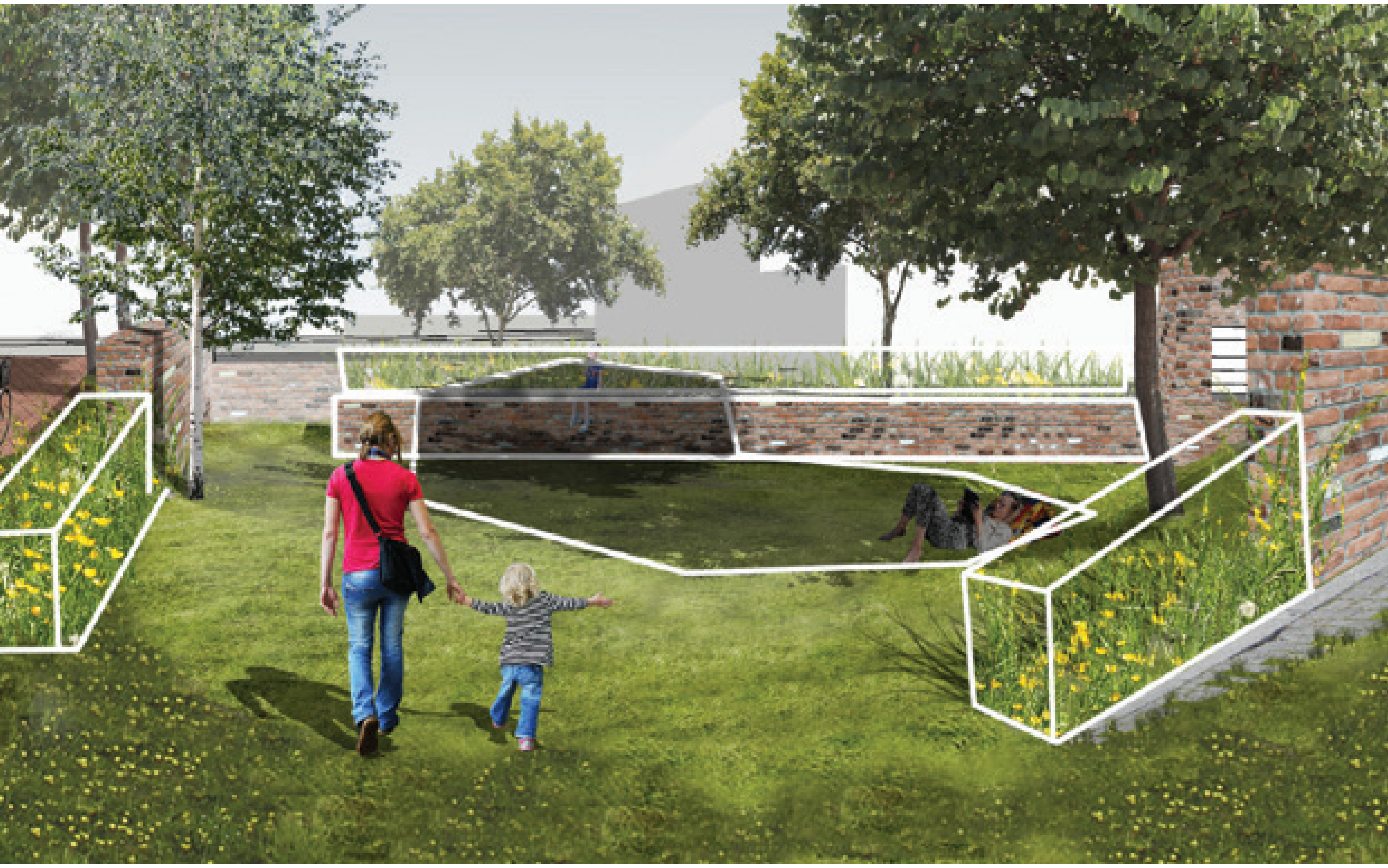
Cool Heritage

Guidelines for combining bio-climatic design and built cultural heritage



Freek de Bruijn

Landscape Architecture

Msc Thesis 2018

Cool Heritage

Guidelines for combining bio-climatic design and built cultural heritage

Cool Heritage

Guidelines for combining bio-climatic design and built cultural heritage

© Freek de Bruijn
Chair Group Landscape Architecture Wageningen University
December 2018

Freek Jeroen de Bruijn
Registration number: 910214-141070
freek.debruijn00@gmail.com
LAR-80436 Master Thesis Landscape Architecture

Landscape Architecture Chair Group
Phone: +31 317 484 056
Fax: +31 317 482 166
E-mail: office.lar@wur.nl
www.lar.wur.nl

Postbus 47
6700 AA, Wageningen
The Netherlands

Supervisor and examiner
Dr. João Cortesão
Assistant Professor Landscape Architecture
Wageningen University and Research

Examiner
Prof. dr. ir. Adri van den Brink
Chairholder Landscape Architecture
Wageningen University and Research

Abstract

Due to climate change cities suffer increasingly from urban heat stress during hot summer peak hours. Severe urban heat stress affects the everyday life and decreases urban comfort and a healthy living in a city. Cities need to adapt for mitigating urban heat stress. Climate responsive design answers to the need of adaptation for a thermally comfortable city. With climate change ahead and increasing urban heat stress, climate responsive designing is important and a highly urgent aspect for creating future-proof city centers.

However, adaptation of urban environments often conflicts with the built cultural heritage valued landscape, because it is often approached with a traditional perspective of preserving and maintaining. These two domains, bio-climatic design and built cultural heritage, interfere evidently in urban environments.

To help urban designers and landscape architects with climate responsive design in a built cultural heritage valued landscape, design guidelines are generated during this research.

In order to combine the two domains, they need a different approach. Therefore, three basic bio-climatic design principles are defined: *shading, ventilation and evapotranspiration.* For built cultural heritage, seven fundamental principles are defined that affect environmental urban experience: *visual dominance, focal points, visual diversity, local materials, native species, fitting and enhancement of coherence and context.*

Every design decision made during designing is assessed on three basic bio-climatic design principles and seven built cultural heritage principles. This resulted in a cooler urban environment in a built cultural heritage valued landscape: the Herman Moerkerkplein in 's Hertogenbosch.

This informed design guidelines that help urban designers and landscape architects make cities containing built cultural heritage future-proof and thermally comfortable.

Preface

This thesis was the last step to fulfill my master studies in landscape architecture at the Wageningen University and Research. For me, as a landscape designer, the topic of this thesis couldn't be more relevant considering the hot summer of 2018. I always think that landscape architects should address topics or issues that relate to our society. Because in landscape, from rural to urban, we spend our largest part of live. To hook on to the research project REALCOOL and address the micro-climate in cities was a great opportunity and a head start for this thesis. Still, there is I think, a great challenge in adapting design strategies for urban development considering climate responsive design. With this thesis I hope to contribute to the adaptation of cities to a climate proof future and mitigation of urban heat stress during hot summers, like last one in 2018.

During this thesis I faced lots of difficulties and struggled with several aspects of the research and design. I had the pleasure to have João Cortesão as supervisor who always stayed positive and motivated me to carry on at times I needed it the most. Not only he helped me stay focused on the important aspects but also helped me when I struggled with designing. I'm grateful that I could always drop by to test or discuss research and design decisions. I also want to thank my colleague students and Sanda Lenzholzer in the fruitful *Climatelier* sessions where we discussed our research and relevant topics and guided each other into the right direction.

Through the preface I want to thank my fellow colleague 'thesisroom' students who were always there for coffee breaks, discussions or plenty of other irrelevant distraction. Nevertheless, it kept me motivated working on the thesis through all times.

I especially want to thank my girlfriend who always supported me throughout the 24/7 process of doing a master thesis. She always stayed interested and asked the right questions to increase the quality of my thesis. Last but not least, a big thanks to my family and friends who were always interested and supported me until the end.

Now, with the thesis finished I am satisfied with the result and I am looking back on an interesting time on an interesting topic. Hopefully this thesis inspires urban designers and landscape architects to contribute to a thermally more comfortable urban environment maintaining a built cultural heritage valued landscape.

Table of Contents

1 Introduction

1.1 Problem identification

Nowadays, the impact of humanity on planet earth is increasingly involving the daily lives of people. The climate changes drastically and the effects can be experienced all around us. Another phenomenon that occurs is an exponential growth in world population. Cities suffers from side effects a dense population causes. As a result of urbanization and industrialization urban heat is one of the major problems posed to human beings(see appendix A). More people are vulnerable to these urbanization problems as the ever increasing urban population is expected to continue in the near future (Rizwan, Dennis and Liu, 2008). In the Netherlands cities are coping with urban heat as well, cities as a whole are affecting the differences in temperature between the city and its surroundings (see figure 1) (Charlotte Huisman, 2011). But not only on a large scale it modifies the climate conditions, the micro-climate can vary significantly from already a few meters (Kleerekoper, Esch and Salcedo, 2012).

1.1.1 Urban Heat

The urban heat island has significant effects on the comfort of the living environment in a city and even causes an increase of mortality rates (Changnon, Kunkel and Reinke, 1996) (Kleerekoper, Esch and Salcedo, 2012). Lack of shading, lack of vegetation, storage of solar radiation in massive construction materials and a decreased Sky View Factor, which represents the ratio between the visible sky and a hemisphere centered over the analyzed location (Oke, 1981), are considered as the main cause of the higher urban heat (Rizwan, Dennis and Liu, 2008). Research on the generation, determination and mitigation of urban heat island has already been done thoroughly. However, climate-responsive designing in urban development is still not a common approach amongst urban designers and landscape architects.

The current climate change issues and significantly warming up of urban environments show the relevance of research on cooling potential in cities. Local governments might face difficulties to remain their city centers comfortable to live in whilst cities are rapidly warming up during hot summers. Because it is quite a new phenomenon, research about the urban heat island effect is still mainly focused on the effects instead of mitigating the issue (Tweed and Sutherland, 2007).

However, mitigating urban heat is increasingly a major subject in landscape architectural research. Because urban heat has a large impact on the behavior of people, thinking of e.g. high temperature at squares, it is an increasingly vital topic for research.

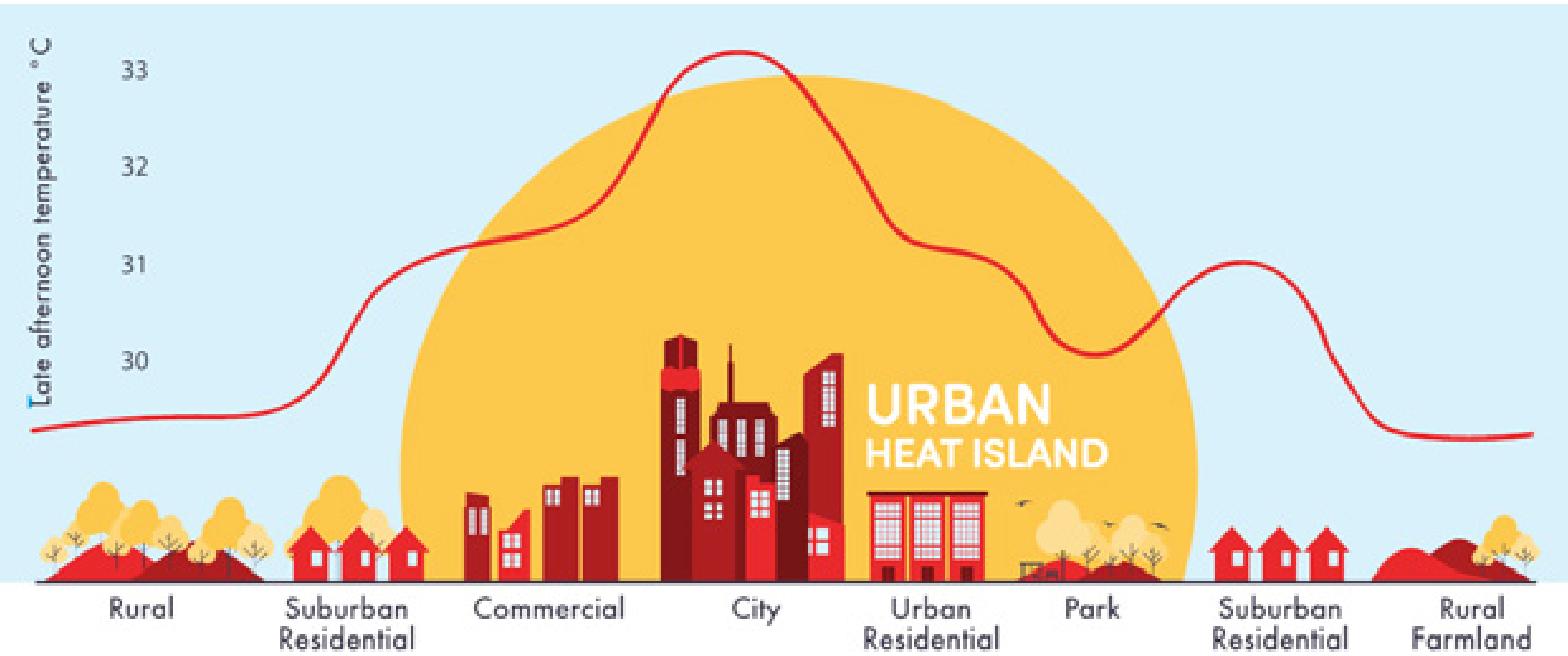


Figure 1 Illustration of the urban heat island effect (Source: www.coolparramatta.com.au)

In order to deal with urban heat problems and uncertainties regarding the future climate it is best to build new urban environments, and as well adapt existing urban environments, in a robust way. Kleerekoper, Esch and Salcedo (2012) describes design principles in four categories: vegetation, water, built form and material, that can mitigate the urban heat island effect in a city. Each of these categories has a significant effect on urban heat in Dutch cities. Amongst these, the cooling potential of urban water environments are particularly relevant for climate-responsive design, especially in the Netherlands.

There is a possibility that water might cool its surroundings due to evaporation, it transports heat out of the area by airflow or it absorbs heat when there is a large water mass. Bearing in mind that "the effect of cooling by water depends on the airflow that replaces the cooled air through the city"(Kleerekoper, Esch and Salcedo, 2012), the water environment needs to be designed in a way it has an optimal cooling potential. "When addressing urban heat problems, climate-conscious urban design has been assuming that urban water bodies such as canals, ditches or ponds cool down their surroundings." (Cortesão *et al.* 2017). There are indications of cooling potentials if the shading, evaporation and ventilation is in the right place (*idem*).

1.1.2 Built Cultural Heritage

Urban development often faces difficulties when dealing with built cultural heritage, which is often protected. Governments recognize that built cultural heritage contributes to the social-well-being of different groups living within cosmopolitan towns and cities (Tweed and Sutherland, 2007). Heritage is seen as a major component of quality of life (*idem*). However, the protection of built heritage, listing of individual monuments and buildings, impedes the transformation and thus possible mitigation of the urban heat island effect (*idem*). This presents great challenges but, even more important, opportunities in climate-responsive design.

1.1.3 Knowledge gap

Although there are plenty of design solutions for mitigating urban heat problems, the fit between climate responsive design and built cultural heritage has not yet been sufficiently addressed. Research on how to combine climate responsive design solutions with heritage values is needed. In particular the context of the Netherlands, and bearing in mind the cooling potential of urban water bodies, urban designers and landscape architects are lacking know-how in designing urban water environments that combines climate adaptation and built cultural heritage. This is a knowledge gap in landscape architectural research and therefore this is taken as the key topic of this thesis. This thesis bridges urban heat stress, climate-responsive design, urban water environments and built cultural heritage.

"Climate change is the single greatest threat to a sustainable future but, at the same time, addressing the climate challenge presents a golden opportunity to promote prosperity, security and a brighter future for all." (Ki-Moon, 2014)

1.2 Thesis Objective

The objective of this thesis is to develop design guidelines assisting urban designers and landscape architects with designing cooler urban water environments in a built cultural heritage valued landscape. The design guidelines will not only fit into the city of 's Hertogenbosch but will help landscape architects and urban designers throughout different circumstances and locations.

1.2.1 Research Questions

The main research question of this thesis overarches the entire research and the sub-research questions contribute to the answer of the main research question (Table 1).

The sub-research questions relate to specific parts in the main research question. In this way I am able to answer the main research question through the sub-research questions. Table 2 shows the relations between the sub-research questions and the main research question.

Table 1 — Research questions

Main research question

What design guidelines can be used for cooling water environments to fit and even enhance built cultural heritage?

Sub-research questions

1. What is the cooling potential of the REALCOOL prototype gracht 3 at the Herman Moerkerkplein?
2. How to fit climate responsive design with heritage values in urban water environments?
3. How to enhance the heritage values of urban water environments through climate responsive design?

Table 2 — Sub-research question relating to main research question

Sub-research question 1: What is the cooling potential of the REALCOOL prototype gracht 3 at the Herman Moerkerkplein?

What design guidelines can be used for cooling water environments to fit and even enhance built cultural heritage?

Sub-research question 2: How to fit climate responsive design with heritage values in urban water environments?

What design guidelines can be used for cooling water environments to fit and even enhance built cultural heritage?

Sub-research question 3: How to enhance the heritage values of urban water environments through climate responsive design?

What design guidelines can be used for cooling water environments to fit and even enhance built cultural heritage?

1.3 Context

This thesis partially builds upon the 'Really cooling water bodies in cities' research project (REALCOOL). To achieve the objective of this thesis research is done through a test location that consists of an urban water environment retrieved by the REALCOOL research project. The test location consists of an urban water environment with a sufficient built cultural heritage valued landscape: the Herman Moerkerkplein (Figure 2).

Two reasons underlie this choice: first the site has a diversity of built cultural heritage and a water body (the Binnendieze) which allow testing of the fitting and potentially enhancement of built cultural heritage and climate responsive design; it creates the chance to explore the friction between climate responsive design and built cultural heritage. Second, REALCOOL partnered up with the city of 's Hertogenbosch.

Figure 2 Aerial of 's Hertogenbosch with detailed inlay of the Herman Moerkerk square (adapted from Google Maps)

There is already a design for the Herman Moerkerkplein made by Hans van Heeswijk Architecten (Figure 3). In this design the micro-climatic values are not taken into account. Important is that the daylighting of a part of the Binnendieze is incorporated in the design. This means the canal (the Binnendieze) that has been covered for years, will be opened up. This design proposal is used in this thesis to check the micro-climatic cooling potential of the Herman Moerkerkplein with the help of the REALCOOL research project.

This research aims to “define design prototypes showing the physical processes behind the effective cooling potential of urban water bodies” (Cortesão *et al*. 2017). For this thesis one of the prototypes generated by the REALCOOL research project is used to test the micro-climate of the Herman Moerkerkplein. Specifically, design elements of the prototype gracht 3 (Figure 15) will be applied in the urban water environment of the Herman Moerkerkplein. The resulting cooling effects are described in chapter 4.

Figure 3 Design made by Hans van Heeswijk Architecten commissioned by the municipality of ‘s Hertogenbosch (source: municipality of ‘s Hertogenbosch)

Figure 4 shows the Herman Moerkerkplein hosts architectural and spatial elements that are of significant value for experiencing built cultural heritage. In Figure 4 picture 2 the base of the former gate of the city of ‘s Hertogenbosch can be seen. This element is of major value for the characteristics of the Herman Moerkerkplein. In picture 1 of Figure 4 the Binnendieze flows into the city through a tunnel. These historical relevant elements are typical for the city of ‘s Hertogenbosch and the Herman Moerkerkplein.

1

2

Figure 4 | Picture 1 & 2 | Base structure of the former gate of the city ‘s Hertogenbosch and the arch for the Binnendieze (source: author)

2 Methodology

2.1 Research through designing

In order to answer the main research question and the sub-research questions the research through designing method is used in this thesis (Lenzholzer, Duchart and Koh, 2013). By using the research through designing method the design process can function as a tool for researching. As shown in the figure below, the research through designing process consists of three loops, eventually resulting in the aimed design guidelines (Figure 5).

As can be seen in this figure each loop focuses on a particular sub-research question. The loops are preceded by a preparatory stage where literature reviewing has been done to understand more about the subject.

Loop 1 and 2 informs the answer to sub-research question 1, 2 and 3. These loops consists of a design phase, testing phase and literature reviewing. Therefore, there is a continuous feedback between designing, testing and literature reviewing. Also between the different loops there is feedback, which means the results of each loop informs the next one. This is the key-motive for using the research through designing method, because within climate responsive designing there is no possibility of doing research and having one outcome to put in the design. It needs to be tested along the way of designing, where the testing informs the design. Testing is done through discussion sessions where interim products are communicated to experts that are familiar with the topic and site. During these sessions the interim products are discussed for clarity and understanding. The comments retrieved from these sessions are processed during designing. Each loop contains a testing phase for feedback from experts and designers.

During loop 3 the main research question will be answered. In this loop the design guidelines are generated with the help of the results of the previous loops. Interim guidelines are proposed to experts during a discussion session to discuss clarity and usefulness of the interim design guidelines. This is followed by generating the final design guidelines.

