niche diversity and natural niche dynamics? Thus, the ocean position is prognosticated to continuously rise, presumably by accelerating (IPCC 2001). Does it beget the tidal apartments to vanish and the muddy sediments to come more flaxen? Territories also change when niche generating species (ecosystem masterminds, sensu Jones et al. 1994), similar to seagrasses, oysters, and mussels, are affected (Lotze 2005; Wolff 2005).

Flood defense along the Dutch Wadden Sea seacoast

Central in the Netherlands Wadden region is the Wadden Sea, one of the world's largest intertidal areas, famed for its beach apartments and mudflats (see. g. Wolff 1983; Common Wadden Sea Secretariat (CWSS) 1991; De Jong et al. 1999; Essink et al. 2005; Reise et al. 2010) assessing the effect of climate change on unborn deluge protection, to develop new deluge protection strategies that can increase the sustainable adaptability of the region while easing mortal use and observe the goods of climate change on the Wadden Sea system.

Understanding between Port terrain and Megacity relation

Anchorages and delta metropolises are the areas where the mortal population is concentrated, where the air quality is low and the energy consumption is high (Merico, E., Cesari, D., Gregoris, E., Gambaro, A., Cordella, M., Contini, D., 2021). Indeed though there's a lot of mortal suffering, the natural area of the region is destroyed, which causes several problems (fish migration, sedimentation, ocean-position rise). The adding goods of climate change and the consequent increase in seawater position will put further pressure on anchorages and delta metropolises (Nicholls, R.J., Hanson, S. Herweijer, C., Ranger, N., 2014). In the traditional harborage megacity, the harborage and megacity functions are close to each other and occasionally mixed (Hein, 2016). The local context of the city, the enhanced-multifunctionality, the integrity and ambiguity of the port city environment are all functions of global tourism and mobility.(Holler,2021). With the development of large artificial harborage complexes and the need to change public mindfulness of ecological and environmental littoral problems, harborage functions have migrated out of the megacity. At the end of the last century, the spatial and functional decoupling between anchorages and metropolises came apparent in numerous harborage metropolises around the world (Hayuth, 1989).

CONTENT

Dynamics of Wadden Sea

01 INTRODUCTION FLOODSCAPES AS TRANSITION ZONE

1.1 Issues and Risks of Floodscapes

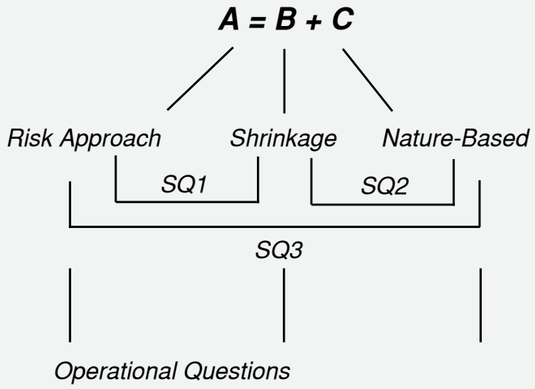
1.1.1 Problem Statement

Coastal cities have a very important position as they host many opportunities together (Day, W. J., Gunn, D. J. and Burger, J. R., 2021). For example; the dynamics of the sea, trading, and shipping, built environment, industrial development, sustainable sources, tourism. But since many years, Climate change it started to affect our lives visibly, and the rising sea level rise has the power to negatively impact these opportunities. (IPCC, 2014). Nowadays, Sea dikes are still applied to coastal areas as a popular flood defense system (Katz, C. 2013). Due to the changing hydrological cycle, sea-level rise, extraordinary river discharge, heavy rainfall, erosion, and precipitation suggest that it is still necessary to continue with an engineering-based risk approach to protect shorelines. Risk can be defined as probability and consequences; flood risk reduction can be achieved through measures that reduce the likelihood and/or consequences of flooding, and therefore, reducing consequences can replace probability reduction (Simoni, S.,Vignoli, G.,Mazzorana,B.,Volcan,C., 2016). Although this system is seen as an engineering solution to the rising water level, cannot be seen as a solution in the urban context that connects the city and the coastal region. On top of this, the need for new dynamic strategies it is addressed with an engineering-based risk approach and a design-oriented landscape approach. Due to the increasing appreciation of this relationship, spatial quality is increasingly included in the goals to be achieved in the development of flood risk management strategies. Spatial development is a part of the risk approach and engineering is a part of a spatial design. in such a framework is necessary not only to reduce the possibilities but also to reduce the consequences of the risk of flooding. Working on the consequences of risk, cultural landscape, and technical construction of urbanized areas (acceptance of water, implementation of solutions based on nature, improvement of emergency and evacuation plans, etc.) It means that water protection systems it should no longer be considered as a line, but as a gap, between urban systems and flood risk management. There is a strong relationship between flood risk management and spatial quality:new or improved flood defense infrastructure with an urbanized spatial quality can have a significant effect on the built environment (Klijn et al. 2013). In recent years, several experimental programs have spawned where flood infrastructures converge to the water area involved in designing a wide range of urban, rural, or natural landscapes. The program room for the river, new concepts of dams (double-dike, wide green dike), use of nature-based solutions means that todays water conservancy infrastructure is a larger footprint than traditional dikes had in the past (Van Loon-Steensma & Vellinga, 2019). We explore the possibility to further demonstrate that flood defense infrastructures can be developed with a spatial approach, as they are physical producers integrated into the landscape and affect urban development, but also the way people interact with water. Therefore, the defense system can become a tool by adapting to nature-based solutions, integrating marine dynamics to reduce climate risks, integrating the citys critical network to also take on some urban functions. Thus, instead of a sharp and rigid barrier, it becomes a temporary buffer zone connecting the sea and the city.

These Nature-Based Solutions, to address the challenges of urban flood management, more cost-effective and flexible approaches and also to provide wider environmental, economic and social improvements, contributing to a wide variety of water supply and urban planning to provide benefits to other public increasingly integrated.

As a result, people have developed strategies against these changes, namely engineer-based defense systems. The dykes and sea walls did protect the cities from the main flood risk, the storm surge, in the past, but it created dysregulation between land and sea at the same time, also it is insufficient while climate change continues. These areas is prone to erosion and puts the primary dike at the outer edge of the transition zone. Besides, the dike inside is complete anymore and is positioned far behind the built environment. This makes the dike unsuitable as an inner outline of the zone. The principle that considers the primary dike within the coastal area is not suitable for these locations. In this way, nature-based defense solutions are needed. Except for the risks from the seaside, Especially the cities has a problem with shrinkage, the population of the cities is declining so that people are moving to where areas that are more economically satisfied and lively. On the seaside, the oyster reef restoration helps to reduce the wave energy. On the coast, using the current defense line system as a part of the landscape element and integration of the city are considered. On the urban side, the main idea is to make the city much more resilient and attractive. Interventions on the three sides are interrelated.

1.1.2 **Research Questions**



MAIN-QUESTION IS

How can we reduce the future flood risk in a shrinking coastal town by implementing Nature-Based Solutions?

SUB-QUESTIONS

SQ1: How can shrinkage be mitigated as part of the flood risk approach (e.g.reducing consequences)?

SQ2: How can a NBS approach be benefical for dealing with consequences of shrinkage?

SQ3: How can NBS impact the risk approach is dealing with reducing of probablity and consequences?

01 INTRODUCTION FLOODSCAPES AS TRANSITION ZONE

1.2 *Floodscapes Literature Survey*

1.2.1 *Flood Risk*

The present-day ocean position change is of considerable interest because of its implicit impact on mortal populations living in littoral regions and on islets (IPCC,2014). Global mean ocean position change results from two major processes, substantially related to recent climate change, that alter the volume of water in the global ocean thermal expansion, and the exchange of water between abysses and other budgets (glaciers and ice caps, ice wastes, other land water budgets). Global ocean position is projected to rise during the 21st century at a lesser rate than from 1961 to 2003 (IPCC Fourth Assessment Report Climate Change, 2007). Under the IPCC Special Report on Emission Scripts (SRES) A1B script by the mid2090s, for case, the global ocean position reaches 0.22 to 0.44 m above 1990 situations and is rising at about 4 mm yr1 (Bindoff et al.,n.d.). Civic areas in littoral and erected surroundings are on the frontal line of flooding, and development in these areas is adding the world exposure to the threat (Woetzel, J., Pinner, D., Samandari, H., Engel, H., Krishnan, M., Boland, B., Can littoral metropolises turn the drift on rising deluge threat? April 2020). These locales have vulnerable characteristics for urbanization ending to swell and gutters facilitate transportation, and deluge plains offer sources of fresh water and flat land for rapid-fire development, among other benefits. At the same time, their civic development has been destroying natural shells and civic structures by mortal interventions. Also, the adding demand for land in civic areas encourages development in advanced deluge threat areas. The littoral area is the interface between land and ocean surroundings. From both environmental and (socio-) profitable perspectives (Barbier et al. 2011), these are areas of enormous applicability, since 38% of the world's population lives within 100 km distance from the bank (UNEP 2014). Climate change and rising ocean situations affect the littoral areas disproportionally relative to their size, giving them the description as the frontlines of climate change (Barbier 2015). For case, it's anticipated that rising ocean situations will increase land loss, storm intensities, floodings, and saltwater intrusion in littoral areas (e.g., McGranahan et al. 2007; Werner and Simmons 2009; Nicholls and Cazenave 2010). The redefining of one of the prognosticated goods of climate change on the spatial association of littoral boundaries is at the top of the list of different countries around the world (PBL, 2012). Another effect is that due to the increase in global warming, the rate of water inflow into the ocean is dwindling, and this means that further brackish storehouse capacity is demanded on land against failure. As a result, the threat of flooding in numerous countries increases if the current water security strategy of the land is continued. This leads to an increased threat of mortal deaths and profitable damage. Thus, another point of view regarding the littoral boundaries is important. In natural ecologies, the littoral transition zone between land and ocean can be considered a gradational transition between land and ocean. Since the dynamics of movements and functions between land and ocean are passable, the whim-whams that exist in it decay over time. Currently, as a result of mortal troubles, the mortal whim-whams are intruded. Thus, the littoral border naturally is no longer suitable to stabilize itself and needs mortal backing without causing too important damage to climate change vaticinations.

This questioning of a new coastal strategy can be approached by considering the coastal border as an operative system. As a direct effect on their location, these cities are at major risk from climate changes, such as coastal storms, cyclones, flooding, and coastal erosion.

The amount of possible victims and damage to the built environment in the event of a possible flood is of great importance in decision-making (Pieterse et al. 2009). In this way, the flood risk of an already flood-prone area will raise as a result of densification. For various areas, this results in higher flood risk due to both the changing climate as well as densification, as this leads to an increase in vulnera -bility. Coastal and delta regions globally show the attractiveness, both visually a ndeconomically, of settling close to where land, sea, and waterways meet. Histor yproves that these regions prevail when it comes to international trade, fertility of ground, living conditions, and ecosystems (Constanza 1997). Which all results in increasing prosperity, continuous urban growth, and therefore the occupation by the worlds largest metropolis. Coastal regions in specifically are very for multiple reasons, firstly, these low-lying coastal areas are in danger from different aspects:r ising seas, rivers draining vast hinterlands, and more intense precipitation. The effects on urban settlements are not uniform, the mobility and different permanence of floods gain diversity on a geographical and temporal scale. (Nicholls, R.J.; Cazenave, A. 2010). In the north of the Netherlands, including the Wadden Sea, it is covered with sea dikes, as it is covered the whole of Netherlands. Wadden area is the coastline of Germany and Denmark and the islands in front of the countries. This area is also an inter-tidal zone because of that reason it is in UNESCO World Heritage Site. Recently, it is unclear whether the Wadden region will be completely suffocated by sea-level rise or silt by sediment. (Wang et al., 2012).

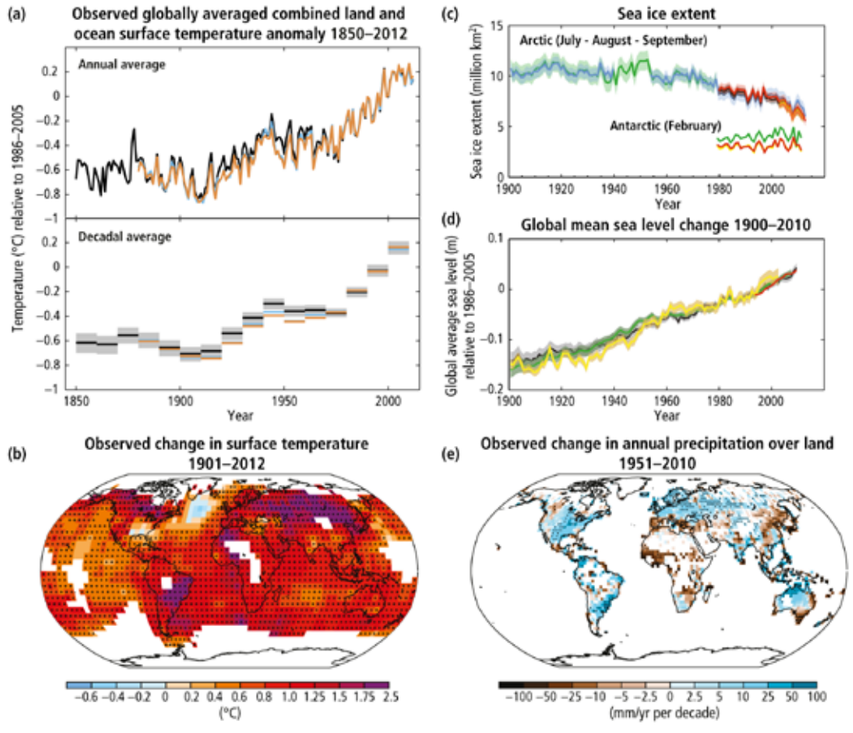


Fig. 07
Review for multiple indicators of a changing global climate system *(IPCC)*

1.2.2 *Shrinkage Risk*

After a century of moderate flood activity, specifically, Central Europe experienced several extreme floods at the beginning of the Millenium (Elleder, 2015; Kundzewicz, Zamalek, & Kowalczak, 1999). These floods have caused significant damage to urban areas, including areas that are in decline as a result of urban shrinkage and are often fragmented in terms of property. The whole of these effects had pioneered the changes in overall social behavior and regional economic performance, often resulting in urban shrinkage and the reduction of certain areas. Rising sea levels and coastal population growth will increase the risk of flooding for more people and assets if land-use changes are not adequately planned. In the coming years, it is expected that the impact of coastal, fluvial, and pluvial floods will increase significantly with climate change, urbanization, and demographic growth. Effective flood risk management is critical to protecting people and livelihoods from flooding and limiting future losses. For example, After the hurricane of New Orleans, they imagined the city bigger and better, and it turned into the opposite and the city continued population decrease and chronic housing stock. Against this, they encouraged the development business and tourism sector. On the contrary to rising shrinkage strategy does not solve the problem itself such as leaving abandoned areas and unused vacant properties which is lead to depopulation. Climate and economic crises need really careful and global solutions not wrong and monofunctional solution-based strategies.

The reduction of flood risk is essential for a successful approach. The way flood risk reduction is combined with adding public and ecological value is where this research aims to deliver its scientific relevance. By using an ecological approach to reduce flood risk rather than the more conventional ways of combatting the threat of flooding. Couch and Cocks (2013) give three main explanations for population decline in urban areas; firstly, the natural dynamics of a city (urbanization, suburbanization, dis urbanization, re-urbanization) in which suburbanization is seen as a cause, followed by immigration out of the city. Secondly, the decline can arise from demographic changes, like a decreasing birth rate or a natural disaster. Lastly, urban shrinkage is caused by economic development that is distributed unevenly between regional and urban areas, followed by a change in the population of both areas. Not only do urban areas face a population decline, but also more rural areas in Europe. However, most are written about current spatial planning policies in cities (Dreijerink, Noort, & Kortman, 2012; Lorentzen, 2012) and more generic about the causal relation of shrinkage between periphery and urban areas (Hospers, 2010).

At the same time, other scholars only state two main reasons for shrinkage in non-urban areas in Europe. On the one hand, there is a simple movement of citizens from rural areas to more urban areas, leading to shrinkage in some areas and growth in other (urban) areas, On the other hand, a combination of aging and a decreasing birth rate results in a shrinking population, without taking immigration from other countries into account (Hospers, 2010). Although the overall world population is still increasing, the average growth rate has been in decline for a few decades (Martinez-Fernandez, Kubo, et al., 2012). The decrease of birth rate is a trend in Europe since the twenty-first century (Derks, Hovens, & Klinkers, 2006).

1.2.3 *Nature-Based Solutions*

The European Commission defines nature-based solutions for social change as solutions inspired and supported by nature, cost-effective, but also contributing to the environment, social and economic, and helping to develop resilience to natural disasters. Such solutions can be adapted to the local area, through planned interventions and resource-efficient cities, landscapes, nature, and natural features and processes to provide more and more diverse sea views (European Commission, 2020).

Definitions of NBS based on (EC)	***Definitions of NBS based on (IUCN)***
Inspired and supported solutions nature that is economical at the same time provide environmental, social and economic benefits and help improve sustainability. Such solutions bring more and more diverse nature and natural features and processes to cities, landscapes and seascapes through locally adapted ,resource efficient and systemic interventions (EC, 2015).	To protect, sustainably manage and restore natural or modified ecosystems to effectively address social problems and in an adaptable way, it simultaneously provides human well-being and biodiversity benefits (Cohen-Shacham et al., 2016).

Explanations of Nature Based Solutions based on European Commisions and International Union for Conservation of Nature

The purpose of nature-based solutions is to maintain and ensure sustainability, solve problems that people face (eg. climate change, food, and water security, or natural disasters) to repair by a natural way. In addition, nature-based solutions provide wider contributions to human well-being and biodiversity. Nature-based solutions are spreading in cities that want to speed up sustainable urban development and face many problems. it contributes to the establishment of a durable city against disaster risk reduction and climate change adaptation by creating intelligent green infrastructure. That is why these solutions also called green and blue infrastructure. Thus, neglected and regenerative processes, and it is used for urban renewal in degraded areas to increase the livability of a city. Each city is unique and comes with its own road dependencies related to past cultural values and planning approaches. Nature-based solutions and urban green spaces provide this planning approaches into the location for recreation, social interaction, building community cohesion, and contributing to physical and mental health and well-being (Jennings & Bamkole, 2019). Nature-based solutions behave sufficiently as decentralized, distributed infrastructure service into the cities, which are generally more flexible than large, decentralized infrastructure by nature (Depietri & McPhearson, 2017). In general, nature-based solutions planning principles in the literature can be listed as the development of a long-term strategy within the framework of the concepts of multi-functionality, connectivity, integration with other infrastructures, participatory process, sustainable development.

These solutions, within the framework of the principle of connectivity at the heart of landscape ecology, spread green spaces of different scales into the city in the form of a continuous network. In other words, it establishes the connection between the built environment and the ecological environment. In recent years, these facilities will serve a wide range of flood and carbon management it is also used to highlight urban elements and includes all ecologically based approaches, from small scales for example green roofs to larger scales for example environmentally friendly flood management systems.

Single-function flood protection, such as sea walls, which are typical urban shorelines are prone to failure and are detrimental to marine ecologies that existed before the infrastructure was built. Urban growth strategies can be solutions instead of implementing these hard techniques which are dams, dikes, and seawalls, protecting the water and rising sea levels and managing the coastal retreat, thinking about shifting new developments like soft based techniques to vulnerable areas of coastline and embrace the water, integrate the flood protection through to the city. Reconstruction of this infrastructure has become part of the design lexicon of contemporary landscape architects, who propose adaptable and safe design strategies for urban shorelines, as well as providing a transition to aquatic habitats, farms, and migration corridors.

Gray solutions are often overpriced, this is because high maintenance requirement and low flexibility. In addition, while it has great negative effects on the ecosystem in the long term, it causes great disasters in the society and social environment. (Depietri &McPhearson, 2017). Grey solutions for flood protection, such as sea walls, which are typical urban shorelines are prone to failure and are detrimental to marine ecologies that existed before the infrastructure was built. Urban growth stategies can be solutions instead of implementing these hard techniques which are dams, dikes, and seawalls, protecting the water and rising sea levels and ma naging the coastal retreat, thinking about shifting new developments like soft based techniques to vulnerable areas of coastline and embrace the water, integrate the flood protection through to the city. In this way, a balance between green and gray infrastructure is the most effective solution to maximize benefits and system efficiency as well as minimizing costs and compromises (WWAP,2018). Reconst ruction of this infrastructure has become part of the design lexicon of contempora ry landscape architects, who propose adaptable and safe design strategies for ur ban shorelines, as well as providing a transition to aquatic habitats, farms, and m igration corridors. Many researches and projects have been carried out in nature adressing these climate problem of based solutions and it shows that it can play a important role. For example, using by soil and water in urban places the total amount of carbon storage provided rural-urban environments, although small compared to areas as well as the additional carbon footprint of nature based solutions. a range of verticals where it can provide storage capacity and horizontal artificial surface. nature based solutions under conditions of rapid urbanization in maximizing storage potential they can play an important role (Naturvation, 2020). In this way, it is obvious that these solutions can integrate every part of cities and works together in a flexible way.

Flexibility, the concept of infrastructure, landscapes, and ecosystems can withstand and get rid of several such inconveniences as a result, it has emerged as a guiding principle for urban coastal design. These strategies are also widely accepted as a pragmatic and cost-effective approach to flood risk management with the added benefit of enriching ecosystems, improving aesthetics, and increased value for convenience. Ecologist Nina-Marie Lister suggests, "If flexibility is to be a useful concept in informing design strategies, it must ultimately teach how to safely adapt to change – adapt with transformative capacity – rather than resisting change based on the illusion of a perpetual normal."

When we look back at the past, we see that the cities were divided more strictly and disconnected from each other. This also shows us that people, that is, in their people, live in a disconnected way from each other. Because of this problem that has been going on from the past to the present, many cities are still facing the same problem. However, with doga-based solutions, these problems that have come from the past to this day are easily solved and have made it easier for the city to connect, as well as adding nature to the city and allowing people to live together with this flexibility. For this reason, we see how the concept of flexibility is an integral part of nature-based solutions.

Fig. 08
IUCN, 2019

Fig. 09
Coastal wetland restoration creates a space for diversity habitats

Project PACCo(Promoting Adaption to Changing Beachfront) will restore 100 hectares of the littoral swamp at two airman spots. the Otter Estuary in Devon (UK) and Saane Valley in Normandy (France). The restoration of this land will enable better operation of flooding, absorb carbon, and give benefits to people and wildlife.

