Graduation thesis

KEEP YOUR HAGUE COOL

Mitigating heat stress and the urban heat island effect through urban design

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ABSTRACT

This graduation thesis looks at the possibilities of densification in the city without having negative effects on the thermal comfort in the micro climate. During warm periods heat stress arises in the micro climate. Heat stress is the stress on the human body caused by a large heat load. People suffering from heat stress experience discomfort, health problems and in some cases death as the core temperature rises due to more heat being absorbed than given off (McGregor & Vanos, 2018).
Due to the high pressure on the housing market, more space is needed, but in the cities there is a lack of space. This often goes hand in hand with more surfacing, causing more heat stress. Due to climate change, heat stress will become more common and to prevent this, the thesis will address the question:

How to densify in The Hague in order to mitigate and prevent heat stress and the urban heat island effect to improve the livability of the city and the health of its inhabitants?

Through targeted research and analysis of heat stress, densification and the test location The Hague, more insight is gained into the problems and solutions in Moerwijk. By using the Pattern Language the analysis is linked to the design.
In this way the solutions can be transformed into patterns. The results of this thesis is a toolbox of heat patterns and densification patterns that can be applied in different ways and be used flexibly in a city. Also the translation step is made to an implemented design whereby the district Moerwijk is taken as an example. Ultimately, a maximised situation for heat stress and densification is created, which also takes the livability and ecology problems of the neighbourhood into account. The design focuses on different scales from neighbourhood to street level, applying different patterns at each scale.

Keywords: Densification, heat stress, the urban heat island effect, micro climate, The Hague

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Secondly, I would like to thank my fellow students. Because of the COVID-19 pandemic I had forgotten how nice it is to study at the faculty together with other students. It is very nice to learn from each other, and to discuss the subjects. I would especially like to thank Rosemarijne, Zahra and Lotte for the pleasant days at the faculty.

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Jasmijn Hofman

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1.1 GLOSSARY OF TERMS

SUSTAINABILITY
Sustainable development is development that addresses current needs without compromising future needs of future generations or residents around the world (WCED, 1987).

LIVABILITY
Livability is a aspect of sustainability. Livability can be described as the framework of conditions for a reasonable life for all inhabitants of a city. These conditions are about physical and mental well-being. Livability is subjective as it focuses on the experience of the inhabitant (Ramboll, n.d.).

HEAT STRESS
Heat stress is the stress on the human body caused by a large heat load. Little ventilation and a lot of direct sunlight in combination with high tempartures and moisture levels causes this large heat load. People who suffer from heat stress experience discomfort, health problems and in some cases death because the core temperature rises as more heat is absorbed than released (McGregor & Vanos, 2018).

URBAN HEAT ISLAND EFFECT
Urbanized areas experience higher temperatures than outlying areas. This phenomenon is called the heat island effect. Structures such as buildings and paved roads absorb and radiate more heat than natural surfaces. Thus urban areas where these structures are highly concentrated and where greenery is limited will become heat islands. During hot days the temperature will be higher especially at night in these areas than outlying areas (EPA, 2021).

DENSITY
Density is an aspect of urban form. Density can be described by the relationship between a certain area and the number of certain entities in that area. Density can be social or physical. Social densities can be the number of inhabitants per certain area unit and provides information for socio-economic aspects. Physical densities are physical tangible measures per unit area and provide information about ecological aspects. GSI, FSI and OSR help evaluate physical densities (Berghauser Pont & Olsson, 2017).

OSR
Open Space Ratio (OSR) also called the spaciousness provides an indication of the intensity of the use of open spaces in the city and focuses on the non-built areas in a city (Berghauser Pont & Olsson, 2017).

GSI
The Ground Space Index (GSI) is a variable of density and it is the use of the ground level in two dimensions, the length and the width. It is the ratio between the footprint of buildings and the block area. It represents the correlation between built and unbuilt at the ground level. The GSI is always displayed in a range between 0 and 1 (Berghauser Pont & Olsson, 2017).

FSI
The Floor Space Index (FSI) is the intensity of the use of the ground floor. FSI focuses on a third dimension of height, and is the ratio built-up area and the block area. The FSI is displayed in a range between 0 and 1 (Berghauser Pont & Olsson, 2017).

1.2 MOTIVATION

This graduation project finds its roots in years of personal observations of the urban environment. First without any knowledge and critical eye. Later provided with more knowledge and an ever-growing questioning attitude.
During academic training, especially the last months, my appreciation was increasing in wicked problems in the urban environment.
Rittel and Webber (1973) define a wicked problem as a social problem that cannot be solved by using scientific methodology alone. Just like the wicked problem, the solution is unique and not true or false, only good or bad.
The urban heat island effect and heat stress can be framed as wicked problems, because these problems pose a range of economical, societal and healthcare challenges.
The urban heat island effect and heat stress occur mainly in cities. All my life I have lived near cities, and I have a fascination for living in the city later. For this, I want to make the comfort of the city as pleasant as possible.
I experience discomfort from heat in the summer, but my 86-year-old grandmother suffers much more from heat stress. On days when people go out to enjoy the warm weather, she sits inside to keep it bearable.
This gradutation thesis provides an opportunity to address the wicked problem of thermal comfort and densification, while at the same time enjoying the support of a consolidated research group and the resources an institute like the TU Delft and the Municipality of The Hague can provide.

1.3 PROBLEM FIELD

1.3.1 INTRODUCTION TO THE HAGUE

The Hague is a city on the North Sea, it is the third largest city in the Netherlands and part of the Randstad area. Recent research has shown that more people have moved to regions outside the Randstad during the Covid-19 pandemic than to the Randstad. It is assumed that during the impact of the pandemic, inhabitants will need space and it is expected that working from home will become more common so that people can live further from work (CBS, 2021a).

Fig. 1 The location of the city of The Hague.
Source: Edited by author (Google, 2021).

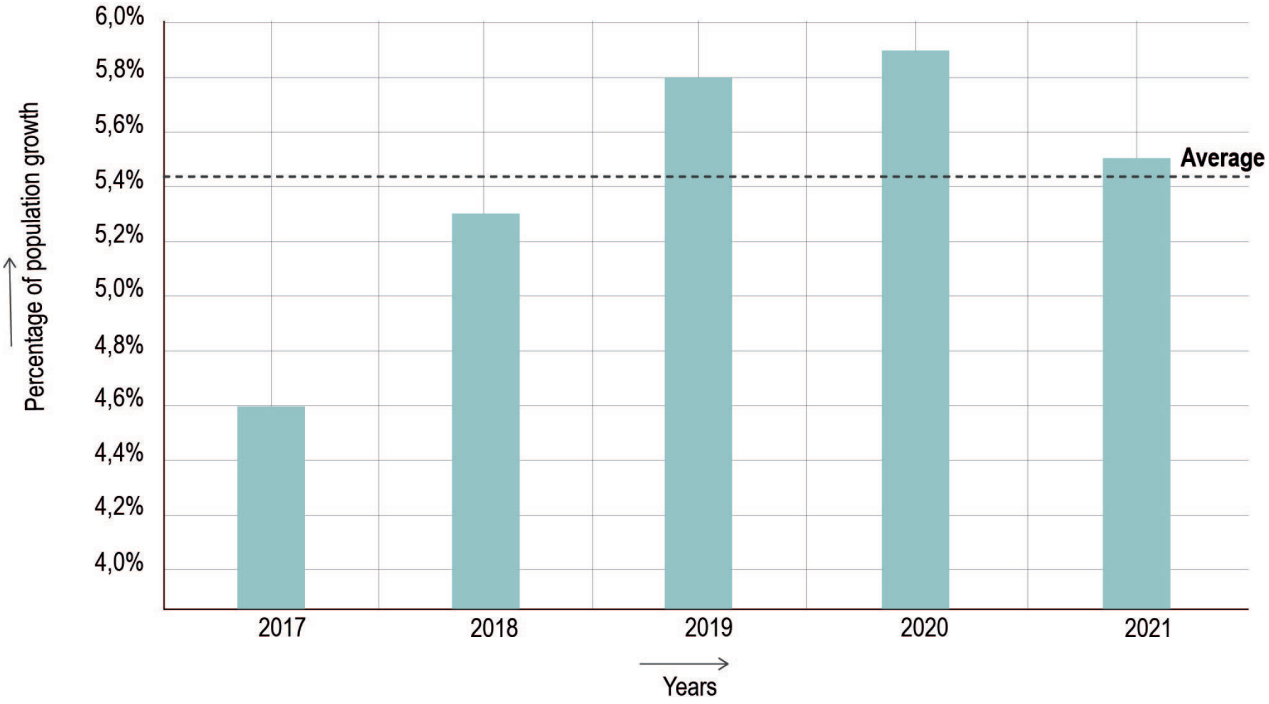


Fig. 2 Population growth of the past 5 years in The Hague.
Source: Reproduced by author (Gemeente Den haag, 2021b).

Interestingly, the population of The Hague is not decreasing but increasing. When the pandemic started, the population of The Hague grew above average (fig. 2). The city had 520,697 inhabitants in 2016 and in the past 5 years this number has grown by 5.5% leading to 549,163 inhabitants in 2021 (fig. 3). The population will continue to grow in the future. It is expected that in 2030 601,072 inhabitants will live in The Hague (Gemeente Den Haag, 2021a).

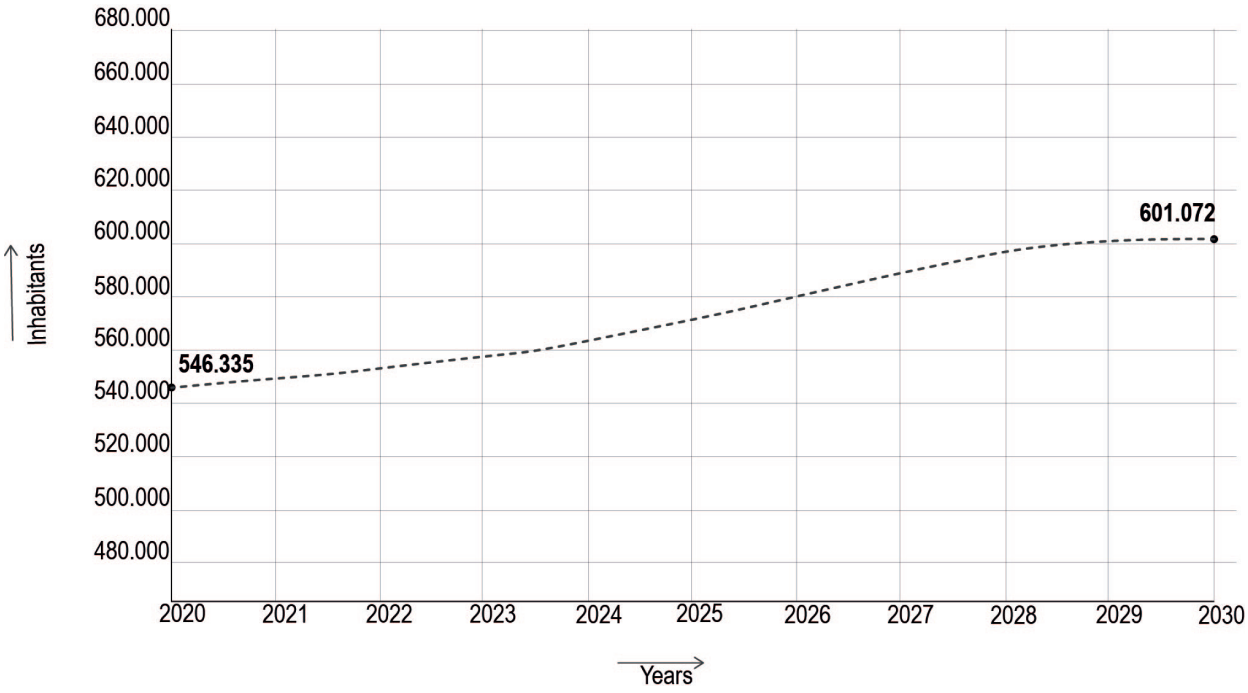


Fig. 3 Expected development of residents of The Hague.
Source: Reproduced by author (Gemeente Den haag, 2021d).

For this reason, The Hague will have to build more houses. Lack of space is the problem in the urban environment. This is stagnating the construction of new homes (Kasteleijn & Nieuwenhuijzen, 1994).

1.3.2 INTRODUCTION SUSTAINABILITY AND LIVABILITY

Liveability is based on a principle of sustainability (Ramboll, n.d.). In other words, an environment cannot be sustainable without being livable. There is an interdependence between livability and sustainability.
The urban literature is full of references to the terms “sustainability” and “liveability”. These terms have a positive connotation and are often associated with a good urban plan. A sustainable and liveable environment is always desirable regardless of the context.
Since sustainable and livable are terms that are desirable, these terms are also used in projects that are not truly sustainable or livable. For this reason, it is useful to explain the terms through the existing literature.
The most commonly used definition of sustainability is from the World Commission on Environment and Development provided in 1987. A sustainable development is “A development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987). This definition emphasizes the balance between a self-centered attitude and the common good. This view requires an understanding that actions by one individual will have an effect on future generations and other people around the world.
Because sustainability works on a small and large scale, sustainability in the Netherlands is measured on different scales by three aspects (CBS, 2016).

1. The current quality of life.
2. The chances of the future generation to achieve the welfare goals.
3. The influence that the dutch pursuit of prosperity has on the prosperity of the rest of the world.

So sustainability focuses on the present and the future while livability focuses mostly on the “here” and “now”. Focused on tangible and immediate interventions and conditions on a local scale (Ruth and Franklin 2013), the definition of livability can be described as the frame for conditions for a decent life for all inhabitants in a region, city or neighbourhood. These conditions are about physical and mental well-being (Ramboll, n.d.). So livability focuses on the interpretation of the user. This is personal and difficult to measure.

In the Netherlands, liveability is measured by the Leefbaarometer. This meter uses five dimensions:

1. Housing
2. Residents
3. Facilities
4. Safety
5. Physical environment

These dimensions do not all count equally in the total liveability score (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, n.d.).

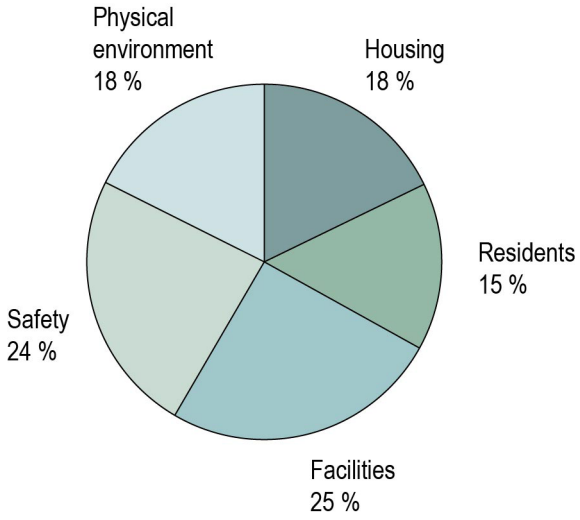


Fig 4 The different dimensions that measure livability in the Netherlands and their proportions.
Source: Reproduced by author (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, n.d.-a)

It is possible to set common goals for a livabilty policy. Due to the difference in focus between livability goals and sustainability goals, the two terms can collide with each other. The needs of the present generation for a liveable neighbourhood may not be the needs of the future generation. So urban plans that are currently livable may not be livable or sustainable in the future.
In the end, to evaluate an area on the basis of liveability and sustainability, it is much more important to use the indicators for sustainability and liveability. These indicators are much more concrete and clear for measuring livability and sustainability than the terms themselves.

1.3.3 INTRODUCTION THERMISCH COMFORT AND DENSIFICATION

The population of The Hague is growing every year, and it is expected that the current number of inhabitants will increase. As a result, more homes will have to be built, and neighbourhoods will have to be adapted. Due to the growing recognition of sustainability and liveability, the microclimate of the city will have to be taken into account. One of the aspects in the micro climate is the thermal comfort and especially the degree of heat stress in the cities.

Thermal comfort is not a simple concept as it depends on a person's ability to adapt to their environment. The definition of thermal comfort is a state of mind that indicates satisfaction with the thermal environment (Kurvers et al., 2012).

However, there are situations where thermal comfort is considered to be very unsatisfactory. If the temperatures are too high, this causes a person to feel stressed. This is also known as heat stress.

The extent of a negative or a positive effect on thermal comfort depends on the density applied in the area. The meaning of density is the degree of mutual proximity (van Dale, n.d.). Densification is increasing this mutual proximity. Urban densification involves building on undeveloped spaces within the existing built-up area, or building at higher densities in order to make more intensive use of the existing space. Densification changes the environment by making efficient use of space, this changes variables such as percentage of pavement, vegetation and shade. These variables in the environment have an impact on the temperature. This tests the person's ability to adapt to the environment.

1.4 SOCIETAL RELEVANCE

All over the world, attention is currently being paid to heat stress and the urban heat island effect (fig. 5). Worldwide, more than 5 million people die every year from extreme cold and hot conditions. In the past 20 years, more people have died from cold weather conditions, but climate change is shifting the balance (Lu & Cox, 2021). The temperature in the Netherlands has increased by an average of 1.1°C over the past 30 years. This is twice the increase of the global average. The weather extremes have mainly changed with a decrease in ice days from 10 to 6 days per year, and an increase in tropical days from 2 to 5 days per year (KNMI, 2021a). This results in a higher chance of heat waves, warmer summers and winters. If residents are exposed to this heat they may experience heat stress leading to sweating, headaches, nausea, dehydration and muscle cramps.
The urban heat island effect causes that many inhabitants often suffer from insomnia as warm days lead to extremely warm nights. This causes a bad mood, fatigue, reduced resistance, concentration problems and reduced performance. Extreme heat can even be deadly (Atlas Leefomgeving, n.d.).
During a heat wave in 2019, there were 400 extra deaths from heat stress. Often these are inhabitants over 75 years old, since the elderly have a less effective cooling mechanism and dry out faster. Babies, children, chronically ill people and people who work outside a lot are in the risk target group (Atlas Leefomgeving, n.d. -b). Many people can suffer from heat and this can have major health consequences and it is therefore important to prevent heat stress and the urban heat island effect as much as possible.

Fig. 5 Newspaper headlines about extreme heat stress.
Source: 1. (Lu & Cox, 2021), 2. (Hart, 2021), 3. (van Dijk, 2018), 4. (Thompson, 2021)

1.5 SCIENTIFIC RELEVANCE

As mentioned earlier, the heat stress problem and urban heat island effect has received much attention in papers and urban theory. The necessity of the problem is clear. However, there is a large knowledge gap. Many municipalities know where heat stress and the urban heat island effect come from. Maps have been modelled with the current situation of heat stress and the urban heat island effect. Municipalities are devising general measures to reduce this current heat stress problem and the urban heat island effect (van Tongeren et al., 2021). These measures are not detailed, not translated into an urban design and not a preventive approach for the heat stress problem and the urban heat island effect.

