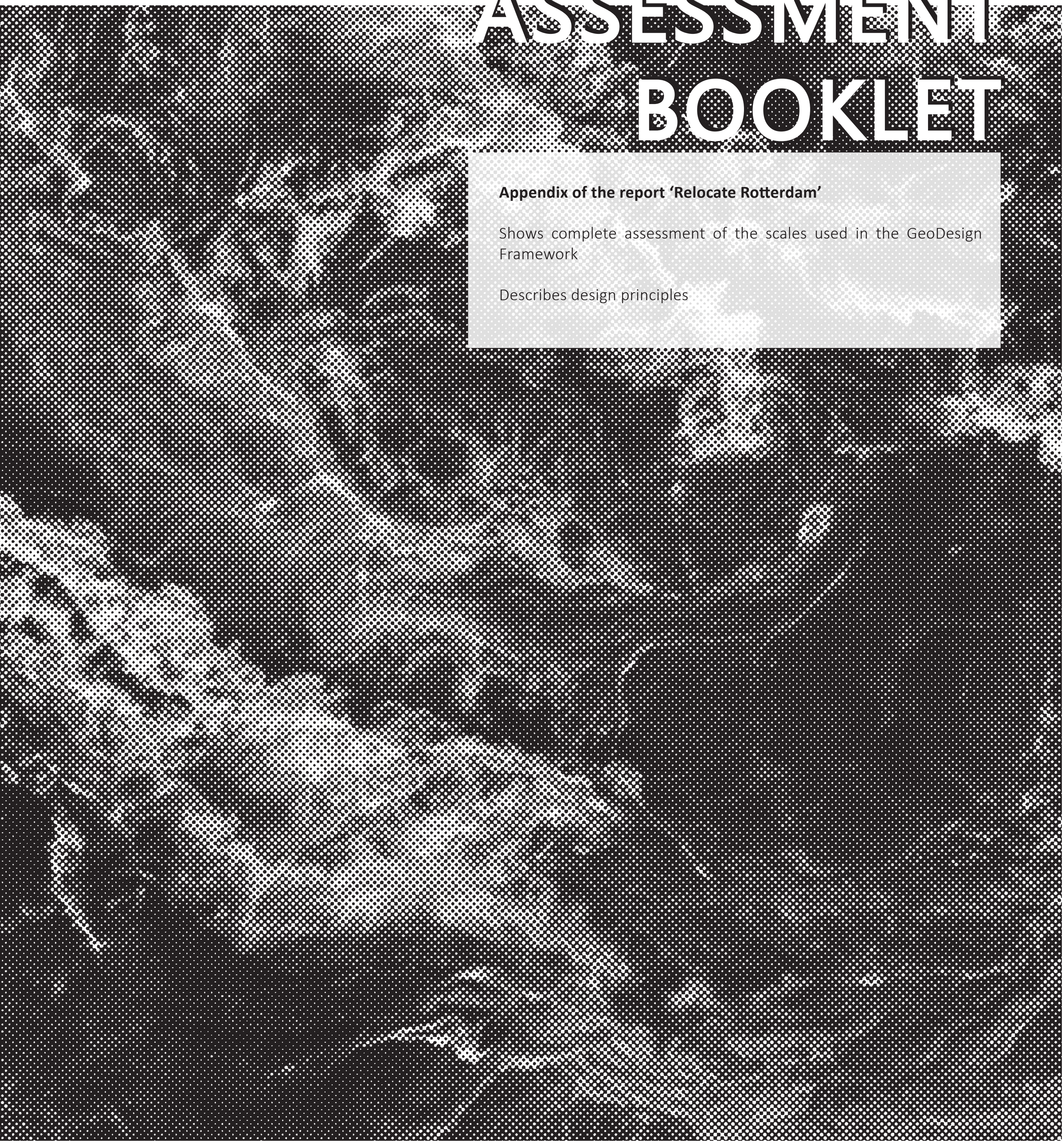
ASSESSMENT BOOKLET



Appendix of the report 'Relocate Rotterdam'

Shows complete assessment of the scales used in the GeoDesign Framework

Describes design principles

// Analysis booklet

This booklet provides extra information on the analysis that was done fore the graduation project *Relocate Rotterdam.* The Analysis follows the same structure as the GeoDesign chapter of the research (see Figure 1) :

- National scale
- Regional scale
- City scale
- Neighborhood scale
- Street scale

The first three steps of the GeoDesign model will be used for the assessment since this focuses on *the world as it is.*

The world as it is:
-Data inventory : How can the geography of the specific scale be described?
-Process models: How does the system currently work?
-Capability/sustainable models: Is the current system working well. Taking future changes into account?

So these three steps of the world as it is will be described for all the scales. Per step, the assessment looks at the physical, the social and the mental component of the scale.

This means that per scale, 3 steps will be described and per step 3 components.

For every scale there is a conclusion of the assessment. Design principles will be derived from this that form input for the Design phase; the world as it could be.

Figure 1| The scales of analysis and the steps in each of the scales. On the City, neighborhood and street scale 3 components get discussed: the physical, the social and the mental city.

//System- Netherlands

Data inventory

Water

The geography of the position of Netherlands in relation to flood risk can be described best in terms of water bodies. With the North Sea on the west side of the country and in the Delta of three major rivers Rijn, Maas and Schelde, the Netherlands is framed by water (Figure 2). As the west part of the Netherlands has been swampy area in earlier days large regions have a peat soil. This is a soil build up from old plants that are not completely turned into compost, but are remains of plants. The peat soil is still subsiding, which is one of the reasons that the Netherlands has become so low (Erkens, Van Der Meulen and Middelkoop, 2016) (Figure 5). This results in a 4 direction water flow in the Netherlands, each bringing a part of the future task with them: Rain water, Sea water, River discharge water and ground water.

The scenario of the KNMI show changes on the water systems of the Netherlands. Not only will the sea level rise, also the precipitation levels will change. The scenario of KNMI 2014 show a range of 50 to 120 centimeters in sea level rise for the year 2100. In 2017 this number has increased drastically to the scope up to 300 centimeters (Figure 9, report)). There are even more factors that make the expectations more uncertain, such as the geoide of the earth that shows that the average sea level rise could differ locally (IPCC,2014) (Figure 4).
Another factor that increases the uncertainty is the changing position of the tectonic plates, that turn downwards in the west of the Netherlands and erode in the east. This process takes a lot of time, but can increase the uncertainty of the land level as well (Figure 3).

Within the Netherlands the used scale to measure water level is NAP (Normaal Amsterdams Peil). The climate prediction of sea level rise is expressed in a deviation of the average water level. On global scale there is an average sea level, which means that it does not take currents, tides and wave heights into account. However, in reality these factors always influence the water level. In 1992 the average year level of the sea was for the first time higher than NAP. The figure shows the yearly average in centimeters related to NAP. It shows that the sea level is currently above NAP, so the level the Dutch relate to is even below sea level (Figure 6).

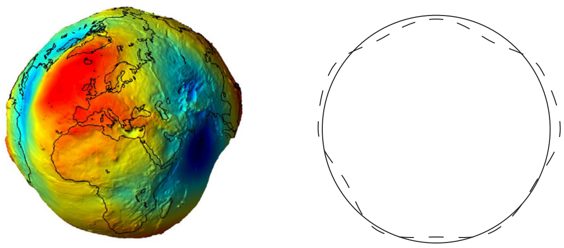


Figure 4| The earth as a geoide shows that sea level rise would not mean the same everywhere on earth. Due to changes in gravity (left image) the local sea level can vary (right image). Source www.sron.nl/ (left) and by author (right)

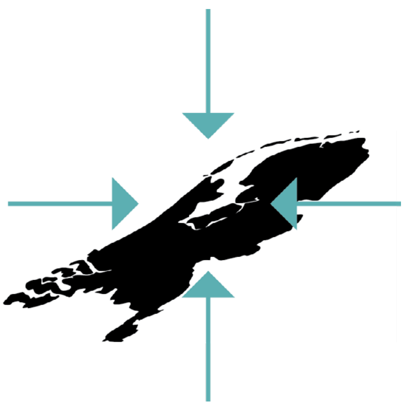


Figure 2| The geographic position of Netherlands as a Delta country framed by the North Sea and the rivers Scheldt, Rhine and Meuse. (Image by author).

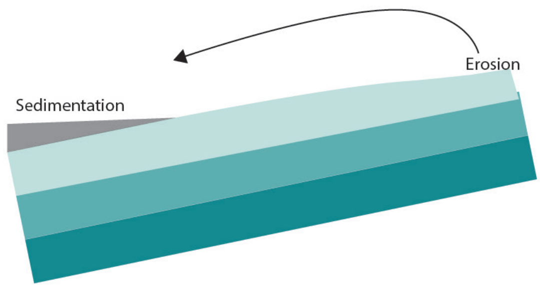


Figure 3| The tectonic plates flip and cause the western part of the Netherlands to go down,while the east part goes up. The lower part is higher because of sediment, (but this process does not take place in polders). (image by author)

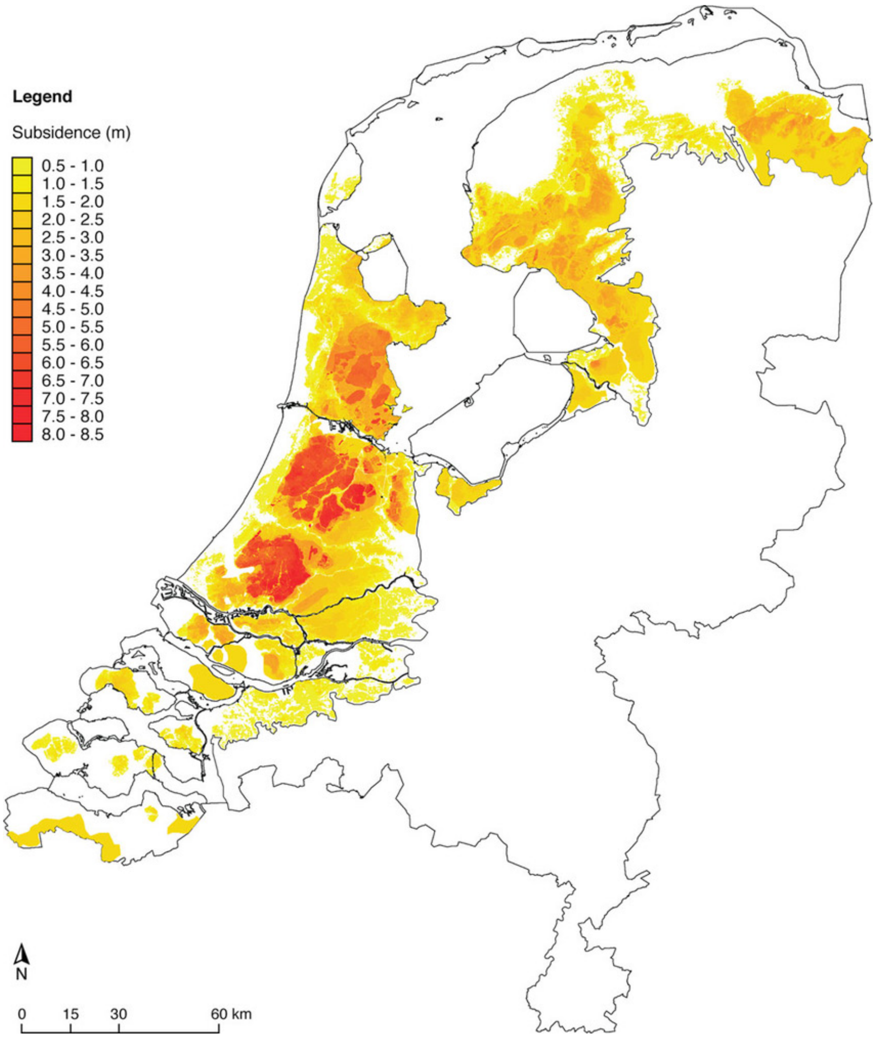


Figure 5| The Netherlands and the areas in it affected by ground subsidence. Some parts have sunk already over 8 meter since the year 1000. ((Erkens, Van Der Meulen and Middelkoop, 2016), p.13)

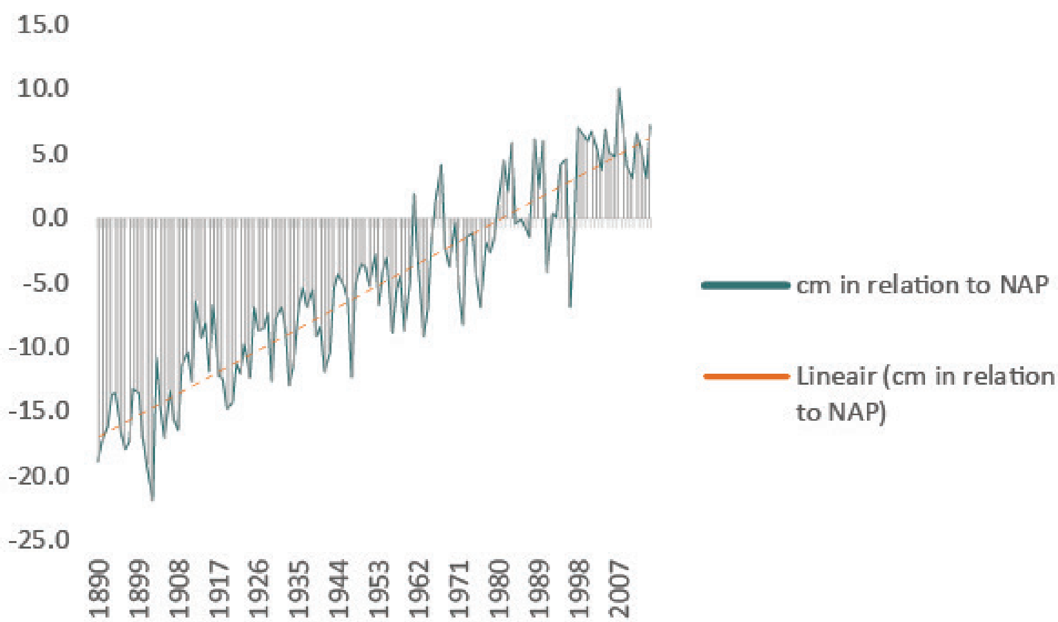


Figure 6| This figure shows the level of the sea compared (in cm) to the NAP level. In 1992 the average year level of the sea was for the first time above the NAP. This means that the level the Dutch relate to is even below sea level (image by author, raw data by RWS; PSMSL.).

Society
Upon this sinking land that is framed by water at most sides the economic and social center of the Netherlands, the Randstad, is build, as described in the problem fields as well. The predicted growth of inhabitants in this region (see page 22 and 23) and of the economic value puts more stress on looking for changes for the future.

Risk management
The Netherlands use a multi-layered safety approach, consisting of three layers: (Figure 7)

- Layer 1: Primary prevention, dyke improvement
- Layer 2: spatial planning
- Layer 3: evacuation

The first layer is very detailed and also gets maintained continuously. Even though the defense systems do not always meet their norm, this layer is the most emphasized one. On spatial planning there are zoning plans on a very large scale (rijk or province). The water boards and municipality need to align their plans with for example the plans stated in MIRT (Long term infrastructure plan). The Deltaplan Spatial Planning is still acting on a large scale and is not leading to interventions in order to reduce the water stress that are taking the risk into account. The urge for municipalities to check what they can do in their spatial interventions is only set in a legal statement that municipalities need to ask the water board what water task has to be solved in a specific zone. This 'Watertoets" is regulated by the Spatial Planning Decree (Jong & Hobma, 2011).

Process models:

Water
Currently the water system works in a way that it can deal with several extreme storms. As described in the problem field the norms of the water defense systems are based on the consequences a flood would have. So per dyke ring a certain norm is set that the defense systems need to meet, based on a combination of extremes that would be possible per time span. The example listed before shows that a 1/250-year norm dyke needs to be able to protect the hinterland to the combination of the highest tide and wave height that have a chance of existence every once in 250 years. Looking to the components that together form the amount of risk, reducing the consequences has not been the main focus of the risk reduction. As the problem statement states; the high protection level against floods has resulted in less attention to reduce the vulnerability of a region. A check up on the dyke system showed that " 22% of the civil engineering works did not meet these standards whereas 49% of these works could not be assessed."(Deltacomissie,2008).

Risk management
The multilevel approach should focus on several aspects in order to reduce the risk. However in reality the main focus of the plans that have been realized so far are on level 1 ((van Sprundel, 2017),Appendix 2). Even when there is a special emphasize on using spatial planning as the leading option in a risk reduce plan, the conventional prevention interventions are chosen.

Capability/sustainability models:

Water
Trends such as sea level rise, higher precipitation, more intense precipitation and urbanization will only worsen the situation by increasing the vulnerability of the area, there needs to be made a change in the way the layers are functioning right now. To have a more specific view on these layers, a zoom in to the next scale will help. The area will zoom in to the Randstad area, being the socio-economic center of the country.

Society
There is a worldwide trend of moving towards cities. Since 3 out of 4 large cities in the Netherlands are positioned in the Randstad area the effects of a flood will only grow if the amount of people in this region grows.

Risk management
The system of multi-layered safety must be complied better to work in a sustainable way. For now the focus is a lot on prevention. If the more extreme scenarios of the KNMI will become reality, the focus on prevention will not keep the Netherlands safe in the long term (Appendix 2).

Figure 7| Scheme of the Multi layered safety approach in the Netherlands. The first layer is focused on prevention or dyke improvement. The second layer focuses on spatial planning and the contribution it could have in terms of risk. The third layer is about evacuation: if the first layer and the second layer do not prevent an area from flooding, it is best t have clear evacuation and safe spots. (Source: (Ministerie van Verkeer en Waterstaat, Ministerie van Infrastructuur en Milieu and Ministerie van Landbouw Natuur en Voedselkwaliteit, 2009,2009), p.15)

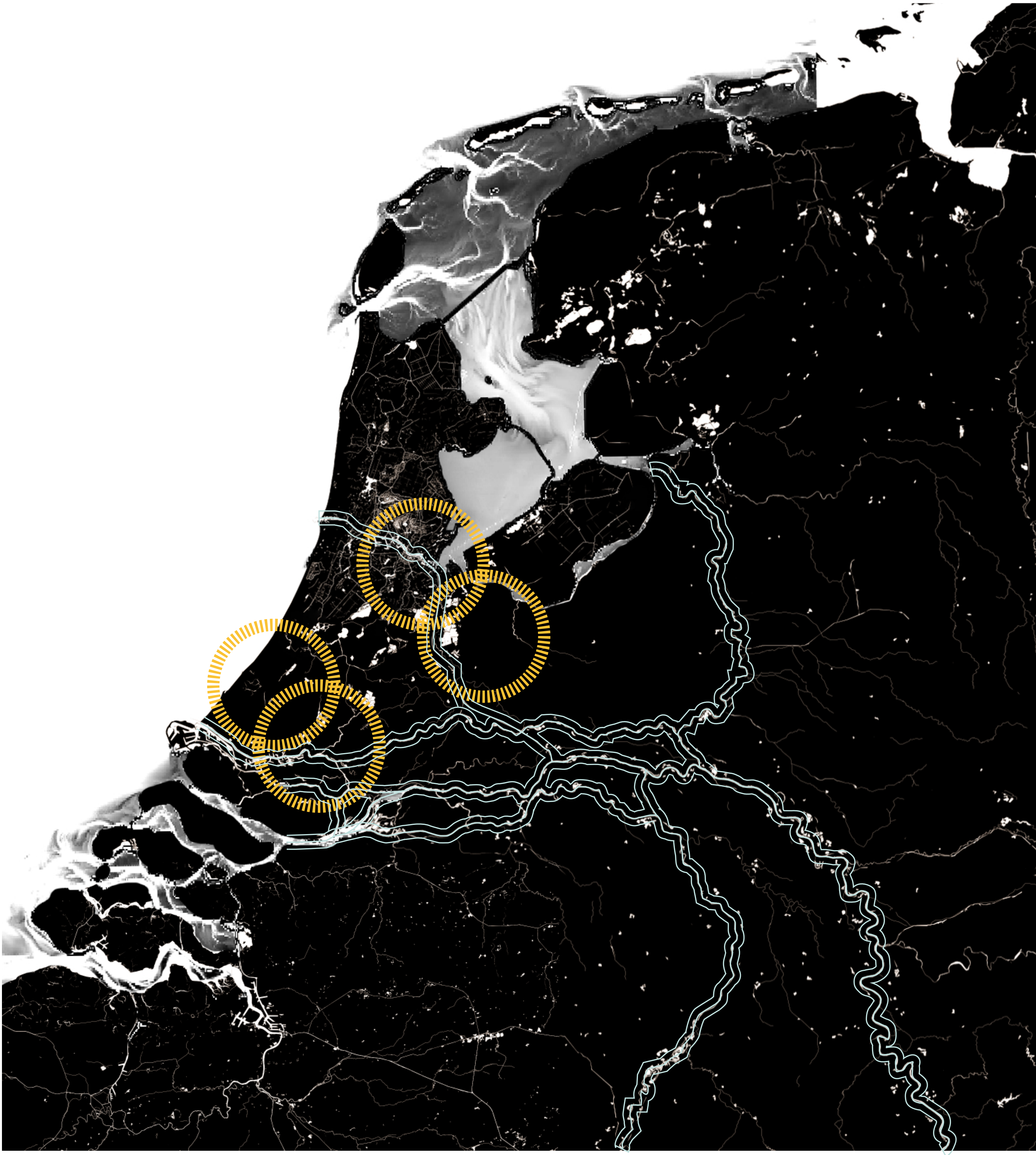


Figure 8| The Randstad as cluster of four cities, positioned in the Delta of the Netherlands.

// Design properties- system scale

The system scale shows the unilateral approach that the current risk management in the Netherlands has. The country has blocked out the natural system of erosion and sedimentation in order to protect the land. The pumping and peat extrusion result in extra land subsidence. How long do we continue heighten up the dykes? The important role the Randstad plays for the society combined with the rising water threat results in the urge to find a new system that approaches risk differently but enhances the qualities the delta has.

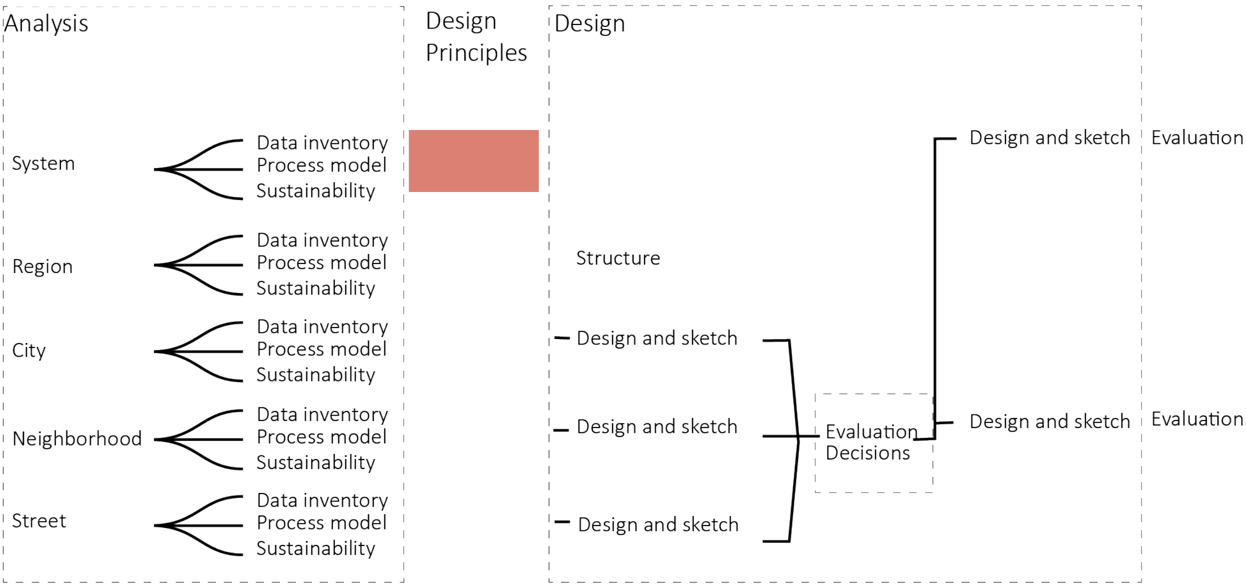


Figure 9| The scheme of the analytical framework and where we are now: The design principles of the system scale. Image by author

// Qualities//

//Enhancing Multi-level safety approach//
Emphasize on spatial planning and evacuation level as well.

//Keep being innovative in water engineering//
Find ways to deal with the water problems of the future

//Using the water we have in the delta//
Make use of the leisure qualities and transport options of water.

// Changes//

//Making use of the sediment of the river//
The dykes prevent for heightening up the hinterland, so subsidence and tectonic plate changes are cannot be corrected. The low lands could benefit of its position in the Delta.

//Preparing for the consequences of climate change//
Increased river discharge
Extreme precipitation
Drought
Sea level rise

//Investing in the higher grounds //
Accepting that parts of the Netherlands are below sea level could lead to discovering centralities in the country.

//Region-Randstad

Data inventory

The selection of the area is based on the administrative boundary of the water boards. The water boards have a history that go way back and are still responsible for the management of water on the regional scale (water quality, water defense) and a close connection to the municipalities about spatial planning (Figure 11). Since the project aims on changing the structure of the Randstad to reduce risk, this regulatory boundary seems a logical one. The water boards that are together covering the dyke ring that contains the most economic and social value (dyke ring 14) are Delfland, Schieland en Krimpenerwaard, De Stichtse Rijnlanden, Hollandse Delta, Amstelen Gooi en Vecht and Rijnland (Figure 12).

As described in the methods different data layers will be combined in clusters. The clusters are based on two scales of information: the suitability for settlements to be at a geolocation(1) and the suitability for densification(2) (Figure 10). In this way no-go areas can be distinguished that are highly exposed to flood risk, assigned to relocate. Areas that are suitable for more inhabitants can be assigned to be densification zones. This way of defining suitability for planning through the combination of physical and cultural characteristics of land has been developed by Ian McHarg already in the 1960s. This concept embraces that there is an intrinsic vulnerability that can help to optimize the greatest benefits of an area and minimizes the cost to the society and the environment (Wagner, Merson and Wentz, 2016).

There are different layers important per suitability map. The suitability map that shows the suitability of the land for settlement (1) could be also described as a risk map (only in terms of probability). This map focuses on the substratum layers, layers that are hard to change. In the case of flood risk there are two layers that of high importance: evidently the height layer, showing areas that are more exposed as a result that they are below sea level. The second important layer is the soil type because of the relation the soil type has to height. Peat soil leads to ground subsidence, as the peat is easy to compress and therefore unstable. In the Netherlands the peat layers can reach up to 20 m resulting in a large amount of subsidence per year, varying from the average 1,9mm/year of the past 1000 years to the estimated 2-25 mm/year in the current situation (Erkens, Van Der Meulen and Middelkoop, 2016). Areas that consist out of peat are thus unsuitable for housing, since they will keep subsiding in the future and will only increase the depth of the area.
In the suitability map that is to assign densification zones, the focus is mostly on the facilities and critical infrastructure that are needed for urbanization. On the next pages the layers that are taken into account in the suitability and risk map are described. These pages also function as legends to the maps in this paragraph.

In the suitability maps there are made several groups of the aspect shown in the map. The aspects are then visualized in a special color representing a certain suitability, in this case the suitability for densification. As it is important for the final suitability map to overlay all the features that influence the suitability of an area, in the following page it the features and whether they are suitable or not will first be explained. Each theme map is therefore translated to a black and white map, where black represents less suitable locations and white represents more suitable locations. These maps will be discussed in order of aspects that are 'given', or really difficult to adapt towards aspect that could be adapted less difficult.