To answer sub-research question 1 the

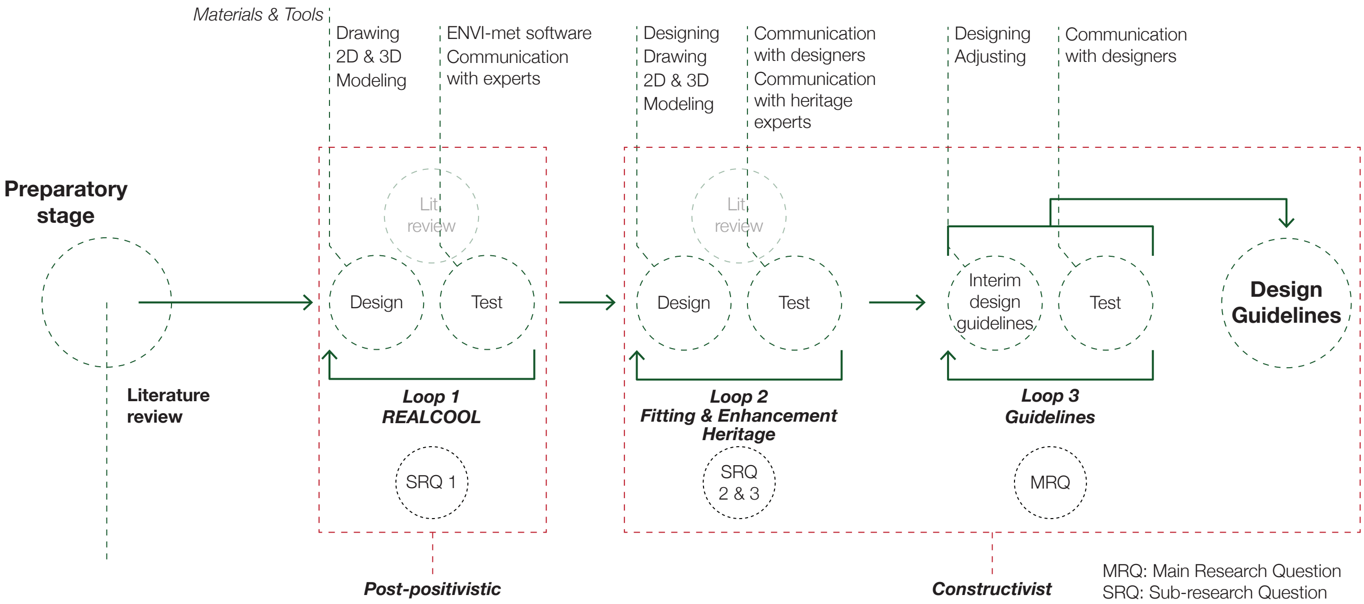


Figure 5 Methodology used in this thesis

REALCOOL prototype gracht 3 (Figure 15) is applied at the Herman Moerkerkplein. This spatial configuration considering micro-climate is tested through a software simulation (ENVI-met), which is carried out by the team of the REALCOOL research project. During loop 2 the fit of climate responsive design and enhancement of heritage values in urban water environments will be researched. Through a continuous feedback between design, testing and literature review the outcome of each loop will inform the answer to the sub-research questions. The design process consists of sketching, drawing and modeling in 2D and 3D.

The steps in the research through designing process lead to the research objective of this thesis. The results of the preparatory stage, loop 1 and loop 2 combined will evolve in design guidelines. These design guidelines will be tested in loop 3 as can be seen in Figure 5. The guidelines are tested by assessing them through the help of experts of the municipality of 's Hertogenbosch.

2.2 World Views

Within the process of research through designing two different world views are used (Figure 5). This is because loop 1 and loop 2 differs significantly in research approach. As loop 1 consists of testing with numerical simulation software it can be addressed as a post-positivistic world view. In this hypothesis based world view the prototype gracht 3 from REALCOOL will be tested at the specific site by quantifying the actual derived cooling effects

Loop 2 and loop 3 are approached as a constructivist world view. For landscape architectural research through designing this world view is important. First because, according to Lenzholzer, Duchhart and Koh (2013), "socio-cultural issues forms a crucial aspect in landscape architecture. Second, constructivist research is mostly embedded in context (as is in this thesis). And third, the research in loop 2 and 3 is predominantly about 'problem finding' and generating new 'insights or constructs' rather than testing them. This perspective on the process of research is applicable to loop 2 and 3 (Figure 5), where continuous feedback informs generating new insights and/or constructs.

3 Theoretical framework

3.1 Bio-climatic urban design

Bio-climatic design features are with a greater extend needed in urban design due to the changing thermal environments in urban areas. As mentioned in the introduction of this thesis, cities are heating up during hot summer days. Severe urban heat stress is not uncommon anymore. In order to cope with this relatively new challenge in creating a comfortable living environment, a new perspective on urban design is needed. Outdoor thermal comfort can be seen as one of the most important aspects of people's welfare and social interaction in public spaces (Cortesão, 2013). To cope with climate change impacts on urban environments, it is vital for public spaces to possess the necessary conditions (related to outdoor thermal comfort) to keep a comfortable living environment.

When taking the micro-climate of outdoor public spaces as a serious aspect in urban design, the climate change impact can be addressed and possibly mitigated. The focus in this thesis lies upon bio-climatic urban design addressing outdoor thermal comfort of public spaces. When addressing this outdoor thermal comfort an understanding of bio-climatic design is needed. In the following paragraphs the basic theory of bio-climatic design is elaborated. This is used further on during the research through design process. Bio-climatic design is for this thesis narrowed down to three basic principles that affects environmental thermal comfort the most.

3.1.1 Three basic bio-climatic design principles

Bio-climatic design features address the micro-climate in urban environments. The quality of micro-climate is important when increasing the outdoor thermal comfort. Micro-climate can be defined as the climate near the ground, where conditions change rapidly and interactions between plants, insects, and other animals take place (Barry and Blanken, 2016). The conditions of micro-climate in an urban environment consist of countless variations, due to the different physical factors such as topography, wind flows, built density, orientation, materials or vegetation (Cortesão, 2013). In micro-climate "the effects of weather are both relatively uniform and easily modified" (Meerow and Black, 1993, p. 1). "Micro-climate modification involves the best use of structural and landscape design elements to maximize or limit sunlight, shade and air movement" (Idem). This means, the micro-climate can easily be adjusted with spatial configuration of environmental design elements. This is important to keep in mind when creating a thermally comfortable living environment. A change in spatial configuration can increase or decrease the thermal comfort significantly.

The three basic bio-climatic design principles are:

Shading
Ventilation
Evapotranspiration

In this thesis, these are taken as the three principles that form the basic ingredients for climate responsive design. In the next paragraphs the three principles are explained and argued in detail together with supporting basic illustrations.

Shading

Shading can be seen as one of the most effective and most tangible features of cooling the environment. One of the main aspects of heating is the direct radiation from the sun. Solar radiation can cause the urban environment to severally heat up. Blocking this direct sun radiation transmitted to ground level can reduce heating up the environment (Papadakis, Tsamis and Kyritsis, 2001) (Figure 6). Shading can be created through the use of high vegetation, such as trees or large shrubs, or artificial shading devices, such as canvas. Also pergolas can be used to block direct sun radiation. It is assumed that "less than 20% (it may be as little as 5%) of the incoming short-wave radiation effectively reaches the ground of a mature stand" (Oke, 1987). So, shading could be one of the most effective principle for reducing urban summer heat stress.

Ventilation

Ventilation plays an important role in the human micro-climate of an urban environment (Lenzholzer, 2015). Air ventilation distracts heat and moisture from the human skin and thus a cooler perception of the environment (*Idem*). An increase of air ventilation in an urbanized area creates airflows that can distract heat from hot surfaces.

The stronger the air ventilation the more heat will be distracted. A sufficient airflow in an urban environment is therefore an important aspect in climate responsive designing (Figure 7).

Evapotranspiration

Evapotranspiration is a biological function that exists in all plants, which means a combined loss of water through evaporation and transpiration (Santamouris, 2001). In order to live "plants release water through pores in their leaves as vapor – transpiration" (Cortesão, 2013, p. 79). This transpiration is fundamental for being alive as a plant. This transpiration absorbs heat from the surrounding hot air through evaporation and therefore it cools down the environment. This transpiration and evaporation together is called evapotranspiration, which has a cooling potential during peak summer air temperatures (Wong, 2008).

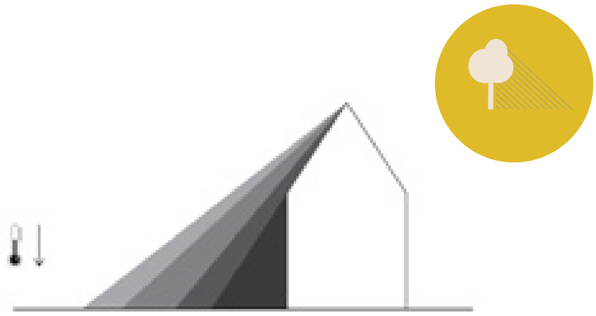


Figure 6 Shading

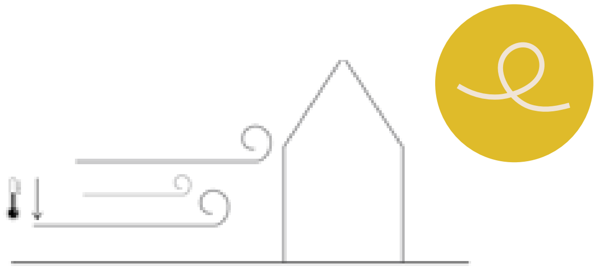


Figure 7 Ventilation

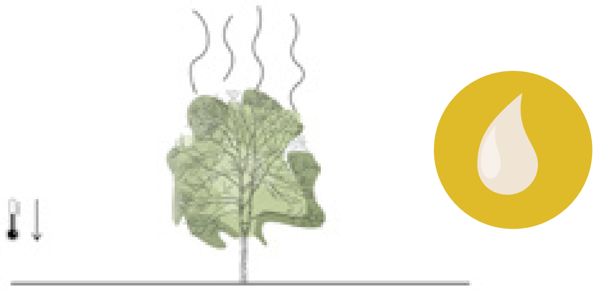


Figure 8 Evapotranspiration

3.2 Built Cultural Heritage

In a traditionally designed city urban development has to deal with built cultural heritage which is often protected. Research about sustainable development in urban areas tend to focus on technical issues like energy consumption or air pollution. Research about built cultural heritage also tends to address mostly technical issues like minimizing damage to buildings by air pollution. This chapter elaborates on the definition of built cultural heritage. The research in this chapter is done through literature reviewing of the subject built cultural heritage. In order to define the subject and create boundaries within the broad term of built cultural heritage, there is a need of elaboration on built cultural heritage situated in an urban environment. First, the definition of built cultural heritage and its meaning to this thesis is made clear. Thereafter, the subject of built cultural heritage is categorized into basic fundamental principles that affects environmental urban experience.

3.2.1 Definition of built cultural heritage

Built cultural heritage is an important part of the societal and community well-being (Tweed and Sutherland, 2007). In the fast modernization of the past centuries built cultural heritage could be seen as an important role in preserving the cultural history of a city. National governments, but also international institutions, are more and more aware of the value of cultural heritage. For example, the Council of Europe opened a treaty for ratification on this topic, whom underlines the importance of cultural heritage to sustainable development (CoE, 2005). Besides this, another example says “the UK government also recognizes the links between the built environment — particularly built heritage — and quality of life” (Tweed and Sutherland, 2007). It can be concluded that built cultural heritage is important in the well-being of the urban environment and plays an important role in a city.

There has been research done on built cultural heritage and the effects of climate change. However, this tends to address mainly technical issues. For example, minimizing damage to buildings by atmospheric pollution (Brimblecombe, 2004). As Tweed and Sutherland (2007) mention, this can be seen as the ‘how’ of heritage research. However, it is important to know what should be protected before knowing how to protect. What qualifies as cultural heritage is one of the main topics of debate about built cultural heritage. In this thesis this is an important question on how to address this subject. To make the subject suitable for the research in this thesis, it is needed to define what qualifies as built cultural heritage or possibly how it affects (visual) environmental experience of the urban landscape.

Built cultural heritage is often stated by legislation, which makes the definition narrow and it relies mostly on conventional conceptions of historical and architectural value (Tweed and Sutherland, 2007). So, protection of individual buildings or even complete districts or towns is rarely a problem because it is directly addressed by legislation (Hassler, Algreen-ussing and Kohler, 2002). Hassler, Algreen-ussing and Kohler (2002) say that the areas that are not considered worthy as conservation areas and yet form an essential part of the city or town are evenly important to address. These parts provide the context in which the built cultural heritage is located. However, they say that these parts should not be considered as mere context, because it is often the ensemble of the objects and their context that create the worthy value of a city or town. Considering this, climate responsive designed areas can be considered as important context to built cultural heritage. Rautenberg (1998) says in Tweed and Sutherland (2007) cultural heritage can be treated in two ways, either as heritage by designation, or heritage by appropriation. The first one can be considered as the traditional one, where heritage is applied as a label by experts. This follows, also in the Netherlands, mostly a top-down process with little influence of the general public. This results in predictable designations. However, as Tweed and Sutherland (2007) says, it therefore can be difficult to gain any recognition for anything else than conventional heritage. In this case for example, a climate responsive designed urban water environment.

The second one, contrary to the traditional way of heritage designation, emerges more from public behavior rather than through organized lobbying (Tweed and Sutherland, 2007). Thus, it is possible to formulate that, for example, the adaptation to climate change effects in urban environments contributes to the cultural identity of this generation. And therefore, it also contributes to the cultural heritage in urban environments. Whyte (2015) suggests in his paper that “the meanings afforded to the extant remains of the past in the landscape were made through intangible heritage practices, customs, memories, naming, rituals and performance by ‘ordinary’ people.” This means built cultural heritage is not only constructions built by the elite of the past, but also shaping a city to its current form including its streets, structure and boundaries (*Idem*).

In this way, adaptation of urban environments in order to deal with urban heat should be seen as context of built cultural heritage. To argument this, we can look into Maslow his hierarchy of needs (Maslow, 1943). He describes the basic needs of humans divided in two groups, D-needs and B-needs

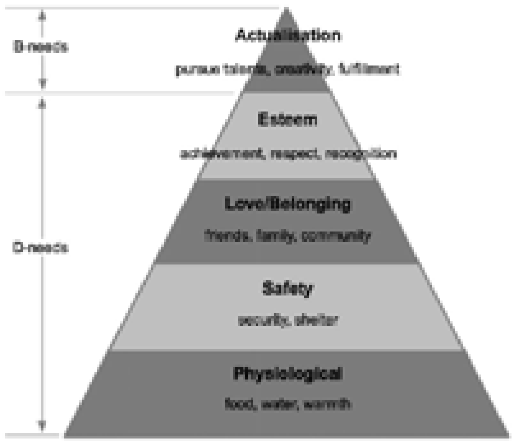


Figure 9 Maslow hierarchy of needs (Maslow, 1943)

(Figure 9). D-needs are considered as basic needs; esteem, love/belonging, safety and physiological. B-needs are considered as being needs, which pursues talents, creativity and fulfillment. In relation to built cultural heritage this is relevant (Tweed and Sutherland, 2007). To meet the basic needs buildings are obviously essential, e.g. to provide shelter from hostile conditions. However, important to mention is that “buildings are never purely functional and so they also contribute to satisfaction of higher needs” (*idem*). As Tweed and Sutherland (2007) conclude that “built cultural heritage conveys different meanings to different groups of people and that these meanings are likely to be important in the future growth of towns and cities and so need to be considered part of sustainable development”. Therefore, the broad concept of cultural heritage covers all aspects of space and time: from buildings, historic places towards living experiences or even mental connotations. According to ICOMOS (2002), cultural heritage is “an expression of the ways of living developed by a community and passed on from generation to generation, including customs, practices, places, objects, artistic expressions and values” (Sowińska-Świerkosz, 2017). This is highly relevant to the subject of this thesis, because the research questions cannot be answered when built cultural heritage is considered in a traditional way. It defines the way built cultural heritage is considered during this thesis.

Built cultural heritage cannot be clearly defined over time. The definition of built cultural heritage has changed and is still changing. It is submissive to culture, traditions and society but also to trends and development. Urban landscapes contain huge amounts of layers of heritage, ever-evolving over time. This also means they are more easily lost, “because of ravages of time and men on the building heritage, the trades and cultures that make them more fragile and exposed to transformations caused by the economic-social development and changeable conditions of these settlements” (Elia and Ostovich, 2011). Built cultural heritage is seen in different ways through time, for example in the late nineteenth century the growth of cities was priority, at the expense of the existing one. “The historical building heritage was considered as an obstacle or in the best case scenario as an item to protect, opportunely isolated from the context” (*Idem*). Last years can be seen that the built cultural heritage is more recognized in its “values”, apparently there is a “need in standing up to the simplification of the urban reality derived from the homogenization of the urban planning zoning” (*Idem*).

3.2.2 Seven fundamental built cultural heritage principles

To narrow down the concept of built cultural heritage specific criteria that have an effect on environmental experience are put into simplified basic principles. These built cultural heritage principles do not focus on the traditional approach of built cultural heritage. The following explained principles rely on aspects of built cultural heritage that affect the environmental urban experience. As Whyte (2015) concludes the landscape itself is “a product of negotiation expressed through the activities and performances of people working in cooperation, or in tension with one another in the past”. Here, in the processes of shaping and reshaping the landscape the “activities of ordinary people are revealed as being of central importance” (Whyte, 2015).

With the basic simplified principles the multitude of concepts the term built cultural heritage contains is tried to be addressed. Based on the literature review Sowińska-Świerkosz (2017) did it can be said that the multitude of concepts, approaches, methods and indicator types about understanding the diverse term of cultural heritage, are informing the synonymous of cultural heritage and therefore it is no longer traditional built or listed heritage.

This chapter elaborates on defining these specific principles by the use of literature review and creating corresponding illustrations for clarifying the subject. The defined principles are categorized into three classes: perception, cultural history and coherence and context. These three categories comprise in seven fundamental principles of built cultural heritage that support the environmental experience.

Perception:

1. Visual dominance,
2. Focal points,
3. Visual diversity

Cultural history:

4. Local materials, structures and boundaries,
5. Native species

Coherence and context:

6. Fit,
7. Enhancement

In the next paragraphs these principles are clarified in detail and illustrated with simplified illustrations (see Figure 10, Figure 11 and Figure 12).

3.2.2.1 Perception

Kevin Lynch (1960) mentions that a city is a construction in space. It is perceived only in the course of long spans in time. Nothing in a city is experienced by itself, but always in relation to its surroundings. A citizen has always long associations with a city, or at least parts of it. The image is soaked in memories and meanings (*Idem*). This could mean that perception of the observer/receiver is an important aspect of the idea about what is seen and experienced.

Lynch (1960) defines an environmental image in three components: identity, structure, and meaning. First, identity means the recognition as a separate object. Second, it must include spatial patterns in relation to the observer. Finally, and this is important for this subject, the object must have some meaning for the observer. Whether it is practical or emotional. Practical in relation to cooling the environment such as a shading pergola and emotional in relation to built cultural heritage.

Lynch (1960) is discussing the physical qualities which will relate to the attributes of identity and structure of the mental image. He says this leads to the definition what might be called image-ability or legibility or even visibility. In this way objects, in this case the built cultural heritage, is presenting sharply and intensely the senses. He mentions in his book that there are other basic properties in a beautiful environment such as: meaning or expressiveness, sensuous delight, rhythm, stimulus or choice. The image development, as what you see or what is shown, is a two-way process. It is a process between the observer and the observed. Important is, that Lynch (1960) says that by this two-way process it is possible to strengthen the image by symbolic devices, retraining the perceiver or by reshaping one's surroundings.

For this thesis that last part is crucial, because with the interventions the surroundings are reshaped. This is sub-defined into three principles that inform the perception of urban environments and built cultural heritage: visual dominance, focal points and visual diversity.

Visual dominance

One of the form qualities of Lynch (1960) that informs the definition of perception is dominance. He states that dominance of one part over another by means of size, intensity, or interest results in radiating the physical characteristics towards the surroundings from a center. Referring to the subject of this thesis dominant structures in an urban water environment can radiate its characteristics to the climate responsive designed surrounding. This could contribute to the positive perception of the observer.

Focal points

Taking the definition of perception literally the visual scope could be one of the most important parameters. Lynch (1960) defines this as "qualities which increase the range and penetration of vision, either actually of symbolically". He discusses that there is sometimes the tendency of not seeing the interrelation of parts of a city as a whole. This is however an important aspect to create a dense and vivid image, which sustains over the complete area of the metropolitan scale. Peter Calthorpe (2011) states that the whole, where he means in this case the region, would be similar to its neighborhoods, is an important analogy. Therefore linking all systems, realm and integrated cultures creates neighborhoods that are sustainable, integrated, and coherent.

Visual diversity

Another important aspect in urbanism and designing urban environments is diversity. “Diversity is a fundamental design principle for both the neighborhood and the region” (Calthorpe, 2011). For example, Lynch (1960) suggests singularity is a quality for urban design, which means it should contain contrast of surface, form, intensity, complexity, size, use, or spatial location. This might be freely translated to rich diversity in urban design.

3.2.2.2 Cultural history

The characteristics of cities are often created by certain periods in the history of time. As Mah (2012) states that the use and interests of the past in constructions of place identity and distinctiveness still continues in modern times. The character of a place is often associated with historical connotations (*Idem*). This provides people an important link to their roots of a place and thus contributes to a sense of belonging (Wheeler, 2017). Whyte (2015) argues that there is an importance of approaching mundane and commonplace features such as roads, fields and boundaries as an essential part of our social and cultural landscape heritage. In this way built cultural heritage is approached in a different non-traditional way. There is a potential of approaching historic landscape studies “considering the landscape as lived experience, produced and reproduced through the activities, knowledge practices and memories of ordinary people” instead of objectifying the landscape (Whyte, 2007, 2011, 2015). This category is narrowed down to two sub-categories: ‘local materials, structures and boundaries’ and ‘native species’.