Preventive research has not yet been done, and the relationship between thermal comfort and densification has also not been investigated much. By conducting research into densification that tackles the heat stress problem preventively, the general measures of the municipality are not necessary.
This graduation project can contribute to a preventive approach to improve the thermal comfort by using densification. There will be a direct link between urban planning, densification, heat stress and the urban heat island effect creating new possibilities for public spaces.

The growing number of residents and the current status of The Hague make it one of the largest cities in the Netherlands. This creates many complex situations in which many problems and opportunities converge. These problems and opportunities are further explained in this thesis.

Fig 6 Aerial view of the city center of the Hague
Source: (van Middelkoop, 2016)

2. THE PROBLEM

PROBLEM STATEMENT

RESEARCH AIM

RESEARCH QUESTIONS

THEORETICAL FRAMEWORK

RESEARCH APPROACH AND RELATED METHODS

INTENDED OUTCOME

2.1 THE PROBLEM STATEMENT

Much attention has already been paid to heat stress. Maps are being developed to provide a better picture of heat islands. Toolboxes are being developed to reduce the negative effects of heat stress as much as possible. Municipalities are currently lagging behind and trying to solve the consequences of heat stress with new measures.

Heat stress and the urban heat island effect is a problem that is underestimated, and in the future we will have to deal with longer periods of drought and heat. This will increase heat stress and lead to health problems as insomnia, nausea, dehydration, and mortality. Another physical consequence is low productivity. This has a major long-term economic impact (Atlas of the Living Environment, n.d.).

Just like surrounding cities, The Hague suffers from heat stress and the urban heat island effect. At certain times of the year and certain parts of the day, it can be significantly warmer in the city than in its rural or natural environment. This difference can be up to 10 degrees (van der Hoeven & Wandl, 2018).

The growing number of residents means that more houses need to be built in The Hague. For this reason, densification is required. Without measures, this will increase the current level of heat stress, as well as its major negative consequences. It is therefore important that the extreme heat problem is tackled properly for the health of the residents and the quality of the city.

2.2 RESEARCH AIM

As mentioned in the problem statement, heat stress and the urban heat island effect are underestimated problems, which can have major consequences for the quality of the city and the health of its residents. It is not only The Hague that suffers from these problems of lack of space and extreme heat. Other cities in the Netherlands also suffer from these problems. These are mainly cities in the Randstad.
The aim is therefore to develop a method to densify in an efficient way to prevent heat stress and the urban heat island effect from getting worse and possibly reducing it. This will be done by using a theory and design approach in which theory is applied through design. The connection between the densification, heat stress and the urban heat island effect will be examined through the lens of existing knowledge found in literature on this environmental issue. The possibilities are explored for spatial interventions that improve the balance between densification heat stress and the urban heat island effect.
In particular thermal comfort that focuses on the outside environment and inside of buildings will form the theoretical framework for densification strategies. The implementation of interventions for the mitigation of the heat stress and the urban heat island effect can become an important guideline for the urban environment of many cities. The possibilities of this approach in the specific context of The Hague will be explored through design and research. Aiming for a future in which the quality of the cities and the health of its inhabitants improves.

2.3 RESEARCH QUESTIONS

MAIN RESEARCH QUESTION

How to densify in The Hague in order to mitigate and prevent heat stress and the urban heat island effect to improve the livability of the city and the health of its inhabitants?

SUB-RESEARCH QUESTIONS

CONCEPTUAL BACKGROUND

1. How can densification provide an opportunity for the integration of a better living environment?

2. What is the relation between heat stress and the urban heat island effect?

ANALYSIS

3. In what way is the heat stress and the urban heat island effect manifesting in The Hague?

4. What is a physical density typology in The Hague?

5. In what way is the heat stress and urban heat island effect affected by different morphologies and densities?

6. In which locations are people most affected from heat stress and the urban heat island effect?

7. Which stakeholders are most important in the densification process, and how can their interests and needs be met?

DESIGN

8. Which spatial interventions against heat stress and the urban heat island effect can be applied in a densified The Hague?

9. To what extent are the interventions in a typical neighbourhood in The Hague transferable to other cities?

2.4 THEORETICAL FRAMEWORK

There is currently a knowledge gap between preventing and mitigating heat stress and the urban heat island effect. The theoretical framework will further explain terms, correlations and applications to reduce this knowledge gap. The theoretical framework adresses 2 different topics “Density” and “Thermal comfort”, and eventually the relation between these two different topics.

DENSITY AND PUBLIC SPACE

Analysis of the different forms of density, parameters and variables. Further explanation about the relationship between density and public space and the experience of public space. This relationship also has an effect on the experience of public space and the quality of life.

DENSITY AND THERMAL COMFORT

There is a strong relationship between density and thermal comfort. The satisfaction of thermal comfort and degree of heat stress depends on density. Density affects indicators of heat stress negatively or positively.

HEAT STRESS AND URBAN HEAT ISLAND EFFECT

A definition of the terms “heat stress” and “the urban heat island effect”. Explanation of the independence between the two terms, and their relationship to heat waves. The current situation of the urban heat island effect in the Netherlands and its cities.

There are many different forms for density. Currently it is possible to recognize the different forms of density in cities all over the world. From the urban sprawl of American areas to the high-density cities in Asia. Figure 7 shows that the same number of dwellings with different methods of densification gives a different layout. There is no such thing as good or bad density as each type of density has its own pros and cons depending on which aspect is being assessed.
The compact city is a counter-movement to the urban sprawl. In the Netherlands we will increasingly see compact cities as the decision-makers do not choose for the urban sprawl. The Compact city is a city with high-density housing, mixed use, based on well-functioning public transport and promotion of slow traffic such as walking and cycling (Williams et al., 2016). The compact city also has negative effects due to the high density, such as low quality of life. The strategy of a compact city consists of economic, social, and ecological goals. However, it has become apparent that economic goals are currently central to urban planning, which often hinders livability (Hofstad, 2012).
Another aspect that jeopardizes liveability is the lack of green spaces in the compact city. Due to the densification, the public space has to be designed more efficiently, which is often at the expense of the green areas. This has ecological consequences such as the reduction of biodiversity, a lack of coherent greenery and ecosystem services (Haaland & van den Bosch, 2015). During the COVID-19 crisis, it has become clear that urban nature is extremely important for resilience in the short and long term. Urban greenery improves people's mental and physical health, social interaction and interaction with nature in the city (Samuelsson et al., 2020).
Other findings suggest that residents' dissatisfaction with livability is often not due to high density, but is related to other factors such as environmental quality, noise pollution, lack of community involvement, lack of facilities, and traffic (Howley et al., 2009).
It turns out that people can be dissatisfied with traffic. Research has shown that densification means that a lot of public space is filled by traffic facilities and this leads to high traffic concentrations that have a negative effect on environmental conditions (Melia et al., 2011).
In order to measure a city for density, a distinction has to be made between social and physical densities. When it comes to density, reference is often made to the number of inhabitants or homes per surface unit. These are social densities as it says little about physical space. Nevertheless, social densities are relevant for social economic aspects such as livability.
Physical densities are physical tangible measures such as floor area ratio and ground coverage. The variables GSI and FSI are used for this density. GSI (Ground Space Index) is the use of ground surfaces in two dimensions. The FSI (Floor Space Index) is the intensity of the use of the ground floor by stacking floor space in the third dimension, height. The third variable is the average height and the fourth variable is the OSR (Open Space Ratio). The OSR provides an indication for the intensity of use of the open space (Berghauser Pont & Olsson, 2017).This density provides more information about the quality of the urban form and connections can be made with ecological aspects such as sustainability and thermal comfort.

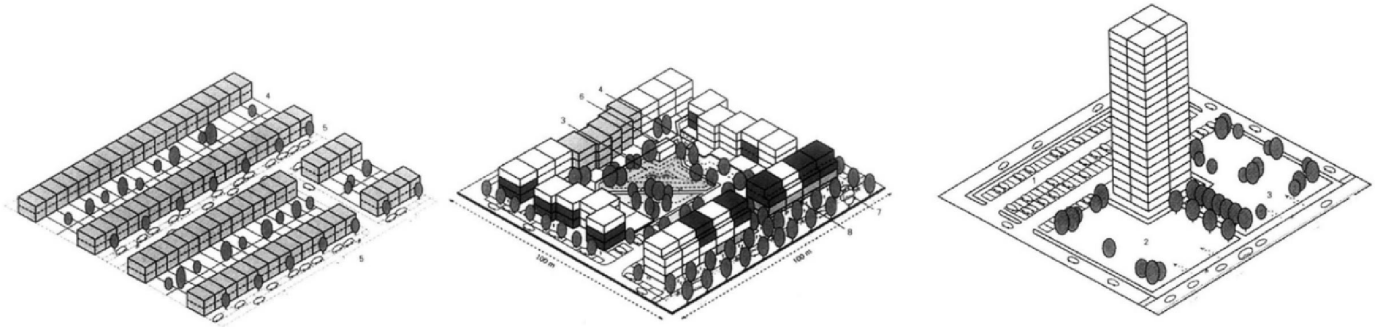


Fig. 7 Three variants of 75 homes per hectare with a different density, which results in different GSI, FSI, OSR. These different variables create different types of public spaces and building forms, which gives a different relationship between inside and outside.
Source: Fernández Per and Mozas, 2004: 206-207

There is a correlation between the urban heat island effect and physical density. The urban heat island effect increases as the GSI and FSI increases. A large GSI and FSI therefore has a negative effect on the urban heat island effect. The OSR has a positive effect on the urban heat island effect. When the OSR increases, the urban heat island effect decreases (van Milgen, 2016).
There is also a relationship between the experience of public space and the density. For this reason, it is important to look at the physical and social densities for evaluating a city. Social density looks at the people who experience the public space, while physical density looks at the perceivable public space (Berghauser Pont & Olsson, 2017).
By ensuring that the GSI remains low during densification, space is created for public space. In this way there is room to improve the livability and sustainability.

However, this does not ensure that the livability improves as this depends on several factors such as environmental quality, noise pollution, lack of community involvement, lack of facilities and traffic.
Space for sustainability does not ensure a sustainable space. This depends on the viability of the space, which must also comply with the factors mentioned earlier. It also depends on the opportunities that are offered to achieve the welfare requirements of the future generation (CBS, 2016).
According to some authors, a sustainable city is an elusive goal. The process is more important than the form to achieve a sustainable city (Neuman, 2005).

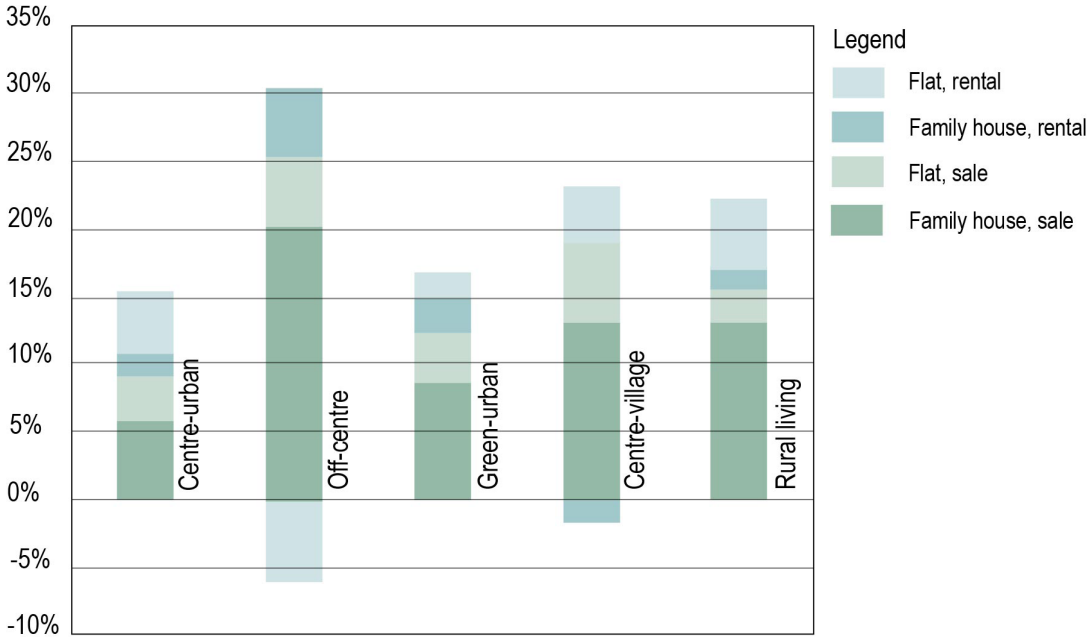


Fig 8 A diagram showing the demand for desired housing and ownership in different residential environments.
Source: Reproduced by author (de Zeeuw & Keers, 2020).

More and more compact cities are being realised in the Netherlands. Due to the lack of space in the cities, the buildings are being built higher and higher. Because of this, mainly flats are built (Williams et al., 2016). However shown in figure 8, the new building demand in 2018 requires other types of housing. Demand for housing depends on living environment. The focus here is on enabling residents to move on to a home that better suits their needs. By focusing on the wishes of the residents, they will move on to a desired dwelling, whereby a dwelling becomes available for another household. With one newly built home, two households will benefit. This effect is not achieved with the fixation on flats, because the demand is highest for family houses. Furthermore, the willingness to pay is lower for stacked houses than for single-family dwellings. This can be explained by the fact that people with a lower income live in a flat due to affordability and not first preference. Since the cost of a flat is on average 25% lower than a single-family house (de Zeeuw & Keers, 2020).

After analysing the first topic “Density and public space”, we will focus on the second topic “Heat stress and urban heat island effect”.

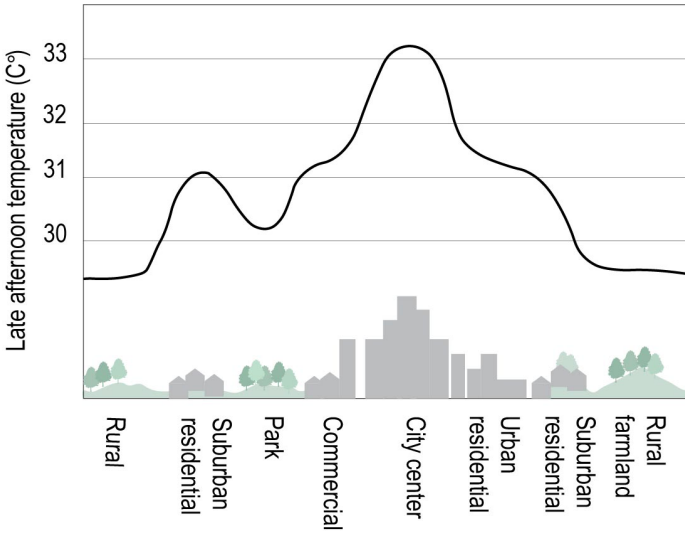


Fig 9 A diagram of the urban heat island Effect in different urban environments.
Source: Reproduced by author (Giguère, 2009).

“Heat stress” and “the urban heat island effect” are terms that are often used in urban planning literature. However there is a certain confusion between these two terms, which in some cases are used interchangeably. In order to solve this misconception, it can be useful to bring some references to these two terms from existing literature.

The urban heat island effect is the phenomenon that the temperature is higher in the cities than in the rural areas. This difference is especially greater at night as materials in the city store heat and release it at night. This hinders the natural cooling mechanism of the air (Oke, 1982).

Illustration 9 shows that density and vegetation have a strong effect on the urban heat island effect. Areas with little vegetation and a high density, such as the city, can become much warmer than rural areas with a lot of greening and a low density.

The urban heat island effect combined with climate change creates a heat wave risk. In the future, climate change will be more and more present, which will increase the heat wave risk (Lemonsu et al., 2015).

In the Netherlands, a heat wave is a series of five summer days (higher than 25 °C), three days of which must be tropical (higher than 30 °C) (KNMI, 2021b).

As shown in figure 10, heat waves are increasingly common in the summer. Another finding is that there are more tropical days in the last few heat waves. This increases the risk of heat stress.

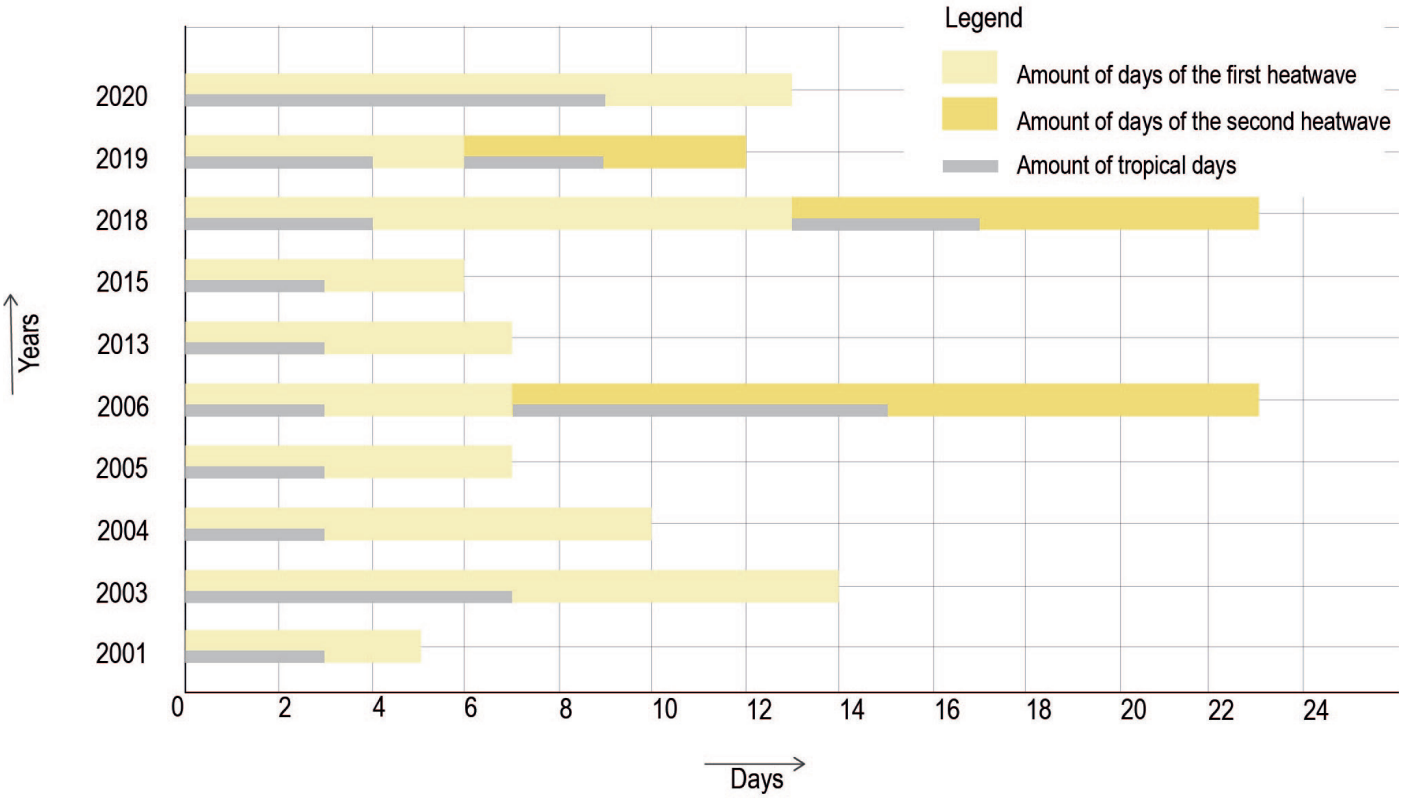


Fig 10 The heat waves in the 21st waves with their duration, and number of tropical day.
Source: Reproduced by author (KNMI, 2021b).