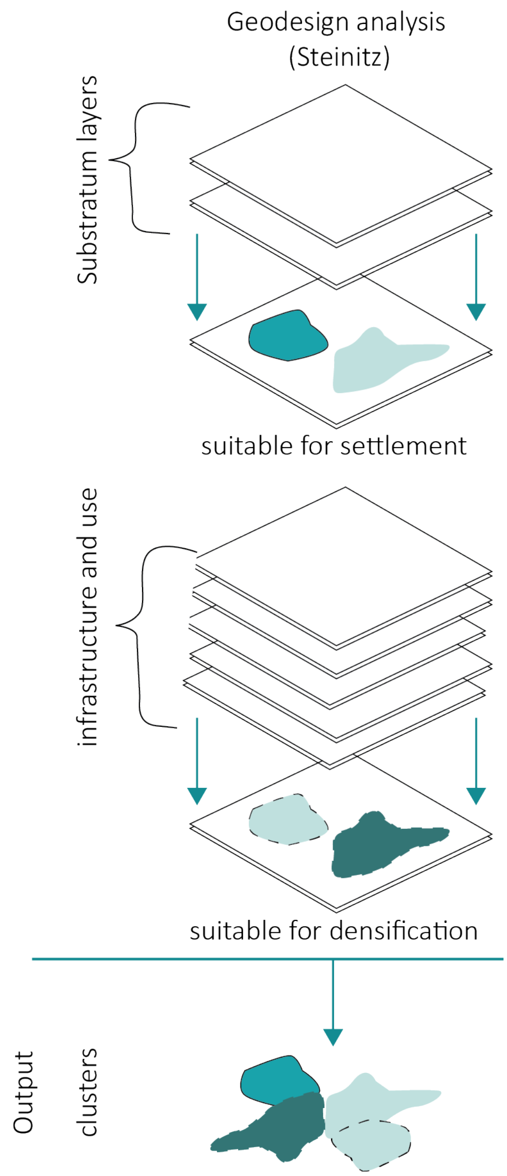


Figure 10| The Layers in overlay will together deliver suitability maps.

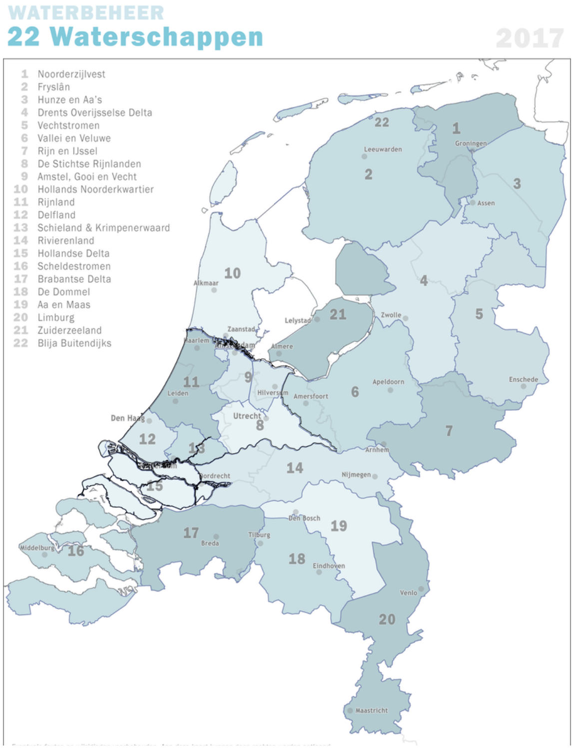


Figure 12| The water boards of the Netherlands, they are responsible for the regional water management, quality and defense and work closely together with the municipalities. (Image Janwillemvanaarst)

National Government (Rijk)	Province	Municipality	Rijkswaterstaat	Waterboard
Policies regulations Supervising that these are being respected	Spatial Planning (general) Nature Recreation Regional infrastructure Toerism public transport Supervising waterboard + municipality	Governance closest to citizen. Public safety citizen registration education spatial planning (specific) infrastructure culture	Management of water: national water defense management nationalwater quality	Management of water: regional water defense management surface water management water quality water infrastructure Close relation to spatial planning and infrastructure, so tight relation with spatial planning.
Water Specific: Safety norms Primairy water defense system	Water specific: Translation national guidelines to regional approach Quality of ground water	Water specific: Ground water in urban area. Storm water management		

Figure 11| The administrative groups and their tasks. The Water board is an interesting administrative border, as it deals with water and has a close connection to the municipality and province about spatial planning. This is the reason why the location is shaped by a group of water boards. (Image by author)

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Soil-

The soil map of the Netherlands could be roughly brought back to 3 groups: the sandy grounds, the peat grounds and the clay grounds. The characteristics of these soils are defined by the shape of the parts they are made of.

Peat is basically just old vegetation with water, resulting in the fact that it is very easy to compress and does not have a lot of carrying capacity. As the peat soil is subsiding, it is not suited at all for densification. At the one had because it enlarges the gap between ground level and sea level, at the other because unstable grounds are not preferred building upon. In the selected area the grounds have been subsiding between 0 to 8 meters in the past 1000 years. The current rate is varying between 2-25 mm per year (Erkens, Van Der Meulen, & Middelkoop, 2016). In the west the buildup area op peat have foundation piles that reach until the sandy grounds. The public area in for example Vlaardingen is supplemented with a layer of sand that spreads the load, but needs to be heightened up every once in a while as the buildings do not subside as the unfounded public area.

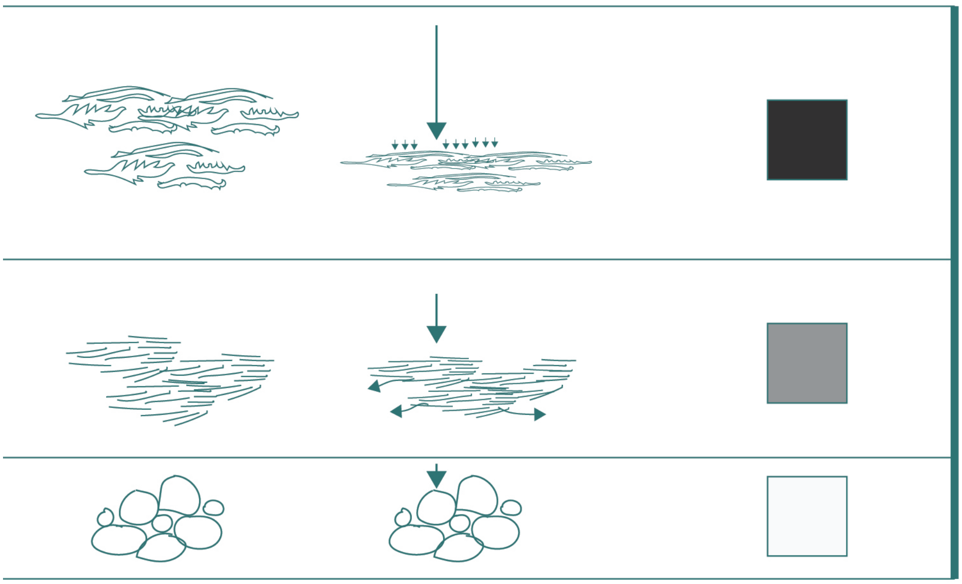
Clay has a medium carrying capacity and is therefore more suitable for urbanization then peat. However when there is a heavy load on the clay ground for a long time, the water parts between the clay parts is pushed out, which results in deformations and therefore unstable ground. The parts in clay have a plate shape with water in between(0,0002mm). Clay is not easy permeable for water, so this could have a negative effect when there is a lot of precipitation. So even though the soil is more appropriate for building, it is not even close to the suitability of sand.

Sand has a large carrying capacity due to the small round parts it is formed of (0,06mm). Because these small parts are round, there are a lot of small gaps that make sand permeable. If there would be larger holes the sand could deform when there is a lot of pressure. Therefore the sand is often shaked and pressured before they build upon it. After this it is very stable to build upon.

Height-

Another aspect that is relatively set information is the height profile of the area. Although in the Netherlands height is a factor that has been quite often manipulated altering water tables or adding sand, the factor height is not easy to manipulate and assumed to be a set value in the process of exploring whether land is suited for densification or not (Erkens et al., 2016). Within the selected area the height varies from-6,74 NAP to 69,2 NAP. The height has the biggest influence on the risk of flooding of an area, together with the safety norms. In the suitability map there is made a division in 5 classes. These classes show besides if the area is suitable for densification also what areas should be relocated or restructured first.

<-4 m NAP	The class below that lies below minus 4 meters NAP, consists mostly reclaimed land of old peat areas that have been excavated in order to extract the peat.
-4 to 0 m NAP	Not suitable,
0,01 to 3 m NAP	could be used now, but not suitable taken the sea level rise into account
3,01 to 6 m NAP	suitable now, but need attention in the future
>6m NAP	suitable



Infrastructure layers are somewhat less immovable then the factors described above. Infrastructure layers consist of a connected system of lines and/or nodes.

Transport-
infrastructure deals with the connectivity of an area and is shown in both highway accessibility and train stations and tracks. As transport is beneficial for densification, the areas with a proximity to the infrastructure are marked white. For the train the steps are 0-500m ; 500-3000m; >3000m respectively close; medium ; far. For the highway the steps are: 1 minute ;3 minutes ; 5 minutes ; 10 minutes ;>10 minutes. As a result an overlap of the two.

> 10 minute by car	away from a highway exit by car, less suitable
10 minutes by car	medium suitable
5 minutes by car	suitable
3 minutes by car	suitable
1minute by car	suitable

>3000 m	to traintrack or station , less suitable
500-2999	medium suitable
0- 499	suitable, new stations can be implemented

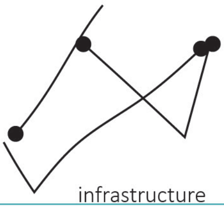
Energy-
Energy infrastructure is a feature of the suitability for densification on the one hand but can also be used in defining what area to protect or relocate as the structure is very dependent. Electricity shows the areas where the high volt lines are placed, shown in white. In case of densification it is positive when the houses can connect to the current system. The locations where gas is distributed is also attractive as the pipelines can be shorter.

no electricity line	Less suitable
electricity line	suitable

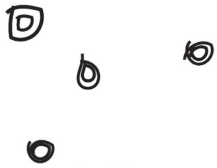
no gas distribution centre	Less suitable
a gas distribution centre	suitable

Communication-
The antenna network of radio and telecommunication is very dense. With almost 14000 antennas in the region, the connection is strong enough every where in the location, so this will not be an important feature in determing suitable areas for densification.

less connection	Less suitable
connection	suitable



infrastructure



facilities

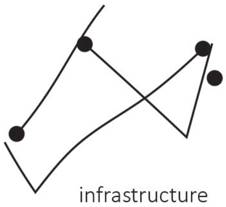
Facilities are the layers that are mostly formed of nodes, in contradiction to the infrastructure layers. They do not necessarily have an interconnection. There is a distinction in key facilities and social facilities. Key facilities are facilities like hospitals, fire brigades. The social facilities like elderly homes or primary schools are more important for defining what areas we should focus on first, when relocating. They define less the suitability for relocating, as they are more easy to be built or replaced.

emergency-
The facilities that are most important to be available already when densification start are emergency posts like hospitals, firebrigades an police station.

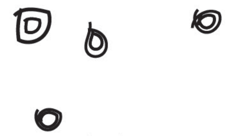
no hospital in 10 km	Less suitable
hospital within 10km	suitable

no firebrigade within 10 km	Less suitable
firbrigade within 10km	suitable

no police station within 10 km	Less suitable
police station within 10km	suitable



infrastructure



facilities

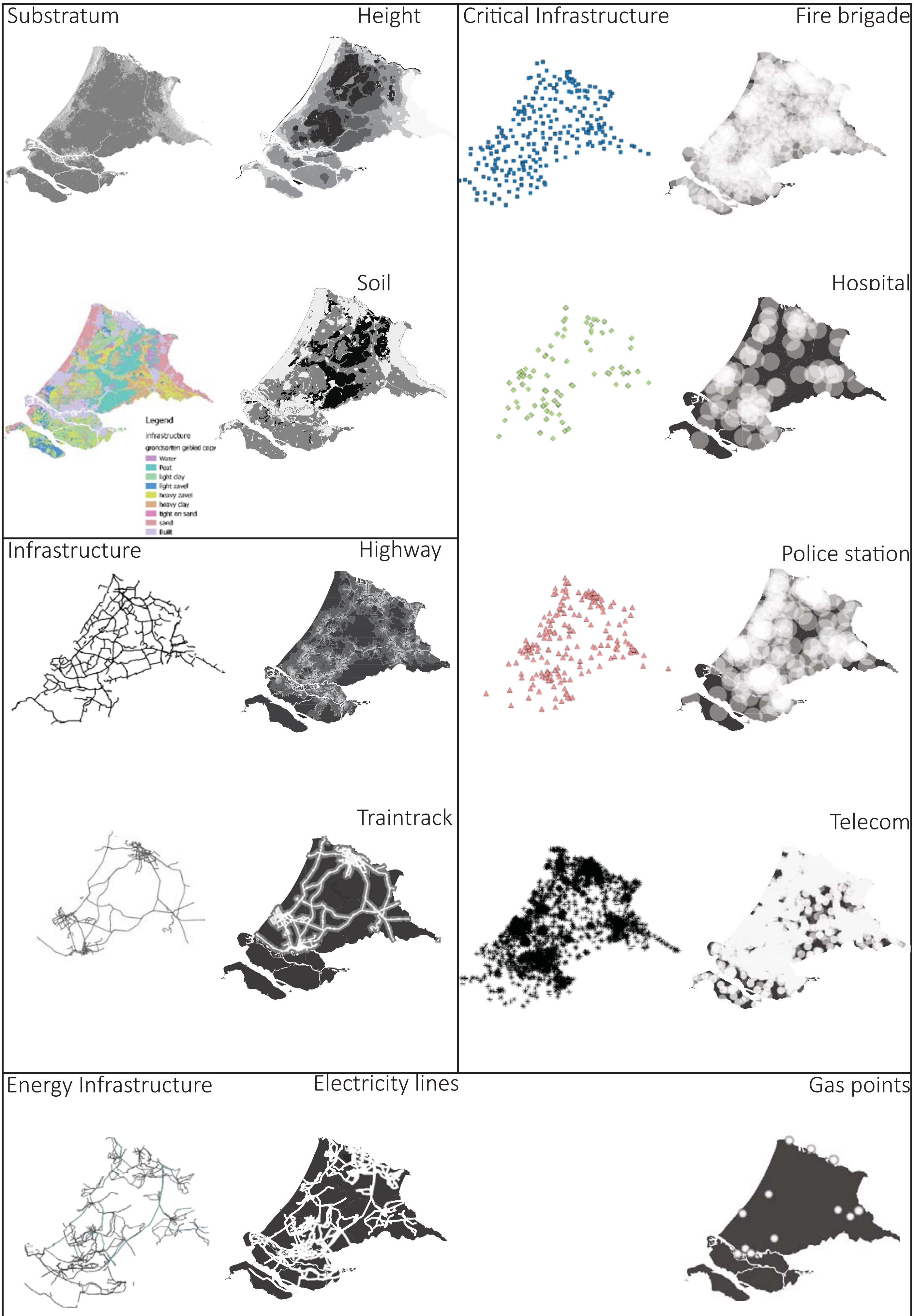


Figure 13 | The translation from theme map to black and white value map that can be used for the suitability overlay.

Suitability for urban settlement- and city outline

To create the map that shows the suitability for urban settlement, the substratum layers 'height' and 'soil type' are combined as explained in the legend of the previous pages. The green area in the map shows the no-go area, a combination of the two least suitable areas in terms of height or soil type. This means the area is either below -4 NAP or its soil consist of peat. If this map is combined with the city shapes it is interesting to see that most of the city centers are outside the no-go area. The expansions and suburbs only grew there after the Dutch were able to control and manipulate the water. The suitability and the no go areas are now determined, but what does this mean? What are the patterns? How many people are actually exposed to extreme risk? How many houses are there in the area's?

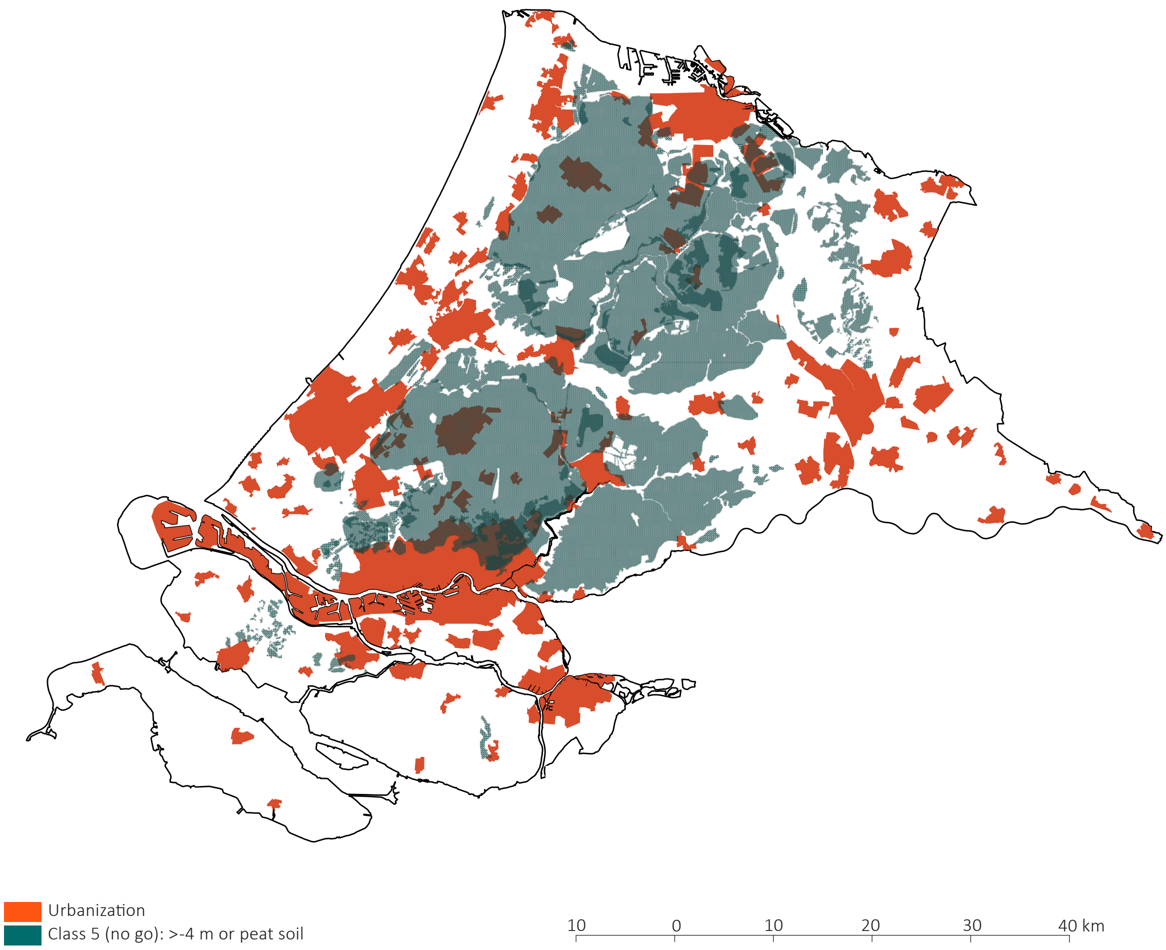


Figure 14 | The image shows the no go area (based on height and soil type and the red areas are cities. It is interesting to see that most of the city centers are actually on better grounds. Zoetermeer and Hoofddorp are large exceptions. Zoetermeer has started to grow in the sixties, so after the Delta Plan has been started, so this could explain the choice to start building there on larger scale. Hoofddorp is a city in one of the reclaimed lake areas (Haarlemmermeer), and is therefore typically a city from after the manipulation phase. In the middle of the image there is a white line that separates the no-go area in the north and the no-go area in the south. This higher line is a result of the sediment the 'Oude Rijn' has placed there for centuries. The ground is therefore more stable and also higher.

Suitability for densification- and city outline

To create the map that shows suitability for densification the layers of critical infrastructure, energy infrastructure and transport are taken into account. The image shows the outlines of cities in combination to the suitability to densify. A logical conclusion is that the city areas are all very suitable for densification, since the city has already a lot of critical infrastructure available for its own inhabitants. A black spot (unsuitable) is visible south east of Amsterdam. This could be explained by the fact that there is a lot of agriculture and lakes, so less facilities. The land is also very wet as is visible by all lakes and ditches. What happens if the two suitability maps get combined?

Figure 15| The image shows the suitability for densification based on the layer in the previous pages. The more suitable, the more white. On top of this suitability layer, the outlines of the city are shown.

Process models:

Currently the relation between the suitability for functions and the risk for flooding is limited to the norm of the defense system, as described in the above. However new development is not regulated per norm zone. This means that when the economic and social value as consequence of a defense system grow, the norm goes up. In other word the probability factor is again lowered instead of the vulnerability. This is where the downwards spiral, explained in the problem field, comes in again(see Figure 9, report). Especially dyke ring 14 has a large surface and contains the most dense urban areas. Outside the dyke ring there are some spatial planning restrictions: since 2008 floodplain areas that are not embanked cannot have development that block the river in the floodplain.

Capability/sustainability models

The data maps and show the amount of people and households that are present in each of the zones. The combination of the two suitability maps show the areas that have a mismatch in terms of land use and the suitability for that land use (Figure 19, Figure 16). If a certain layer is more set it is more difficult to alter it. The substratum layers height and soil type are a datum difficult to change, especially on a larger scale. The main layers that defined the suitability for the land use of living are also hard to change, though easier than the substratum ones. New networks can be built in areas that would be suitable for densification in substratum terms.
Even though the infrastructure layer is also not easy to change, adapting this layer may optimize the benefits and minimize the cost to society and ecology, since the people are now exposed to a high level of risk that is only increasing (ground subsidence, climate change and others). If a flood would occur there will be less casualties and economic loss.
On the region scale of the Randstad the neighborhoods can be classified into four groups (Figure 67).

Group 1 (-+) represents the areas that have a low potential for densification(-) and a low risk (+). These areas are often higher grounds in a rural context and lack the infrastructure required for densification.

Group 2 (--) represents the areas that are unsuitable for densification (-) and have a high risk of flooding (-) as well. These areas are low grounds in rural areas.

Group 3 (++) represents the areas that are suitable for densification and have a favorable position in terms of height. They are urban areas on high grounds.

Group 4 (+-) represents the areas that are suitable for densification (+) but have a high risk of flooding (-).

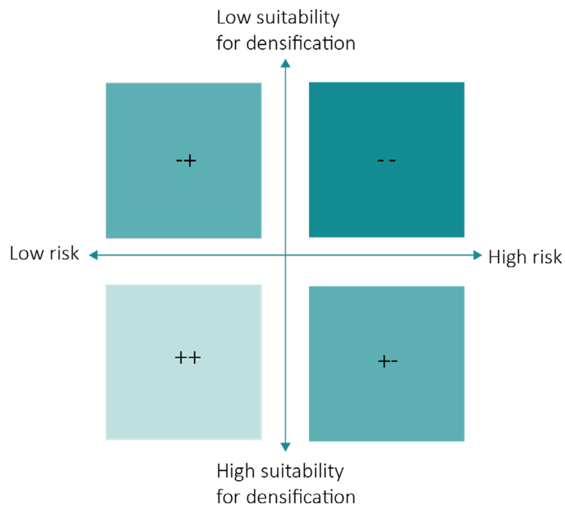


Figure 17| The two suitability layers are combined in the administrative border of the neighborhood These are the quadrants that can be made. Clearly the ++ area is very suitable for densification. The +- and-+ areas are two very different groups, since the-+ can be changed to ++ by making interventions.

These groups all have different potentials and threats if the trends and the scenario of the future are taken into account (Figure 17).
Group one has potential for future development, since the substratum layers can facilitate urban development.

Group two seems to be the most threatful for it has two negative factors in terms of suitability. However, this group is logically seen less vulnerable then group four, since the low suitability for densification can be explained as a low urban function at the moment. In other words, the amount of people living in the group two area is significantly smaller than the amount of people living in group four areas. Group two needs evacuation on the small scale and

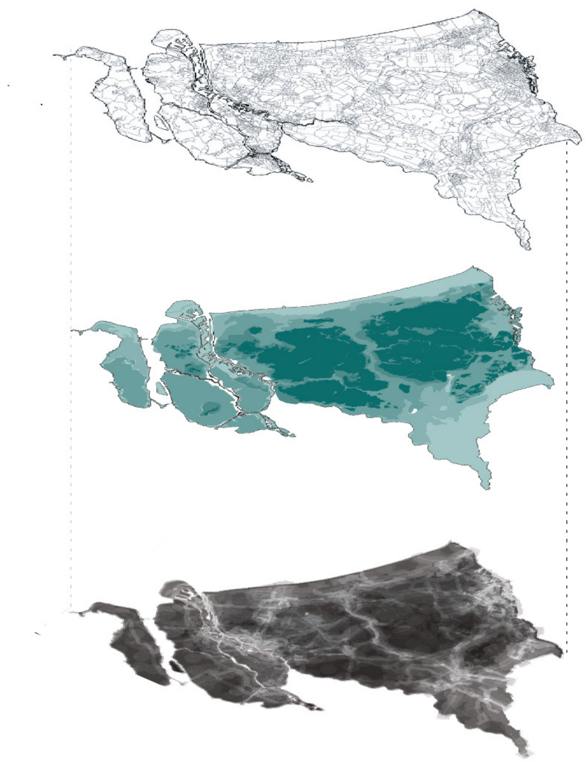


Figure 16| The two suitability layers are combined in the administrative border of the neighborhood (schematic map). In this way there can be made clusters per neighborhood, as in figure 45. (Image by author).

could function as room for the water. Developing a more elaborate evacuation system is one of the key tasks for the neighborhoods in group four.

For group three both layers are positive, therefore densification is the main task for these neighborhoods. The clustering of neighborhoods has been made on a large scale. Per area a more specific analysis is needed to be able to find more specific design goals. The GeoDesign steps of 'the world as it is' are resulting in the option of changing the layers that people have added to the natural landscape in order to benefit most of the intrinsic values of the area and minimize the socio-economic cost.

The neighborhoods that have a large difference in suitability in the two maps are have a mismatch, considering the hypothesis of flooding the lower areas and densification of the higher areas. Either the area should not be urbanized or the area could be densified more. On the possible interventions will be more elaborated in the design chapter.

To show the amount of people that live in the danger-area or no-go area the five clusters are linked to the households and inhabitants (based on CBS). To explore the options per area more into depth there is again a shift in scale; the city.

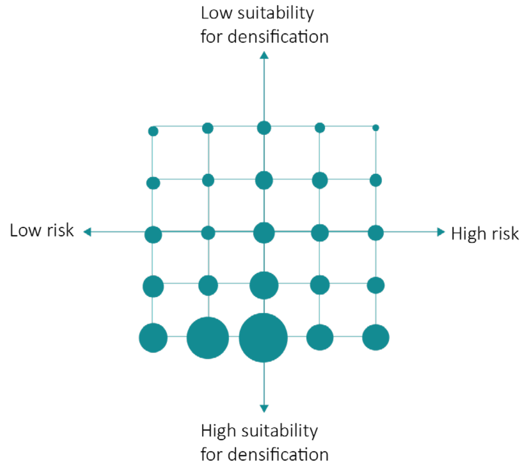


Figure 18| The dots show the percentage of neighborhoods and in what cluster they currently belong. Luckily a large amount of neighborhoods is in the ++ quadrant. The +- Neighborhoods need to be relocated and the-+ areas could be adapted to get suitable for densification as well.