Local materials, structures and boundaries

It is important to incorporate the ideas of movement and flow, e.g. walking, for understanding how people in the past created and experienced the landscape (Whyte, 2015). Whyte (Idem) says that the “archival record shows that landscapes were made and remade by people as they walked, observed and interpreted their surroundings”. Rose (2012) arguments that “dwelling needs to be conceived as modality of practice that marks and claims a world through the building of material objects and/or environments”. This can be interpreted that the presence of people is marking and claiming the surrounding world, e.g. a city, through local material, structures and boundaries. Supporting this, Jackson (2008) says “local historical work demonstrates a

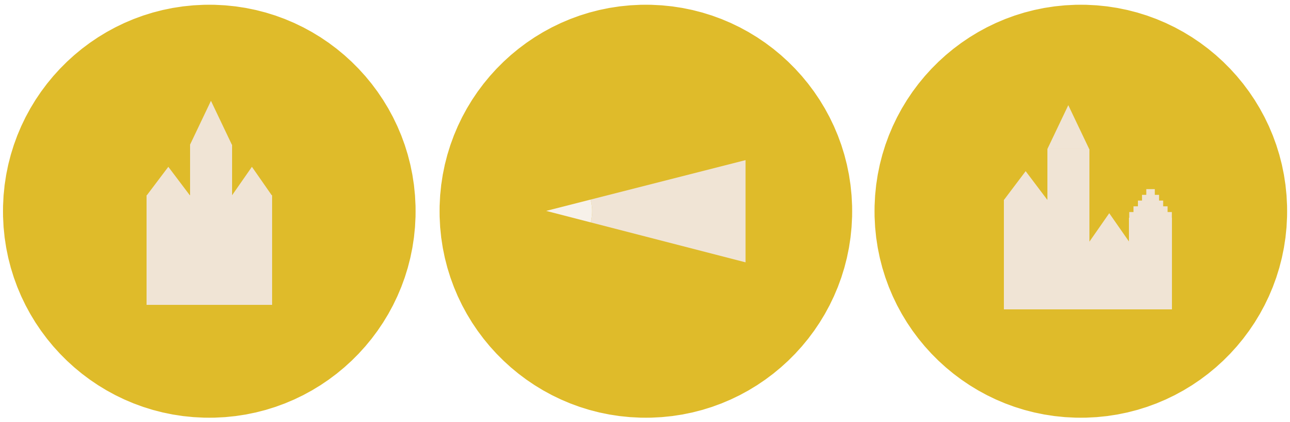


Figure 10 Simplified illustrations of the principles of built cultural heritage — Visual dominance, focal points and visual diversity

concern for, and potential to foster, a contemporary sense of local and regional identity, distinctiveness and consciousness". Thus, it can be said that local materials, structures and boundaries form an important part of the context in a city, which creates certain characteristics relevant to the city.

Native species

Another important, yet more tangible, aspect in cultural history is the use of native species. For this thesis this is an important category to address because native species touches the field of landscape architecture. Because landscape architecture (often) takes place in a vegetation rich environment where plant-, shrub- or tree-species are common to use. As mentioned, local heritage contributes strongly to the identity of a place and its distinctiveness. So, it might be obvious to take native species into account, yet it is an aspect that should not be undervalued.

Figure 11 Simplified illustrations of the principles of built cultural heritage — Local material and native species

3.2.2.3 Coherence and context

To understand the concept of built cultural heritage and its impact at the urban environment, a closer look is taken to coherence and context. Coherence and context take a great deal in how (urban) landscape is experienced. As discussed in the previous paragraphs built cultural heritage cannot be clearly defined as something solitary. It has a great potential for contributing to its environment and vice versa. Therefore coherence and context can be seen as important aspects. This is subdivided into two parts: fit and enhancement. This means fitting of built cultural heritage into its environment where it, in an optimal case, seamlessly merge into its context. This obviously supports the coherence of a certain place. Enhancement of built cultural heritage in an urban environment can, where possible, be a potential for increasing the environmental experience and heritage value.

Fit

Often, place identity is to a large extend based on the past (Massey, 1995). If this is the case, it follows that changes made in the environment often are judged according on how they fit in the context and what is customary in that place (Huigen and Meijering, 2005). The desire to preserve historical context and elements of a place can be interpreted as an attempt to hold-on to its identity (Wheeler, 2017). To keep the identity of the place it is clearly important to fit environmental changes into its context. Fitting into context means the environmental change by adding a dissonant object or changing the existing spatial configuration does not replace or eclipse the context. Therefore coherence of the place is a predominant factor in the place identity and distinctiveness.

Enhancement

Changes in spatial configuration can support the coherence and context as stated already in the previous paragraph. However there is a potential that it can even enhance the built cultural heritage. Specific spatial configurations can point out or accentuate certain elements and therefore potentially enhance the built cultural heritage and the experience of the urban environment. This contributes to the place identity and distinctiveness of a place. Enhancement of built cultural heritage in their context contributes to the environmental experience and even potentially enhances the environmental experience.

Figure 12 Simplified illustrations of the principles of built cultural heritage — Fit and enhancement

3.3 Impact of climate change on built cultural heritage

Climate change is not only affecting the thermal comfort of a city but, the slight increase of temperatures and increasing precipitations in Northern European countries also affects monuments in a city (Lefèvre, 2015). This can be a great threat to heritage, the increased rainfall can overload roofing and gutters, penetrate traditional materials or deliver pollutants to building surfaces (Sabbioni *et al.*, 2009). Also an increase in humidity affects the growth of microorganisms on stone or wood (*Idem*). Because climate change is not only affecting the living environment but also the conservation of built cultural heritage, climate responsive design in relation to built cultural heritage is an important aspect to deal with. Landscape architects and urban designers can play a significant role in the shift towards a climate responsive way of designing in relation to built cultural heritage. This is important in the process of urban development because "urban areas will be particularly vulnerable to heat waves and hot days because of the urban heat island effect" (Klok and Kluck, 2018).

As mentioned before, the role of cultural heritage conservation has proven beneficial for the development of cities and communities (Guzmán, Roders and Colenbrander, 2017). It is important to bridge the cultural heritage conservation with the development of sustainable urban environments. Cities can be seen as an important factor in the climate change issue, they have a negative external impact on the global environment. E.g. the 'negative contribution' of cities to global climate change due

Figure 13 The water environment of the Herman Moerkerkplein. (Source: www.vrijeacademie.nl)

to emissions of greenhouse gases is an issues" (Mori and Yamashita, 2015). As is known, the capacity of natural depletable and renewable resources is limited on earth, the environmental burdens that each city produces have to be restricted (*Idem*). However, as Mori and Yamashita (2015) say, the "social and economic living standards should not be sacrificed only to achieve environmental sustainability". Reflected on the subject of conservation of built cultural heritage in a city and climate responsive design in an urban water environment, this is an important note to keep in mind.

Governments recognize that built cultural heritage contributes to the social well-being of different groups living within cosmopolitan towns and cities (Tweed and Sutherland, 2007). Heritage is seen as a major component of quality of life (*Idem*). However, the protection of built heritage, listing of individual monuments and buildings, impedes the transformation and thus possible mitigation of the urban heat island effect (*Idem*). This presents great challenges but also opportunities for climate responsive design.

In order to get grip onto the integration of built cultural heritage and climate responsive design it is important to define the concept of the integration between this. There are three possible scenarios (Figure 14). A scenario where built cultural heritage is predominant, a scenario where bio-climatic design is predominant and a scenario where these two are integrated. In this thesis scenario 2 is aimed for, where built cultural heritage values and bio-climatic design is integrated into each other. To create a solid integration and find a solution how to fit and even enhance the cooling potential with built cultural heritage in an urban water environment, a clear outline should be made. It is logical to think about technical engineering, such as joints or construction materials, when modifying built cultural heritage. This scope has already been researched thoroughly, also with climate change in mind. It can be concluded that these technical adjustments have the potentially highest physical impact on built cultural heritage.

However, when thinking about cooling potential in an urban water environment these adjustments do not have the highest potential to cool the urban water environment. For this thesis the aim is to create a comfortable and cool living space in an urban water environment. So, the integration of built cultural heritage and climate responsive design is more related to social sciences. Built cultural heritage is often a major aspect in cities. For a lot of people this could be perceived as a certain characteristic of the city, for example the canals of Amsterdam with its characteristic canal houses or the small Binnendieze that crawls under the houses through the city of 's Hertogenbosch. This is not per definition because it is labeled like a monument or registered built heritage, but it creates a certain atmosphere in a city. This draws the question of how built cultural heritage is perceived in a city when (cooling) elements are added that

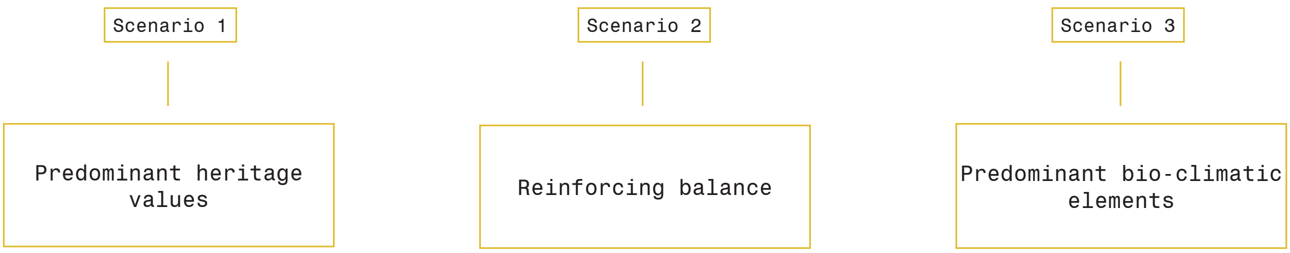


Figure 14 Three Scenarios in this thesis

increase the cooling effect. To integrate the built cultural heritage and bio-climatic design, the experience of built cultural heritage in a city should remain the same or even enhance it when increasing the cooling effect. In this way the two 'conflicting domains' can start actually work together in a win-win situation. Thus, the concept of integration between built cultural heritage and the cooling potential of urban water environments lies upon experiencing cool, comfortable and meaningful living urban environments.

Because this thesis aimed for design guidelines that will help designers and architects create a cooler water environment in a city, the focus shifts from technical to social aspects.

4 Research Through Designing

In this chapter the method research through designing is elaborated. The previous two chapters discussed two domains that concerns this thesis: bio-climatic design and built cultural heritage. This resulted in principles that are useful for the progress in this thesis. These principles form the basis in the further research about fitting or even enhancing built cultural heritage and bio-climatic design. However, the principles are still solitary and do not have any connection with each other. Besides, the principles within the domain do relate to each other, the two domains do not.

It is essential for answering the research questions to somehow connect these two domains. These two domains mainly consider spatial aspects, which is important to notice when relating the two to each other. Spatial design elements are in this case the key instruments to relate the two different domains to each other. These spatial design elements are a diverse collection that affects the (urban) landscape, such as trees and shrubs but also grass, color and texture. To narrow down the endless amount of spatial elements that can be used it is filtered down to spatial elements that affect the urban environment considering climate responsive design. These spatial elements are put together in a toolbox.

Through a matrix with a five point rating scale the spatial elements from the toolbox are brought together with the principles retrieved in the previous two chapters. This matrix is used in the research through designing ensuring an optimal score through trial and error. This will eventually lead to a design where built cultural heritage and bio-climatic design elements are incorporated in one design to a specific site, the Herman Moerkerkplein.

Designing is a vital step in the research process. As Figure 5 shows, the design phases consists of drawing, sketching and modeling. This is always connected with the test phase where interim designs are tested. In the first loop where research is done through cooperation with the REALCOOL research project designing is important. However, it is subordinate to the software simulation and prototypes retrieved from REALCOOL. The designing phases are informed by the preparatory phase and outcomes of the previous loops. The sketches, drawings, 2D/3D models and finally the interim designs are discussed thoroughly through meetings with experts and designers. This continuously sharpens the design and will lead to the design guidelines. In the next sub-chapters the different loops are explained followed by answering the research questions.

4.1 Loop 1 — Answering sub-research question 1

Loop 1 and, thus, sub-research question 1 concerns the part where the REALCOOL research project comes into account. The design that is made by Hans van Heeswijk Architecten (Figure 3) for the Herman Moerkerkplein is analyzed for micro-climate related issues, in this case heat stress. The prototype generated by REALCOOL is implemented in the area to create a potentially optimal spatial configuration for micro-climatic issues. The prototype is implemented through educated guesses with the help of team-members of the REALCOOL research project. This research is done through computer simulation software (ENVI-met) that simulates the urban heat stress of the specific site (the Herman Moerkerkplein).

4.1.1 The cooling effects of water — the REALCOOL research project

Urban heat problems could be addressed in several different ways of climate-conscious design. It is assumed, among urban designers, that water bodies such as canals or ponds cool down their surroundings (Cortesão *et al.*, 2017). In contrary to this, research showed that water bodies might not cool but even warm the environment (*Idem*). However, with the correct spatial configuration around water bodies there might be a potential for a cooling effect. This challenge is addressed by REALCOOL.

REALCOOL aimed to “define design prototypes showing physical processes behind the effective cooling potential of urban water bodies, that design professionals can take as conceptual design frameworks” (Cortesão *et al.*, 2017). It is possible that urban water environments, such as canals, ditches or ponds, can cool down their surroundings bringing it together with the right shading, evapotranspiration and ventilation strategies (*Idem*). It is not yet clear how this spatial configuration should be developed and used in urban design practice. Therefore,

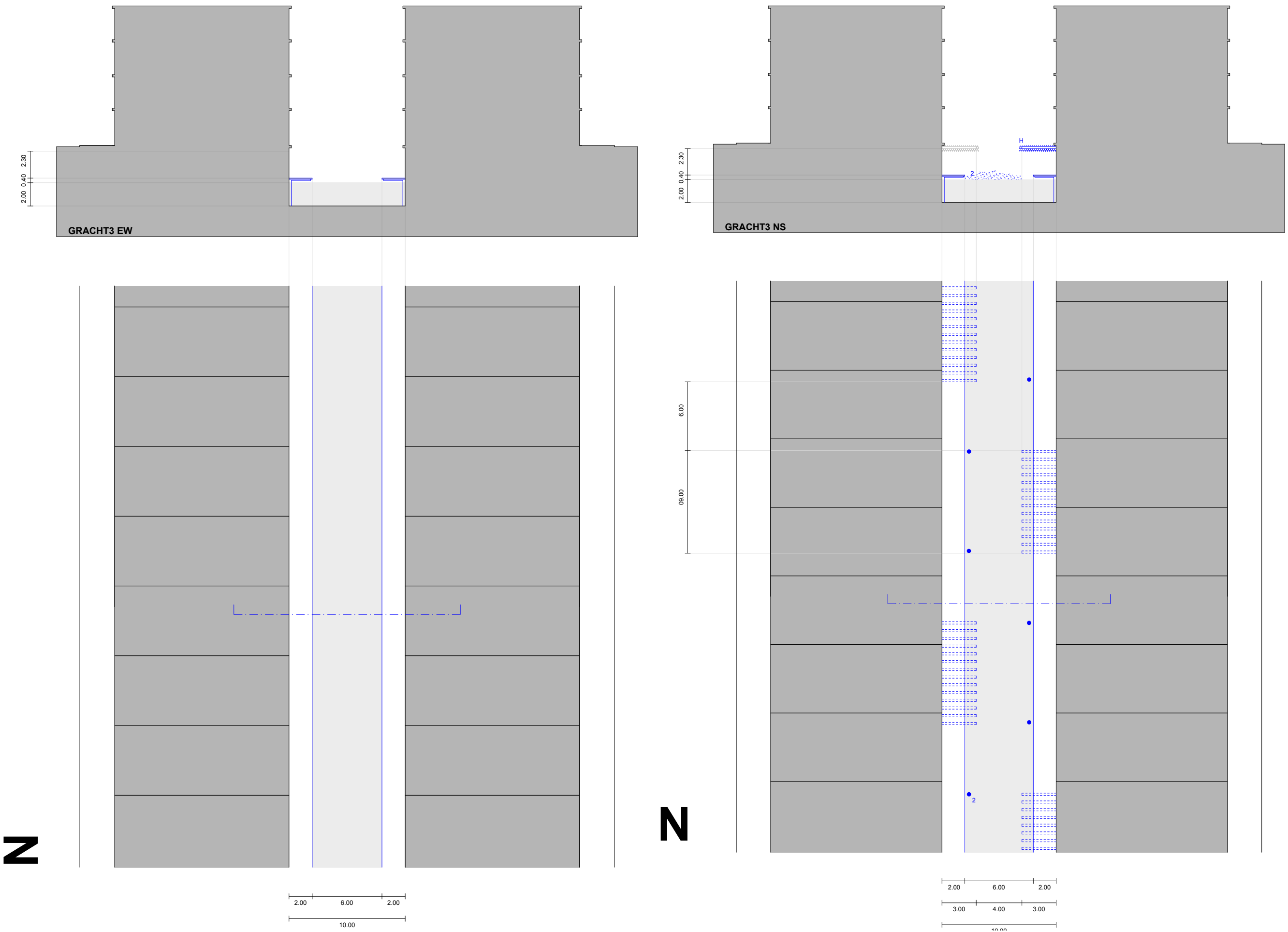


Figure 15 REALCOOL prototype gracht 3 north-south (right) and east-west (left) orientation

REALCOOL generated sixteen prototypes that consist of an optimal spatial configuration considering shading, ventilation and evapotranspiration. These were categorized according to four layouts as ‘Gracht’, ‘Singel’, ‘Sloot’ or ‘Vijver’ (Cortesão *et al.*, 2017). These four layouts inform the sixteen typical spatial configurations.

From amongst these sixteen REALCOOL prototypes, prototype gracht 3 (Figure 15) was applied at the Herman Moerkerkplein because it matches the spatial configuration of the Herman Moerkerkplein the best.

For the REALCOOL research project this is the so-called reality check of the prototype, when it was tested in a real life situation. In this thesis, the REALCOOL reality check functions as a check for a cooling potential at the Herman Moerkerkplein.

4.1.2 Checking the site-specific cooling effects of water at the Herman Moerkerkplein

Through a software simulation the site-specific cooling effects of water were tested. This is done by the use of ENVI-met, this is a simulation model widely used to describe micro-climate and human thermal comfort. The ENVI-met simulation was carried out by the team of REALCOOL because of their expertise in using this software. The results of the simulation gives temperature differences in PET – Physiological Equivalent Temperature. Envi-met simulates the 23th of June at 3:00 o’clock in the afternoon. This day was selected because of its most critical sun angle (Cortesão *et al.*, 2017). The ENVI-met simulation was done at two different heights, at 150cm above water-level and 450cm above water-level. This difference in height is because in this case the water-level is significantly lower than street-level.

4.1.3 Applying the REALCOOL prototype gracht 3 at the Herman Moerkerkplein

The gracht 3 REALCOOL prototype was implemented in the design of Hans van Heeswijk Architecten (Figure 3). Because the prototype could not be implemented without adjusting the spatial measurements, the design elements retrieved from the prototype were implemented through educated guesses with experts in the field of bio-climatic design and urban meteorology.

The east-west prototype (Figure 15) contains no bio-climatic design elements except for the pathway along the water. Because of the orientation the prototype is more or less self shading. The buildings along the water reduces direct solar radiation at the site and ensures the water environment is as cool as it can get. The absence of any obstacles enables the wind flow freely along the water body, which cools the environment as well. At the Herman Moerkerkplein the pathway along the waterside was added.

In the north-south oriented prototype shading devices (pergolas with climbing plants) were added because of the direct solar radiation that is casted during peak hours of the day. Pergolas were added to shade the pathway along the water. Decks were added along the water to enable visitors to walk near the water in the shade and create a cooling experience by providing direct access to water. Ventilation is still taking place as the pergolas do not block the ventilation in the prototype.

4.1.4 Educated guesses

The educated guesses were carried out during meetings with experts, where the implementation of the design elements from the prototype were proposed. Feedback was retrieved from these meetings to eventually create the optimal spatial configuration considering micro-climate. As can be seen in Figure 16 to Figure 18 the design elements were implemented at the Herman Moerkerkplein. At the first proposal (Figure 16) a pergola was added to shade the pathways. However, during the meeting with experts it was decided to extend the site and therefore increase the impact of the design elements on the micro-climate. The water body in the south-east part of the Herman Moerkerkplein is included to test the site-specific micro-climate. The three figures show the process of feedback during the educated guesses. Through the meetings the final proposed spatial configuration of the design elements were achieved. Figure 19 shows the design with the final proposed design elements to test with the ENVI-met simulation software.

Figure 16 First proposal of implementing design elements

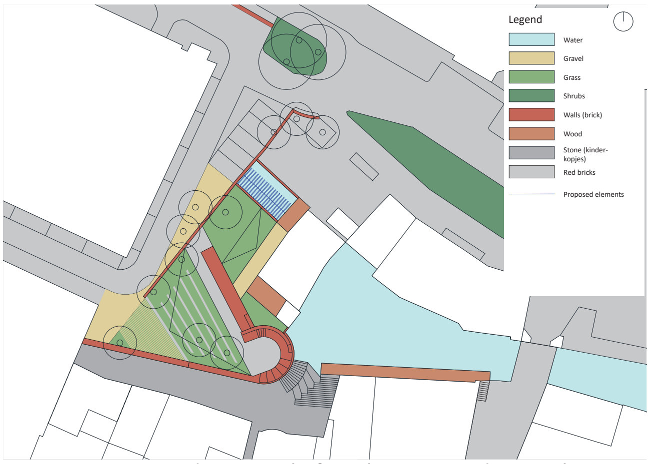


Figure 17 Second proposal of implementing design elements

Figure 18 Third and final proposal of implementing design elements

4.1.5 Micro-meteorological simulations

The micro-meteorological simulations by ENVI-met were carried out by experts on urban micro-meteorology from the REALCOOL team who are familiar using this software. The maps with the proposed design elements and necessary sections were prepared in a way they can be processed by the ENVI-met software (Figure 19). They are simplified and stripped of unnecessary elements, to decrease the amount of variables as much as possible. At Figure 20 on page 32 and Figure 21 on page 33 the results of the ENVI-met simulations can be found.