PET (°C)	RELEVANCE	PHYSIOLOGICAL STRESS LEVEL
18 - 23	Comfortable	No heat stress
23 - 29	Slightly warm	Mild heat stress
29 - 35	Warm	Moderate heat stress
35 - 41	Hot	Major heat stress
> 41	Extremely hot	Extreme heat stress

Fig 11 PET index with linked relevance, and measures of heat stress.
Source: Reproduced by author (Klimaateffectatlas, n.d.-a).

Heat stress is the stress on the human body due to a large heat load caused by high temperatures and moisture levels in combination with little ventilation and a lot of direct sunlight McGregor & Vanos, 2018).
As heat stress increases, the human mechanism will be compromised as the body then gains more heat than it dissipates. This will cause the internal core temperature of the human body to rise causing discomfort, health problems and in some cases death (Havenith & Fiala, 2015).

The degree of discomfort is estimated by means of a PET index. There are several heat stress indicators, but the PET index is used in the Netherlands. PET means Physiological Equivalent Temperature and is used to determine the degree of heat stress In the Netherlands, people experience a PET of between 18 and 23 as comfortable. Lower temperatures are experienced as cold. At higher temperatures, people experience it as warm and heat stress arises (fig. 11) (Klimaateffectatlas, n.d.).

HEAT STRESS INDICATOR	RELEVANCE
Urban heat island effect	Controlling temperature effect in the built environment
Heat risk	Objectification of the temperature effects
Number of warm nights (current and future)	Scale on which heat stress occurs at night
Number of tropical days (current and future)	Frequency of heat waves (current and future)
Wind chill (PET)	Indication of thermal comfort and livability
Shadow (vegetation)	Locations to look for and avoid

Fig 12 Different indicators for heat stress that are relevant for multiple target groups that may suffer from health risks caused by heat stress.
Source: Reproduced by author (Royal HaskoningDHV, n.d.).

As shown in figure 12, one of the indicators of heat stress is the urban heat island effect. The urban heat island effect is a possible cause of heat stress and are therefore independently linked.However there is a difference between the two terms. Heat stress focuses on the body and the effect is noticable outside during the day and inside during the day and at night. The urban heat island effect focuses on the storage of the materials and has an effect on the air temperature.This phenomenon is more present at night.

In the Netherlands, the urban heat island is strongest in the cities (fig. 13). This will be because the cities have the highest density of buildings with a lot of hard surfacing. The Randstad suffers most from the urban heat island effect, because the largest cities are located here.
The Hague is also one of the cities that suffers greatly from the urban heat stress problem, proven by a study by TNO has shown that during the day, The Hague suffers most from the surface heat island effect. In the center of The Hague it is on average 8.6 °C warmer than in rural areas. This can rise to a maximum of 15.4 °C. This may be due to the paved surfaces and the sand surfaces of the dunes, which can reach high temperatures during the day (Klok et al., 2021).
Wind also affects the thermal comfort in the city. The influence of wind on heat stress is significantly less than that of vegetation and shade, but it can still have a cooling effect on a hot day. The most common wind direction is south-west. This is mainly in winter and autumn. During these seasons the wind is also much more present than in the summer and spring months. This is mainly because in the summer months the temperature difference between the equator and the North Pole is less. In the summer months, there is more often a northerly wind that brings colder air, which is desirable during hot days (Janssen, 2021). But heat stress is most common during heat waves These are caused by southerly winds that blow over the warm countries in the south. This wind direction provides the most cooling during a heat wave (Wageningen University & research, 2019).

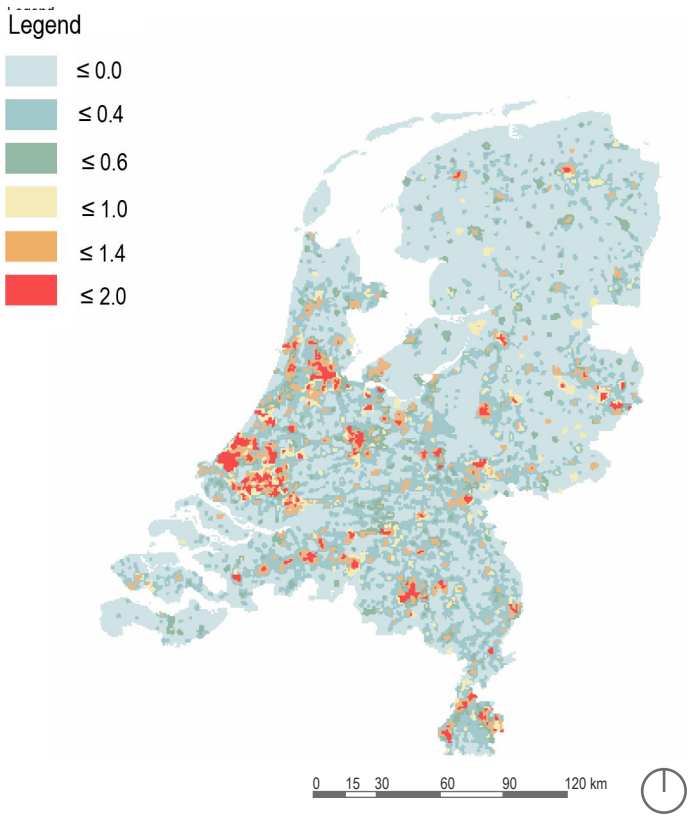


Fig 13 The urban heat island effect in the Netherlands.
Source: Reproduced by author (Esri Nederland, 2021a)

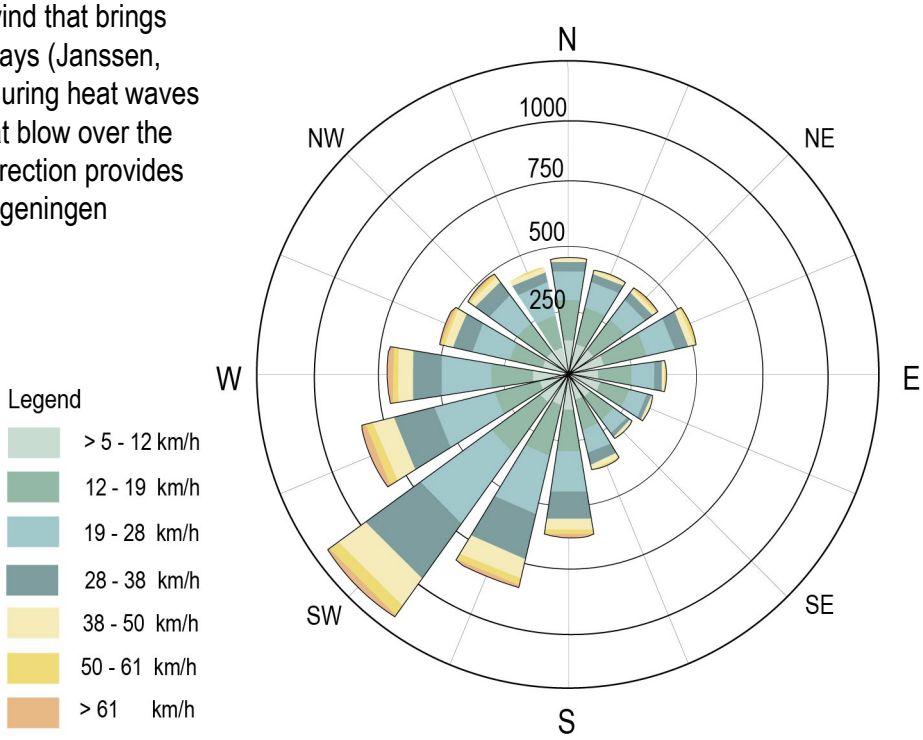


Fig 14 Wind rose of The Hague.
Source: Reproduced by author (Windfinder.com, 2018).

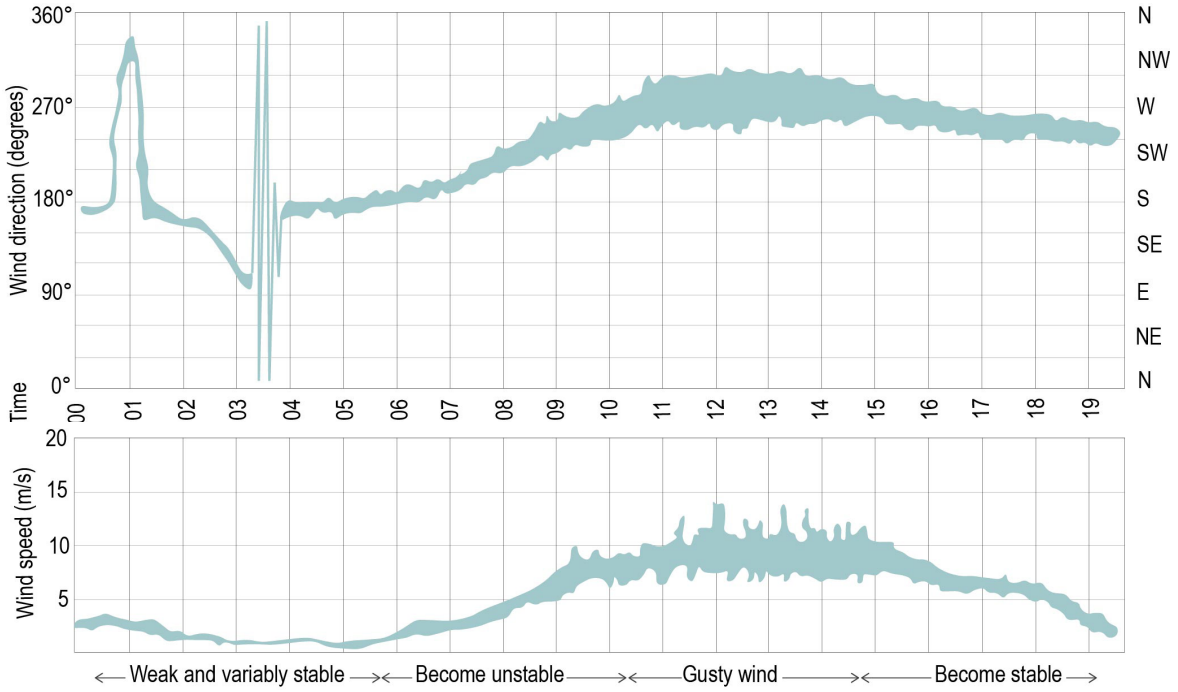


Fig 15 Wind direction and strength of the wind during an average day.
Source: Reproduced by author (Meteo-Julianadorp, n.d.).

Wind can be very cooling and reduce the wind chill. On an ordinary day, the direction and strength of the wind change. At dawn, the earth's surface is still cold and air bubbles can form that warm up and rise. This causes the wind to become more turbulent and the wind speed to increase gradually. In the afternoon, the sun is at its highest and the wind is also at its strongest. Later in the afternoon, the friction increases again and the wind speed gradually decreases due to the warmed-up earth's surface. As a result, heat stress is more prevalent again (Meteo-Julianadorp, n.d.)

It is important to know who suffers most from the extreme heat. Figure 16 shows that people over 80 are particularly at risk of overheating. This is probably because at an older age the human mechanism for regulating temperature is less flexible. As a result, elderly people are more likely to experience discomfort, and possible serious consequences such as death.

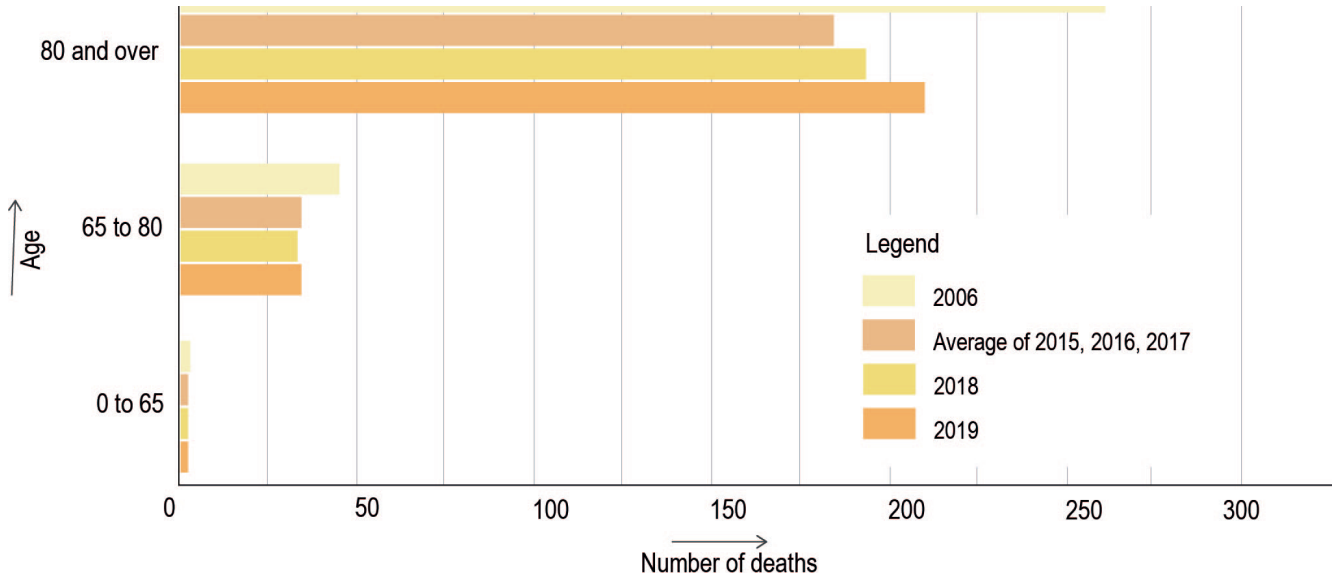


Fig 16 Deaths due to extreme heat in the various age categories (deaths per thousand inhabitants per week).
Source: Reproduced by author (CBS, 2019).

DENSITY AND THERMAL COMFORT

As can be seen in the previous topics, the topic of heat stress, the urban heat island effect and densification are often discussed in the literature. Densification is linked to many social and physical elements in terms of liveability and sustainability. Heat stress and urban heat island effect arise from many different variables. Densification also affects these variables causing heat stress. As a result, there is a strong relationship between heat stress and densification.
The study by Jae-Ik Kim et al. has found that areas with a high density have a lower land surface temperature (LST). This study says higher buildings are preferred by residents with a higher income. In practice, this is not always the case, but often high-rise buildings are provided with facilities and combined with greenery. Vegetation is one of the variables that has a postive effect on the thermal comfort and will lower the LST. High rise can therefore contribute to reducing heat stress and the urban heat island effect (Kim et al., 2019). Not only is vegetation important for thermal comfort. Existing greenery is often more developed and has a greater impact on heat stress. To improve thermal comfort on hot summer days, it is important that this existing greenery, especially large trees, is preserved during the redevelopment, as this has a big impact on the physical equivalent temperature (PET). The construction of parking facilities and other buildings results in the decrease of these existing trees. New strategies will have to be formulated to reduce the need for above and below ground parking facilities as this has a negative effect on the temperature (Erlwein & Pauleit, 2021).
Another indicator of heat stress is shadow. The vertical densification ensures that the total amount of incoming direct radiation from the sun is reduced. Likewise, the number of sunlight hours available at street level is reduced leading to more thermally comfortable urban environments during heat waves. As there is less direct sunlight on the house facade, this can become a problem in the winter. The house will remain colder and darker in the winter, so people will turn on the heating and light more quickly. Resulting in a negative effect of higher energy consumption. A positive effect is that the surfaces of the buildings will absorb and store less energy during the day due to the increased amount of shade (Loibl et al., 2019).
The heat risk is also an indicator for heat stress, but is not only related to heat stress and urban heat islands. The heat risk also depends on exposure to heat of population. By increasing the physical density of the buildings, the social density will also be increased. Areas with a high density of inhabitants are likely to experience the most severe impact of the thermal comfort. This increases the general vulnerability of the population (Lemonsu et al., 2015).
The relationship between densification and thermal comfort is strong. Density changes indicators that are positive or negative for thermal comfort. The literature shows a preference for high-rise buildings when it comes to thermal comfort. High-rise buildings lower the GSI, creating more room for other indicators such as vegation that have a positive effect on thermal comfort. Also, the shaded areas are increased which lowers the surface temperatures (van Milgen, 2016).