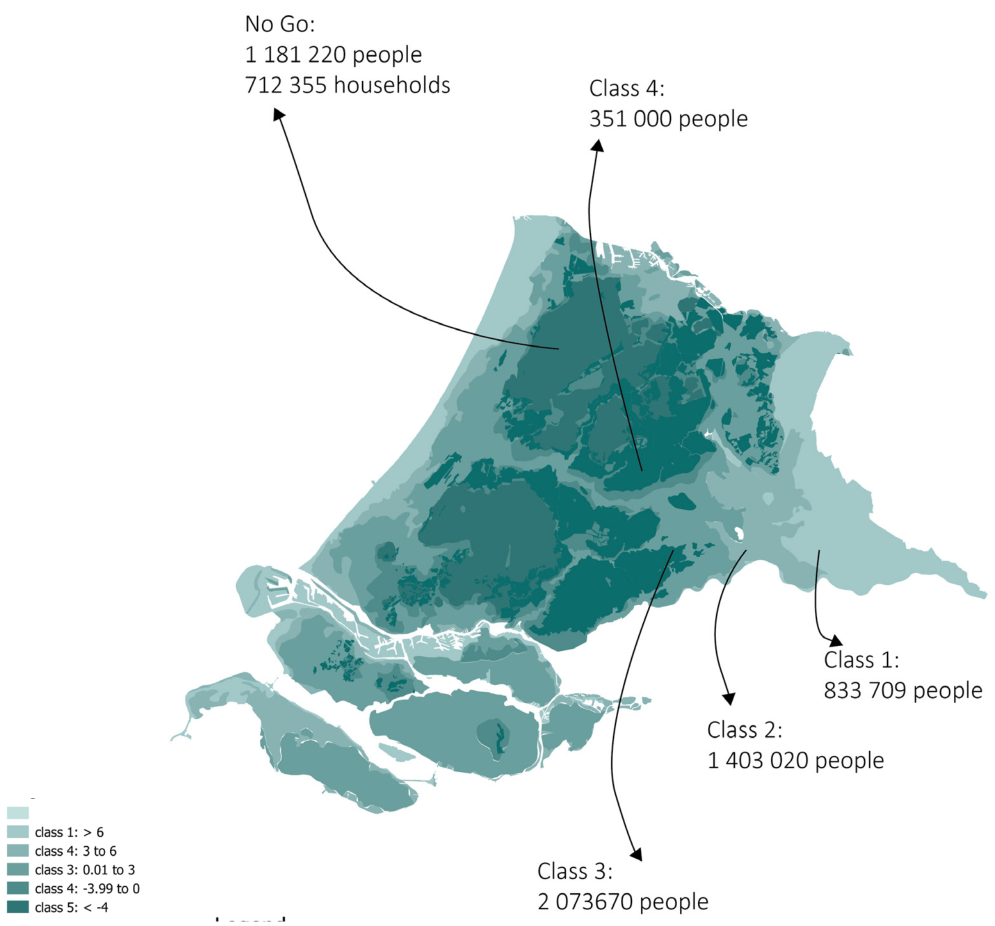


Figure 19| What does it mean in more tangible numbers? How many people live in each of the classes, that are currently exposed to various levels of risk.

The substratum layer is very defining in the division of suitability clusters since these layers are hard to change. The height/soil type cluster shows five classes. Class 5 and 4 are already below sea level. Class 5 is now set as no – go area since it is more than four meters below NAP, this means that even when a house has two floors, the second floor could be flooded. To see how many people are currently living in these zones in the Randstad the amount of inhabitants per neighborhood of the CBS is used. The classes do not follow the administrative borders of the neighborhoods. Therefore the percentage of surface the neighborhood lies in a certain class is used to define the number of inhabitants. The real amount of inhabitants can of course vary.
As the clusters describe there are two extreme scenarios that are interesting to observe on a smaller scale. If an area in Figure 71 is extremely unsuitable in terms of risk but extremely suitable in terms of settlement (red), it is likely that there will live a lot of people in an area posed to risk. The other extreme (yellow) shows the high areas that have the potential in terms of risk (high grounds) but have no critical infrastructure to start building up a city.

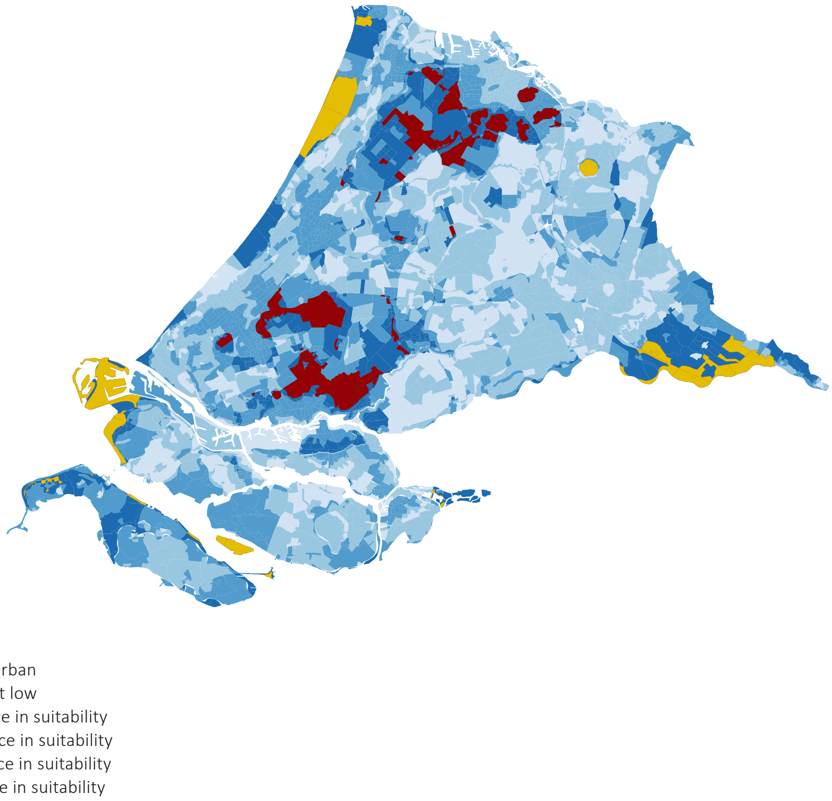


Figure 20| This maps shows the differences of the value of suitability for densification (value 1 to 5) minus the suitability value of urban settlement (value 1 to 5). The areas with the highest values of difference are interesting, because there is a mismatch. Either a very low peat area is currently a highly urbanized area, or a high ground is not urbanized at all.

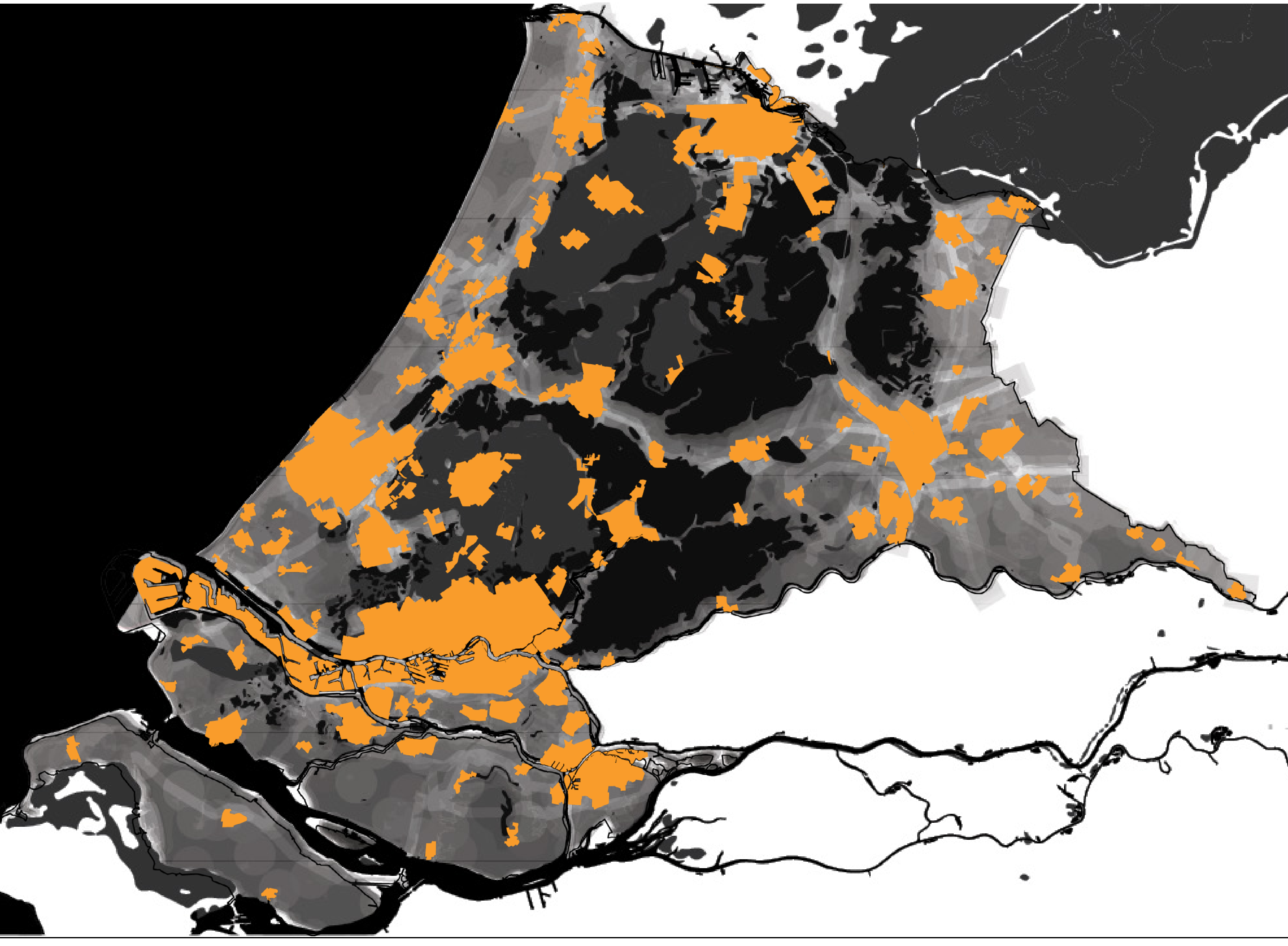


Figure 21 | The suitability maps show the unsuitable areas of the Randstad, and highlight the suitable areas. Design objectives are derived from the suitability maps and shape the outline of zooming in to the lower scale.

// Design properties- Region scale

The region scale takes a closer look to what elements are actually placed where. The Randstad region is vulnerable as dyke ring, but what does this dyke actually protect? What areas should be relocated in a new system and where can they be relocated the best? The overview shows that around 1 million households are built and around 1,4 million people live in an unsuitable location in terms of risk. At the other hand there are locations where potential could be activated: higher grounds that have no urban function.

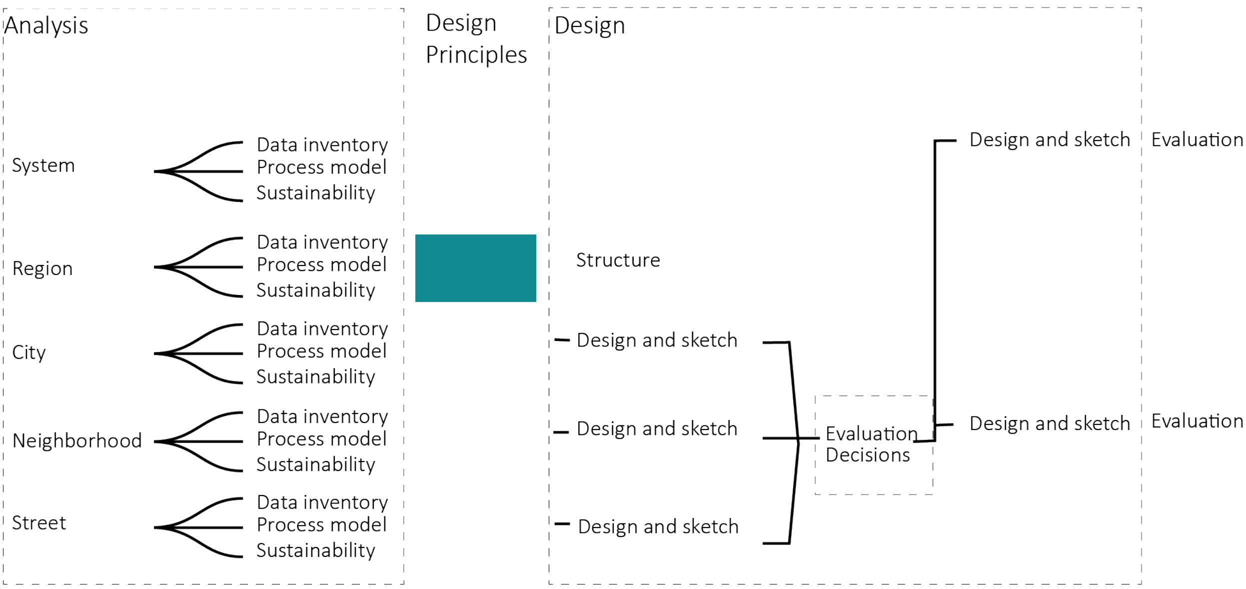


Figure 22 | The scheme of the analytical framework points out where we are: the design principles that are derived from the region scale.

// Qualities//

//Cluster of cities //
Benefit of the cluster, but do not be dependent on the cluster. (This is the change).

//Critical infrastructure//
Use the critical infrastructure that is already there.

// Changes//

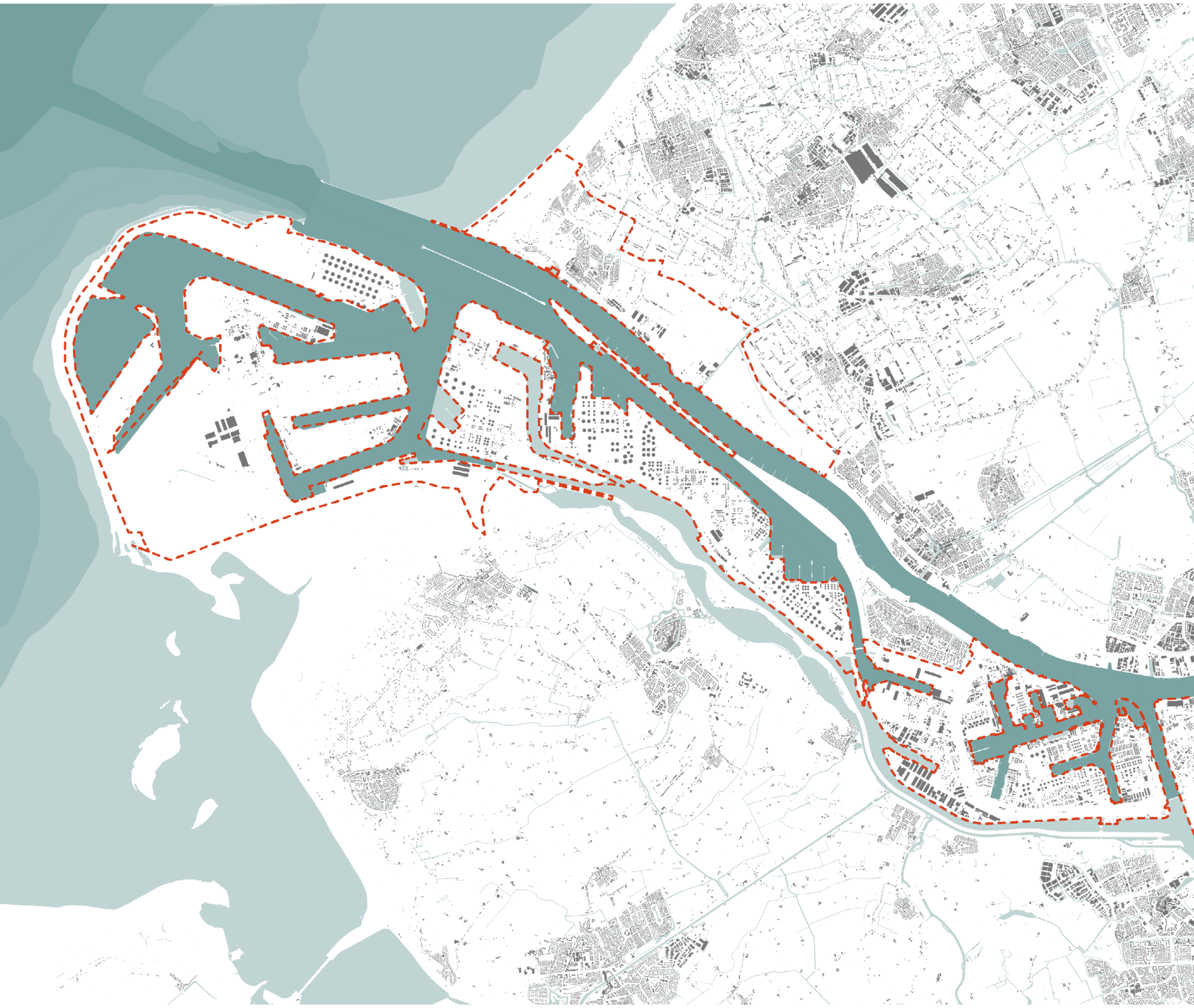
//Cluster of cities//
Be less dependent on cluster. In case of extreme flood the cities need to function as well.

//Relocate unsuitable areas//
Define settlements based on the substratum layers.

//Densify suitable areas//
Define settlements based on the suitability for densification.

//Relocate economy in unsuitable areas//
Invest in industry at the higher grounds

// The City- Rotterdam



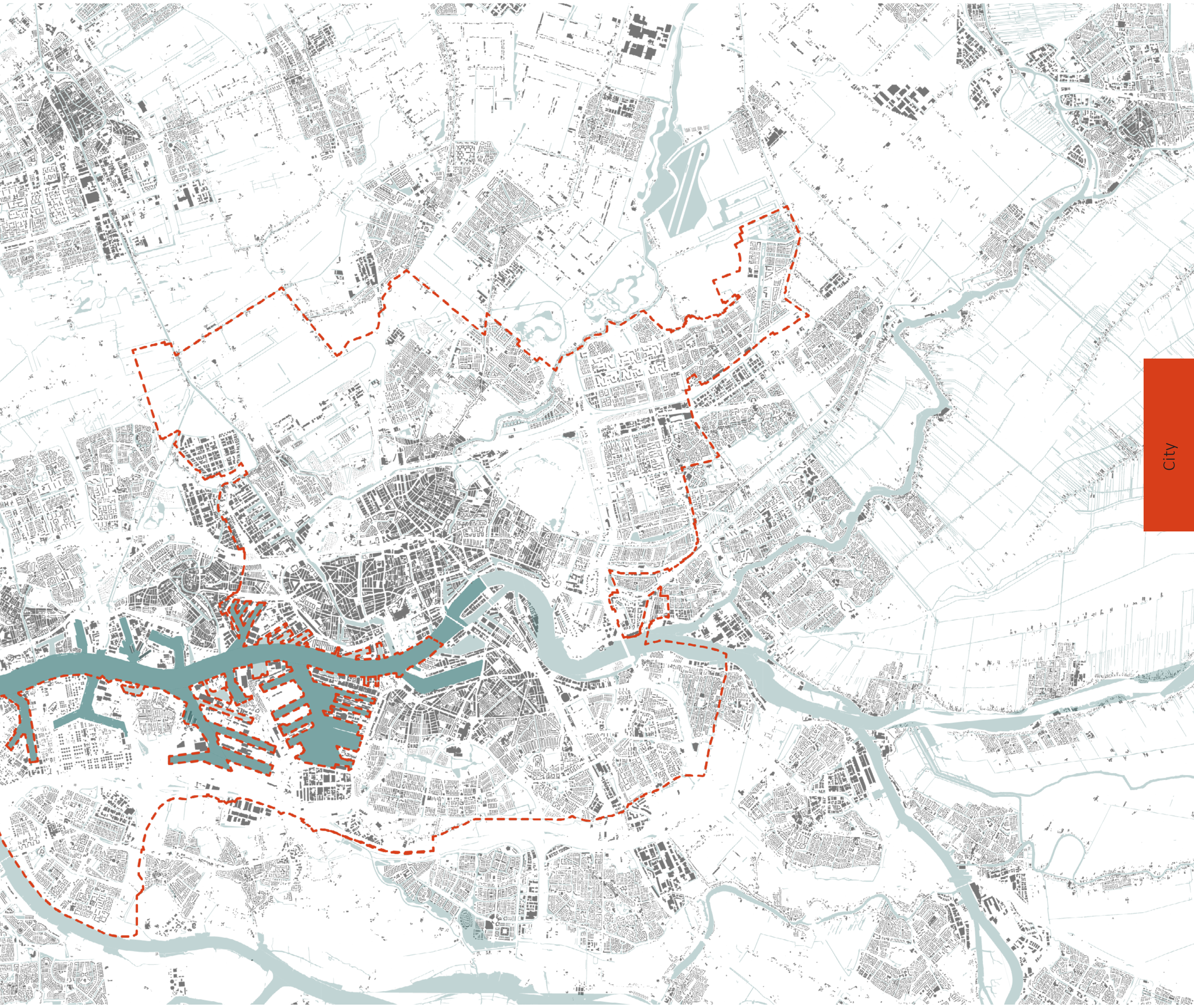


Figure 24| Map of the municipal area of Rotterdam.

Area Municipality 325.79 km2
Land 208.80 km2
Water 116.99 km2
Population
Municipality 619,879
Density 2,969/km2

// The City- Rotterdam- Physical

The above analysis focuses a lot on the infrastructures and functions that are available in a certain neighborhood. This general perception of critical infrastructure is sufficient for analysis on such a large scale. However, infrastructure and networks and functions are connected to each other on the smaller scale. Looking to the maps in Figure 25, Figure 26 and Figure 27 it only shows a general impression on whether the area is suitable or not. Every city has to have a certain amount of hospitals, has to be able to connect to electricity systems and has to have a more dense public transport system. Zooming into the city scale of the two suitability maps shows that this analysis is a rough one. Infrastructure and functions are not limited to neighborhood administrative borders and are just used as the smallest possible cluster. Moreover the citizen perspective and the demographic information is not at all represented in the larger scale analysis. The data analysis of the city will focus on the city of Rotterdam. First of all since Rotterdam has one of the lowest polders in its city. Besides this there is an area that shows very well on suitability for densification, but really low on urban settlement, and one the other way around. The city will be explored covering the three perspectives mentioned in the theoretical framework; the mental, the social and the physical city.

Rotterdam is a true harbor city. The success of the city as industrial city grew and the city outgrew its city walls in the nineteenth century. People started to live in lower areas (Figure 30). The harbor expanded more to the West. The Nieuwe Waterweg made it possible that larger ships could enter the harbor as well and the capacity of the harbor only got larger. The city harbors got transformed to neighborhoods. The harbor structure is still recognizable by the waterfront, but also by the infrastructure that shows slowly bending roads build upon the former train rails.

Physical

The first harbors where build upon natural higher sand grounds that where shaped by the river New Meuse. When the harbor expanded the techniques where more elaborated and artificially new islands where made using the silt and sand combination that was dredged from the river. Since the harbors needed to be accessible from the sea, they are in an area without dykes. Therefore the height map of the surface level shows a high island in the middle of the low lands (Figure 28 and Figure 29). This important data, since the height layer is difficult to adapt in relation to urban layers.

Figure 25| The suitability in Rotterdam municipality based on the suitability for densification. The (white) center shows that there are sufficient functions available so that densification would be possible. The newest land reclamation (Tweede Maasvlakte) has currently not the right properties for residential densification, which is logical since it is reclaimed to be a port.

Figure 26| The suitability in Rotterdam municipality based on the suitability for urban settlement. The suburbs is clearly placed in the lower areas (even in the former peat lakes). The outer dyke area (harbor) has a surface of around 4 meters above sea level. This is logically since the land is not protected by dykes and has to be accessible for boats.

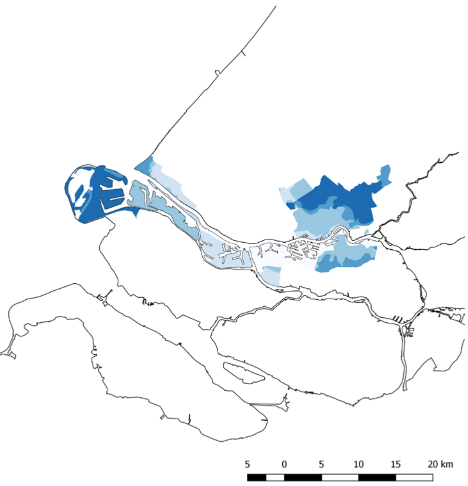


Figure 27| This map shows the combination of Figure 76 and Figure 77.

Figure 30| Rotterdam and its borders. The city grew rather fast in the 19th century due to the success of the Harbor. The city harbor expanded West wards in order to be able to host larger ships and to larger the industry.

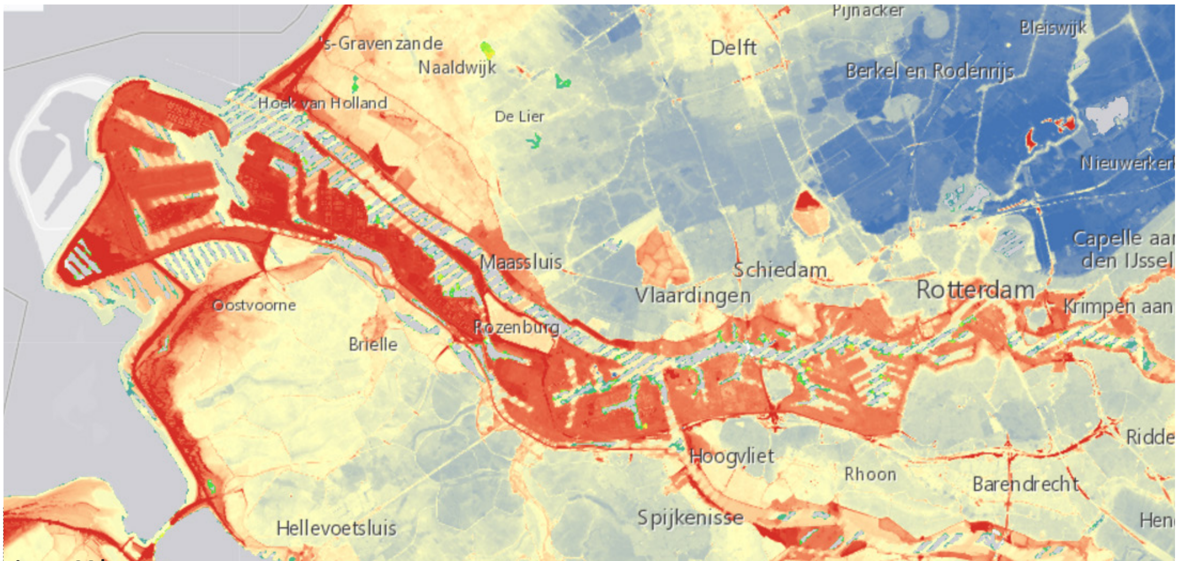


Figure 28| The height map of surface level of Rotterdam shows that the harbor is a high island in midst of low lands. This is due to the fact that the harbor needs to be accessible by the boats from the sea and needs to be above sea level (4-5 m)

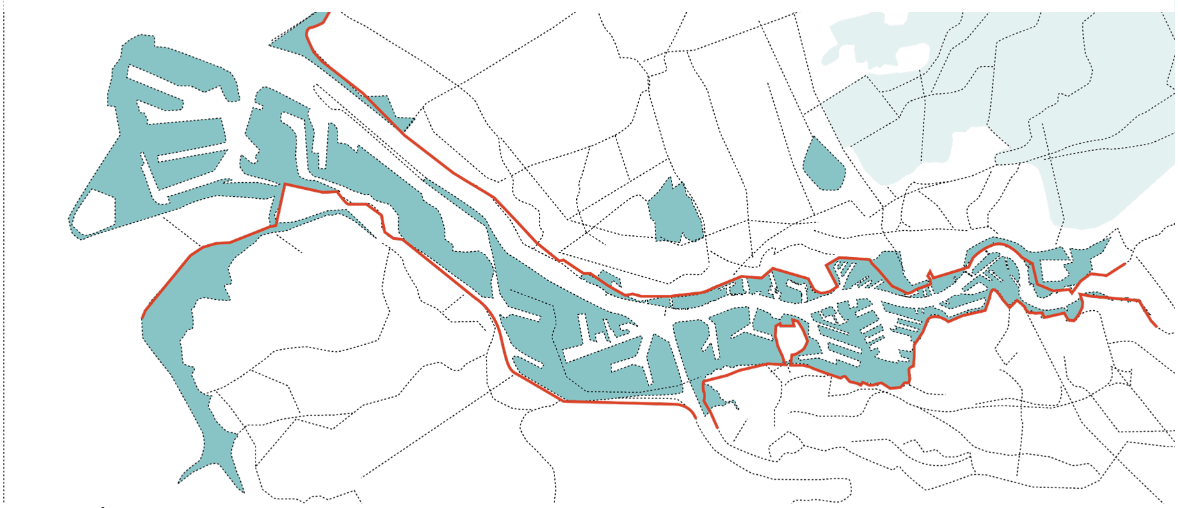
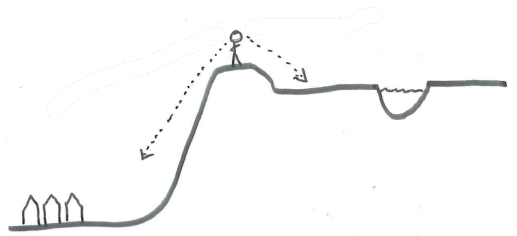


Figure 29| The high land and in the North the low peat lake area. The red line represents the dyketrace.