Fig. 10
The grounded leaves provides reactiviting tourism and economic activites cities.

The grounded leaves of Posidonia from the mouths of the channels (Torre San Giovanni and Torre Mozza) in Italy are used to reconstitute and cover drift cords that have been degraded. Posidonia leaves control corrosion, restore typical drift foliage and give niche for a variety of organisms. This is important for maintaining tourism in the area.

Fig. 11
The polluted space converted into dynamic urban areas which provides new ways to explore for inhabitants.

Fornebu field, near Oslo, was abandoned in 1998 and has ago been converted into a multifunctional green space that reduces flooding, purifies water, and boosts biodiversity, whilst also being a point for recreation, and domestic and artificial land uses.

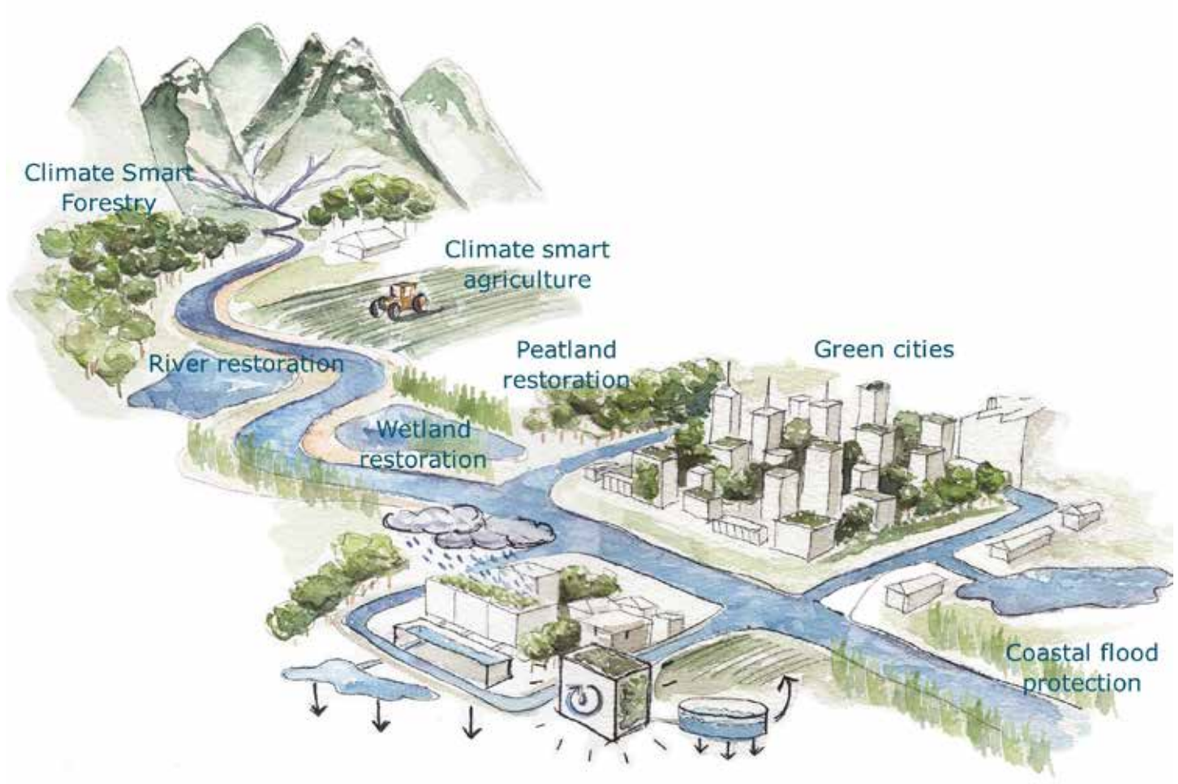


Fig. 12
General concept of NBS

01 INTRODUCTION FLOODSCAPES AS TRANSITION ZONE

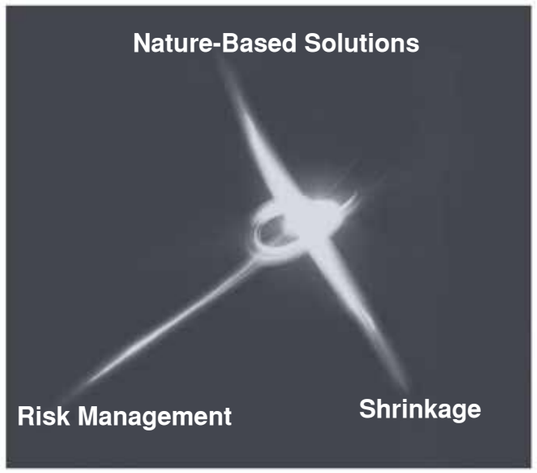
1.3 *Transition Zones as an Oppourtinity for Sustainability*

1.3.1 *Hypothesis*

What are Transition Zones?

According to the problem statements, the research aims is trying to create a more sustainable, self-sufficient, and adaptive flood defense system in the city of Harlingen based on nature-based solutions and applying to all urban systems. Research starts to investigate elements of the urban system, elements of sea, and transition part between sea and urban land. It has a high ecological, social, and economic potential in the spatial planning of coastal cities, the points where the sea and the city are combined are considered. In this research, the spatial principles of neighborhood, land, and sea systems are common to do this. The integration between these systems in design can be seen by looking at an example of Mud Motor Project in the Port of Harlingen. By using Nature-Based Solutions, a Sludge Engine is the disposal of dredged sediment at a specific location in the Port of Harlingen, where the sludge is transported by natural processes such as tidal runoff to nearby salt marshes and adjacent tidal flats. By increasing the supply of sediment to the tidal flats, these will increase in height creating more favorable salt marsh expansion conditions. The aim is to contribute to the growth of salt marshes and to increase the safety of more dikes, as well as to reduce the recirculation of dredged sediments.

Therefore, it is aimed at three goals: the development of nature and the preservation of habitat, the increase in the height of the front land of the dike, and the method of implementing more economical dredging. This Building with Nature study, proposes an alternative approach to sediment management: depositing the dredged sediment further north of Harlingen and allowing natural processes to spread the sediment to nearby salt marshes which protects the Wadden Sea ecosystem.



Triangle of Main Hypothesis
Made by Author

1.3.2 ***Rethinking Transitional Zones***

Transition Zones as Opportunities to Integrate Ecosystem Services into Urban Systems

Ecosystem Services are a combination of ecosystems that are used (laboriously or passively) to ameliorate mortal well-being (Fisher, et al. 2009). It has come to a mainstream conception for ecosystem services as the expression of values devoted by humans to colorful functions of ecosystems (Bennett & Elena, 2015). Ecosystem-grounded deluge defense has several fresh benefits compared with conventional engineering approaches, including the enhancement of water quality, carbon insulation, the product of fisheries, nature conservation and the creation of recreational space (Temmerman et al., 2013). Ecological systems give a wide variety of functions that profit people and the metropolises they live in. Nature-grounded results have surfaced as a conception or marquee term for the eco-system-grounded approaches that address societal challenges similar as climate change, natural disasters, food and water security, mortal health and well-being, and profitable and social development (Cohen- Shacham, Walters, Janzen, & Maginnis, 2016; EC, 2015).

Fig. 14
Vildaphoto/Yves Adams
Ecosystem-based coastal defence in the face of global change (Temmerman et al., 2013).

Transition Zones are Sustainable Catalysts for Understanding Approaches

The Multi-Layer Safety approach was also introduced in 2009 in the Dutch National Water Plan (Ministry of Public Transport and Water, 2009). The Multi-Layer Safety approach consists of three situations. Prevention is the first subcaste of the Multi-Safety Approach, the specialized characteristics of heads, water retention areas, and dikes defended from deluge pitfalls. The alternate subcaste is dwindling the negative impacts of cataracts by using spatial planning through the perpetration of spatial structure. The third subcaste is disaster operation. it increases public mindfulness and creates evacuation plans in case of disaster happens.

The Multi-Layer Safety approach aims to integrate deluge forestallment with flexible spatial planning and disaster operation to drop both probability and consequences of flooding within one approach (De Moel et al., 2014; van Herk et al., 2014; Zandvoort & van der Vlist, 2014).

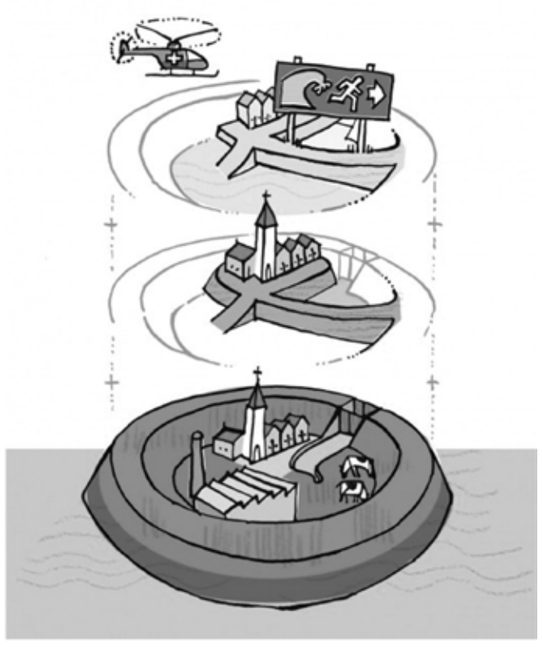


Fig. 15
Schematization of the layers of the Multi-Layer Safety approach
(Ministry of Infrastructure and Water Management, 2009)

Transition Zones may Develop Alternative Ways of Inhabiting

The phenomenon shrinkage is visible in different parts of the world, from more rural to urban environments. It is a concept that has developed quickly in the last decades and becomes more relevant every day. Not only is it diverse in its form, but also its complexity (Haase et al., 2013). According to Hospers (2010), you can distinguish two types of shrinkage: hard shrinkage and soft shrinkage. Hard shrinkage is more focused on the clear decline in population, the increasing number of houses that are for sale, a decreasing price of housing, etc; all obvious spatial-physical effects. On the other hand, there are soft effects: the changing social structures. This idea is shared by Rocak, Hospers, and Reverda (2016) who mention the different changing aspects of the shrinking area; not only physically (infrastructure, vacant buildings), ecologically, and economically, but also socially. Another viewpoint is given by Sousa and Pinho (2015), who see shrinkage as a pattern of urban development, taking population and spatial development into account. They understand it as a process that could have been started with spatial shrinkage, caused by different reasons (decline of population, economic decline, importance of the area). The shrinkage of historical naval bases is a the common problem is not only in Europe, but especially along the coast of the North Sea of the regions. According to literature reviews, common strategies adopted by the cities of these regions. It can be divided into categories to manage shrinkage four strategies: ignore shrinkage, oppose shrinkage, guide shrinkage.

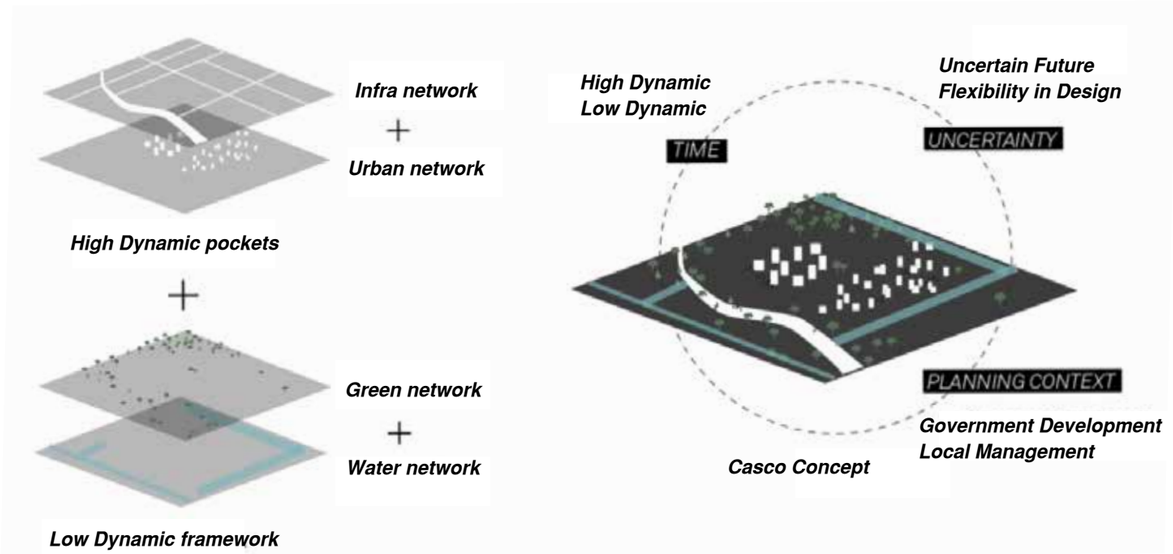


Fig. 16
The concept of casco approach

The Casco Concept is a spatial strategy concept in the Netherlands. It was developed by Kerkstra, Vrijlandt and Sijmonds (1990). It is called the Framework concept in English but Casco in the Netherlands. “Casco” in Spanish means a protective structure. The casco concept is a spatial strategy rather than a specific design proposal. It is an ecological framework for planning and designing sustainable landscapes (Buuren van and Kerkstra 1993, Smith and Hellmund 1993).

This strategy aims to design development processes in the landscape. It attempts to analyze landscape problems and study if certain landscape qualities can be placed next to each other. The qualities which are analyzed in the landscape are; the high dynamic (infrastructure and the built environment), low dynamic (nature and environment). These two qualities need to be in one framework because nature has to be developed spontaneously in urban spaces. By doing this, the complexity of the landscape can be preserved as a whole. The landscape can also be organized more efficiently in the rural development areas.

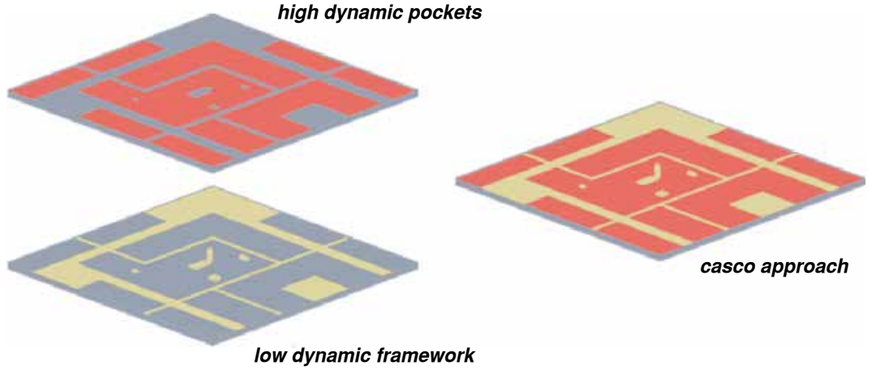
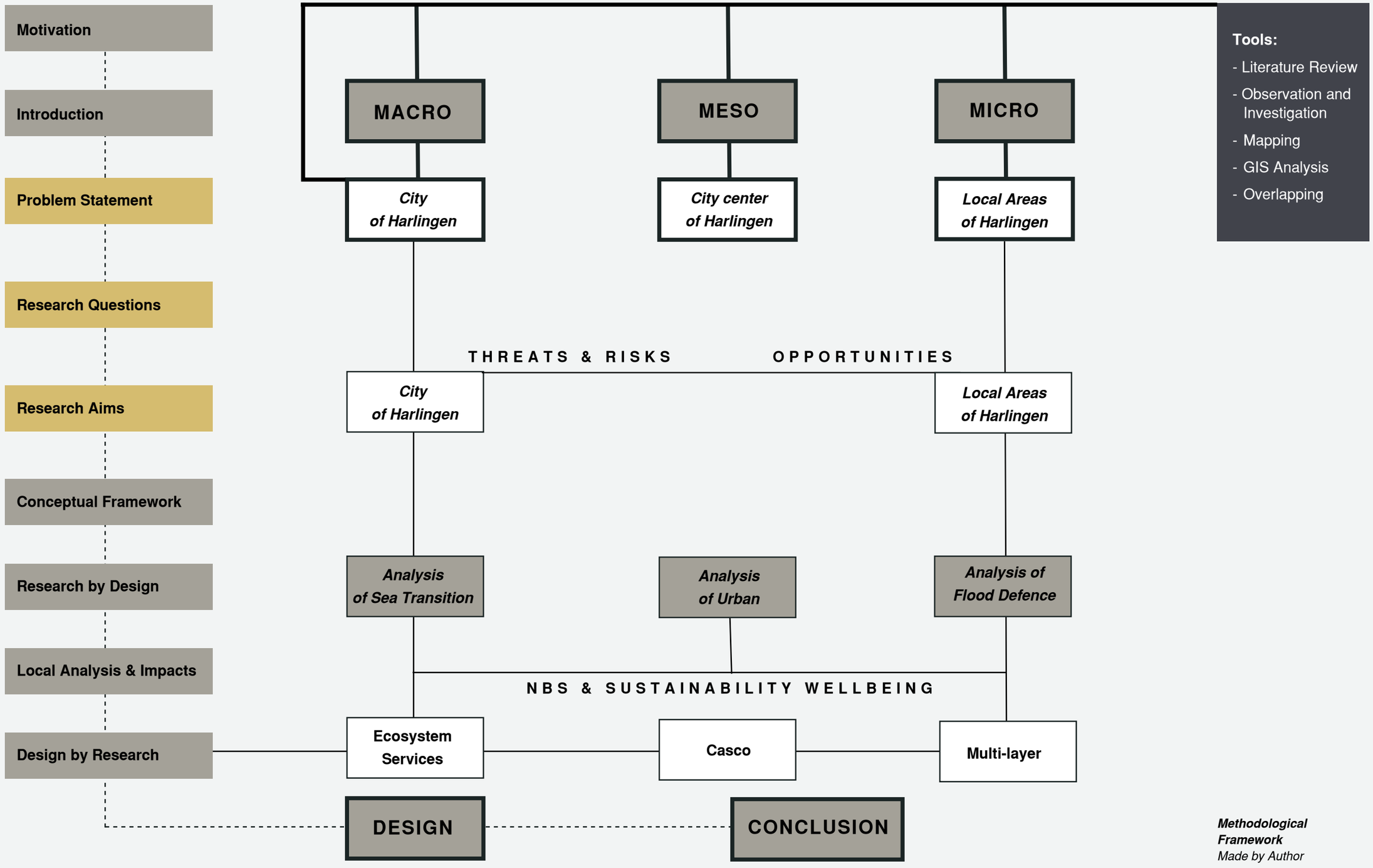


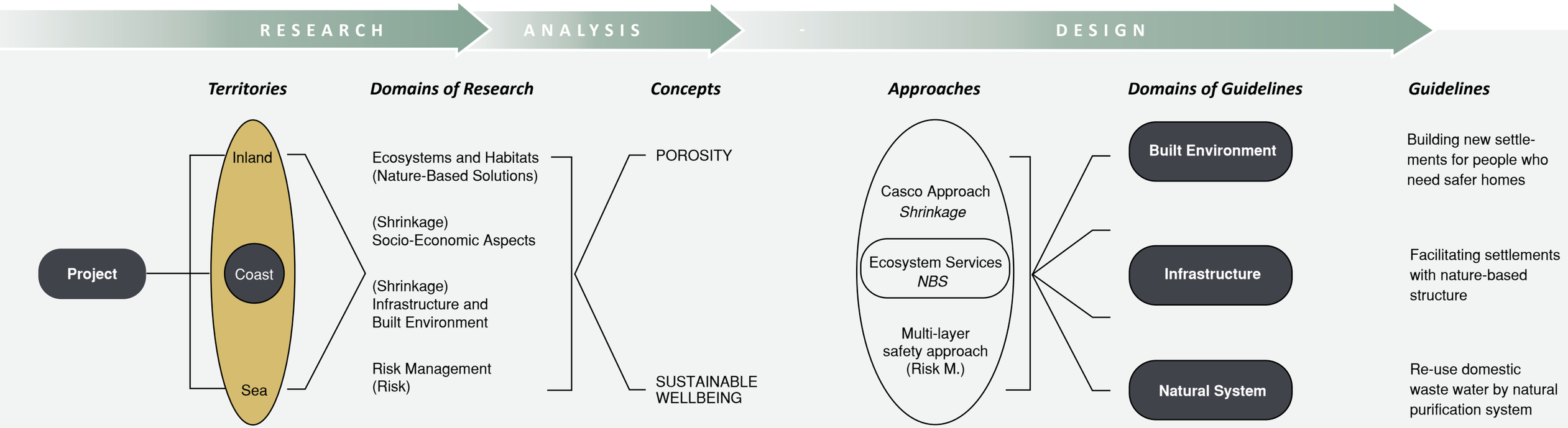
Fig. 17
The renewed casco approach separates the city on the basis of dynamics

Hoekstra I., Mulkens J. (2014) developed the hypothesis that the casco approach could provide a basis for the development of shrinking cities in the Netherlands. The hypothesis was that with the flexibility of high dynamic pockets it can react to the uncertain developments of shrinking cities and strengthen the special qualities of a city in low dynamic frame, otherwise it could be adversely affected by shrinkage.

1.3.3 *Methodological and Conceptual Framework*



Methodological Framework
Made by Author



Humans are porous by nature, described by the sociologist and philosopher Georg Simmel as the bordering creature who has no border (Simmel 1998:174).

Coastal area or Land-Sea Continuum as porous and transitional inbetween-scape to accommodate a complex interrelated web of flows of goods, people/nature and ideas/mindsets.

The concept of Sustainable wellbeing is comparable to the concept of shared values. Personal wellbeing is highly correlated with improving others wellbeing (other members of society AND the natural environment). Under this concept, individual and others wellbeing are highly interrelated and interactive, and one can not be achieved without the other (Ronen & Kerret, 2020).

