P2 REPORT

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INTERACTIVE WATER STORAGE BUIKSLOTERHAM

DELTA INTERVENTIONS

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RESEARCH PAPER

Adaptive delta design & the city's future

A discussion on the role that adaptive design in relation to delta interventions play in the future design of the city

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Abstract – In today's urbanism practising focussing on how to make our cities more resilient to climate change and more sustainable towards the future, discussion rises on the best strategy and approach. With this and cities rising more rapidly nowadays than ever before, high density urban patterns develop mostly in delta areas. They, being attractive places in terms of climate, connectivity and resources, also pose a big challenge for designers. Delta structures form one of the most fragile man-made structures, often facing treats from both the sea and its hinterlands (H. Meyer, 2015). This paper discusses the way urban design thinking has changed over the years and how this relates to delta design. It also looks at delta design in practise and relates this back to the theories.

The paper will, after an introduction into the problem state, provide an overview of the system thinking approach now and then. After that it will look at how those theories relate themselves to the theories in delta design, followed with some examples of delta design

in practise. It will end with a discussion, showing the authors point of view on the different aspects of the theories and how they relate themselves to practise. It will end with some questions and recommendations for future urban design practises.

Key words – adaptive design, delta cities, complex city, flexible design,

Introduction

Large river deltas are currently the places that experience the highest level of urbanization, population growth and economic development. But at the same time these regions are the most vulnerable areas to climate change. The Netherlands is one of those areas (Meyer, 2015).

With the effect of climate change becoming more clear every day, it becomes a proven fact that we should adapt, both as individuals and society. For the Netherlands the KNMI expect a sea level rise between 60-80 cm in the next 70 years, and an increased amount of rainfall of about 7% (Koninklijk Nederlands Meteorologisch Instituut, 2015). It can therefore be said, that water in urbanized river deltas, and how to deal with it, is one of the mayor issues that urban designers need to solve in order to ensure the future of urbanized delta areas.

Water flows in urban areas come in different shapes and sizes. While at one time we expect an increase in rainfall and a sea level rise, at the other hand large part of the world are expected to have a shortage of fresh water supplies. This raises the costs for cities and damaging the environment. Ironically, these cities seem oblivious to the abundant water flowing through them, an obvious (clean) water source, limiting its own potential.

The urban water circle consists of 3 mayor elements; ground water, surface water and water vapour in the atmosphere. But the circle itself is much more complex, with different flows connecting the elements together (Forman, 2014). For urban designers the challenge lies in how they will use and adapt their design to the water surrounding it.

Future city – thinking approach

Urban thinking and urban planning has changed over the last 50 years. While at first the most prominent movement was that the city was a collection of different systems, all seen mostly separate from each other. This system resulted in a design approach that was very top down. But the biggest problem of this way of thinking was that it resulted into an urban design method that it very separated from the environmental surroundings of the city. The city was seen as a machine (Batty, 2013).

But the movement we see currently, approaches the urban system in a more organic way. It has moved, from thinking in controlled systems, to a complex system approach. This system gives more insights into the different subsystems, which remain defined as their own system, and how they influence each other and the surroundings of the city. This provides a connectivity between systems that shows the unpredictable nature of the systems. It also makes clear that there is a certain limitation to the amount of control we, as urban designers and planners, can have over the systems.

It could then be argued, that they should not be controlled at all. But designed in a way that they can sustain themselves. This would result into an urban system that is robust, meaning it can withstand changing conditions, resilient, so that it can recover from possible damage, and adaptable, so it can adjust to the unpredictable nature of the systems (Allmendinger, 2002).

Because most of the population will be living in cities at the end of the century, it might be time to accept this complex system approach. The current movement still focusses on locations, instead of interactions, on cities as idealized morphologies, instead of cities as patterns. In short, in order for the city to become adaptable, robust and resilient to the unpredictable nature of the surroundings of the urban fabric, urban designers and planners need to think of them as networks (Batty, 2013).

Future city – delta design possibilities

The complex system approach might be accepted in theory, but, as always, it is a big step from theory to reality. Even in delta design theories there is a different point of view on the role adaptivity should play. We see several of the teachers from the TU Delft, including Han Meyer, starting to work on the process of relating the theory of complex system design to more specific parts of urban design, like delta design.

Han Meyer starts his book with 'After nearly half a century of the "Dutch Planning Doctrine", the time is now ripe for a new approach to spatial planning and design. In complex urban areas in particular, the question is no longer how to register and guide spatial development. Instead, the question is how to enable conditions so that areas can adapt to changing circumstances.' He argues that delta systems are complex systems, influenced by the environment, which is always changing. In order to design with such a system, we need to create a complex adaptive system. Such a system has a few features, so that it is adaptable. First of all, the system needs to be an open system, meaning that it reacts to and with it's environment, but is also subject to external influences. When the environment is identified and analysed in relation to the urban system, the urban designer can create a working system of the whole. This relationship should be clear through the different scales of the design. The adaptation side of the system makes it possible for it to evolve. This approach conceptualizes, in the authors eyes, all aspects of integrated design, as well as operationalizing them (H. Meyer, 2015).

While the Complex Adaptive Systems theory of Han Meyer fully embraces the complexity and uncertainty, arguing that the design approach of such systems in a very abstract and complex manner, there are also more direct and simplified theories about how to deal with adaptivity in delta design. One of these theories is described by Frans van de Ven. He describes 3 different approaches to delta design, each focussed on efficiency and simplicity. The first, the one he calls 'target image approach', centralized the problem and forces the planner or designer to develop multiple different scenario's, each designed for a different outcome. The driving force behind the project is the goals set for the future, the image they want to achieve in the end. Adaptivity in this process comes from the different scenario's, but only when the designer consciously seeks this. The different scenarios form a base to design the urban fabric, based on different starting points. When chosen to combine these scenarios into a system capable of dealing with all of them, the system in itself becomes adaptable. The second approach, the guiding principle approach, says to create a toolbox, to help the designer achieve a solution to the problems. This approach lets complex problems stay complex and encourages the designer to work with the systems the way they are. Adaptivity in this process comes from the fact that the systems aren't simplified down, which could hide the possible need for adaptation.

The complexity shows all the different elements the project is influenced by, indicating that it needs to be able to adapt to all its different circumstances. The last approach is called the negotiations approach, and this names the stakeholders and the discussion between them as the main driving force behind the project. Adaptivity is needed in this process to create a design that will foresee in the needs of all the different stakeholders, both in the current as well as in the future (F.M.H. van de Ven, 2005).

In current designs now being developed we see an interesting change, from adapting the city to be able to withstand water, to it becoming more in balance with this nature element. One interesting plan is that of Denmark's Delta District in Vinge, by SLA architects. It's a sustainable city located close to Copenhagen. The plan uses the features of the landscape to create an unique residential community with a close connection to the environment. The main issue driving the development of Vinge is the challenge of storm water management in the region. This region of Denmark is hit by seasonal flooding almost every year. The design of Vinge aims to be flexible enough to allow space for the seasonal flooding, in a way that the city itself can still function both when it's flooded and when it is not. Thomas Sichelkow, the project manager of the project, has an interesting view on the problem, seeing as he describes water as 'having a great value, we cannot see the point in hiding it in big drains and pipes, therefore we would rather emphasize it and use it in the Delta' (Arch Daily, 2014).

But while some plans, like the one of Vinge in Denmark, specialize their design on flexibility, allowing for the unpredictable nature of delta design to take its course. Many other projects take delta design in a different direction. One example is the Aarhus' Waterfront design by BIG. What is interesting here is that they use the water as an element of identity, and an opportunity to connect the visitors and inhabitants of the area more to the environment. This is something that can often be found in

BIG Aarhus waterfront’

House integrated water

Vinge Delta

water design, as many architects and designers do apparently see the value of the water that it offers as an element of identity to the place. But often the unpredictable nature of it creates a design uncertainty, which would rather be solved by creating a strong enough barrier, so that the area behind it becomes more controlled, then to allow for flexibility and movement in the design plans itself (Arch Daily, 2014).

When looking at delta design on a smaller scale we see a different movement. The combination of climate change and a shortage of development sites leads to a trend in floating buildings, from London to China, they are being developed all around the world. Interesting here is the ambition for people to increasingly live and work on water, showing a stronger connection between inhabitants of the city and its environment. On a smaller scale people are looking at the opportunities the water offers us, the identity it gives and for ways to interact in a flexible way (Dezeen, 2015).

Delta design – discussion

When looking at the different theories we see that in the last 50 years there have been many discussion on the complex system thinking approach. But at the moment it is a generally accepted theory, educated at some of the mayor architecture and urban development Universities, like the technical University in Delft. It can be argued that specially for areas vulnerable to the effect of climate change, adaptivity is key. We have seen the problems with the previous design thinking methods, the more separate system related thinking approach, and are currently experiencing the results. Many cities nowadays struggle with the changing environment; it can be seen in the Netherlands after a period of heavy rainfall. Often cities experience inconveniences after a day of heavy rainfall, because the sewage system is not capable of discharging the large amount of water, and the high percentage of concrete prevents the rain water from seeping into the ground (Nagtegaal, 2016). But also in cities like Copenhagen, that experience a flood almost every year due to heavy rainfall (Ploeg, 2011).

While Universities are pointed to the complex city theory and adaptivity in design, in practise this is sometimes hard to find. The paper has mentioned examples of small scale design, houses and other buildings, where we do see an integration of water, living and building.
But in larger developments this trend is harder to find.

The discourse is to where the problem lies in larger scale developments. Why is it, that there are plenty of examples on small scale designs where adaptivity in delta design is present, while the issue is harder to find in large scale design? Can it not be argued, that due to the nature of climate change and flooding, the issue should be tackled mostly on a larger scale, since it is always a bigger area that feels the effects of flooding?

The discourse lies in the different stakeholders and parties involved in the development of projects. Smaller scale project involves less people, so it becomes easier to convince all the parties of the importance that flexibility and adaptivity have in the design. This may be clear to urban planners and designers, as their education usually has pointed to this importance, but in many other practises this is still overlooked. The responsibility then lies with the urban planner or designer, to convince all the other parties of the importance that adaptivity has in delta design.

Concluding

With the paper focussing on the role that adaptive design in relation to delta interventions play in the future design of the city, it can be said that the theory agrees. The complex system theory has pointed to the need for adaptivity and flexibility in urban design in order to make cities more resilient to change. With climate change now as one of the main drivers and threat to a delta area, environmental circumstances are changing and the future of the city depends on its capability to adapt to this change.

But we see a big problem in practise, that lies at the misunderstanding between different parties. The responsibility now falls on the urban planner or designer, to realize the need for adaptivity in delta areas, to design with this need for adaptivity and mostly to convince other parties of this need for adaptivity. Otherwise the future of the city will be a short lived one.

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GRADUATION ORIENTATION

Research group: Delta Interventions
First mentor: Kristel Aalbers
Second mentor: Frits van Loon

Main motivation: To create a (test)plan for an inhabitant interactive water storage system, that creates a sustainable community in a delta area.

Link your theme and research group focus:

The project creates a link between the technological aspect of water management and the societal possibilities that these technologies bring. It aims to create a new application of rain water management. For the Delta Interventions studio, the believe is they aim to achieve new design ideas, technologies and principles for delta cities to become more in balance with the water management problems that they face. In this project this is done by implementing water storage techniques in a new way, so that the neighborhood itself will become more involved. This will help the area become resilient to the problems they are facing in their water management (mainly heavy stress from rain water). The project achieves this through a design that connects the different scales together, making the area adaptable to water at every scale.

Methodology:
- Scenario approach
- Research objectives and design objectives
- Theoretical background
- Research questions
- Analysis and comparison between problems and opportunities

(For detailed schematic see P2 report, chapter Methodology).

Main issues to study:
Research question: How can a spatial flexible interactive water storage system be designed for Buiksloterham, to help it prepare for climate change, in x years, in a way that it also creates sustainable awareness through neighborhood participation?

Sub questions:
- What is the water system of Buiksloterham?
- What problems is Buiksloterham going to face because of climate change?
- What is the best water storage method(s) for Buiksloterham?
- How can we combine the use of a water storage system to sustainable awareness in a way that adds an attractive identity to the Buiksloterham living environment?
- What would be a suitable timeframe for the design of Buiksloterham?
- How can Amsterdam benefit from the design of Buiksloterham?
- How does water storage create sustainable awareness in Buiksloterham?

Main variables:
- Interactive infrastructure
- Sustainable awareness
- Living with water
- (rain)Water storage
- Sustainable society

Planning base:

The idea (at the moment) for the project is to create a neighborhood which is based upon a flexible sustainable living environment. The main focus of the sustainable design will be an interactive water system, where water can be stored at different places, at different times, decided by the inhabitants of the neighborhood, with feedback from the municipality. Both the inhabits and the municipality can use an app in order to decide when and where they want to store their water. The location is Buiksloterham, located in Amsterdam Noord, which is pointed out by the municipality as a location for sustainable development. A design for this area will be created, based upon research done by the development of different scenarios, which will be reflected on both the process and the actual design, to see which elements may be applicable elsewhere.

THESIS PLAN

THESIS PLAN

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MOTIVATION OF STUDY

There are two issues that underline the thesis. The first is climate change, the second sustainable cities.

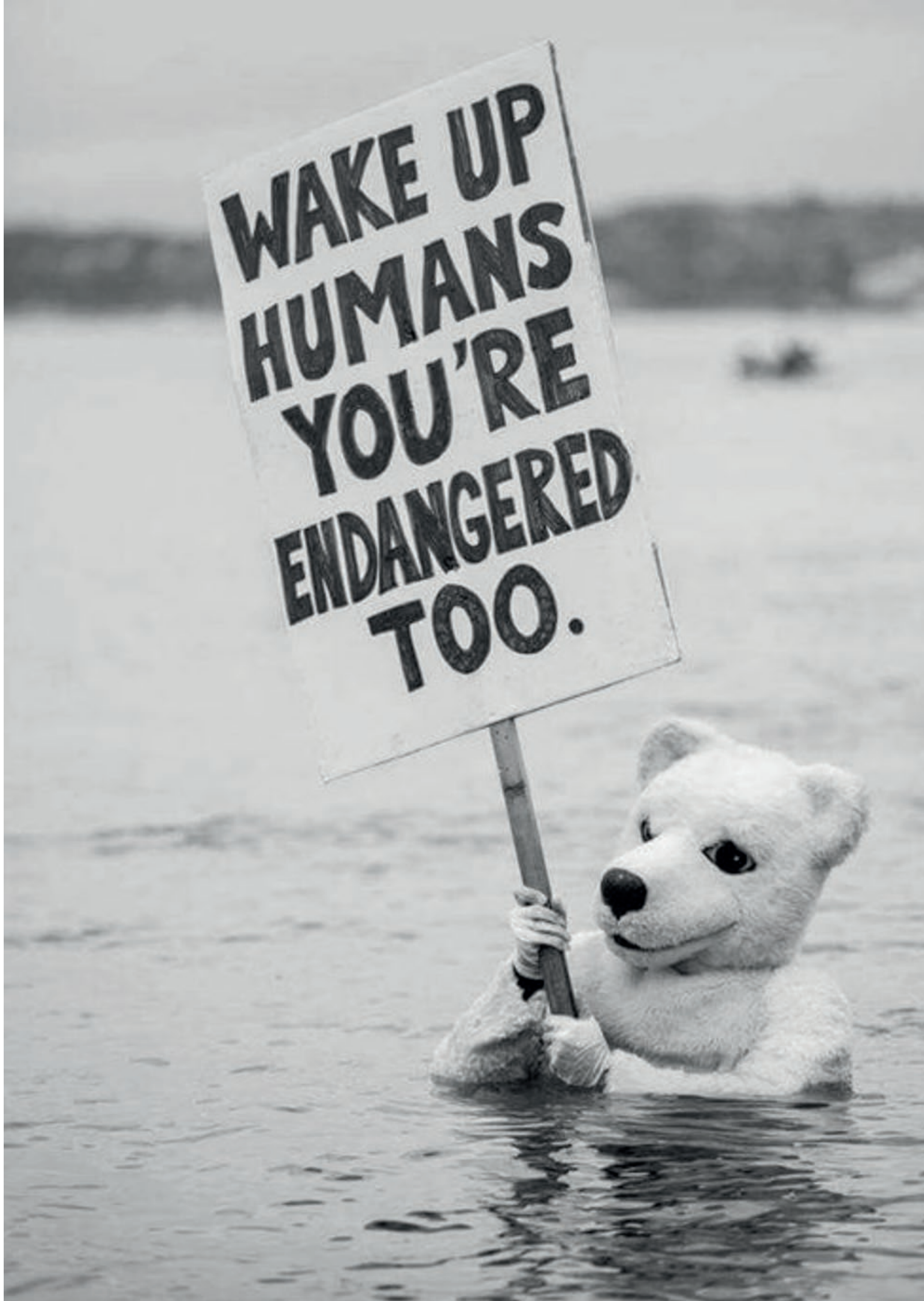
Since the report from the UN World Commission on Environment and Development was published in 1987, the concept of sustainable development has become an important aspect of worldwide developments. It views the future development of cities in such a way that they 'meet the needs of the present without compromising the ability of future generations to meet their own needs'. The report brought such a change, that a completely different strategy for spatial planning of the urban fabric was necessary (Allmendinger, 2002). The UN World Commission on Environment and Development has agreed that the world as a community needs to take actions to keep the effects of climate change under a 2C temperature rise. With the average European land temperature rise already up to 1.3C, they have formed a strategy to stop this rapid increase. The strategy focusses on a couple different areas, of which one delta landscapes are one of the most vulnerable ones.

The Netherlands is such an area, a densely populated floodplain. Over the next decade it is expected that it will experience an increase in winter precipitation, river flow and risk of river and coastal flooding (European Commision, 2013). Growth of the population and the possibilities for economic activity in the delta region, in combination with climate change, means that this segment is increasingly vulnerable to flooding (H. Meyer, 2015).

The meteorological institute of the Netherlands, the KNMI, has made a prediction for the next 70 years, where we see increase of rainfall by about 7%. It is also possible that there will be longer periods of draught, resulting into a water shortage, reduced water quality and salination. And of course, the temperature will increase with a maximum average of 4C, but it is to be said that this also predicts higher maximum temperatures (Koninklijk Nederlands Meteorologisch Instituut, 2014).

But it's not only because of climate change that the way we design our cities has changed. Over the past 50 years we have seen an increased movement from thinking of the city as separate systems, to thinking of the city as complex system. This way of thinking calls for a more flexible approach to the design of the city, as it focusses on the interaction the different systems have with each other, and with its surroundings. The environment of the city plays a much bigger role in this type of approach. The complex city theory makes it possible for cities to become more flexible, allowing them to react to unforeseen circumstances (Allmendinger, 2002). For cities to develop in a sustainable way, it is necessary for urban planners to give priority to the concerns of sustainable development. Planners have a responsibility to point to the likely consequences of different proposed future scenario's, so that the eventual plan is capable of adapting to all scenarios (Naess, 2001). But what makes it so that the inhabitants of the city will be aware of sustainability?

We have seen from studies in the 1970's that knowledge and awareness does not directly lead to pro-environmental behavior. This is because people need a direct experience, to adjust their behavior. People are not that likely to change their behavior, unless they see immediate results. But the effects of non-environmentally friendly behavior are usually promoted in a 10-year+ timeframe, which keeps it very distant. That combined with people's social norms, cultural traditions, customs and attitudes, makes it very hard to promote pro-environmental behavior for people (A. Kollmuss, 2002). One of the ways to bring pro-environmental behavior closer to the inhabitants of the city, is the direct urban structure they live in. Neighborhoods are as important as any other element in the urban system, and they can be seen as the frontline in the battle for sustainability (Choguill, 2008).



PROBLEM ANALYSIS

SUBJECT DEFINITION

To combine the issues of climate change and the need for sustainable cities, the most relevant issues for the Netherlands will be look, as this is the preferred location for the thesis. This is also in combination with a personal interest in these subjects. For the Netherlands, rain water is a big issue. With many of the cities consisting of a high percentage of concrete surface, the sewage systems are not capable of discharging all the rainwater, causing flooding or smaller issues. The thesis aims to form an innovative solution to rain water storage. This is done by creating a flexible interactive water storage system. By doing this, the second issue described previously becomes involved. By making the water storage system flexible, it fits into the philosophy described by the complex system theory, which will later be explained in more detail. And by making the system interactive for the inhabitants of the area, we create a more direct personal connection between sustainable water use and rain water storage. This will create a bigger drive for the inhabitants to adjust their behaviour to a more sustainable way of life. The interactive water storage system can respond to the wishes of both the government and the inhabitants. In the end, the thesis will give the possibility to create a (test)plan for an inhabitant interactive sustainable delta neighbourhood.