The height map of Rotterdam shows the high island, as the former harbor. As has been explained in the theoretical framework – the city and surrounding- the first harbor activity happened on natural sand banks. Later on as the harbor started to expand, silt was used to make artificial higher grounds. These higher grounds are again dykes, but not to protect them, but the hinterland behind it. The Dutch system is in this case exceptional, since the urban activity takes mainly place on the lower lands behind the dyke as shown in Figure 31 .These height differences are visible in the urban structure, if however you pay attention to it Figure 32,Figure 33, Figure 34 and Figure 35. On the right page there are some pictures of places in Rotterdam that show the dyke or harbor edge. For example the dyke where the Kunsthal building is built against. Or the slope when you try to cycle over the Erasmus bridge that starts already before you reach the water. Or the parallel road when you walk on the Mathernessedijk that lies some meters lower.

Since the height layer is very important in this project analysis maps of the city scale will show where the higher grounds are (by showing a red frame of these higher grounds). The dotted line show the municipality administrative border.



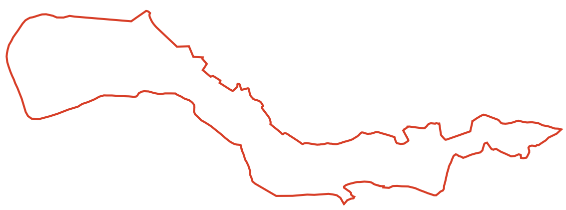


Figure 31 | A schematic section of the situation in the West of the Netherlands: The dyke divides high unembanked areas from low embanked areas. In the lower areas there is urbanization.

Figure 32 | The dyke that divides the harbor area from the hinterland. Photo is made at the South bank, close to metro station Rijnhaven.

Figure 33 | Height differences that you do not see until you pay attention. Location, the North bank close to Erasmus bridge.(Image by author)

Figure 34 | A height difference at the Brede Hillelaan, on the left the harbor area, on the right the start of the hinterland. (Image source: Google street view)

Figure 35 | The dyke that divides the Museumpark. The Kunsthal you can see on the photo (image source: Google street view)

Area Municipality	325.79 km2
Land	208.80 km2
Water	116.99 km2
Population	
Municipality	619,879
Density	2,969/km2

Rotterdam as a city has an industrial character mostly because of the fact that the industrial sector plays a large role. Moreover the historical city center was destroyed by the bombing in 1940 in the second world war and the fire it started that literally punched a hole in the city structure. Over 25 000 buildings have been destroyed (Stadsarchief Rotterdam, 2008). The debris of this event has been disposed partially in former canals. So not only the buildings were destroyed, also other layers of the city have changed drastically because of the bombing.

Already during the second world war the reconstruction phase started, after the war the plans changed and resulted in a more modern city plan. The car played a large role in that time which is clearly visible in the city of today. Even though the municipality has made several interventions to make the pedestrian the leading factor (for example by changing the infrastructure along the water front to be more slow traffic), the city still has a car based infrastructure. In the reconstruction plan one of the guidelines was the separation of several function. The first plan had no space for residential functions at all, and art, retail and business had separate clusters. This was in line with the CIAM – mindset.

Although the functions are more mixed nowadays, the city center has still not much residential functions and does have a lot of business and retail functions. This leads to a very crowded city during the day, but a rather empty city center during the evening and night. The height of the buildings contribute to this as well, since the center has a lot of high-rise, resulting in losing the human scale. Luckily the municipality has invested a lot in creating more residential functions and more liveliness in the past decade and change is visible. The residential areas of Rotterdam today are located at two sides of the river, at the east side. Towards the west the harbor is located without residential areas. Two exceptions, Rozenburg and Pernis are two former villages surrounded by the harbor activity.

The city of Rotterdam has a highly paved surface, especially in the city center. Problems related to this can be the urban heat island effect or inadequate sewer capacity as a result of rapid water runoff. Where in a natural condition only 10 percent of the rainwater runs off, in the this amount increases to 55 percent. The municipality tries to mitigate these effects by implementing more infiltration surface, a slower water runoff (for example by green roofs), local buffers (green/blue infrastructure), or a surface runoff towards local buffers. Systems like the Water square combine the water task with social functions and make it possible to collect water even in a dense urban fabric.

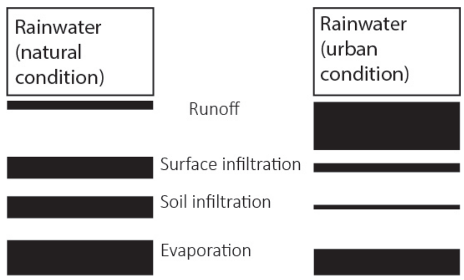


Figure 37| How much water goes where? Natural versus city condition.

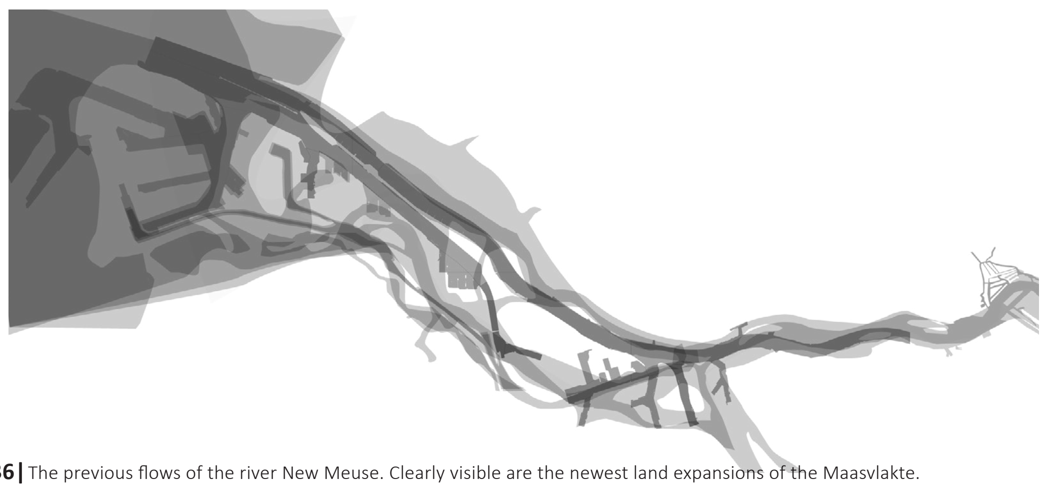


Figure 36| The previous flows of the river New Meuse. Clearly visible are the newest land expansions of the Maasvlakte.

Function

Figure 39| The buildings colored on there function. Housing is mainly in the center. The harbor area contains not many buildings. Also the large greenhouses in the Westland are visible.

Building year

Figure 38| Building year of each building in Rotterdam. It shows the older city parts in the center, with a 'gap' in the middle where the large bombing in the second world war destroyed the heart of Rotterdam.

Height

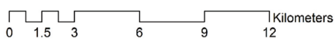


Figure 40| The buildings and their height. The suburbs are in general lower buildings.

City

To understand a bit more of the infrastructure and important nodes that are present in Rotterdam, these five maps show several topics. In all of the maps the higher island as described in 29 is displayed as well. In this way it is possible to see what infrastructure is currently placed below sea level. The maps show each features of the physical perspective, electricity lines, roads, functions related to centralities, critical infrastructure functions and the green infrastructure. The dotted line shows the administrative border of Rotterdam, Infrastructure crosses this border logically, since it is part of a bigger network.

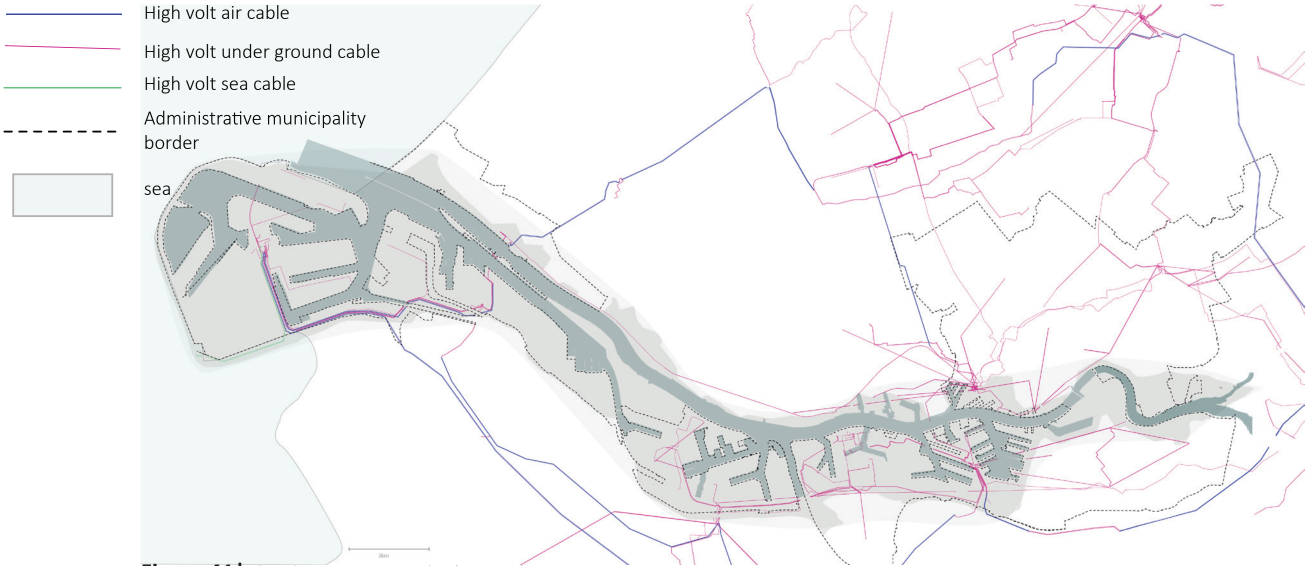


Figure 41 | The electricity network of Rotterdam.

Main road structure

Figure 42 | The main road structure of Rotterdam.

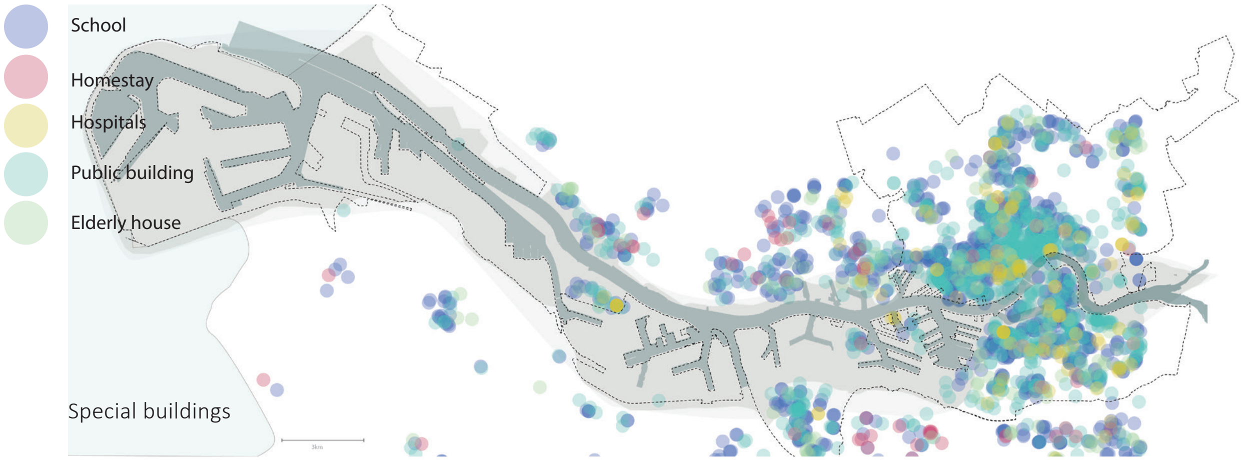
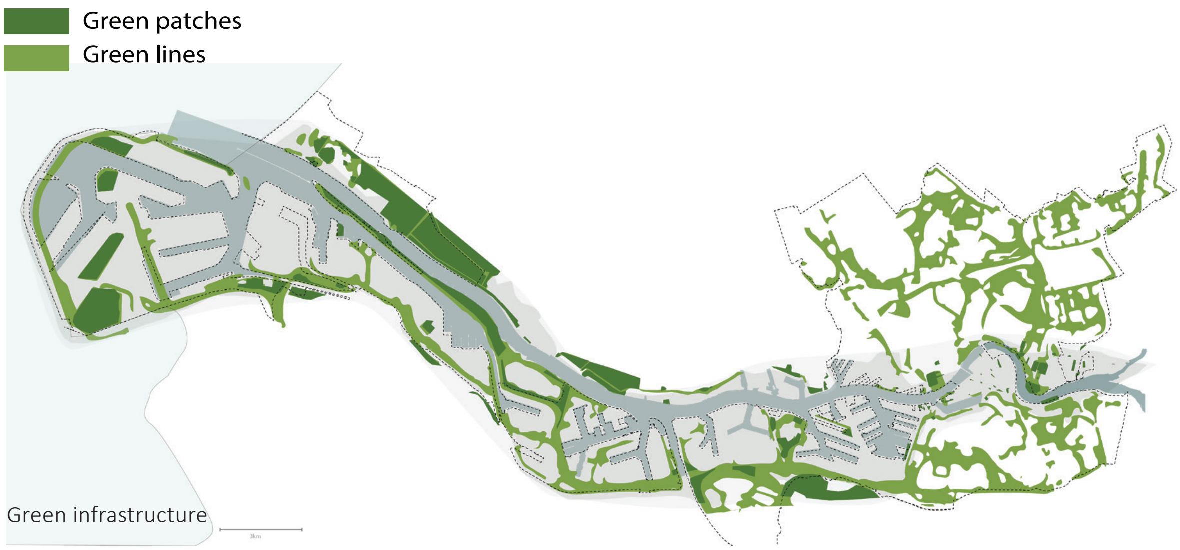


Figure 43 | The special buildings as home-stays, hospital, public building and schools shown. The functions are clearly mostly in the east.

Figure 44 | The critical infrastructure and the plot size.



To understand where the centralities of Rotterdam are, spatial analysis can be used to check the betweenness of the roads. PST (Place Syntax Tool) is used to visualize the betweenness of the road network. In the map the municipality border and the higher island are also visible. The network betweenness is set to show the amount of roads that is reachable within 1000 meter (including the road itself). This distance is not a radius, but follows the path of the road as explained in figure 45. The map shows several centralities, most of them in the east. Moreover the river splits the two banks clearly, in terms of centralities.

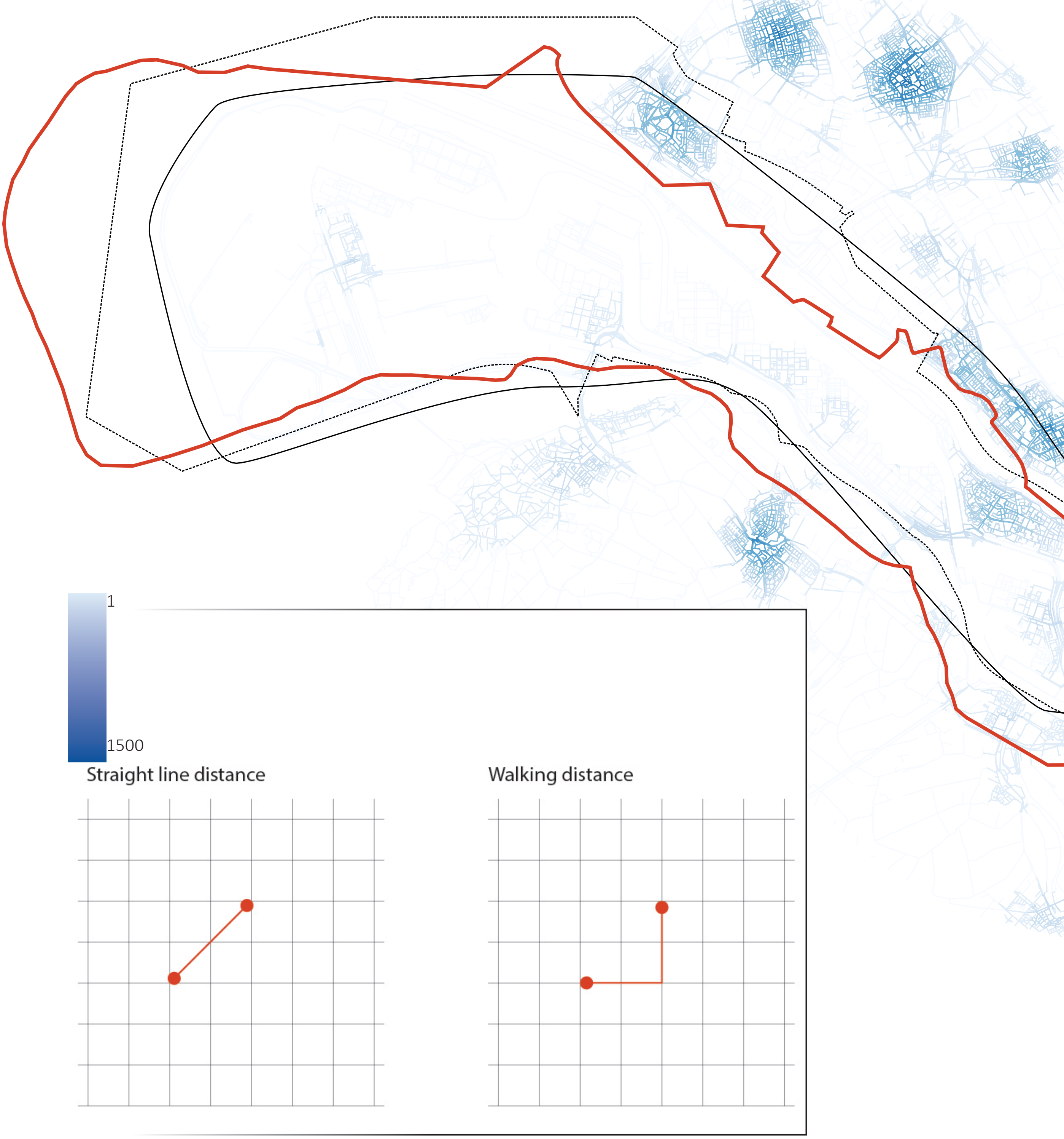
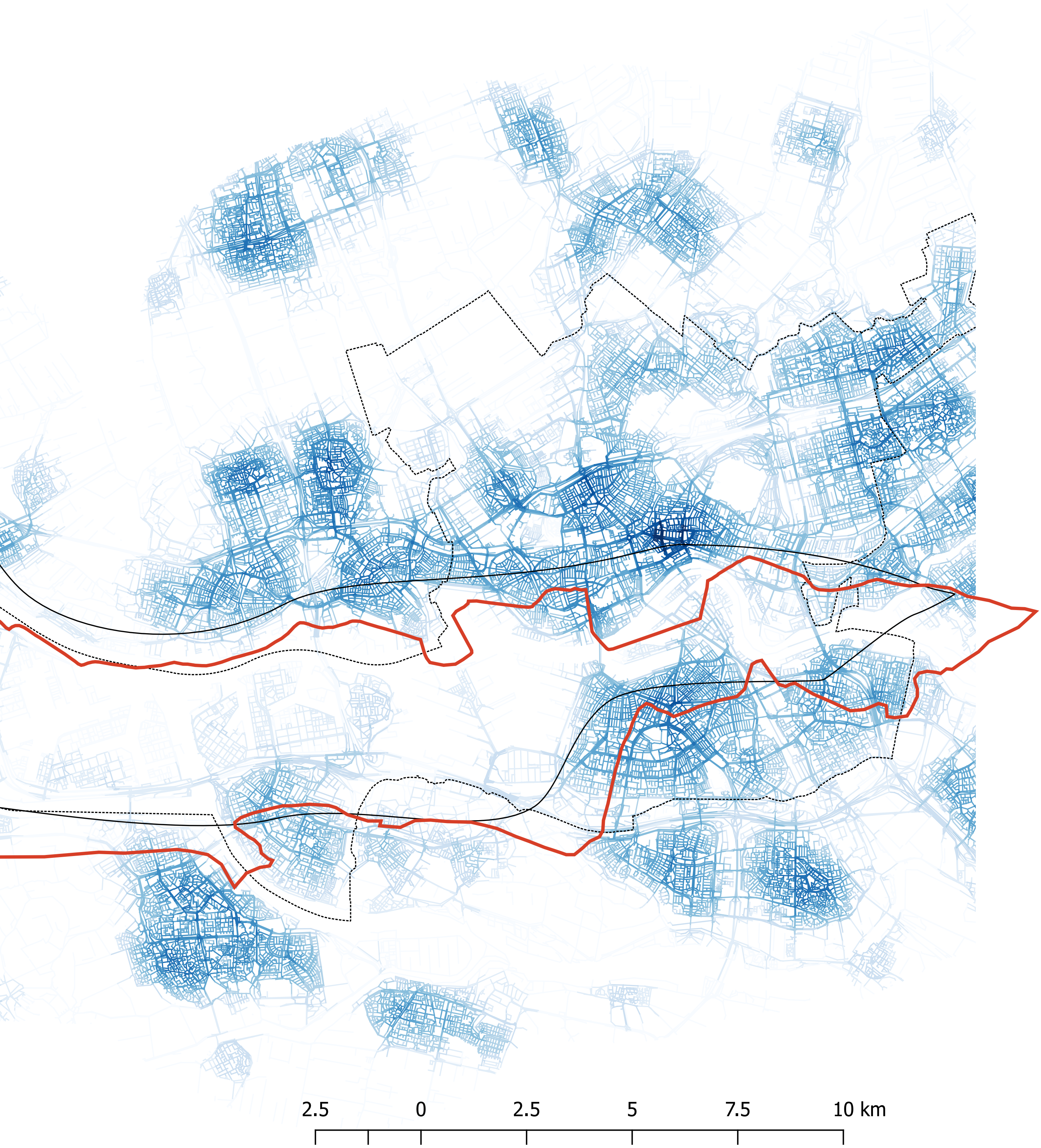
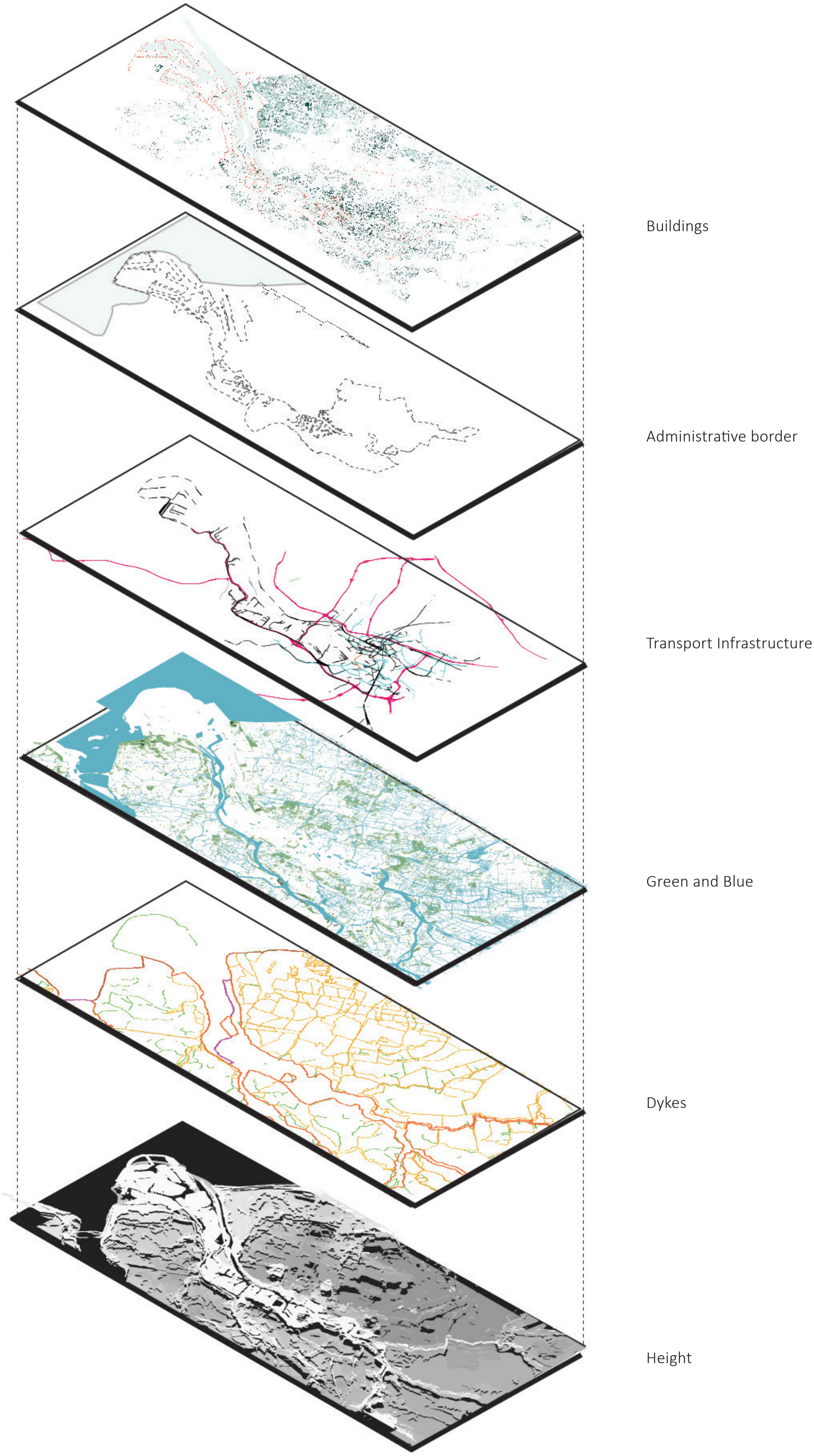


Figure 45 | The centralities based on the number of connecting roads within a kilometer of walking distance. This takes the length of the line and not as the crow flies. (Image by author, tool PST plug-in used)


2.5
0
2.5
5
7.5
10 km


Buildings
Administrative border
Transport Infrastructure
Green and Blue
Dykes
Height

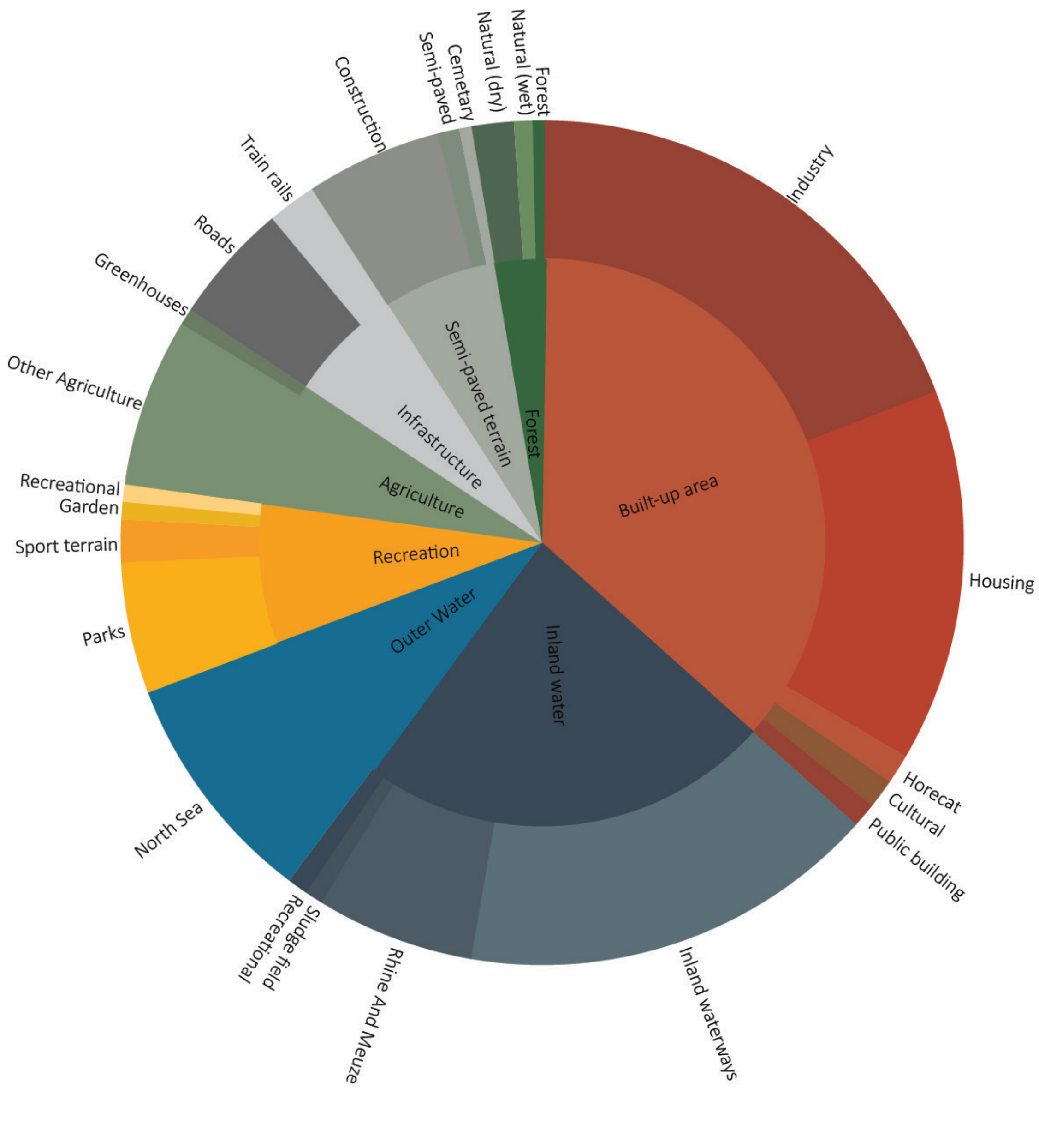


Figure 46| Layers of the city on the left page. On the right page the division of the land use in within the borders o the municipality. It shows a large patch of built up area and infrastructure. This built up area has a close relation with the possibility to drain the water.

effects of this.