Conceptual Framework
Made by Author

Fig. 18
Canals of Harlingen City

02 DESIGNING TRANSITION ZONES

2.1 Harlingen a transition zone

2.1.1 Historical Aspects

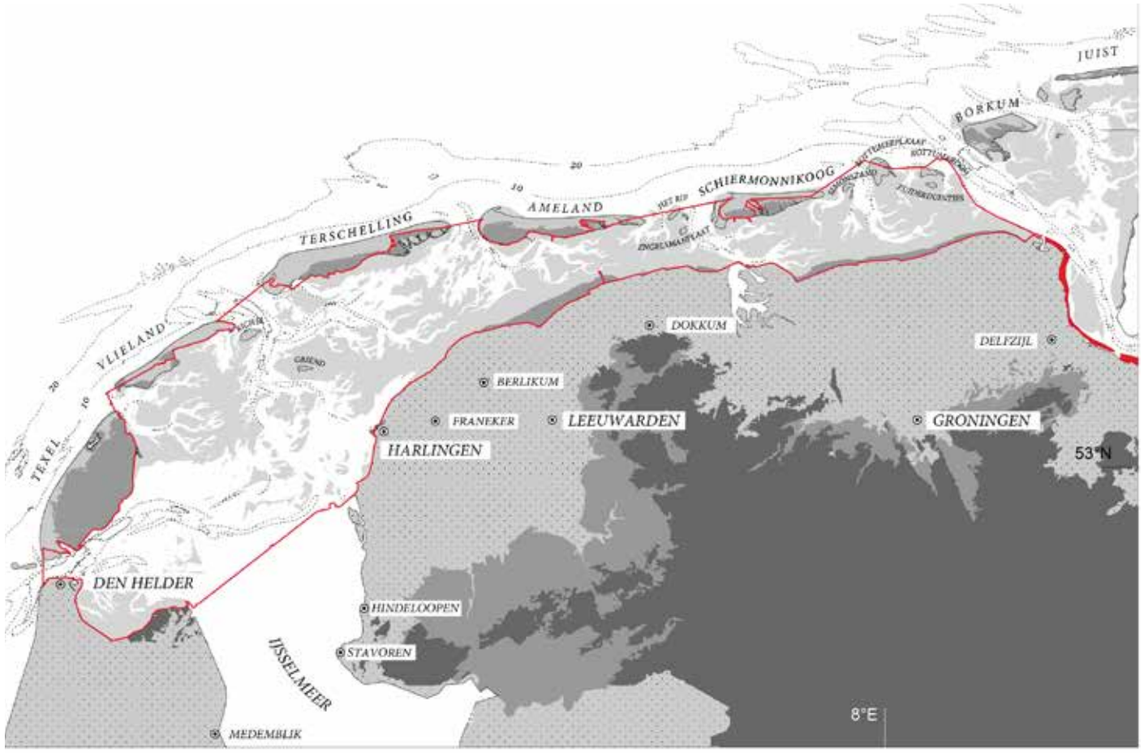


Fig. 19
Protected area by UNESCO

Dynamic Islands in the Wadden Sea, Waddden Sea Ecosystem No. 33 Common Wadden Sea Secretariat 2014, Ulrich Hellwig, Martin Stock

Wadden sea is one of the largest tidal regions in the World. The Wadden Sea is a nature conservation area that is part of the UNESCO world heritage and the Natura 2000 network because of its unique geological and ecological values (Rekenkamer, 2013). The (embanked) salt marshes that are present at the foreshores of the Wadden Sea and the dike area are of great value for both ecology and water safety in the area (van Reijn and Franssen, 2020). Although the existing (engineered structures have proven to be effective to guarantee flood safety, climate change and the associated increasing water levels and more frequent flood events together with the high safety standards (Dutch Water Act, introduced in 2009 (Rijksoverheid, 2020b)), asks for reinforced structures. In the Netherlands, Wadden Sea coastal cities are particularly sensitive to economic shift and environmental change, regarding the delicate coexistence of protected tidal ecosystem and port-initiated urbanization. Harlingen is the only port city in the Frisland region in the Netherlands. Its important location for maritime industry and shipping logistics enriched prosperity to the city, after the post-war reconstruction phase. The port city has a strong important background in fishing and shipping activities. Mainly shipping is about salt transportation. The city is important for transportation to daily ferries to the Frisian islands of Vlieland and Terschelling.

Fig. 20
Aerial Photo of Harlingen

After the storm surge in the summer of 1573, the embankments north and south of Harlingen had to be built inland. In 1157 Eilwardus Ludinga opened the monastery called `Ludingakerke` in the city of Almenum. Harlingen started to improve trade activities in the 12th century, by the monks of a close monastery digging canals for improving the trade dynamics in the region. Because of increasing trade, Harlingen became an important place so that the city got its rights in 1234. Wealth and fame are remained increasing because of the connection with the North sea. The city used to be more western than it is today, but the sea regularly overturns the land. In 1543 and 1565 they enlarged through the northern direction so that the Noorderhaven became the inner harbor that still exists today. After the flood in the summer of 1573, dike sections north and south of Harlingen had to be constructed inland. In 1574, Holder of the city started to provide food for the dike workers and at the same time also the city was struggling with famine. Therefore, they were not allowed to leave the city in the pain of losing their property. The dike they had planned had become 3 meters instead of 3.50 meters. In 1644, the Frisian Admiralty moved from Dokkum to Harlingen. So Zuiderhaven was given a seaport character. Harlingen port was replaced by Amsterdam and Rotterdam ports. However, Harlingen remained important for coastal shipping and fishing activities with so many facilities, and the recently established Van Harinxma Canal has great economic importance for Friesland and the rest of the Netherlands. Around 1875 a current dam called Pollendam It is built on the shallows between Blauwe Slenk and deeper water. In front of Harlingen harbor. Tidal currents were channeled with construction and The Fairway may have been scanned. This created a direct sailing route to the sea, even at low tide.

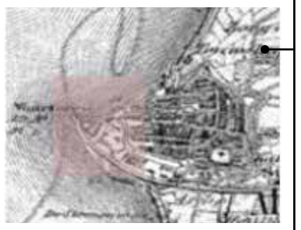
Overview of Harlingen (from port through the flood defence system)

Noorderhaven Harlingen, Netherlands

Birds eye view to Harlingen city

1664 Main roads are clear and boundaries of the city is clear. The walls surrounding the city have formed

1850 Port of the city started to under construction. Sea dikes became visible



1890 Main part of the port is constructed

1920 Port of the city had reached capacity and the city has grown outward. Secondary roads are developed

1950 Due to the port development population of the city developed

1999 After post war new ports began to form. Population had reached full capacity.

2014 Population reached peak point

Fig. 28
Historic Development of Harlingen

Historical flood events in Harlingen

The 1953 North Sea flooding was a major flooding event caused by a heavy storm from 31 January night to 1 February morning. The floods mainly affected the Netherlands, Belgium, UK. The Great Storm of 1703. This storm caused flooding and thousands of victims died. It was heaviest in an area of approximately 500 kilometers wide in Wales, central and southern England, the North Sea, the South part of Friesland, Netherlands, and the north of Germany. British journalist and author Daniel Defoe (author of Robinson Crusoe) wrote of the scariest storm the world has ever seen. The storm was so terrible, according to Defoe, that there was no pen to write it with.

Geïndexeerde bevolkingsontwikkeling Harlingen, GGD Fryslân en Nederland, 1990-2013, prognose tot 2040

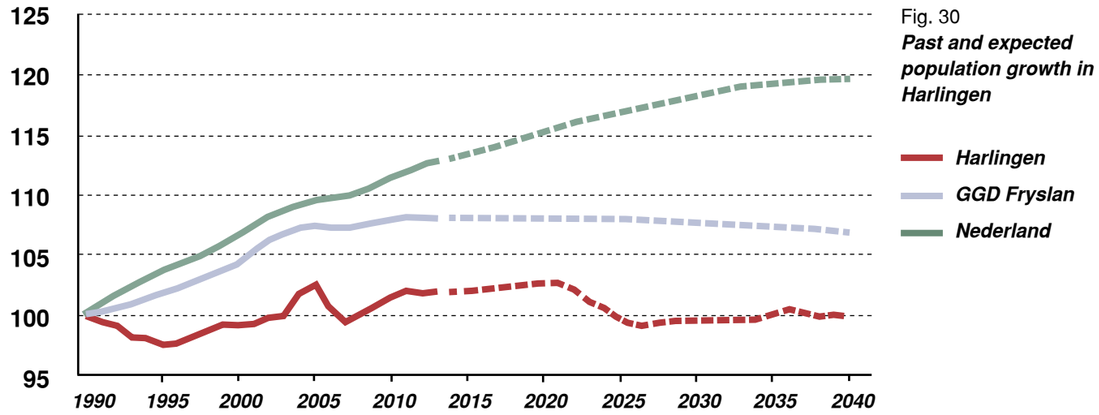


Fig. 30
Past and expected population growth in Harlingen

Harlingen is one of the shrinking cities in the Netherlands. As you can see the figure, In the begining of 2000s, the city has risen compared to previous years. The population of the city declined in the mid-2000s and will continue to do so in the years to come.

Old port area in Harlingen

Nowadays in the port

Fig. 34
Noorderhaven, Harlingen
Recreational harbor and inland harbour

Fig. 35
Zuiderhaven, Harlingen
Recreational harbor and inland harbour

2.1.2 *Urban Aspects: Economical, Environmental and Social*

The city of Harlingen occupies this important position on the 17th. It was able to preserve it until the first half of the XIX century. After that, as in the rest of the Netherlands, economic growth stopped, and the city shrank. 19. the population increased again in the XIII century. This had to do with the growth in the industrial sector. With the opening of the railway to Leeuwarden and the new port, positive energy came to the city (Harlingen Municipality, 2010). In the XIII century, the city grew out of its original walls and experienced its second golden age (Schroor, 2015 s233). However, soon the city again went into decline. This was because trade became more intense in Rotterdam, and therefore the importance of Harlingen as a commercial city decreased (Schroor, 2015 p249). After the Second World War, the city had difficulty restarting its economy. Therefore, the city he decided to lower his ambitions. The main focus has changed towards becoming a local port, with a focus on fishing and local industry. In addition, Harlingen wanted to become the city of Wadden to attract tourists with an emphasis on the monumental character and location of the city. Harlingen lost its commercial advantages over time (Schroor, 2015). Harlingen may have experienced the effects of a negative lockdown where legacy port functions did not match modern demand (David, 2000). Therefore, Harlingen had to change its economic focus. after the Second World War. Fishing, Zeeuwsefishermen Harlingen (Schroor, 2015). With the opening of De nieuwe industriehaven and Het Harinxmakanaal, trade and industry continue to play a role, but on a more regional scale (Harlingen Municipality, 2010; Schroor, 2015). Also, Harlingen has taken advantage of its historic city center and location to attract tourists. Industry and mining remain but the main sources of employment in the municipality of Harlingen.

	Harlingen		Friesland		Netherlands	
	abs.	%	abs.	%	abs.	%
Agriculture						
incorporations	10	17.6	670	16.4	7645	12.3
cancellations	5	7.8	545	13.4	7885	12.6
balance	5	9.8	125	3.1	-235	-0.4
Industry						
incorporations	15	5.1	680	7.5	17655	9.2
cancellations	20	7.1	655	7.2	16565	8.6
balance	-5	-2.0	25	0.3	1090	0.6
Wholesale and transport						
incorporations	30	12.2	520	8.8	15255	10.1
cancellations	20	8.9	485	8.1	14330	9.5
balance	10	3.4	35	0.6	925	0.6
Services						
incorporations	40	10.4	2070	14.8	77145	15.8
cancellations	60	14.3	1465	10.5	58080	11.9
balance	-15	-4.0	605	4.3	19065	3.9
Retail and catering						
incorporations	25	11.0	865	11.5	19675	11.3
cancellations	25	11.0	700	9.3	16225	9.7
balance	0	0.0	165	2.2	3445	2.0

Fig. 36
Number of new and closed branches, 2010
CBS (Centraal Bureau voor de Statistiek, Den Haag/ Heerlen, 2011)

Harlingen`s economy has become more regional and it has given up its ambitions of becoming an international port. This means that there is a more internal development in Harlingen. The city is mainly devoted to tourism, regional trade, local crafts and fishing (Schroor, 2015). from 2001 to 2016, the number of jobs in Harlingen increased by 13.9%. During the same period, the number of jobs in Frisia increased by 12.5% (Province of Frisia, 2017).
This it means that during the crisis years in Harlingen, the percentage of jobs grew more than the Frisian average. In addition, the effects of the economic crisis in the 1970s were much lower in Harlingen. Thus, Harlingen did not grow as much as other cities in Friesland; however, the growth was more resistant. This means that external disturbances, such as the economic crisis, have less impact on Harlingen (Carlsson, 2014).

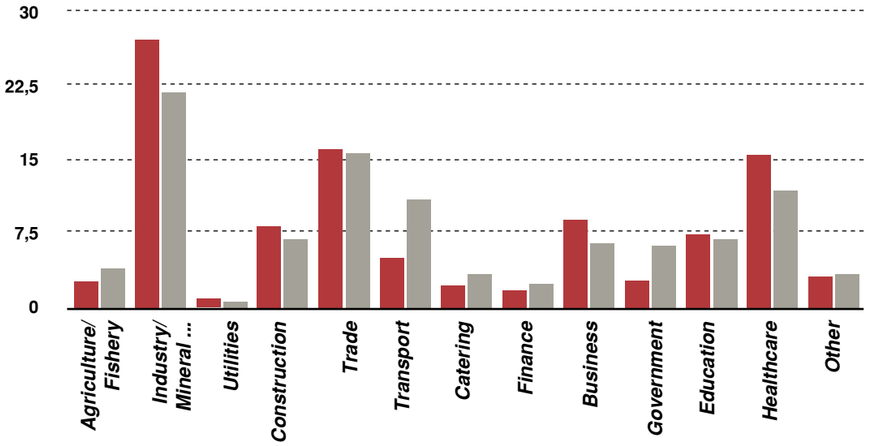


Fig. 37
Job classification in Harlingen

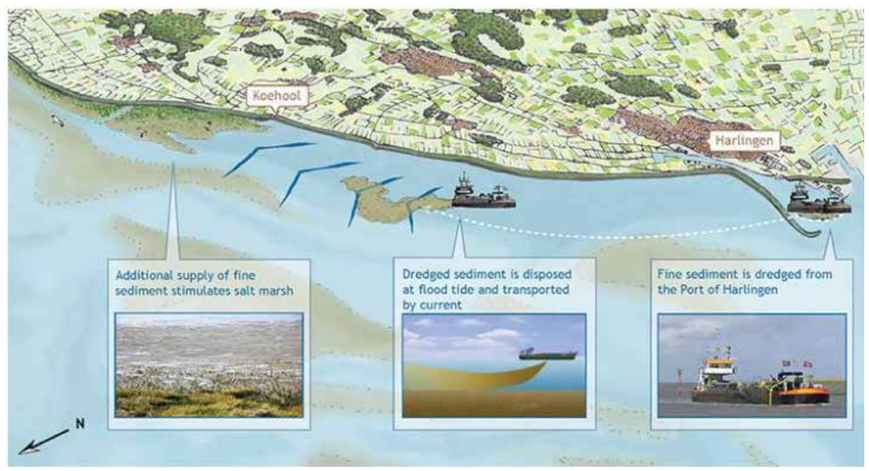


Fig. 38
Mud Motor project in Port of Harlingen, Netherlands

02 DESIGNING TRANSITION ZONES

2.2 *Urban issues of transition zone*

2.2.1 *Risk Analysis of Flooding and Shrinkage*

Fig. 40 / 41 / 42
Flood event in Netherlands, 1953

Risk Analysis of Flooding

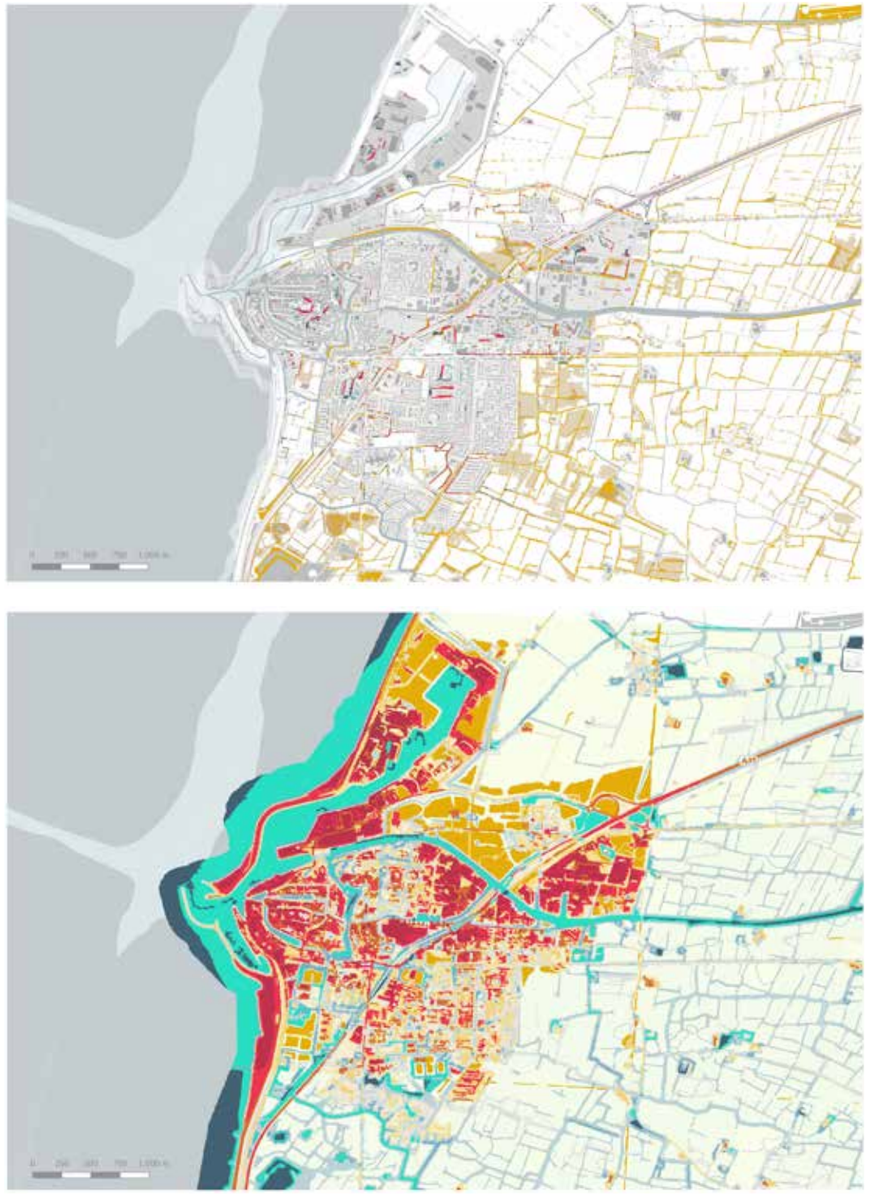


Fig. 43
Extreme Precipitation 60 mm-100 mm

Waterdepth Build Environment - 60 mm/h

- *<10 cm*
- *10-20 cm*
- *20-30 cm*
- *>40 cm*

Waterdepth Unbuild Environment - 100 mm/h

- *0-10 mm*
- *11-20 mm*
- *21-30 mm*
- *31-40 mm*
- *41-50 mm*
- *51-60 mm*
- *61-70 mm*
- *71-80 mm*
- *81-90 mm*
- *91-100 mm*
- *>100 mm*

Fig. 44
Current Heat Stress in Harlingen

- *Felt Teperature Much Colder*
- *Colder*
- *Normal*
- *Warmer*
- *Much Warmer*
- *Too Warm*

Risk Map of Flooding

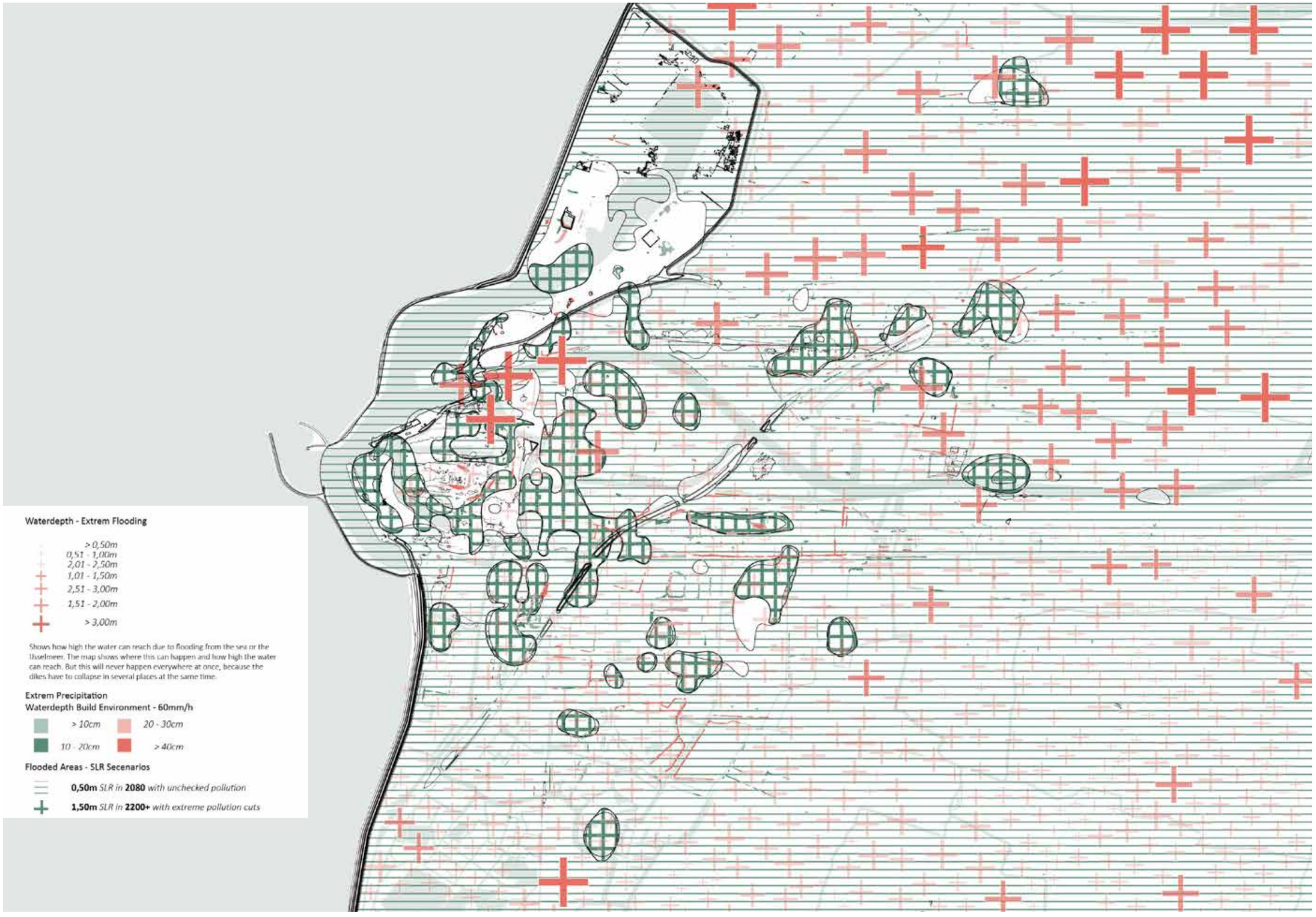


Fig. 45
Risk Map of Flooding

Flooding maps of Harlingen shows that with the Sea Level Rise of current situation, 1m and 2m are shown.