EMBED THE CASE IN KNOWLEDGE

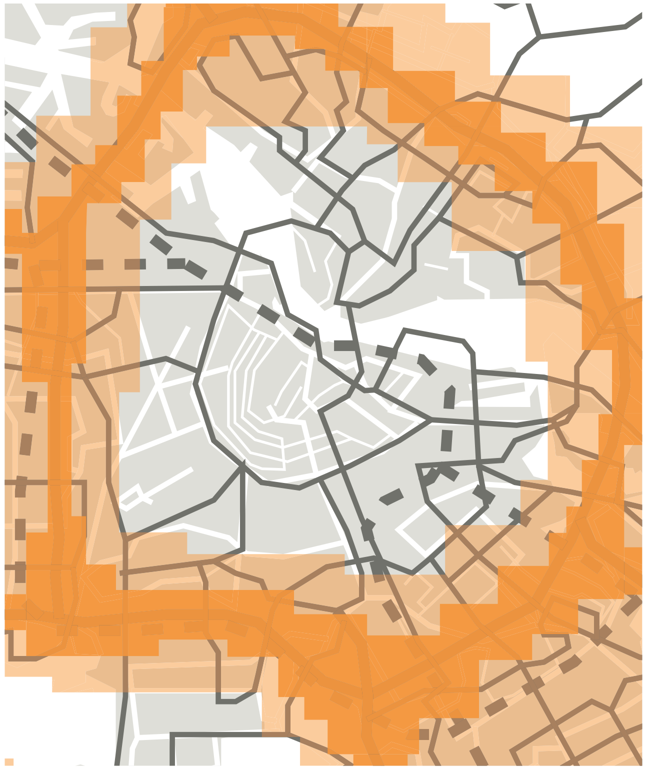
For the project, the thesis looks at Amsterdam, as the biggest urban metropolitan area in The Netherlands. Amsterdam mentions the sustainable development and transformation of the city as the main focus point of their future developments. In order to achieve this, they have appointed several developing areas to use innovative design approaches (Gemeente Amsterdam, 2011). One of these location is Buiksloterham.

Flood treath

Hard surfaces

Density

Air pollution



Noise pollution

Green structures

Located in the North of Amsterdam, at the IJ-shore. It is an old industrial area that is now mainly abandoned. It will develop into a combined work- and residential area (Gemeente Amsterdam, 2009). The municipality wishes to develop the area as a test location for Amsterdam's broader transition into becoming a circular, sustainable city. The objectives for the area include:

- Buiksloterham is energy self-sufficient with a fully renewable energy supply.
- Buiksloterham is a zero waste neighbourhood, with a near 100% circular flow.
- Buiksloterham is rainproof and has a near 100% resource recovery from waste water.
- Infrastructure is maximally-used and local mobility has zero emissions.

When looking at those objectives in a bit more detail, for water it means they wish to:

- Manage all rainwater above ground with the capacity to handle heavy peak rainfall without flooding.
- Reduce domestic & commercial water demand by 25%.
- Intelligent drinking water use.
- Separate wastewater.

(Gemeente Amsterdam, 2015).

But when looking at the other objectives they have set for themselves, for example the ones for energy and waste management, the objectives for water are a little unimaginative and uninspiring. Modern understanding of circularity and the Netherlands strong history with water management offer more possibilities to develop the area sustainable in terms of rain water use. When taking into account the wish from the municipality to become 'the smartest and most innovative water site of the Netherlands' (Gemeente Amsterdam, 2015), the thesis aims to set higher goals for Buiksloterham in terms of rain water storage and use.

The location is perfect; it is a sustainable based community where participants are already aware and interested in sustainable development. It is located in the biggest metropolitan area of the Netherlands, that has already expressed the wish to become very innovative in their water use. This creates an opportunity for Buiksloterham.

UNKNOWN IN THE RESEARCH FIELD

Rain water storage methods are a known thing, but they have never been made interactive on a large scale before. This adds a new level of flexibility to the possibilities, but it requires a creative way and understanding of the current methods, so that they can be adjusted.

PROBLEM DEFINITION

RESEARCH QUESTION

How can a flexible interactive water storage system be designed to help Buiksloterham prepare for climate change, as well as increase sustainable awareness through neighbourhood participation, for x years, through the different scales?

SUB QUESTIONS

Water system: What is the water system of Buiksloterham?

In order to be able to store rainwater, first the existing water system has to be made clear. The opportunities and weaknesses, for both the big scale of Amsterdam and the small scale for Buiksloterham, will be made clear. The relationship between these two systems will also be determined, showing the possibilities Buiksloterham might offer in relationship to the bigger scale.

Climate change: What problems is Buiksloterham going to face because of climate change?

For the climate change issues that influence the plan it will look at the general problems that come from climate change, what these problems mean for Amsterdam and what they mean for Buiksloterham.

Water storage: What is the best water storage method for Buiksloterham?

The thesis looks at the current water storage methods, how they are applicable in Buiksloterham and how they help create sustainable awareness. Then the methods are adjusted, to see if they can be made interactive and if so, what extra benefits this adds for Buiksloterham. The flexibility of the methods will be taken into account as well.

Buiksloterham: How can we combine the use of a water storage system to sustainable awareness in a way that adds an attractive identity to the Buiksloterham living environment?

When designing for Buiksloterham, the existing elements of Buiksloterham need to be analysed in order to understand the starting point of the project. The current problems and opportunities of the neighbourhood need to be made visible, as well as the identity it has now and the identity that would be preferable for the area in the future.

Timeframe: What would be a suitable timeframe for the design of Buiksloterham?

For the timeframe, it is important that we realize that all the different aspects that have an influence on the design have a different rhythm. By looking at the different timeframes there are for water management, society, the built environment, day and night rhythms, seasonal change and water storage, the difference in pace will become clear. These different paces will be combined together to determine the best suitable timeframe for the project, and to realize which timeframes have the biggest effect at different elements of the design.

Amsterdam: How can Amsterdam benefit from the design of Buiksloterham?

Buiksloterham's water storage will have an impact on the entire city of Amsterdam as well. For the design, it needs to become clear in what way, and the possibilities the design offers for the entire city. Also, the design needs to be evaluated on whether or not it could be implemented in a different location.

Sustainable awareness: How does water storage create sustainable awareness in Buiksloterham?

When the design has to increase sustainable awareness, first it needs to become clear what sustainable awareness currently is, in relation to water. And it needs to become clear what the sustainable awareness of the current and future inhabitants of Buiksloterham is. This will then be related to the different design choices, so that the methods are picked that also benefit the sustainable awareness of the neighbourhood.

Impresison of Buiksloterham

Aerial view of Amsterdam with the locaiton

Impression wanted design look

OBJECTIVE/AIM OF RESEARCH

The end goal of the thesis is the develop a design for Buiksloterham that offers enough water storage possibilities to meet the demands for grey water reuse (washing machine, toilet, garden) for every inhabitant and employee in the area, while at the same time creating an attractive environment in the Buiksloterham area. This will be done by the design of a flexible, interactive system, that can respond both top down and bottom up. This system will help the inhabitants of the city gain sustainable awareness and responsibility, allowing them to decide for themselves when and where they want to store rainwater. The system will also relieve some of the water stress on the city of Amsterdam.

Objectives

- Buiksloterham becomes self-sufficient in water use
- Buiksloterham re-uses rainwater
- Buiksloterham re-uses grey water
- Buiksloterham has a good water quality and improves the current rain and grey water quality
- Water becomes part of the identity of Buiksloterham
- The Buiksloterham area functions as a sustainable water community
- The water storage in Buiksloterham is flexible
- The water storage in Buiksloterham is interactive
- The water storage in Buiksloterham is applied through the different scales
- The design of Buiksloterham releaves heat-stress on the area
- The design of Buiksloterham increases the biodiversity in the area
- The design of Buiksloterham will adress the problem of the polluted soil condition in the area, when possible.

Buiksloterham becomes self-sufficient in water use.

The official definition of an area being self-sufficient is that it can maintain itself without outside aid (Merriam-Webster dictionary, 2016). For water use this means that Buiksloterham has no need to import water from the municipality, with the exception for tap water. There should be enough water for every inhabitant (60,5L per person/per day) and employee (40L per person/per day) (WMD Water, 2014). In order to do this, Buiksloterham needs to be able to store water in the area, create a circular system, re-use grey water and rain water and create a good water quality in this system.

Re-use rain water.

Rain water that falls on the Buiksloterham area will be used in the households and businesses located in the area, for all functions that demand water with an exception of the ones that can only be met with tap water.

Re-use grey water.

Grey water that comes from the households and businesses in Buiksloterham should be used again in the area.

Good water quality.

In order to re-use rainwater and grey water in the Buiksloterham area, the water should have a good quality. The rain- and grey water will be cleaned in the area itself, with the use of helophyte filters. When this is not possible due to the nature of the pollution (for example when it has been in contact with the ground water), the possibility of on side mechanical cleaning should be considered. There should be m2 reserved for the helophyte filters (4m2 per person) in the area (Stichting Medume, 2016). And the water should be able to flow.

Water becomes part of the identity of Buiksloterham.

In order for water to become a recognizable and memorable part of Buiksloterham, it's important water plays on all the senses on the users of the public space of Buiksloterham. People should be able to see, hear, smell, touch and, if they want to, taste the water when they are in the public space. Water should therefore be a design element in the public space. Also, in order to further enhance the relation with the water, all houses should be connected (visually or physically) to the water system. And, to enhance the relationship between the neighbourhood and water, water storage should be an element that inhabitants can decide on together.

The area functions as a sustainable water community.

A community is often described as a group of people in a particular area that have a common goal (Merriam-Webster dictionary, 2016). A sustainable water community can therefore be described as a group of people that have the sustainable use of water as their common goal. In Buiksloterham this can be accomplished by having the inhabitants work together on water storage, connect all the households to the water system, have households share water storage, re-using grey- and rainwater and encourage inhabitants to participate in the maintenance of the water storage system.

Flexible water storage

Flexibility in design is one of the key aspects of designing sustainably, as explained by the complex system theory. The water storage system in Buiksloterham must be able to resist the expected climate changes, as well as function throughout the entire season. Therefore; the water system needs to be designed through the different scales, functioning on all scale levels. It needs to be designed in a way that it functions just as well in extreme water levels (wet vs dry). And it needs to be able to handle an expected
5%-10% increase in rainfall, as expected by the KNMI.

Interactive water storage

As explained in the theoretical framework, people are more willing to adjust their behaviour when they see results/changes immediately and when they can influence things. Water storage is more likely to stimulate sustainable behaviour, when it can react to the wishes of the inhabitants. In order to achieve this, the system needs to be able to have a flexible water level, function both wet and dry, respond to the wishes of the inhabitants (with an overrule possibility by the municipality in times of expected great water stress) and allow people to decide together on the water storage.

Water storage will be applied through the different scales

In order to be as interactive as possible and encourage people to work together, as well as create a strong connection in the area with water, the system works best when it is applied and visible in all scales. Water storage methods should be created for all scales, able to respond to the wishes of different people. And it should all be connected together in one system.

Relieve heat-stress

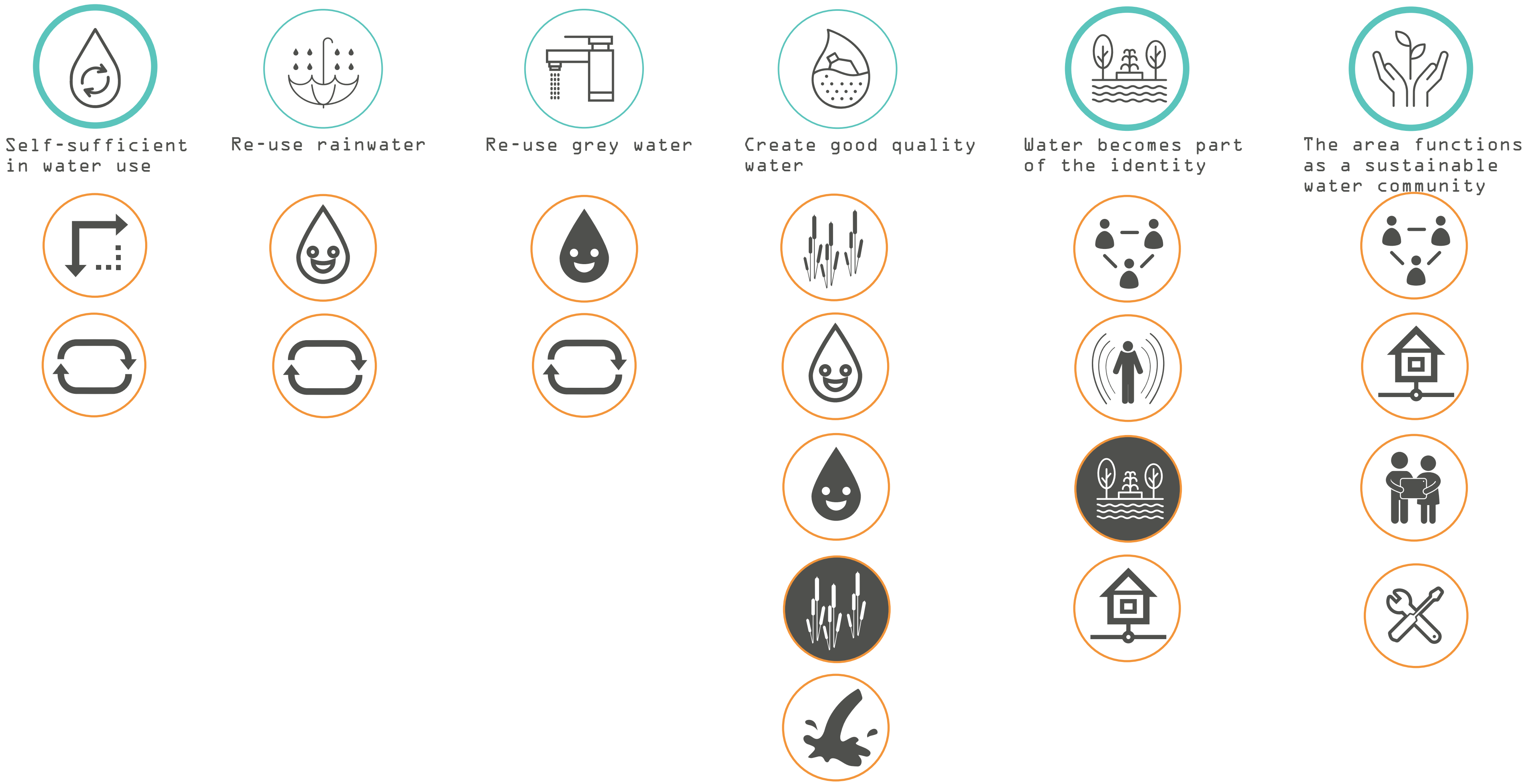
The design of Buiksloterham will combine the design of the water storage system with as many measurements against heat-stress as possible. These are to create open areas, so that the wind can flow through the area. To create green space, in order to create shadow and air. To re-use the rain-water in the area and to use green roofs and facades.

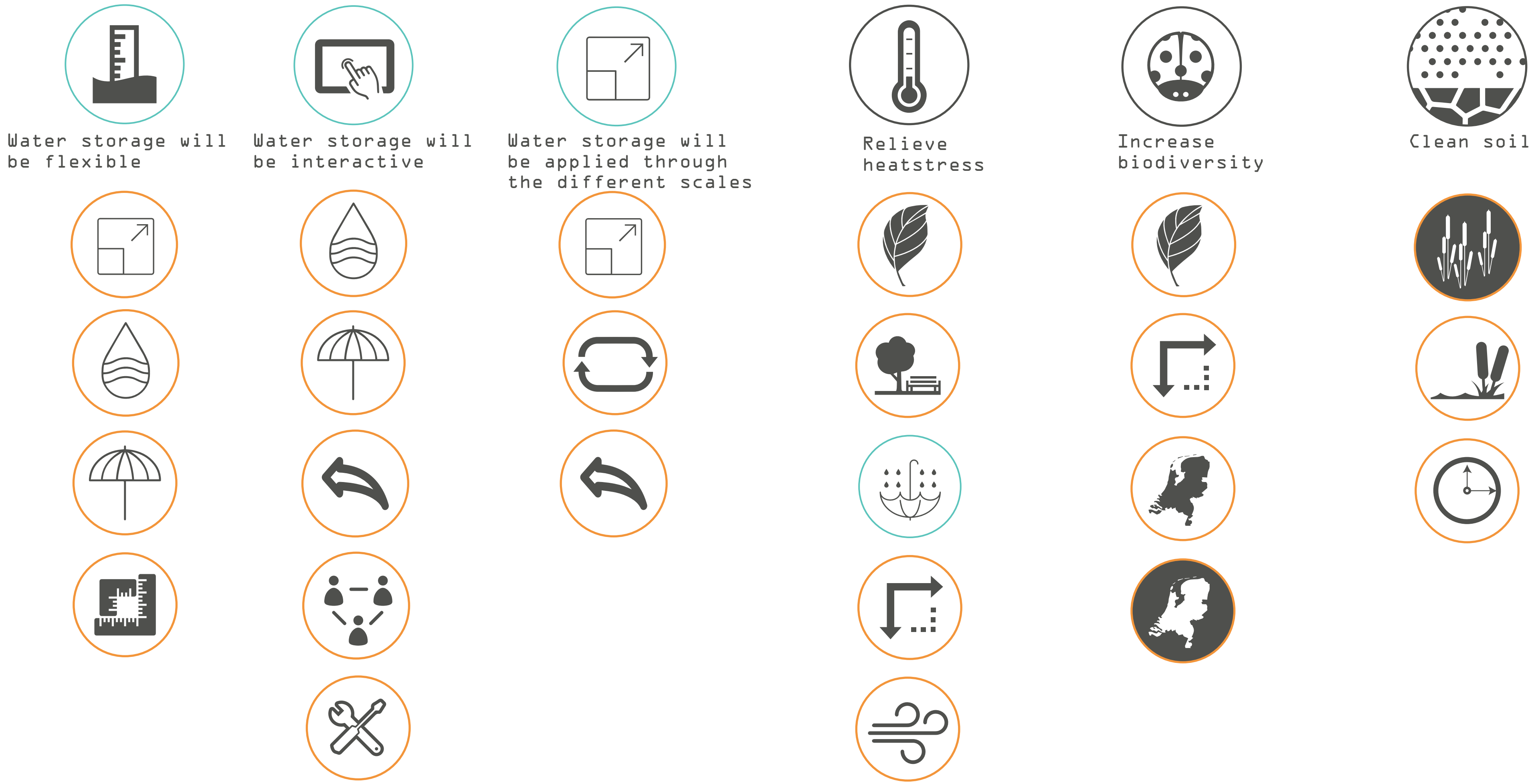
Increase biodiversity

The design will also help increase the biodiversity in the area, through the design of the water storag system. In order to achieve this it needs to reserve space for green- and water areas. And the area will be designed with native plants, for native wildlife.

Better the soil condition

The design will also strive to better the soil condition by the use of plants and trees. This will be done in steps, and primarely in the green structures that are to be formed in the area.


Self-sufficient in water use
Re-use rainwater
Re-use grey water
Create good quality water
Water becomes part of the identity
The area functions as a sustainable water community


Water storage will be flexible
Water storage will be interactive
Water storage will be applied through the different scales
Relieve heatstress
Increase biodiversity
Clean soil

Reserve m2 for rainwater storage

Create circulair water system

Clean rainwater

Clean grey water

Create enough m2 for water cleaning

Create visible cleaning areas

Create systems where water can flow

Create the possibility to store water at every scale

Allow the water level in storage areas to vary

Create unpaved space

Create room for wind

Use native plants

Design for native animals

Apply soil cleaning plants

Create plan in different steps

Alow inhabitants to maintain the water storage elements

Create water storage that function both wet and dry

Create over dimentioned water storage

Allow the water system to respond to different wishes

Make inhabitants decide together on water storage

Allow people to feel, see, smell and hear water

Use water as an design element in public space

Create a connection between every household and the water system

Allow for households share water storage

Create (connected) green structures

Bosco Verticale by Stefano Boeri

RESEARCH APPROACH

The diagram shows the different methods and techniques, and their relation, that are used for this graduation project. The project starts with a personal interest, a problem statement and theoretical background that together form the research goal and questions.