It is categorized into: results of the current design without the proposed design elements, results of the design with the proposed design elements and last but not least one with the difference between these two results (Figure 21). This one is the most important, as it shows the difference in PET-temperature before and after implementing the proposed design elements. Figure 20 shows PET-temperature of the Herman Moerkerkplein before and after implementing the design elements. As can be seen before implementing there are some severe urban heat spots in the area (red parts in

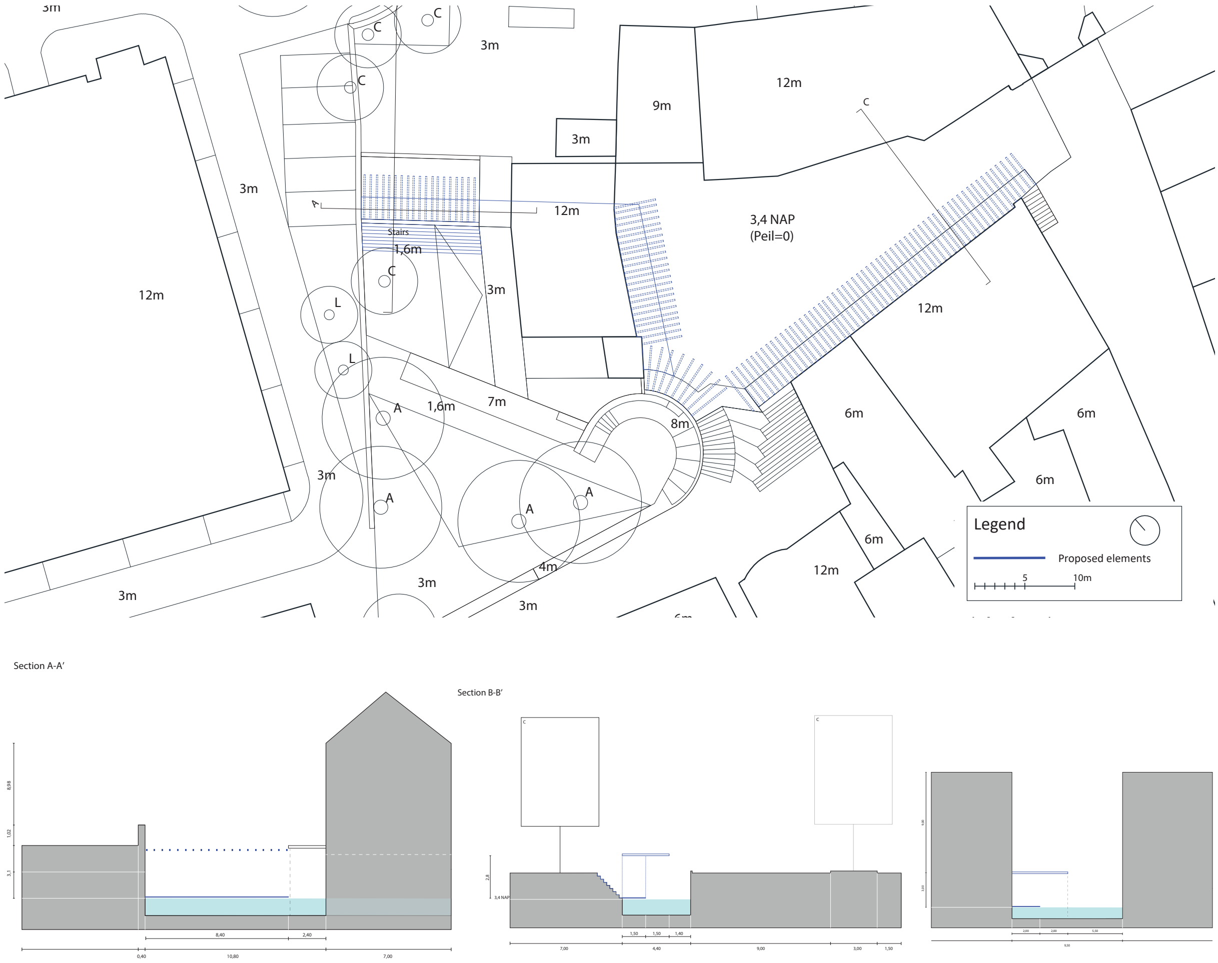


Figure 19 Design with final proposed elements (in blue) including sections and stripped down layout for processing into ENVI-met software.

the maps). The difference between the design without the proposed elements and the design with the proposed elements show clearly the cooling effect of the water body in Herman Moerkerkplein. Figure 21 shows there is a significant difference in PET before and after implementing. At 150cm above water level the PET difference is at some places 10°C. This means there is a cooling potential within the Herman Moerkerkplein if creating the correct spatial configuration. Even at 450cm above water-level the difference is less but still significant. This motivates to incorporate micro-climatic design elements in future designs for the Herman Moerkerkplein.

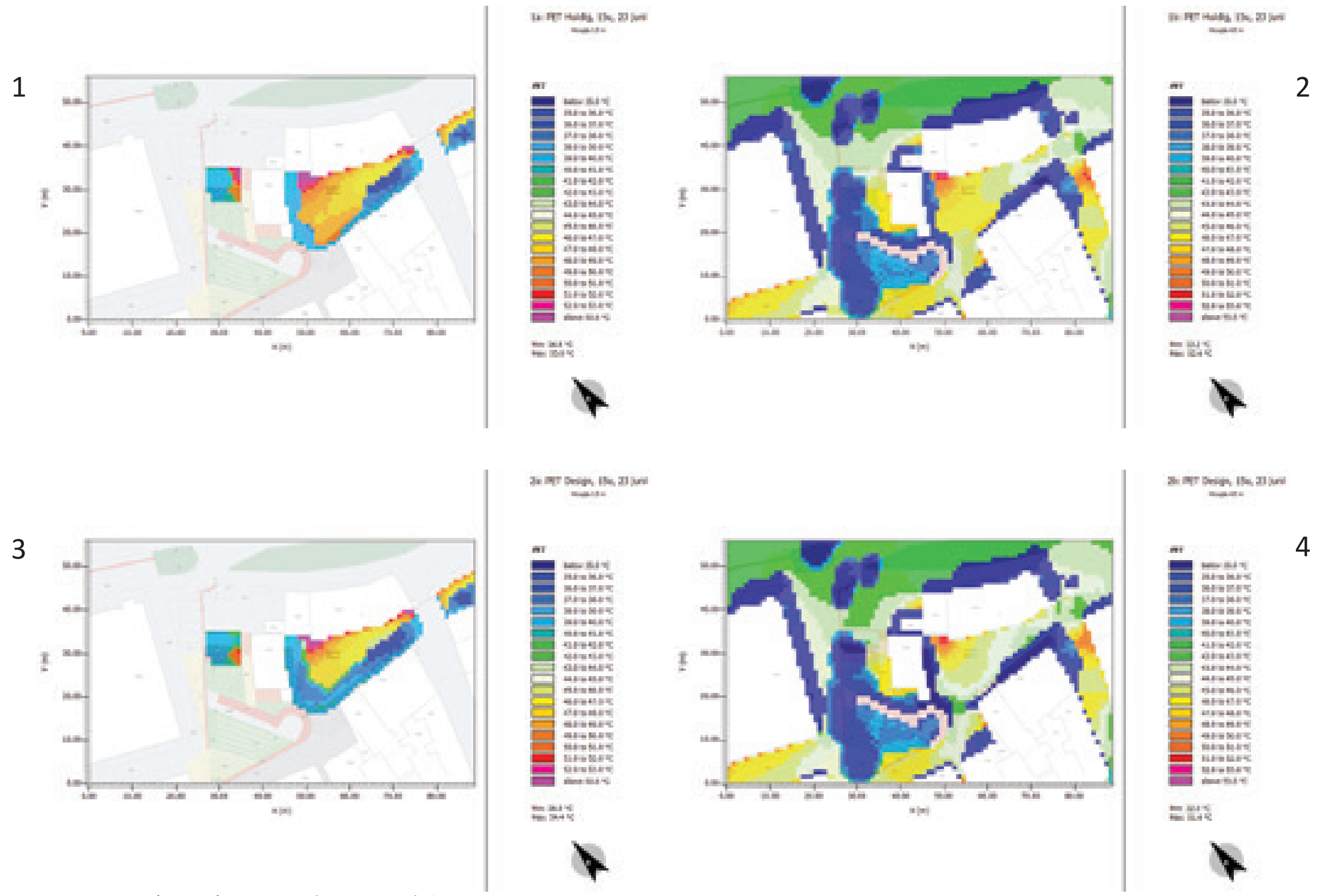


Figure 20 |1 - 4| Results (in PET °C) from the ENVI-met simulations. 1: 150cm above water level without bio-climatic design elements, 2: 450cm above water level without bio-climatic design elements. 3: 150cm above water level with bio-climatic design elements, 4: 450cm above water level with bio-climatic design elements

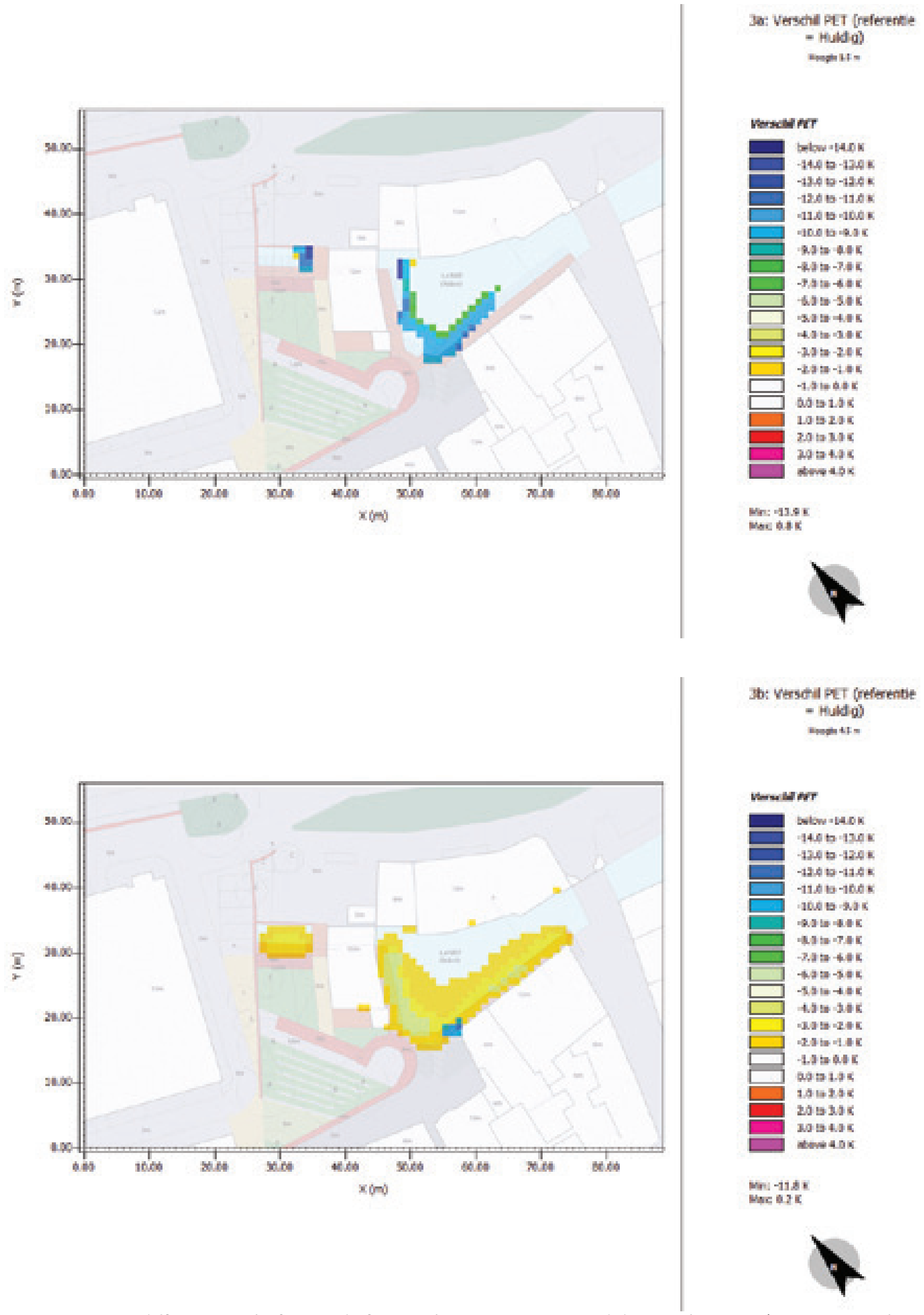


Figure 21 PET difference in before and after implementing proposed design elements (Top: 150cm above water-level. Bottom: 450cm above water-level). In this maps the parts from green to dark blue indicate the cooler PET areas.

4.2 Loop 2 — Answering sub-research question 2 and 3

During loop 2 sub-research question 2 and 3 are answered with the help of the results of loop 1. A new design is made putting together bio-climatic principles and built cultural heritage principles. In this way climate responsive designing is considered together with built cultural heritage in mind. This design is used to test the micro-climatic elements (from sub-research question 1) in a built cultural heritage valued landscape. In this sub-chapter it is elaborated how this leads to fitting and enhancement of built cultural heritage and bio-climatic design.

4.2.1 Site-specific heritage values at the Herman Moerkerkplein

Figure 22 shows six photographs of typical characteristics of the Herman Moerkerkplein. In picture 4 of Figure 22, with in the background the water body, the view to typical architecture is clearly visible. At picture 2 the Binnendieze can be seen where it flows into a tunnel, further into the city. Picture 1, 4 and 5 (Figure 22) show historical elements of the Herman Moerkerkplein. The Herman Moerkerkplein hosts structures of the former city gate along the Binnendieze. These are predominant features for the Herman Moerkerkplein. The pictures show important detailed elements (picture 5 in Figure 22) and iconic entrances (picture 3 Figure 22). These site-specific heritage values are taken into account during the research through designing process.

Figure 22 | Picture 1 - 6 | Spatial elements of the Herman Moerkerkplein with built cultural heritage values

4.2.2 Design toolbox

The toolbox can be seen at Figure 23. The left side presents the built cultural heritage principles and the right side presents the bio-climatic design principles. The middle part of the toolbox consists of the spatial design elements that can be used during design and have an effect on both built cultural heritage and micro-climate. Figure 23 show how the 'tools' (the spatial design elements) are related to the built cultural heritage and bio-climatic design principles.

This toolbox is essential for the research through designing process, it bridges the two domains of bio-climatic design and built cultural heritage. The toolbox is used as input during the design process and it informs the design matrix. The design elements in the toolbox (middle part) are rated in the matrix to achieve an optimal spatial configuration for the design elements according to built cultural heritage and bio-climatic design.

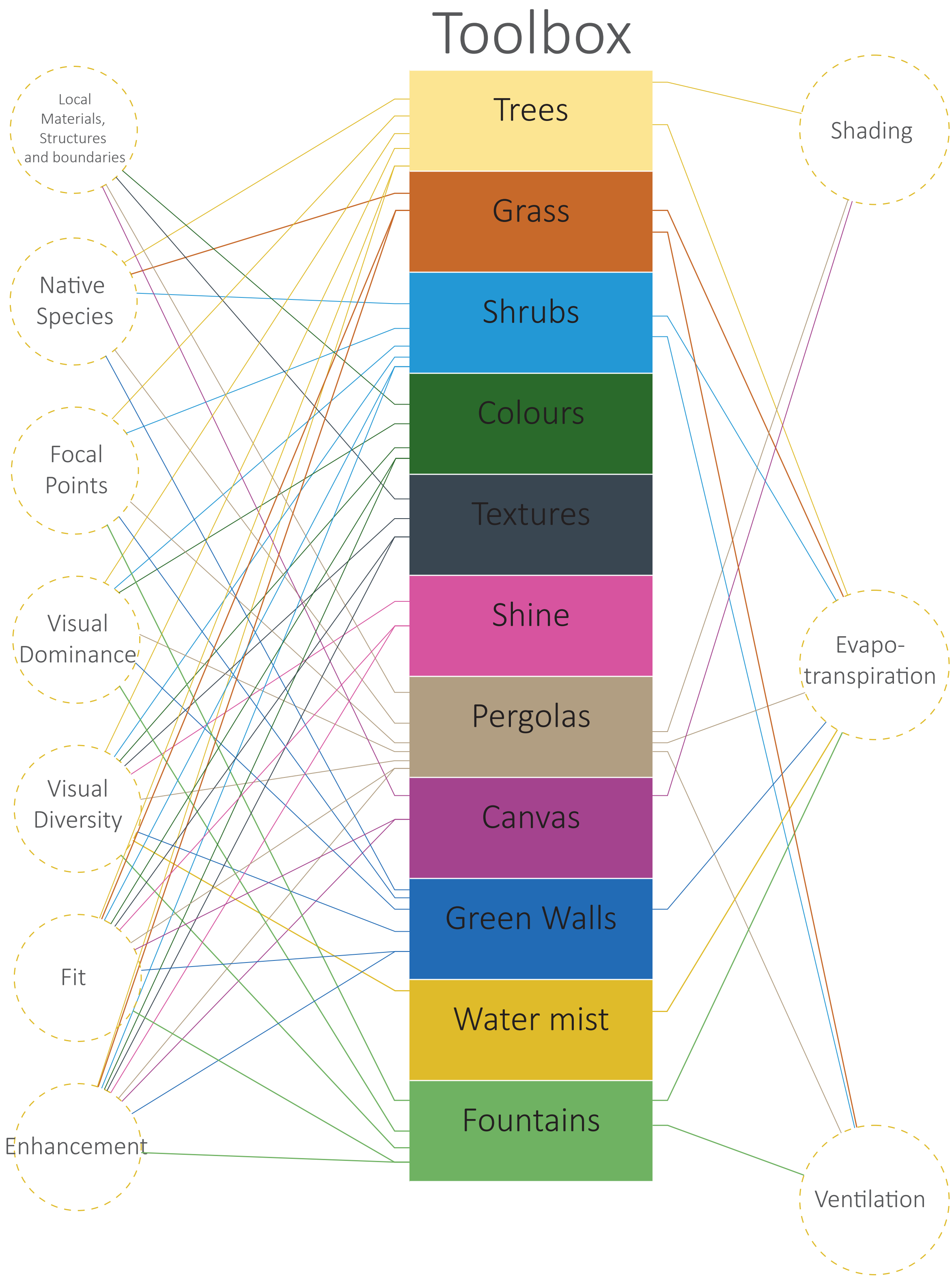


Figure 23 Toolbox containing spatial design elements and the 10 principles.

4.2.3 Design matrix

Through the use of a design matrix with a qualitative five-point rating scale from very negative (-2) to very good (+2) the principles are applied in the design. The horizontal rows are the spatial design elements from the toolbox and the vertical columns are the principles from built cultural heritage and bio-climatic design. In Figure 24 there is a rating already filled in as an example, where gray squares are neutral or not applicable and yellow squares are the actual score. During the use of the matrix a maximum score is aimed for at all times. This helps to achieve an optimal design with all principles implemented in an optimal way.

Figure 24 Example of a detailed part of the design matrix

Figure 25 Complete design matrix with all spatial design elements and principles

4.2.4 Design concept

The research through designing process helps preventing the designer being carried away by infinite design possibilities during designing. However, some design decisions are made purely for aesthetic reasons. The design concept helps to argue these decisions.

When looking at ‘s Hertogenbosch I figured that the city center is a beautiful yet very busy shopping area with a lot of small stony streets. In this roaring street life an escape, such as a park or quiet square, was not easy to find. In this way I found that ‘s Hertogenbosch needed an oasis to escape from the busyness of the shops. To have an escape to relax and sit back. Therefore the concept ‘oasis’ fits the specific site in ‘s Hertogenbosch as it creates, with the correct spatial configuration, an escape from the busy city life.

The concept ‘oasis’ is used as a guide during designing in the research though design process. Some design decisions are made in a purely aesthetic mindset. To argue these design decisions, made as a designer, the concept supports the decisions. Design decisions are not always arguable by a clear argument, but just because the designer thinks it is the best, aesthetically seen, option. The concept is followed during designing, but it is inferior to the principles that are used in the research through designing process. This helps me when designing the Herman Moerkerkplein and making certain design decisions.

4.2.5 Design layers

On the next pages the design matrix is explained and how it is used during designing. An important aspect of research through designing is the iterative loop between research and design. As the name says research is done *through* designing, there is after each design decision feedback from the matrix to the design and vice versa. The next pages show the final results of this iterative process. They explored the ‘ideal’ situations that tackled the design principles defined in the toolbox. Figure 26 shows examples of interim sketches and moments of the design process. A selection of the remaining interim sketches that are generated during the research through designing are added in appendix B.

When generating these layers it was important to keep the correlation between the layers in mind. They could affect each other during designing, e.g. the ventilation increase by removing trees, shading decreases. Whenever doing an intervention it is always checked with the previous layers if they were affected. This created the iterative process which was vital for the research through design process. This also meant it did not matter which layer was assessed first. When the matrix is used correctly the results should be the same. These layers together with the matrix helped ensuring each principle is thoroughly explored during designing.

O·a·ses [oh-ey-seez] /oʊˈeɪ siz/.

1. A small fertile or green area in a desert region, usually having a spring or well.
2. Something serving as a refuge, relief, or pleasant change from what is usual, annoying, difficult, etc.

Figure 26 Photographic collage of design activities included in the research through designing (source: author)

In design layer 1 shading was the focus during designing. In this layer together with the first column in the matrix an optimal spatial configuration was aimed for considering shade. To create the highest amount of shade at the Herman Moerkerkplein several trees and shrubs were added. Besides shading caused by vegetation, shading is achieved by the use of canvas shading devices and pergolas. In this way the spots that suffers the most from heat-stress are covered with shade. Because shrubs do not cast large amounts of shade, it scored a +1 instead of the maximum of +2.

1 Adds canvas shading devices where vegetation can not grow

2 Pergolas for shade sunny areas where trees can not grow

3 Shade sunny areas with various types of trees

Figure 27 Design layer — shading

During this step in the research through design process solely evapotranspiration was taken into account. A maximum of evapotranspiration at the Herman Moerkerkplein was achieved by increasing the amount of vegetation. In the second column of the matrix a maximum rating was aimed for. Instead of pavement grass was used as surface material. However, densely used pathways still needed to be paved. Only the necessary spots, for traffic and walking, were paved. Hard pavement was replaced by soft surface such as grass. In this way a maximum rating in the matrix for evapotranspiration was achieved at the site.