Segregation can also be related to flood management, as has become clearly visible over the hurricane events of the summer of 2017 in America. Hurricane Harvey has led to major floods in the city of Houston. Citylab has published a cluster of maps showing that Harveys path of destroy mostly affected the poor. The lower areas that are exposed most to the risk of flooding, is inhabited by the most poor people of the city that often do not have an insurance (Misra, 2017). Misra also mentions that it is not only about the vulnerability in terms of flooding, but in general the poor inhabit that places in a city that is unsuitable for residential function, where the rich have a choice not to live (figure 47).

As visible in the maps on the right page this link between unsuitable areas (in terms of risk) are not clearly visible (figure 50-53). Moreover the most wealthy group lives in the lowest polder in the North East of Rotterdam. The real estate value of the vulnerable area is also higher than average.

Figure 47 | Poor families are mostly hit by the hurricane Harvey in Houston in the summer of 2017. (Source: San-diego union)

Social

The social aspect of the city is essential, taking the hypothesis into account. When relocating people, it is necessary to know with what people live where. What is the image per area that needs to be relocated? How diverse is the city? What is the level of density in residential areas? Are people feeling safe?

The city of Rotterdam is very diverse in terms of the background of the citizens, as shown in the diagram that half of the population is non-Dutch. Figure 101 shows that the backgrounds of the citizens are not mixed so well throughout the neighborhoods. There are clusters where a lot of non - western people live, spatially seen. This spatial separation between groups of a certain background could be defined as either socio-economic or ethnic segregation. It is important that these two are not necessarily connected linearly, as policy makers often assume that non-western migrants are all of a lower class (Marcińczak, Musterd, Ham, & Tammaru, 2016). Segregation takes inequality to the spatial dimension, since it ask the question whether inequality in social background leads to inequality in the living environment of people as well (Leidelmeijer, Schulenberg, & Noordhuizen, 2015). The location in the city of economically more vulnerable groups is often related to the possibilities they have in life. One way of creating more social cohesion is by offering spatial places where people can meet, such as parks, community centers or on a small scale even banks. What is often visible is that community centers in a socially not mixed area the center does not feel approachable by someone from a different socio-economic or ethnic group. Sometimes these community centers lead then to more segregation. So even if someone of another group would start to live in this area, it would be less likely he would use the meeting places of his neighborhood. Another clear example is visible with education and schools. In the areas with less diversity children lack learning about the other spectrum than the one they are already are familiar with (Frey & Fisher, 2004). If a neighborhood is inhabited with a single type of group of for example income, the area as a whole could be described as less robust (Legeby, 2009). Diversity of socio-economic an ethnic background within neighborhoods of the people that live there, could decrease the feeling of segregation and the negative side

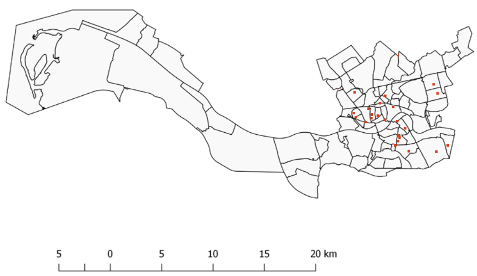


Figure 48 | These dots represent the community centers in Rotterdam .They can help creating social cohesion, but can also lead to more segregation if they are a community center used by one social/ethnic/economic group. (Image by author)

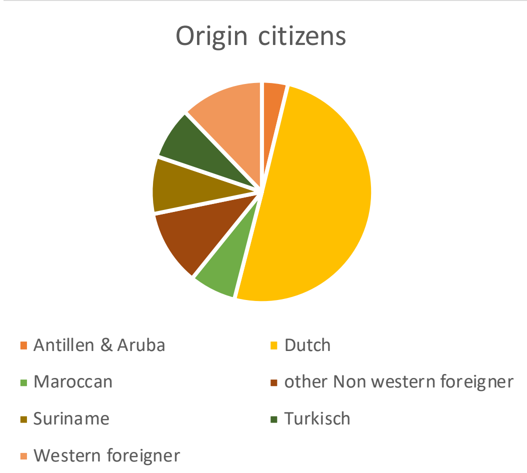


Figure 49 | The background of the citizens in Rotterdam is mixed. With half of the people non-native Dutch it is the most diverse city of the Netherlands (Image by author, data by CBS).

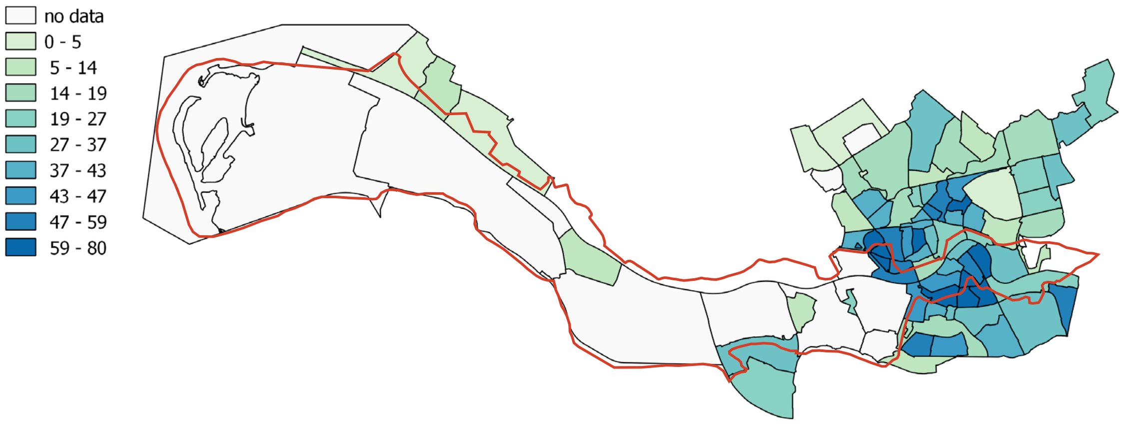


Figure 50| Percentage non western inhabitant per neighborhood. In red the higher grounds. There is not the event as in a lot of cities that non-native live in the lower flood areas. (Image by author)

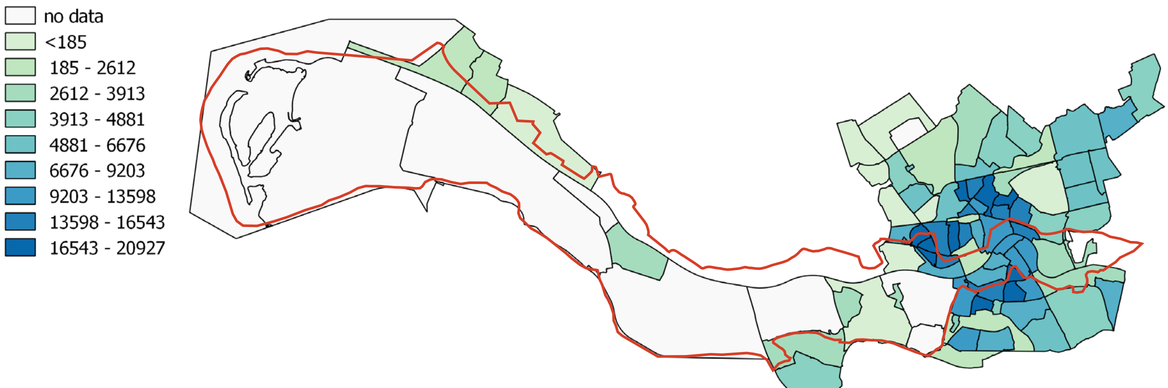


Figure 51| Inhabitants / km2, value per neighborhood. The low area has a lot of lower density suburbs neighborhoods. (Image by author)

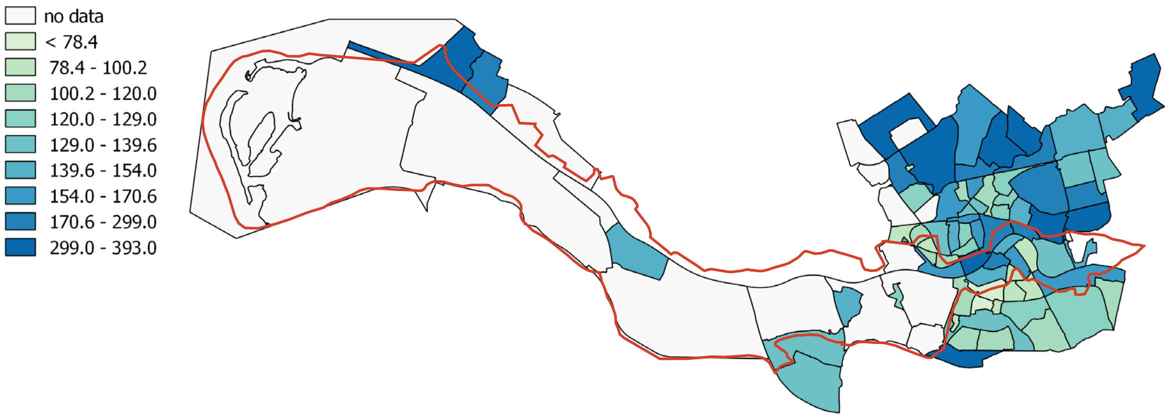


Figure 52| Average value of a house (x 10.000 euro). The North of Rotterdam has more expensive houses. These are also the low areas. (Image by author)

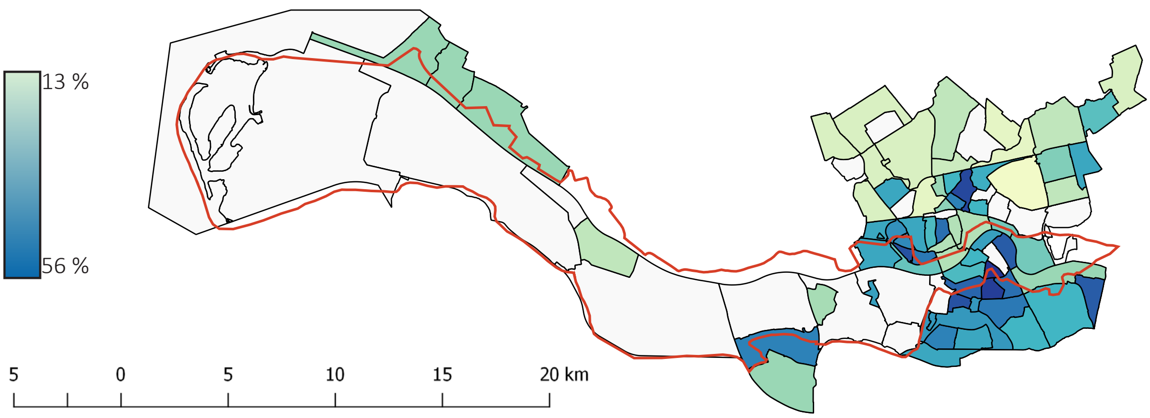


Figure 53| The percentage of people above 19 years old that struggles with its income per neighborhood. This is clearly connected with the Figure above. (Image by author, data by CBS)

As explained in the theoretical framework, density is closely related to this project, since it involves relocation. The hypothesis of relocating entire neighborhoods to the higher grounds asks for a density analysis. How many people are living in the areas that have to be relocated? And what areas can be densified in order to settle them again? Since the higher grounds are already defined based on their altitude is possible to do some studies to see how many people could be housed on the new 'island' if a certain density is practiced. The current density in the municipality of Rotterdam has a broad range, especially since the harbor areas are rather large without many buildings. On the first two pages the FSI and GSI are computed on the level of the urban block. The outlines of these blocks are a combination of the street network, the neighborhood border and the waterscape.

To explore what Rotterdam would look like and how many people could live in the city if it would be build up with densities of certain neighborhoods, the pages after that shows the FSI and GSI per neighborhood instead of per block. In this way it takes streets and so on into account (Figure 54). On the pages after that, 3 neighborhoods are evaluated on their FSI, GSI and amount of inhabitants. Then these values are extrapolated to see what would happen if these would be built on the complete new area. This is of course a not very precise value, but it is good to use it as tests to see the genera amount of inhabitants possible per value.
FSI and GSI images provide information on possibility for densification. A low GSI could mean that there is space to create new buildings, or horizontally expand old ones. A low FSI could mean that old buildings could get topped up, so extra floors could be added.

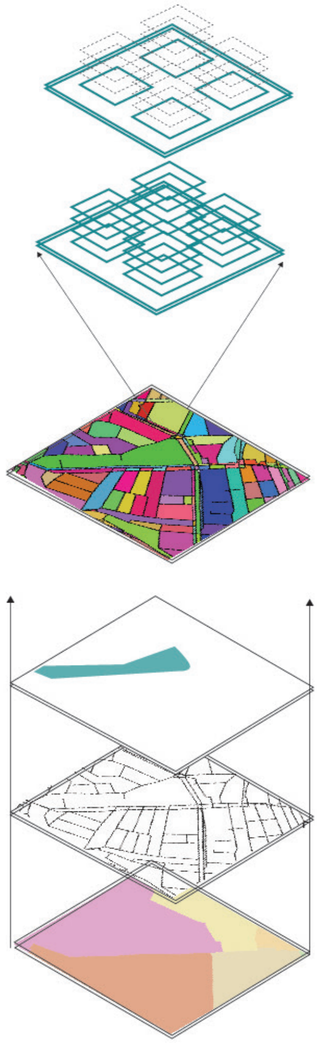


Figure 54| How to get the density values of the urban block? The urban block is defined by the road structure, large water bodies and the administrative neighborhood borders. Together they shape the urban block. (Image by author)

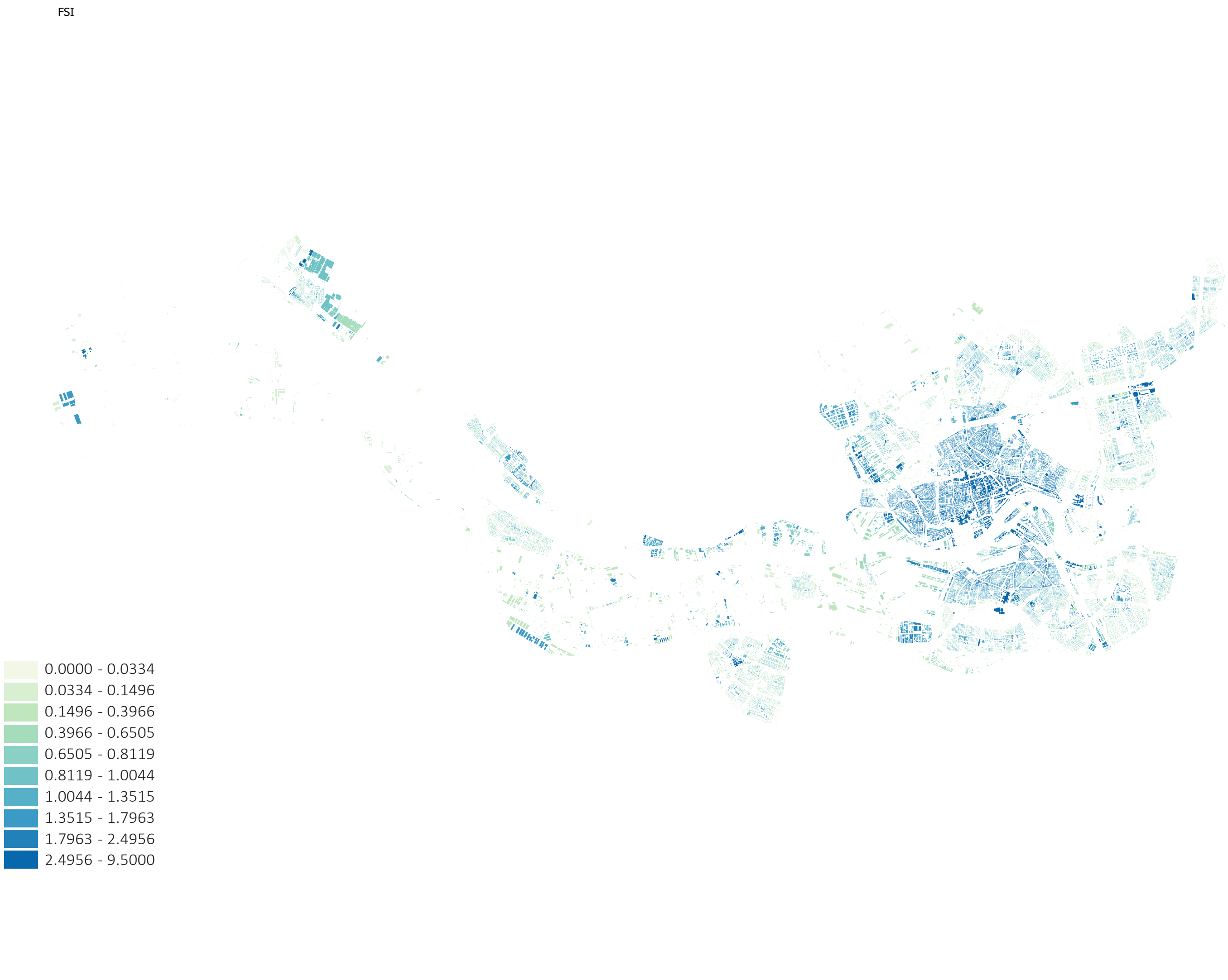


Figure 55| The city of Rotterdam and its FSI values show a wide variety throughout the city. Off course the harbor area has low values. The density values give information about the areas where densification (in more floor space) could be an option. (Image by author)

Figure 56| The city of Rotterdam and its GSI values show a wide variety throughout the city. Off course the harbor area has low values. The density values give information about the areas where densification (in more ground space) could be an option, or where there is a lot of ground space available for example water or green. (Image by author)

Average FSI per neighborhood

Average GSI per neighborhood

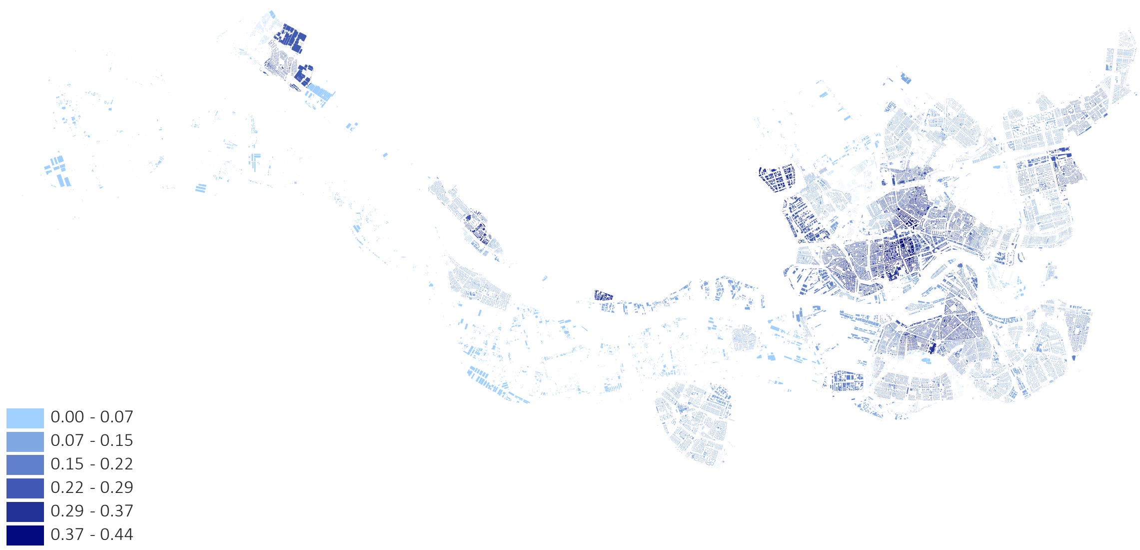


Figure 57 | The average values of the FSI and GSI per neighborhood show the density of the neighborhood. It is clearly visible that the city center is more dense in FSI and GSI values. The GSI maps shows also other centralities as Hoek van Holland, schiedam and Rozenburg. (Image by author)

Mental

The mental city is about understanding the identity of the city or the place. Does the city have its own identity? Which traditions does the city have? Are there events where all the citizens want to be part of?

In 2017 there has been written a story of the city Rotterdam. This magazine contains the perspective of 9000 inhabitants on their city and of how they would like the city to be in 2037 (Kruisman *et al*., 2017). Moreover the magazine focuses partly on how the inhabitants would like the city to be. Using questionnaires and interviews an identity can be distillated from all the stories. The dreams of the city are important, because dreams stand at the basis of each change. To visualize the dreams and narrative of the city the next page shows the main 10 topics where the citizens would like to see financial support (Figure 58). Moreover some quotes and ideas that where mentioned in their story are shown as well. The key values of Rotterdam of the Future are according to the interviewed inhabitants 'Connection, cohesion and harmony'.

Ten topics where the citizens would like the municipality to invest in:

1. Education: stimulate talented young people. The younger people should get a lot of attention, since they will shape the future.
2. Green space: More parks, and more green. Green means relaxing and safety to the citizens. Green spaces also facilitate human interactions.
3. Sustainability: we need to reuse and recycle more. We should pay attention to stimulate Renewable energy and think about the circular economy. Also we want less cars in the city center to improve the air quality.
4. Safety: more safety, provide bicycle parkings that are safe. Also more policemen.
5. Dwelling: Rotterdam needs a sustainable but affordable new building stock. Appreciate the mixed wishes of the people and look for a strong equilibrium between cheap and expensive housing.
6. Public transport: We would like to become the bicycle city of the world. Public transport should be accessible and available 24/7.
7. Innovation: This should stimulate the economy, especially focus on sustainability and the knowledge economy.
8. Clean City: The livability increases and city feels more safe. The citizens should be responsible for clean streets and parks. There should be guidance instead of strict rules. There should be more public toilets.
9. Job opportunities, focus on opportunities in the economy in order to create jobs. Also take jobs for the lower educated people.
10. Connection between citizens. Focus on accepting each other and have faith in the diversity of the citizens. Facilitate interaction and dialogues. Bring the people together. Create neighborhood community centers.


I HAVE NEVER DONE THIS, SO I TH
SCHOOL
EDUCATION
NICE TO MEET YOU
LOCAL
SUPER MARKET
BLA BLA
PUBLIC
LOCAL
NO RULES
MEN
ROTT

Figure 58| A visualization of the mental Rotterdam shows what elements the citizens find important to invest in for the future.

Process models

Physical

The process models of the city scale are related to a lot of separate fields. Within the municipality there are departments that deal with their specific tasks. The municipality tries to make project integrated between different field to create synergy. Rotterdam as municipality is known for the hands on approach, and is not afraid to try something new. The industrial character attracts a lot of creative hubs and start-ups.

Rotterdam is a growing city and expands towards the north. New neighborhoods as Nesselande have been set up in 2008, and are placed in one of the lowest polders. In the city planning there is not so much attention for reducing risk. There is attention for the rainwater discharge, since Rotterdam has had a problem with the capacity of the sewer system and the overflow in the surface water in the city center. The Water square is a well-known example as well as the green roofs. The municipality provides financial support for home owners that develop a green roof.

Social

Rotterdam has inhabitants from a lot of different backgrounds (Figure49). There are several community centers or places that function like one (school, playground) that are used by a non-mixed group. Within the city there are clusters of social housing and villa parks, that discourage the mix of socio-economic groups.

Mental

The citizens are not so aware of the fact that they live below sea level. If you ask around you to people that live in Rotterdam they often do not know if they live below sea level, or how much. They also do not have an emergency kit in the attic.

Capability/Sustainability models

Physical

The approach in terms of water management is mainly decided on the large scale (Rijkswaterstaat). The city planning is a more local task. Rotterdam has marked the outer dyke areas as suitable for living, resulting in around 40.000 people living outside the dykes. With the harbor moving to the west, especially after the expansion with Maasvlakte II there is more high space in the east. The municipality is investing in new building blocks and neighborhoods in the North (oude noorden and Kralingen) and the South (Ahoy and Zuidplein) of the city. Considering the trends of climate change the investments that are made now in lower areas, will face a high risk of flood.

There are also investments in areas that are more suitable. On the south bank of the river energy neutral houses are developed.

Social

There could be a more active approach for mixing people of different socio/economic/ethnic background. Mixing social and home-owned dwelling can stimulate interaction between these groups. The community centers can be gathering points for the mixed communities. If there is more necessity of going to a community center for different groups, there is more chance for interaction.

Moreover there could be a more social system in sharing goods. Sharing cars, tools, space can be a more sustainable use of the available goods. It can again stimulate interaction.

Mental

The citizens of Rotterdam (and the rest of the Netherlands as well) have not so much awareness of the vulnerability of the lower areas. The common thought is that the government will keep them safe. A lot of people do not realize that they live below sea level. The project could stimulate this awareness by giving feedback in public space about the rising water problems (Figure 59).