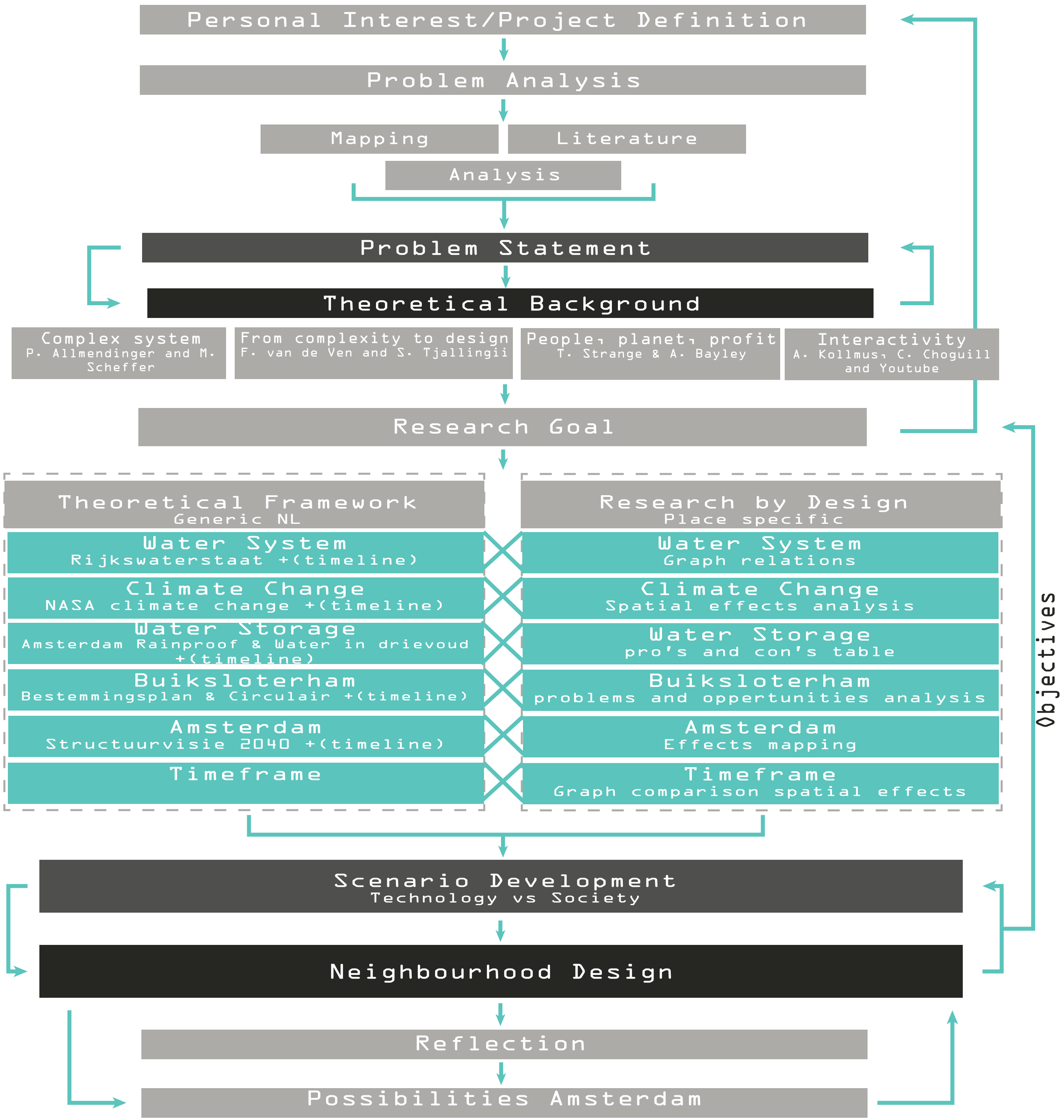
The theoretical background looks at 4 different theories; the complex system theory, the existing methods on how to design with this complex system, the people, planet and profit theory and how the interactive part of the design objective relates to the psychology of the people.

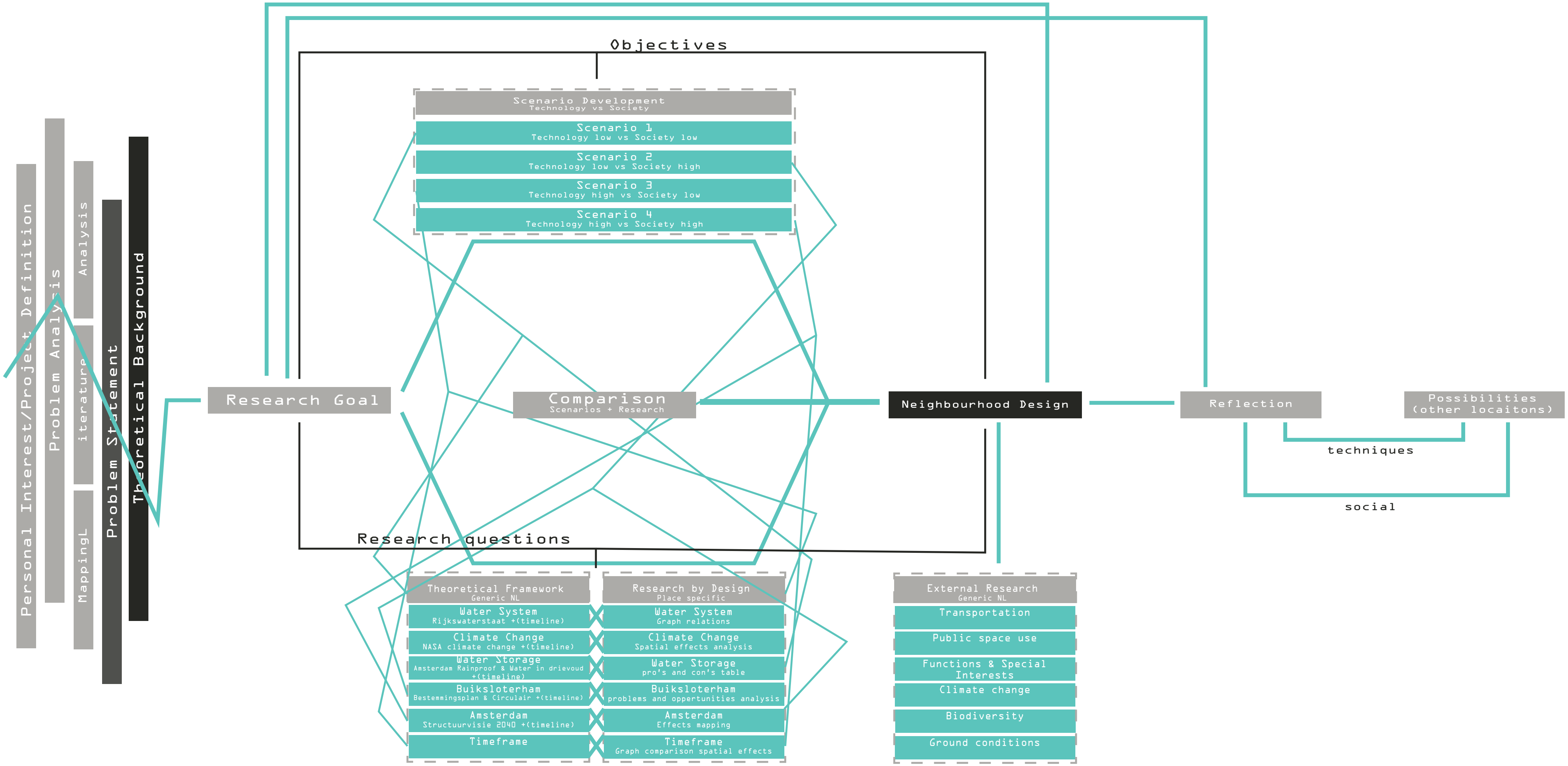
The research goals, formed based upon the previous steps, is further determined and investigated by both the research questions and the objectives set for the thesis. The research questions are based upon various theories, plans by the municipality, techniques and climate data. These are then applied to the location to see what their effects are on the Buiksloterham area.

The objectives are set by the goal, and are the elements that are needed to achieve this goal. With the help of scenario development, 4 different extremes are created. These extremes are then tested to see how well they meet the objectives (and the research questions). Together with the applied data from the research questions, they will form the base for the actual neighbourhood design.

But the neighbourhood design is also influenced by other, external factors. These are elements like transportation, the use of public space, climate change, biodiversity, functions in the area and the ground condition. The scenario's form a base to start with, with the objectives and research questions as a way to test them and see what works best. From this base, an actual design needs to be created. In this step, it is important to see how the rest of the design functions, looking into the daily life of the (imaginative) inhabitant.

This design process will eventually be reflected on, to determine the parts that are location specific and the parts of the design that could also be implemented on other locations. This will then relate itself to possibilities for the city of Amsterdam as a whole, which will have a feedback loop to the design itself. We will split this reflection in two parts, to see how both the technological and the social aspects of the design are transferable. It might also be possible to look at a bigger scale, such a transferability to the rest of NL, EU and other delta landscape regions.


Personal Interest/Project Definition
Problem Analysis
Mapping
Literature
Analysis
Problem Statement
Theoretical Background
Complex system
P. Allmendinger and M. Scheffer
From complexity to design
F. van de Ven and S. Tjallingii
People, planet, profit
T. Strange & A. Bayley
Interactivity
A. Kollmus, C. Choguill and Youtube
Research Goal
Theoretical Framework
Generic NL
Water System
Rijkswaterstaat +(timeline)
Climate Change
NASA climate change +(timeline)
Water Storage
Amsterdam Rainproof & Water in drievoud +(timeline)
Buiksloterham
Bestemmingsplan & Circulair +(timeline)
Amsterdam
Structuurvisie 2040 +(timeline)
Timeframe
Research by Design
Place specific
Water System
Graph relations
Climate Change
Spatial effects analysis
Water Storage
pro's and con's table
Buiksloterham
problems and oppertunities analysis
Amsterdam
Effects mapping
Timeframe
Graph comparison spatial effects
Objectives
Scenario Development
Technology vs Society
Neighbourhood Design
Reflection
Possibilities Amsterdam



Personal Interest/Project Definition
Problem Analysis
Analysis
iterature
MappingL
Problem Statement
Theoretical Background
Research Goal
Objectives
Scenario Development
Technology vs Society
Scenario 1
Technology low vs Society low
Scenario 2
Technology low vs Society high
Scenario 3
Technology high vs Society low
Scenario 4
Technology high vs Society high
Comparison
Scenarios + Research
Neighbourhood Design
Reflection
Possibilities
(other locaitons)
techniques
social
Research questions
Theoretical Framework
Generic NL
Water System
Rijkswaterstaat +(timeline)
Climate Change
NASA climate change +(timeline)
Water Storage
Amsterdam Rainproof & Water in drievoud +(timeline)
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pro's and con's table
Buiksloterham
problems and oppertunities analysis
Amsterdam
Effects mapping
Timeframe
Graph comparison spatial effects
External Research
Generic NL
Transportation
Public space use
Functions & Special Interests
Climate change
Biodiversity
Ground conditions

SOCIETAL AND SCIENTIFIC RELEVANCE

Societal Relevance

As mentioned in the introduction, climate change creates problems for cities in delta areas. The Netherlands is one of those areas. In the next 70 years, the KNMI has predicted an increase in rainfall of about 7%, a sea level rise of 80 cm, reduced water quality, salination, temperature rise by 4C and longer periods of draught (Koninklijk Nederlands Meteorologisch Instituut, 2014).

For cities in the Netherlands this means that they will have to deal with a higher stress on their sewage system, due to the increase in rainfall. This while over the past 3 years there have been multiple occasions on which the sewage system already failed to cope with the rainfall. It also means that they have to increase their flood defences (Tooms, 2017). The increase in temperature will mean that heat-stress in cities will become more dangerous. And the longer periods of draught might cause a shortage in fresh water supplies. Rain water becomes a problem because most cities are not designed to hold, let alone use, the rain water that fall on their surfaces.

We could reduce the stress on the sewage system due to increased rain fall, keep the water quality, keep the fresh water and lower the heat-stress by storing and re-using rain water.

Scientific Relevance

As mentioned in the theoretical framework, we need to start building our cities in a more flexible, adaptive and sustainable way. The complex city theory mentions that we need to look at the sustainability of the whole of the system (Allmendinger, 2002). For delta cities, water management is key to their future and success. For the Netherlands, this means not only flood defences, but also especially rain water management. All over the Netherlands, cities are now adjusted and redesigned so that they can better cope with the increasing amount of rainfall.

With the design of the city, sustainability becomes more and more important. Not only in the design but also in the use of the city. In Scandinavia, we already see examples of cities that are (partly) designed to work with the water, allowing for space. Interesting projects here are the Vinge Delta, in Vinge, Denmark (Arch Daily, 2014), the Western Harbour of Mälmo, Sweden (Urban Green-Blue Grids; for sustainable and resillient cities, 2015) and the design of Nørrebro in Copenhagen, Denmark (Arch Daily, 2016). We see here that water formed an inspiration for the designers, both technically and aesthetically, to make sure the area functions both in very dry but also in the very wet seasons.

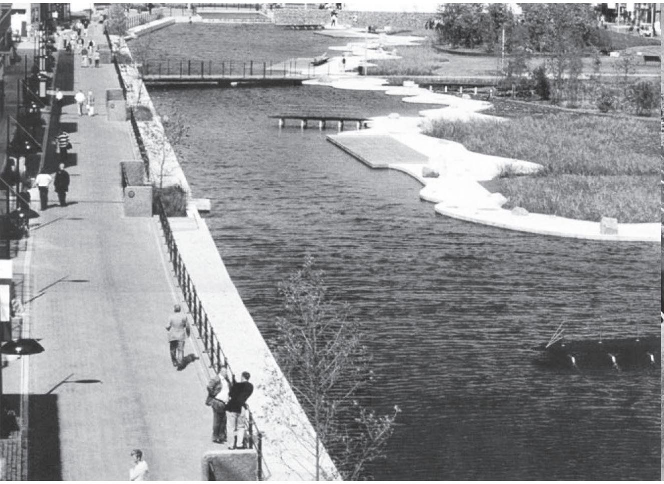
But what we often lack in urban design, is the link to the people. When looking at the tree pillars of sustainability, we design with planet and profit, with maybe even an emphasis on the planet part, but the ideas we construct fail to reach the inhabitants of the city (A. Bayley, 2008). This thesis aims to include them by creating an interactive design that can respond to the wishes of the inhabitants of the area and the municipality of the city.

INTENDED END PRODUCTS

The end result of the thesis will be a design on Buiksloterham, consisting of:

- A detailed plan/map, showing the design from a top down view, indicating the different elements that will help Buiksloterham gain from climate change and gain sustainable awareness
- Sections, showing the relationship between the plan and the 3D images.
- 3D images, to indicate the identity and atmosphere that will be designed for the area.
- A time table, indicating which elements of the total plan will be realized at what time.
- Schematics that show how Amsterdam as a city benefits from the design.
- Recommendations on how to implement the outcome of the design on other locations in Amsterdam/NL/EU.

These products will be based on the flexible interactive water storage system, which has been created with the knowledge gathered in the theoretical background, the scenarios and the different timeframes.



Ankorpark Mälmo

Vinge Delta

Nørrebro Copenhagen

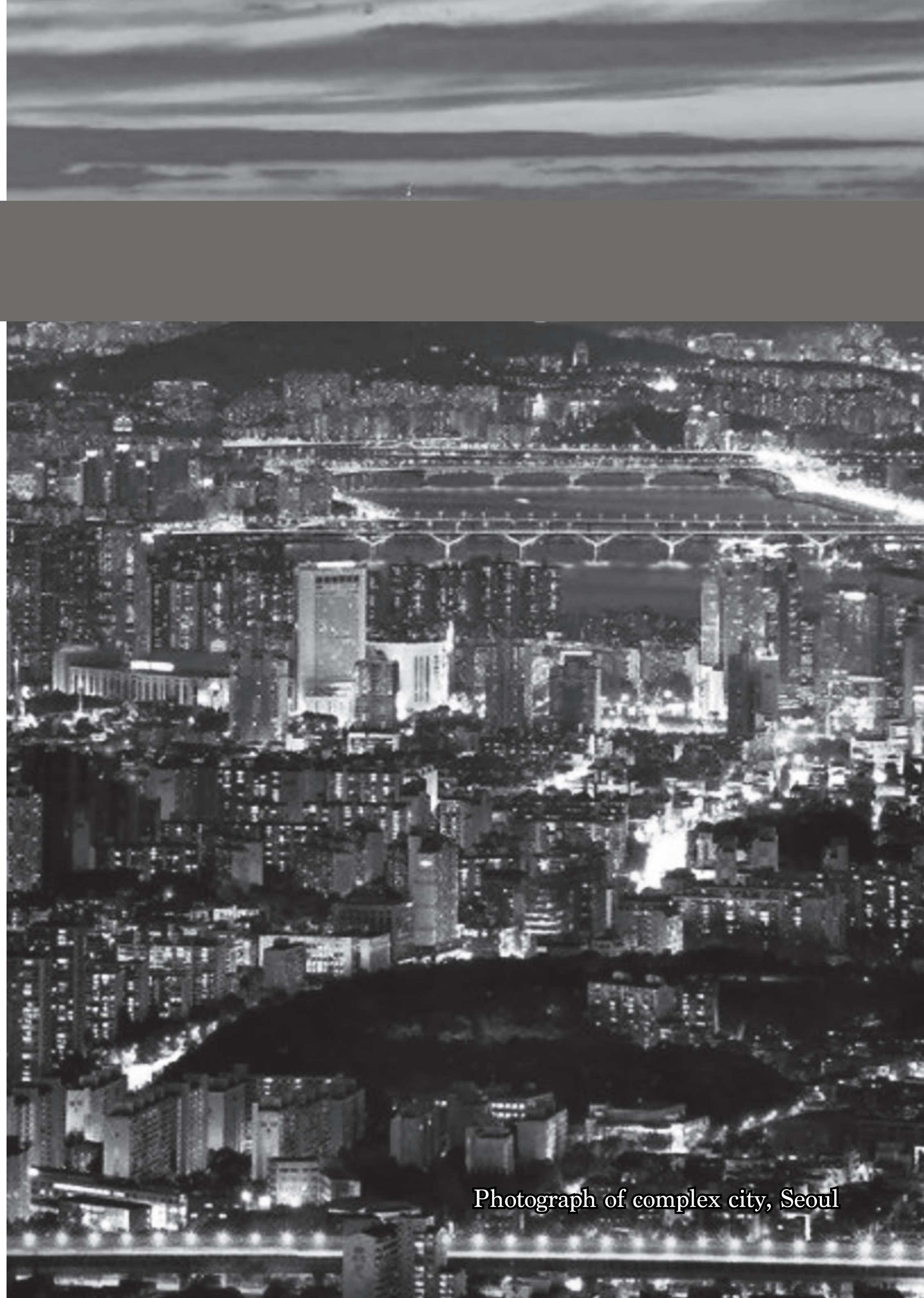
THEORETICAL FRAMEWORK

There are a few theories that underline the importance for flexible and interactive sustainable design. The first one explains the need to need for flexible design of the urban fabric, based on the complex system theory, described by P. Allmendinger and M. Scheffer. The second theory, by F. van de Ven and S. Tjallingii, forms a guideline how to deal with this complexity in design principles, indicating different approaches and when best to use them. Also, there is another paper by S. Tjallingii that follows on these approaches, explaining the guiding principle models. Then we quickly look at the three pillars of sustainable design; people, planet and profit, as described by A. Bayley and T. Strange. The last will delve more into the way we can connect people to sustainable development, by neighbourhood participation, explaining the need for interactivity. This will be based on theories develop by A. Kollmus, C. Choguill and a very helpful Youtube video.

The city as a complex system

Throughout all aspects of urban planning and design, over the last 50 years or so we can see a shift of focus. Before this transition period, cities used to be seen as a collection of different systems. It was acknowledged that there is a connection between the different systems that form the city, but they were all approached separately. The focus of the design was on one system in its entirety, forming a very set plan for its developments. This approach leaves very little space for unforeseen side effects, changes and circumstances. It was approached more in a way that the design should be so resilient and firm, that it would still function in the same way even though circumstances have changed.

But nowadays we are in a transition phase to a different way of thinking about the urban fabric. We are moving away from the system



Photograph of complex city, Seoul

thinking approach, seeing the city more as a collection of elements we can't all control. This theory is describes as thinking of the city as a complex system. The systems that forms the city are still recognized as their own system, with its own characteristics and dynamics, but it also shows the interaction the different systems have with each other and the external influences on the city. And it determines a constant interactive connectivity between all subsystems of the city, that together form the whole of the urban fabric (Allmendinger, 2002).

This way of thinking forces the urban planner to let go of (illusions of) control, determining flexibility and adaptivity as some of the main driving forces of future design. It shows the non-linear and unpredictable nature of societal, economic and environmental changes. A city should focus on robustness, the ability to protect itself to changes, resilience, when a system can recover quickly from change, and adaptivity, so that it can adapt itself to changing circumstances (Scheffer, 2009). The complex system theory indicates the need for flexible design, in order to allow the urban fabric to become more robust, resilient and adaptive.

From complexity to design

While thinking of the urban fabric as a complex and unpredictable system sounds great in theory, it poses a massive challenge for urban planners and designers to translate this complexity and unpredictability to a physical design. F. van de Ven and S. Tjallingii talk about 3 different methods that can help translate the complexity of design, especially designing with water, while not losing it at the same time. The 3 methods are: the target imagine approach, the guiding principle approach and the negotiations approach. In practise we see that an urban plan or design often starts with one of these 3 principles.

The target image approach centralized around the problem of the design objective. From there they set goals for the future of the urban water system, which becomes the driving force behind the project. Multiple scenarios can be used to test different principles, ending up with the one that best approaches the target goals. Important for this approach is that the goals set for the future are clear, unambiguously and distinct. It directs a very rational approach, bordering on a technical approach. Interactivity and flexibility are found in a more modern version of this approach, but again more as a technical approach to the problem.

With the guiding principle approach a toolbox is created for urban planners that want to design in an interactive way, to achieve a solution for water management and urban development. A leading idea and direction of search are the leading elements through the design process. The design process focusses on choosing a guiding principle and combining this to the location and its context. To help the process, guiding models have been developed that can be chosen to the specific condition of the location, that can be used alone or in combination with each other. One of the mayor benefits of this approach is that complex problems stay complex, they aren't simplified down, but rather encourage the urban designer to work with the systems the way they are. Flexibility, in this approach, comes from a different usage of the guiding principles on different occasions.

And the negotiations approach choses the interactive participation of the different stakeholders as its main focus point. Urban planning or design is seen as a transaction between the different stakeholders of the project. The planning process should be open to discussion and input for every participant of the project. To make this possible, the location, the themes and the procedure of the project have to be set form the beginning. Flexibility is hidden in participation, because it allows the design to adapt to the wishes of the different stakeholders from the begging of the process. The question is whether or not this flexibility is still achievable after the design is completed.