From these maps we can see clearly that +1 SLR And 2+SLR, more than 40% areas in Harlingen are under the risk of flooding.

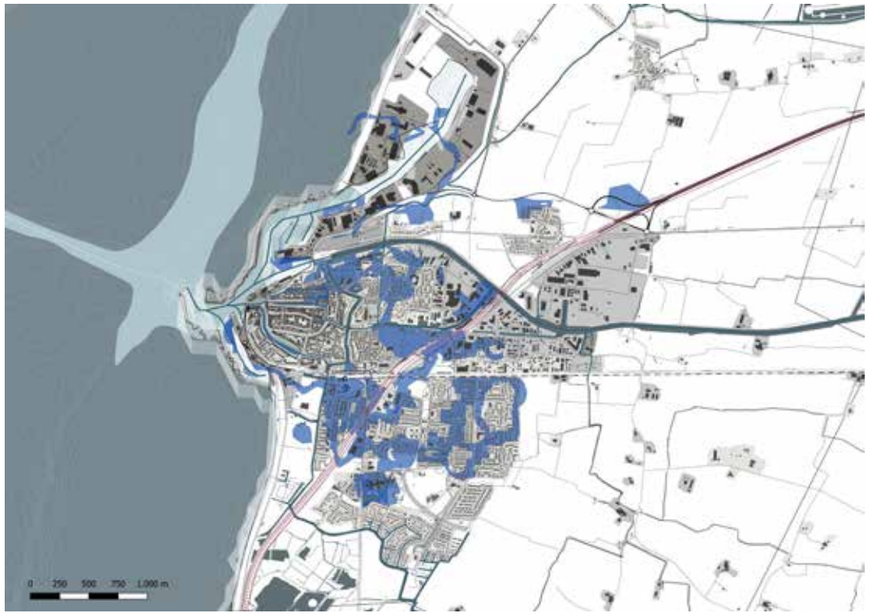


Fig. 46
Extrem Flooding
+ 1m Sea level Rise

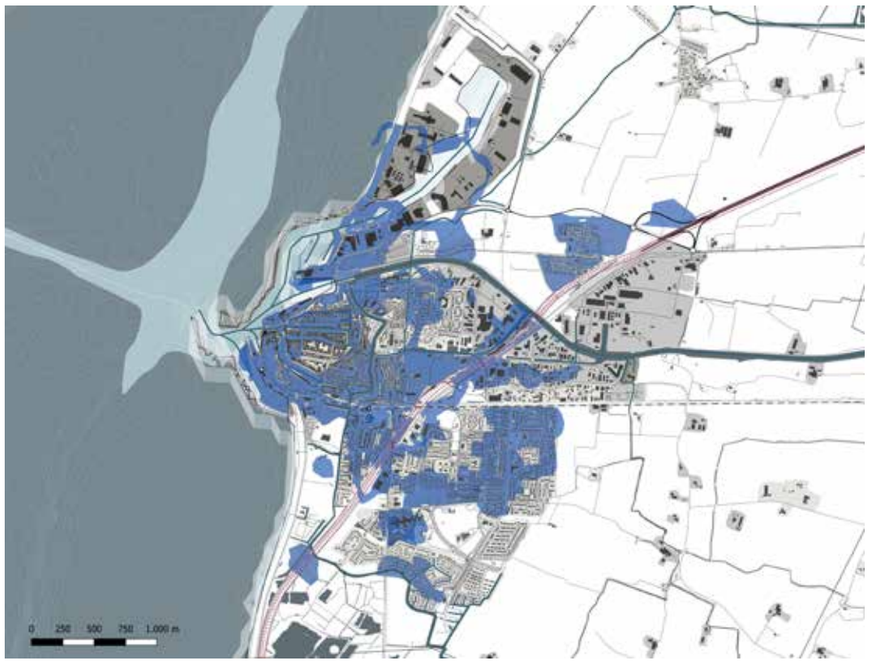


Fig. 47
Extrem Flooding
+ 3m Sea level Rise

The charts show that the frequency of abnormal water levels is rising significantly, which means that in the future with global change it could happen more often in recent years.

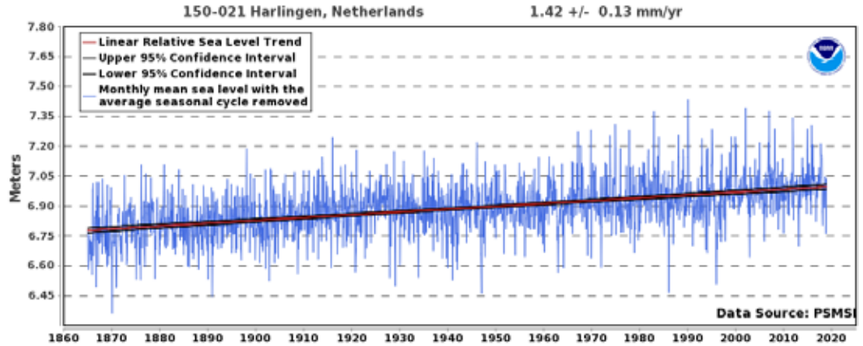


Fig. 48
Graphic of Sea-Level Rise from 1860-2020

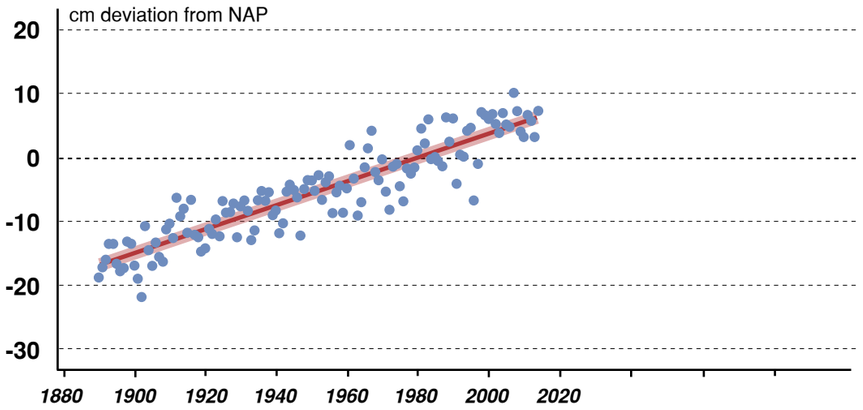
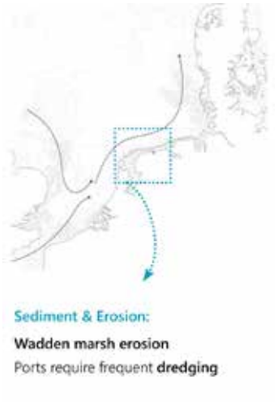


Fig. 49
Sea level along Dutch coast from 1880 to 2020

Erosion Risks



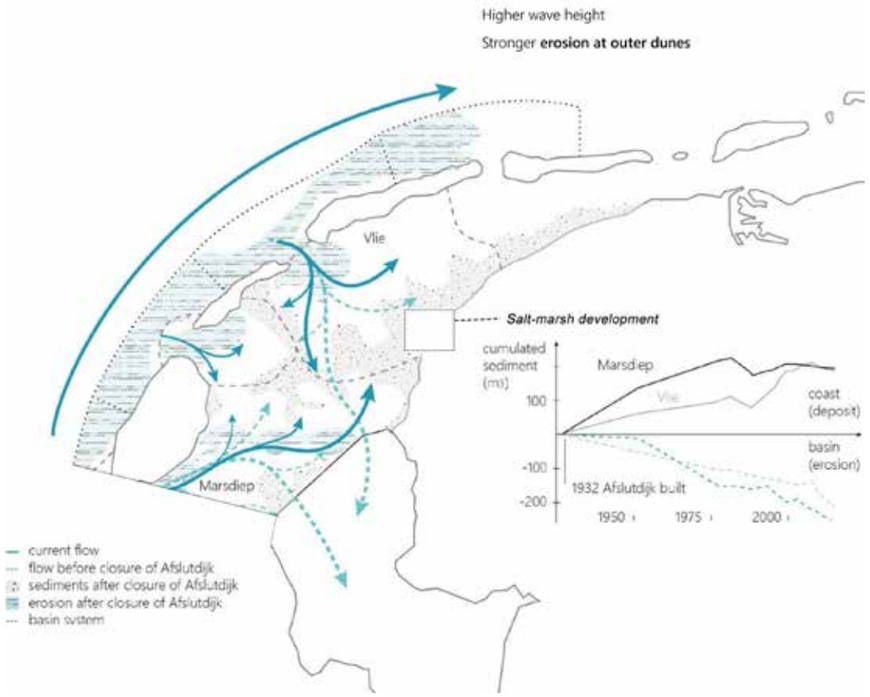


Fig. 50
Development of Erosion and Sediment Risk from Wadden Sea to Harlingen

In the Port of Harlingen, the monthly conservation dredging demand to guard navigation is about 1.3 a million m^3 of substantially fine sediments. This material is conventionally disposed of in the Wadden Sea, at two designated disposal locales that are fairly close to the harborage entrance. A considerable quantum of this deposition is transported back towards the harborage, by natural hydrodynamics similar to tidal currents and swells, leading to a cyclic series of dredging and disposal. This is not only economically hamstrung, it may also lead to increased original turbidity, with a negative impact on primary product and ecological food chains (Reise 2005, Lotze et al. 2006, Eriksson et al. 2010, Elias et al. 2012).

Fig. 51
Sedimentation on the beach of Harlingen

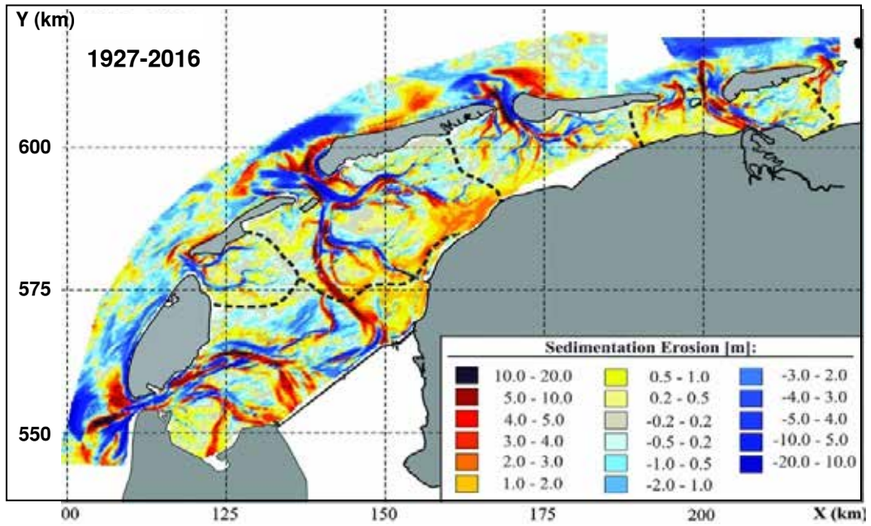


Fig. 52
Sedimentation erosion pattern over the interval 1927-2016.

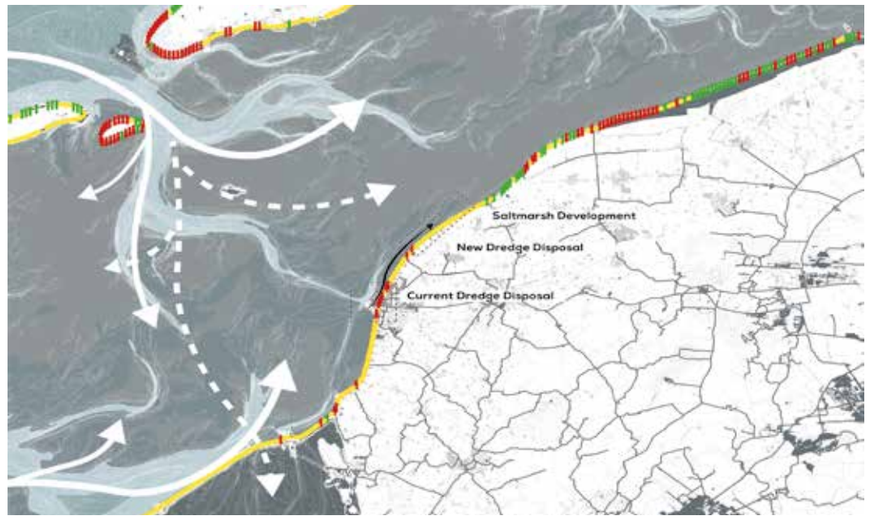


Fig. 53
The way of where the Sedimentation and Erosion accumulated

Fig. 54
Retroregradation and Accreation of Coastline of Harlingen

CONCLUSION MAP: Flood Analysis

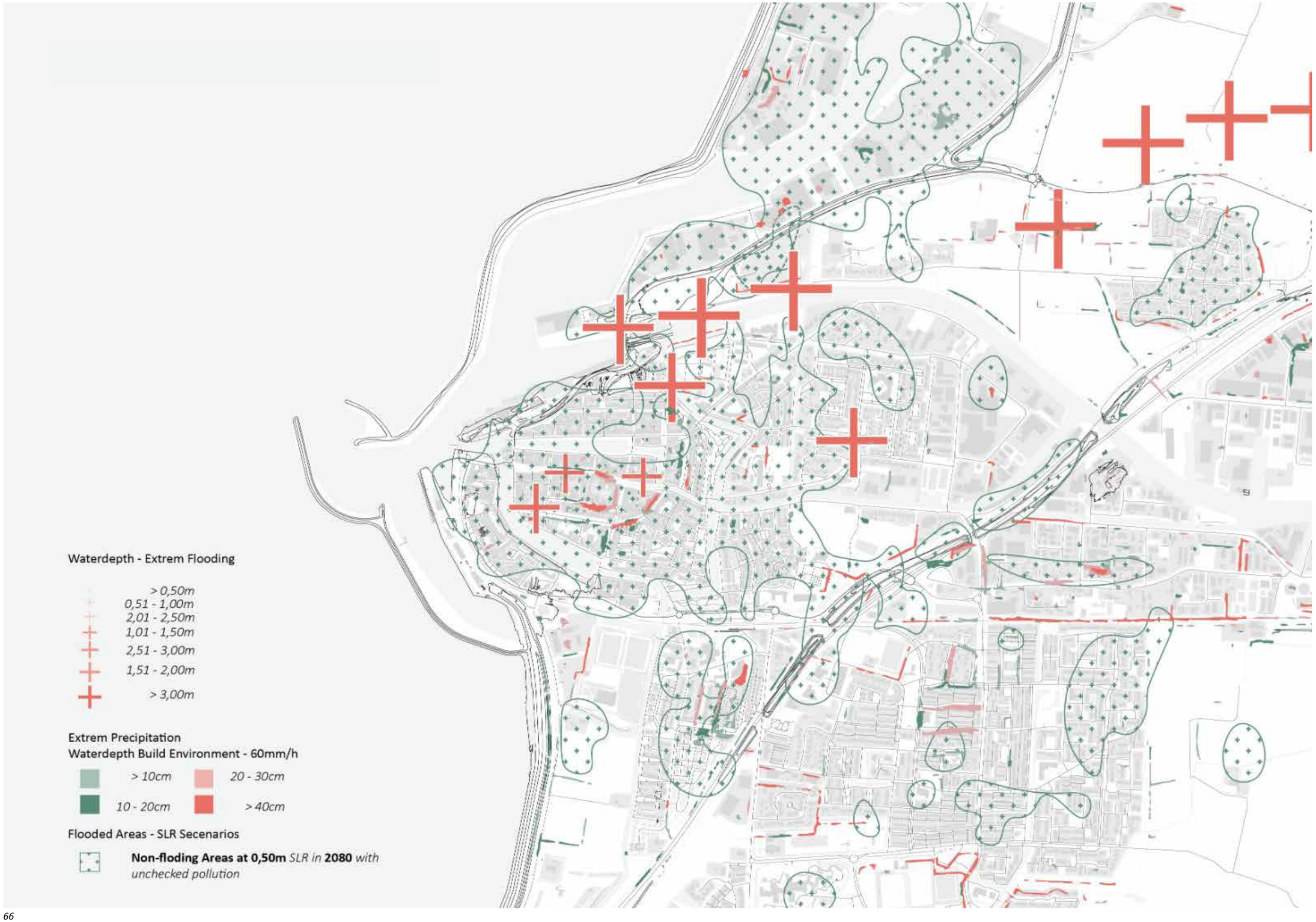


Fig. 55
Conclusion Map Flood Analysis

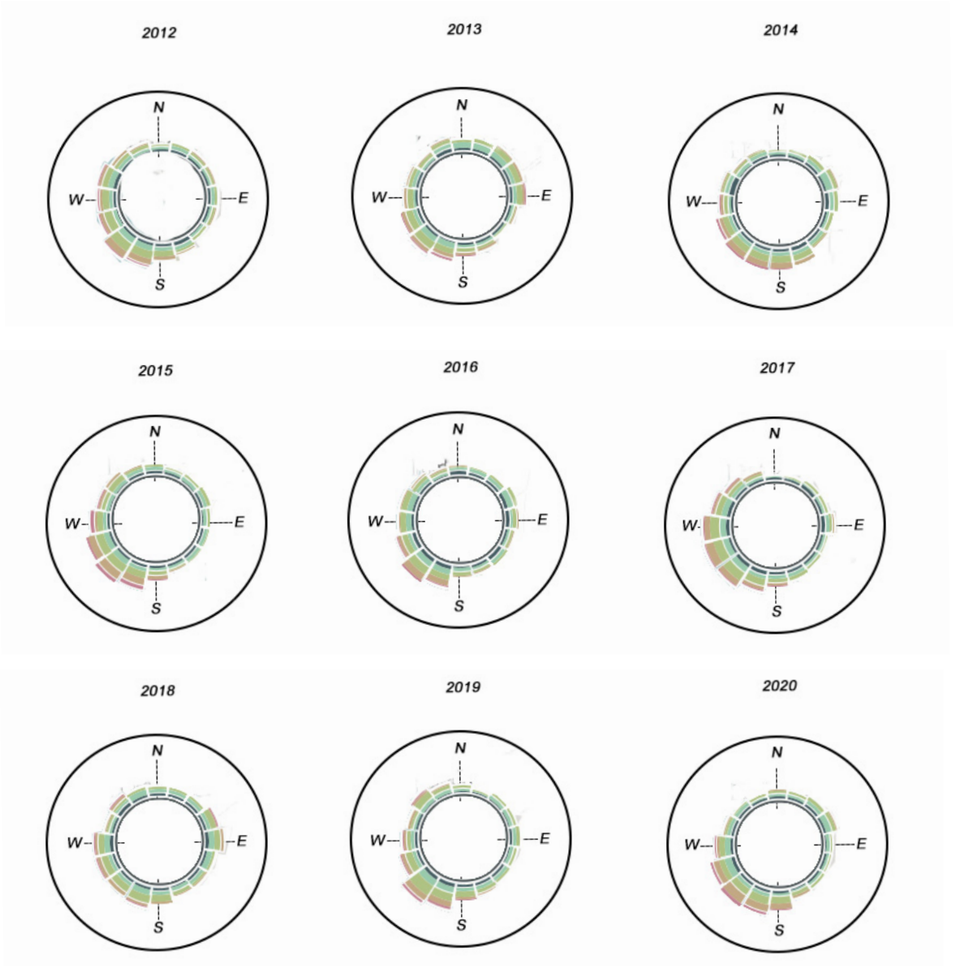


Fig. 56
Wind History of Harlingen

- *8 - 12 knots*
- *12 - 17 knots*
- *17 - 23 knots*
- *23 -35 knots*
- *35+ knots*

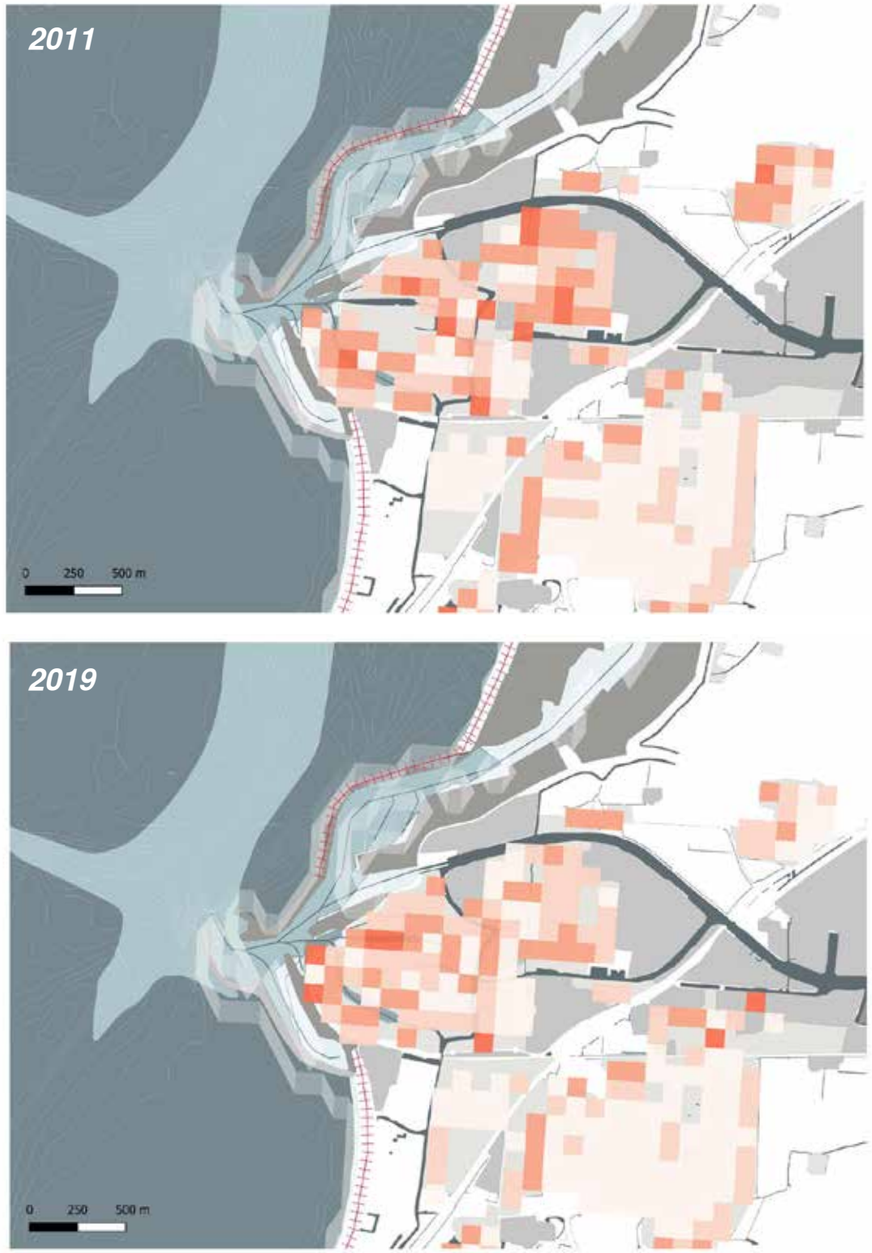


Fig. 57 / 58
Recently Housing Values

- *> 150.000*
- *150.000 - 200.000*
- *200.000 - 300.000*
- *300.000 - 500.000*
- *500.000 - 750.000*
- *750.000 - 1.000.000*
- *< 1.000.000*