Figure 59| The art project of Daan Rozengaarde projects water waves to create awareness about the rising water levels. It feels as if you are standing below water and the city is flooded. (Source: studioroosegaarde)

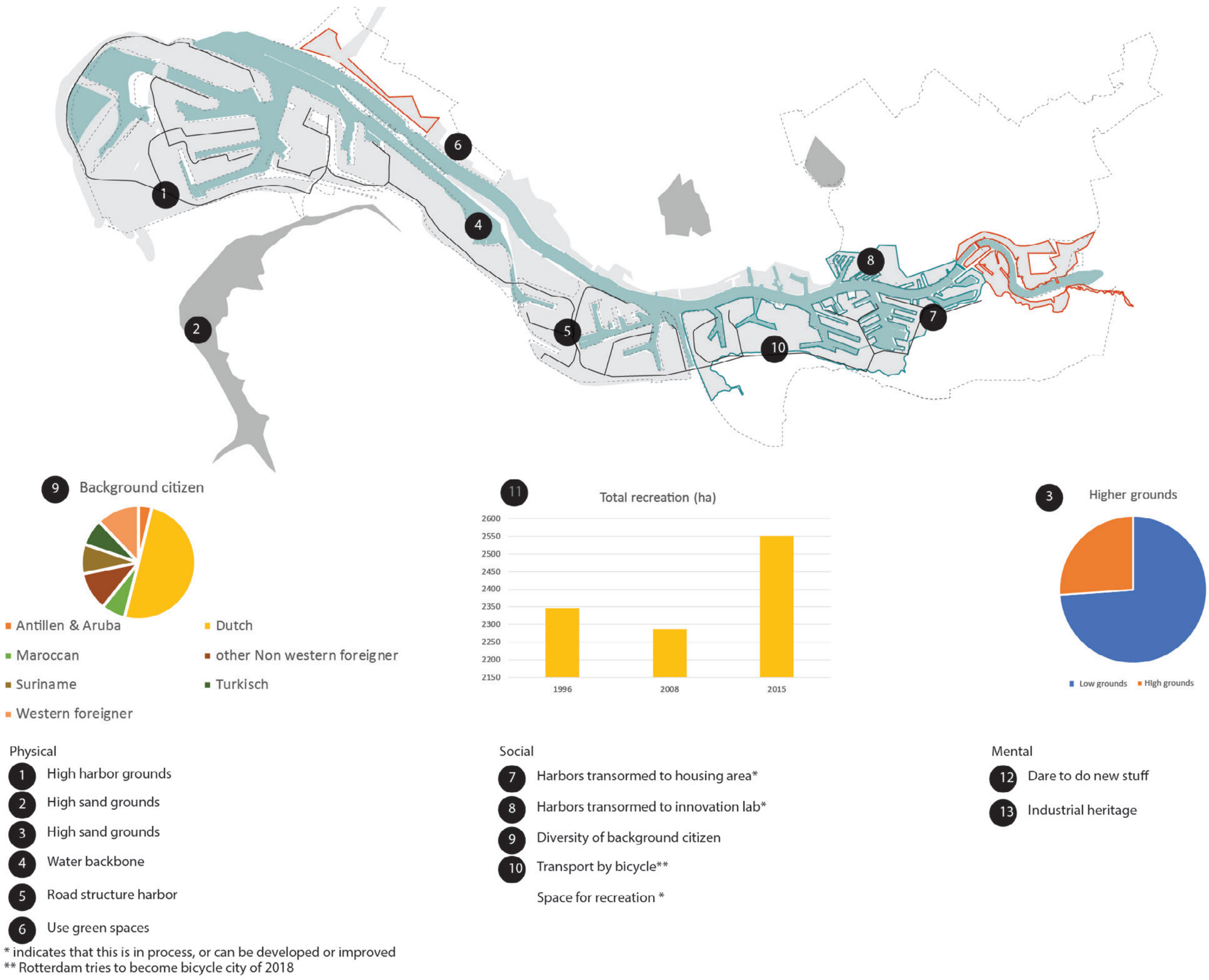


Figure 60| This map shows the qualities that are currently there in the city. It is a conclusive map of the assessment of the mental physical and social components. These qualities can be emphasized on in the future. (Image by author)

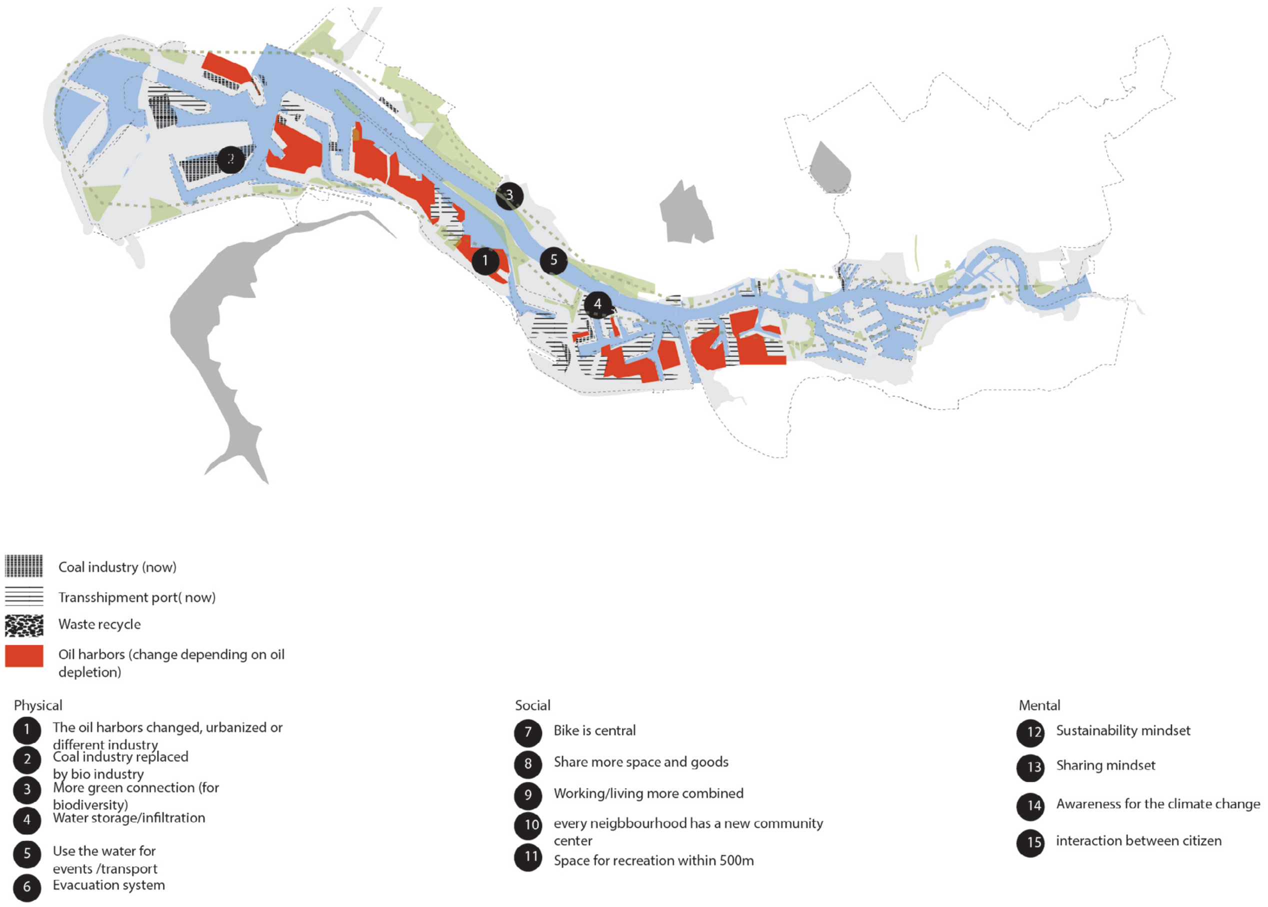
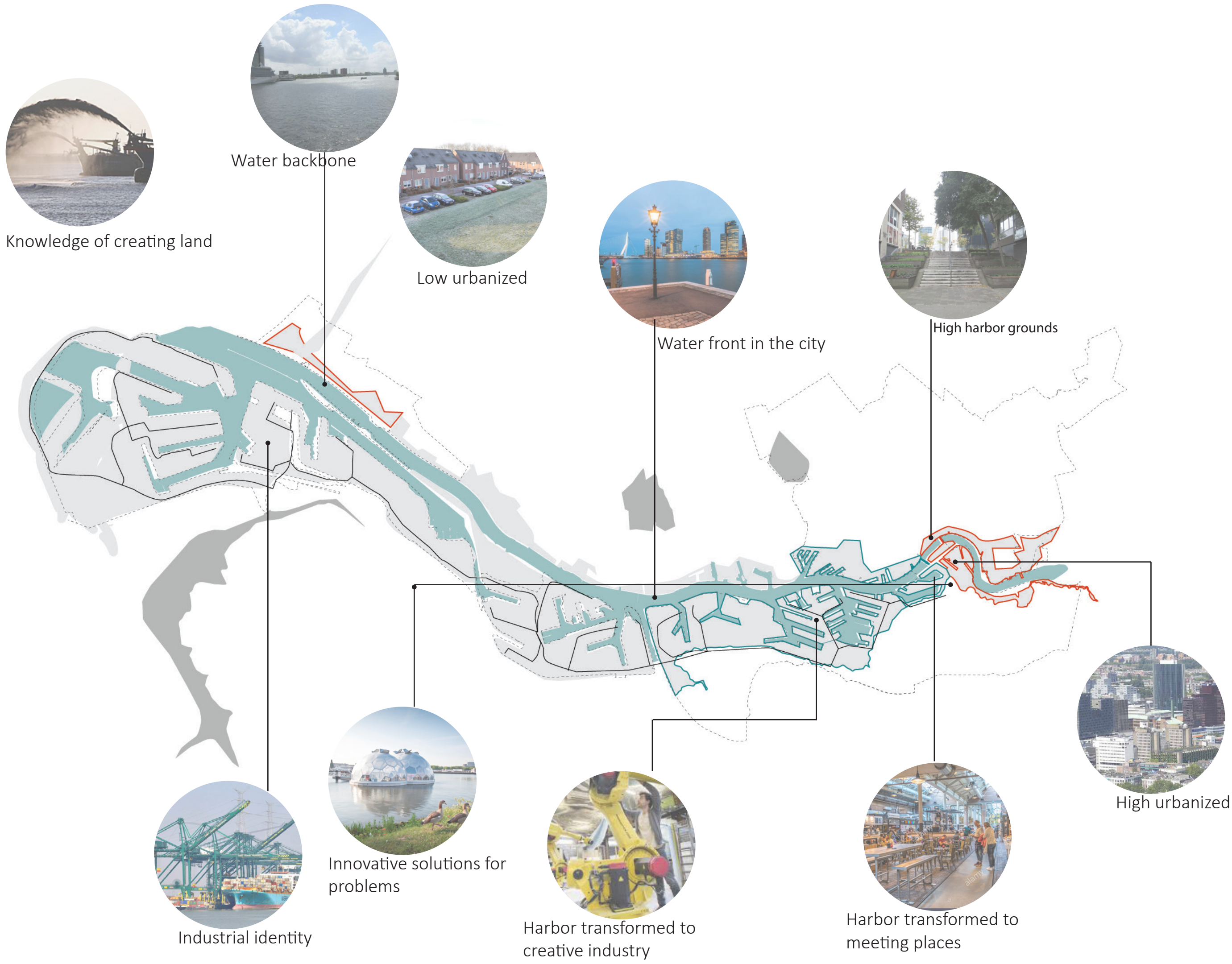
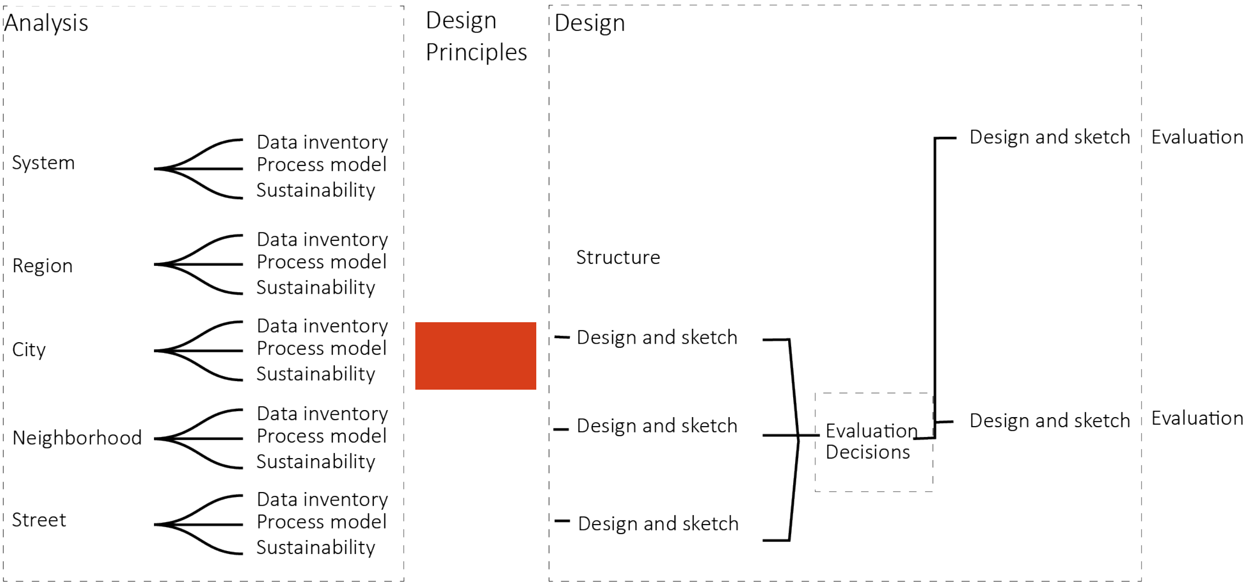


Figure 61| This map shows the changes that should be made. It is a conclusive map of the assessment of the mental physical and social components. (Image by author)


Water backbone
Knowledge of creating land
Low urbanized
Water front in the city
High harbor grounds
High urbanized
Innovative solutions for problems
Industrial identity
Harbor transformed to creative industry
Harbor transformed to meeting places

// Design properties- City scale
The city scale provides a lot of information of the connectivity between networks. Also it shows that social mental and physical focus points can geographically overlap, but can also have different locations.



// Qualities//

//High grounds//
Use the high grounds for future development

//Water backbone//
Use the water backbone as buffer or as retention basin

//Use the existing road network/
The city has an organized road network, even in the harbor there is a clear structure.

//Existing green patches/
There are already large patches of green. They can create a connected network using streets as new connection lines.

//Industrial atmosphere//
The former harbor areas give an industrial atmosphere

//Industrial buildings//
The large industrial buildings and machines of harbors can be used for new industries (3Dprinting lab)

//Bicycle transport//
The municipality wants to be the bicycle city of 2018

// Changes//

//Open up the built up surface/
To improve infiltration of rainwater

//Water backbone/
Give the river more functions to make it a connecting factor instead of a gap.

//Evacuation system/
Focus also on the third layer of safety approach. Create a clear evacuation system.

// Generate green energy /
For energy supply for the city.

//More mixed neighborhoods/
Embrace diversity by creating mixed housing

//Shared economy/
In the light of sustainability space and goods could be shared

//Community/
Every neighborhood should have a community place or center

//Space for recreation within 500 m/
Every citizen should have space for leisure within 500m

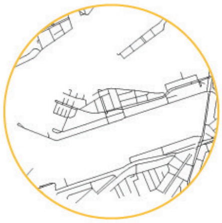
//Interaction between citizen/
The interaction between citizens should be stimulated

///
The built environment can contribute in raising awareness for the climate change.

// Micro- Neighborhood

This is the introduction to the smaller scale, where design starts to play a large role. To be able to develop the city as a whole in a different way, the design needs to be made more tangible. To see what the impacts are of the current infrastructure in terms of dimensions and to see how much space is now used for what, the project zooms in to the neighborhood scale (Katendrecht). Rotterdam has a lot of different typologies in neighborhoods. However there is only one area analyzed in more detailed (Figure 62). It can function as an example for more neighborhoods. To be able to start the design phase the analysis of these areas focuses mostly on the current lay out of the urban structure and the way it is used by the people living there. As the other scales the qualities and changes will be discussed to prepare the design properties.

The main reason why Katendrecht is selected is the fact that it is an old harbor transformed to an residence area. There is still some industry left. The example of Katendrecht can show how densification in a existing city structure can take place. It is important that the findings on the city scale can be further explored on the neighborhood scale.



Katendrecht-
Buildings
Streets
Open space

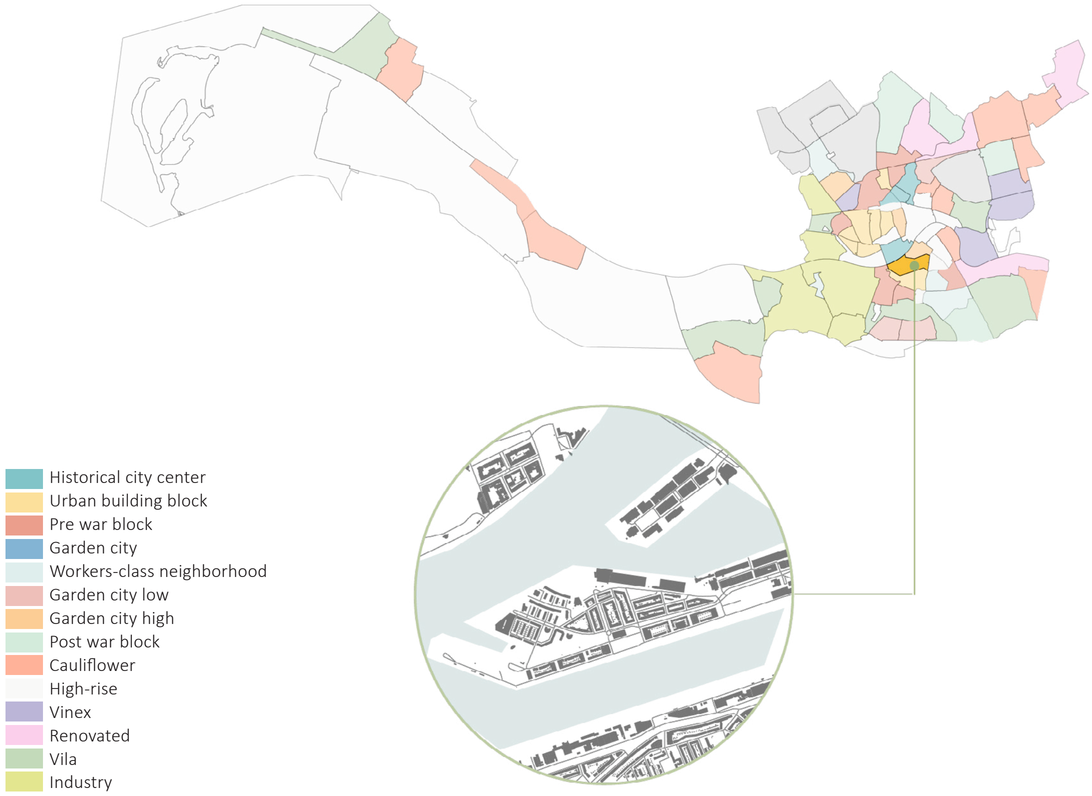


Figure 62| The diversity of types of neighborhoods in Rotterdam could be clustered in this way. Katendrecht could function as an example for other neighborhoods. However, every area has its own context that needs to be taken into account in the assessment and design phase. (Image by author based on Wijkprofiel.rotterdam.nl)

// Katendrecht

Katendrecht has a rich history as a small part of land that was dyked in the 14th century and under government of a landlord. More recent (1895) Katendrecht has been Annexed together with Charlois to the municipality of Rotterdam. Katendrecht has a variety of atmospheres going from dense in the east (1) to park neighborhood (3) in the west. Since Katendrecht is surrounded by water there are also waterfront housing. The water that surrounds Katendrecht gives the opportunity to have great views from the Katendrecht waterfront to the opposite sides of the water.

Besides the connection to the water and the long waterfront, the previous harbor life can be recognized in more features. The roads bend slowly as they were former rail tracks and there are still some industry buildings left (phoenix hallen).

The density within the area vary a lot, since the 'center' has a more urban block system, where towards the west a more park area is built up.

In the following maps several features will be mapped and then the main qualities or improvement points will be highlighted. The data inventory and process models therefore overlap.
The following themes will be explored in maps:

Physical
-Green (Figure 63)
-Height (Figure64)
-Roof shape (Figure 65)
-Water (Figure 66)

Social
- Density (Figure 67)
- Use (Figure 69)
- Function (Figure 68)
-Type (Figure 70)

Mental
There are two community centers in Katendrecht. One has a entrance fee and is therefore not accessible. The other is a meeting place for people more broad than the neighborhood. Community center 'Belvedere' promotes as a story center, where it tells stories of the citizens in words, images, movie clips or food. This kind of community center is very desirable as it brings people from different backgrounds together.


1


2


3

Green

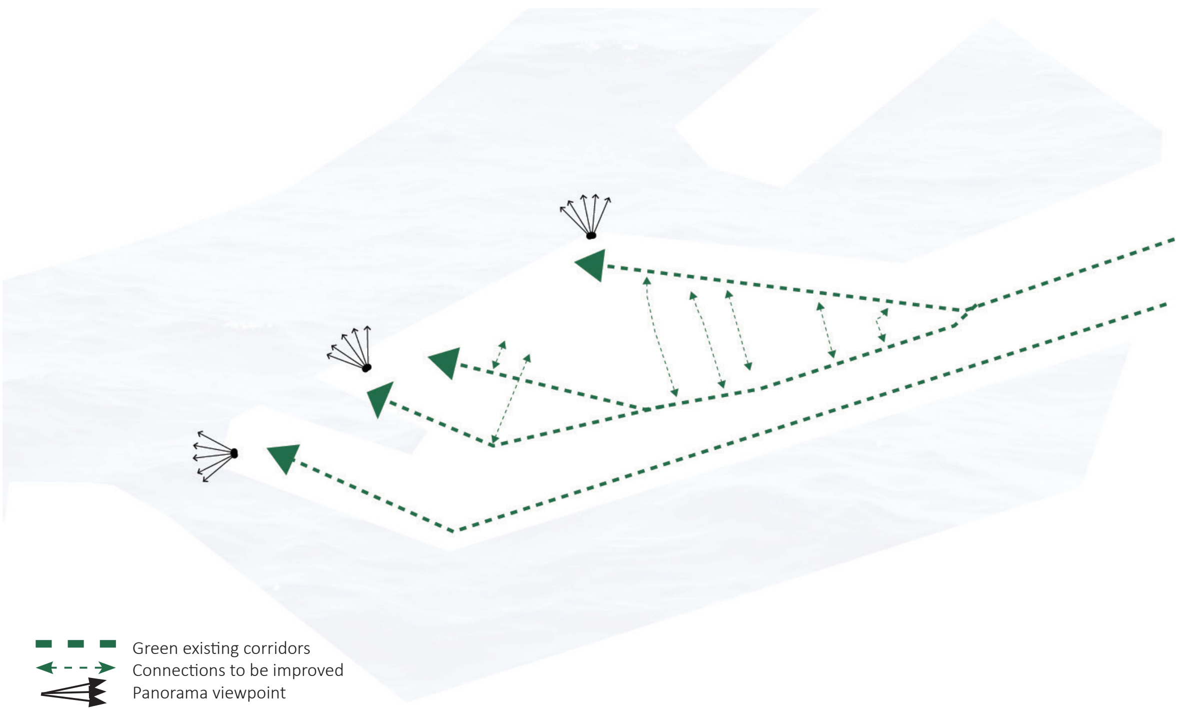


Figure 63| The green structure of Katendrecht shows a large diversity within the area. The west has a lot of parks, but the east part is rather paved. The green corridors lead to the view points on the quay.

Height

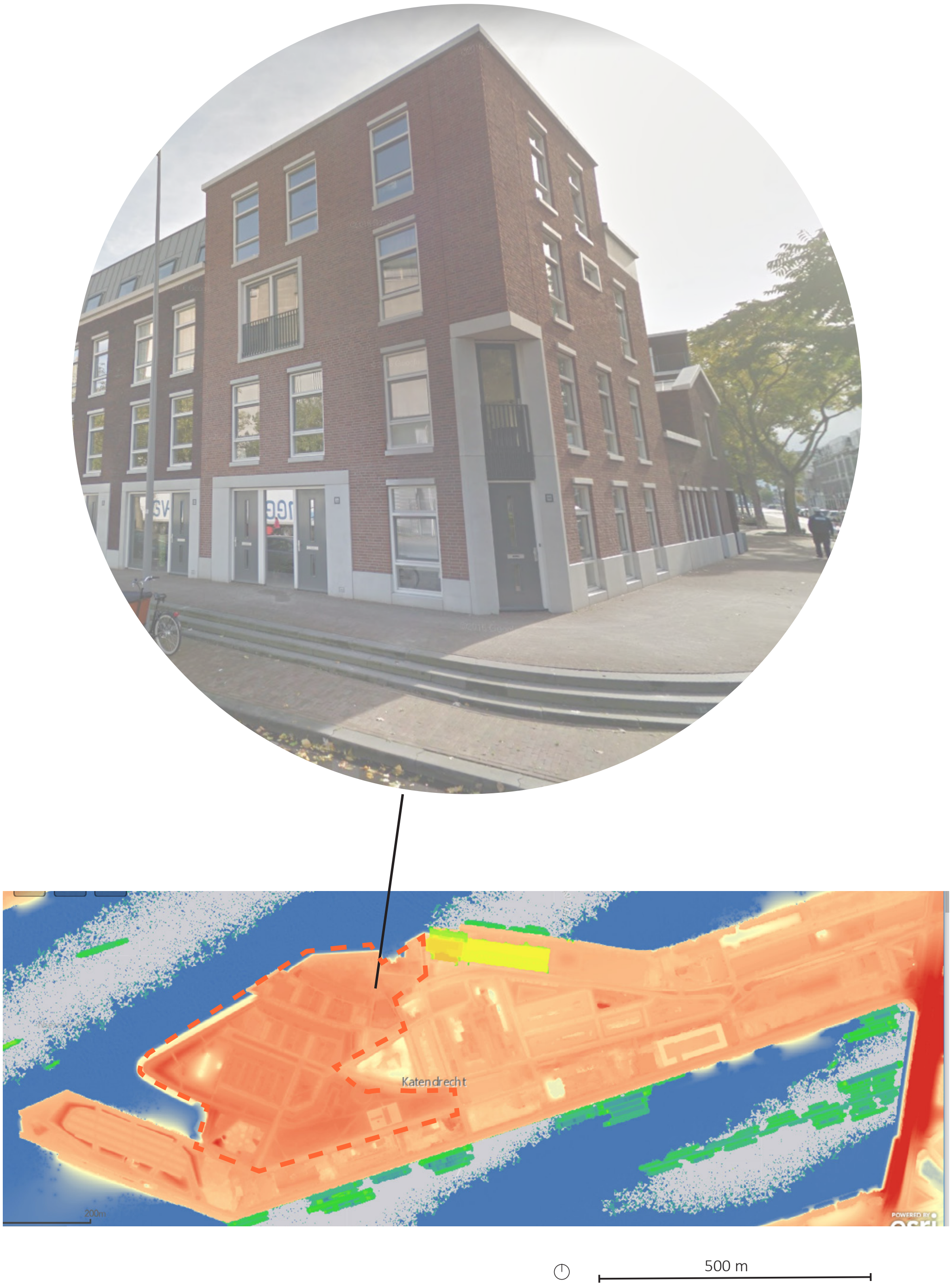


Figure 64 | The area has almost everywhere the same height. In the west the surface is topped up a bit, mostly because the houses there are build more recent. (Source : AHN.nl)