F. van de Ven and S. Tjallingii have tested these theories based on 2 different models and after a comparison between the two they can recommend the use of the target image approach in a situation where there is a clear problem and a unambiguous solution, for example polluted canals, or, in more complex situations, more abstract problems and s olutions, for example self-regulating water systems. The guiding principle approach is best when the need for improvement has become clear for many parties, but there is a lot of insecurity about the exact goals and means. An example of this would be measurements to guard ourselves to the consequences of climate change. And the negotiations principle is best used when there is either a lack of knowledge, indifference or tensions caused by the water management.

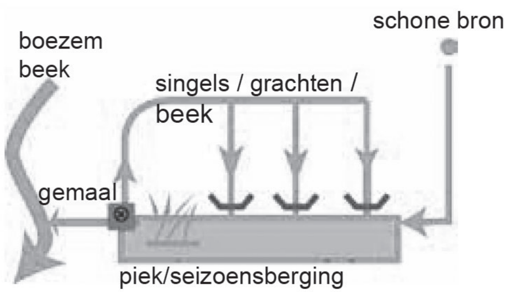
Based on this for the project it would be most likely to use a combination of the guiding principle approach and the target image approach, starting with the guiding principle approach (S. Tjallingii, 2005).

Guiding principle models

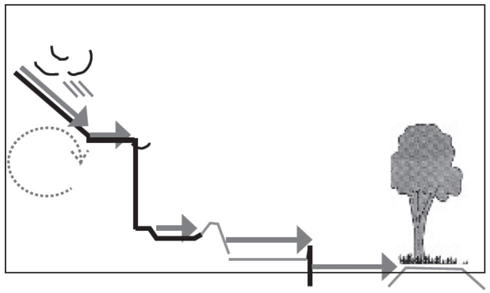
For the thesis, the guiding theme of the project would be to create a flexible, interactive water storage system for Buiksloterham, that also helps Buiksloterham prepare for and gain from climate change and increases sustainable awareness through neighbourhood participation.
To help the design we will look at the guiding models developed by S. Tjallingii.

All models want to hold water and keep it clean, but have different methods of achieving this. The first base model, the cascade model, gradually releases the rain water flow in one direction. Rain water is held on rooftops, streets and in gardens. This model is mostly used in high density areas (like the center of Amsterdam). The infiltration model stores water in the ground water. This model is mostly used in urban landscape areas. Notice that, since the rain water in this model joins the ground water, the quality of the ground water becomes a very important factor.

Circulatiemodel



Cascademodel



And the last model, the circulation model, guides the rain water to fresh water storage areas, where it is being cleaned, and then again brought back to the urban fabric. This model also works as seasonal storage. It is often used in the urban landscape, mostly in newer developed areas (Tjallingii, 2011). The cascade model and the circulation model are the best fit for the location of Buiksloterham, mainly because of the quality of the ground water in Buiksloterham.

With these guiding principles, more concrete goals can be created for the neighbourhood, flowing more into a target image approach. The concrete goals will be set for the water storage aspect of the neighbourhood, mentioning how much water should be stored, and in what way. Scenarios testing will help determine how to best achieve this, as well as showing other problems and opportunities that arise with the different scenarios.

People, planet, profit

Sustainable development is described as development (growth or progress) that meets the needs of the present without compromising the ability of future generations to meet their needs. At the heart of this sustainable development are three so called pillars; people, planet and profit. Mankind depends on the environment, planet, and the services it provides in order to maintain our way of life. At the same time, the stability and success of societies relies on a healthy and productive population. When designing there needs to be an understanding of these three components, and the way they are connected together (A. Bayley, 2008).

Interactivity and inhabitants

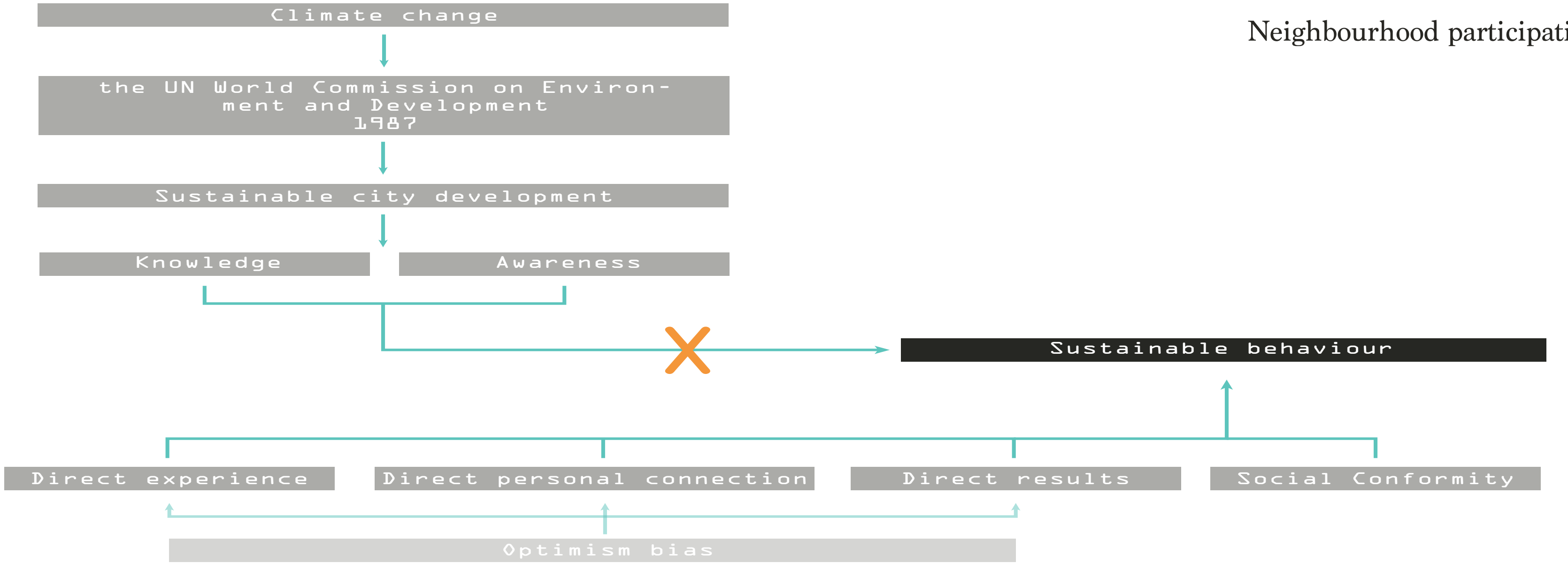
With all the data, we have on climate change, still about 25% of the population does not believe in climate change. We respond more strongly to treats that are personal, abrupt, immoral and affect us now. In that way, climate change is the perfect problem, it's a gradual impersonal thing that always happens in the future. Our brains will come up will all kinds of excuses, why we should not act today. Due to our brain's optimism bias, climate change stays very far away from us, not allowing it to affect us (It's Okay to be Smart, 2014).

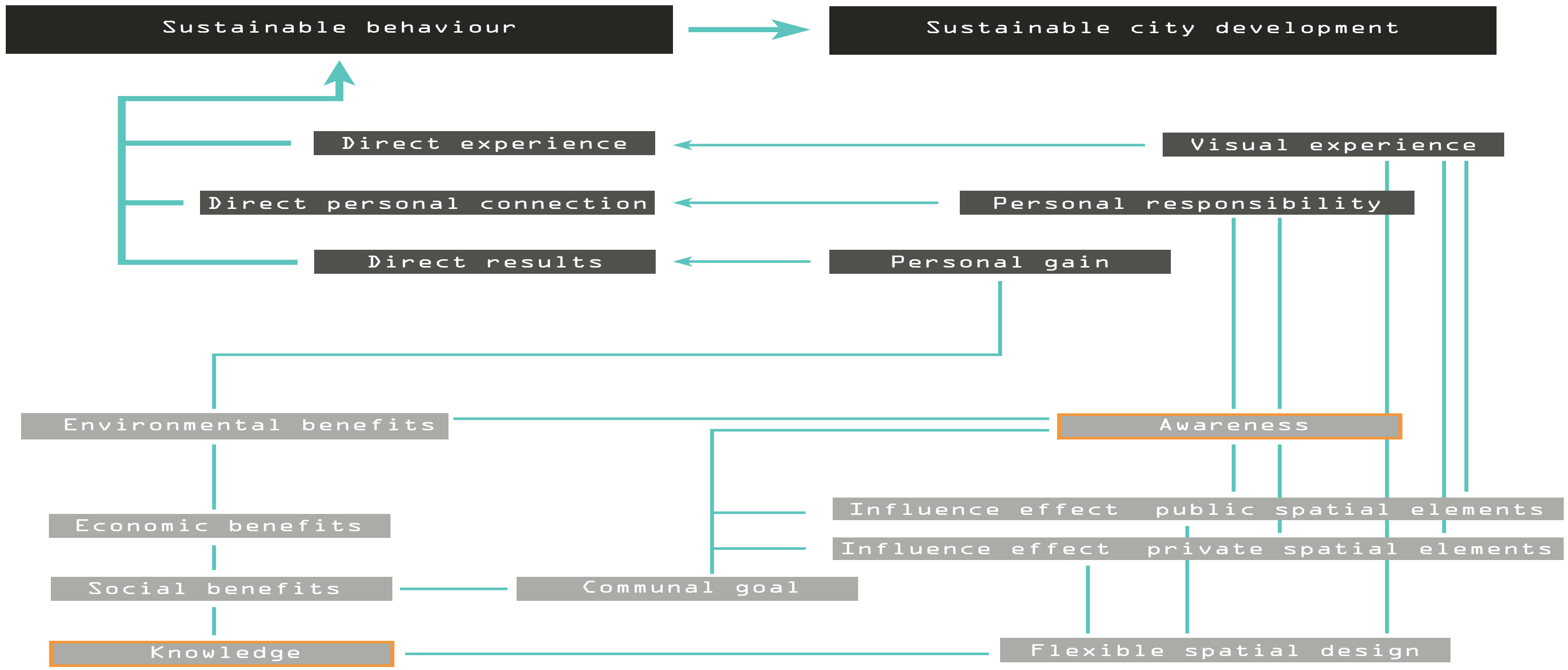
We have seen from studies in the 1970's that knowledge and awareness does not directly lead to pro-environmental behaviour. This is because people need a direct experience, to adjust their behaviour, instead of an indirect experience, as is usually the case with climate change. People are also not that likely to change their behaviour, unless they see immediate results. But the effects of non-environmentally friendly behaviour are usually promoted in a 10-year+ timeframe, which keeps it very distant. That combined with people's social norms, cultural traditions, customs and attitudes, makes it very hard to promote pro-environmental behaviour for people (A. Kollmuss, 2002).

One of the ways to bring pro-environmental behaviour closer to the inhabitants of the city, is the direct urban structure they live in. Neighbourhoods are as important as any other element in the urban system, and they can be seen as the frontline in the battle for sustainability. Sustainability can be split in 4 different categories; economic sustainability, social sustainability, technical sustainability and environmentally sustainable. In order for a neighbourhood to function in a sustainable way, all these 4 categories need to be sustainable and work together in balance (Choguill, 2008).

In order to get people to work sustainable, we need to give them a direct experience, direct personal connection, direct results and fit it with our social conformity (It's Okay to be Smart, 2014). Creating awareness through an interactive system could help here, since the interactive part of the design gives people responsibility, a communal experience, direct visual results and a personal gain. This are all elements that direct to people on a closer, more direct and personal level. Which is why they will be more motivated to do something, changing their behaviour to a more sustainable way. With that, it could be argued that interactivity in design is key to creating a sustainable community.

Sustainable living environment


Climate change
the UN World Commission on Environment and Development 1987
Sustainable city development
Knowledge
Awareness
Sustainable behaviour
Direct experience
Direct personal connection
Direct results
Social Conformity
Optimism bias


Sustainable behaviour
Sustainable city development
Direct experience
Visual experience
Direct personal connection
Personal responsibility
Direct results
Personal gain
Environmental benefits
Awareness
Influence effect public spatial elements
Economic benefits
Influence effect private spatial elements
Social benefits
Communal goal
Knowledge
Flexible spatial design

WATER SYSTEM

To understand the water system of Buiksloterham, it's important to first look at the bigger scale, towards the water system of the Amsterdam metropolitan area.
Amsterdam is situated at het IJ (-0.41 NAP). This is a river that connects the North Sea, salt water (-0.34 NAP) with the IJsselmeer, sweet water (-0.41 NAP). From het IJ flow many side rivers towards the polder systems of North and South Holland. The boezem system of the polders of Amsterdam (-0.91 NAP) separates in many different smaller stream systems, forming the entire water system of the region of Amsterdam.

The IJ is disconnected from both the North Sea and the IJsselmeer with 2 boat locks. In case of the North Sea this boat lock also functions to maintain the difference in water level, however small it might be. The main function of these 2 boat locks is to guard the IJ from the treat coming from both places in case of sea level rise due to climate change, storms and heavy rainfall. Het IJ and its side canals also aren't directly connected. There are 7 boat locks and 2 pumps that form a barrier between het IJ and the boezem's towards the different polder systems. Those barriers function both as a means to maintain the ~0.50 m height difference and as a safety measure. In case one of the 2 main boat locks of het IJ fails, the land behind it is still protected by the smaller boat locks (Rijkswaterstaat, 2016).

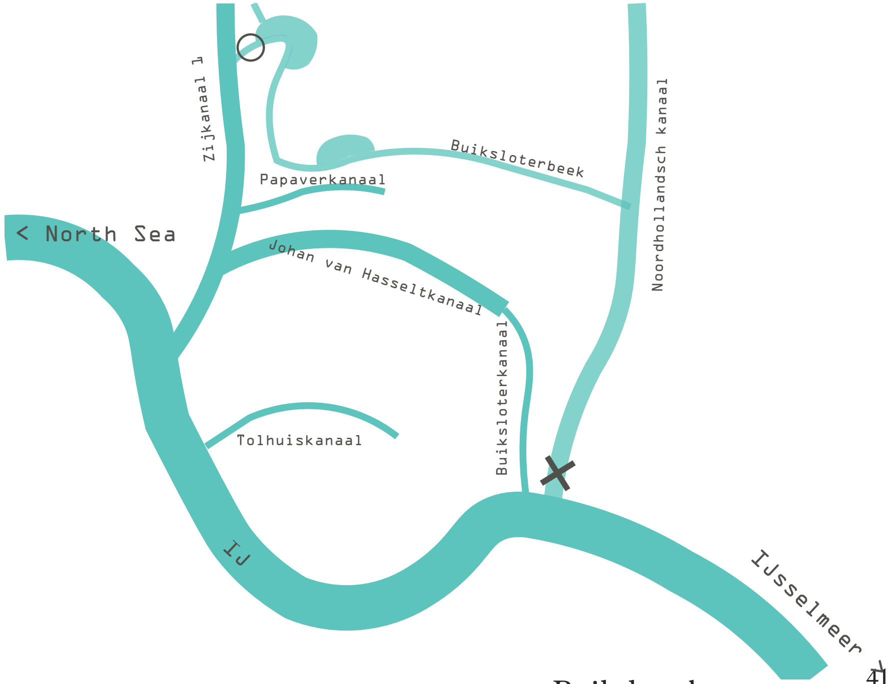
The system of Buiksloterham is a lot less complicated then the bigger system. Buiksloterham has 3 canals, which are all directly connected to het IJ. This also creates the opportunity for people to sail their boats directly from Buiksloterham onto het IJ, which is preferable, especially when you take into account that the municipality of Amsterdam has a wish to

Aerial view of Amsterdam Metropolitan area

Amsterdam Metropolitan Area water system create a harbour in the Buiksloterham neighbourhood. But it also creates several problems. First is that in case one of the 2 main boat locks of het IJ fail, Buiksloterham will be in direct contact with het IJ, lacking a secondary flood defence system. Next, the water quality of het IJ is poorly, which means it cannot be used in households. When rain water comes in contact with this water, it therefore can't be re-used. This combined with the fact that the ground water in Buiksloterham is heavily polluted with chemicals and metals, limits the possibilities for rain water storage in the current systems when the possibility to re-use is preferable.

The Buiksloterham water system is directly connected to het IJ, which means that rain water that falls on the surface of the Buiksloterham neighbourhood puts a direct stress on het IJ. And this has as a result that it also puts stress on the secondary flood defence systems that defend the rest of Amsterdam and the further located polder systems. The possibility to store rain water would relieve the stress caused by het IJ slightly.


Aerial view of Buiksloterham



Buiksloterham water system

WATER STORAGE

In order to see what the best storage methods are for Buiksloterham, first the thesis will examine all the methods currently available for rain water storage. Then the different scenario's will test to see which methods work in what circumstances, to see which are the best match for Buiksloterham.

Note, the methods are all from the book: Green-blue grids; Manual for Resilient cities 2016). By Hiltrud Pötz.

Rainwater pond

Rain water ponds temporarily store rain water. They can be connected to a system that determines when it's going to rain, so that the pond is only emptied just before rainfall. The depth of the pond should preferably be 1.5m or more, to ensure a good water quality. The pond can b e combined with plants, like helophyte filters, to further improve the water quality. Then the water needs to flow through the pond, which means it needs to be connected to a circulating system. If needed, they can be lined with a water proof foil, to prevent filtration of the water into the ground.
Apply when: When there is a high ground level, it needs to be applied with the water proof foil. There are no other criteria.
Added benefits: improves the water quality, the biodiversity and relieves heat stress.
Negatives: Maintenance is needed.
Possibility to become interactive: Yes.
Flexibility: Medium.
Visibility: High

Intensive green roof

An intensive green roof is a green roof with various types of plants, which means that it can hold quite a bit of rainwater. They store the rainwater in the substrate layer. It also increases the quality of the water.
Apply when: The roofs of a building are constructed to bear a higher load then usual (more than 1kN/m2). Or additional constructive measurements are taken to bear the higher load.
Added benefits: improves water quality, biodiversity and relieves heat stress.
Negatives: Construction needs to be tested to see if it's strong enough and maintenance is needed.
Possibility to become interactive: No
Flexibility: Low.
Visibility: Low.

Relief

Relief, a difference in height, creates different areas where one can overflow with water while the high parts remain dry. This can create a landscape that is capable of overflowing once in a while, without doing damage to the buildings, the infrastructure, the inhabitants etc.
Apply when: When it's possible that some parts of the area overflow with rain water once in a while.
Added benefits: Increases the water quality and it's a natural solution to water storage.
Negatives: When the rain water comes in contact with the ground water it's no longer usable and parts of the area can't be used when they are flooded.
Possibility to become interactive: No.
Flexibility: High.
Visibility: High.

Infiltration barrels

These are plastic barrels that are placed underground, that are connected to a pipe. This pipe gathers the water from above the ground and then it transports through this pipe towards the barrels. From the bottom of the barrels the water can be, slowly, released towards the ground again.
Apply when: Anywhere under the ground, above the ground water level.
Added benefits: Little.
Negatives: They need to be placed above the ground water level.
Possibility to become interactive: Yes.
Flexibility: High.
Visibility: Low.

Wadi

Intensive green roof

Water squares

A water square is a lowered square that can hold rain water. The rain water flows from elsewhere in the area to this square. It combines water storage with other daily urban life.
Apply where: High density urban areas.
Added benefits: Can be created with non-permeable street coating, like concrete or asphalt.
Negatives: Very high in maintenance, every time the square is used as water storage it needs to be completely cleaned.
Possibility to become interactive: Yes
Flexibility: High.
Visibility: High.

Urban waterways

Urban waterways are in theory like oversized open gutters. They are concrete structures where rain water can be stored. The rain water is gathered there from the surrounding area. They can be combined with rocks, plants and other elements to make them look more interesting and increase the water quality.
Apply when: In urban areas where there is space, the width is preferably >1m.
Added benefits: Increases the water quality.
Negatives: There needs to be attention in the design process for both the wet and the dry extreme, to make sure it's still aesthetic even when completely dry.
Possibility to become interactive: Yes
Flexibility: High.
Visibility: High.

Seasonal storage

Seasonal storage is an area where the excess of water from the winter period can be stored until it needs to be used in summer. They also create extra storage for peak rainfall periods. They can be combined with helophyte filters as well, increasing the water quality. Or they can be created with nature friendly shores, to increase the biodiversity.
Apply when: Anywhere where a large area (>/=50m2) for water storage can be made available.
Added benefits: Functions as peak rainfall storage as well, increased the water quality and biodiversity and it relieves heat stress.
Negatives: Loose the use of large area for a long period of time.
Possibility to become interactive: Yes.
Flexibility: High.
Visibility: High.

Water roof

A water roof is a roof that is designed so that rain water can be stored on top of it.
Apply when: The construction of a roof can bear a load of minimum 1kN/m2.
Added benefits: The water also keeps the temperature of the building underneath it down.
Negatives: Because the water level fluctuates, this temperature also fluctuates.
Possibility to become interactive: Yes.
Flexibility: High.
Visibility: High.

Wadi

A Wadi is a ditch or small stream that is filled with gravel or sand. This way the Wadi can both hold and filter the rain water. The water flows from buildings and streets into the Wadi. Plants can be added to the Wadi to increase the water quality and the appearance.
Apply when: A Wadi is most effective with a low ground water level, but it could be applied elsewhere as well. It works best with a permeable soil.
Added benefits: Increases the water quality, the biodiversity and relieves heat stress.
Negatives: They are high in maintenance and maintenance costs.
Possibility to become interactive: No.
Flexibility: High.
Visibility: Medium.