2.5 RESEARCH APPROACH AND RELATED METHODS

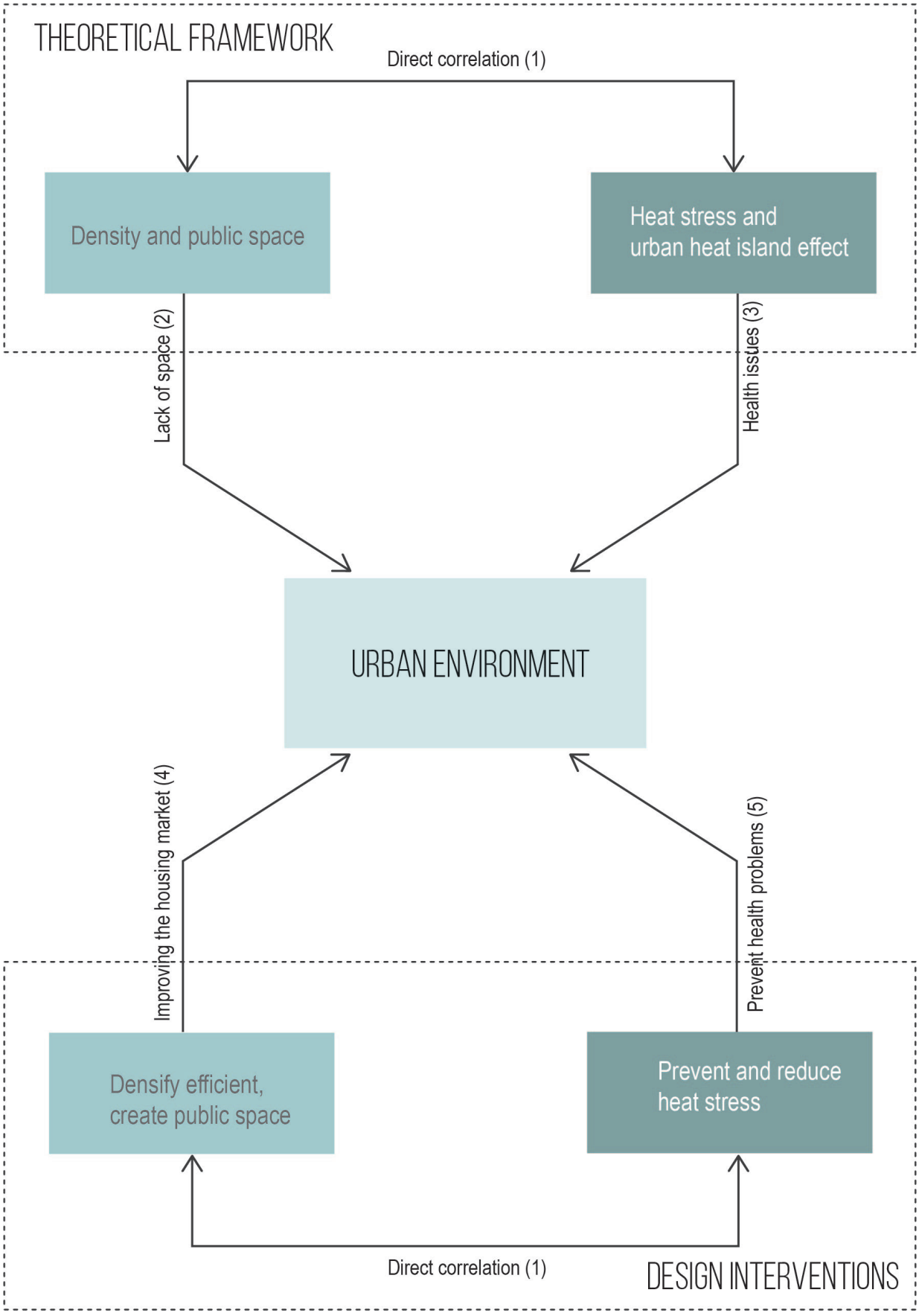


Fig 17 Conceptual framework
Source: Produced by author

2.5.1 CONCEPTUAL FRAMEWORK

The conceptual framework shows the relationship between the theoretical framework, the urban context and the design interventions.
The theoretical framework consists of two different terms “Density and public space” and “Heat stress and urban heat island effect” (fig. 17). These two terms are related to each other.

(1) Direct Correlation - Different densities have different consequences with regard to the heat stress and urban heat island effect. Currently, public spaces are seen as the solution locations for heat stress. As buildings, infrastructure and facilities are added, the limited public spaces become small.
(2) Lack of space - Today’s cities experience a lack of space in the urban environement. The many layers of the urban structure ensure that there is little space for further development and densification.
(3) Health issues - The urban heat island effect that occurs in urban environments causes heat stress. This can have a negative effect on the thermal comfort of indoor and outdoor spaces in the urban environment.

In the extension of the theoretical framework are the design interventions (fig. 17). The design interventions consist of two goal: The first goals is “Densify efficiently”, because The Hague is on the rise in terms of population, more
houses will have to be built. Because there is limited space the densification is often at the expense of public space, resulting in smaller public areas and less greenery, which increases heat stress. As a result, vulnerable target groups might avoid public spaces during warm periods. Since these target groups experience health effects from heat stress, for example, sweating, headaches, nausea, dehydration and muscle cramps. The last goal is “Prevent and reduce heat stress”. These 2 goals have the same relationship to each other as the 2 terms in the theoretical framework.
The relationship with the urban context is different, however. This is because the theoretical framework explains the problems and the design interventions seek solutions to them in order to improve the urban context.

(4) Improving the housing market - The lack of space requires efficient densification to relieve pressure on the housing market, and to create space for each target group inside the house and outside in the public space.
(5) Prevent heat issues - Extreme heat stress occurs in the urban environment during heat waves, which can lead to serious health problems. Mitigating and preventing heat stress can also alleviate these health problems.

2.5.2 METHODS

The research framework provides a short impression of the research and design process of this thesis (fig. 18). There will be a strong relationship between the different parts of the graduation process. It seems as if the process is taking place in a chronological order, but elements are constantly being moved back and forth. After each step in the process, it is important to look back and reflect on the steps taken.
The outcome and the evaluation are also connected to each other. The evaluation assesses the goals set in the outcome.
A further detailed explanation will be given about the different steps in the process. The focus will be on contents, methods and outcomes.

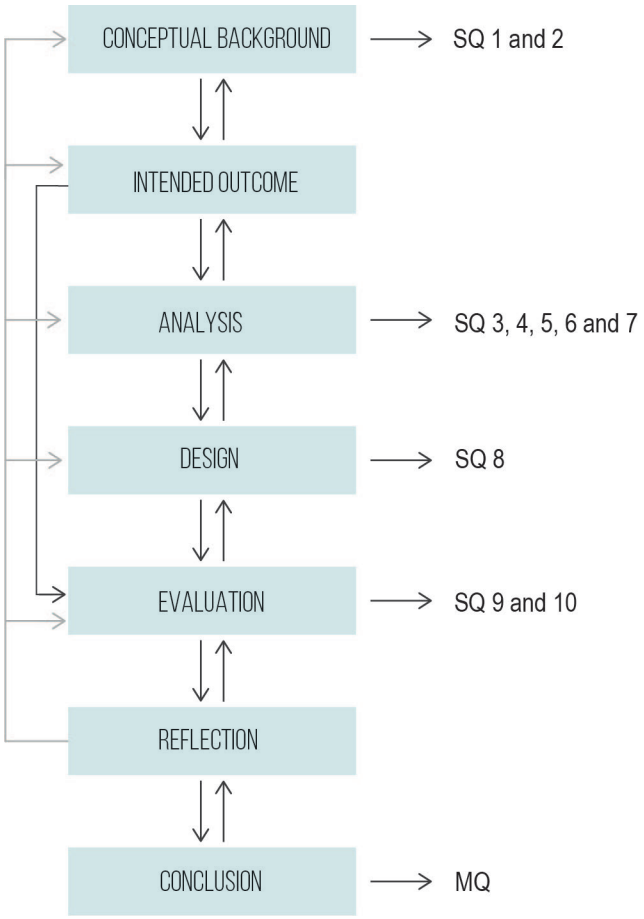


Fig 18 Research framework
Source: Produced by author

CONCEPTUAL BACKGROUND

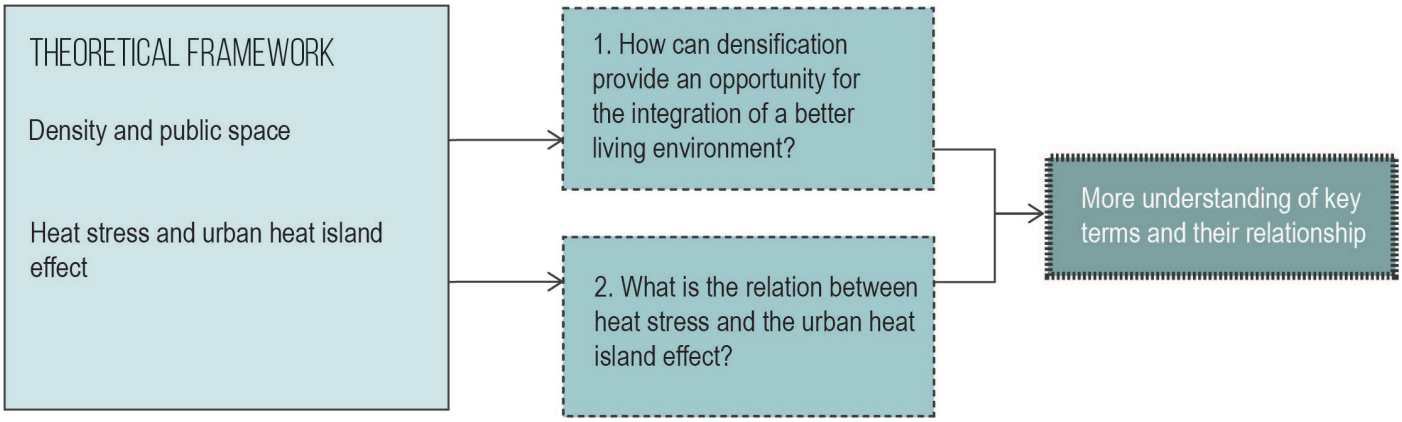


Fig 19 Research framework, conceptual background
Source: Produced by author

The first step is to collect information in the theoretical framework to identify the different terms that are important for the thesis. The terms “density and public space”, and “heat stress and the urban heat island effect” will be explored. These terms are also used as search terms to find the scientific reports and papers. The outcome of the theoretical framework will be the basis for the analysis.

INTENDED OUTCOME

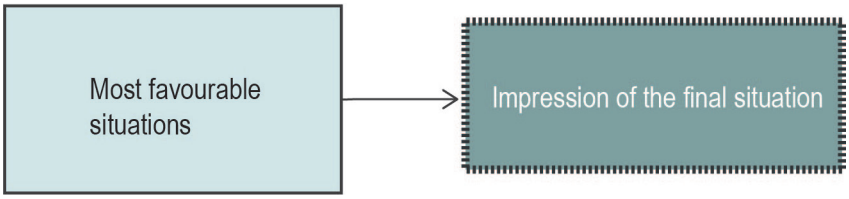


Fig 20 Research framework, intended outcome
Source: Produced by author

The intented outcome will show what the final product will be, and will show the ideal situation for heat stress and the urban heat island. The final outcome is an impression of the final situation where densification has improved the problem of heat stress.

ANALYSIS

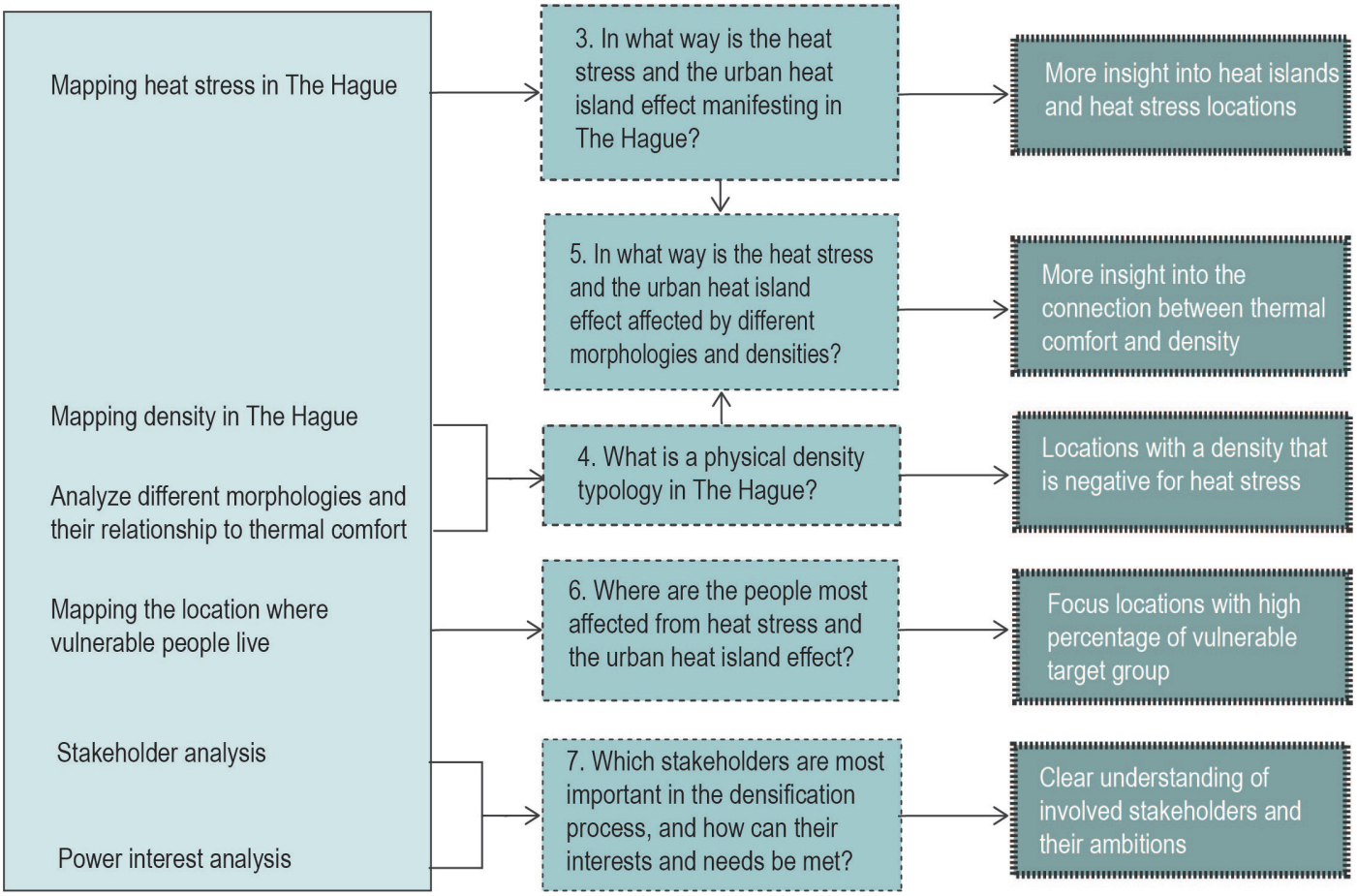


Fig 21 Research framework, analysis
Source: Produced by author

The analysis answers several research questions. The research questions can be worked on simultaneously. As shown in figure 21, research question 5 follows from two other research questions and can only be answered afterwards.
To answer these research questions maps will be made on three topics temperature, density and people. This results in maps about heat stress, the urban heat island effect, densification locations, vulnerable people locations and a livability map. These maps are the requirements to select a focus location in The Hague. By superimposing the different maps, a focus location is determined.
In the focus location there will be an analysis on three slightly different topics temperature, buildings and people.

The temperature analysis looks at the current situation of the heat stress level and the cooling locations. For buildings, the state of the current buildings is examined by means of energy label maps, age and a field trip.
People are analyzed by statistics and maps of income, age, crime and liveability. From these statistics, a picture is formulated of the type of residents living in the focus area.
A stakeholder analysis will be carried out to get a better picture of the involved stakeholders.The stakeholders will be found through policy documents and a meeting with a consultation team of the municipality of The Hague. Through this analysis, an overview will be formed of the interests and needs of the stakeholders involved. Together with a power interest analysis, a division will be formed between the involved stakeholders and possibly a strategy to adjust this division.
The analysis provides more insight into the current situation of The Hague. Mainly on the topics of thermal comfort, density, residents and other stakeholders.

DESIGN

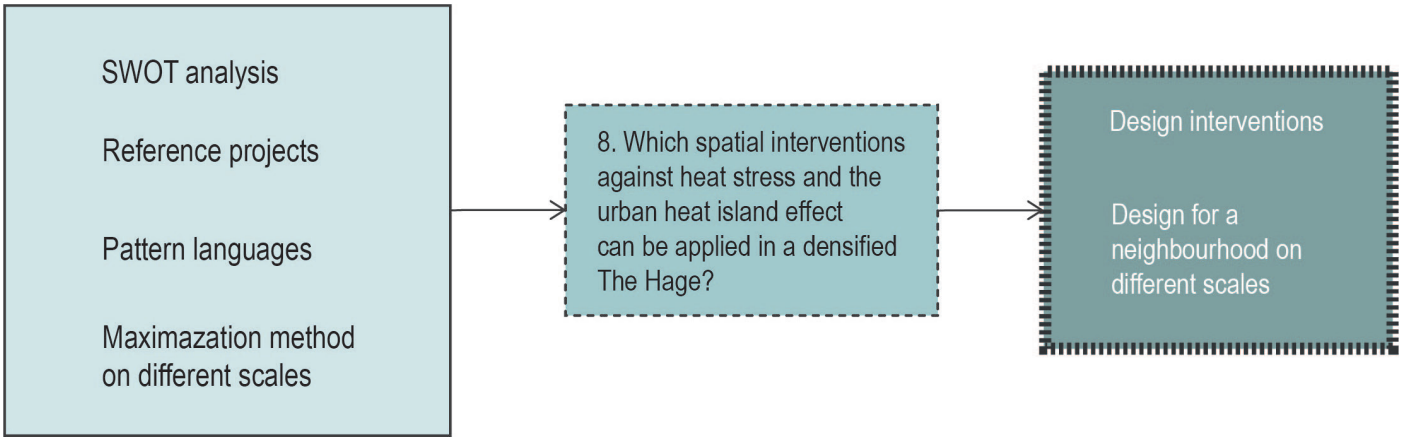


Fig 22 Research framework, design
Source: Produced by author

In order to make a seamless transition from research to design, a SWOT analysis will be carried out first. The SWOT focuses on the analysis at district level. It takes into account the aspects of temperature, buildings and people. From the district analysis, possible opportunities, threads, strengths and weaknesses will emerge.

Reference projects are used to identify interventions against heat stress. These projects score well on the PET index and each addresses heat stress in a different way. The interventions are described in patterns and the relationship between the patterns is examined. These patterns are then applied to the location to create a design for the district.

EVALUATION

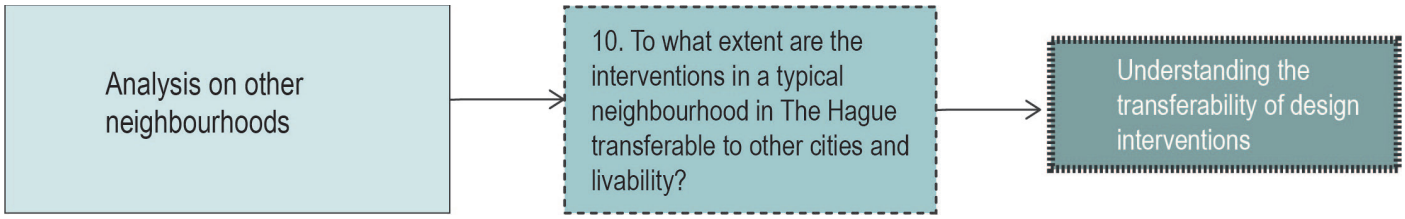


Fig 23 Research framework, evaluation
Source: Produced by author

The interventions are examined in terms of their applicability to other cities using Google maps to do an analysis on the structure and lay out of other neighbourhoods.

In this way, it can be seen whether there are neighbourhoods that are very similar to the focus location and whether it is then possible to apply the design to these locations.