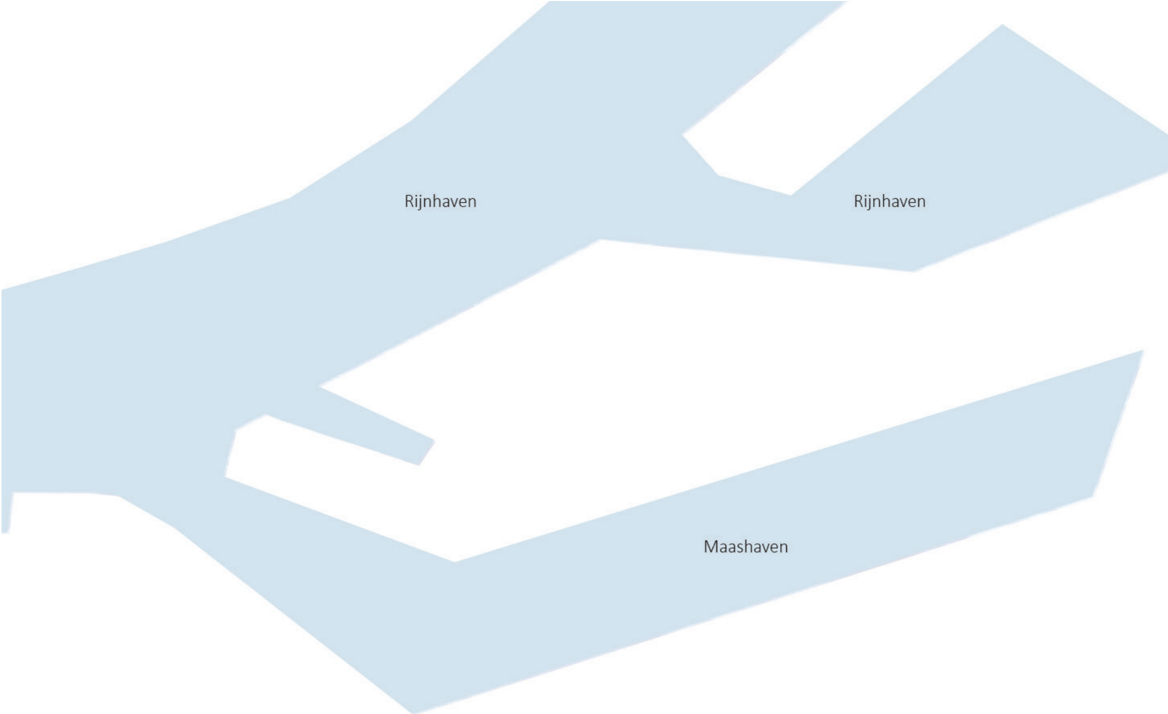
Roofshape

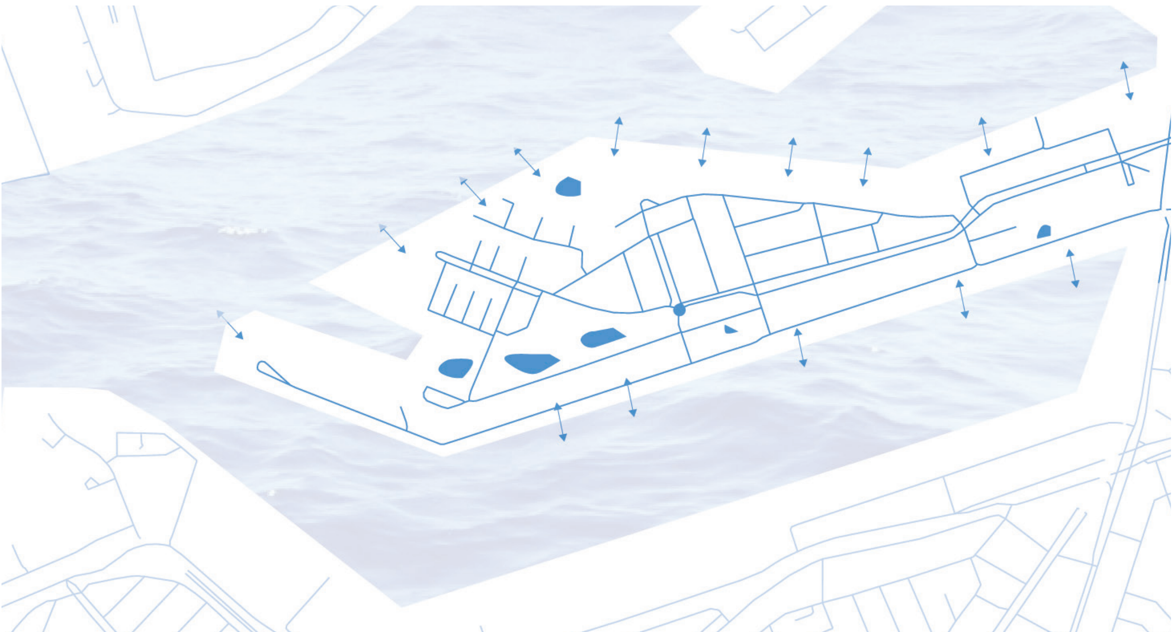
Green patches
Buildings with flat roof
Buildings without flat roof

1887-1921
1921-1934
1934-1956
1956-1966
1966-1979
1979-1987
1987-2000
2000-2015

500 m

Figure 65 | The top map shows the amount of flat roofs. Most of the roofs of the buildings in Katendrecht are flat. This is beneficial for the option to top the existing building stock up with one or two floors. The map on the bottom shows the building year. Topping depends of course on the structural capacity of the old building too, which is also depending on the building year. Moreover the industrial buildings can often carry a lot of weight. Using a wooden frame construction a light floor could be added.





Better connection of daily life to water
Local street run off
Local storage pond

500 m

Figure 66| The water structure of the current situation is limited. There only water body is the river Maas. There is no on-land water storage or pond. Therefore there is a possibility to improve that (see the image below). Besides the function of storage and cooling down, water in the urban structure can provide an image or for example be used to beautify the street. (Image by author)

Densities

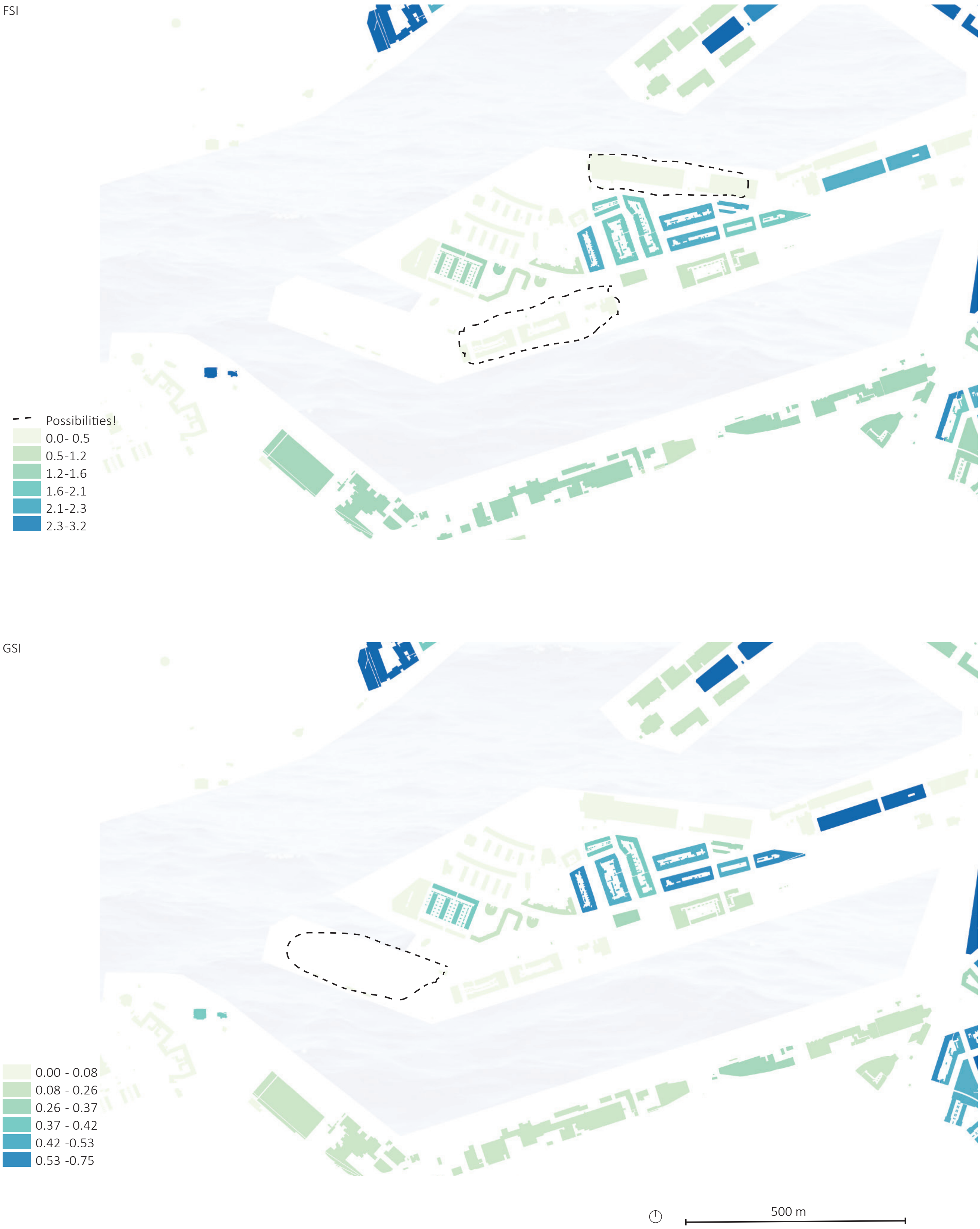


Figure 67 | The density values of the neighborhood show what type of densification is possible on what block. It also shows that there are still large plots empty that can be reserved for future development. (Image by author)

Functions

Sporting

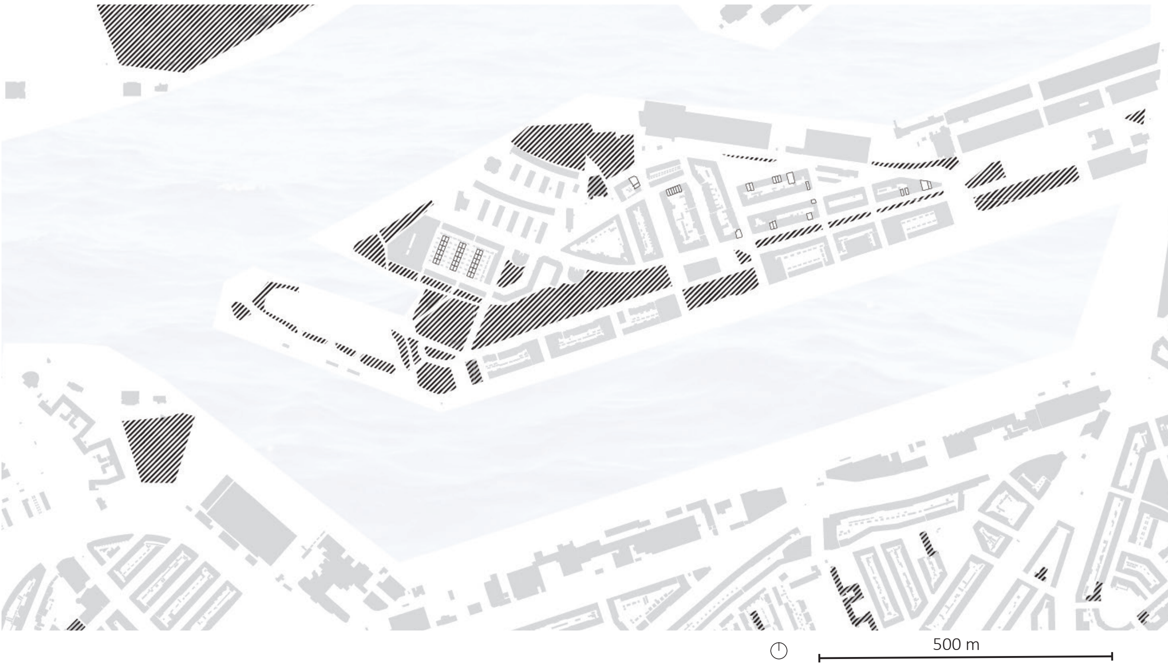


Figure 68| This map shows the functions per building. Most of the blocks have a residential function. There are also large patches of industry. If functions could share space and use it in different time slots, this could result in more space for residential functions. The activities are marked in the categories of eating, meeting and sporting. (Image by author)

Eating

Meeting

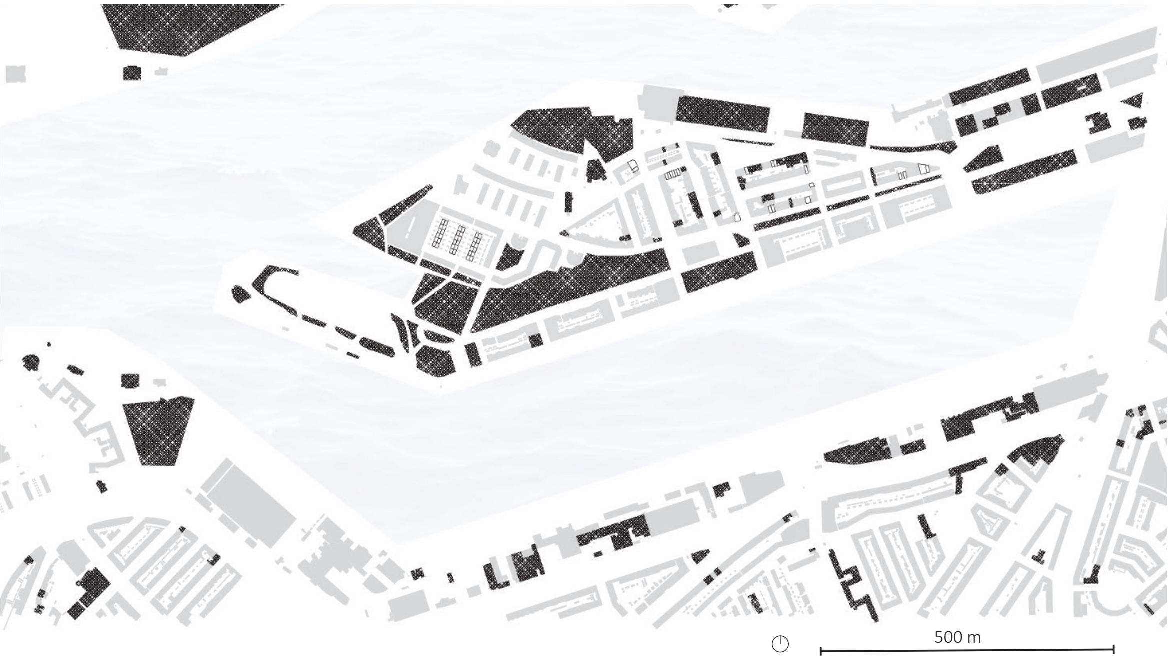
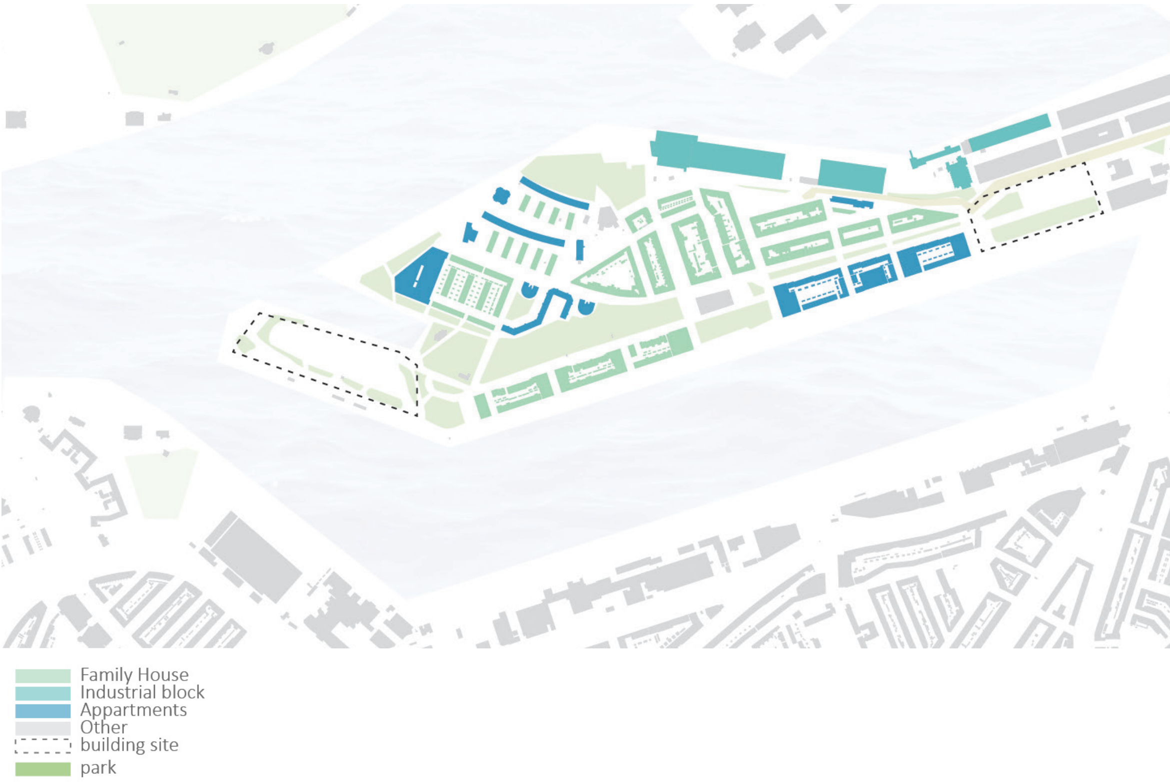


Figure 69| This map shows the functions per building. Most of the blocks have a residential function. There are also large patches of industry. If functions could share space and use it in different time slots, this could result in more space for residential functions.

Type of housing



Type of topping up per type of existing building

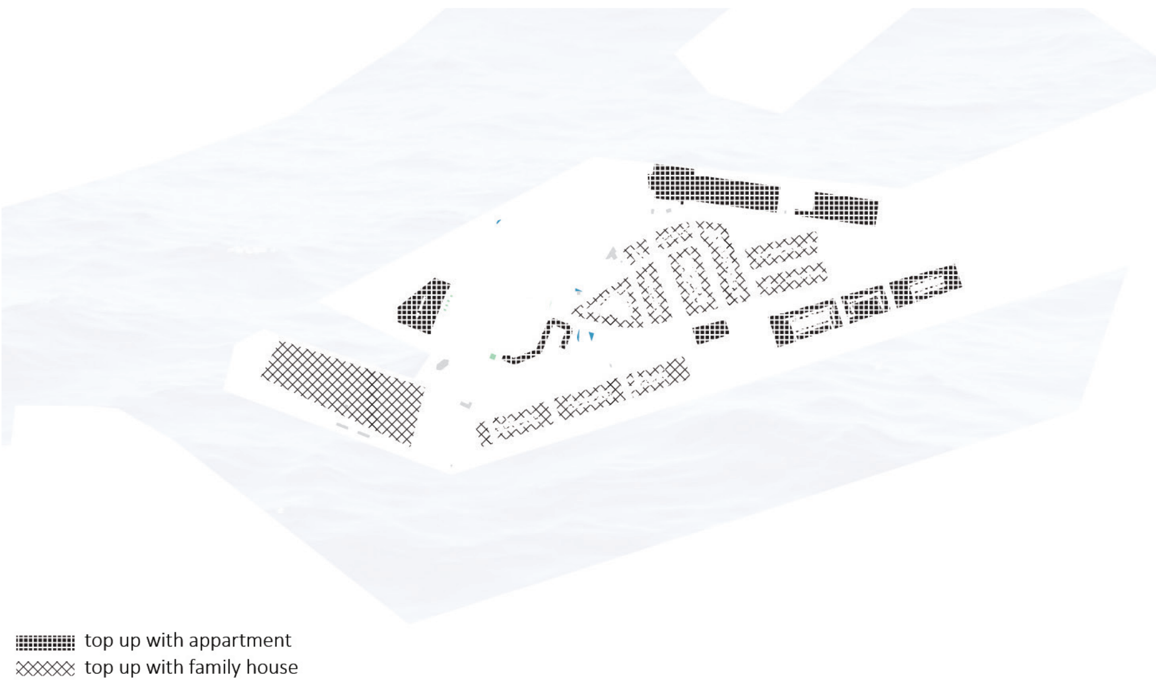
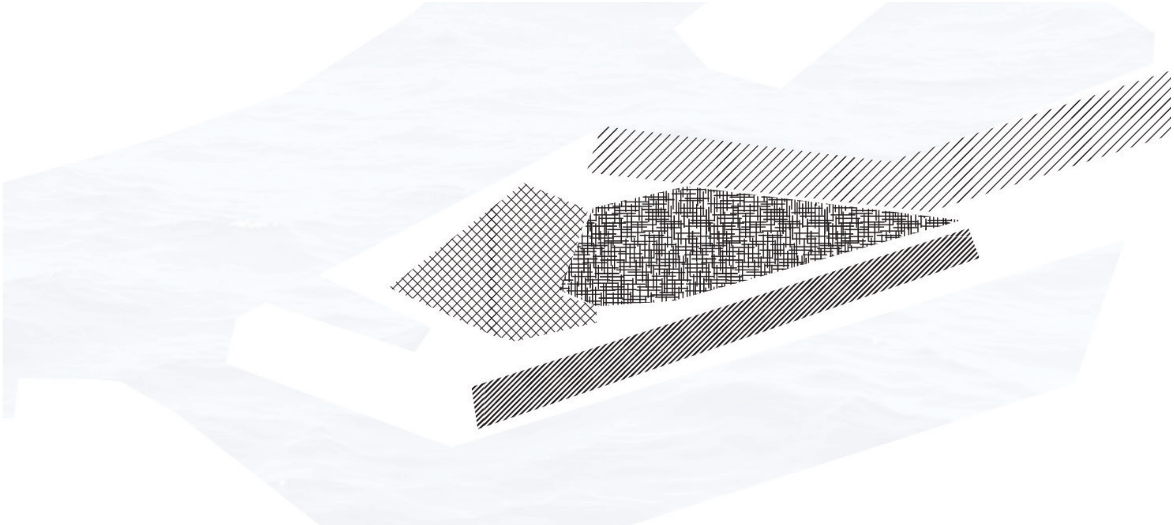


Figure 70| This map shows the main type of housing per block. The family houses have their own entrance where the apartment blocks have a shared staircase. In the light of a more mixed neighborhood it could be good to add the opposite type of housing to the current structure. So the apartment blocks would be topped up with family houses and the family houses will be topped up with apartment blocks. (Image by author)

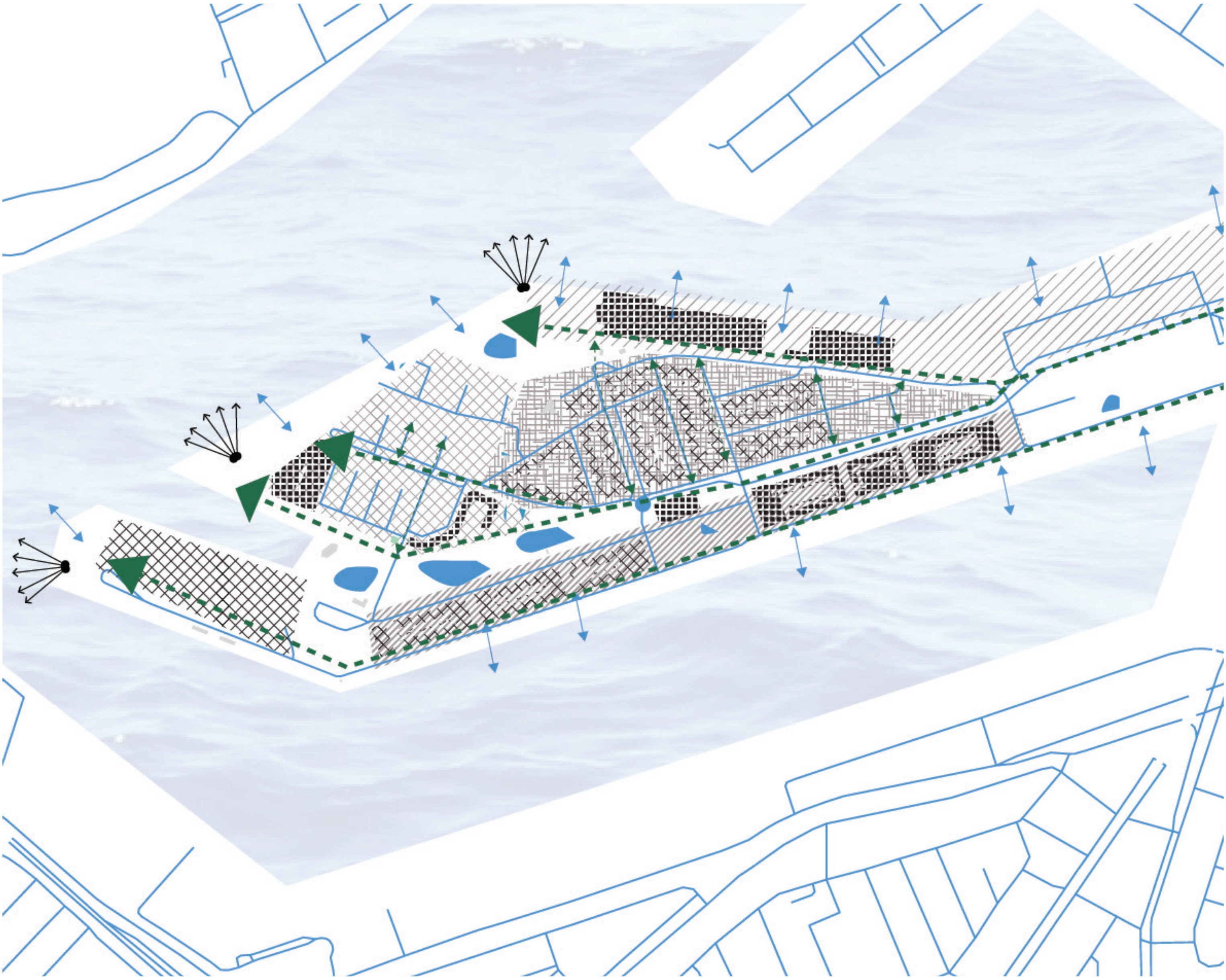
Time slot per type



Mixed use and shared use on different time plots on the day. Gives more space for dwelling.

Densification of dwellings. Since the new island has less space, the space that is there has to be used smarter.

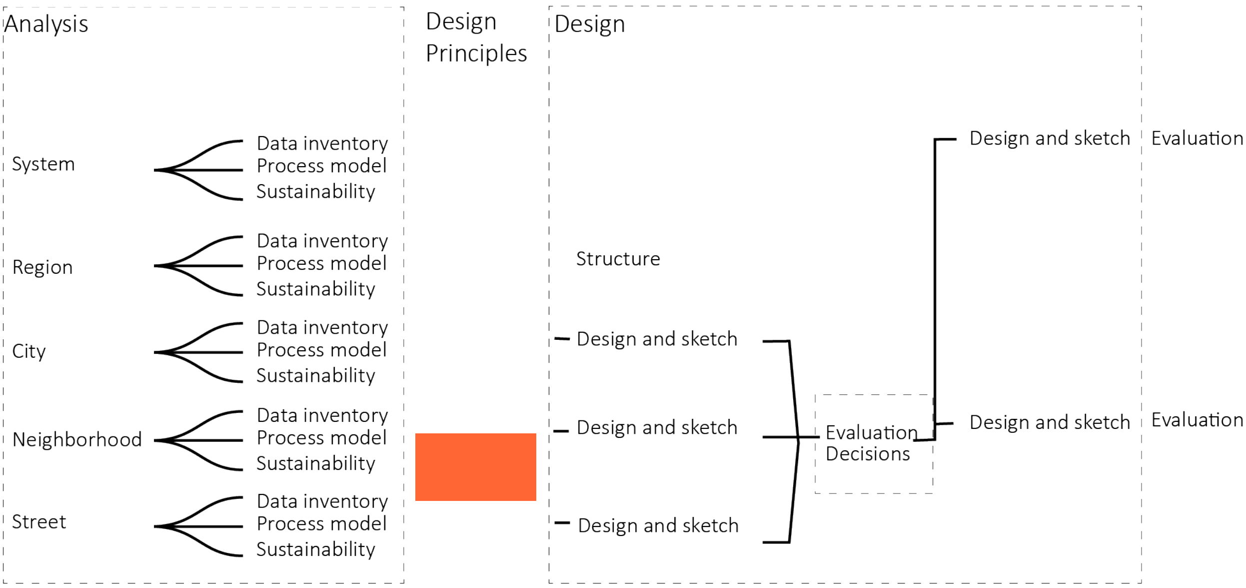
Densification in use Sharing facilities for several functions possible on other times of the day. This creates space that can be used for dwelling



Densification of 'tools' such as cars or working tools. Sharing is in sustainable perspective one of the goals for the new development.