Garden roof

Storage under buildings

Storage under buildings can be created in different ways. One can store water in the basement, create a water storage area in unused space or form a water reservoir underneath the structure of the building.
Apply when: The construction of the buildings is strong enough.
Added benefits: Easy storage without effect on the public space.
Negatives: Expensive and usually the water does not flow in these r eservoirs.
Possibility to become interactive: Yes.
Flexibility: High.
Visibility: Low.

Water holding planters

Water holding planters are planters that are closed at the bottom and filled with gravel (underneath the soil and the plants). They have a drainage pipe that is connected to the regular sewage system.
Apply when: High density urban areas.
Added benefits: Creates a better water quality and increases the biodiversity.
Negatives: The planters need to be made at least 1m high in order to store water. Mostly made out of concrete.
Possibility to become interactive: Yes
Flexibility: High.
Visibility: Low.

Underground storage

Underground storage is created much in the same way as storage under buildings, by creating a reservoir underground.
Apply when: There is enough space in the subsoil for underground storage.
Added benefits: Easy method for storage without effect on the public space.
Negatives: Expensive and the water doesn't flow in these reservoirs. Also, it might not be possible to build high structures on top of these reservoirs.
Possibility to become interactive: Yes.
Flexibility: High.
Visibility: Low.

Water walls

A water wall is a wall that is made with blocks, which are hollow, that can store rain water.
Apply when: A non-constructive wall can be made out of these blocks.
Added benefits: Easy to integrate in households.
Negatives: When used indoor they can create cold-bridges.
Possibility to become interactive: Yes.
Flexibility: High.
Visibility: Low.

Rain barrels

A rain barrel is a barrel that can store rainwater. It is connected to the drainpipe from the roof. They can store up to 200L per barrel. They are easy to apply, and might not be able to store the most water but they highly increase sustainable water awareness.
Apply when: Possible for every household, but it needs to be connected to the sewage system.
Added benefits: Very cheap solution.
Negatives: They don't store a lot of water and they can freeze in winter.
Possibility to become interactive: Yes
Flexibility: High
Visibility: High

Garden roof

A garden roof is a green roof on which you can walk, sit, dance, run etc. It needs a heavier construction then the other types of green roofs.
Apply when: The roofs of a building are constructed to bear a higher load then usual (more than 1,5kN/m2). Or additional constructive measurements are taken to bear the higher load.
Added benefits: improves water quality, biodiversity and relieves heat stress.
Negatives: Construction needs to be tested to see if it's strong enough and maintenance is needed.
Possibility to become interactive: No
Flexibility: Low.
Visibility: Low.

Polder roof

A polder roof is a green roof with an added substrate layer to increase the capability to store rainwater.
Apply when: The roofs of a building are constructed to bear a higher load then usual (more than 1kN/m2). Or additional constructive measurements are taken to bear the higher load.
Added benefits: improves water quality, biodiversity and relieves heat stress.
Negatives: Construction needs to be tested to see if it’s strong enough and maintenance is needed.
Possibility to become interactive: No
Flexibility: Low.
Visibility: Low.

Infiltration areas with storage

Infiltration areas are unpaved areas where the rain water can be temporarily stored. They are lowered about 30 cm from the ground level. Gutters can lead the rain water from buildings and streets to these infiltration areas where, in time, the water simply seeps into the ground.
Apply when: There is a low ground water level and the soil type makes filtration into the ground possible.
Added benefits: Increases the water quality.
Negatives: They can’t be walked on and not all soil types are suited.
Possibility to become interactive: No
Flexibility: High.
Visibility: High

When looking at the Buiksloterham area, most of these storage methods can be applied. The ones with the need for a low ground water level might be more difficult, since the ground water level at Buiksloterham is at -0.50m. When using these methods, extra measures need to be taken in order to make sure they still work (Pötz, 2016).

The different scenario’s will use varying combinations of the storage methods, depending on the technologies they use, the visibility, flexibility and possibility to be made interactive.

Pictures: (Amsterdam Rainproof, 2017)

SCENARIOS

SCENARIO APPROACH

In order to test the different methods and elements that are important for the design, 4 different scenarios are created to test 4 different extremes. The outcome of these scenarios is a sketch design, that can be tested against the objectives and research questions set for the thesis.
The first scenario, scenario 0, is a zero-point scenario, it is based on a technology low – society low framework, meaning that the storage methods used are basic and that there is no neighbourhood participation possibility in the design. This scenario is to see how we can create a water self-sufficient neighbourhood. The second scenario, scenario 1, is based on a technology low – society high framework. It uses mainly natural means of water storage, but encourages people to live in close relationship to the water. The design of scenario 2 focusses on a technology high – society low framework. It uses integrated water storage methods together with the possibility of parts of the area to be flooded. But there are no means of water storage on the small scale, only on the large, and the methods that are used are non-interactive methods. The last scenario, scenario 3, is based on a technology high – society high framework. It looks towards integrated storage methods throughout all scale, adding water storage at as many places as possible and using interactive methods in order to get people as involved with the water storage system as possible.

SCENARIO 0 - GREEN HIGH DENSITY URBAN
TECHNOLOGY LOW - SOCIETY LOW

The first scenario, scenario 0, is developed to fulfil in the required m3 of rain water storage needed to be able to deliver the required rain water to every household in the designed area. But this is done in a way that it least impacts the further design of the area, so that it becomes a zero perspective to test the other scenario's against.

Therefore, for scenario 0, the water storage in the area is mainly underground. There will be storage underground and underneath buildings. The buildings in the area are connected to these underground storage reservoirs, which makes it possible to re-use the rain water in the households and businesses of the area. Above ground, rain water ponds and wadi's could be created to lower the stress on the sewage system and underground storage system. They also have an added benefit of improving the water quality when combined with helophyte filters.

The design of the area is inspired by the street pattern of the historical Amsterdam housing, but instead of water structures, the design uses green structures. The inspiration for the aesthetical part of the design is that of a green urban village, creating a high density urban atmosphere but with green all throughout.

The sustainability in this design comes from the re-use of rain water and the added green structure to Amsterdam North to increase biodiversity and heat stress. Possibilities for interactivity and neighbourhood participation in this model are very low.

GENERIC DATA

Housing:	26 HA, 3500 households, 9.500 inhabitants
Businesses:	32 HA, 30 large scale, 300 small scale
Water:	23 HA
Public space:	11 HA
Public green:	08 HA
Hard surface:	66 HA
Soft surface:	34 HA
Possible water storage:	200.000 m3
Needed water storage:	150.000 m3 (6700 m3 daily inhabitants, 3300 m3 daily businesses, 140.000 m3 peak rainfall)

RESERACH QUESTIONS (IN SHORT)

Watersystem

Direct connection het IJ: Direct connection stays

Flood defence: This design does not add additional flood defence to protect the area from flood risk from het IJ

Heavy rain stress: The design does prove a solution to store heavy rainfall and relieve stress on the sewage system. It does this by creating underground reservoirs for rain water storage, that can store all the rain water of a peak rainfall.

Climate change

Heavy rainfall: The design offers the possibility to store all water of a heavy rainfall, with extra m3 of storage to allow for an increase in rain.

Heat stress: The green structure of the area may relieve heat stress, but the orientation of the design prohibits wind from flowing through the area, because it is not designed towards the main direction of the wind and there is are very little large open spaces.

Increased flood risk: The design does not create additional flood defences.

Longer dry periods: By storing all the rain water the design becomes more resilient to longer dry periods.

Water storage

Visible water storage: There is no visible water storage in the design.

Interactive water storage: The storage methods used in this scenario do not lend themselves to become interactive.
Flexible storage: The methods used are flexible, they function just as well when dry as when wet.
Storage throughout scales: In this scenario, water storage is mainly on the large scale. There are no methods that can be used to storage water on the smaller scale.

Buiksloterham

Visible water: There is no visible water storage. The rain water ponds and the cannel that already flows through the area are the only visible water elements in the design.
Water in public space: Again, there is very little visible water in the design of this scenario.
Connect houses with water: There is no direct visible connection between the housing in the area and the water structure.

Timeframe

Day-night dependency: Because the storage methods used are all large scale, the water level will fluctuate little during the day.
Seasonal variation: The water storage elements will vary through the season; they will probably be full in winter and then towards summer they will empty more and more.
Lifespan: The elements created for water storage have a life span of about 50-100 years. In 50 years, the methods could still be useful, since they are reasonably straight forwards and have little effect on their surroundings.

Amsterdam

Self-sufficient in water use: The area is capable of storing enough water so that it becomes self-sufficient.
Relieve stress on the sewage system: Because there is so much storage, the stress on the sewage system coming from the Buiksloterham area will be significantly lower. All the rain water will go to the underground reservoirs, not the sewage system.
Transferability of the technology: The methods used can be applied everywhere.
Transferability of the social aspects: This scenario does not apply any of the social aspects that increase sustainable awareness. Therefore, they are also not transferable, because they are not in the model.

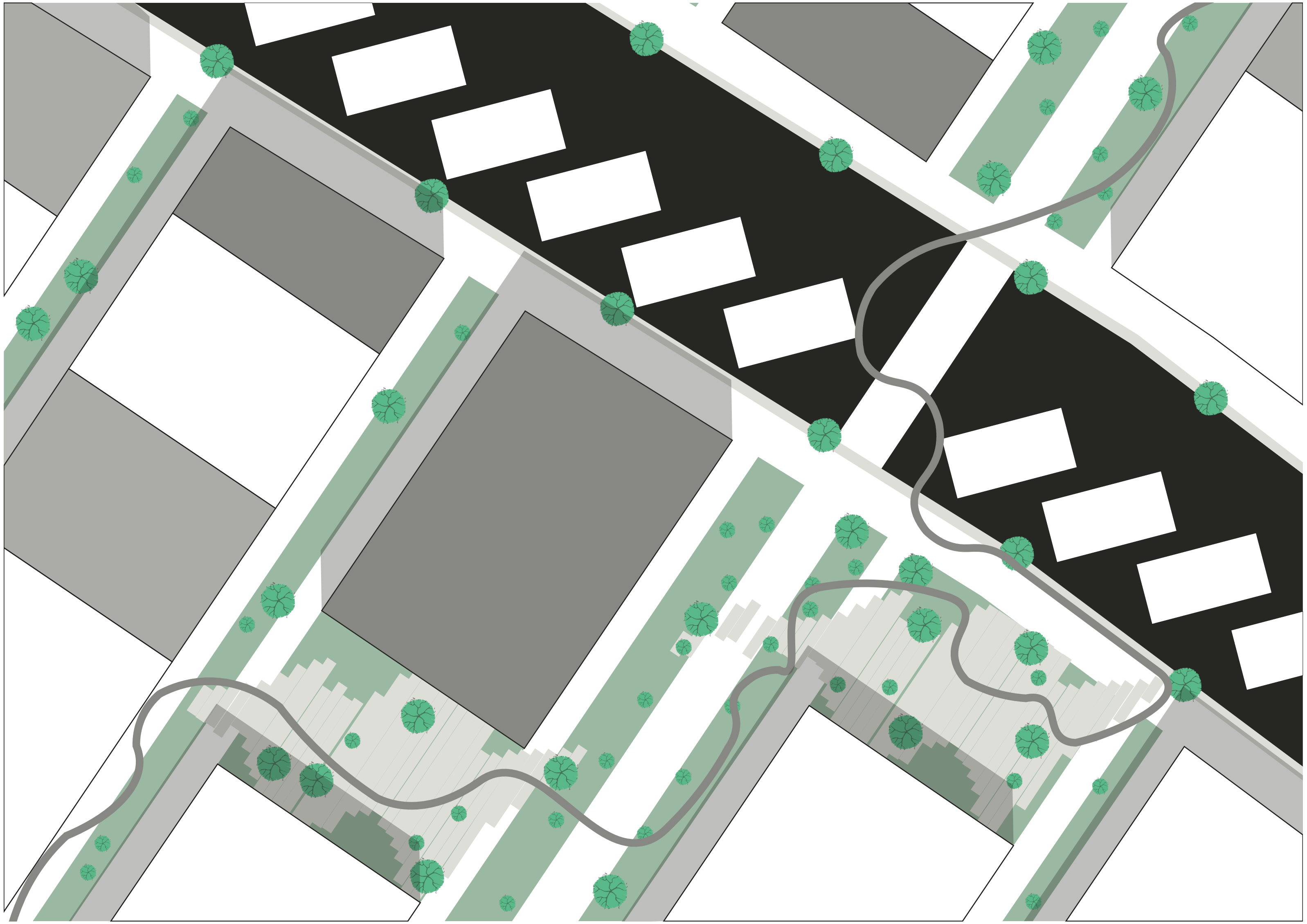
Sustainable awareness

Connecting people: The model does not create an opportunity for people to work together on the water storage system.
Feedback from the municipality: Because the water storage system in scenario 0 is not interactive, it cannot reply to feedback coming from the municipality.
Connection houses with water: There is no visible connection between the houses and the water structure.
Storage through scales: The design only creates storage opportunities on a large scale.

Scenario 0 may fulfil the wish to have a water self-sufficient Buiksloterham design, but it does not do well for the objectives set for the thesis. It does however give us a nice place to start, since we now know that it is possible to become self-sufficient in water use. We can now see how the other objectives relate to this, by testing it in the next 3 scenarios'.

Impression of the athmosphere for Scenario 0

Plan 1:10.000



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DESIGN

The design of scenario 0 is based upon the cannel houses in Amsterdam, the size of the houses determined by a comparable block, just outside of the center of Amsterdam. The blocks will be between 3-6 layers high, creating a high density area. The streets in the middle are wide, one way streets. In the middle, instead of having a cannel, is a green structure. The green structure leading visually towards the cannel in the middle of the area. The blocks also house some small businesses, allowing for the oppertunity to create mixed work-living housing. On the east, next to het IJ is a big park and square, forming the center of the area. This connectes to the NDSM-werf at the east of the location. Living boats are situated in the cannel in the middle, to further enhance the relation between the area and the center of Amsterdam.

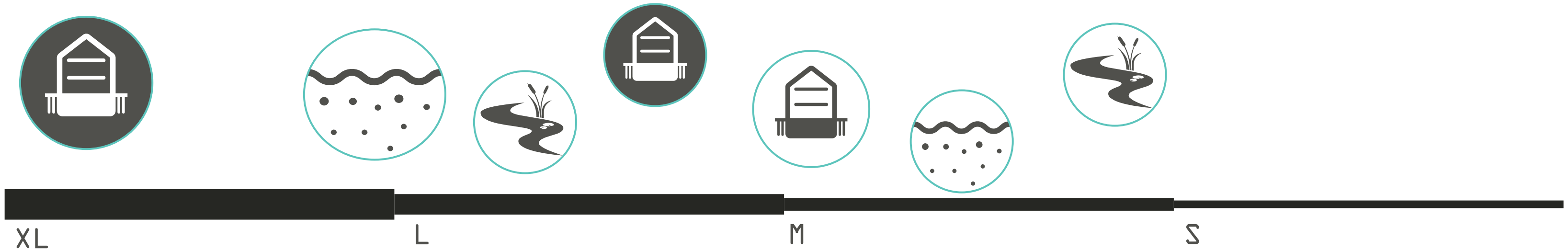
Looking at the zoom-in it becomes clear that space has been left open in between the blocks to create a green area for the inhabitants of the Buiksloterham area. These green spaces are connected together by means of a flowing route, which also connects with the green structure in the middle of every street. This route also flows towards the cannel in the middle of the area, directing people there. The streets next to the cannel in the middle will form a river boulevard area, with a pathway next to the riverside which is framed by trees.

THE METHODS

Scenario 0 uses rainwater ponds, wadi’s, storage under buildings and underground storage to store rain water. The storage methods are connected to the houses by pipes underground. Most of the methods are applied on the larger scales.

THE METHODS


Rainwater ponds
Wadi
Storage under buildings
Underground storage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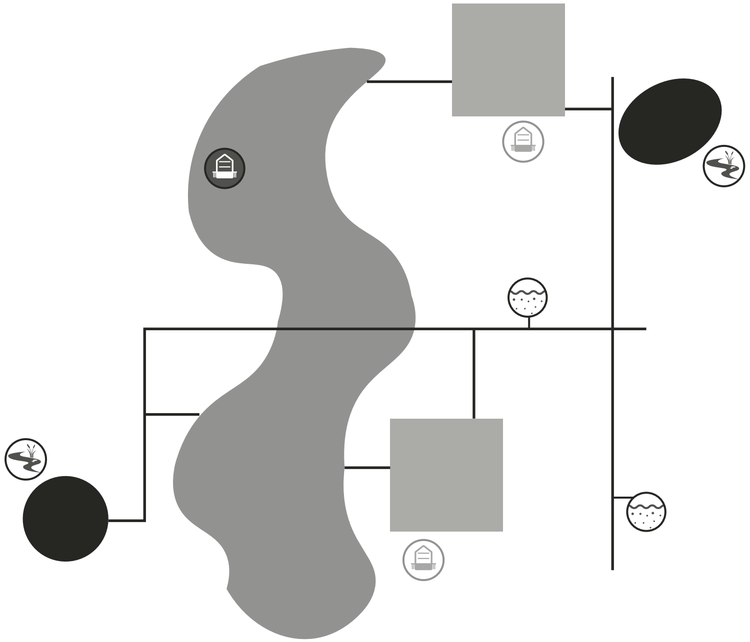


THE PRINCIPLE

SCENARIO 1 - WATER LIVING VILLAGE

TECHNOLOGY LOW - SOCIETY HIGH

The second scenario, scenario 1, is based on creating as much connection between the daily life of the inhabitants and water. It is designed in such a way that every housing block is surrounded by water and the public space areas are surrounded and/or on the water. Rain water storage are mostly natural storage methods, such as the use of wadi's, rain water ponds and relief to store water in the different areas. There is the possibility for houses to use rain barrels to store their own rain water, to further increase the connection between the inhabitants and the water. Important in this model is the condition of the ground water. The soil in the area is heavily polluted, which means so is the ground water. With the storage methods chosen for the design, the rain water will come in contact with the ground water, after which it cannot be used any more in the households. In this model, either the areas where rain water is stored need to be separated from the soil with a foil, or the soil needs to be cleaned.

The sustainability in this design comes from the living with water aspect, allowing for lots of storage and movement of the water in the area. In this scenario lots of permeable soil, soft surfaces and green space is created. This also helps increase the biodiversity, relieve heat stress and improve the soil conditions.

GENERIC DATA

Housing:	23 HA, 1500 households, 4.000 inhabitants
Businesses:	18 HA, 30 large scale, 100 small scale
Water:	33 HA
Public space:	21 HA
Public green:	04 HA
Hard surface:	51 HA
Soft surface:	49 HA
Possible water storage:	660.000 m3
Needed water storage:	146.000 m3 (3400 m3 daily inhabitants, 2600 m3 daily businesses, 140.000 m3 peak rainfall)

RESEARCH QUESTIONS (IN SHORT)

Watersystem

Direct connection het IJ: The direct connection between het IJ and the water in the area can be severed in this model.
Flood defence: This design does add additional flood defence to protect the area from flood risk from het IJ
Heavy rain stress: The design does prove a solution to store heavy rainfall and relieve stress on the sewage system. It does this by creating flexible floodable areas.

Climate change

Heavy rainfall: The design offers the possibility to store all water of a heavy rainfall, with extra m3 of storage to allow for an increase in rain.
Heat stress: The green structure of the area relieves the heat stress and there is a lot of open space in the area.
Increased flood risk: The design creates additional flood defence by separating the area from het IJ.
Longer dry periods: By storing all the rain water the design becomes more resilient to longer dry periods.

Water storage

Visible water storage: Water is stored all through the public spaces in the area, creating highly visible water storage.

Interactive water storage: The storage methods used in this scenario do not lend themselves to become interactive, with exception of the rain barrels.
Flexible storage: The methods used are flexible, they function just as well when dry as when wet.
Storage throughout scales: In this scenario, there is a connection between the storage methods on every scale, going from small scale storage interventions on the private level to large scale public storage methods.

Buiksloterham

Visible water: All storage methods used in this model are visible.
Water in public space: The public space in this design is used for water storage, creating public space that can either be (partly) flooded or public space that is on the water.
Connect houses with water: There is a visible connection between the houses and the water.

Timeframe

Day-night dependency: There are some small-scale storage methods, these will vary throughout the day.
Seasonal variation: The water storage elements will vary through the season; they will probably be full in winter and then towards summer they will empty more and more.
Lifespan: The elements created for water storage have a life span of about 50-100 years. In 50 years, used now might be outdated. They are all mainly natural storage methods, so it is very possible that new technologies will develop that will make the methods less efficient. Their use comes from their aesthetics and their flexibility, in the future it will be interesting to see if the methods can be added on or adapted to fulfil in future needs.