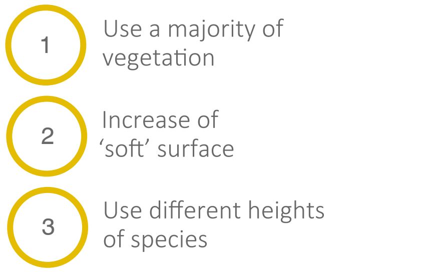


Figure 28 Design layer — evapotranspiration

During this step of the research through design process ventilation within the area was increased to its maximum. Because the most common wind direction is south-east and the street functioning as a wind corridor, the spatial configuration of trees was adjusted to this (Lenzholzer, 2015). The trees at the end of the street would block fresh air coming into the site, some trees were removed to open the potential wind corridor for ventilation. In this way the maximum rating was achieved in the design matrix. Interesting to notice, is the feedback to the rating of shading in the design matrix. Trees were removed and therefore shading decreased in the area.

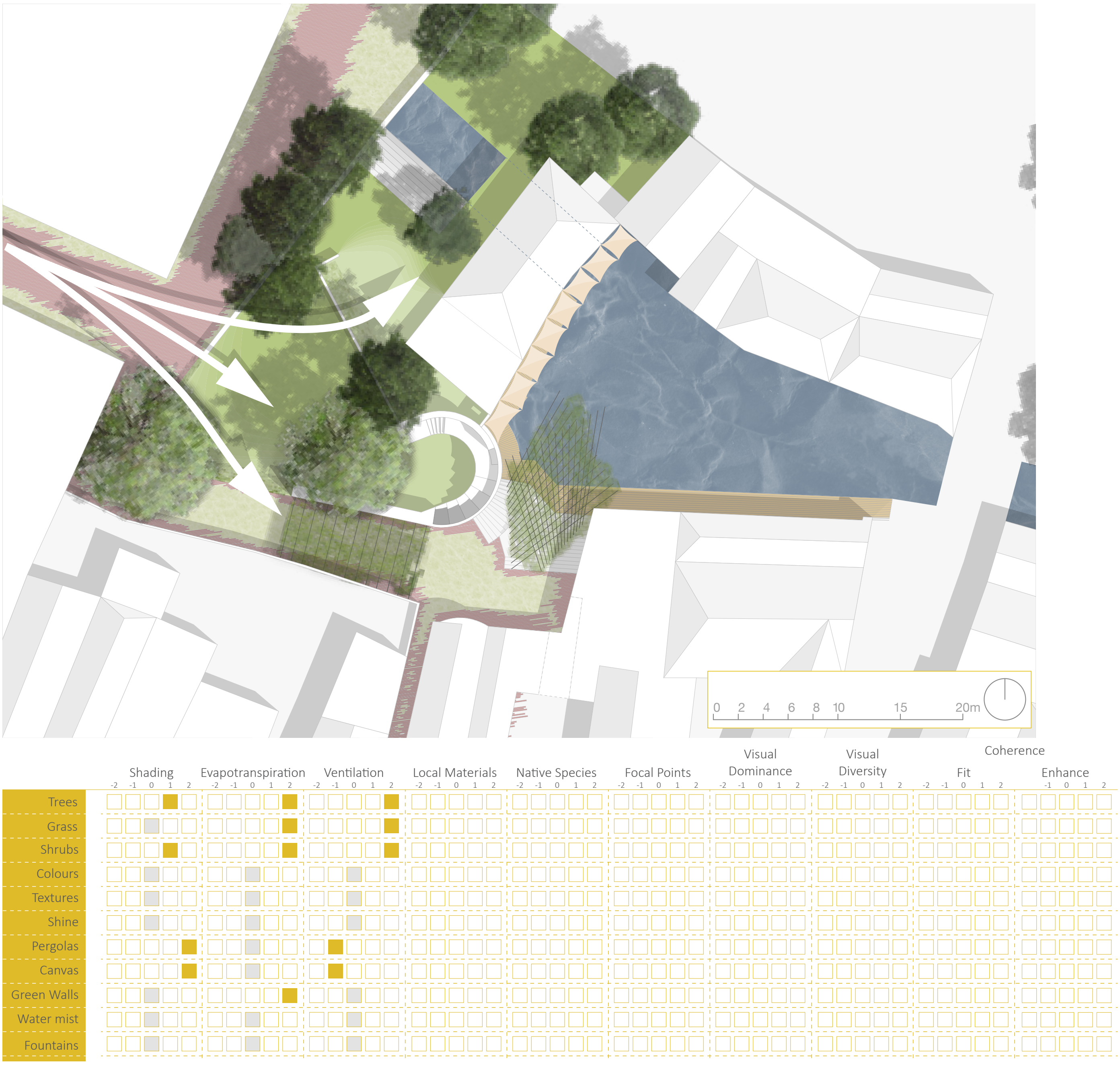


Figure 29 Design layer — ventilation

During this design step local materials were taken into account. Here, for example local bricks for pavement or local wood for the pergola were used. The bricks are clay red bricks from the rivers nearby, and next to the water body hard-stone 'kinderkopjes' are used, because they are widely common in 's Hertogenbosch.The wooden structures are from trees in the region. Important is to prioritize local material that could be made by a craftsman above cheaper material from further away. In this way the local economy is supported and less transportation is used. Another aspect, like color, might be interesting in some cases where a certain color belongs to the region. Because color is not used widely in the area it score a +1 instead of the maximum of +2.

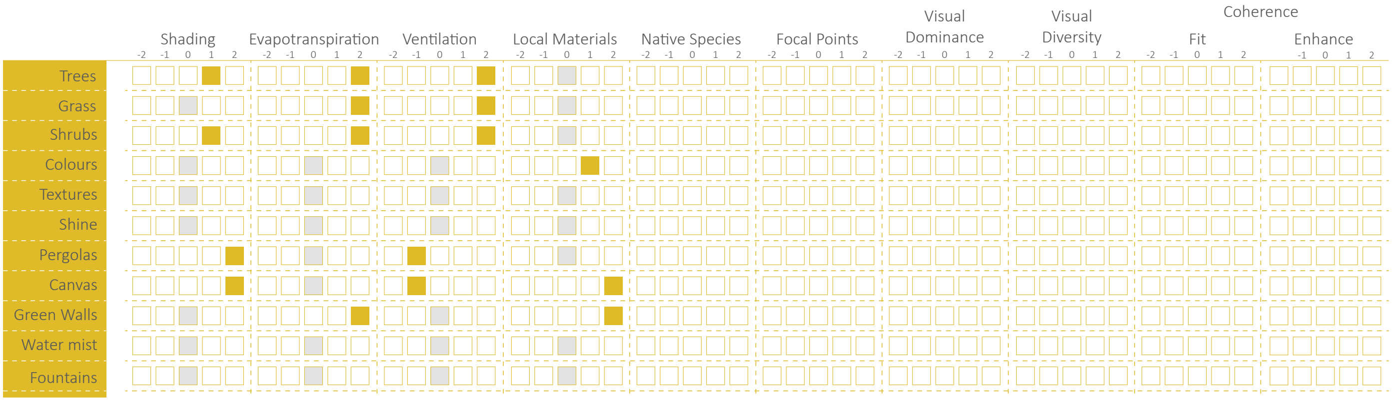


Figure 30 Design layer — local materials

In this design step native species were focused on. To increase the quality of the local ecology native species that are common in the region are used. In this case birch trees (Betula Pendula), Lime trees (Tilia cordata) and beech trees (Fagus Sylvatica) are implemented in the design layer. With every design decision considering vegetation species native species should be taken into account. Grass used in this design layer is not necessarily a native specie from the region. Therefore it did not score the maximum in the design matrix.

1 Native tree species

2 Native vine/creeper species

Figure 31 Design layer — native species

During this design step view lines were considered. View lines might be one of the most important aspects in landscape which have a large influence in the environmental experience. In this step design elements that block the view towards certain important architectural values were removed. For example the pergola that blocks the view towards the water body was removed because the water body is one of the dominant visual elements at the Herman Moerkerkplein. An optimal configuration is achieved for focal points, therefore it scored the maximum in the design matrix.

1 Removal of pergola due to blocking viewport

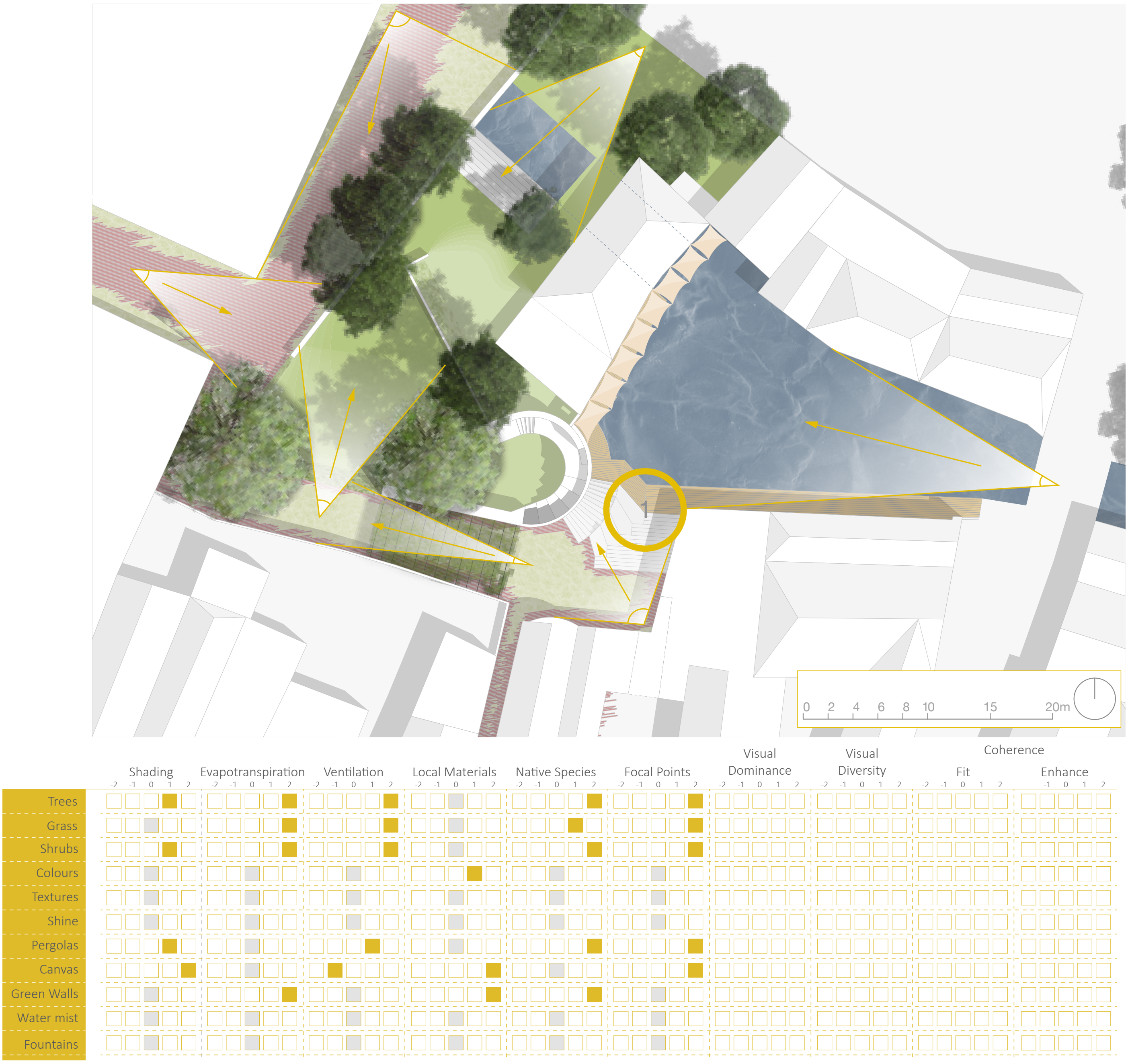


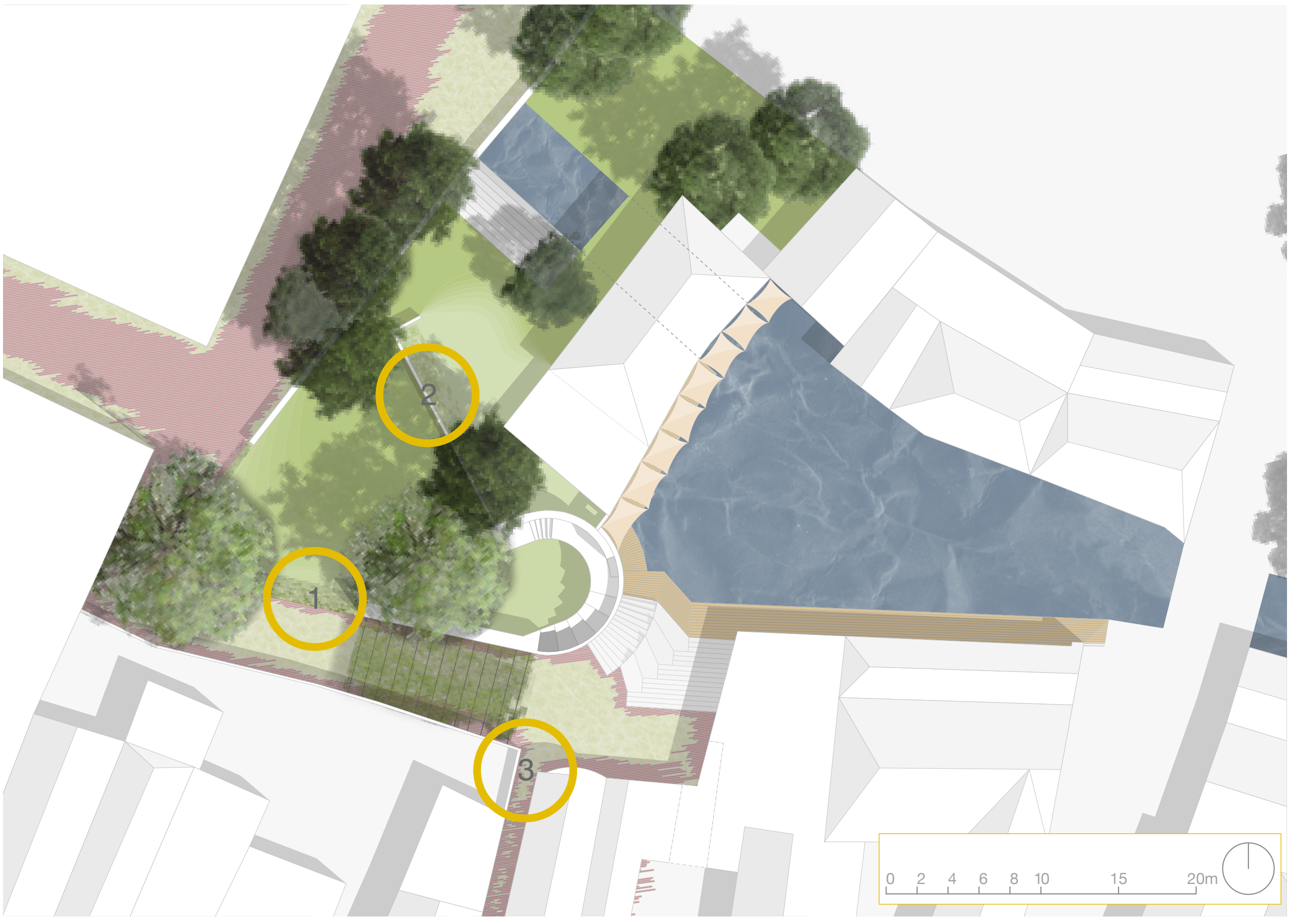
Figure 32 Design layer — focal points

In this design step visual dominance was taken into account. This means visually dominant structures were highlighted or masked depending on the architectural or visual value the element has. This could be done through the use of different vegetation heights or certain vegetation that attracts the spectator's view. Because trees could also block other elements in the area it did not score the maximum in the design matrix. But also colors and textures do not dominate the area.

1 Accentuate potentially dominant structures through vegetation

2 Accentuate structures through vegetation and height

3 Attract visitors with vegetation

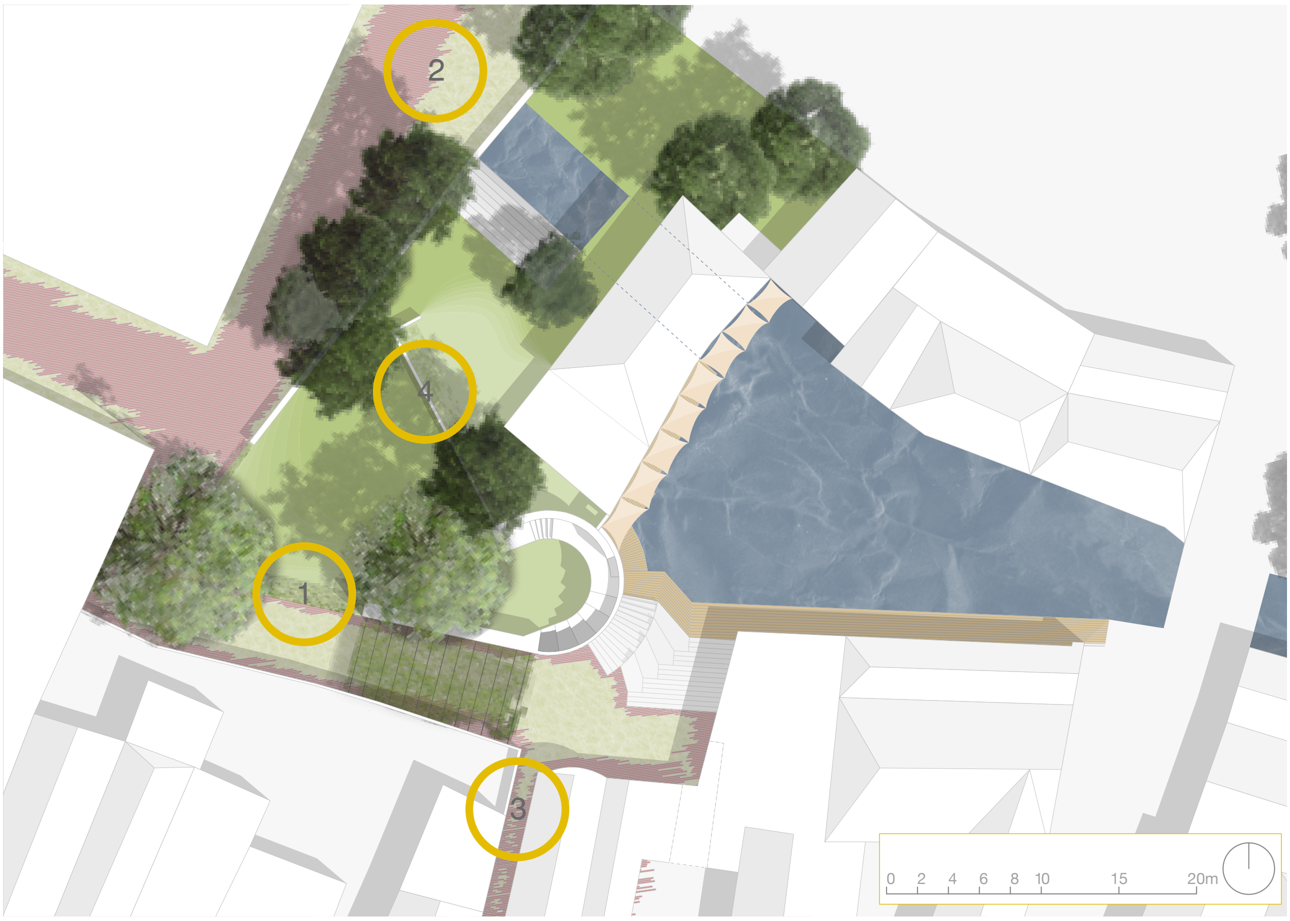


	Shading	Evapotranspiration	Ventilation	Local Materials	Native Species	Focal Points	Visual Dominance	Visual Diversity	Coherence: Fit	Coherence: Enhance
Trees	1	2	2	0	2	2	1			
Grass	0	2	2	0	1	2	2			
Shrubs	1	2	2	0	2	2	2			
Colours	0	0	0	1	0	0	1			
Textures	0	0	0	0	0	0	1			
Shine	0	0	0	0	0	0	0			
Pergolas	1	0	1	0	2	2	2			
Canvas	2	0	-1	2	0	2	1			
Green Walls	0	2	0	2	2	0	2			
Water mist	0	0	0	0	0	0	0			
Fountains	0	0	0	0	0	0	0			

Figure 33 Design layer — visual dominance

During this design step visual diversity was focused on. Visual diversity means there should be a diverse range of material, vegetation and for example elevation present. This created an attractive visual variation that is pleasant for the spectator's eye. For this design it meant adding contrast through the use of different vegetation heights or different vegetation patterns. But also elevated parts in the design created an interesting variation at the site. Because trees can create a monotonous view it scored +1 instead of +2. Colors are not widely used in the area so it did not score the optimal rating.