CONCLUSION

How to densify in The Hague in order to mitigate and prevent heat stress and the urban heat island effect to improve the livability of the city and the health of its inhabitants?

Fig 24 Research framework, conclusion
Source: Produced by author

By answering each sub-question in every component of the process, an answer can be given to the main question in the conclusion. The conclusion focuses on the results of the study.

The reflection follows the conclusion and focuses on the process of the research. After each component, it will be necessary to reflect on the decisions made. This happens throughout the process. For this reason, the reflection will be connected to all the different components of the process and will often result in going back and forth between different components of the graduation project. At the end, a reflection is drawn up that focuses on various topics such as the relationship between research and design, advantages and limitations, the graduation studio and the project, outcome, further research and a personal reflection.

2.5.3. TIMELINE

The components of the entire research and design process will partly take place chronologically and side by side.

P1 In this phase, the main focus is on the initial decisions with underlying knowledge. The problem is formulated and an introduction to the various topics is given.
P2 At this stage, the background information and the outcome will be discussed in more detail. The information that cannot be found in the literature is addressed in the analysis at city and neighbourhood level. At the end of this phase, a conclusion of the analysis is formed, to make a smooth transition to the design.
P3 In this phase, the analysis can be supplemented and the design can be developed. To start the design interventions are drawn up by means of reference projects and literature. These interventions will be changed into patterns.
P4 The design and evaluation are further developed during this phase of the process. The patterns created can be applied to the neighbourhood to create an integrated design. Finally a conclusion is drawn from the current status.
P5 The evaluation will be finished leading to a better shaped conclusion. A final reflection on the process is made.

Evaluation takes place during the entire process in order to strengthen the relationship between the various components. All choices that were made are evaluated upon and reconsidered if necessary.

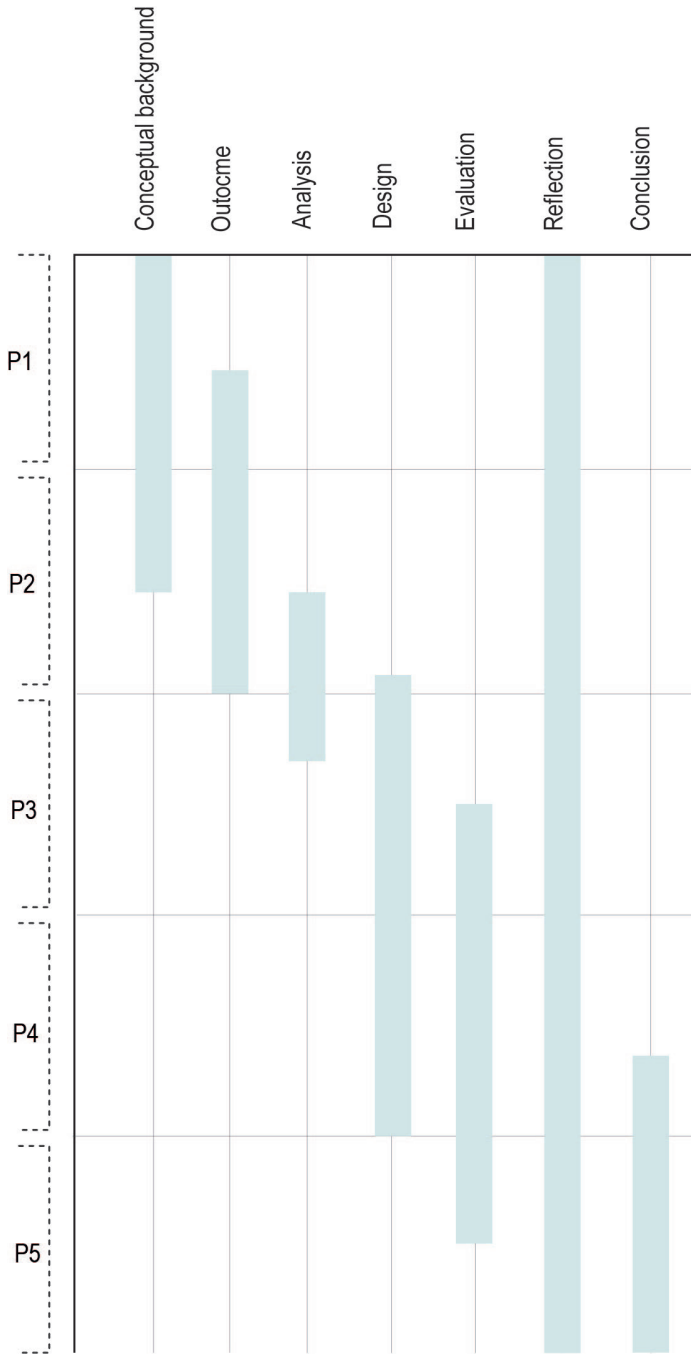


Fig 25 Timeline process
Source: Produced by author

2.6 INTENDED OUTCOME

At the end of the project, there will be an end product whereby a neighbourhood can be better densified while having less effect on heat stress.
It is important to have a clear goal. The goal is therefore: “Densify a neighbourhood where thermal comfort is pleasant, and no to mild heat stress occurs on hot days.”

Currently, the vision of this goal is shown in figure 26. It depicts a high density with lots of greenery and shade to escape the heat on a hot summer day.

Fig 26 Vision of the final product.
Source: Produced by author, the photo’s used are from (Architectenweb, n.d.), (Gemeente Rotterdam, n.d.), (Gemeente Utrecht, 2021), (UN Studio, n.d)

The problem statement and theoretical framework revealed that heat stress can have major consequences for the elderly in society. Together with the ageing population and climate change, this will become an increasing problem as the years go by.

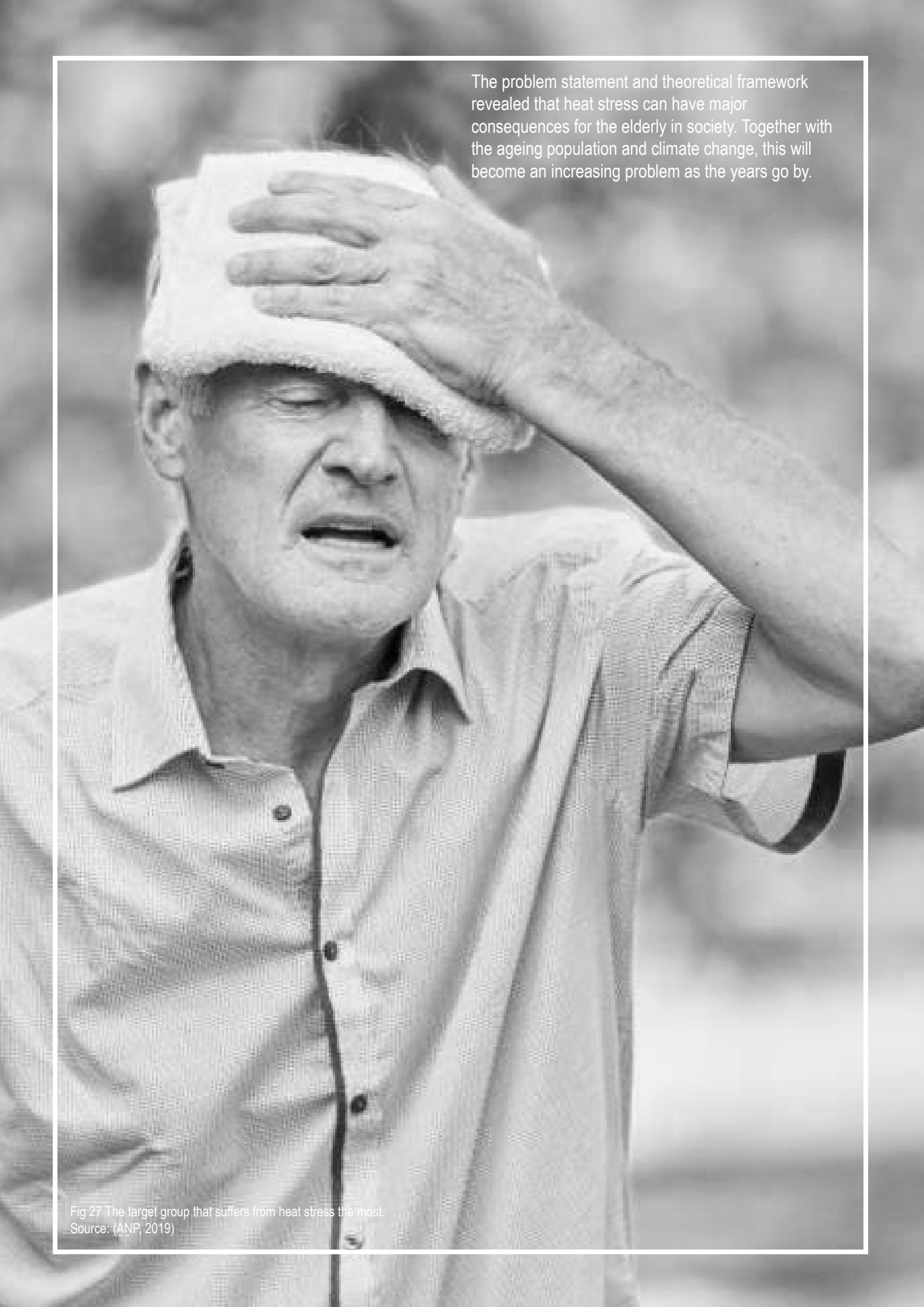


Fig 27 The target group that suffers from heat stress the most.
Source: (ANP, 2019)

3. ANALYSIS

ANALYSIS METROPOLITAN SCALE

ANALYSIS MESO/MICRO SCALE

STAKEHOLDER ANALYSIS

3.1 ANALYSIS METROPOLITAN SCALE

3.1.1 TEMPERATURE

Figure 28 shows that the heat stress caused by warm nights occurs mainly in the centre. Heat stress is often worst at night as the heat remains between the buildings. Residents experience this effect most often indoors. In the current situation, the heat lingers for between one to two weeks. If no measures are taken, this effect will be strongly reinforced in the future. In 2050, the heat will linger for three or four weeks.
Figure 29 shows how many degrees hotter it can get in The Hague than in areas outside the city. Virtually the entire city is warming up. However, the urban heat island effect is the worst in the centre of the city and Scheveningen. These areas will be more than 2 degrees warmer than areas outside the city. As mentioned earlier, this is on average 8.6 °C and can rise to 15.4 °C (Klok et al., 2021).

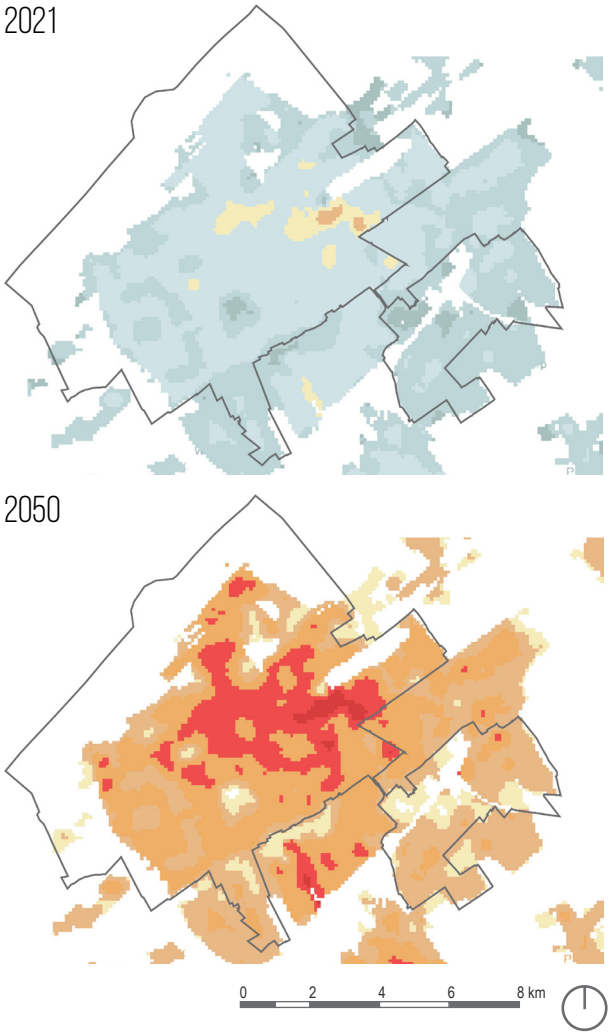


Fig 28 Heat stress from warm nights in 2021, and 2050.
Source: Reproduced by author (Klimaateffectatlas, n.d.-b).

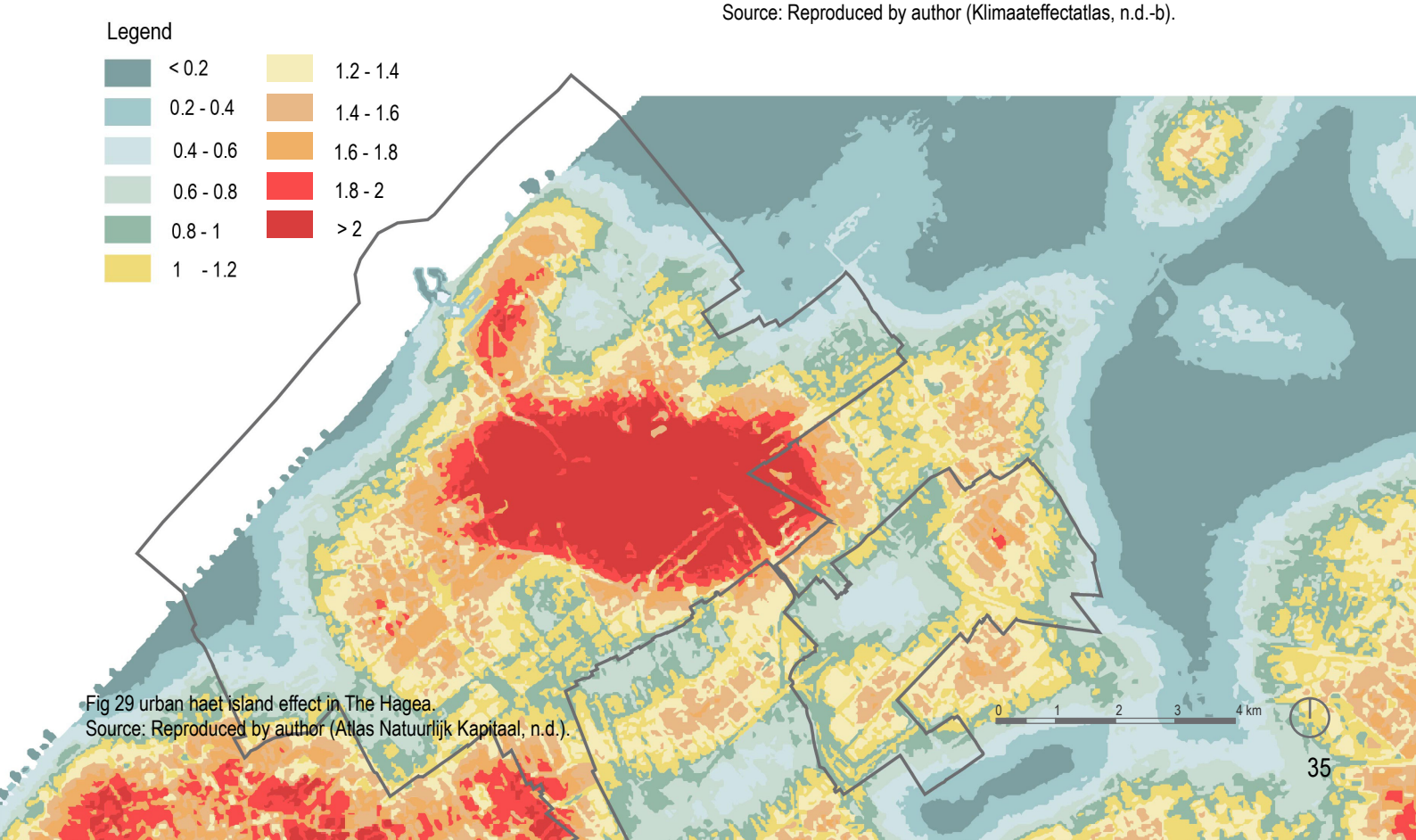


Fig 29 urban haet island effect in The Hagea.
Source: Reproduced by author (Atlas Natuurlijk Kapitaal, n.d.).

3.1.2 DENSITY

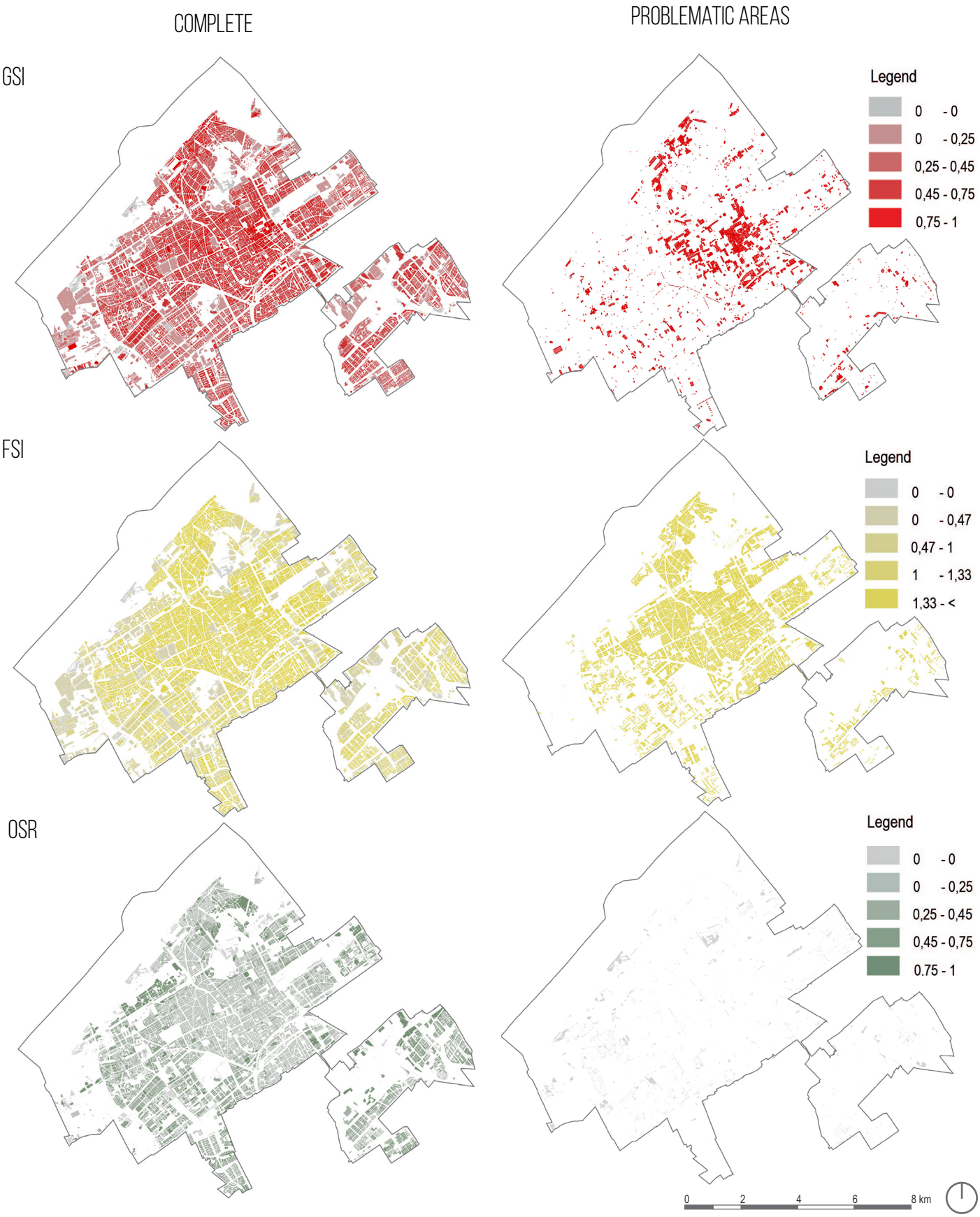


Fig 30 GSI, FSI and OSR of The hague.
Source: Generated by author using GIS software, based on density of buildings blocks.