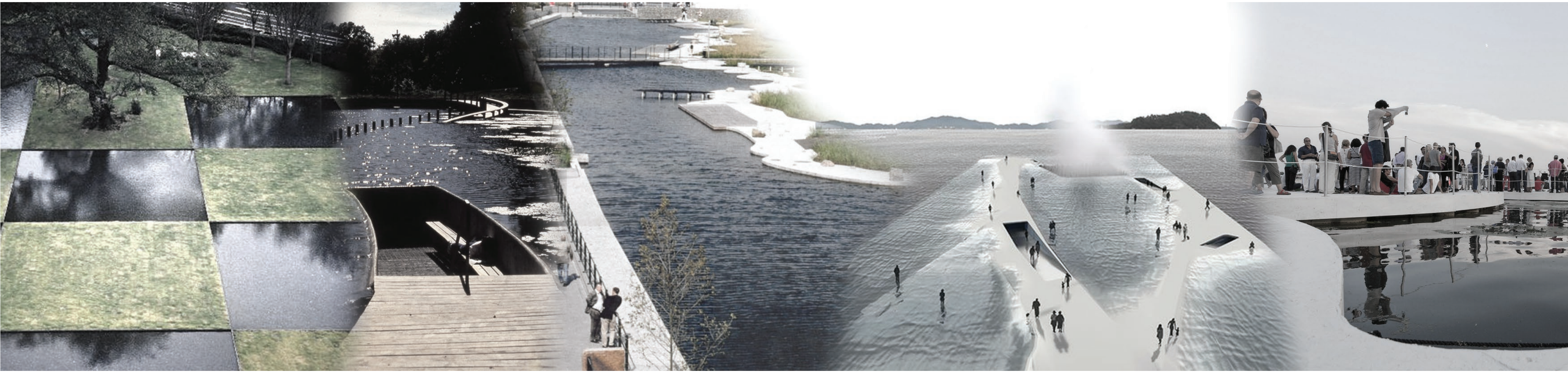
Amsterdam

Self-sufficient in water use: The area is capable of storing enough water so that it becomes self-sufficient.
Relieve stress on the sewage system: Because there is so much storage, the stress on the sewage system coming from the Buiksloterham area will be significantly lower. All the rain water will go to the lowest parts of the area, flooding more and more parts of the neighborhood.
Transferability of the technology: The methods used can be applied everywhere as long as the design of the area allows for water to flow flexible through the intended area and parts of the area can be flooded from time to time.
Transferability of the social aspects: This model creates an environment that is very dependable on the weather and very flexible. This means that the inhabitants will have to be willing to live with these circumstances. Schooling of inhabitants on the importance of this way of water storage can be needed.

Sustainable awareness

Connecting people: The model encourages the inhabitants of a building block to work together on water storage.
Feedback from the municipality: Because the water storage system in scenario 1 is not interactive, it cannot reply to feedback coming from the municipality. The rain barrels are to small scale to be of importance to the municipality when it is in need of water storage.
Connection houses with water: There is a visible connection between the houses and the water structure.
Storage through scales: The design creates storage possibilities for every scale level.

Scenario 1 creates a residential area where the inhabitants will have to live closely to the water. The inhabitants will be forced to give up functioning parts of their public space for weeks, when the water level is high and parts will be flooded. It creates a new way of living with water, forming a water village in the center of Amsterdam.



Impression of the athmosphere for Scenario 1

Plan 1:10.000

Plan 1:1.000

DESIGN

The design of scenario 1 is was inspired by Giethoorn, a small village in the Netherlands where they have no streets, only rivers. Everybody moves there by boats. This living with water idea was what inspired this design. The houses are blocks, with a small green area in the middle which is only meant for the inhabitants of the blocks. The public space is all part of the water storage system, it all can be flooded. The streets are highers then the green surrounding them, so that they remain dry and people can still move through the area in wet periods. The other public space areas, parks and squares for example, are all allowed to be flooded. Functions in these areas will be designed in such a way that they function both wet and dry. All throughout the neighbourhood are little flowing rivers, made by simply digging out the soil so that the water will naturally flow towards these lowers parts.

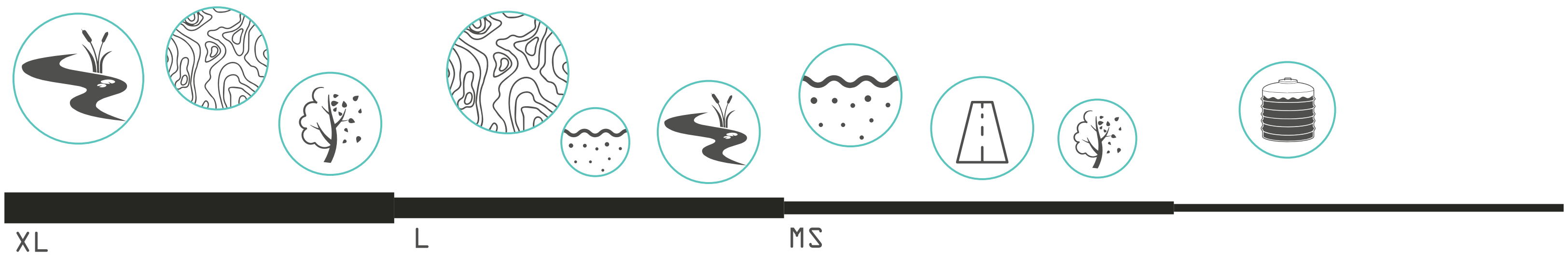
In the zoom-in we see one of the squares. It becomes clear that the square is surrounded by little rivers and streams, that can grow in size depending on how much rain fall there is. Parts of the square itself can also be flooded. There is a slightly elevated route going through the area, which will always remain dry.

THE METHODS

Scenario 1 uses rain water ponds, rain barrels, relief, infiltration barrels, urban waterways, seasonal storage and wadi's. The storage systems are all connected by the small rivers, which form a circulair system. The rain barrels allow people to participate in the storage process on a private scale.


Rainwater ponds
Rainbarrels
Urban waterways
Wadi
Relief
Seasonal storage

THE METHODS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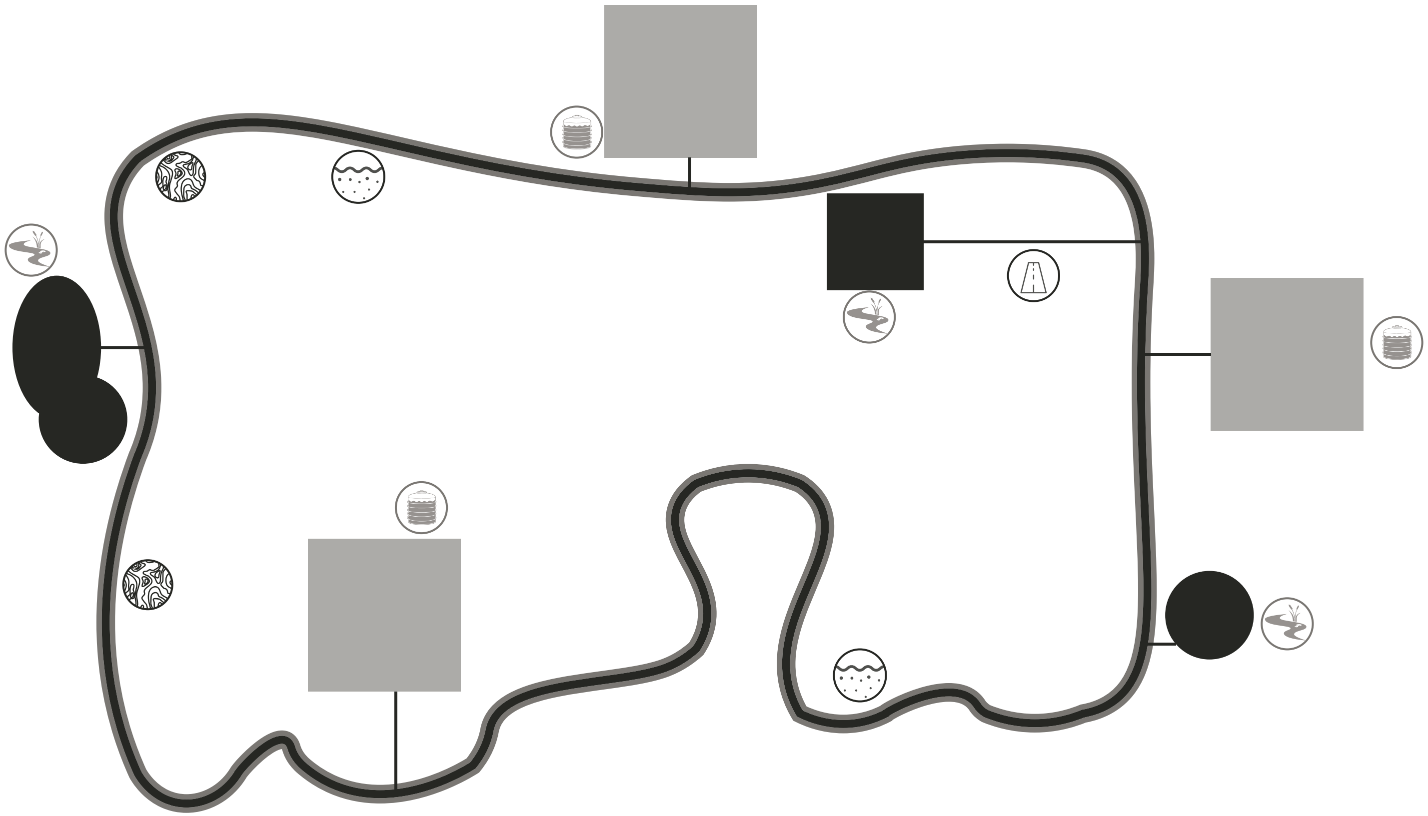

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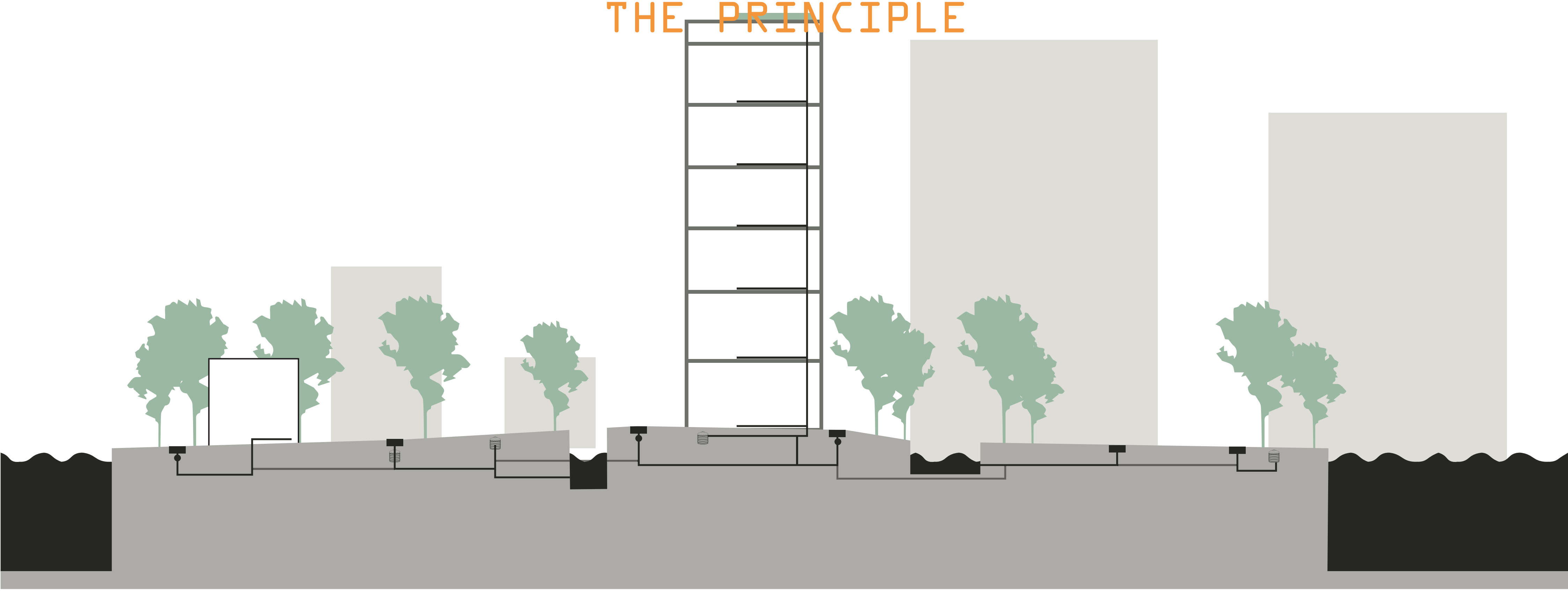


SCENARIO 0 - HEIGHTENED CENTER

TECHNOLOGY HIGH - SOCIETY LOW

Scenario 2 is formed by creating 3 different levels in the area, of which the highest is in the middle. These 3 levels all have a river at the edge, where water can naturally flow into. When the highest level is full, it overflows into the level below and so onwards. At the lowest level the water will simply flow into het IJ. The levels have small rivers going through it as well, connecting them together. Each ring is connected to its own set of other water storage methods. And to the housing blocks on that level. It used a combination of natural storage methods and more integrated ones.

The inhabitants of the area are not that involved, most of the methods chosen are non-interactive, and they focus on the larger scales. The public space is where most of the water storage elements are situated.

GENERIC DATA

Housing:	30 HA, 3.000 households, 8.000 inhabitants
Businesses:	23 HA, 30 large scale, 300 small scale
Water:	20 HA
Public space:	18 HA
Public green:	11 HA
Hard surface:	63 HA
Soft surface:	37 HA
Possible water storage:	145.000 m3
Needed water storage:	150.000 m3 (7.000 m3 daily inhabitants, 3.000 m3 daily businesses, 140.000 m3 peak rainfall)

RESERACH QUESTIONS (IN SHORT)

Watersystem

Direct connection het IJ: The direct connection between het IJ and the water in
the area can be severed in this model, but with the possibility to overflow into het IJ.

Flood defence: Additional flood defence is added by heightening the area.

Heavy rain stress: This scenario relieves stress on the sewage system, because all rain water can be stored in the area itself.

Heavy rainfall: The design has enough room to store all the rain water of a heavy rainfall, but it does not leave room for a lot more.

Heat stress: The green structure of the area relieves the heat stress and there is a lot of open space in the area.

Climate change

Increased flood risk: The design creates additional flood defence by separating the area from het IJ and heightening the area itself.

Longer dry periods: It is possible to store all rain water, but there isn’t room for a lot extra when there has been a peak rainfall or a long wet period. So, it is possible to store rain water for dry periods, but not as much as scenario 0 & 1.

Water storage
Visible water storage: Water is stored all through the public spaces in the area, creating highly visible water storage. And water is also stored on the private level, further increasing the visibility.
Interactive water storage: The storage methods used are interactive, although not all of the large-scale water storage methods are interactive.
Flexible storage: The methods used are flexible, they function just as well when dry as when wet.
Storage throughout scales: In this scenario, there is a connection between the storage methods on every scale, going from small scale storage interventions on the private level to large scale public storage methods.

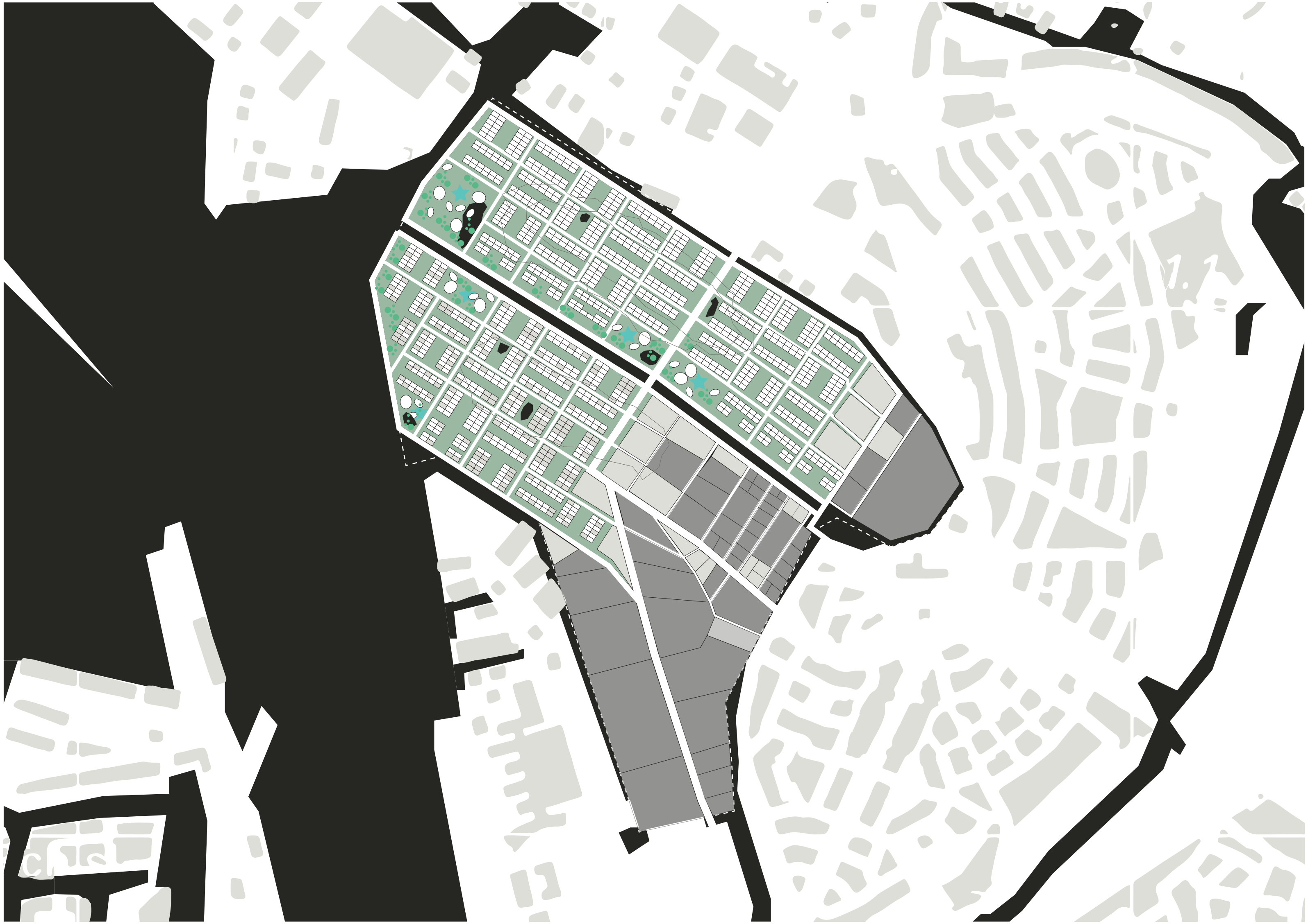
Buiksloterham
Visible water: All storage methods used in this model are visible.
Water in public space: Water storage is also integrated in the public space in such a way that it does not limit the function of the public space.
Connect houses with water: There is a visible connection between the houses and the water.

Timeframe
Day-night dependency: There are small-scale storage methods, these will vary throughout the day.
Seasonal variation: The water storage elements will vary through the season; they will probably be full in winter and then towards summer they will empty more and more.
Lifespan: The elements created for water storage have a life span of about 50-100 years. In 50 years, they might be outdated. They are natural storage methods, which could become very inefficient compared to new develop technologies. And the methods used now that depend on technology will be outdated in about 25 years. The methods need to be applied in a flexible way, with the possibility to change them in the future.

Amsterdam
Self-sufficient in water use: The area is capable of storing enough water so that it becomes self-sufficient.
Relieve stress on the sewage system: There is enough storage to store a peak rain fall, so in most cases this scenario will relieve the stress on the sewage system. But there is not a lot of room for much extra rain water, so it will not take away all the stress on the sewage system. Transferability of the technology: The methods used can be applied in all designs where it is possible to heighten parts of the area, creating different levels.
Transferability of the social aspects: This model has water storage mostly on the large scale, with not a lot of interference from the inhabitants of the area. Awareness in this model will come from visibility and closeness of the water in public space, which could be applied everywhere where it rains enough so that the water is visible most of the year.

Sustainable awareness
Connecting people: The parts of the design of the water storage system that are interactive are both on the small and the large scale. On the large scale, decisions will have to be made by multiple people on how to proceed. In this way it does connect the inhabitants of the area together, but in reality this will only be a select group of people.
Feedback from the municipality: The larger scale interventions could be influenced by the wishes of the municipality. However, because there is limited amount of water storage, the questions is if this is relevant, since the municipality cannot store excess rain water on the location after a heavy rain fall (since the water storage elements will be completely full already).
Connection houses with water: There is a visible connection between the houses and the water structure.
Storage through scales: The design creates storage possibilities for every scale level.

Impression of the athmosphere for Scenario 2



Plan 1:10.000

Plan 1:1.000

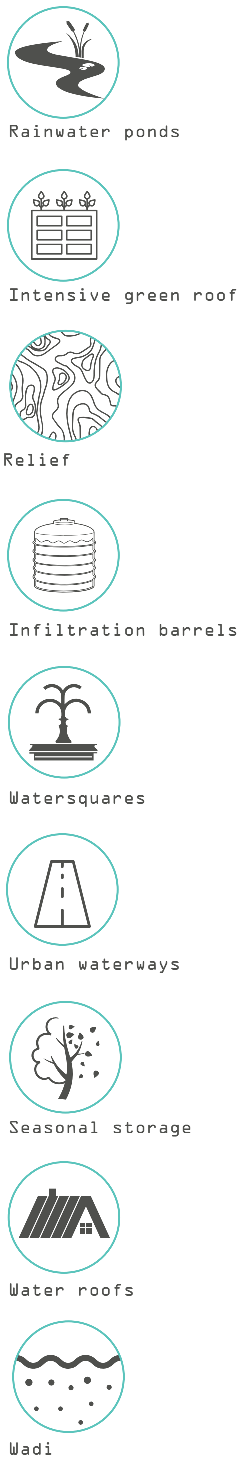
DESIGN

The design of this scenario was inspired by floodable areas and Ankorpark in Mälmo, Sweden. The idea is that is looks like a natural green area with streams flowing through it, in these streams rain water can gather. These streams flow all throughout the neighbourhood. The area in the middle is higher, so that from that point rain water will automaticly flow towards to lower levels, there there is a higher capacity to store rain water.