1. Create contrast through different heights in vegetation
2. Create diversity by using different pavement
3. Create contrast as a trigger to visit
4. Create diversity in elevation



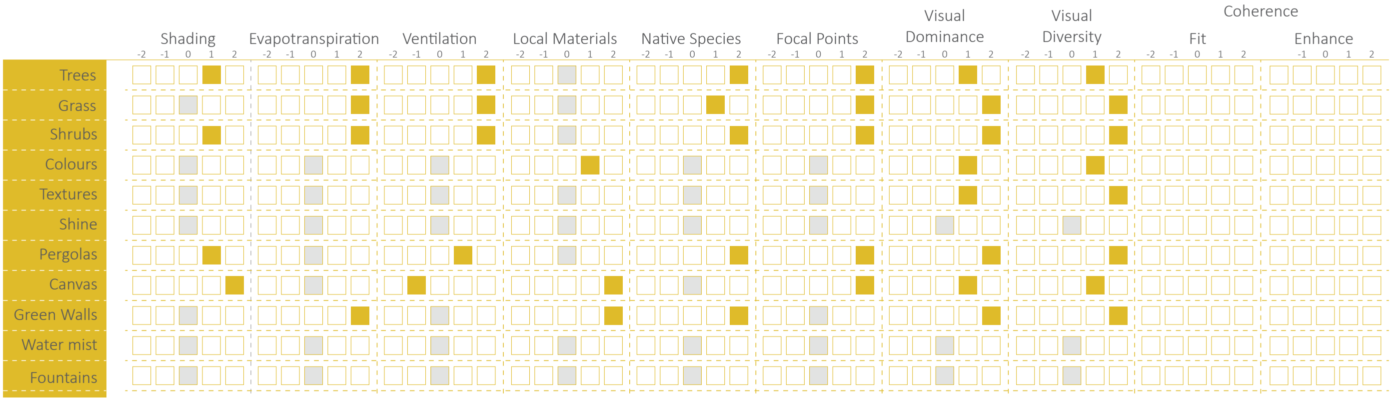


Figure 34 Design layer — visual diversity

During this design layer both the fitting and enhancement within the context of the design elements was taken into account. Because this is related to each other it has been used in the same design layer. In this design step were dissonant structures masked to fit them into the context. In this way they might not dominated its context. When accentuating historical (hidden) structures it could enhance the environment with historical characteristics. During this design step the canvas shading devices were removed because they would not fit aesthetically in the context of the Herman Moerkerkplein. Because trees could also block other important elements in the area it is not necessarily enhancing the built cultural heritage. This also applies to the other design elements that did not score optimal in the design matrix.

1 Masking dissonant structures

2 Invite/seduce visitors inside the area

3 Accentuate (former) structures

4 Create entrances that invite/attract

5 Removal of canvas shading device

Figure 35 Design layer— fit and enhancement

4.2.6 Integration of layers - Final design

The design steps made during the research through design process eventually leaded to the final design. This means all the layers together informed the final design. The design decisions made during the design process incorporate the bio-climatic design principles and built cultural heritage principles. In this way a design was created with an optimal spatial configuration considering these two domains.

During designing, the concept of the oasis was kept in mind. In some cases design decisions were made purely for aesthetic reasons. The concept helped me as a designer giving the research through design process a creative and aesthetic touch. In this way the Herman Moerkerkplein transformed not only in a thermally comfortable place, but also a nice place to be in. It created a great potential for escaping the big fuss in the busy city. During hot summers it has plenty of spots to rest in the shade and avoid the heat from the sun. It includes a field of grass where people can picnic or just relax. However, as some people actually want to be in the sun during summer days there are spots for sunbathing as not all of the site is covered with shade. The old structure of the city wall is visualized through vegetation and elevation differences. This gives the visitor of the Herman Moerkerkplein an idea of the historic values of the place. The dissonant structures, such as the parking garage and rear side of a shop, are masked with climbing vegetation against the wall. This covers not only the structures that do not fit into context but also increases the evapotranspiration and, thus, it cools the environment. The Herman Moerkerkplein contains together with the daylighted part of the Binnendieze a compact and protected atmosphere.

Figure 36 Map of the final design of the Herman Moerkerkplein

Open for the final design

Figure 37 Sections of the Herman Moerkerkplein

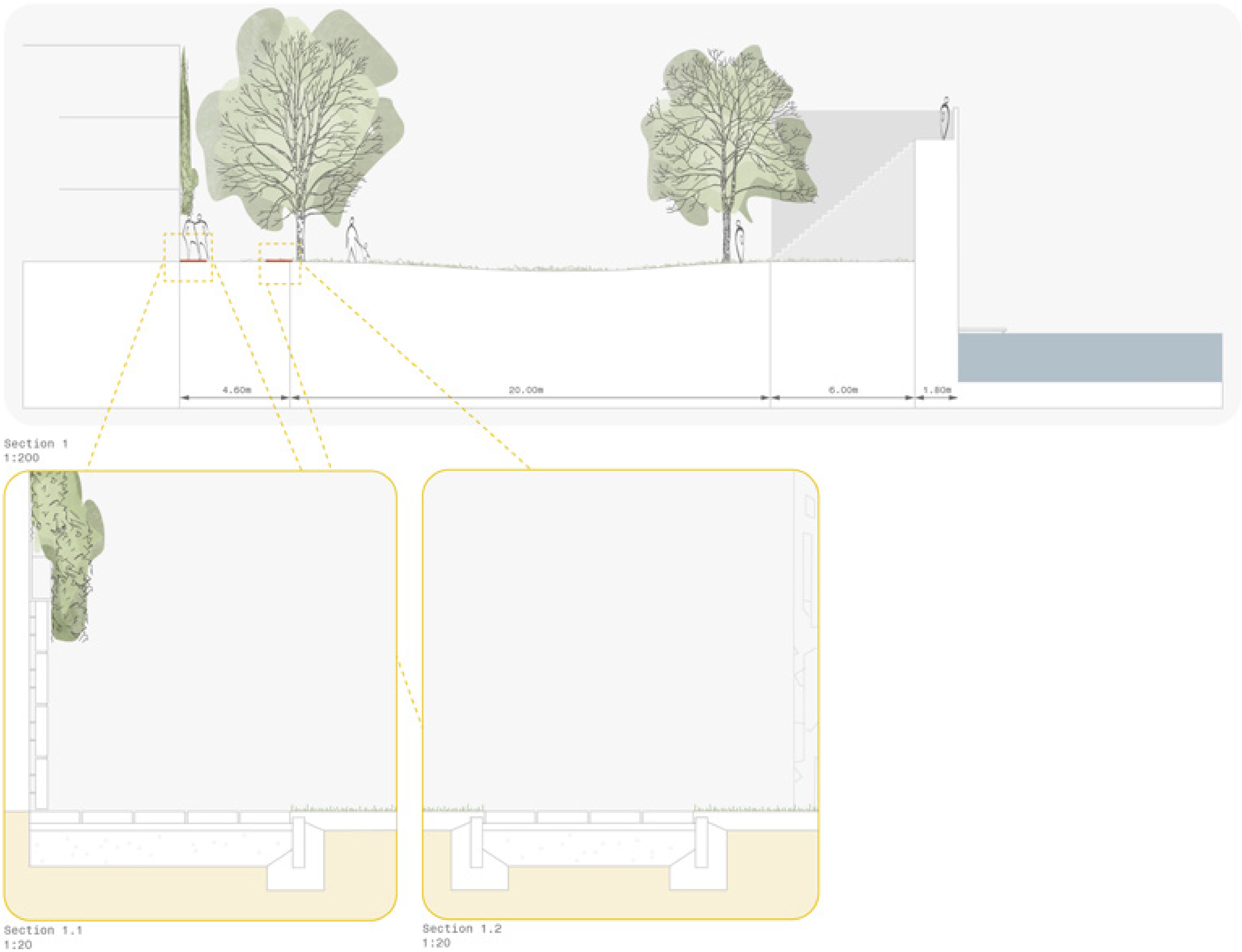


Figure 38 Section 1 — Details in section 1

Stairs towards the water allows people, at hot summer days, relax near the water side. The large water body in the east part of the Herman Moerkerkplein is partly surrounded with a wooded pathway. This allows the visitor to be near the water side and it creates a playful area with an attractive and diverse appearance. In the design native species are incorporated, such as birch trees (Betula Pendula), lime trees (Tilia Cordata) and beech trees (Fagus Sylvatica). The shrubs added in the design are common native species, such as elder shrubs (Sambucus Nigra) and hazel (Corylus Avellana)

Figure 38 shows section 1 of the Herman Moerkerkplein (see Figure 37 for the specific location). In this section the old structure of the city wall is shown. At the left side of the illustration it shows a detailed section of the street and how grass and pavement blend into each other. Because there are no kerbstones visible in the paving, the idea of a seamlessly transition between grass and pavement is achieved. This is an important feature in the design, because the 'soft' and 'hard' surfaces blend into each other. An atmosphere of nature taking over the hard surfaces is created. The pavement is forced back by grass from the grass field in the middle. The vegetation of the green walls at the dissonant structures are blending in the streets.

At the right side of the section the old (restored) city gate tower can be noticed. This structure is an important historic element for the city 's Hertogenbosch where in historic times the Binnendieze was used as a trade way. The tower is designed in a way people can climb it and watch from the top to the Binnendieze.

Open for section drawings

Figure 39 Section of the Herman Moerkerkplein

Figure 40 shows the second section of the design of the Herman Moerkerkplein. In this section the differences of elevation can be clearly noticed. The street level is quite a bit higher than the grass field. A former part of the city gate tower is revealed in the landscape through an elevated part (in the middle part of the section). This ensures the grass field feels as a private enclosure, where people can relax and sit. The elevated wall can be used as a seating element where people can climb it and sit on or against it. The street level is separated from the Herman Moerkerkplein by a brick wall. This is because of safety reasons but also to create an enclosed atmosphere.

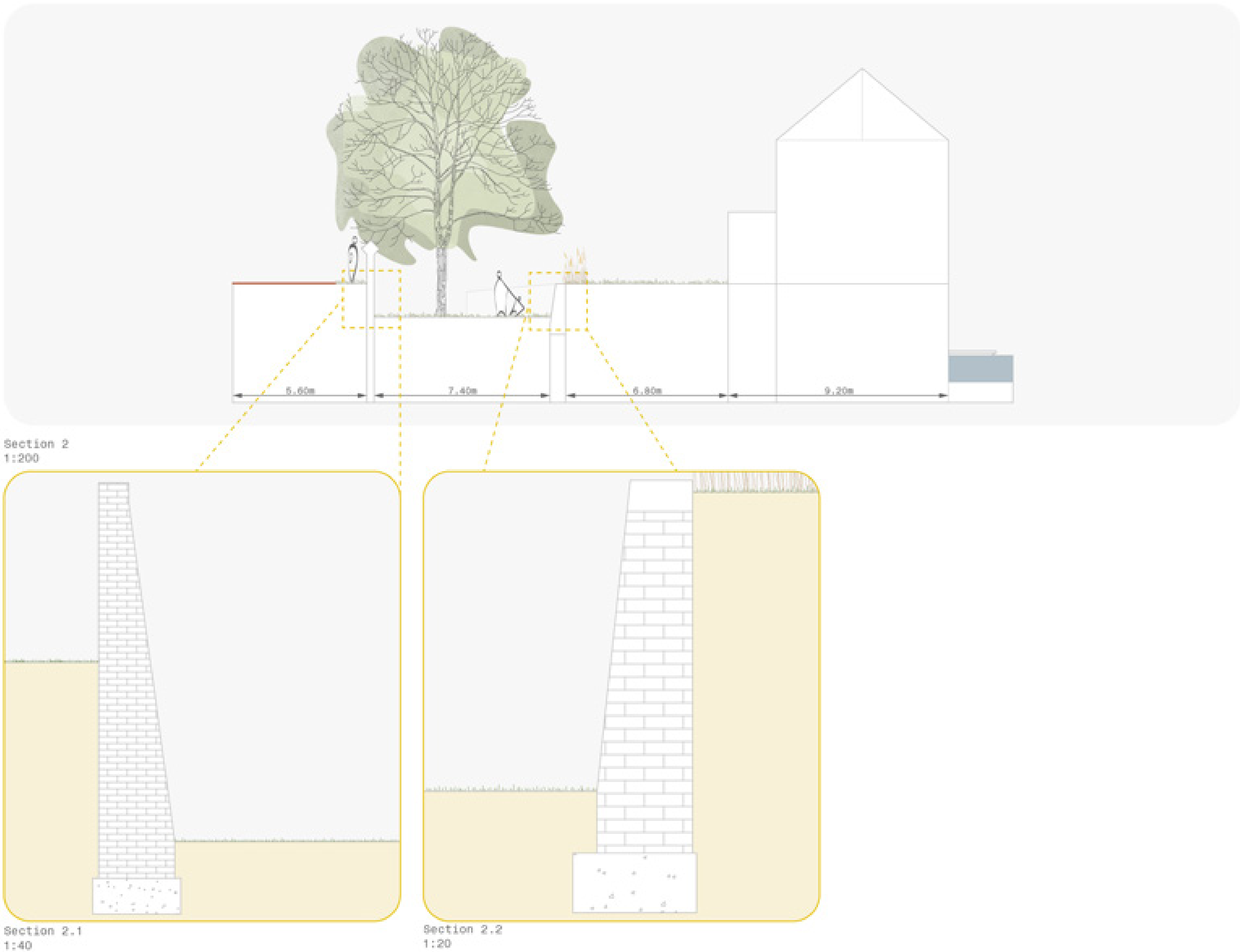


Figure 40 Section 2 — Details of section 2

Open for section drawings

Figure 41 Sections of the Herman Moerkerkplein

In Figure 42 section 3 is shown. In this section the daylighting of the Binnendieze is visible. The elevation within the site is clearly noticeable through the section. Important design features are the use of different vegetation heights as a barrier between two environmental functionalities, such as pathways and the grass field. The higher vegetation used in detail 2 of section 3 is an example of such a barrier. At the north-east side of the section the stairs to the daylighted part of the Binnendieze are shown. This allows visitors of the Herman Moerkerkplein to get close to the water side or even step into a small boat to tour along at the Binnendieze.

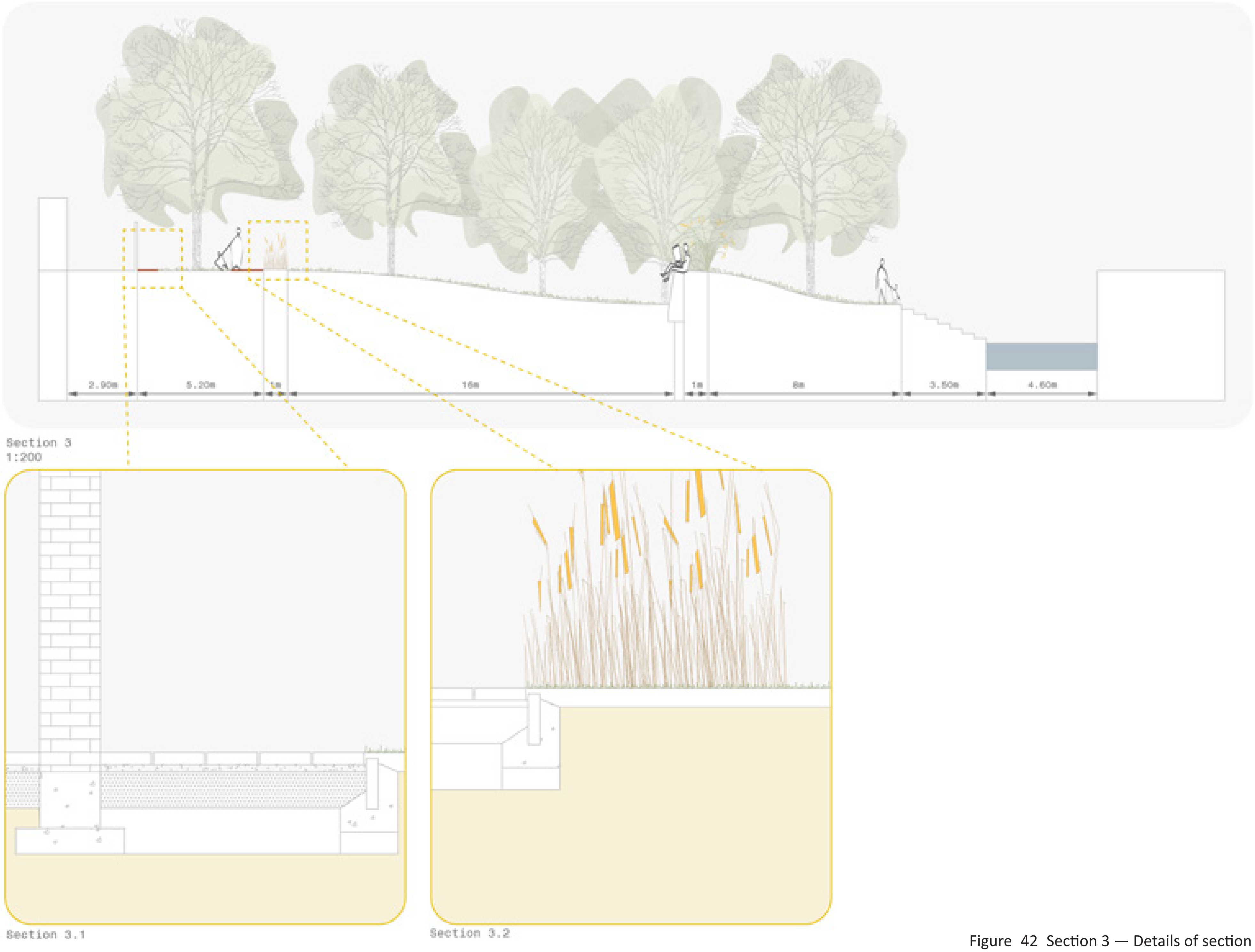


Figure 42 Section 3 — Details of section 3

Open for section drawings

Figure 43 Map of the design without trees

At the figure below the height map of the design is shown through elevation lines. The different heights in the area create a diverse and compact landscape. This might be attractive for children to play and for people to relax at the grassy slopes. In this map it can be seen that the street level is at the same height all around the Herman Moerkerkplein, however in the central area there are differences in height. This causes contrast between the inner and the outer part of the site.

To show the design below the tree-crowns a map is shown without the trees (Figure 43). In this map the structure of the old city walls can be seen more clearly. Because of the absence of trees the specific location of benches and other park or square attributes can be noticed.

Figure 45 on page 58 and onwards show visualizations of the Herman Moerkerkplein.

4.2.7 Testing the design

The design is tested through a session with experts that are familiar with the site. This is the last part in loop 2 of the research process. During this session an interim design is showed and discussed thoroughly. Comments on the design were incorporated in the final design (see appendix C).

Figure 44 Map of the Herman Moerkerkplein with elevation lines

Figure 45 Visualization of inner grass field of the Herman Moerkerkplein

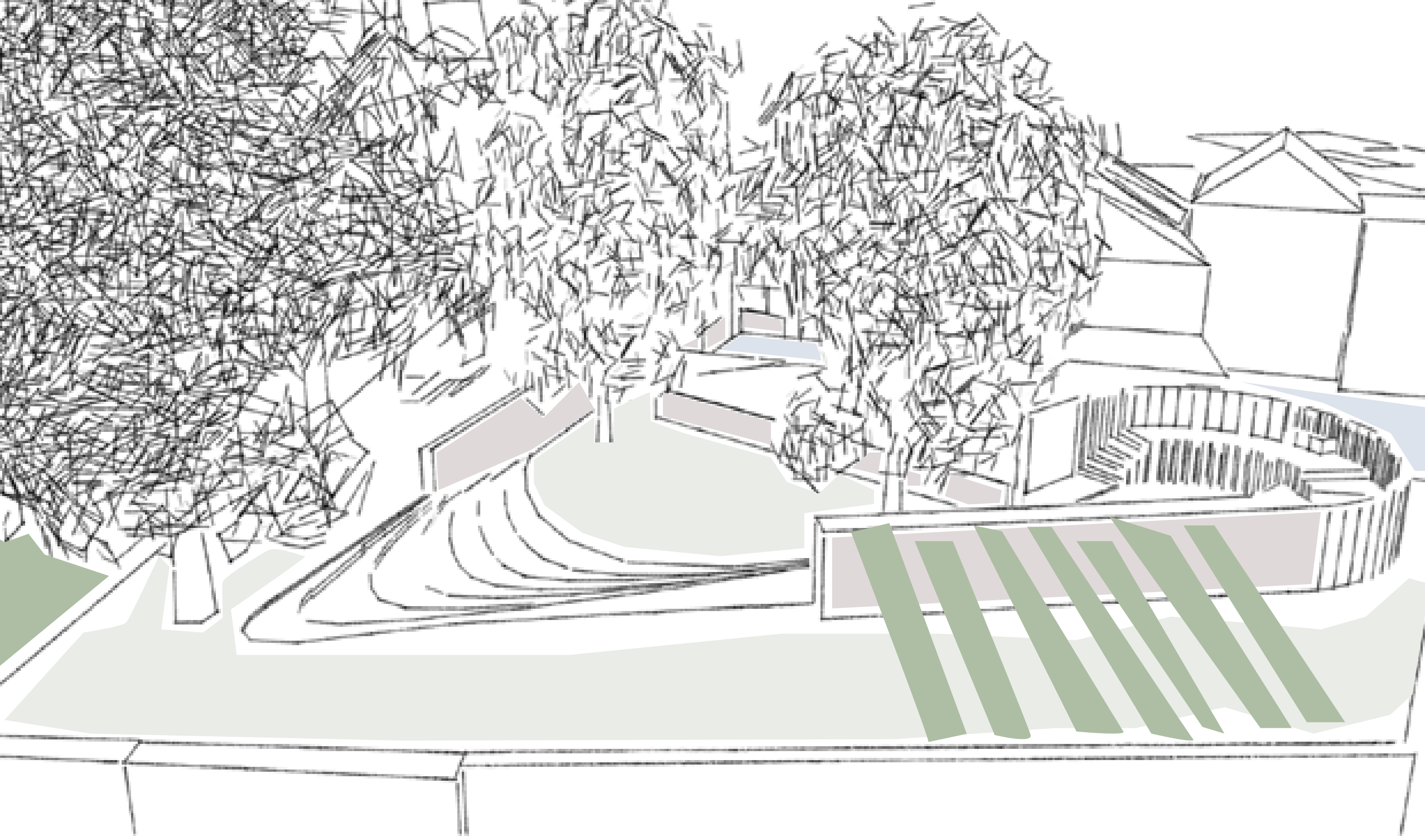


Figure 46 Sketch impression of a birds view of the Herman Moerkerkplein

Figure 47 Visualization of the Herman Moerkerkplein and the Binnendieze

4.3 Loop 3 — Answering the main research question

In loop 3, the last loop, the main research question is answered. For generating these design guidelines the results from the previous loops were used. This loop consists of designing (the guidelines), and testing (through educated guesses). In the following paragraphs the process of generating the design guidelines is explained.