The interventions should bring a stronger community. One of the goals of the municipalities to have a more mixed city with more social cohesion

// Design properties- Neighborhood scale
The neighborhood scale shows how connected the mental social and physical city are. The physical condition influence the social and mental perception and behavior of the inhabitants. To be able to raise the awareness of sharing goods the physical space where those goods can be shared can be crucial. Katendrecht shows a lot of differences in density and in milieu. This makes it an interesting neighborhood as an example.



// Qualities//

//The green street//
There is a green connection trough Katendrecht that leads to the parks in the west. This green corridor connects several green patches.

//Diversity in urban blocks//
There is a more high urban area and a lower dense area

//The industrial background//
The roads on former tram lines and the industrial buildings in the North hint to the former harbor function. This could be emphasized more.

//A long waterfront//
The views you can get in Katendrecht are beautiful. The waterfront is very long.

// Changes//

//Diversity in urban blocks//
The densification has to respond to the different types of urban block, also the FSI and GSI values.

//Green Streets//
The green street could expand and made more use of by adding functions besides it. Also the blue infrastructure could connect with it.

//Creating a blue infrastructure//
Katendrecht is surrounded with Water, but there are no ponds or ditches inside the neighborhood.

//Use the waterfront//
There could be made better use of the visual quality of the waterfront. Also it could be used to connect people to the water or create awareness of the changes in the water level.

//Sharing in the mindset//
To aim at a more sustainable city network, the urban fabric can contribute to stimulating sharing within the community. By opening shared shop where people can share goods as hammers, or having a carpool parking lot.

//Densification in use//
There are several buildings ore spaces that are used for the similar use. By combining for example a school building for education, cultural lessons and a cinema in different time slots, the space is used more optimal.

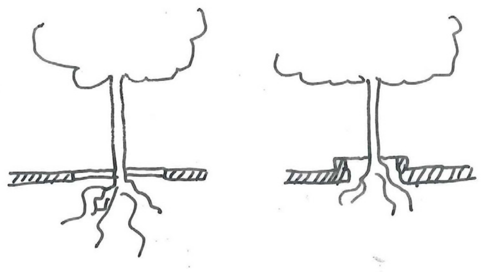
// Neighborhood scale

Data inventory

Physical

Roughly there are two type of pavement in the streets of Katendrecht: asphalt and red bricks. The asphalt road are placed in east west direction and function also as main access roads. The perpendicular and smaller roads are paved with bricks. As the zoom in image 72 shows the roads are a contiguous paved area. There are almost no unpaved areas in the street section of most streets. Only the 'brede hillerdijk' has a green island in the middle of the lanes. On the other streets the only gap is when there is a tree, but often this is even topped up with a rubber sheet.

The brick roads have a small height difference to lead the water to the street, where the manholes are positioned. The asphalt roads have two levels: the water form the pedestrian lane flows to the cycle lane where it is collected in the gutter and manhole. There is a second manhole on the car lane.



Even though the gaps between the brick allow the water partly to infiltrate, a large part will end up in the sewer system and result in extra pressure.

The section also shows that most of the houses have an entrance on the same level as the street. Some doors can only be entered via stairs as figure 71 shows.

Social

The social capacity of the street is closely related to the physical street. Are there spaces to meet each other, or to gather or sit on a bench? Of course it is also related to the higher scale, to what density and functions are there. Most of the houses in Katendrecht do not have a front garden. This could reflect in the fact that people personalize a small part of the pedestrian lane by for example placing chairs or flowers. Walking through the streets of Katendrecht there are not a lot of personalized pavements.

Mental

The mental component of the street could be whether people feel safe in the street. A lot of factors can contribute to feeling safe or not. Street lights, liveliness and the street-on-the-eye effect. If for example the first floor is completely filled with car parking, there is no social control. If something would happen you have the feeling that no one will notice.

Figure 72 | Continuous paved areas in Katendrecht

Figure 71 | In this street in Katendrecht personalized pavement is already happening. Small gardens and terraces make the street more lively. Also the door has small steps in front, that prevents the house from flooding (for a while) The steps could be made higher to increase this effect) (image by Google earth).

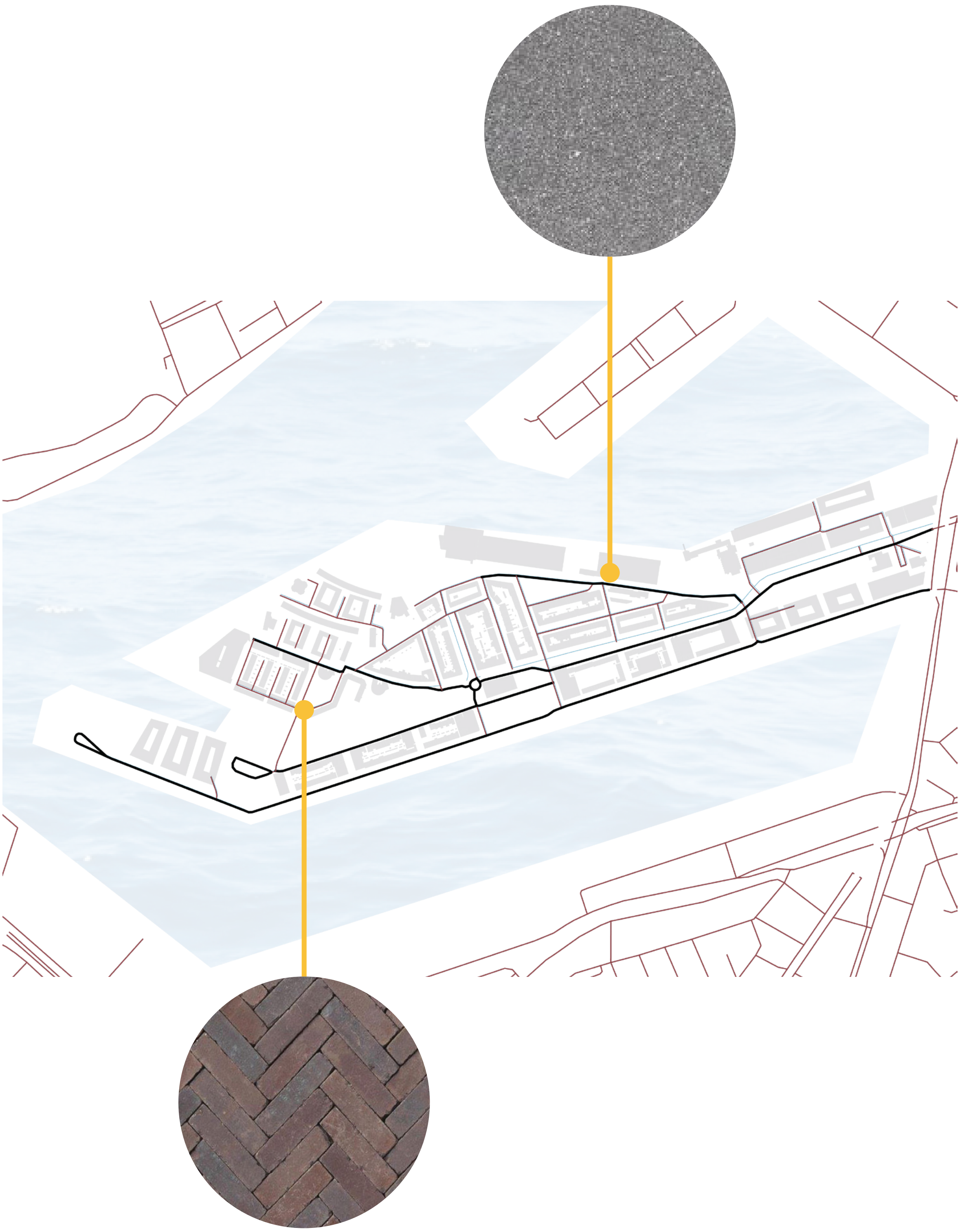


Figure 73 | The two main street types of Katendrecht. One is paved with bricks, the other with asphalt. (Images by author)

Process models

Physical
Rotterdam has goals to have more green areas in the city center to stimulate infiltration. Katendrecht has a lot of green areas in the form of parks, especially at the West side of the island. This does not mean that there could not be more green, especially in the heart of the area. The Street section show only trees and no green patches.

Social
The pavement can opt a lot of behavior. Along the waterfront at the south side there is a distinction in pavement visible that can stimulate people to 'claim' this small patch and personalize it. Urban furniture such as small poles can stimulate this effect even more (figure Figure 74).

Mental
The lights in the area are placed along the roads, not so much in the park. Also the waterfront at the west side does not have a lot of light.

Capability/ sustainability models

Physical
The heavy precipitation that climate change could bring need a more constant infiltration beds or water collecting lines. Green does not only help to infiltrate the excess of water but can contribute cooling down the air as well in hotter times. The street can have a base of green and then a added paved area, instead of the other way around. Considering the possibility of a flood, the section should also be designed in a way that the water can drain away again. To encourage the sharing society mentioned in the neighborhood scale the street scale can limit the car parks. By sharing cars and using shared parking spaces it can be made more beneficial to use the shared cars than private cars.

Social
To stimulate contact between people the distinction between public and private could be less strict. By creating an in-between zone community interaction can be stimulated. (Figure 74).

Mental
The awareness of climate change, sharing economy and the diversity of people can be raised by adding elements in the street that make people think. An example is stimulate sharing cars by limiting the amount of parking spaces. Or make a distinct way of pavement towards the evacuation zone. The street at night shapes also part of the mental street, lights for example can increase the feeling of safety (Figure 75)

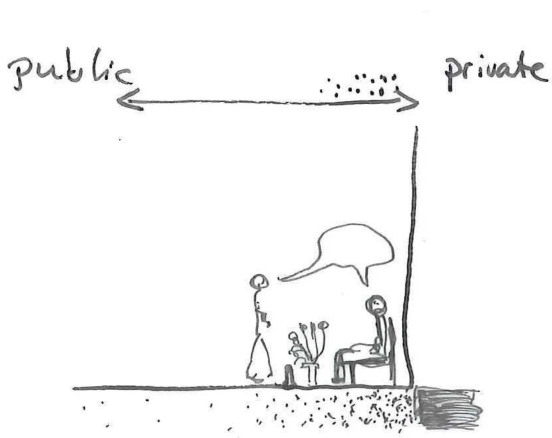


Figure 74| A personalized pavement contributes to interaction between neighbors and citizens. It also softens the border between private and public. (Image by author)

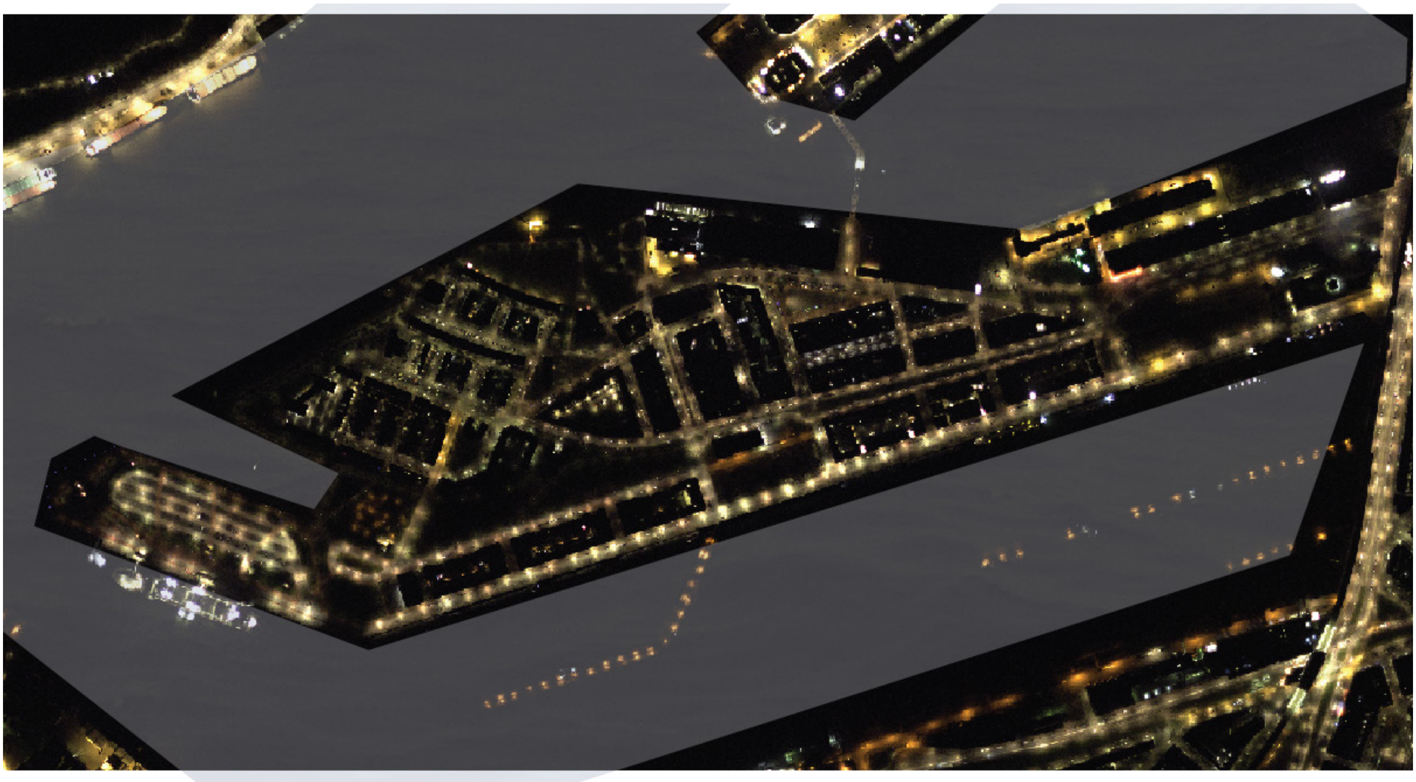
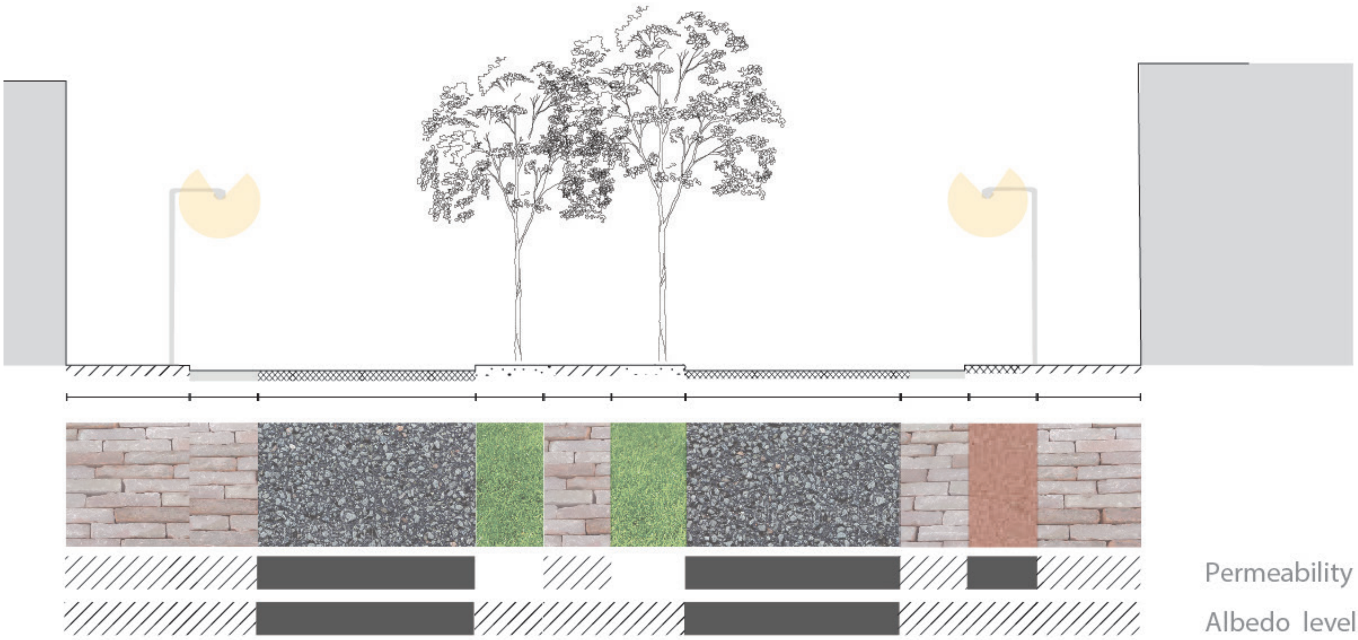
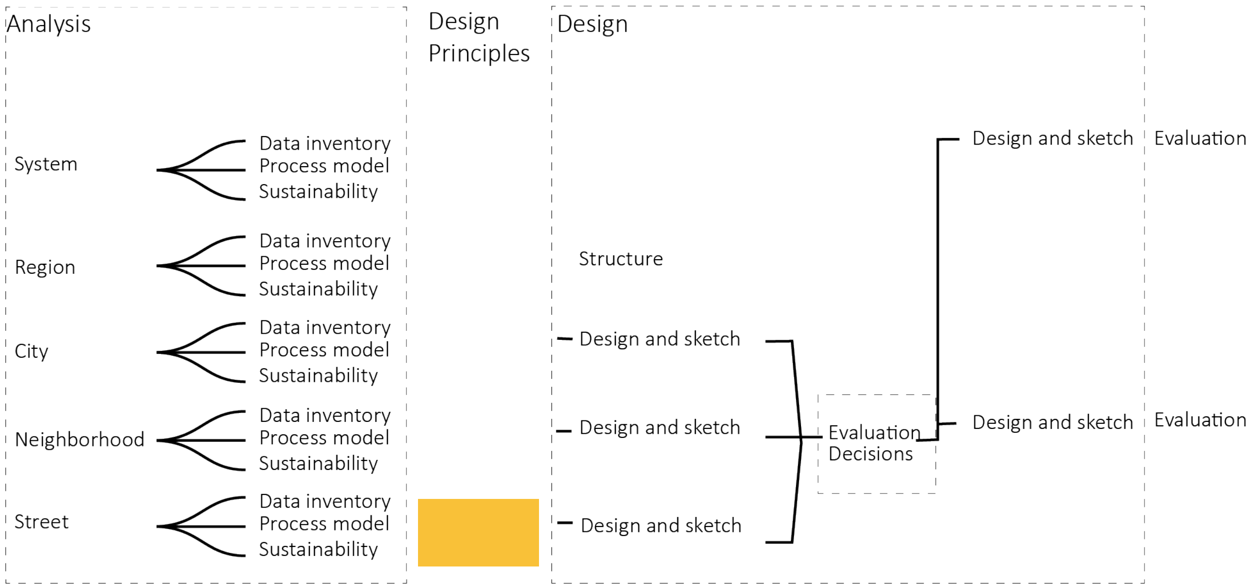


Figure 75| The identity of a neighborhood is partially determined by how it feels at night. Are there enough lights, does it feel safe? (Image by author, data from gisweb.nl)



Permeability
Albedo level

// Design properties- Street scale
The street level brings all the networks together in the smallest detail. Not only get the Grey, Blue and Green infrastructure connected with each other, they also get connected to the social component of the city. The change of a system needs also bottom up action. This can be stimulated on the street scale.



// Qualities//

//Space for personalized pavement//
Some streets have marked a small piece of the road available for residents to personalize. This could be implemented in more streets.

//Higher entrances//
Some houses have the entrance on a different level than the street. This can be beneficial when a small flood occurs.

// Changes//

//Improve infiltration/
The street could offer a more connected line of infiltration, to release pressure on the sewer.

//Green in the street /
Green in the street has cooling down capacity, water storage and can make it a more pleasant area.

//Street lights//
They can be improved to shine more smart (only to the ground, different time slots)

//Meeting places//
The street can offer a space that is a bit more private than public, to generate areas where people can meet or talk.

//Less parking spots//
Decrease the amount of parking space (also stimulate shared car use).

//Less paved area//
The streets are now paved from door to door, this can improve.

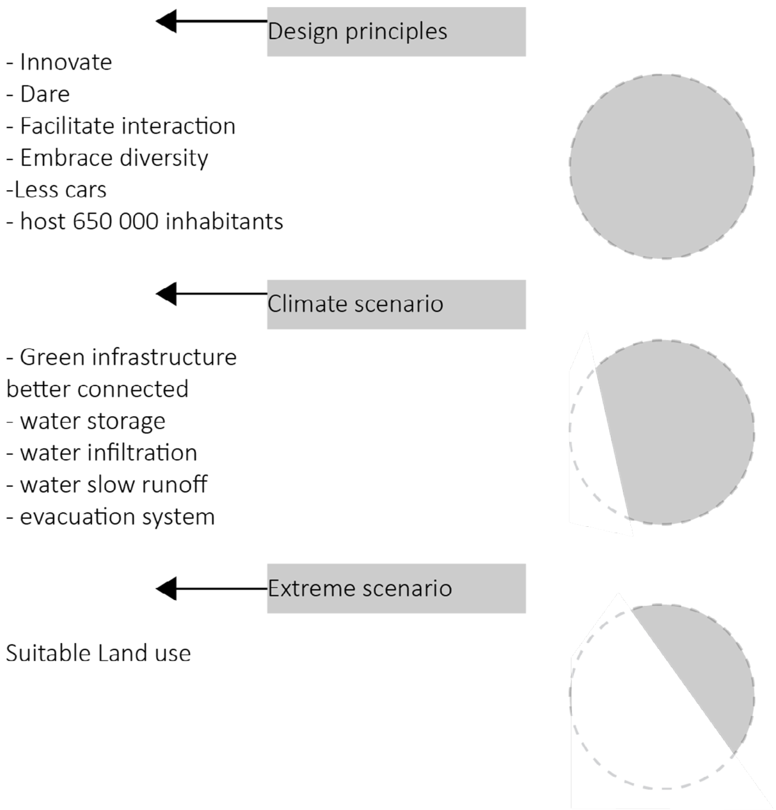


Figure 76| This scheme shows that the 'general' design principles that have been discussed in this document so far need to be achieved on suitable land. The extreme scenario results in less available land. (Image by author)

// The assessment conclusion

The conclusion of the assessment is shown after every scale in a conclusive scheme. The assessment has resulted in design principles that can either state to keep some elements and emphasize them or to change them. The next page shows a large scheme where the design principles are ordered in themes that correspond to the themes in the design intervention phase. The color of the border corresponds with the scale where this design principle is most valuable. Some of these principles are highlighted in the GeoDesign chapter of the report and others are visible in the visualizations.
There are also design principles based on the scenario as described in the theoretical framework, such as the fact that only the higher grounds can be used for development. These principles are overruling. In other words: the design principles have to be achieved only using the land that is suitable for settlement. Figure 76 shows this.

//Densification in use//
There are several buildings ore spaces that are used for the similar use. By combining for example a school building for education, cultural lessons and a cinema in different time slots, the space is used more optimal.

//Industrial buildings//
The large industrial buildings and machines of harbors can be used for new industries (3Dprinting lab)

//More mixed neighborhoods/
Embrace diversity by creating mixed housing

//Community/
Every neighborhood should have a community place or center

//Interaction between citizen/
The interaction between citizens should be stimulated

//Diversity in urban blocks//
The densification has to respond to the different types of urban block, also the FSI and GSI values.

//Diversity in urban blocks//
There is a more high urban area and a lower dense area

//Space for personalized pavement//
Some streets have marked a small piece of the road available for residents to personalize. This could be implemented in more streets.

//Meeting places//
The street can offer a space that is a bit more private than public, to generate areas where people can meet or talk.

//Evacuation system/
Focus also on the third layer of safety approach. Create a clear evacuation system.

//Investing in the higher grounds //
Accepting that parts of the Netherlands are below sea level could lead to discovering centralities in the country.

//Relocate unsuitable areas//
Define settlements based on the substratum layers.

//Densify suitable areas//
Define settlements based on the suitability for densification.

//Relocate economy in unsuitable areas//
Invest in industry at the higher grounds

//High grounds//
Use the high grounds for future development

//Evacuation road/
A higher road that is usable during a flood

Densities

Densities

Design Principles

Grey Infrastructure

Blue Infrastructure

//Preparing for the consequences of climate change// Increased river discharge
Extreme precipitation
Drought
Sea level rise

//Making use of the sediment of the river//
The dykes prevent for heighten up the hinterland, so subsidence and tectonic plate changes are cannot be corrected. The low lands could benefit of its position in the Delta.

//Water backbone/
Give the river more functions to make it a connecting factor instead of a gap.

//Water backbone//
Use the water backbone as buffer or as retention basin

//Creating a blue infrastructure//
Katendrecht is surrounded with Water, but there are no ponds or ditches inside the neighborhood.

//A long waterfront//
The views you can get in Katendrecht are beautiful. The waterfront is very long.

//Using the water we have in the delta//
Make use of the leisure qualities and transport options of water.

//Use the waterfront//
There could be made better use of the visual quality of the waterfront. Also it could be used to connect people to the water or create awareness of the changes in the water level.

// The water collection starts at the street scale/

//Use the existing road network/
The city has an organized road network, even in the harbor there is a clear structure.

//Bicycle transport//
The municipality wants to be the bicycle city of 2018

//Open up the built up surface/
To improve infiltration of rainwater

//The industrial background//
The roads on former tram lines and the industrial buildings in the North hint to the former harbor function. This could be emphasized more.

//Less paved area//
The streets are now paved from door to door, this can improve.

//Less parking spots//
Decrease the amount of parking space (also stimulates shared car use).

//Higher entrances//
Some houses have the entrance on a different level than the street. This can be beneficial when a small flood occurs.

//Existing green patches/
There are already large patches of green. They can create a connected network using streets as new connection lines.

//Space for recreation within 500 m/
Every citizen should have space for leisure within 500m

Green

//Green Streets//
The green street could expand and made more use of by adding functions besides it. Also the blue infrastructure could connect with it.

//The green street//
There is a green connection trough Katendrecht that leads to the parks in the west. This green corridor connects several green patches.

//Green in the street /
Green in the street has cooling down capacity, water storage and can make it a more pleasant area.

//Improve infiltration/
The street could offer a more connected line of infiltration, to release pressure on the sewer.

Centralities

The extreme scenario

//No settlements below sea level/
Use the +3 meters of the scenario

//Avoid building new dykes/

//Increasing adaptive capacity/
Reserve space for future changes

//Wet proofing /
Of the buildings and the streets

//Adapt for heavy precipitation/

//Adapt for dry summers/

//Adapt for oil depletion/
A system that runs on renewable energy

//Enhancing Multi-level safety approach//
Emphasize on spatial planning and evacuation level as well.

//Cluster of cities//
Be less dependent on cluster. In case of extreme flood the cities need to function as well.

//Keep being innovative in water engineering//
Find ways to deal with the water problems of the future

//Shared economy/
In the light of sustainability space and goods could be shared

//Awareness/
The built environment can contribute in raising awareness for the climate change.

//Industrial atmosphere//
The former harbor areas give an industrial atmosphere

//Sharing in the mindset//
To aim at a more sustainable city network, the urban fabric can contribute to stimulating sharing within the community. By opening shared shop where people can share goods as hammers, or having a carpool parking lot.

//Street lights//
They can be improved to shine more smart (only to the ground, different time slots)

//Critical infrastructure//
Use the critical infrastructure that is already there.

//Cluster of cities //
Benefit of the cluster Randstad, but do not be dependent on the cluster. (This is the change).

//Critical infrastructure//
Check infrastructure to define suitability

// Generate green energy /
For energy supply for the city.