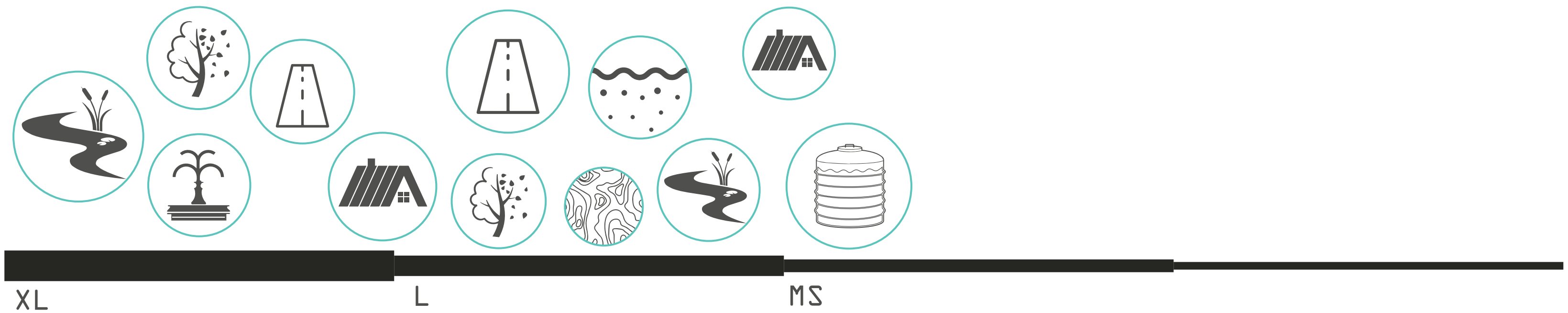
In the zoom-in it becomes visible that there is a rover that flows all along the cannel in the middle of the area. This is the final ring, the one of the lowest level. It is seperated from het IJ, but with the possibility to overflow the excess rain water into the cannels connecting this ring river and het IJ. The design is inspired by the edgy formation that water forms in rock. The round shapes of the paths cut through these edgy shapes. The path connectes the North bank and the South bank together. The North bank has a park on it, because this is the side with the most sun. People can walk all along this edge through the park next to the canal. The square in the zoom-in is partly a water square, to increase the m3 of water storage in the area.

THE METHODS

This scenario used rain water ponds, intensive green roofs, relief, infiltration barrels, water squares, urban waterways, seasonal storage, water roofs and wadi's. All of the storage elements are focussed on the large scale, except infiltration barrels which could be applied on the smallest scale.


Rainwater ponds
Intensive green roof
Relief
Infiltration barrels
Watersquares
Urban waterways
Seasonal storage
Water roofs
Wadi

THE METHODS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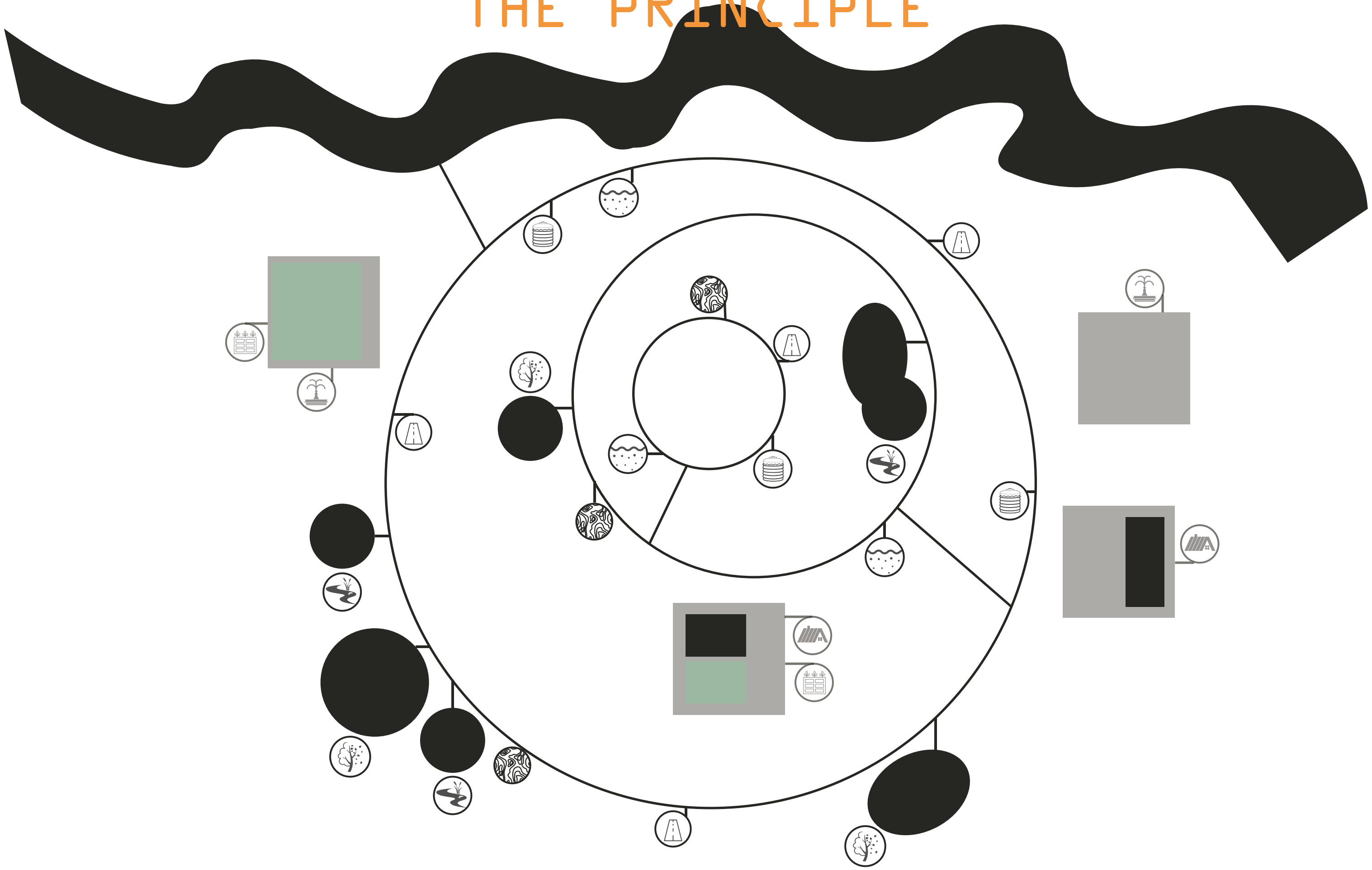
THE PRINCIPLE



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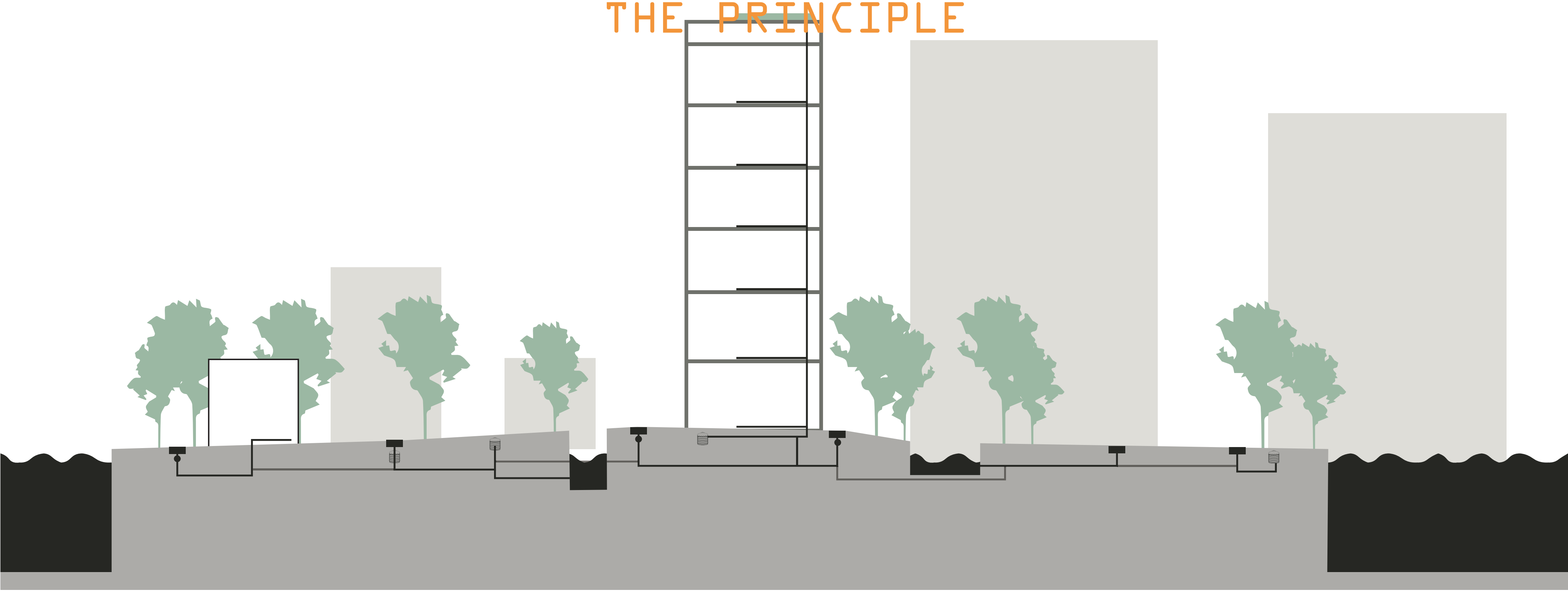


SCENARIO 3 - INTEGRATED SUSTAINABLE LIFE

TECHNOLOGY HIGH - SOCIETY HIGH

Scenario 3 is inspired by the design of the Western harbour area of Mälmo, Sweden. The goal is to integrate water storage at every scale as much as possible, with a focus on the small scale and using as many interactive water storage methods as possible. The design also aims to show as many of these storage methods as possible, so that both visitors and inhabitants of the area are confronted with rain water storage in all the public space areas. Water storage is integrated here with elements like water holding planters, green roofs, water roofs, water walls, but also large scale elements like rain water ponds, urban water ways and seasonal storage.

GENERIC DATA

Housing: 30 HA, 3.200 households, 9.000 inhabitants
Businesses: 23 HA, 30 large scale, 300 small scale
Water: 18 HA
Public space: 19 HA
Public green: 12 HA
Hard surface: 61 HA
Soft surface: 39 HA
Possible water storage: 175.000 m3
Needed water storage:155.000 m3 (7.500 m3 daily inhabitants, 3.000 m3 daily businesses, 140.000 m3 peak rainfall)

RESERACH QUESTIONS (IN SHORT)

Watersystem

Direct connection het IJ: The direct connection between het IJ and the water in the area can be severed in this model.
Flood defence: No additional flood defence is added.
Heavy rain stress: This scenario relieves stress on the sewage system, because all rain water can be stored in the area itself.
Heavy rainfall: The design has enough room to store all the rain water of a heavy rainfall, but it does not leave room for a lot more.
Heat stress: The green structure of the area relieves the heat stress but there are too little open spaces for the wind to flow freely.

Climate change

Increased flood risk: The design creates no additional flood defence.
Longer dry periods: It is possible to store all rain water, but there isn't room for a lot extra when there has been a peak rainfall or a long wet period. So, it is possible to store rain water for dry periods, but not as much as scenario 0 & 1.

Water storage

Visible water storage: Water is stored all through the public spaces in the area, creating highly visible water storage. And water is also stored on the

private level, further increasing the visibility.
Interactive water storage: Most of the storage methods used can be made interactive, every inhabitants of the area should be able to participate in this model.
Flexible storage: The methods used are flexible, they function just as well when dry as when wet.
Storage throughout scales: In this scenario, there is a connection between the storage methods on every scale, going from small scale storage interventions on the private level to large scale public storage methods.

Buiksloterham

Visible water: All storage methods used in this model are visible.
Water in public space: Water storage is also integrated in the public space in such a way that it does not limit the function of the public space.
Connect houses with water: There is a visible connection between the houses and the water.

Timeframe

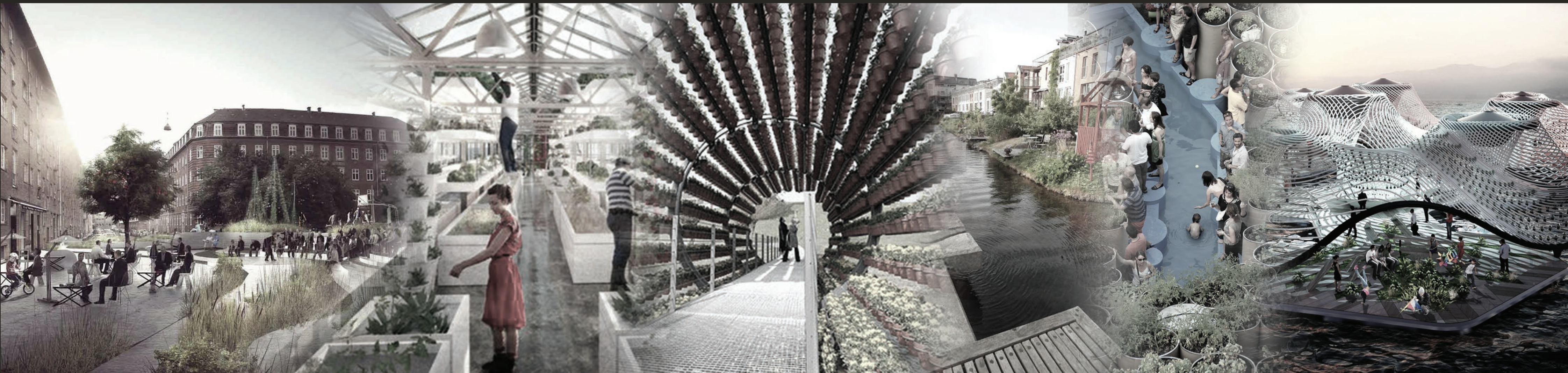
Day-night dependency: There are small-scale storage methods, these will vary throughout the day.
Seasonal variation: The water storage elements will vary through the season; they will probably be full in winter and then towards summer they will empty more and more.
Lifespan: The elements created for water storage have a life span of about 50-100 years. In 50 years, they might be outdated. They are natural storage methods, which could become very inefficient compared to new develop technologies. And the methods used now that depend on technology will be outdated in about 25 years. The methods need to be applied in a flexible way, with the possibility to change them in the future.

Amsterdam

Self-sufficient in water use: The area is capable of storing enough water so that it becomes self-sufficient.
Relieve stress on the sewage system: There is enough storage to store a peak rain fall, so in most cases this scenario will relieve the stress on the sewage system. But there is not a lot of room for much extra rain water, so it will not take away all the stress on the sewage system. Transferability of the technology: The methods used can be applied in most urban areas, given that they have enough space to be executed.
Transferability of the social aspects: The methods used can be applied in most high-density areas, but a willingness of the inhabitants to participate in living sustainable is preferable. If not, then further education might be necessary to convince inhabitants of the importance of the system.

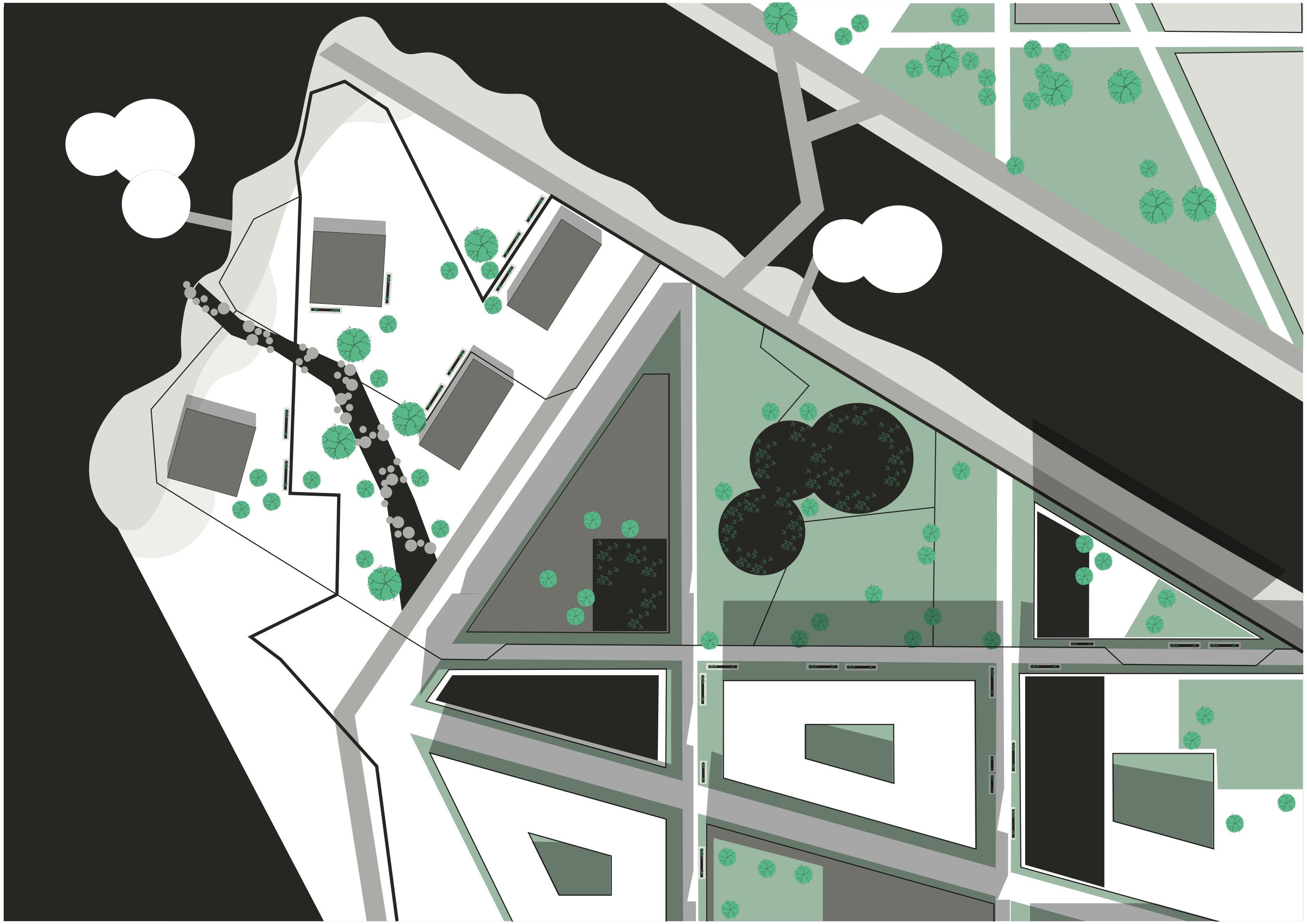
Sustainable awareness

Connecting people: The parts of the design of the water storage system that are interactive are both on the small and the large scale. On the large scale, decisions will have to be made by multiple people on how to proceed. This way, it does connect the inhabitants of the area together, but in reality this will only be a select group of people. By creating medium and small scale storage methods that could be shared, the design encourages all the inhabitants to work together.
Feedback from the municipality: The methods in this design model can respond to the wishes of the municipality on all scales. A higher storage capacity would make this more beneficial to the city of Amsterdam.
Connection houses with water: There is a visible connection between the houses and the water structure.
Storage through scales: The design creates storage possibilities for every scale level.