4.3.1 Building the design guidelines

The process of research through designing eventually informed the final design as is shown in the previous chapter. To head back to the objective of this thesis, design guidelines are aimed for that help urban designers or landscape architects with climate responsive design in a built cultural heritage valued landscape.

During the research through designing difficulties were faced when making certain design decisions. These difficulties relate to combining built cultural heritage and bio-climatic design principles through the spatial design elements from the toolbox. They will inform the design guidelines as they are potentially the biggest issue during climate responsive designing in a built cultural heritage valued landscape. Nevertheless, opportunities were also identified and incorporated in the design guidelines. These are used evidently in urban design, such as shading or increasing the amount of vegetation. However, they are of a great importance for the design guidelines. They can help urban designers or landscape architects through difficulties during designing.

These difficulties and opportunities are the pin points that inform the building of the design guidelines. This is explained on the next page together with an illustrative map of the design.

Simplified illustrations were made to show which bio-climatic and built cultural heritage principles are incorporated in the design guidelines (Figure 48). Every design guideline includes the corresponding principle illustrations.

Figure 48 Simplified illustrations of the 10 principles.

The pinpoints in Figure 47 below are the most important aspects that could inform the design guidelines. To derive these pinpoints from the design process and the final design, a closer look was taken into the tensions and opportunities that were faced during designing. These difficulties are shown in Figure 49 along with the final design of the Herman Moerkerkplein. In this figure the principles used in the research through designing process were informing the pinpoints. It is shown that the retrieved design guidelines originate from the principles in the toolbox, which is used in the research through designing process. These pinpoint do relate to bio-climatic design and the built cultural heritage principles. The research through designing process ensured all principles were encountered in the design. Because major difficulties and opportunities were faced during combining the two domains, the pinpoints relate to bio-climatic design and built cultural heritage. The design guidelines are retrieved from these pinpoints and therefore related to the two domains of bio-climatic design and built cultural heritage. The two domains incorporated in the design guidelines inform fitting or even enhancing built cultural heritage and bio-climatic design.

Figure 49 Pinpoints (on the right) that inform the design guidelines

Figure 50 3D visualization where pinpoints are in the design.

4.3.2 The guidelines

In total seven design guidelines were retrieved from the final design. After evaluating the pinpoints, difficulties and testing the interim design guidelines, these seven design guidelines were generated and visualized. In this sub-chapter the design guidelines are explained. However, these seven design guidelines should generally speak for themselves and therefore do not need much textual explanation.

The seven guidelines are the following:

— Create views
— Camouflage dissonant structures
— Framing typical elements
— Accentuate typical elements
— Highlight (hidden) structures
— Intervene 'hard' and 'soft' texture
— Use of different vegetation heights

In Figure 50 and Figure 51 some of the pinpoints, defined in Figure 49, are highlighted to show where bio-climatic design elements are combined with built cultural heritage in the design. This informed the selection of the design guidelines aimed for in this thesis.

In the design guidelines, presented on the

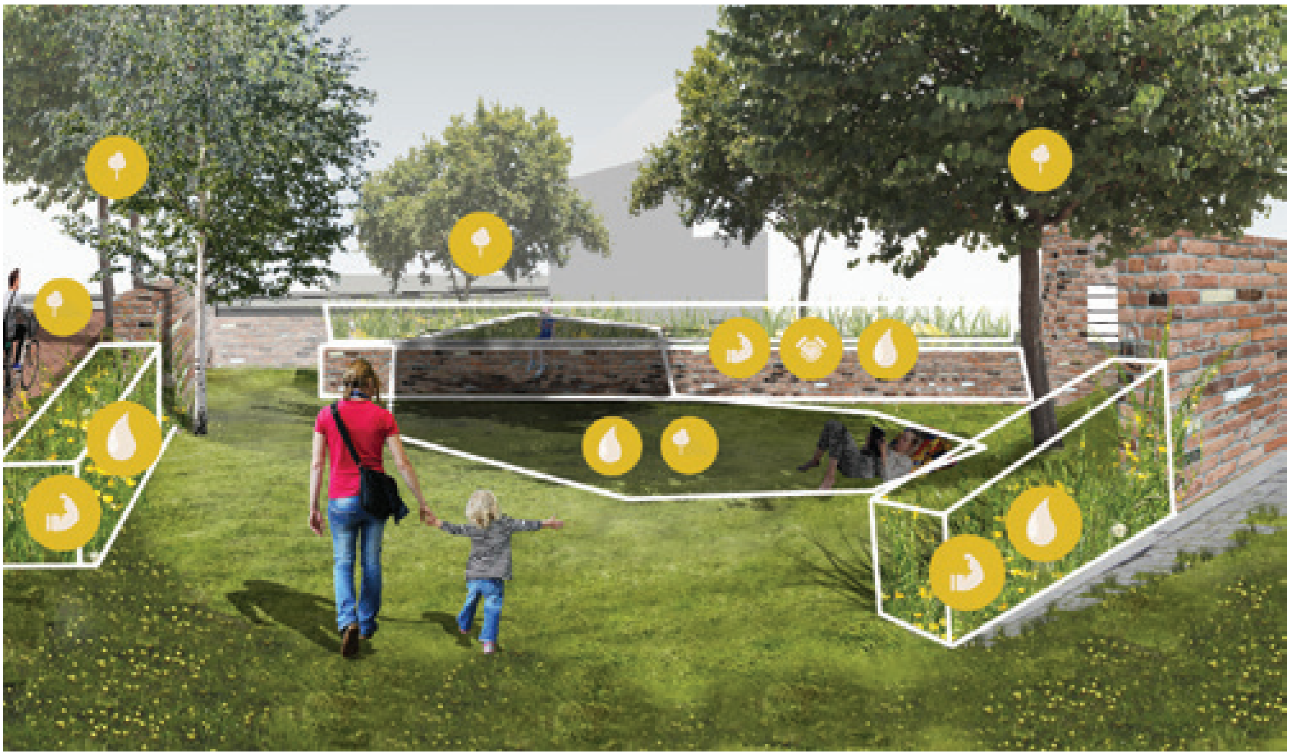


Figure 51 3D visualization where pin points are in the design.

next pages, the basic bio-climatic design principles are incorporated in a way it fits and/or even enhances built cultural heritage. When dealing with implementation of bio-climatic strategies in an urban environment the guidelines should be payed attention to in order to fit or even enhance the local built cultural heritage.

4.3.3 Testing the guidelines

During loop three, testing is done through educated guesses sessions with experts that are familiar with the site and built cultural heritage. During the session interim guidelines were presented. The interim guidelines were discussed thoroughly, which informed the final design of the guidelines (see appendix C). During these sessions minor comments were given on clarity and visual aspects. The comments on the design and clarity were processed into the design guideline. This eventually leaded to the results presented on the next pages.

Figure 52 shows design guideline 1 — creating views. This design guideline gives a simplified illustration of creating view-lines towards a certain (visually valuable) element, such as a church tower or a town hall. In this guideline the spatial configuration of trees and/or shrubs are important to guide the spectators view in a certain direction. The spatial configuration of vegetation, such as trees or shrubs, is sub-ordinate to its context in the area. It is only there to serve a certain (visually valuable) element.

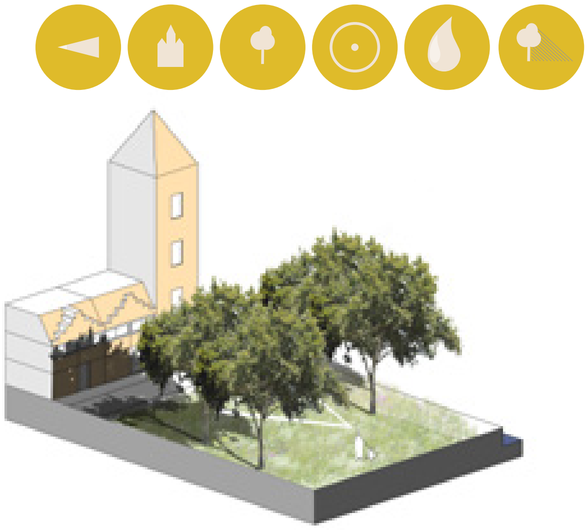


Figure 52 Design guideline 1 — Creating views

Figure 53 Design guideline 2 — Camouflage dissonant structures

Figure 53 shows design guideline 2 — camouflage dissonant structures. Dissonant structures are structures that do not fit in their context visually or historically. It contrasts with the surroundings and therefore does not blend in. This design guideline shows a simplified illustration of camouflaging dissonant structures, such as parking garages or rear sides of shops/shopping centers. This is done through masking the dissonant structures with vegetation, e.g. Hedera or other climbing plants. In this guideline mostly vertical vegetation is used, however also trees or large shrubs can be used as mask in front of an alien structure.

Figure 54 shows design guideline 3 — framing typical elements. This design guideline shows a simplified illustration of framing typical elements. In this design guideline the spatial configuration of vegetation frames typical (architectural) elements. In contrary to design guideline 4 (Figure 55) the spatial configuration of vegetation is predominant to the typical elements. For example, a lane of trees leading towards a specific element.

Figure 54 Design guideline 3 — Framing typical elements

Figure 55 shows design guideline 4 — accentuate typical elements. This design guideline shows a simplified illustration of accentuating typical elements. Accentuating typical elements, such as unique shapes, ornaments or historical structures, is done through increasing contrast and diversity by vegetation. For example, vegetation that follows the form of an ornament where vegetation contrasts with the original structure.

Figure 56 shows design guideline 5 — highlight (hidden) structures. In this design guideline a simplified illustration of highlighting hidden structures is shown. Highlighting (hidden) structures is done through the use of vegetation or texture. Hidden structures, such as former city walls or water structures can be revealed by the use of different vegetation or pavement (texture). It is not needed to fully restore the structure to its original situation, yet in this way the former structures are visible.

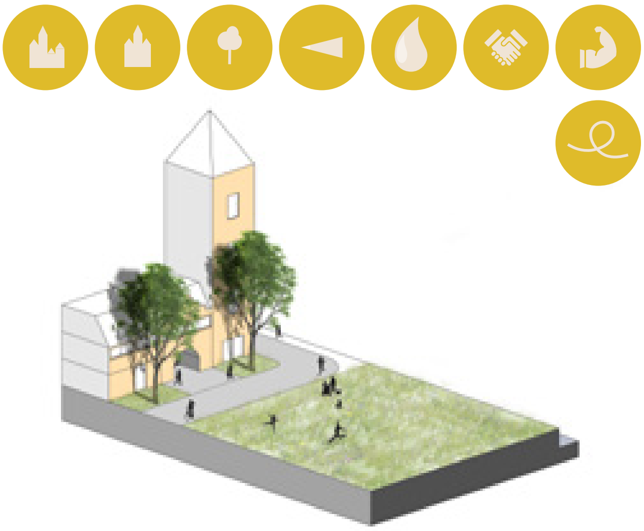


Figure 55 Design guideline 4 — Accentuate typical elements

Figure 56 Design guideline 5 — Highlight (hidden) structures

Figure 57 Design guideline 6 — Intervene 'hard' and 'soft' texture

Figure 57 shows design guideline 6 — Intervene ' hard' and 'soft' texture. In this design guideline the contrast between 'hard' and ' soft' texture is shown. Through the intervention of hard and soft texture a more diverse character is created. When blending these more into each other a more interesting and vivid atmosphere is created. For example, pavement and grass can blend more into each other, instead of having a strict and straight line between pavement and other vegetation.

Figure 58 shows design guideline 7 — Use of different vegetation heights. In this design guideline the use of different vegetation, such as low grass versus higher grass or shrubs heights shows it could function as a guide for a visitor of spectator. With the correct spatial configuration it could be used as for example a barrier without using a fence. In this design guideline the contrast in height of vegetation is the important aspect.

Figure 58 Design guideline 7 —Use of different vegetation heights

5 Discussion and conclusions

The relevance of the field of this thesis might be more than ever after this extraordinary hot and dry summer of 2018. Cities in northern Europe are coping with heat that only cities in the far south of Europe are familiar with. The attention of the micro-climate in urban environments was present in the newspapers during this summer. And even last week (to date 24th of November, 2018) the Dutch government announced to invest in increasing greenery in cities to deal with micro-climate issues (see appendix D).

For me, as a landscape architecture student growing up with climate change issues, it is quite obvious how to tackle these urban heat problems. However, the field of work is adapting to this phenomenon only quite recently. I feel there is a need of a different perspective on urban development to keep city centers a healthy and comfortable living area. Yet, I still see newly build squares and streets in cities where barely trees, or any shading devices, are applied. I can not understand such design decisions nowadays, because maybe today the urban heat is not yet that severe, it will be in the future. And, important to keep in mind, trees do not grow that fast.

There are so many examples in the world; every square, park or street in a city that actually 'works', are mostly accompanied with (large) vegetation. Though, it is clear that a change is needed in perspective and I think cities are actually willing to adapt to this relatively new phenomenon but they lack know-how. During climate responsive a lot of difficulties are faced. It often conflicts with many aspects of urban development, such as hosting big events, traffic space or historical characteristics. As mentioned in the introduction it conflicts with built cultural heritage in a city. I think filling this knowledge gap of bridging built cultural heritage valued landscapes and climate responsive designing is very important when making a city future proof. Yet, it is often underestimated and undervalued.

These two domains could potentially enhance each other and would create not only a more thermally comfortable city but also a nicer city to be in, where special (historical) characteristics are visually better experienced. It could even potentially revalue the city. As literature says the experience of built cultural heritage is not only about historical elitist (built) structures but about context, surroundings and the way people use their environment, climate responsive design should embrace this. It could play a larger role in urban development than it does nowadays.

In this thesis it is tried to create guidelines that can be used by professionals when facing difficulties during climate responsive design and a built cultural heritage valued landscape. This knowledge gap was identified as a lack of knowledge when dealing with built cultural heritage during climate responsive design. However, it was difficult to answer the research questions in a clear and brief way. Built cultural heritage is a huge domain where research has been done thoroughly. But to formulate the concept in a way that it was possible to combine it with climate responsive design was a difficult step to take. As discussed in the theoretical framework built cultural heritage can be approached in a traditional way. But this appeared not useful for this thesis, as more research said built cultural heritage is about context, experience and identity. This was an important step forward combining the two domains and generating design principles that are helpful for urban designers and landscape architects. Creating a solid base for the research through designing phase was one of the most important steps throughout the thesis. And therefore, probably, the toughest part. Hence, answering the research questions was not possible through a few clear sentences.

The choice to use research through designing as the main method helped a lot to combine scientific research and designing. This forced me to incorporate during designing the two domains of built cultural heritage and bio-climatic design. The iterative process between research and design helped to think about their integration into each other for every design decision. The matrix, with its qualitative five-point rating scale, functioned in an optimal way to achieve a maximum cooling effect integrated with a built cultural heritage valued landscape.

5.1 Answering the research questions

In order to be able to answer the main research question the sub-research questions need to be answered first.

The first sub-research question informed the basis of this thesis and checked the cooling potential of the Herman Moerkerkplein. Therefore sub-research question 1 was formulated as such:

1. **What is the cooling effect of the REALCOOL prototype gracht 3 in the Herman Moerkerkplein?**

During loop 1 of this thesis sub-research question 1 was answered through the use of micro-meteorology simulation software. Applying the REALCOOL prototype gracht 3 at the Herman Moerkerkplein informed these micro-meteorology simulations. This resulted in PET maps with a simulated urban heat map. The maps show that there is a cooling effect of over 11 °C PET in parts that suffered the most of heat stress. This shows the cooling effect of the Herman Moerkerkplein when applied the bio-climatic design elements from the REALCOOL prototype correctly. With these micro-meteorology simulations sub-research question 1 is answered. There is a significant cooling effect in the Herman Moerkerkplein.

Sub-research questions 2 and 3 supported the fitting and enhancement aspect of the main research question. The sub-research questions were formulated as such:

2. **How to fit climate responsive design with heritage values in urban water environments?**

3. **How to enhance the heritage values of urban water environments through climate responsive design?**

These sub-research questions were answered through loop 2 of this thesis. These sub-research questions concerned the fitting and enhancement. To create city centers future-proof the two domains should obviously fit each other. The knowledge gap on how to fit and enhance bio-climatic design and heritage values could be seen as a huge opportunity for the field of work in the two domains. It could help increasing support for implementing bio-climatic design principles in heritage valued urban landscapes. If it fits the context and thus heritage values, urban adaptation changes are probably more widely accepted and (financially) supported. The investment of adaptation in a city center to mitigate urban heat stress could be in this way more societal argued. Responsive design could serve the urban environment, if spatially correctly applied.

Besides this, it could even enhance the urban environment and therefore the heritage values in a city. This approach is highly important to the field of work in both domains. It is a huge opportunity enhancing each other in urban environments. These two sub-research questions are therefore very important for mitigating urban heat stress.

In this research the two domains of bio-climatic design and built cultural heritage were combined through a toolbox and matrix. This ensured the principles of the two domains were equally and thoroughly applied in the design. The use of the design layers, together with the matrix, resulted in an optimal spatial configuration considering heritage values and climate responsive design. The design layers therefore informed the answers to the sub-research questions on how to fit climate responsive design or even enhance the heritage values. The answer to sub-research question 2 is: the fit of climate responsive designing with heritage values can be achieved by using the ten principles from the toolbox with a design matrix. This ensures the fit of climate responsive design and heritage values in an urban water environment.

The answer to sub-research question 3 follows the answer of sub-research question 2. However, enhancing heritage values highly depends on context. The answer is that the three basic bio-climatic design principles can be used to highlight, accentuate or frame heritage valued elements in an urban water environment. This results in enhancing the heritage values in urban water environments. To achieve the correct spatial configuration in order to enhance it, the seven built cultural heritage principles need to be assessed during designing.

This leaded to the final design for the Herman Moerkerkplein which informed generating the design guidelines aimed for in the main research question. The main research question was formulated as such:

What design guidelines can be used for cooling water environments to fit and even enhance built cultural heritage?

The answer to the main research question was informed by the answers of the sub-research questions which were elaborated previously. The design guidelines that resulted from the last loop in this thesis are in essence the answer to this main research question. However, the fit and enhancement cannot be distinguished clearly throughout the design guidelines. As should be obvious, they all fit climate responsive design and built cultural heritage. But they will not intrinsically also enhance built cultural heritage. The seven design guidelines that were generated are:

— Create views
— Camouflage dissonant structures
— Framing typical elements
— Accentuate typical elements
— Highlight (hidden) structures
— Intervene ‘hard’ and ‘soft’ texture
— Use of different vegetation heights

To know if the design guidelines also enhance the built cultural heritage a closer look should be taken in the context of the design guidelines. For some design guidelines it can certainly be said they enhance built cultural heritage. *‘Framing typical elements’, ‘accentuate typical elements’ and ‘highlight (hidden) structures’* are enhancing built cultural heritage. This can be formulated as such because these design guidelines, with incorporated bio-climatic design elements, are subordinate to a built cultural heritage valued landscape. However, the remaining design guidelines could potentially enhance built cultural heritage but it depends on the context and how they are applied.

The guidelines generated from the previous loops en the design leaded eventually not specifically to water environments but to urban environments in general. The built cultural heritage principles used during the research were not specifically focused on water environments. This resulted in guidelines that are not only applicable to water environments but can be generalized to the urban environment.

5.2 Validity and reliability

Because there is a continuous process of testing and designing and feedback between the different inputs, there is an ongoing discussion and transparency. This leads to a guaranteed credibility where the research outcomes are open to discussion at all times.

Due to the constructivist world view the strength of the research lies within the innovativeness and flexibility to respond to different contexts (Lenzholzer, Duchhart, & Koh, 2013). This can lead to a 'full design' that tackles the knowledge gap and informs the answer to the main research question.

5.3 Significance of Research

This research could be highly significant to the field of climate responsive designing and built cultural heritage. Nowadays, more cities are adapting and mitigating urban heat stress during peak hours in hot summers. Because the topic is very relevant to urban development it is important for urban designers and landscape architects to take climate responsive design into account. But also the domain of cultural heritage should embrace the adaptation in order to keep the environmental experience of built cultural heritage possible during hot summers. Bio-climatic design strategies can support and even enhance the built cultural heritage in a city. To create and adapt cities for the future this is highly necessary. Not only for a visually better constructed design but also to create thermally comfortable cities that are comfortable to live in during hot summers in the future.

While filled the knowledge gap of combining built cultural heritage and climate responsive design, research about integrating climate responsive design and urban development does not stop. It is important to research further on the impacts of bio-climatic design elements in urban environments. This could support bio-climatic design related design decisions when facing barriers, such as costs or maintenance when presenting to clients, such as cities, provinces or real estate developers.

I think there is still a lot of potential in cooling cities which are not yet adapted to severe urban heat stress.

6 References

Barry, R. G. and Blanken, P. (2016) *Microclimate and local climate*. Cambridge: Cambridge University Press,.

Brimblecombe, P. (2004) 'Damage to cultural heritage', in *Air Pollution and Cultural Heritage*. London: Taylor & Francis Group, pp. 87–90.

Calthorpe, P. (2011) *Urbanism in the age of climate change*, *Island Press*. Washington, DC : Island Press,.

Changnon, S. A., Kunkel, K. E. and Reinke, B. C. (1996) 'Impacts and responses to the 1995 heat wave: A call to action', *BUlletin of the American Meteorological Society*, 77, pp. 1497–1506.

Charlotte Huisman (2011) 'Steeds vaker hittegolven (en vooral in de stad)', *De Volkskrant*, 12 June. Available at: https://www.volkskrant.nl/nieuws-achtergrond/steeds-vaker-hittegolven-en-vooral-in-de-stad-~bf60c282/ (Accessed: 28 November 2018).

CoE (2005) *Council of Europe Framework Convention on the Value of Cultural Heritage for Society*.

Cortesão, J. (2013) 'Thermal retrofitting of public spaces in compact urban areas. A bioclimatic approach', p. 271.

Cortesão, J. *et al.* (2017) 'Creating prototypes for cooling urban water bodies', pp. 1–13.