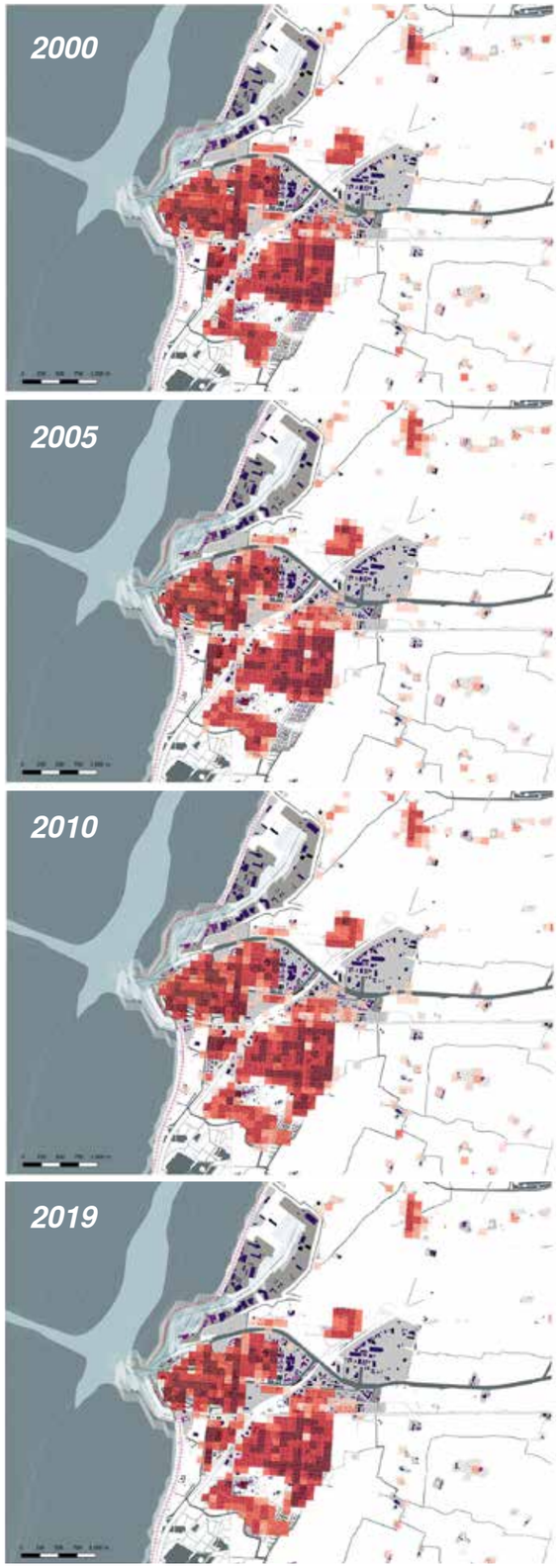


Fig. 59 / 60 / 61 / 62
Inhabitants in Harlingen per 100*100 Grid

- *0-5 inh.*
- *5-10 inh.*
- *10-25 inh.*
- *25-60 inh.*
- *> 60 inh.*

As you can see, the difference between 2015 and 2019 is that uninhabited houses in Harlingen increased. Especially in the city center, where it is closed to canals and ports, these houses have dramatically become empty. The reason behind it was that while young people were getting out of the city, flooding risks escalated. In 2019, it is shown that the outside of the center is also becoming empty. We assumed that the annual precipitation rate had increased for that area.

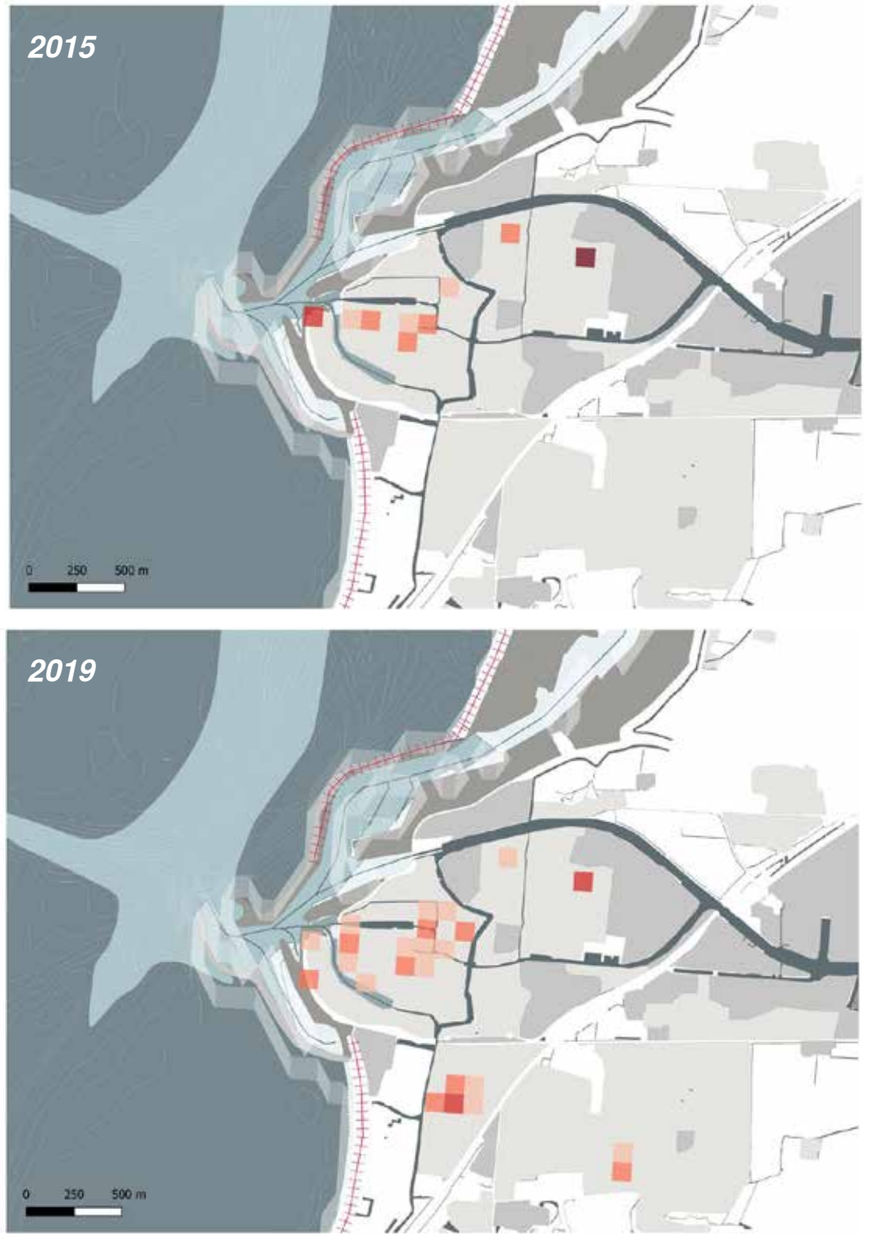


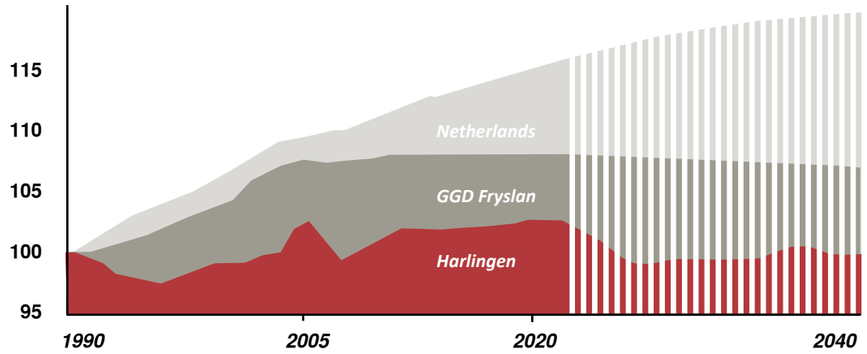
Fig. 63 / 64
Unhabitated Houses

- *0-5 inh.*
- *5-10 inh.*
- *10-25 inh.*
- *25-60 inh.*
- *> 60 inh.*

The total population of the municipality of Harlingen fluctuates. In 2007 the population fell relatively sharply as a result of the closure of the asylum seekers center, but after 2007 the population increased relatively sharply again. The number of inhabitants in the centers of Midlum and Wijnaldum has decreased in recent years.

The housing policy for Harlingen is further elaborated in a housing facet structural vision. The basic principle in this will be that expansion and restructuring will take precedence over the expansion of the residential buildings. The vision must answer the question of how many homes are still needed and for which target groups homes are needed.

Fig. 65
Population Develoment Scenario



relocations and declining immigration

05 jan 2021 - 06:00 • Frisian • read for

In 2020, the population growth in Fryslân will be even smaller than in the previous year. In 2019, the population decreased in three of the eighteen Frisian municipalities, but in 2020 this happened in seven of the eighteen municipalities. This is evident from figures from the Central Bureau of Statistics (CBS) that will be published on Tuesday.

Photo: *Omrop Fryslân*

Fig. 66
Shrinkage News from articles in Fryslan region

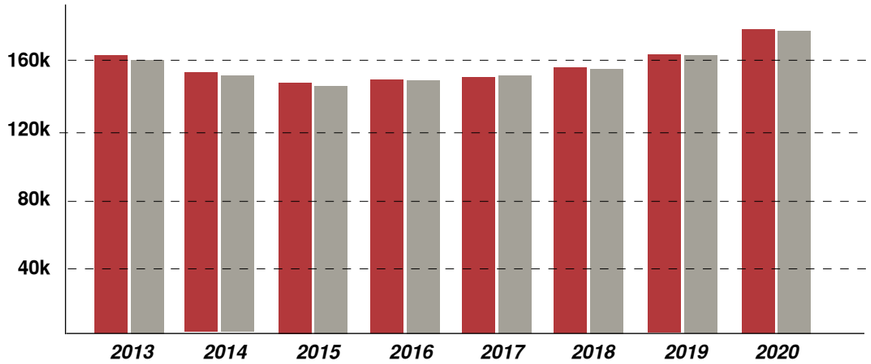


Fig. 67
Recently Housing Values

Municipality of Harlingen
Borough Harlingen

The number of homes grew in almost all Frisian municipalities, except in Harlingen, Waadhoeke and Vlieland

René Smid 5 augustus 2021, 03:00 · Friesland Share this article


Photo: ANP

In the Netherlands you can now find more than 8 million homes, of which 305,477 in Friesland. This is evident from the latest figures from Statistics Netherlands (CBS). The housing stock has increased in almost every Frisian municipality.

Compared to the beginning of this year, three Frisian municipalities recorded a decrease as of 1 July. Nationally, the housing stock contracted the most in Harlingen, with 114 homes. A decrease was also noticeable on Vlieland (shrinkage of 1 percent to 597 homes) and in Waadhoeke (shrinkage of 0.2 percent to 21,323 homes). Ameland had the highest relative increase (1.1 percent). You will now find 1773 homes on the Wadden Island.

Fig. 68
Number of Housing in Frisian municipalities

Demographic analysis of neighbourhood scale of Harlingen

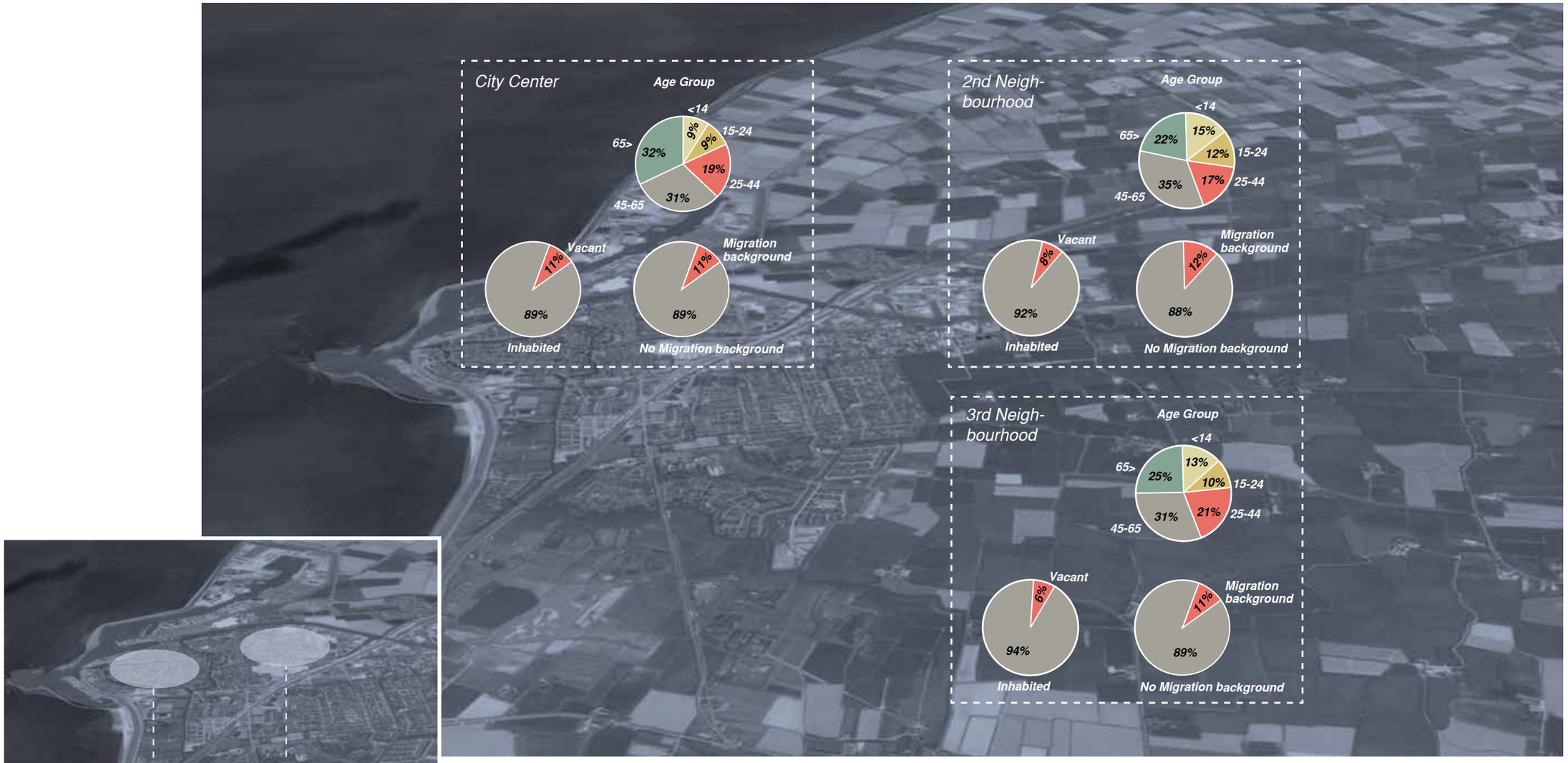
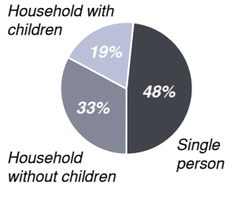
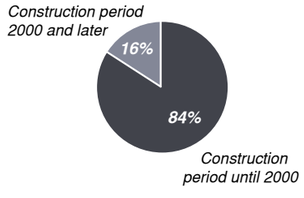


Fig. 70
Age structure, migration and vacant houses analysis of each districts in Harlingen

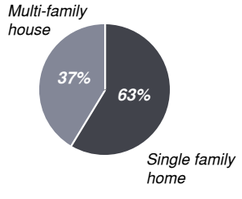
Total number of households: ***1750***



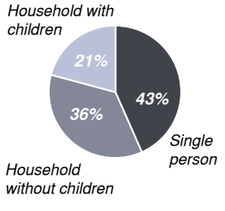
Number of residents: ***1878***



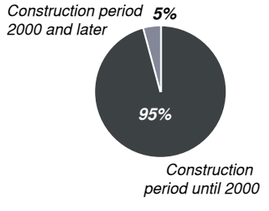
Homes by type



Total number of households: ***1005***



Number of residents: ***1131***



Homes by type

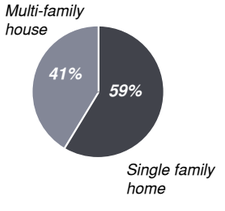
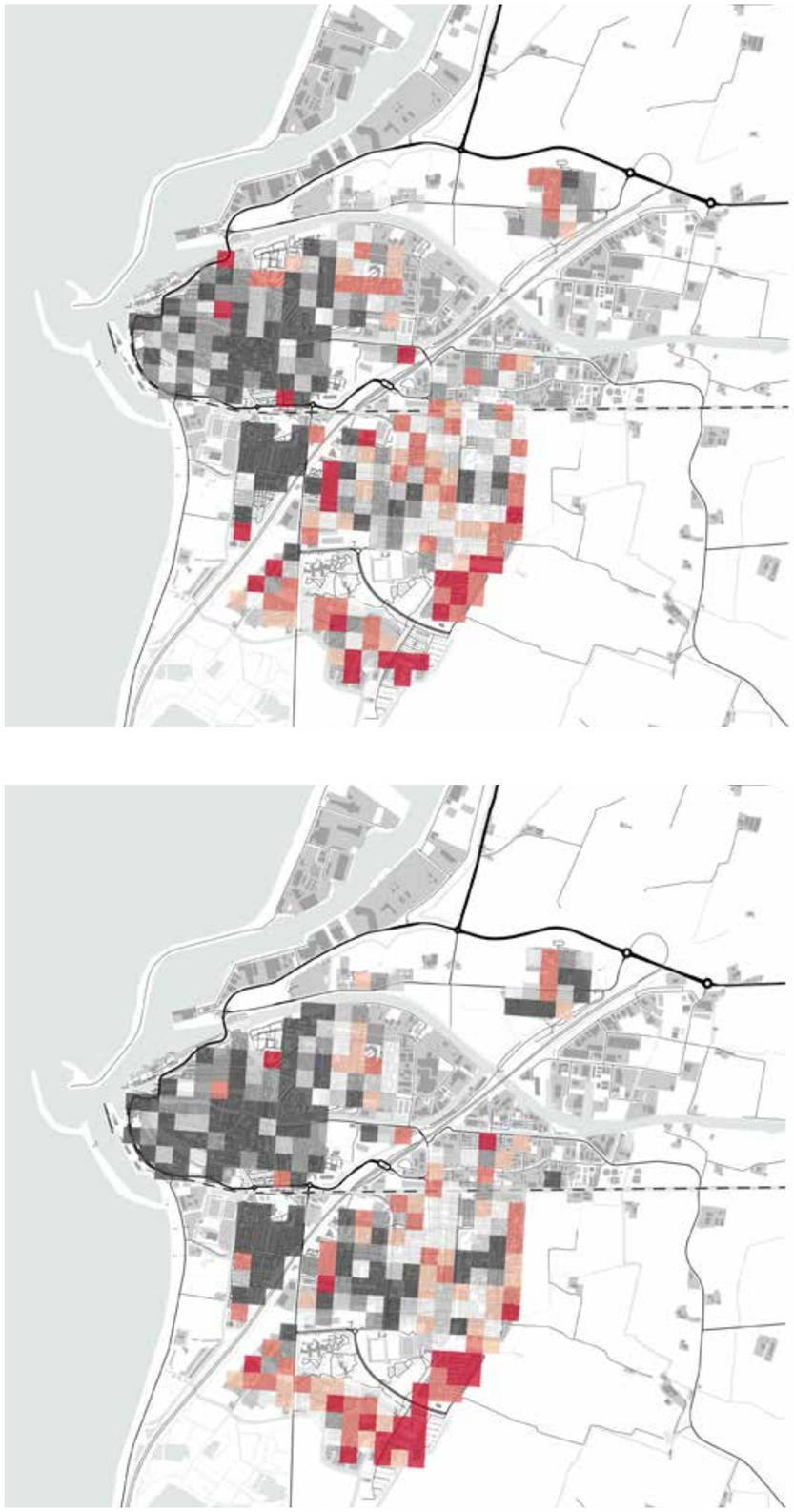


Fig. 69
Household Analysis in Neighborhood Scale



Average HouseHold size

- 0 - 1,8
- 1,8 - 2
- 2 - 2,2
- 2,2 - 2,4
- 2,4 - 2,6
- 2,6 - 3
- 3 - 10

Fig. 71 / 72
Smaller households in city center outskirts of the city there are multi family house holds