Impression of the athmosphere for Scenario 3

Plan 1:10.000



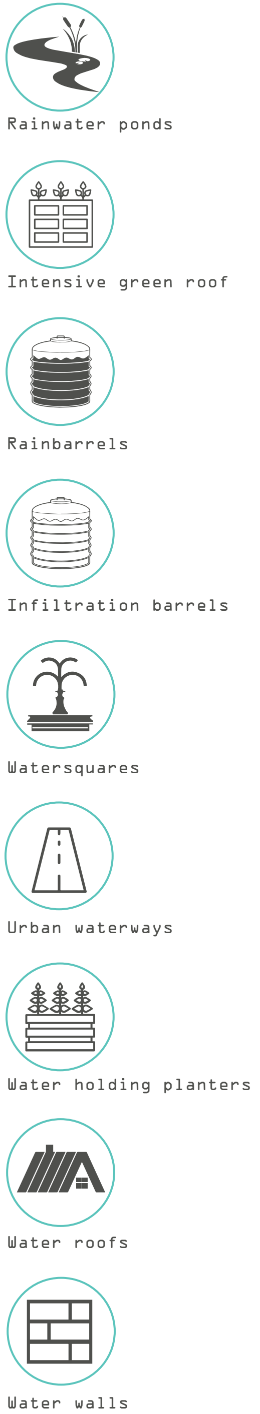
Plan 1:1.000

DESIGN

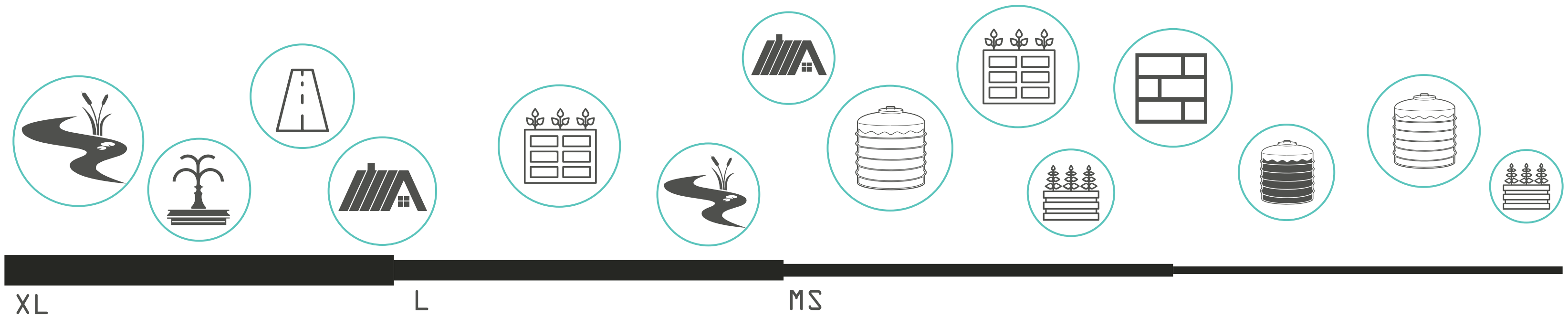
The design of this scenario was inspired by the Western harbour area in Mälmo, Sweden. The goal is to integrate rain water storage as much as possible in the design of the area, both private and public. The cannal from het IJ will become a center point in the area, creating large public spaces next to it. These public spaces have forms of water storage integrated through it. Throughout the neighbourhood all the urban waterways form a flowing circle, where helophyte filteres can be added to improve on the quality of the rain water. The buildings can be equipped with water roofs or green roofs. The grid structure of the area is directed at the sun, so that the streets will have the sun in them during the afternoon. Water is an element of design all throughout this scenario.

THE METHODS

This scenario used rain water ponds, intensive green roofs, water holding planters, infiltration barrels, water squares, urban waterways, rain barrels, water roofs and water walls. These are storage methods that run through the different scales and can react to wishes of inhabitants and the municipality.


Rainwater ponds
Intensive green roof
Rainbarrels
Infiltration barrels
Watersquares
Urban waterways
Water holding planters
Water roofs
Water walls

THE METHODS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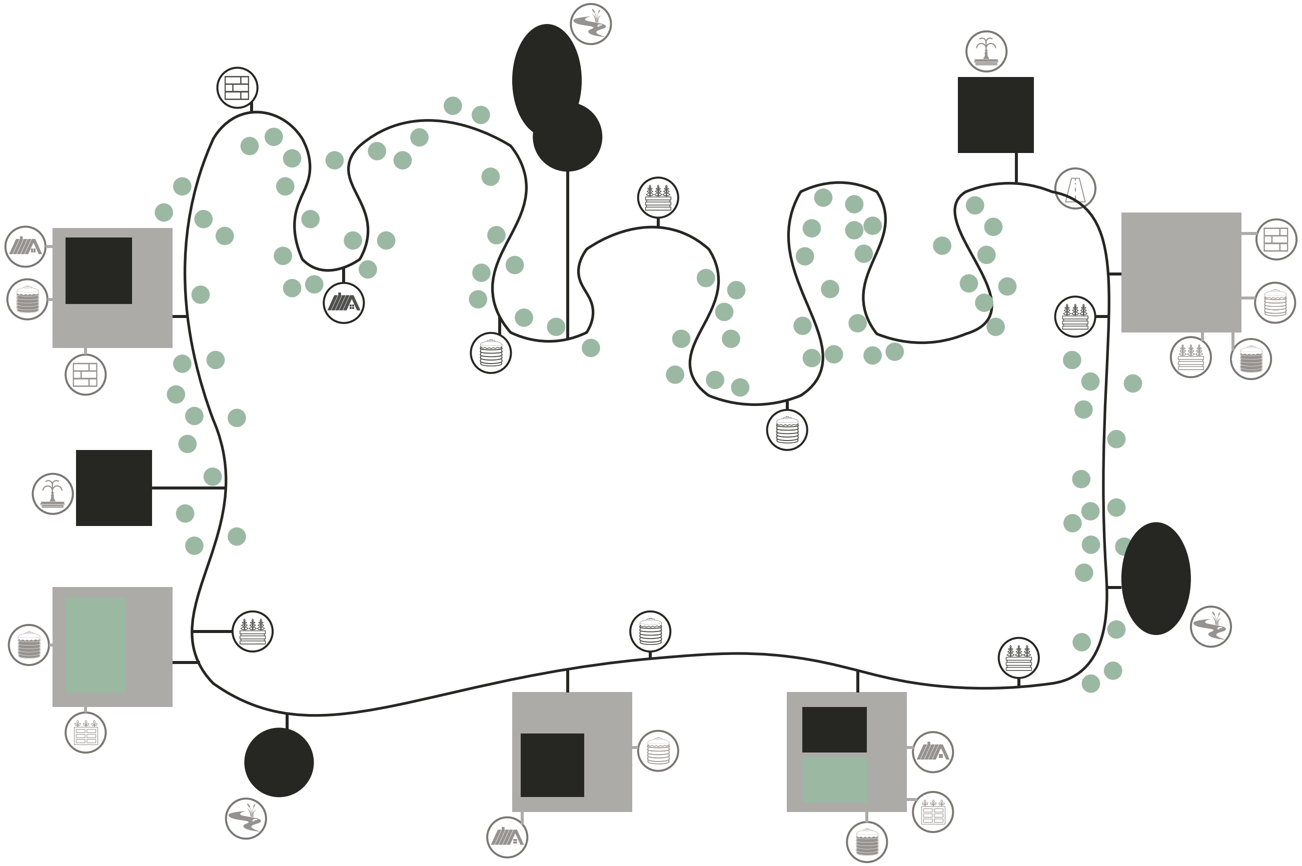

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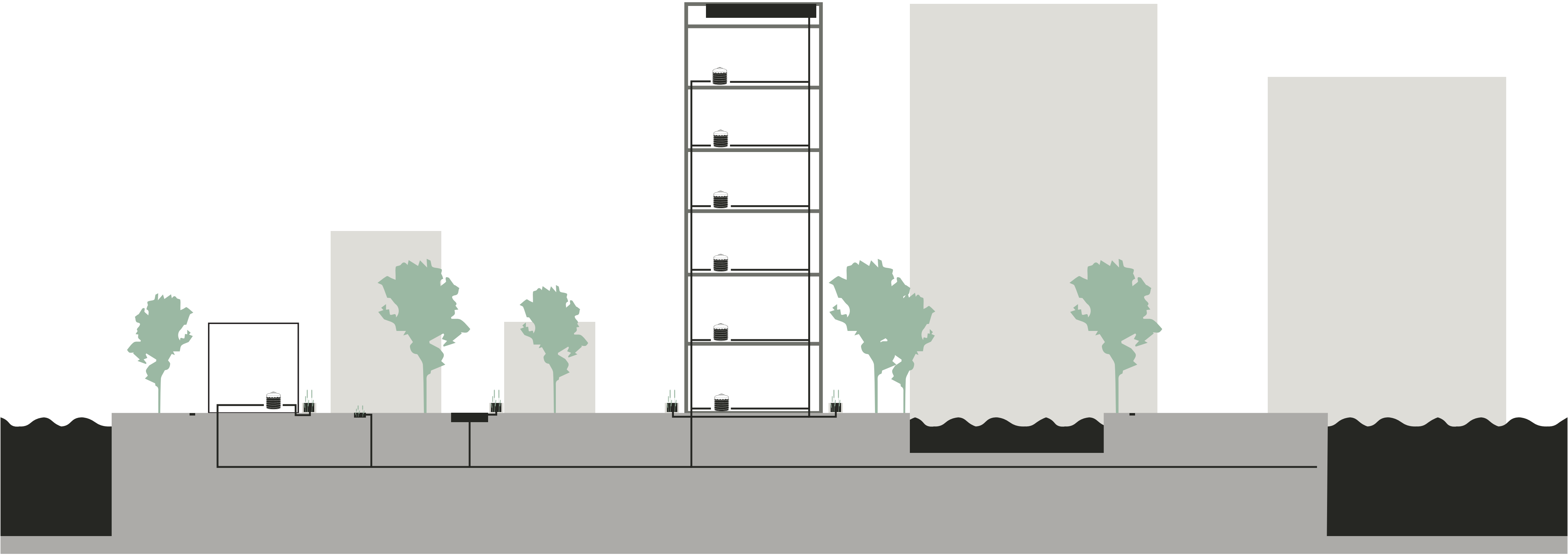


SCENARIO - COMPARISON

The first scenario was to test a zero point, to see what is needed to create a water self-sufficient neighbourhood. The second scenario, scenario 1, aims to test how people can integrate their daily lives with water in their direct environment. Scenario 2 looks at natural ways of water storage that can be integrated into a modern day high density urban area. The last scenario, scenario 3, looks at water storage methods that can be made interactive and tries to apply those in as many ways possible.

The first and second scenario do not live up to the objectives set for the thesis very well. They both fail to meet the 3 main criteria. The first scenario, the zero point, only meets 3 of the objectives, of which two are external ones. However, what is interesting, they do have a much higher storage capacity then the last two scenarios. This means that they could have a more significant contribution to the whole of the Amsterdam system. The last two scenarios, at the moment, lack this, which is a missed oppertunity.

The third scenario scores a lot higher then the first two. But creating a sustainable neighbourhood, interactive water storage and water storage
throughout the scales is still lacking in this model.

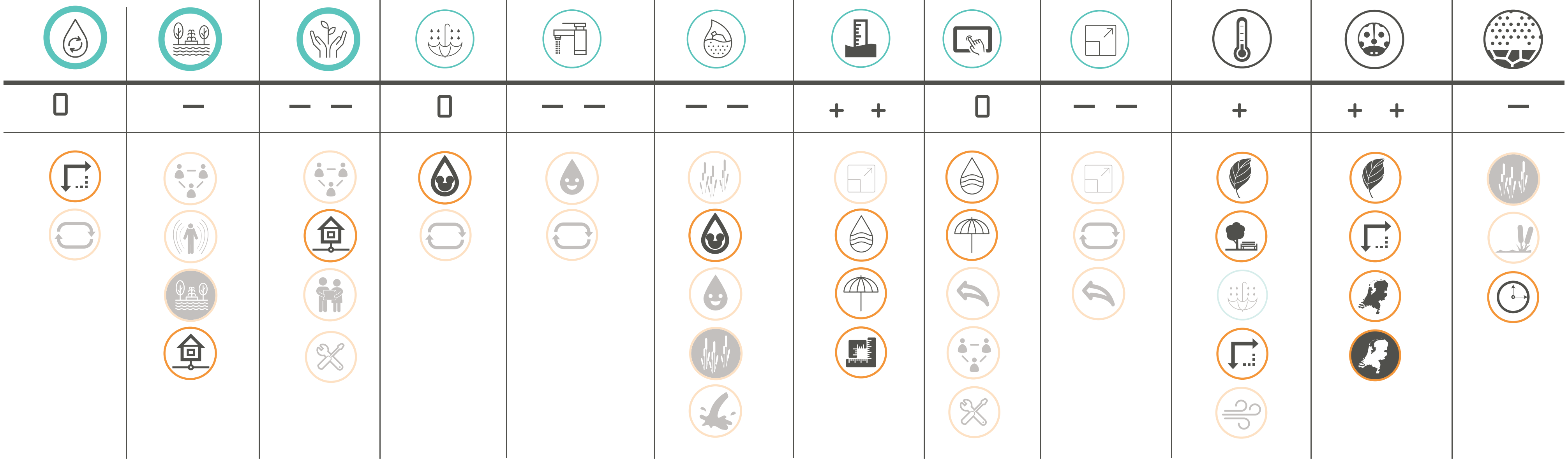
The last scenario, scenario 3, does quite well on the objectives. It does however need to pay more attention to re-using grey water and creating better soil conditions.

When looking at the research question we see the same pattern, the first two scenarios don't solve all the problems. The last two almost do, but in the next step more attention needs to be paid to flood defences, interactive water storage, storage throughout the scales and the social aspects of the design. In general, scenario 4 does quite well, but still leaves room improvement on flood defence and the social aspects of integrated water storage.

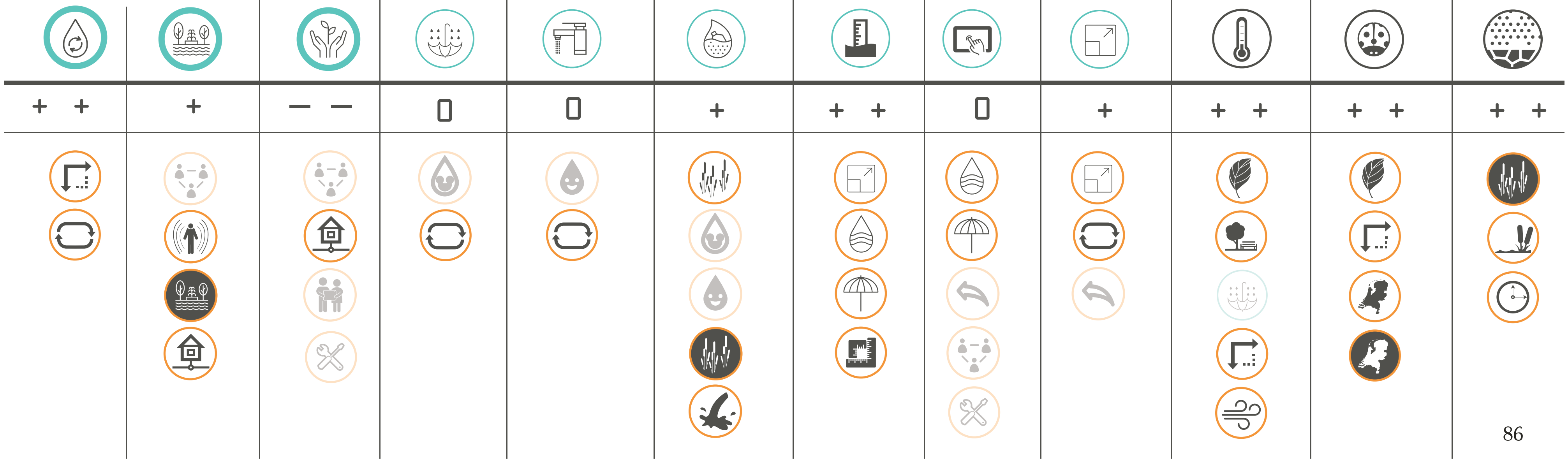
The recommendation for the next step is to look at scenario 1, take some of the elements from scenario 2 and add these to the system of scenario 3. The design will have to look towards the 0 scenario and scenario 1 to see how the capacity for rain water storage can increase.
For the next step, the scenario also has to be translated to a realistic design. The models that are now created are sketches, models to calculate and see effects of different storage concepts. For the actual desi
gn this concept needs to be translated to reality, combining it with elements like transport, daily life functions, social use of public space, landscape and the environment.

All scenarios have good points, for the best design of an interactive flexible water storage system for Buiksloterham, they need to be combined and integrated all throughout the design.

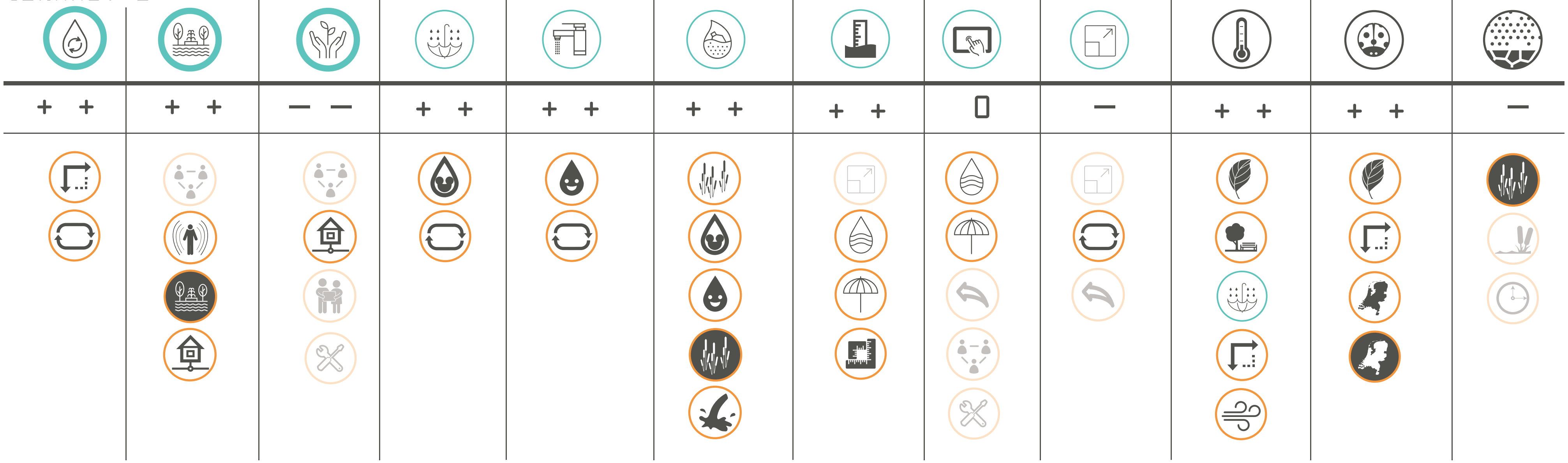
SCENARIO 0



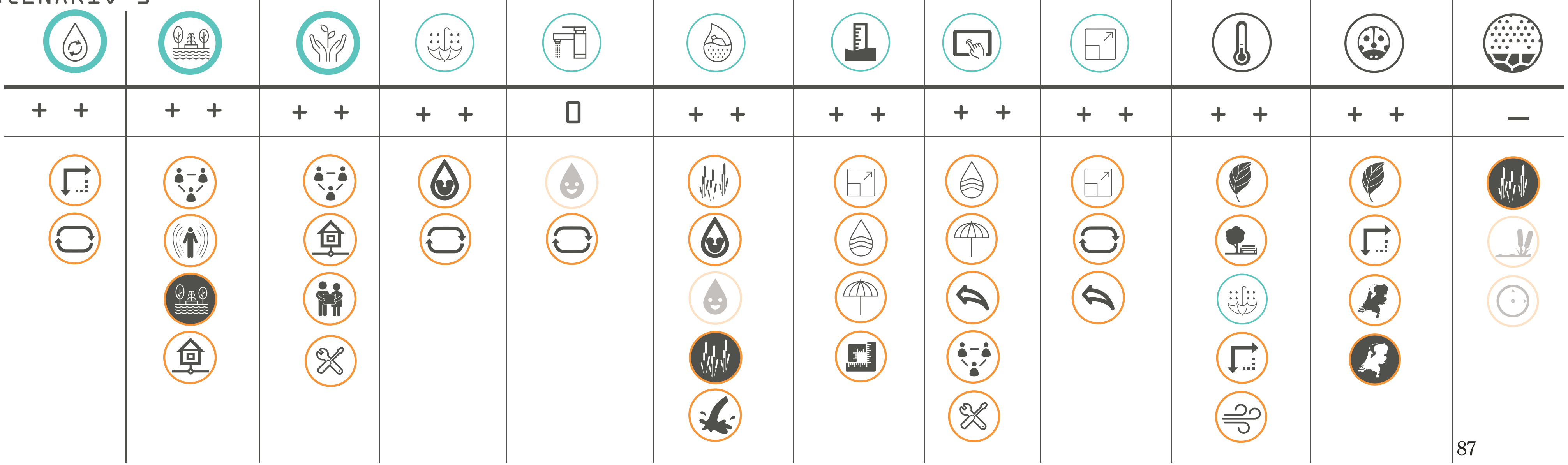
SCENARIO 1



SCENARIO 2



SCENARIO 3



		SCENARIO 0	SCENARIO 1	SCENARIO 2	SCENARIO 3
WATERSYSTEM	direct connection IJ		✓	✓	✓
	no additional flood defense		✓	✓	
	heavy rain stress	✓	✓	✓	✓
CLIMATE CHANGE	heavy rainfall	✓	✓	✓	✓
	heat stress		✓	✓	✓
	increased flood risk		✓	✓	✓
	longer dry periods	✓		✓	✓
WATERSTORAGE	visible water storage		✓	✓	✓
	interactive storage				✓
	flexible storage	✓	✓	✓	✓
	storage through scales		✓	✓	✓
	selfsufficient water use BSH	✓		✓	✓
BUIKSLOTERHAM	visible water		✓	✓	✓
	water in public space		✓	✓	✓
	connection houses with water		✓	✓	✓
TIMEFRAME	day/night dependency			✓	✓
	seasonal variation	✓	✓	✓	✓
	lifespan	50-100 years	50-100 years	50-100 years	5-50 years
AMSTERDAM	selfsufficient water use BSH	✓		✓	✓
	relieve stress sewage system	✓	✓	✓	✓
	transferability technology	✓	✓	✓	✓
	transferability social aspect		✓		✓
SUSTAINABLE AWARENESS	connecting people				✓
	feedback from municipality			✓	✓
	connection houses with water		✓	✓	✓
	storage through scales		✓		✓

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