Elia, R. J. and Ostovich, M. (2011) *Heritage Management*, *Oxford Bibliographies Online: Classics*.

Guzmán, P. C., Roders, A. R. P. and Colenbrander, B. J. F. (2017) 'Measuring links between cultural heritage management and sustainable urban development: An overview of global monitoring tools', *Cities*. Elsevier B.V., 60, pp. 192–201. doi: 10.1016/j.cities.2016.09.005.

Hassler, U., Algreen-ussing, G. and Kohler, N. (2002) 'Cultural heritage and sustainable development in SUIT', (3), pp. 1–5.

Huigen, P. P. and Meijering, L. (2005) 'Making places: A story of De Venen', *ASHWORTH, GJ and GRAHAM, B., Senses of Place: Senses of Time, Farnham: Ashgate*, pp. 19–30.

ICOMOS (2002) *ICOMOS international cultural tourism charter: principles and guidelines for managing tourism at places of cultural and heritage significance*. International Council on Monuments and Sites, ICOMOS International Cultural Tourism Committee.

Jackson, A. (2008) 'Local and Regional History as Heritage: The Heritage Process and Conceptualising the Purpose and Practice of Local Historians', *International Journal of Heritage Studies*. Routledge , 14(4), pp. 362–379. doi: 10.1080/13527250802155877.

Ki-Moon, B. (2014) *Secretary-General's remarks at Climate Leaders Summit | United Nations Secretary-General*. Available at: https://www.un.org/sg/en/content/sg/statement/2014-04-11/secretary-generals-remarks-climate-leaders-summit (Accessed: 24 November 2018).

Kleerekoper, L., Van Esch, M. and Salcedo, T. B. (2012) 'How to make a city climate-proof, addressing the urban heat island effect', *Resources, Conservation and Recycling*. Elsevier B.V., 64, pp. 30–38. doi: 10.1016/j.resconrec.2011.06.004.

Klok, E. J. and Kluck, J. (2018) 'Reasons to adapt to urban heat (in the Netherlands)', *Urban Climate*. Elsevier B.V., 23, pp. 342–351. doi: 10.1016/j.uclim.2016.10.005.

Lefèvre, R.-A. (2015) 'Dresden Papers on Law and Policy of the United Nations Dresdner Schriften zu Recht und Politik Dresden Papers on Law and Policy of the United Nations', *Climate Change as a Threat to peace: Impacts on Cultural Heritage and Cultural Diversity*, 19, pp. 83–100.

Lenzholzer, S. (2015) *Weather in the city: how design shapes the urban climate*. Rotterdam: Nai010 Publishers.

Lenzholzer, S., Duchhart, I. and Koh, J. (2013) 'Landscape and Urban Planning " Research through designing " in landscape architecture', *Landscape and Urban Planning*, 113, pp. 120–127. doi: 10.1016/j.landurbplan.2013.02.003.

Lynch, K. (1960) *The Image of the City*. London: MIT Press.

Mah, A. (2012) *Industrial ruination, community, and place: Landscapes and legacies of urban decline*.

Maslow, A. H. (1943) 'A theory of human motivation.', *Psychological Review*, 50(4), pp. 370–396. doi: 10.1037/h0054346.

Massey, D. (1995) 'Places and Their Pasts', *History Workshop Journal*, (39), pp. 182–192.

Meerow, A. W. and Black, R. J. (1993) *Enviroscaping to Conserve Energy: a Guide to Microclimate Modification*. University of Florida Cooperative Extension Service, Institute of Food and Agriculture Sciences.

Mori, K. and Yamashita, T. (2015) 'Methodological framework of sustainability assessment in City Sustainability Index (CSI): A concept of constraint and maximisation indicators', *Habitat International*. Elsevier Ltd, 45(P1), pp. 10–14. doi: 10.1016/j.habitatint.2014.06.013.

Oke, T. R. (1981) 'Canyon geometry and the nocturnal urban heat island: Comparison of scale model and field observations', *Journal of Climatology*. Wiley-Blackwell, 1(3), pp. 237–254. doi: 10.1002/joc.3370010304.

Oke, T. R. (1987) 'Boundary layer climates. 2nd', *Methuen, 289p*, 548.

Papadakis, G., Tsamis, P. and Kyritsis, S. (2001) 'An experimental investigation of the effect of shading with plants for solar control of buildings', *Energy and Buildings*. Elsevier, 33(8), pp. 831–836. doi: 10.1016/S0378-7788(01)00066-4.

RIZWAN, A. M., DENNIS, L. Y. C. and LIU, C. (2008) 'A review on the generation, determination and mitigation of Urban Heat Island', *Journal of Environmental Sciences*, 20(1), pp. 120–128. doi: 10.1016/S1001-0742(08)60019-4.

Rose, M. (2012) 'Dwelling as marking and claiming', *Society and Space*, 30, pp. 757–771. doi: 10.1068/d6809.

Sabbioni, C. *et al.* (2009) 'Vulnerability of cultural heritage to climate change', *Pollution Atmospherique*, (202), pp. 157–169.

Santamouris, M. (2001) *Energy and Climate in the Urban Built Environment*. 1st edn. London: Routledge. doi: 10.4324/9781315073774.

Sowińska-Świerkosz, B. (2017) 'Review of cultural heritage indicators related to landscape: Types, categorisation schemes and their usefulness in quality assessment', *Ecological Indicators*, 81(December 2016), pp. 526–542. doi: 10.1016/j.ecolind.2017.06.029.

Tweed, C. and Sutherland, M. (2007) 'Built cultural heritage and sustainable urban development', *Landscape and Urban Planning*, 83(1), pp. 62–69. doi: 10.1016/j.landurbplan.2007.05.008.

Wheeler, R. (2017) 'Local history as productive nostalgia? Change, continuity and sense of place in rural England', *Social & Cultural Geography*. Routledge, 18(4), pp. 466–486. doi: 10.1080/14649365.2016.1189591.

Whyte, N. (2007) 'Landscape, memory and custom: parish identities c. 1550-1700', *Social History*, 32(2), pp. 166–186.

Whyte, N. (2011) 'Custodians of Memory', *Cultural and Social History*. Routledge, 8(2), pp. 153–173. doi: 10.2752/147800411X12949180694263.

Whyte, N. (2015) 'Senses of Place, Senses of Time: Landscape History from a British Perspective', *Landscape Research*. Routledge, 40(8), pp. 925–938. doi: 10.1080/01426397.2015.1074987.

Wong, E. (2008) *Reducing Urban Heat Islands: Compendium of Strategies: Trees and Vegetation, Climate Protection Partnership Division.*

7 Appendices

Appendix: A

EveningStandard. News Football Going Out Lifestyle Showbiz Homes & Property

News › Health

Air conditioning breaks down on ward at Royal Free Hospital during London heatwave

TOM MARSHALL | Thursday 2 July 2015 | 2 comments

Sick and elderly patients were reportedly left to swelter in "sauna-like" conditions when air conditioning stopped working on two wards at a north London hospital.

Vulnerable patients including some who had just arrived from intensive care were "cooking" in their beds at the Royal Free Hospital in Hampstead, it was claimed.

David Silver, 73, who was in the ward recovering from a gall bladder removal, told the Daily Mail he had experienced nothing like it living in the tropical climate of Thailand for 15 years.

EveningStandard.

London weather: 'You Englanders wouldn't be able to survive an Australian summer' World pokes fun at UK heatwave

Source: www.eveningstandard.co.uk

news.com.au

National | World | Lifestyle | Travel | Entertainment | Technology | Finance | Sport

environment climate change

Urban island heat effect: Rising temperatures in Aussie cities could create death traps

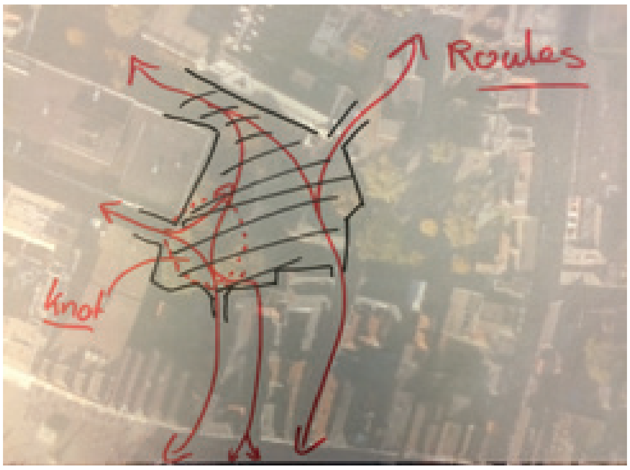
SOME parts of Australia are very hot - unnaturally hot, in fact. They're turning into death traps, and it's our own fault.

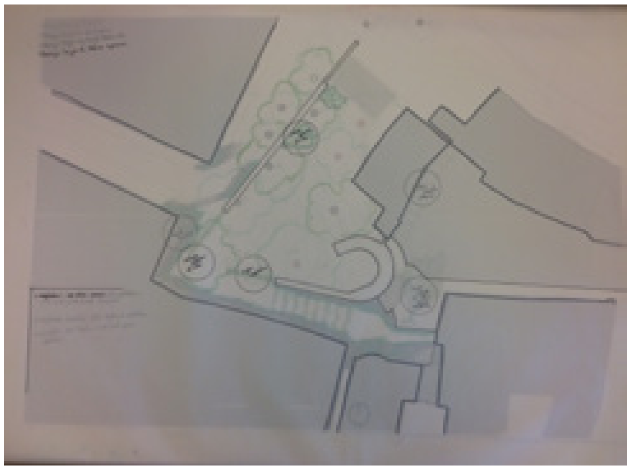
Aerial image of Sydney Harbour including the Sydney Opera House and Harbour Bridge. Picture: Destination NSW

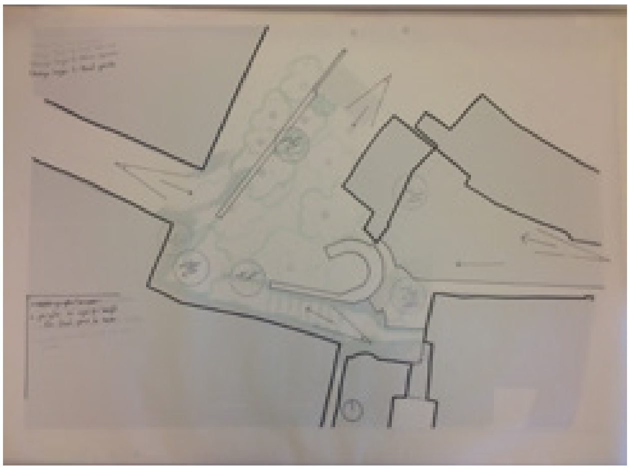
Source: www.news.com.au

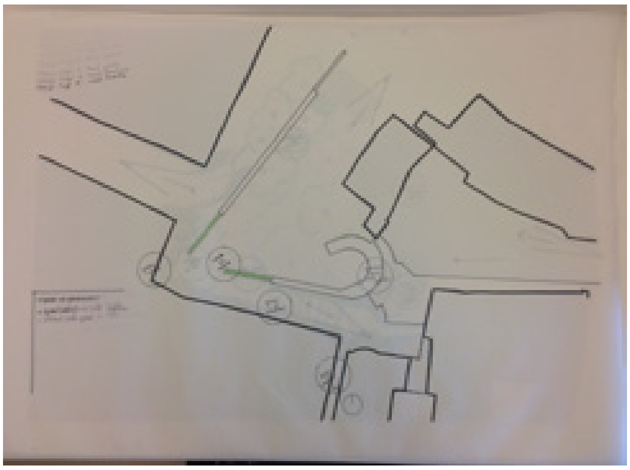
Appendix B

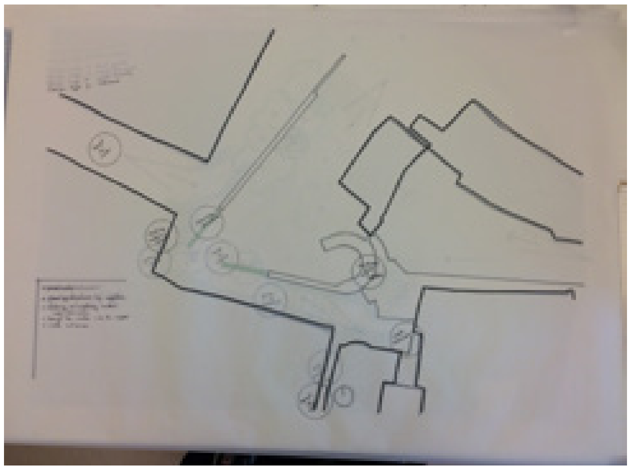
Collection of interim sketches design process

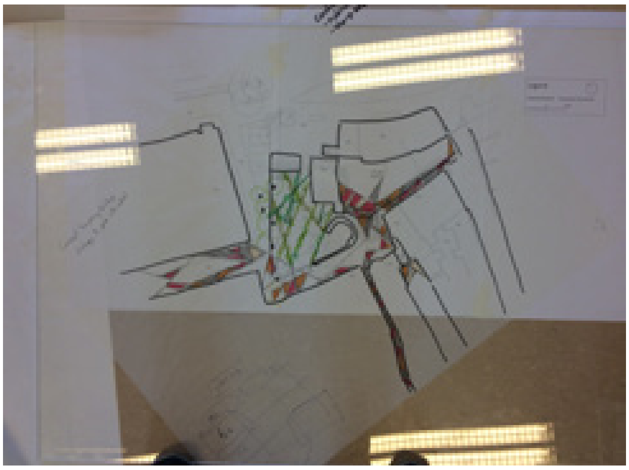


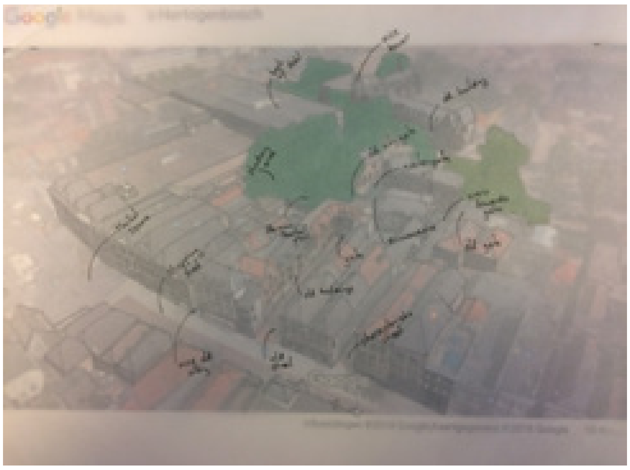






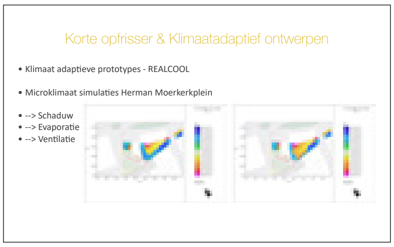


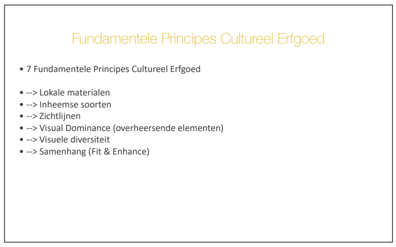


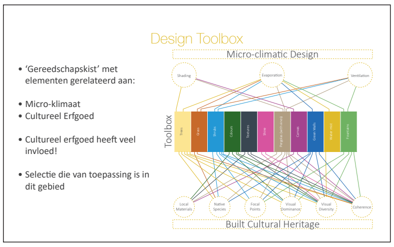


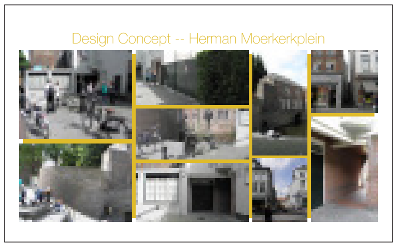
Appendix C

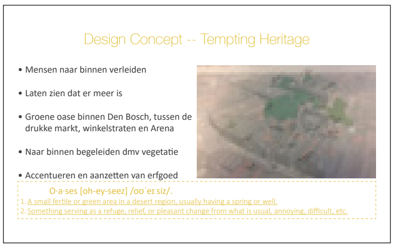
Communication session with experts

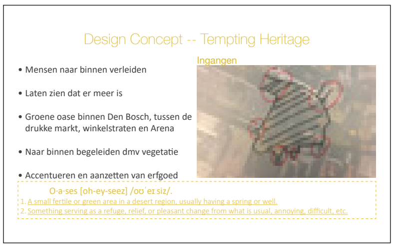


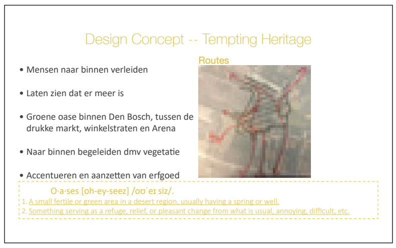


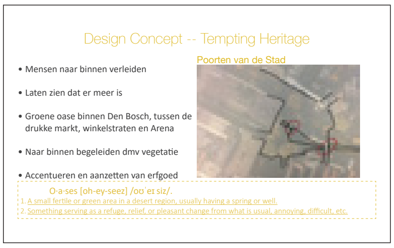


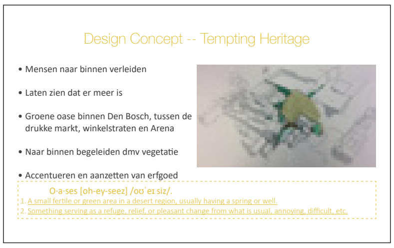


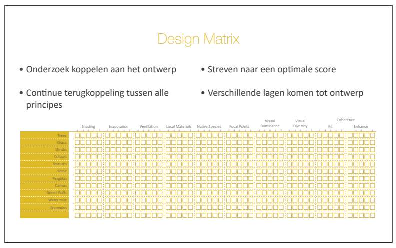


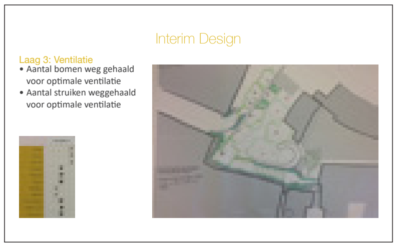


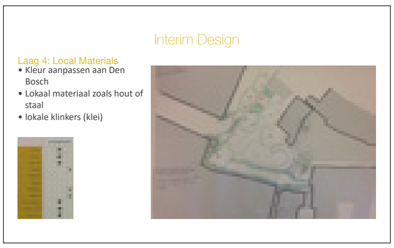


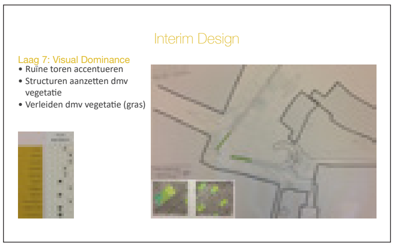


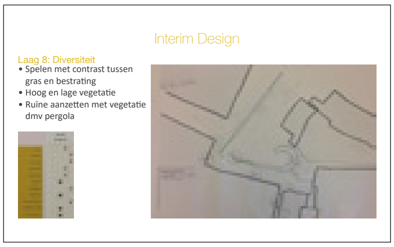


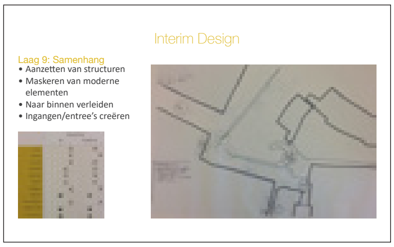


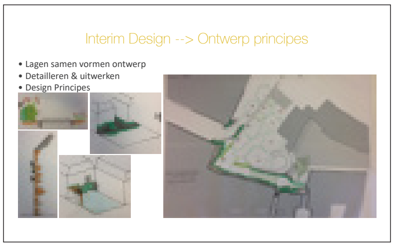





Interim Design
Laag 7: Visual Dominance
• Ruïne toren accentueren
• Structuren aanzetten dmv vegetatie
• Verleiden dmv vegetatie (gras)


Interim Design
Laag 8: Diversiteit
• Spelen met contrast tussen gras en bestrating
• Hoog en lage vegetatie
• Ruïne aanzetten met vegetatie dmv pergola


Interim Design
Laag 9: Samenhang
• Aanzetten van structuren
• Maskeren van moderne elementen
• Naar binnen verleiden
• Ingangen/entree's creëren


Interim Design --> Ontwerp principes
• Lagen samen vormen ontwerp
• Detailleren & uitwerken
• Design Principes


Design Principles
• Ontwerp leidt uiteindelijk tot ontwerp principes
• Overzichtelijk en duidelijk
• Te gebruiken door ontwerpers/ planners/gerelateerde vakgebieden
• Survey
• Dank voor de tijd!

Appendix D

NOS newspaper article

retrieved from www.NOS.nl at 27-11-2018

NOS Nieuws Sport Uitzendingen

Om overlast van extreme buien op te vangen komt in stedelijke gebieden in plaats van bestrating meer groen. En op het platteland en in steden worden meer waterbergingen ontwikkeld waaruit kan worden geput in lange periodes van droogte.

Het Rijk, gemeenten, provincies en waterschappen hebben hierover afspraken gemaakt. De afspraken, die al waren aangekondigd in het regeerakkoord, zijn bedoeld om Nederland weerbaarder te maken tegen de gevolgen van klimaatverandering.

Aan de slag

Minister Van Nieuwenhuizen spreekt van een "echt aan-de-slagakkoord". Volgens haar heeft ook het afgelopen jaar van weer-extremen opnieuw laten zien dat er nu echt extra stappen moeten worden gezet om de leefomgeving anders in te richten.

Het Rijk wil de komende jaren 300 miljoen euro vrijmaken om de afspraken uit te voeren en gemeenten, provincies en waterschappen beloven samen nog eens zo'n bedrag.

Cool Heritage

Freek de Bruijn
Landscape Architecture
Wageningen University & Research
December 2018