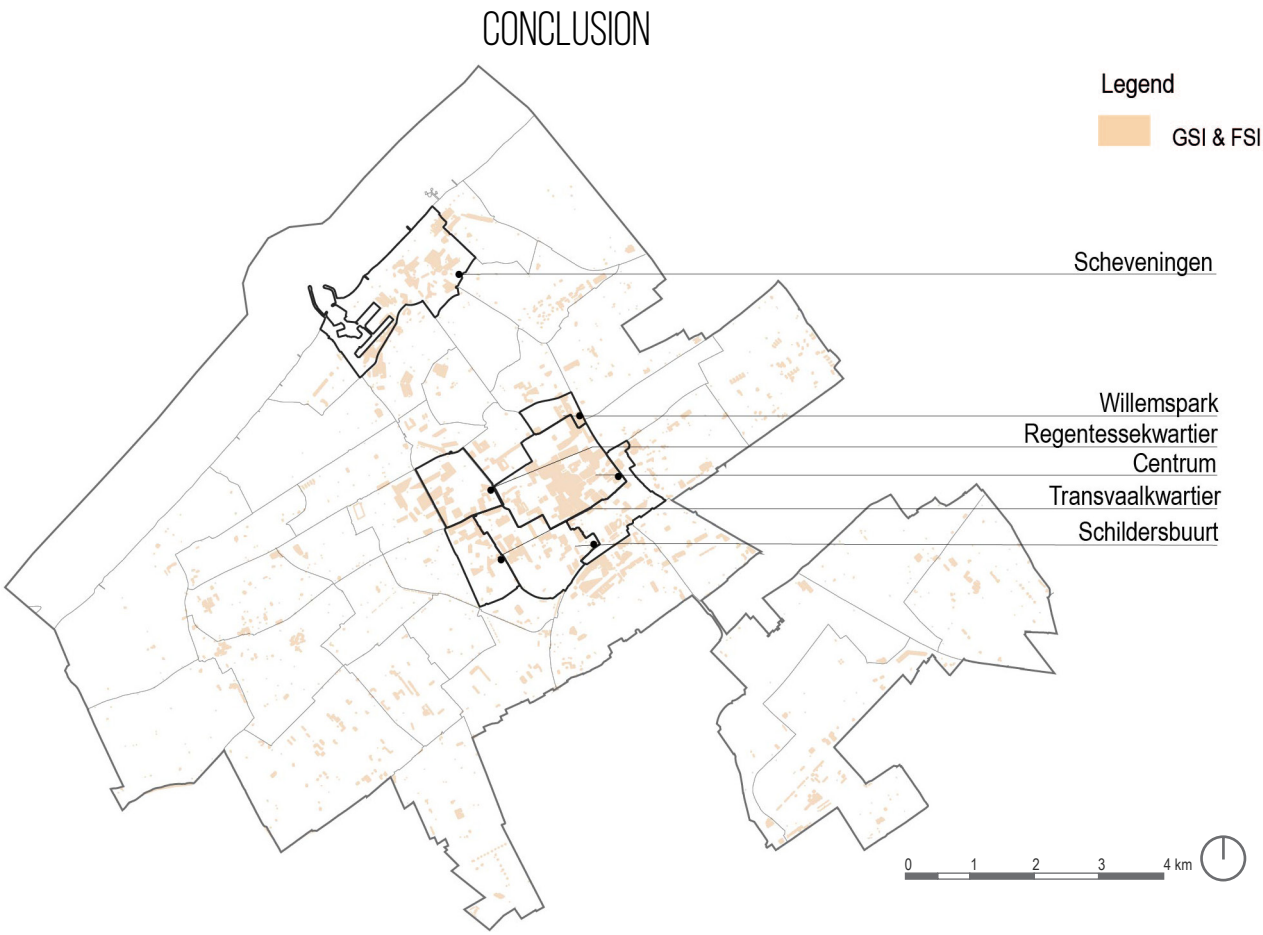


Fig 31 Conclusion of the largest FSI and GSI.
Source: Generated by author using GIS software, based on density of buildings blocks.

The theoretical framework has shown that areas with the highest GSI and FSI can be problematic for the urban heat island effect and heat stress. The urban heat island effect and density maps show that this is also the case in The Hague. The various maps show that high density mainly occurs around the centre of the city and Scheveningen. The OSR map shows the areas with the most empty spaces. In the problematic areas map, the OSR shows the areas where there are virtually no empty spaces. This shows that there is no room for any interventions against the urban heat island effect and heat stress.

Fig 32 Densification locations and densification projects.
Source: Reproduced by author. Information gathered through contact with the municipality of The Hague (Gemeente Den Haag, 2021a). 1. (OPL architecten / re-designers, 2019), 2. (Stebru, n.d.), 3. (Rijnboutt, 2021).

Figures 31 and 32 show that the locations where the municipality of The Hague wants to increase density only correspond to one neighbourhood with the locations where there is already a high density. So the municipality is currently focusing on low density areas like the south of The Hague. There are locations that already have full plans and need further expansion and plans that are still in a very early stage.

STATIONSBUURT

This district is part of the Central Innovation District (CID). This area must develop into the engine of the local economy. For this reason, towers are being developed in the centre of The Hague with a high density of housing, workplaces and facilities.
Housing and public transport often go hand in hand in urban plans. For this reason, there will be considerable densification around the stations (Tilman, 2020).

LAAKWARTIER AND SPOORWIJK

The north of this area, Laakhavens, will also become part of the Central Innovation District. The municipality is trying to find a balance between areas with lots of activity and quiet residential areas. Laakhavens will be a quiet area with residential towers of various sizes. The aim is to design a residential area in which water and the port history of Laakhavens play a central role (Tilman, 2020).

BINCKHORST

In the coming years Binckhorst will be transformed from an industrial and working area into a residential and working area. This will be an area for the growing number of residents of The Hague and will relieve the pressure on the housing market. In total, there will be room for 5000 new homes in this area (Stedelijke transformatie, n.d.). The municipality of The Hague would like to realise an additional 500 houses for which there are no plans yet.

SOUTH WEST

This area consists of several neighbourhoods such as Moerwijk, Zuiderpark, Morgenstond, Bouwlust and Vrederust. There are no concrete plans for this area yet, but there is an ambition to create an attractive, vital, sustainable residential area in The Hague. Work, living and various facilities must go hand in hand with good accessibility. The goal is to realise 10.000 homes in this area (Gemeente Den Haag, 2019b).

3.1.3. PEOPLE

The population of The Hague is slowly changing. In the last five years, there have been slightly more elderly people and slightly less young people (fig. 33). This will change more in the future due to the ageing population. Earlier research has shown that the elderly are most at risk of the serious consequences of heat stress. Figure 34 shows that the elderly are concentrated in the Waldeck, Loosduinen, Scheveningen, Moerwijk, Bouwlust and Vredelust districts.
Many elderly people died during the heat wave of 2006. Figure 35 shows how many more elderly people died above average during the heatwave. However, this is almost entirely spread across the city.

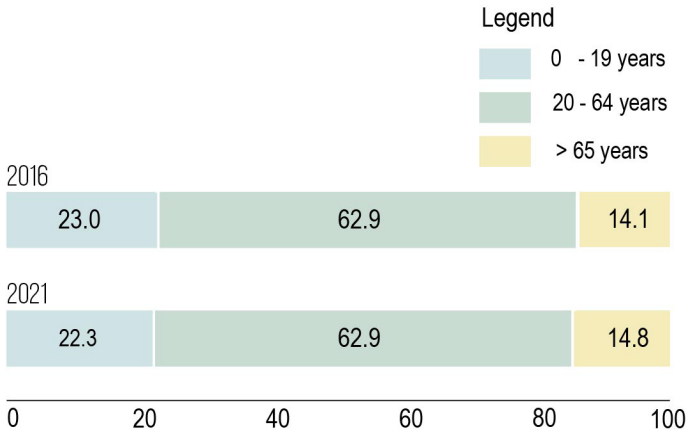


Fig 33 Proportion of different age groups in The Hague in 2016 and 2021 (Gemeente Den Haag, 2021a).
Source: Reproduced by author.

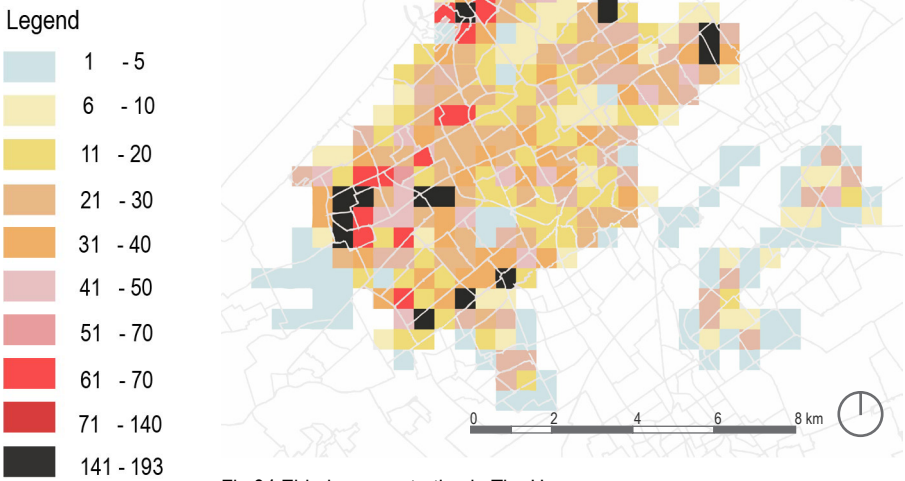


Fig 34 Elderly concentration in The Hague.
Source: Reproduced by author (van der Hoeven & Wandl, 2018).

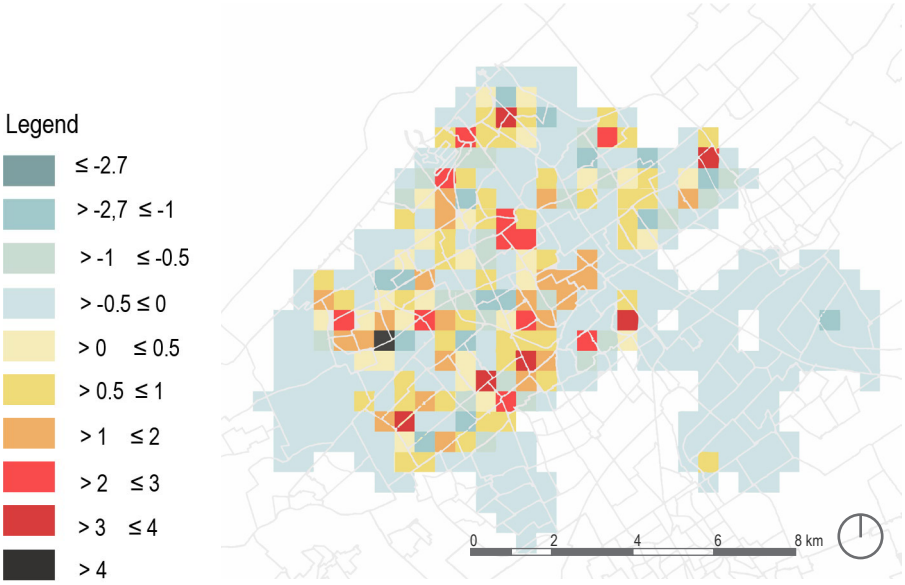


Fig 35 Above-average mortality of over-75s in the heat wave of July 2006.
Source: Reproduced by author (van der Hoeven & Wandl, 2018).

The municipality of The Hague assesses the urgency of a focus area on the basis of the Leefbaarometer (fig. 36), which measures liveability. The neighbourhood that is currently assessed the worst is the Schilderswijk. Neighbourhoods that also score insufficiently are Transvaalkwartier, Moerwijk, Laakwartier and Spoorwijk, Bouwlust and Vrederust. These neighborhoods mainly score poorly on residents, safety and physical environment (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, n.d.).
By comparing this figure with figure 34 and 35 where the concentration of elderly people is described, many neighbourhoods do not match. Many elderly people live in neighbourhoods where liveability is assessed as more than sufficient. Only have the neighbourhoods of Moerwijk, Bouwlust and Vrederust an insufficient livability rate.

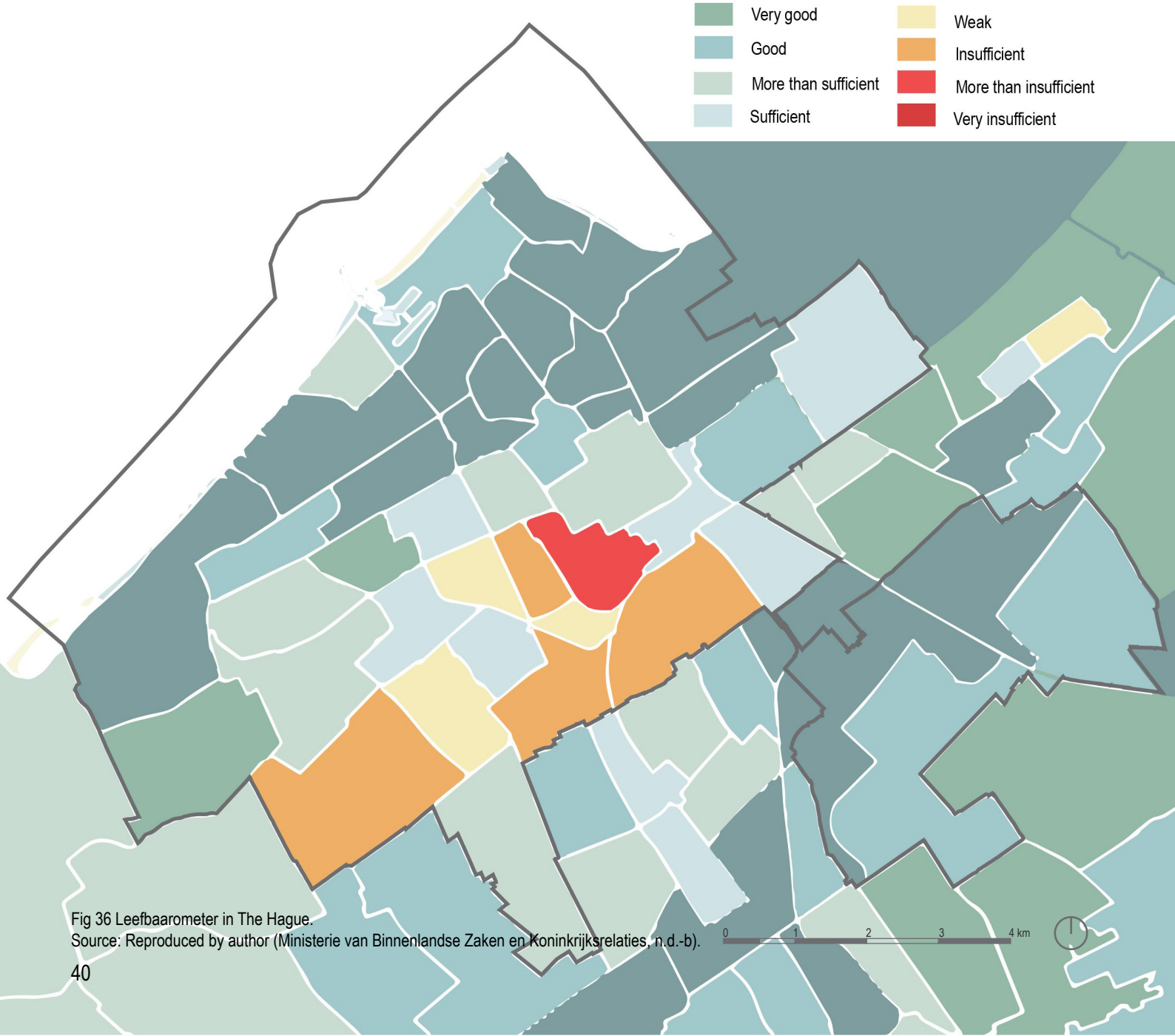


Fig 36 Leefbaarometer in The Hague.
Source: Reproduced by author (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, n.d.-b).