Fig. 73 / 74
100*100 Grids shows only 20 or more people of age group

- ***0-14***
- ***15-24***
- ***25-44***
- ***45-64***
- ***65>***

CONCLUSION MAP: Demography and Shrinkage

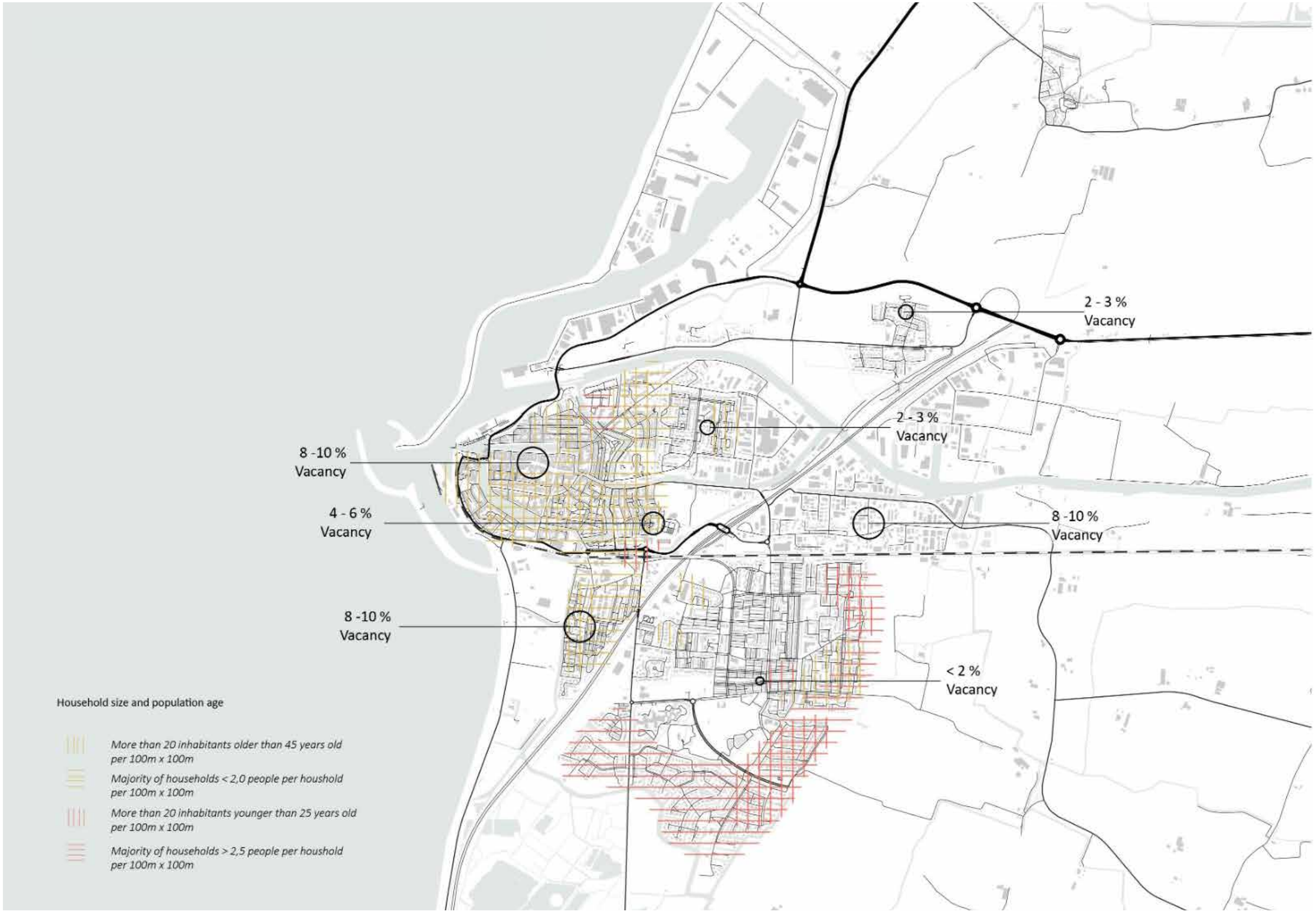


Fig. 75
Demography and Shrinkage Flooding Conclusion Maps

CONCLUSION MAP: Shrinkage and Flooding

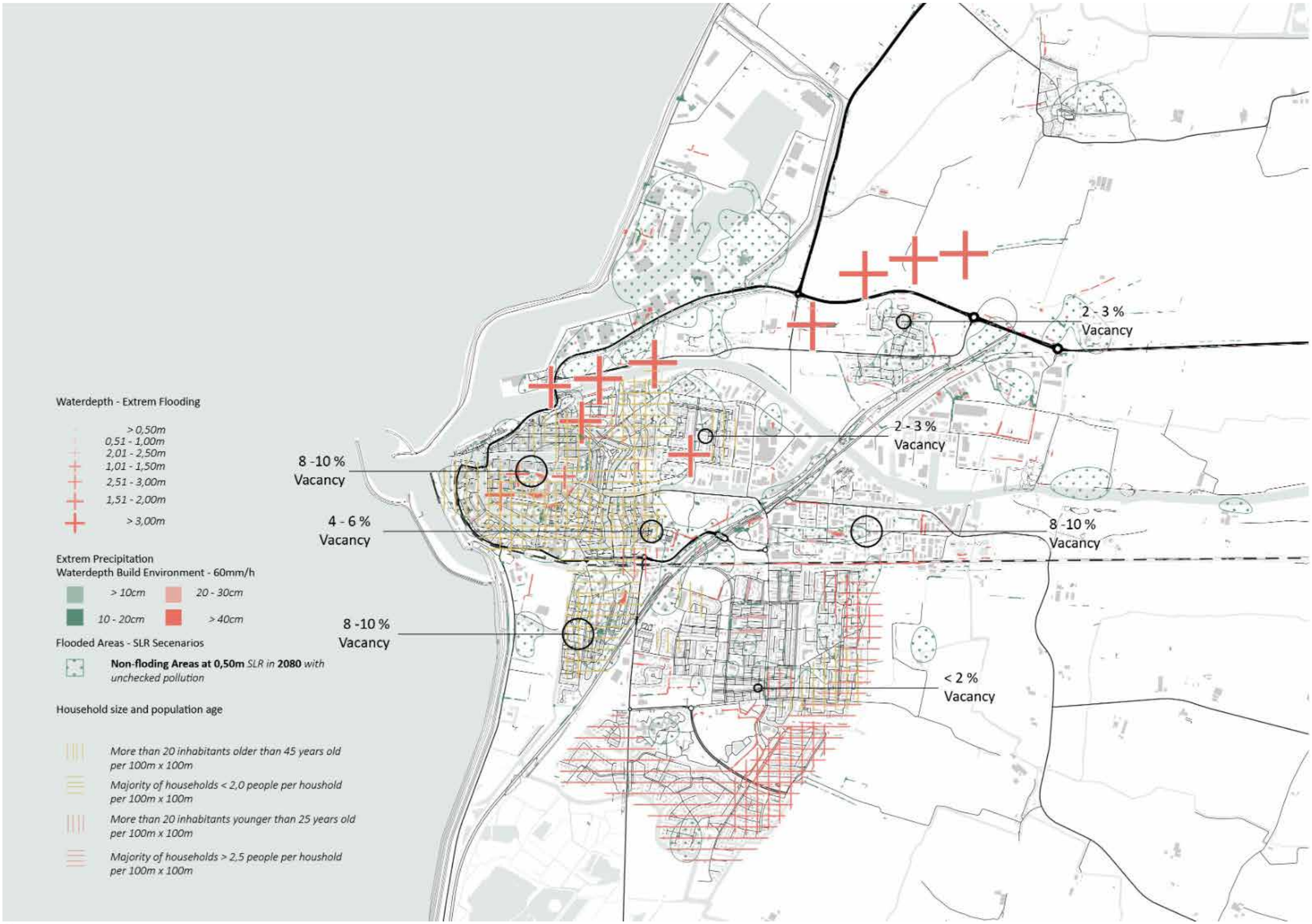


Fig. 76
Demography and Shrinkage Flooding Conclusion Maps

2.2.2 ***Spatial Analysis***


Fig. 77 / 78 / 79 / 80 / 81
City Center of Harlingen

Fig. 82
Flooding scenario of Harlingen

The scenario is created by thinking all flooding types can happen in the Harlingen area. Flooding risk maps and scenarios are depicted in the conclusion maps.It is also shown what might happen if there is fluvial flooding and pluvial flooding in this area at the same time. Obviously not only the houses would be affected but also the trees and soil.

Built Environment

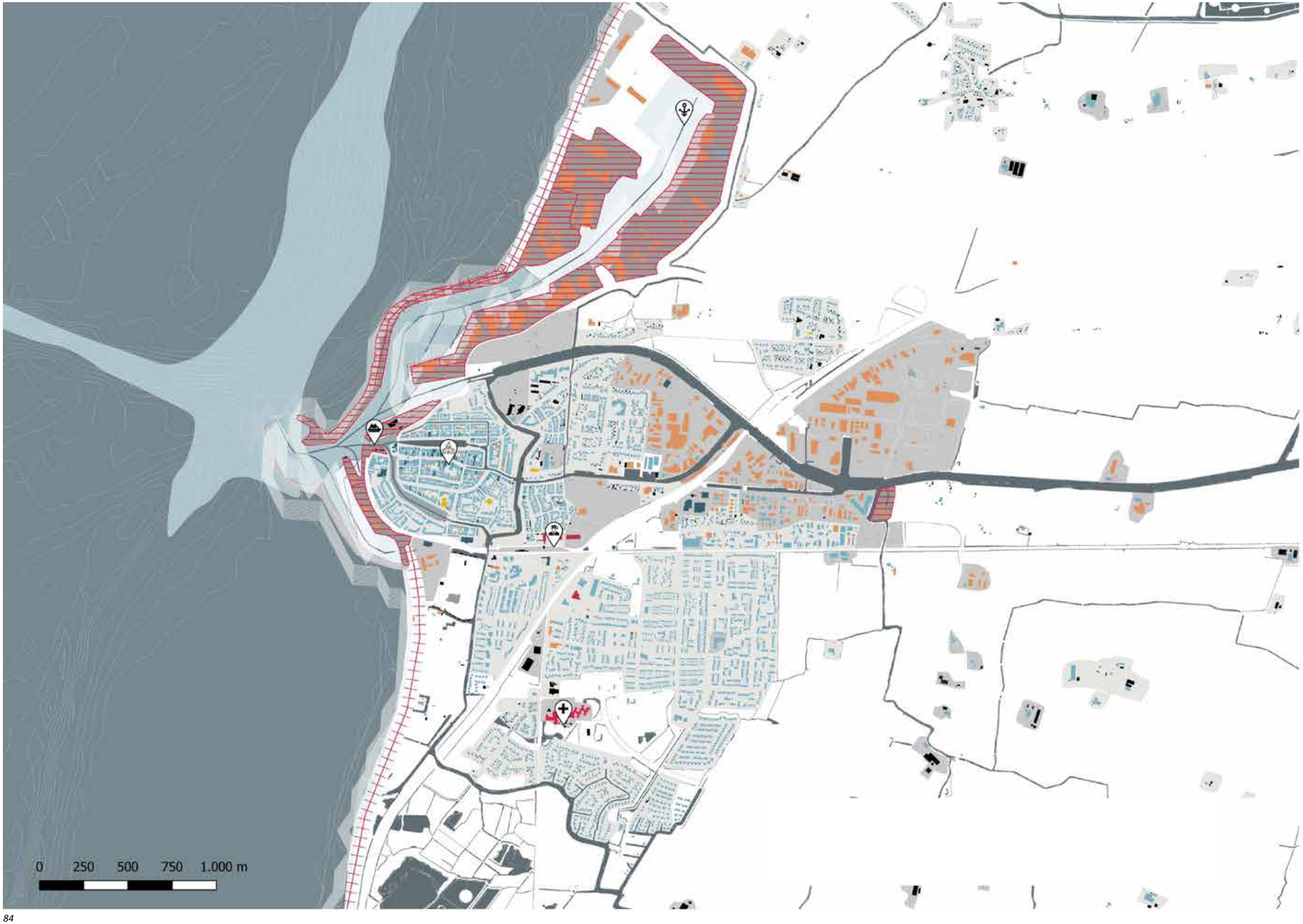


Fig. 83
Map of Built Environment

- *Built-up Area*
- *Industry*
- *Port*
- *Sea Dike*
- *Residential/Housing*
- *Education & Daycare*
- *Hospitals & Health*
- *Industry*
- *Religious/Cultural*
- *Commercal & Offices*
- *Public Buidlings*
- *Others*

Mobility

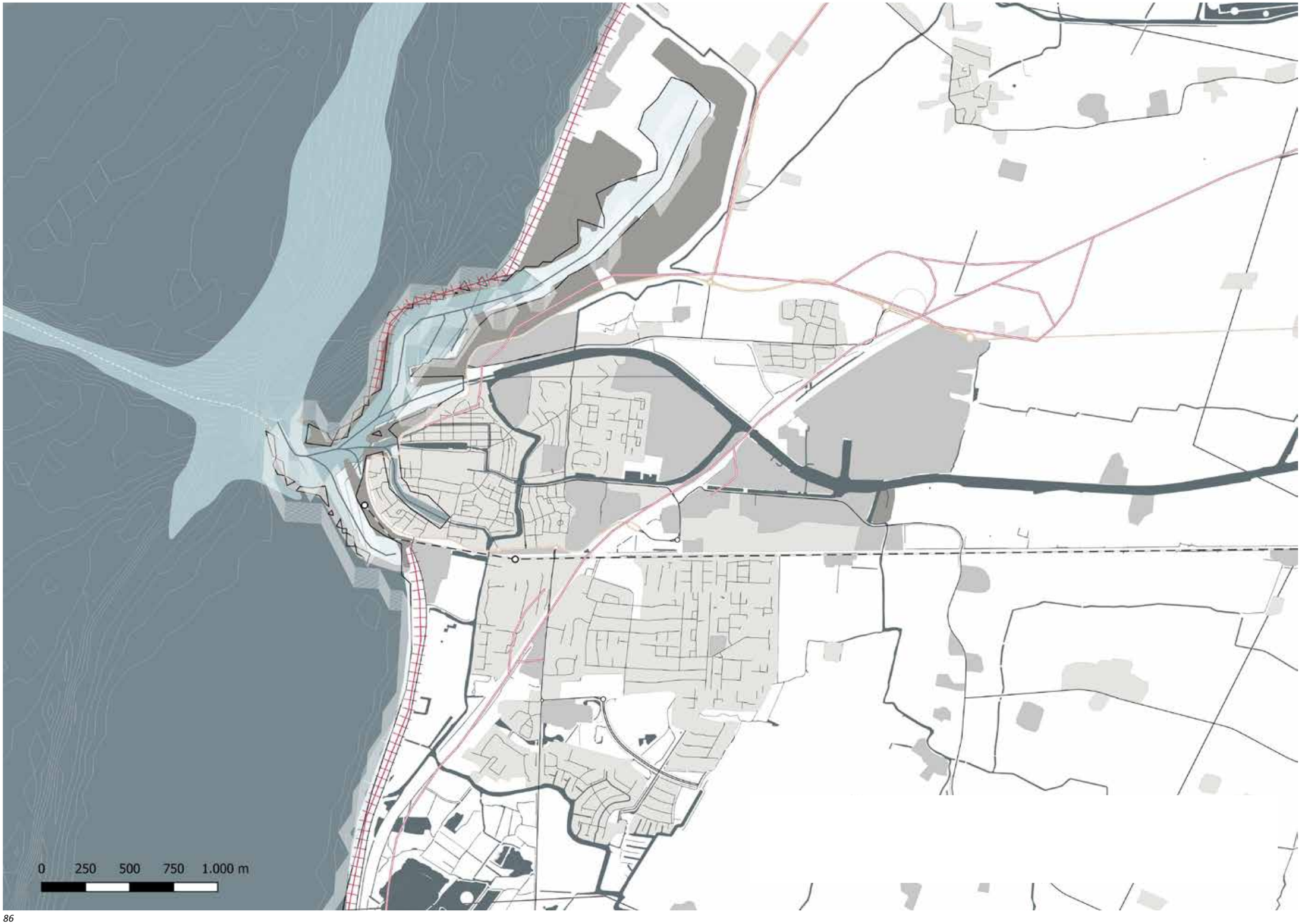


Fig. 84
Mobility Map

Land use

Fig. 85
Land use Map

- *Built-up Area*
- *Industry*
- *Port*
- *Sea Dike*
- *Urban/Recreational Grassland*
- *Semi-natural Grassland*
- *Managed Grassland*
- *Arable Land*
- *Intertidal Flat*
- *Open Water Shipable*
- *Lake*
- *Natural/Seminatural Waterbody*
- *Highly artificial waterbody*
- *5m Heightlines*
- *Bathymetry*

Landscape and Soil Type

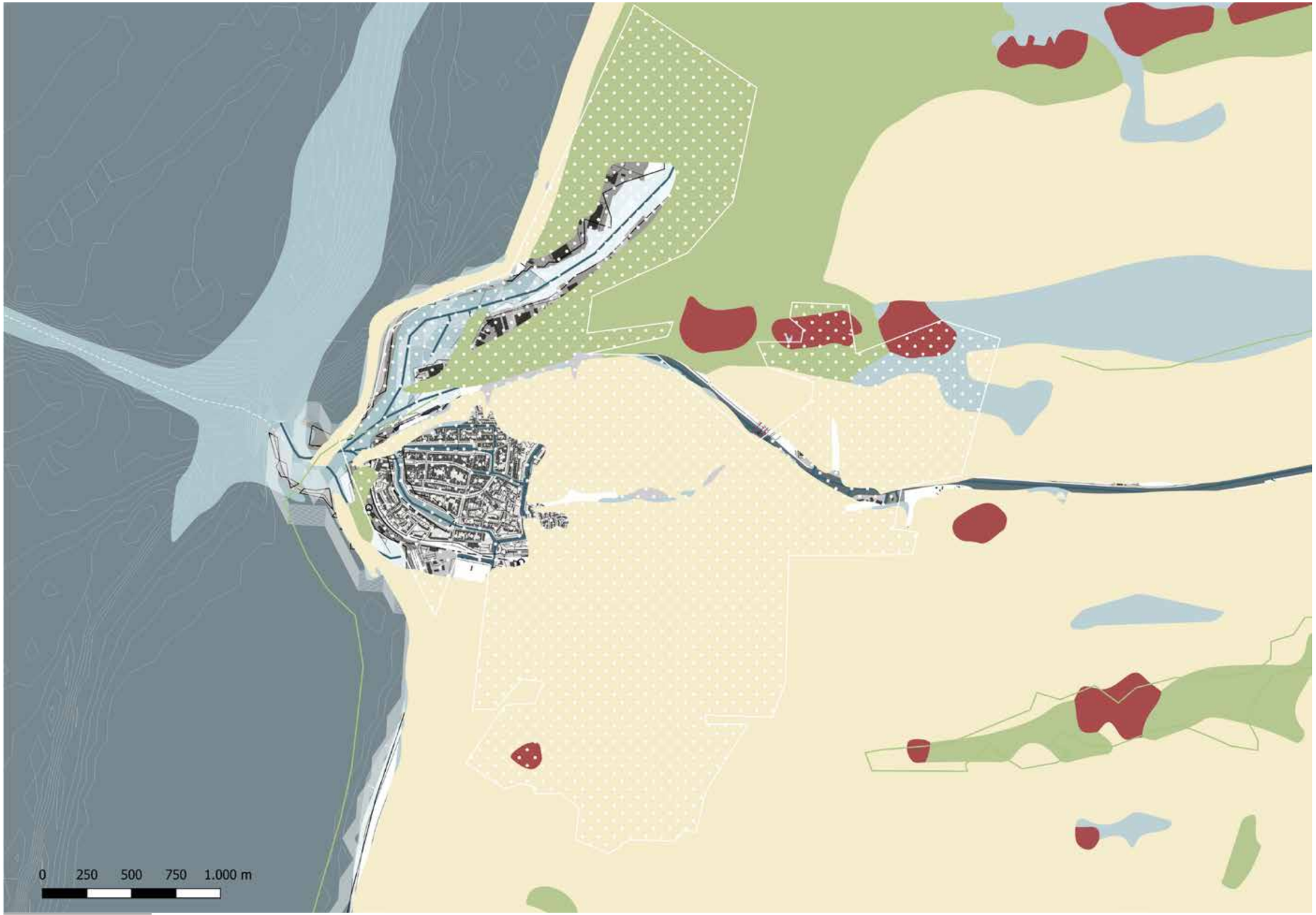


Fig. 86
Soil Type Map

Sea-Clay Plain
Kreekrug
Creek ridges
Terp

Flat and open polder landscape;
Elecation ranges from approx. -3m NAP to +1.5m NAP;
Heigher elements in this region are Dykes, Terps and Mounds

Main soil type marine clay-
Creek ridges: heavy clay and bedding sand

Subsoil: mudflat deposits, peat and surface sand

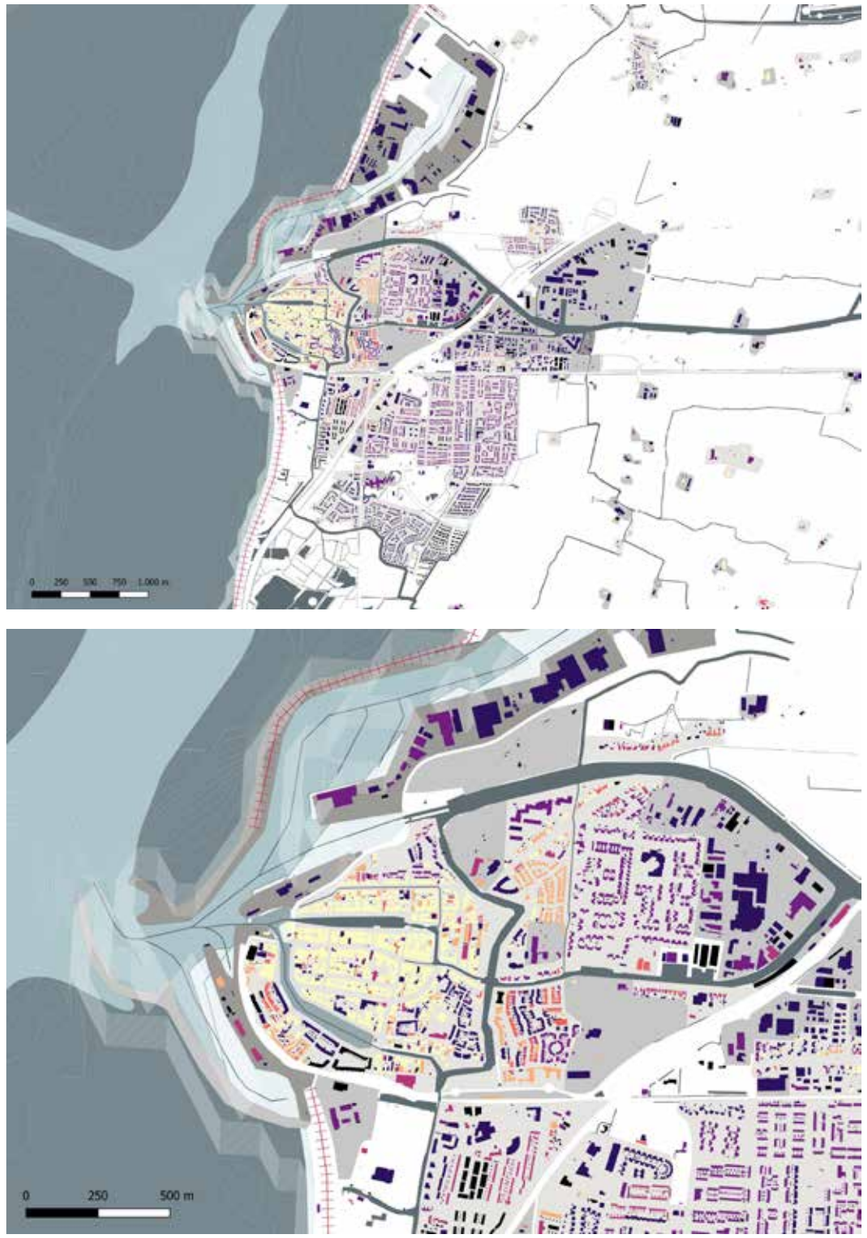


Fig. 87
Map of Building Age

- *>1900*
- *1900 - 1930*
- *1930 - 1945*
- *1945 - 1960*
- *1960 - 1980*
- *1980 - 2010*
- *<2010*