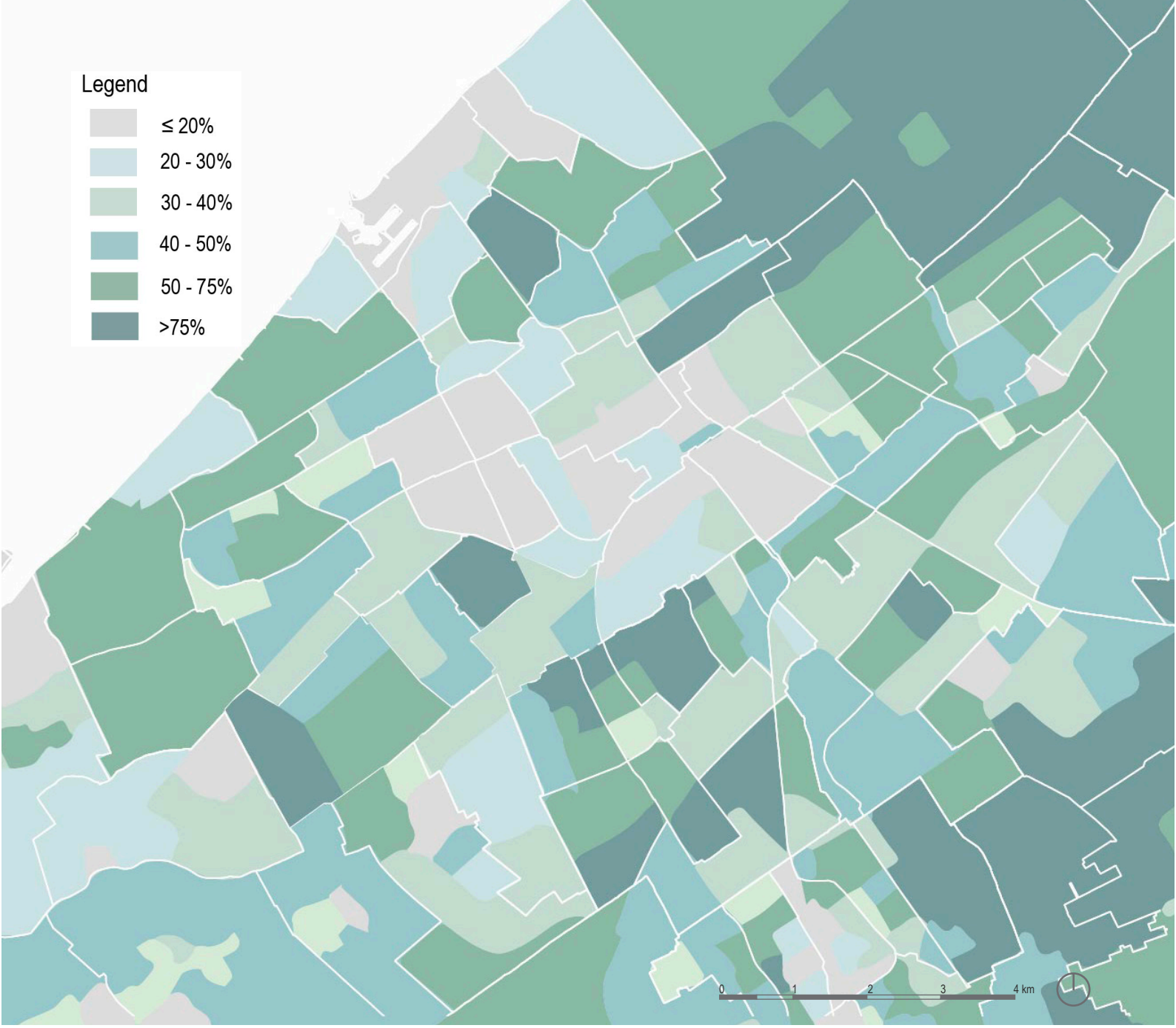


Fig 37 Percentage of green space within the public area.
Source: Reproduced by author (Esri Nederland, 2021b).

A comparison between the liveability of the neighbourhoods and the percentage of green space shows that in many cases the neighbourhoods that score insufficiently with regard to liveability also have limited green elements. Neighbourhoods with many green elements often score better.
The centre, in particular, scores poorly with respect to green space, which is logical due to its high density. Due to high density, there is little open space left and thus little room for greening. The neighbourhoods outside the centre have a lower density and have more greenery. So there is currently a strong relationship between density and the percentage of green space.

3.1.4. SITE SELECTION

The focus location depends on four aspects (fig. 38). The current urban heat island effect and heat stress level are not taken into account, as densification can completely change the level of thermal comfort. In order to make the best
possible choice, a hierarchy has been drawn up.
First of all, the location must be a densification site for which the plans have not yet been approved so that this project can really make a difference.
Secondly, the location must have a high concentration of elderly people. A concentration must be 61 or higher as this is considered a high concentration. This is the most vulnerable target group in relation to heat stress.
Thirdly, the location must score insufficiently on the liveability index.
And finally, the selection will be based on the percentage of green, since vegetation is one of the indicators for heat stress and has a major influence on the termal comfort of the public space. This percentage consists of the

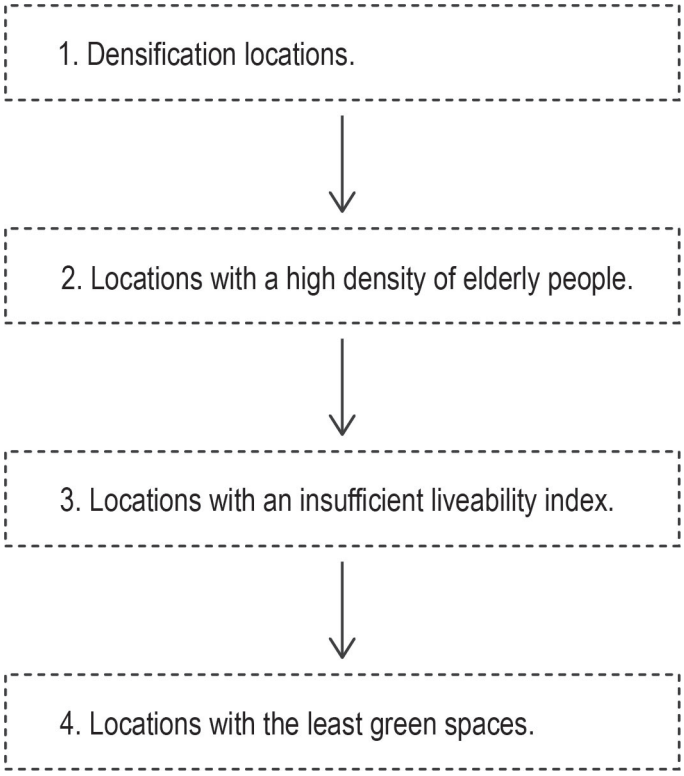


Fig 38 Hierarchy for selecting a location.
Source: Produced by author.

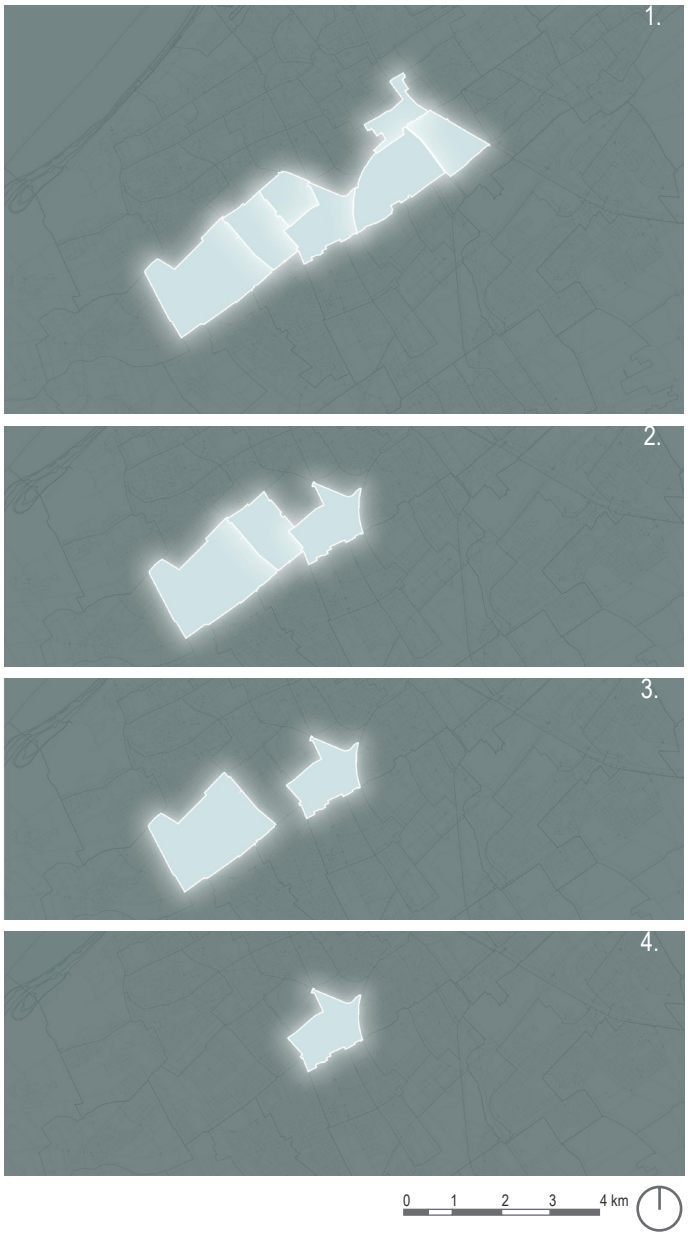


Fig 39 Hierarchy for selecting a location in a map.
Source: Produced by author.

The site selection has shown that the focus area will be the Moerwijk district. Moerwijk is a neighbourhood in the Escamp district close to the centre of The Hague. In this district it can be seen that the balance between the built-up area and the public space is not fairly distributed. The district was selected because it scored poorly on a few issues. This offers opportunities to turn a poorly performing neighbourhood with problems into a new successful part of The Hague.
The rest of the analysis looks at the Moerwijk district and its strengths, weaknesses, opportunities and threats.

percentage of low vegetation, trees and grey paving. The densification locations in The Hague with firm plans are, as mentioned earlier, in the South. This is the first selection for the focus location.

Secondly, the concentration of the weakest target group is considered. The elderly concentration is mainly in the West. This leaves the South-West with the districts Moerwijk, Morgenstond, Bouwlust and Vrederust.

South-West scores quite poorly on the livability index everywhere. The neighbourhoods Moerwijk, Bouwlust and Vrederust, however, score insufficiently. .

Both remaining neighbourhoods are quite spacious with greenery. Now it appears that Moerwijk contains less greenery than Bouwlust and Vrederust, which has a negative effect on the urban heat island effect and heat stress.

Fig 40 Layout of Moerwijk.
Source: Generated by author using GIS software, based on buildings, streets, water and green.

3.2 ANALYSIS MESO / MICRO SCALE

3.2.1 TEMPERATURE

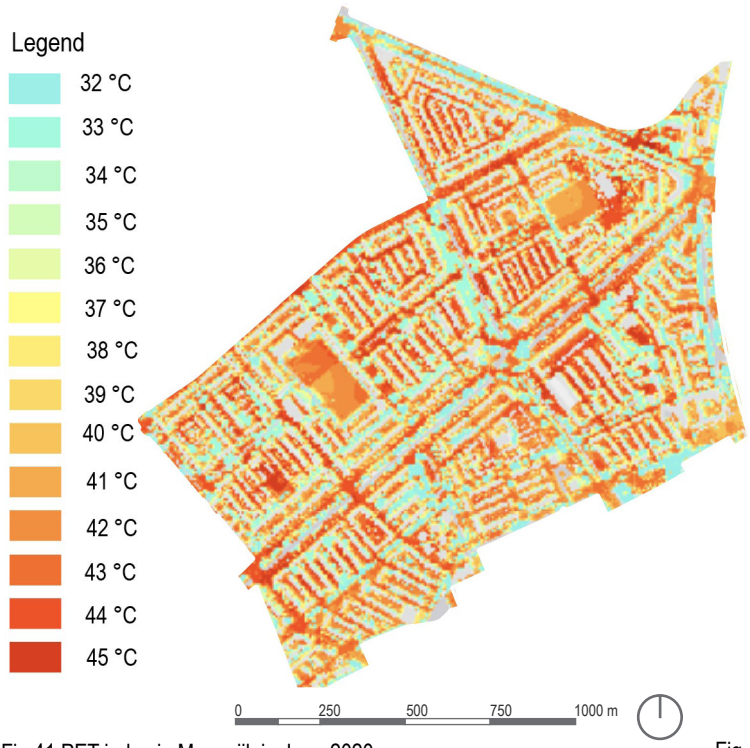


Fig 41 PET index in Moerwijk in June 2020.
Source: Edited by author (Witteveen & Bos, 2020).

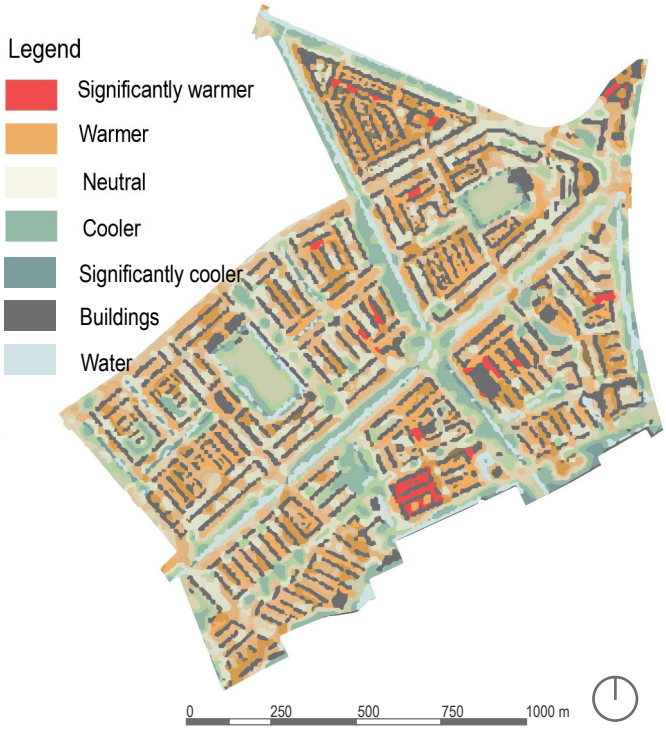


Fig 42 Heat stress in Moerwijk.
Source: Reproduced by author (Gemeente Den Haag, 2016a).

Figures 41 and 42 show that it can become significantly warmer in Moerwijk on a hot summer day. These maps also show that the trees have a strong cooling effect. Along the district's main infrastructure, trees have been planted to reduce the level of heat stress. In areas where there are almost no trees, the temperature will rise above 41°C. According to the PET index, this will lead to extreme heat stress. However, these maps focus only on the heat stress in public spaces and say nothing about the heat stress experienced indoors.

Figure 43 says something about the heat stress that can occur in the dwellings. The heat can linger in the dwellings, causing problems for the residents. If nothing changes in Moerwijk, the heat will linger for almost three times as long in 2050.

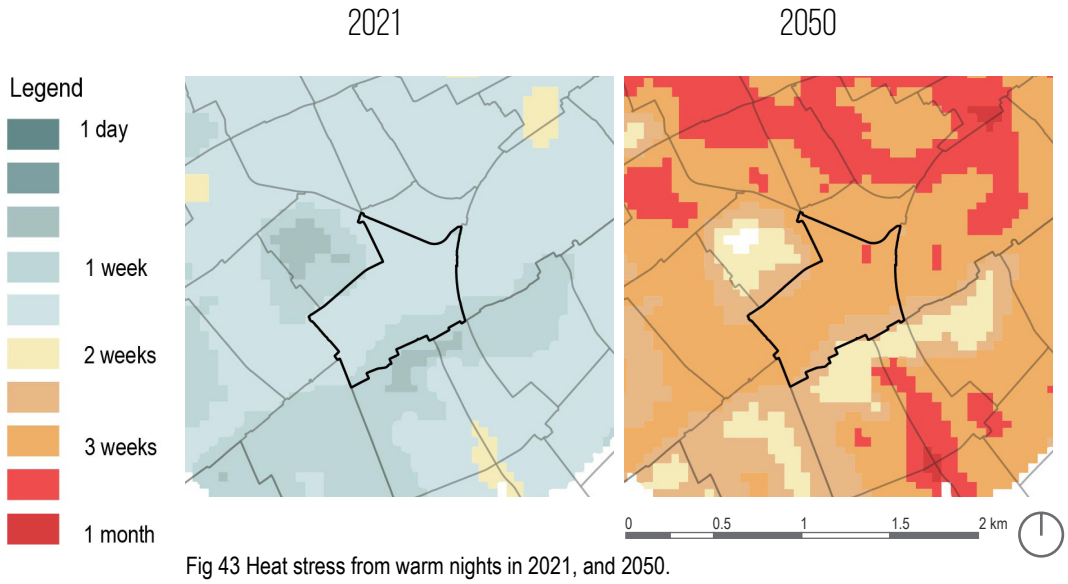


Fig 43 Heat stress from warm nights in 2021, and 2050.
Source: Reproduced by author (Klimaateffectatlas, n.d.-b).

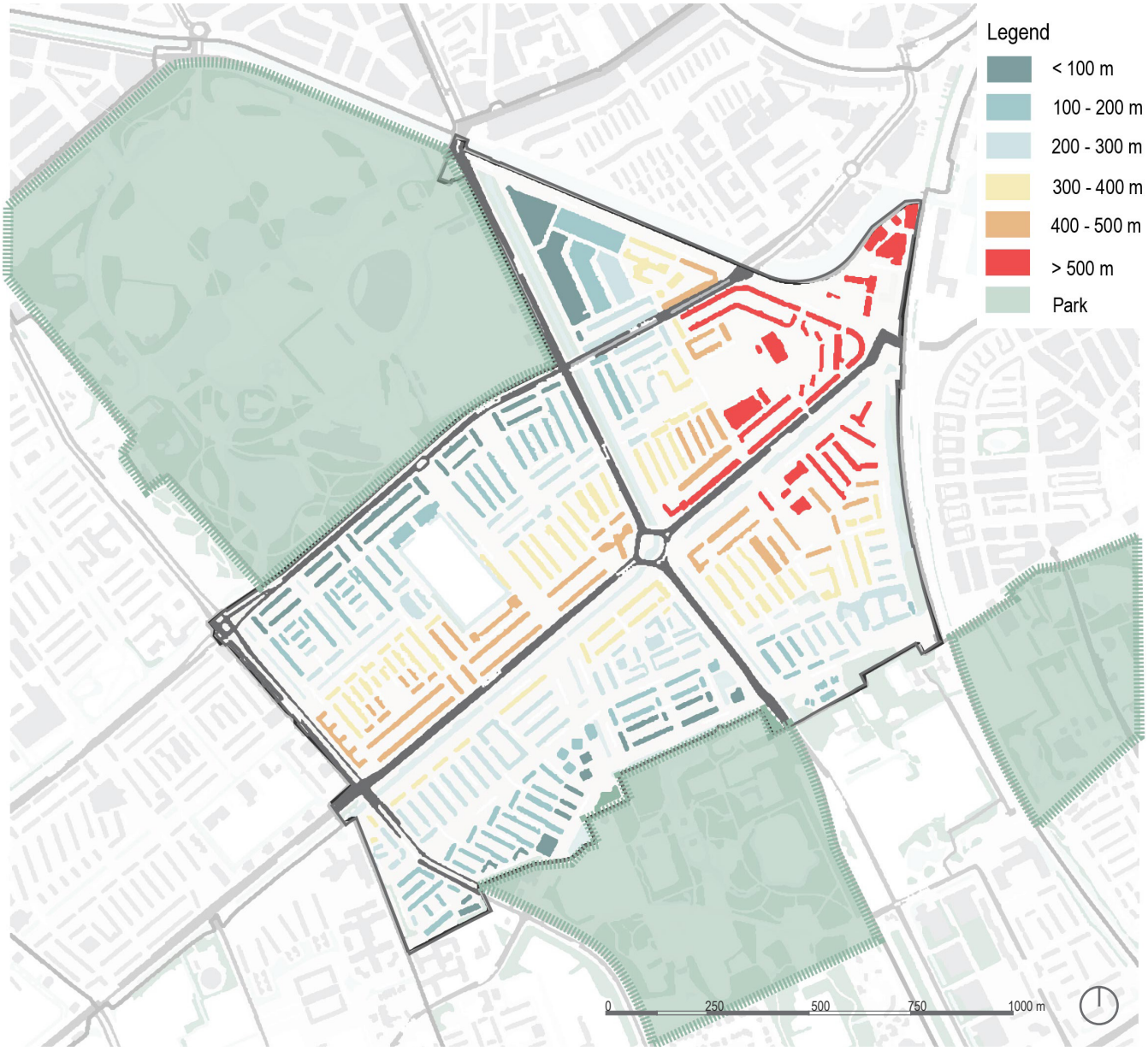


Fig 44 Surrounding cooling facilities and distance between the dwellings and the cooling facility
Source: Generated by author using GIS software, based on buildings, streets, water and green.