Fig. 88
Building Typology of Harlingen

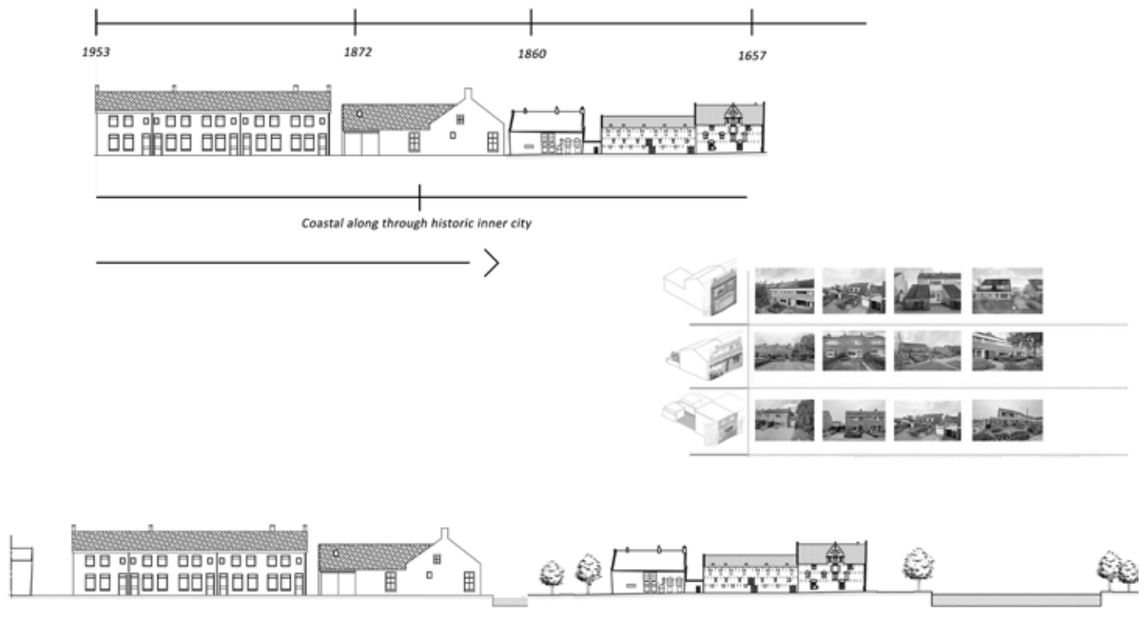


Fig. 89
Timeline of building development of Harlingen

Fig. 90
The dike of the Harlingen

Fig. 91
Composition of dike and houses in Harlingen

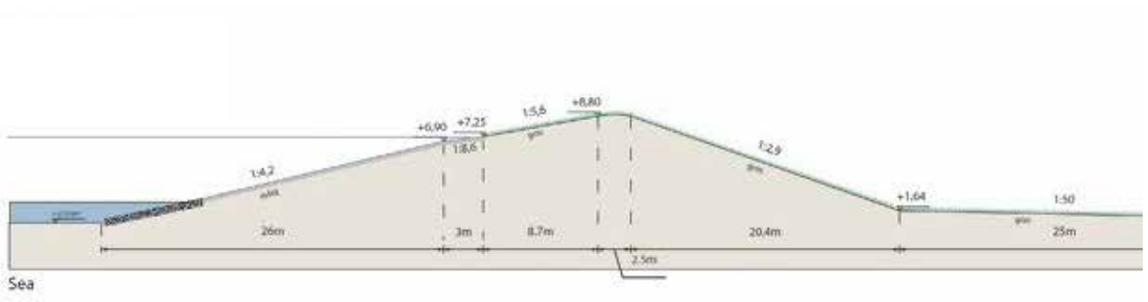
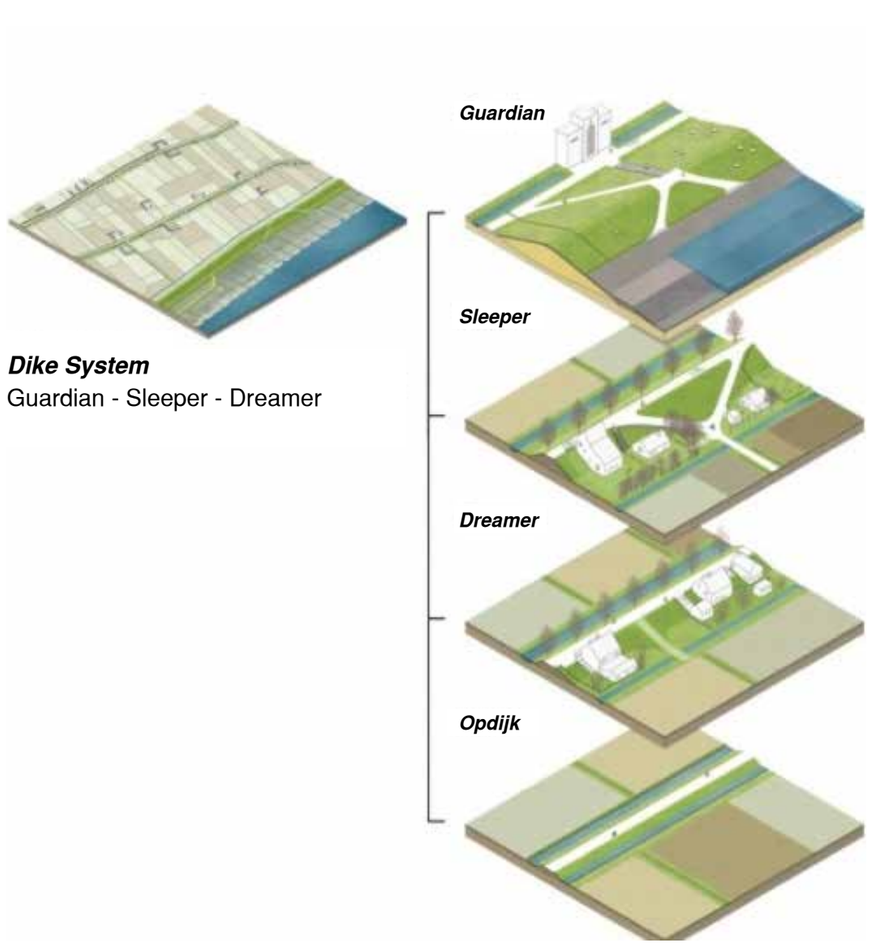


Fig. 92
The dike of the Wadden Sea near Harlingen Basic Profile Sea Dike

Along the coastline of the Wadden Sea, a wide length of trench exists to protect its hinterland from flooding. Also, in the Netherlands and Germany, sand is fed off the coast of the Wadden Islands to combat coastal retreat. Some island areas require additional difficult construction work to combat structural erosion. Management techniques such as (bushwood) groin areas are used to protect salt marshes from coastal erosion. The most traditional protection method is using dikes. Along the Dutch Coast there are, roughly speaking, three different types of defences: dikes, dams and dunes. In this survey we focus on sea dikes, lake dikes and estuary dikes.

In the dike other water regulation structures such as locks that provide access to pumping stations and ports are embedded, also to provide drainage of excess water in the interior to the sea. Salt marshes have formed in front of the embankment, where appropriate, partly with human assistance (M. Schroor, personal communication, 19 April 2019). These salt marshes can act as buffers and protect the dam during storm surges (Vink et al., 2019). The coastal protection and flood risk analysis of the region is carried out by the water boards.



Dike System
Guardian - Sleeper - Dreamer

Fig. 93
Typical Dike Sstem in Wadden coastline

02 DESIGNING TRANSITION ZONES

2.3 *Redesigning a transition zone*

2.3.1 *Design Objectives*

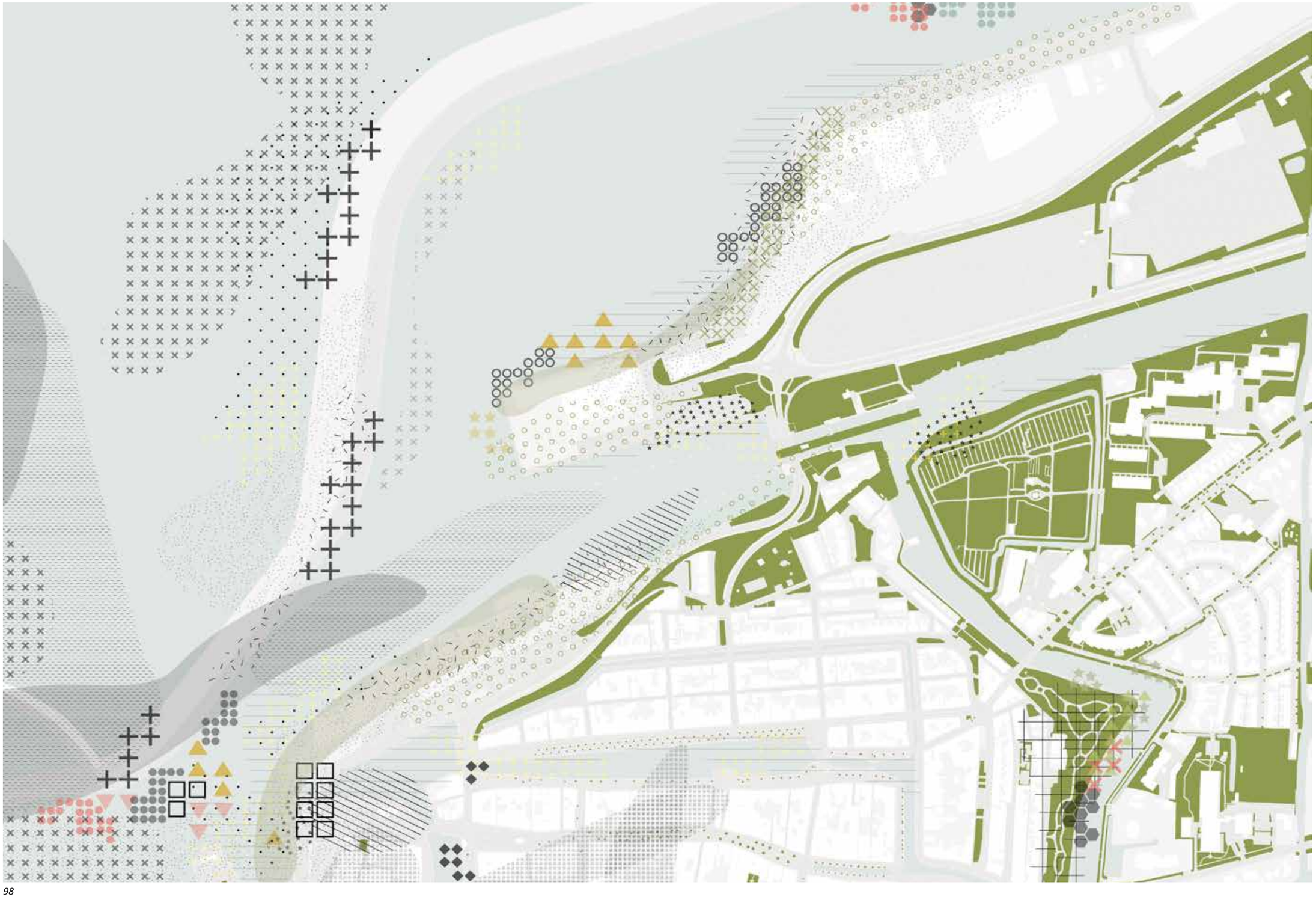


Fig. 95
Ecology and Biodiversity Map of design area

Plants
- *Plantain-family (Plantaginaceae)*
- *Plantain-family (Plantaginaceae)*
- *Grasses (Poaceae)*
- *Asparagus (Asparagaceae)*
- *European water-plantain (Alisma plantago-aquatica)*
- *Mosses (Bryophyta)*

Fish and aquatic life
- *Muscels*
- *Harbour Porpoise (Phocoena phocoena)*
- *Bream (Sparus aurata)*
- *European sturgeon (Acipenser sturio)*
- *Ukelei (Alburnus alburnu)*
- *Eel (Anguilliformes)*
- *Thicklip grey mullet (Chelon)*
- *Aland (Leuciscus idus)*
- *Flounder (Platichthys flesus)*
- *Atlantic Salmon (Salmo salar)*

Birds
- *Herring gull (Larus argentatus)*
- *Mallard (Anas platyrhynchos)*
- *Grey Goose (Anser anser)*
- *Ruddy turnstone (Arenaria interpres)*
- *Common Buzzard (Buteo buteo)*
- *Dunlin (Calidris alpina)*
- *Black-headed gull (Chroicocephalus ridibundus)*
- *Gray heron (Ardea cinerea)*
- *Wigeon/Ducks (Mareca)*
- *Common starling (Sturnus vulgaris)*
- *Redshank (Tringa totanus)*
- *Lapwing (Vanellinae)*
- *Stork (Ciconiidae)*

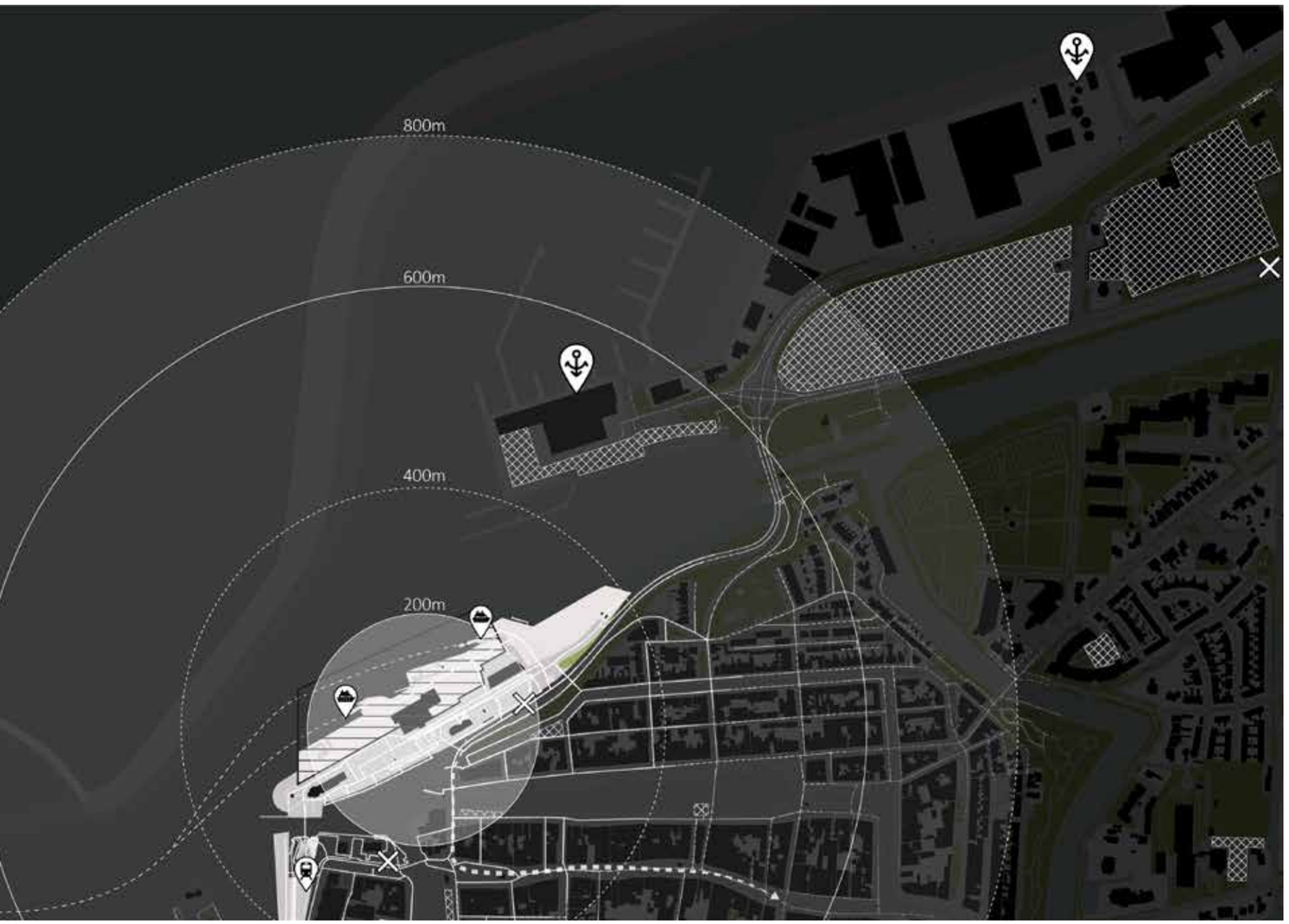
Land use of Design area

Fig. 96
Land Use Map of design area

- *Permeable surface- Greenspace*
- *Impermeable surface Infrastructure*
- *Cadastre*
- *Private land registry Building footprint*
- *Open water*

Mobility Map of Design area

The mobility map shows the distance between the three main spots in the city. Ferry terminal, garage parking, and the city center, which has all the amenities inside. Does the first map show that if the bus terminal were the main spot, how far would it be from the city center? The second map explores what if the garage spot were the main spot, how far would it be from the city center and bus terminal? The third map depicts an analysis of how far the port would be from the city center between garage spots if it were the main location.



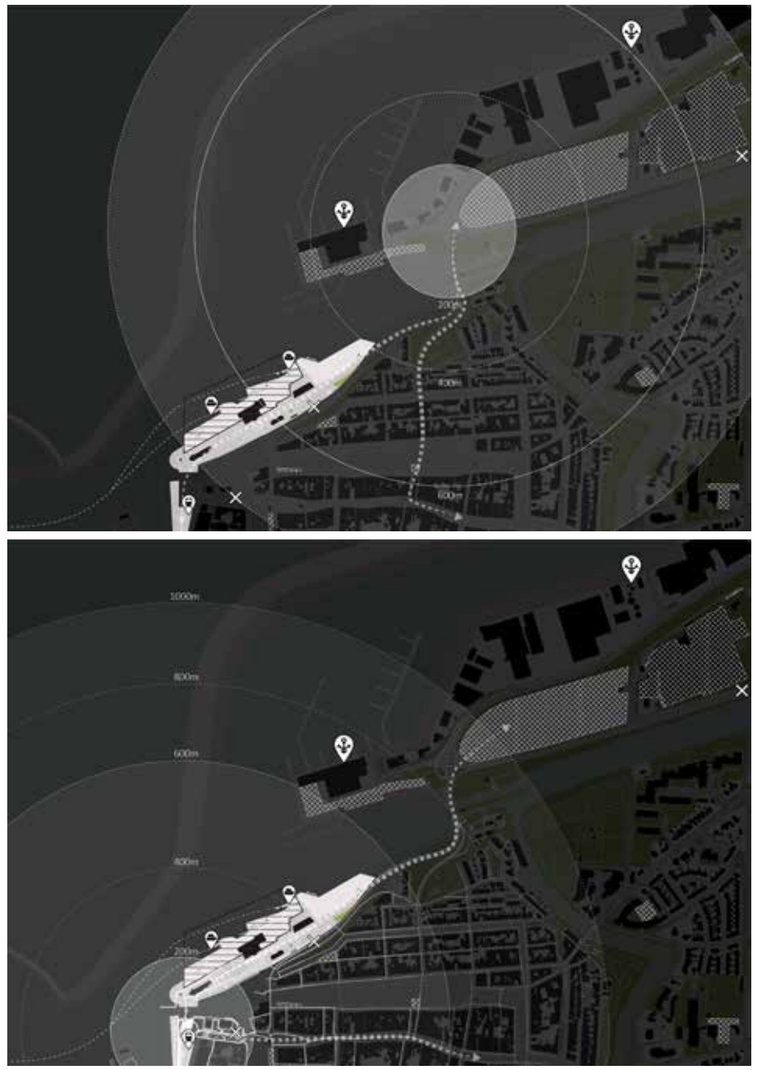


Fig. 97
Mobility Map of Design area

Future scenario of Harlingen development with / without interventions

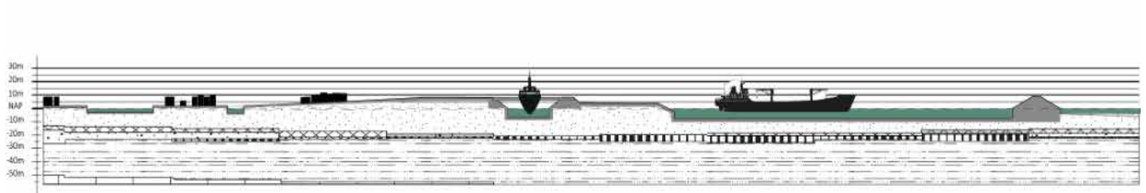
This map shows the future scenarios of Harlingen with and without interventions. On the left-hand side, it is visible what would happen if the city got under the intervention of the strengthening dikes and prevented shrinkage by applying new building typologies. On the right-hand side, it shows that with escalating sea-level rise, the dikes will fall down if we do nothing. The port area will be under the sea, and based on that, people will try to move out of the city. For this reason, the city and its rural areas will be much smaller. It is important to compare two maps and conclude the probabilities and consequences.

Fig. 98
Future Scenario with Interventions

Fig. 99
Future Scenario without Interventions

2.3.2 ***Design Strategies***

Street Section of design area/Detail soil types



Naaldwijk Formation
Highly variable. Generally, grey fine to medium sand, calcareous, shelly. Grey to blue silt and clay layers, organic, shelly. Common coarse lags and clayey fills. Thin discontinuous peat layers.

Boxtel Formation
Light yellow to dark brown very fine to medium sand, silty. Greyish brown to dark grey loam, sandy. Thin peat and gyttja layers, commonly sandy, partly detritic. Locally, fine to medium sand with granule lags. Palaeosols. Common cryoturbation.

Eem Formation
Grey fine to medium sand, mostly calcareous with marine shells that may be concentrated in layers (dominant outside of basins). Dark grey to greenish grey clay, silty, mostly calcareous with shells or shell layers, locally organic (dominant in basins). Subordinate shell crags, diatomite.

Drente Formation
Fine to very coarse sand, gravelly. Greyish blue to brownish grey fine sand, gravelly (up to boulder size) and poorly sorted, very silty, slightly calcareous. Greyish blue to brownish grey clay and loam, very sandy to very silty, gravelly. Dark grey to dark brown silty clay, stiff, laminated.rs.

Urk Formation
Grey to yellowish brown, fine to very coarse sand, slightly to very gravelly, slightly micaceous, non-calcareous (in ice-pushed ridges) to calcareous, with plant remains (including wood), with augite and abundant pink minerals.. Subordinate clay layers, very sandy or silty and locally organic. Fine to very coarse gravel characterised by grey, brown, green and red sandstones and white quartz.

Peelo Formation
Light grey, yellowish grey and brownish grey very fine to very coarse sand, micaceous, slightly calcareous, with subordinate gravel layers (lags) and dropstones. Grey to black or brownish black clay, (very) firm, silty or sandy, commonly calcareous, with local shells.

Fig. 100
Street Section of design area

Street Section of design area after interventions

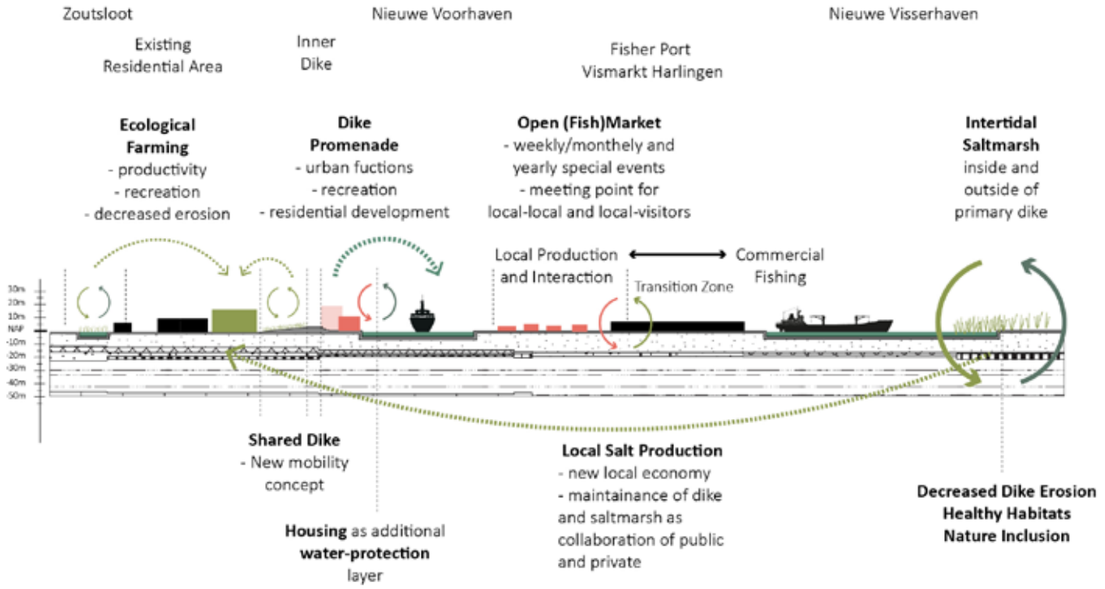


Fig. 101
Street Section of design area with interventions

Master Plan of the design area

The proposal for the new strategy is next to the strengthening dike, adding salt marsh development on the inside and outside of the primary and secondary dike. This nature-based system helps to decrease dike erosion and creates healthy areas for new habitats. It also provides nature's inclusion. Next to this, opening a new fish market is one of the strategies as well. The activities of the port help to give dynamics to the market area for a new concept. In this regard, weekly or monthly special events can be organized. In this way, it can be one of the main attraction points for local visitors around the cities. Adding the function to the secondary dike could also be a good transition zone to the city center and port area. This promenade area can provide a nice vista for those who want to explore the new concepts. The one that we proposed for the intertidal area as a salt marsh product can be used as salt in the streets of Zousloot, which was used to salt the streets during the 19th century, and it provides a reactivation of that street. In the city center, the proposal for the new housing system can also use a water protection layer, which helps the city against flooding.

Fig. 102
Proposal Plan for design area

Vision 2030 for Harlingen

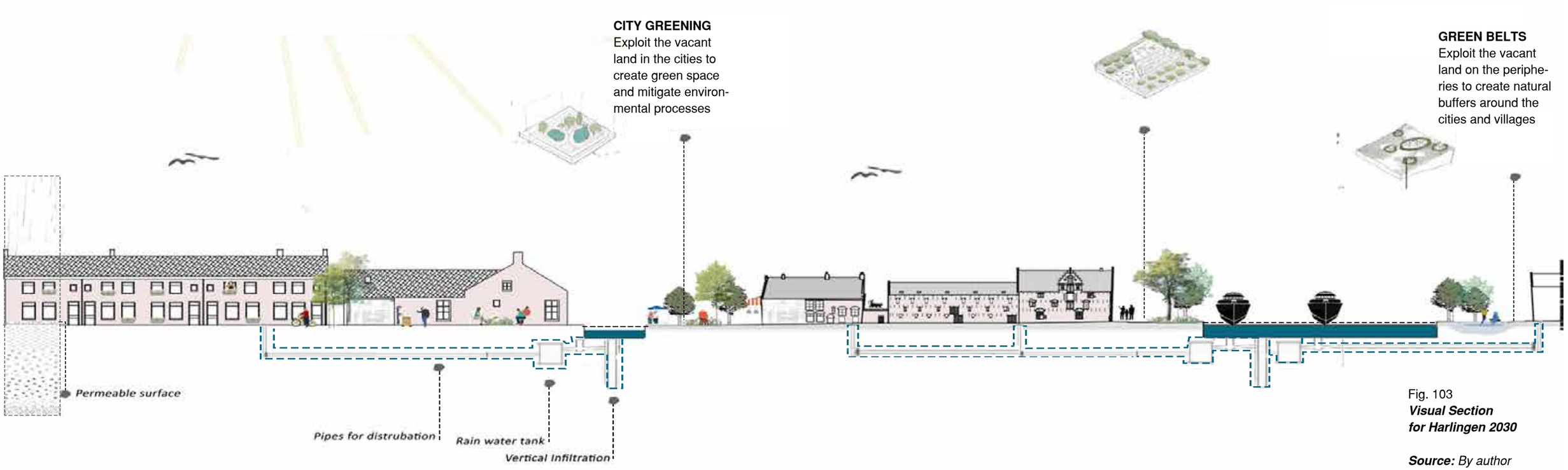


Fig. 103
Visual Section for Harlingen 2030

Source: *By author*

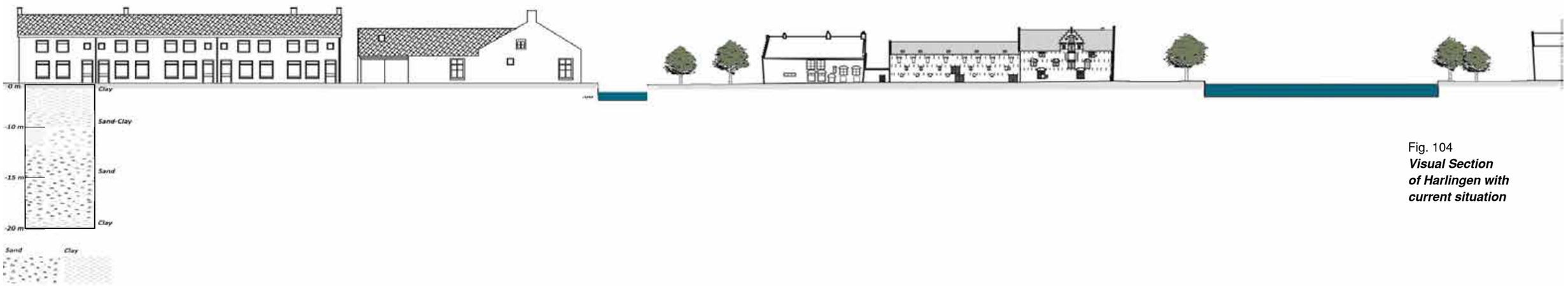


Fig. 104
Visual Section of Harlingen with current situation

Housing Strategies

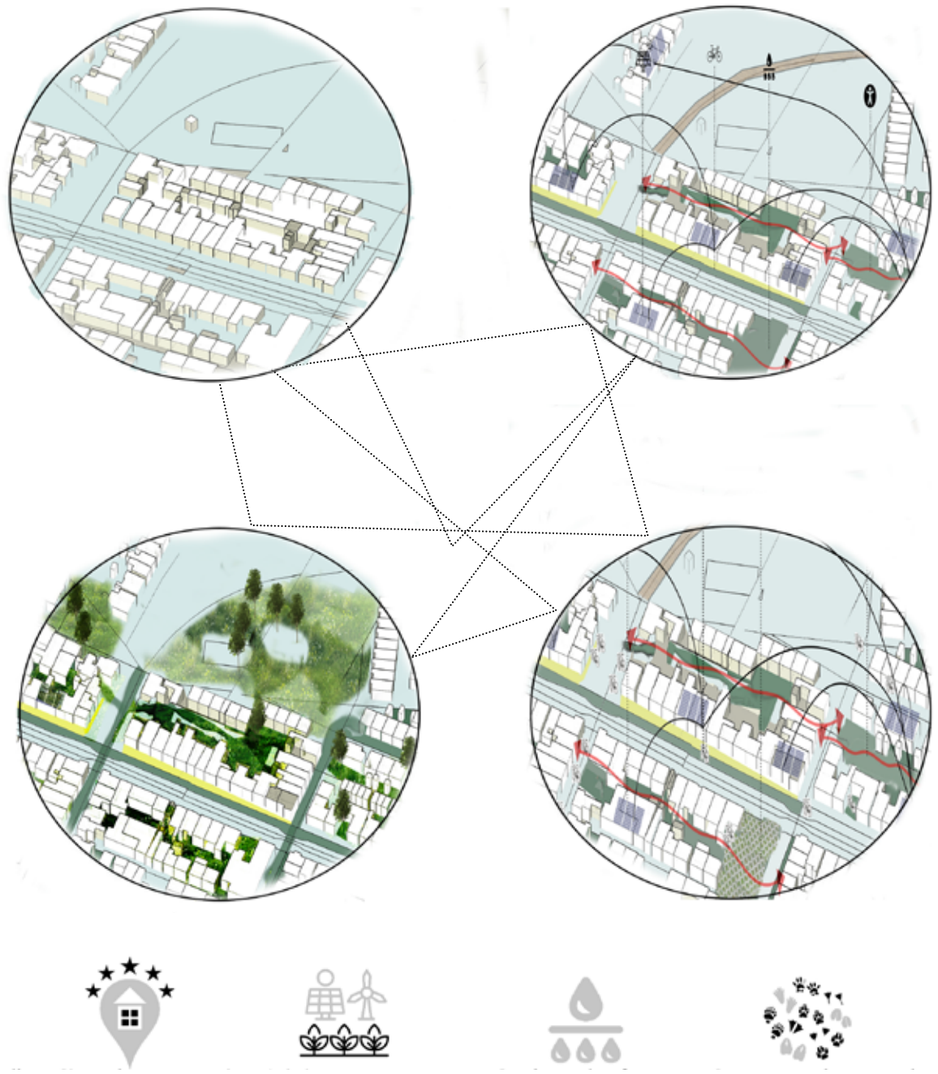


Fig. 105
Proposal for new housing typologies

The area is excellent carriers for recreational facilities and an attractive slow-traffic infrastructure and can promote the use of bicycles, which saves energy and reduces CO_2 emissions.

Since the construction of the first public parks, urban planners have become aware that greenery improves the quality of life for city dwellers. Green areas are places where people can recreate and exercise. This benefits their health and lowers the stress level of the city dweller.

It is important to properly insulate a house in order to minimize the heat demand. The use of sustainable energy sources, such as solar collectors and PV cells, heat recovery from shower water and the use of ambient heat is an important second step.

On the scale of a neighborhood and the street, there are many starting points for a more climate-proof approach. The basic principle here is the local retention of rainwater. This can be achieved through less paving, the construction of green roofs or infiltration of water.

Contrary to the general idea, the city offers opportunities for many species of flora and fauna. This can be further improved by the development of green-blue structures and the more optimal use of the many surfaces of the city as a substrate for vegetation such as roofs and parks.

Terminal Strategies

Fig. 106
Sketches for terminal proposals

New Harlingen

This terminal strategy is proposed for reactivating the area with the local open markets and creating an attraction point from the city center through the garage area. This part also had a secondary dike, which is a promenade also provided to explore the whole area at a high level. Generally, this area is one of the most important parts of the city because of the waterfront.

The waterfronts connect the cities and the seaside with each other and create harmony with them. These areas also have a high effect on people who want to spend their lives at the seaside. Creating a green-blue network next to the waterfront helps people explore and enjoy their time.

Fig. 107
New proposal for Harlingen 2030

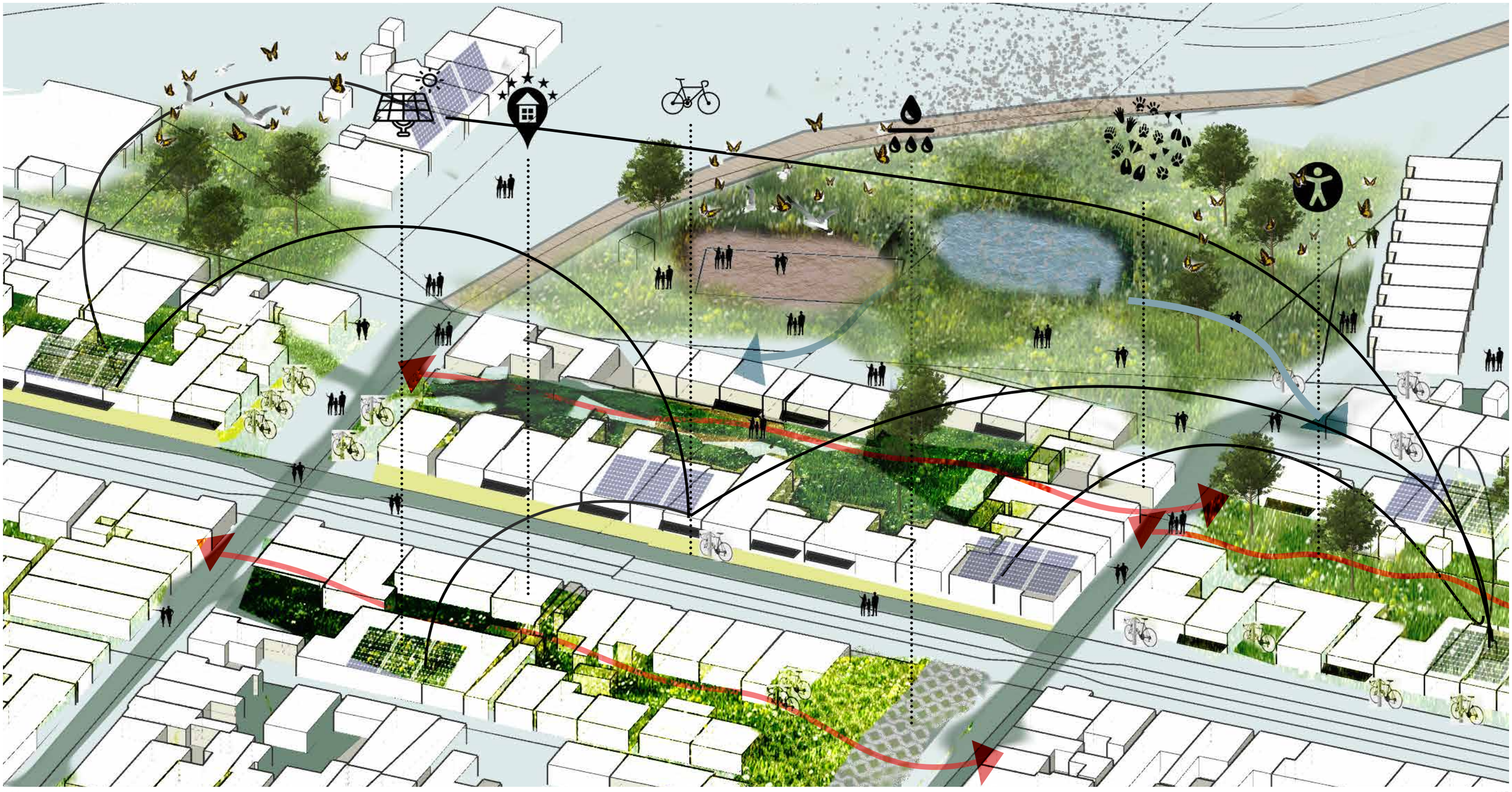


Fig. 107
Wadden Sea
with stone man

03 CONCLUSION

Currently, global warming is becoming increasingly important. Accordingly, the flood risks experienced also affect coastal cities more specifically. The Netherlands, which is one of the countries with an important coastal area in Europe, especially the flood defense system, which forms the coasts of the Wadden Sea, has an important place in the coastal areas, while at the same time it has a large place in the whole country. Although this importance gives a different aspect to urban design and regional planning, it also responds to negative effects such as sea-level rise caused by global warming and an increase in annual rainfall rates. Considering these negative factors from an economic point of view, they also cause great damage to cities. These coastal cities, especially the cities on the Wadden sea coast, are leading to a decrease in the population (shrinkage). In addition, only the solutions based on engineering that contribute to this have separated cities and society from each other. This phenomenon has allowed me to analyze the sea-land and human relations again and at the same time, it helped me to deal with these relations in a single way by mounting nature-based solutions in these areas and integrating them with the flood defense system. This pioneered the first research part of my thesis.

In the first part of my thesis, While doing research, I divided this part into three main parts; one of them is shrinkage risk, the other is a flood risk, and the solution is nature-based solutions. During researching them, I realized that the coastal zones are a transition zone, that is, the section from the sea to the land, and in case of any risk, both the sea and the land are separated from each other. First, I concluded that the flood defense system should be integrated into all three areas, rather than just being in the form of a single line and losing its integrity. While thinking of this as a method to bring back the lost population of the city and increase its dynamism of the city, I also thought that it could be a solution against the advancing sea level rise by using nature-based solutions.

In the second part of my thesis, these results mentioned above have allowed me to draw a clear path in terms of the design part. Generally, this risk can be defined as probability and consequences. the main goal is to consolidate the flood defense system on the shore, which is currently in the water, and reduce it at the first moment it should be. However, this time has led me to nature-based solutions from an engineering solution that has been tried in previous years. This method was both a cost-effective method and its probability was reduced by building with natural techniques. At the same time, innovations made in the city have reduced the consequences of risks, for example, by changing the typology of new buildings and adding new solutions based on nature. The innovations made in these two parts can be considered together to overcome the risks that may be experienced in the future and provide a dynamic infrastructure for new areas.

Lastly, the aim of this project is also to raise public awareness about the risks that will occur in the future and to involve the public in this process. for example, flooding risks works carried out on buildings. The area selected as the design area is the most affected part of the region both in terms of flood risks and in terms of shrinkage. In addition, due to both the economic advantages and the more developed transportation, the people turned to other cities. That is why the project proposed in this area of design was proposed not only to eliminate the consequences that have arisen or will arise due to global change but also to the way of life of the city socially. Thanks to urban transformation, both the quality of life of people has increased and their relationship with the public spaces has improved. The idea of the salt marsh development proposed and eco-farm ideas, which were added at the same time, allowed people to draw attention to this area again. These changes and innovations can be easily integrated into areas with the same risks.

Overall, This project has been looking for an answer to the question of how we can implement flood defense nature-based solutions in urban areas with shrinkage issues. As a result of the conducted literature research, the most important part achieved is the redefinition of the transition zone between the city and the sea and the integration of the flood defense system in place of the cities. The redefined flood defense system can be integrated into the city more than before, but it is also a system that is more compatible with nature and ecology and has more public values. It also reduces future risks with its multi-layer safety approaches. for example, the proposed salt marsh development creates the basis for new habitats on the coast, while the green-blue strategy, on the other hand, allows the creation of new large green areas in the city. Coastal cities have important economic and social values that need Nature-Based Solutions to reconsider nature benefits as well as urban and public benefits. Moreover, The project not only aiming the multifunctionality of each intervention itself but also tries to think larger ones about the benefits and impacts of combining a variety of interventions. The big parking area located in the city has been redesigned and contributed to the holistic ecosystem. In this case, some scattered spaces in the urban areas are made used and linked to each other.

The methods used in the research and design process, for example, gis mapping, and the analysis allowed us to understand the needs and basic problems in the region. The scientific articles found next to this have allowed us to predict the possible projections that may occur in the future. The historical development and building typologies derived from the history of the region allowed us to further understand the urbanization policy of the city and to continue future designs on this path.

Suggestions for Future Studies

The studies carried out so far and the results reached have been made in local areas. although the design is planned on up to three main scales, which are the city center, the city itself, and the local area, these approaches discussed in the project should also be applied to different regions. The applied strategies can be applied in different areas of the region by rearranging them into different concepts. This project was focused on how to reduce the risk more and how much nature can be integrated into the city, and the relationship between the humans - the city, and nature was considered.

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REDESIGNING FLOODSCAPES

» For the great does not happen through impulse alone,
and is succession of little things that are brought together. «

VINCENT VAN GOGH