An important element in escaping heat stress and the urban heat island is green spaces that function as cooling areas during a hot day. Moerwijk has no large public green areas for residents to recreate. However, the district is surrounded by parks that can fulfil this function. In some cases, the distance to the parks is too big. The desired distance is 300 metres to a cooling facility (Kluck et al., 2020), but from the centre of the district the distance to Zuiderpark and Park Overvoorde is 500 metres and Juliana Park 1 km. Figure 44 shows that the distance is too great mainly along the main road the S105 and in the east of the district.

3.2.2 BUILDINGS

It is important to get a clear picture of the current buildings in Moerwijk. By means of this visualisation, a decision can be made as to where the opportunities lie for densification, renovation and possible demolition. To get a clear picture of the built-up area in Moerwijk, we look at the type of houses and their ownership (fig. 45).
There are significantly more apartments in Moerwijk than in the rest of The Hague. The percentage of social housing is more than twice as high as in the rest of The Hague. The percentage of rented homes is counteracted by the fact that all new-build homes are owner-occupied. However, there is no growing diversity when it comes to housing types. All new homes are 100% appartments (PvdA, 2016). This explains the low WOZ value of the dwellings in Moerwijk (fig. 46). Because in most cases flats are cheaper than other types of housing.
There is a high percentage of flats and social housing, the opportunities for development within the district are very low. As a result, the district continues to attract a certain target group and prevents diversity.

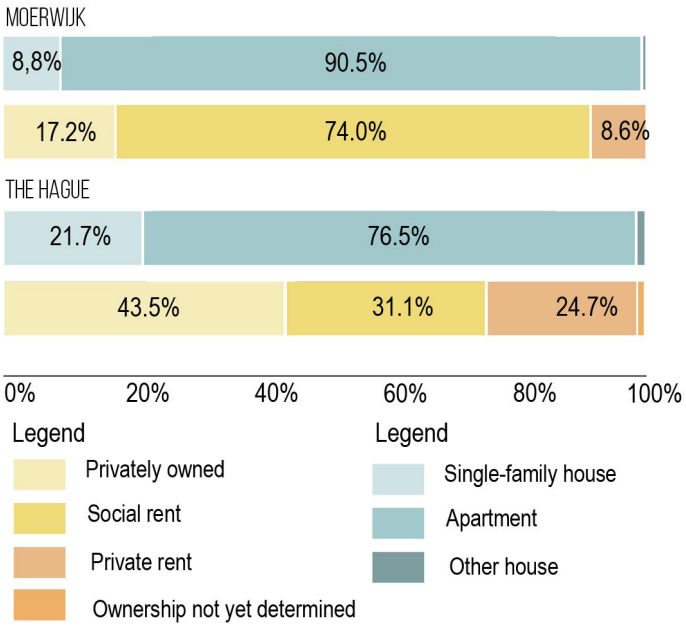


Fig 45 Houses by ownership and type.
Source: Reproduced by author (Gemeente Den Haag, 2021e).

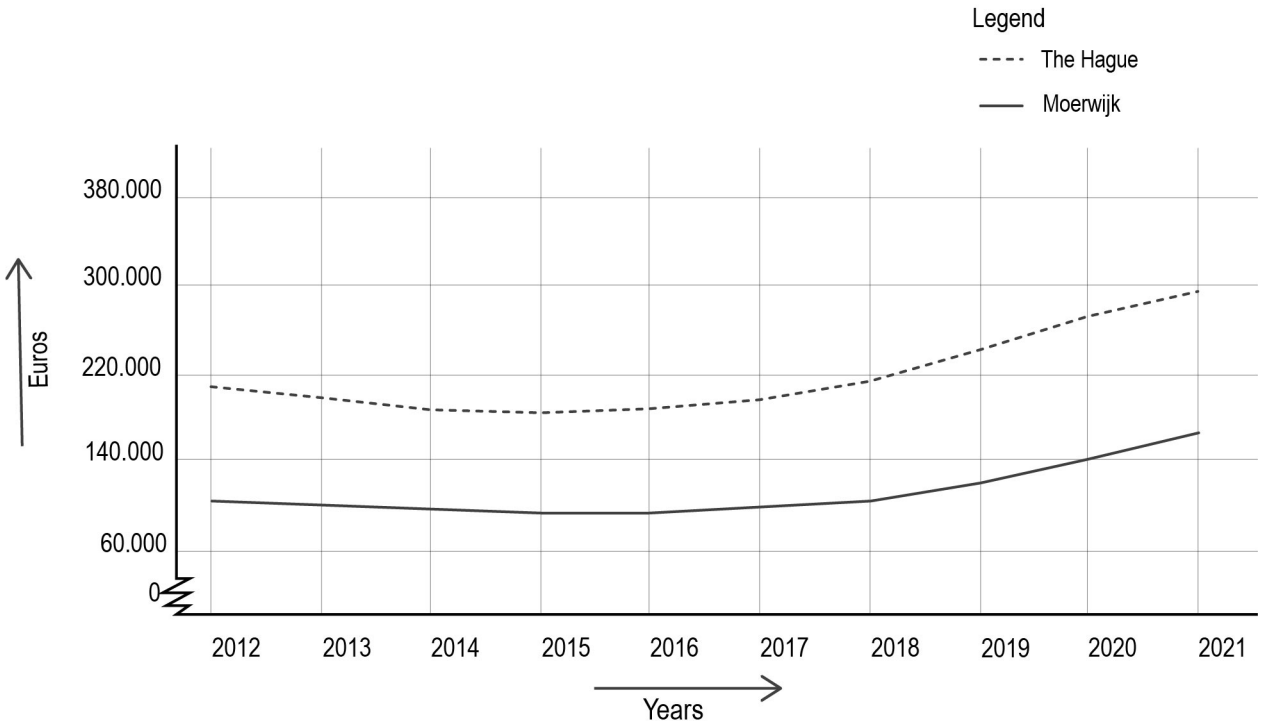


Fig 46 Average WOZ-value houses.
Source: Reproduced by author (Gemeente Den Haag, 2021c).

Many homes are outdated in Moerwijk. Houses that were built before 1975 do not have an insulation requirement, and are often less well insulated (fig. 47). Because of this, the house loses a lot of heat in the winter, but will also absorb heat from outside more quickly in the summer (Woonbewust, 2021). The energy label is used to check whether these houses still meet current requirements.

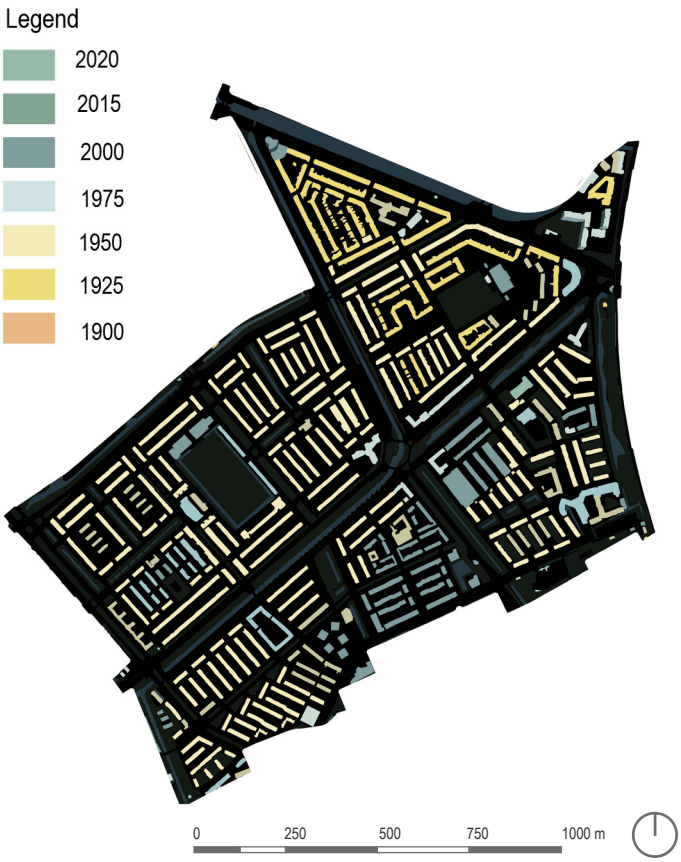


Fig 47 Building ages in Moerwijk.
Source: Reproduced by author (TU Delft, 2020).

A few outdated houses have been renovated and are satisfactory. These houses will have been isolated to protect against the cold outside.
However, there are some houses that score between class C and G. These homes will not be adequately isolated and the residents will experience heat stress sooner (fig. 48).

Fig 48 Energy label of the buildings in Moerwijk.
Source: Reproduced by author (Atlas Leefomgeving, 2020).

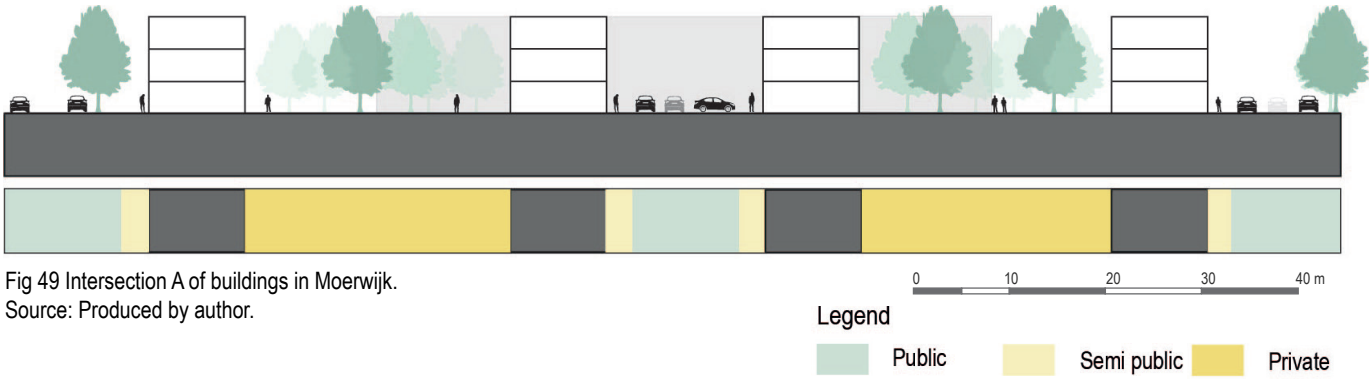


Fig 49 Intersection A of buildings in Moerwijk.
Source: Produced by author.

The district is designed with a lot of green. However, this greenery is private to the houses. In between two buildings there is a private space, which are owned by the housing associations for residents to recreate in. The cross-section shows that the public space is filled with cars. The space consists mainly of pavement, parking spaces and a road.

FENCING

SIGNS

Fig 50 Demarcation of private space by fences and signs.
Source: Photos taking by author.

The interstices of the housing cooperatives are strongly demarcated from the public space. Children's playgrounds, parking lots and alleys are also closed off from the public space (fig. 50). Residents are afraid of nuisance and crime, so they close themselves off from the public space.

As mentioned earlier, the housing type is 90.5% appartments. This is reflected in the image of the district (fig. 51). Many buildings have the same height and structure, mainly because the district is a post-war district and many houses were built in the same period. However, there is a high variety in architecture.

Fig 51 Building morphology in Moerwijk.
Source: Generated by author using GIS software, based on buildings, streets, water and green and photos taking by author.

3.2.3 PEOPLE

Looking at the composition of the residents, relatively more young people live in Moerwijk than older people. The residents over 65 years of age are the target group that experiences the most consequences of heat stress. Moerwijk-West currently has 845 residents over the age of 65, this is the neighbourhood with the most elderly in Moerwijk (CBS, 2018–2021). However, there are also some nursing homes in Moerwijk. The largest is in Moerwijk East. Moerwijk-East has a nursing home where about 90 elderly people live together. The elderly live there in their own flats. For residents with dementia, there is a separate department where the residents live together in a residential group of 15 residents. (HWW Zorg, 2019). At the location of the care centre extra consideration must be given to heat stress.

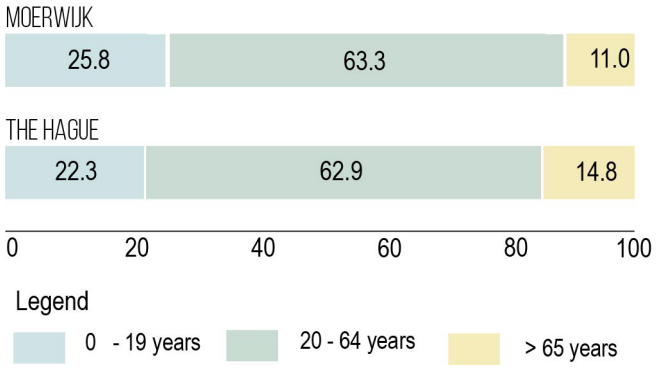


Fig 52 Age of residents in Moerwijk.
Source: Reproduced by author (Allecijfers, 2021).

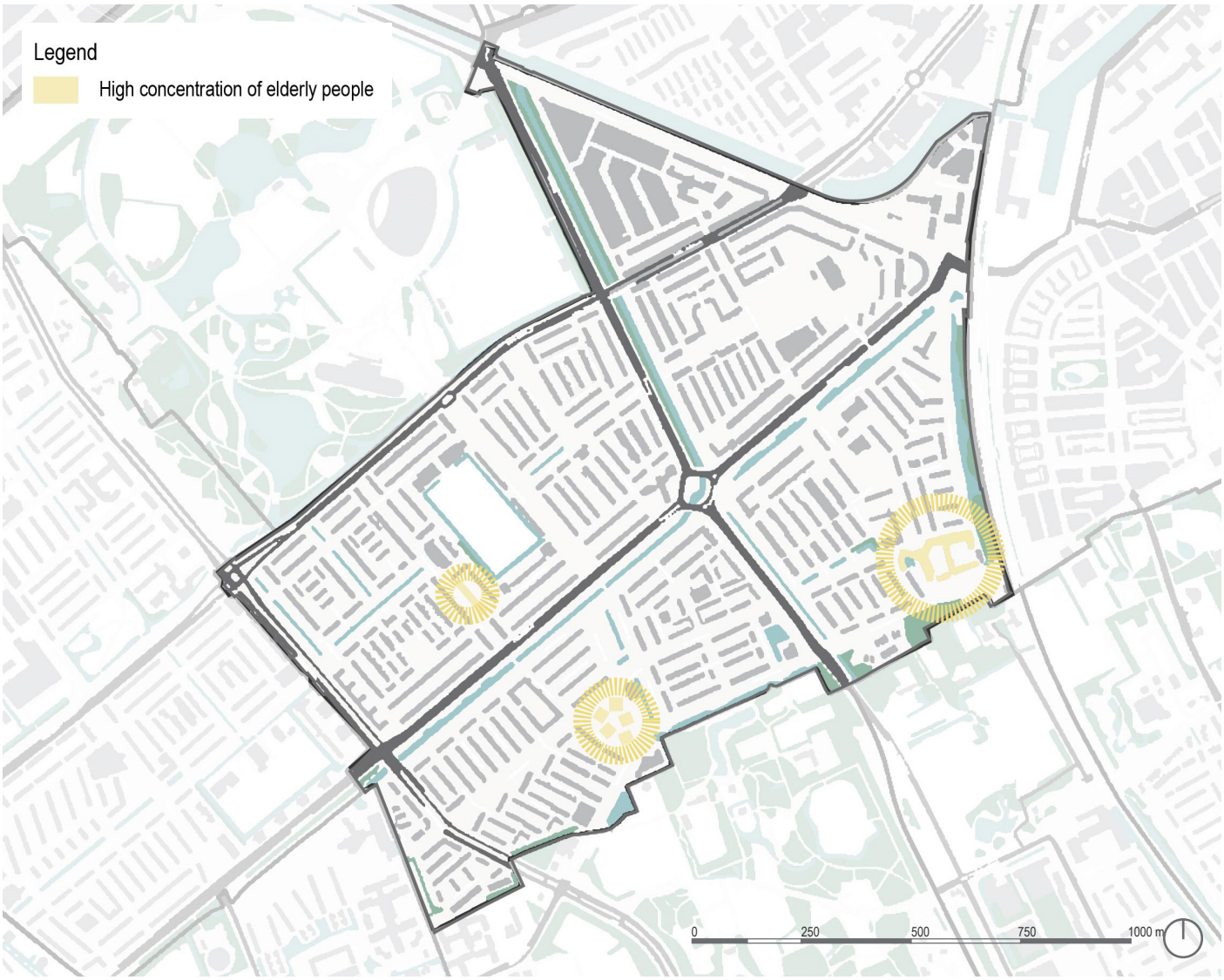


Fig 53 Focus areas in areas focused on high concentration of elderly people.
Source: Generated by author using GIS software, based on buildings, streets, water and green.

The houses in Moerwijk are in poor condition, cheap and mainly social housing. This attracts low-income households. For this reason, the percentage of low-income households is higher in Moerwijk than in the rest of The Hague (fig. 54). There is a relationship between low income households and migrants. In The Hague, the percentage of migrants is 54%, in Moerwijk this percentage is significantly higher at 74% CBS, 2018–2021). Persons with a Turkish, Moroccan, Surinamese and Antillean migration background have an income that is between 31% and 16% lower than persons without a migration background. This can be explained by a lower hourly wages, lower level of education, and lower gross participation of persons with a migration background (Koot et al., 2019).

90% of people without a migration background have work as their main source of income. This percentage is significantly lower among people with a traditional migrant background. For men, it is between 70% and 80%, and for women it is even between 50% and 70%. This explains the high unemployment benefit rate in Moerwijk (Koot et al., 2019).

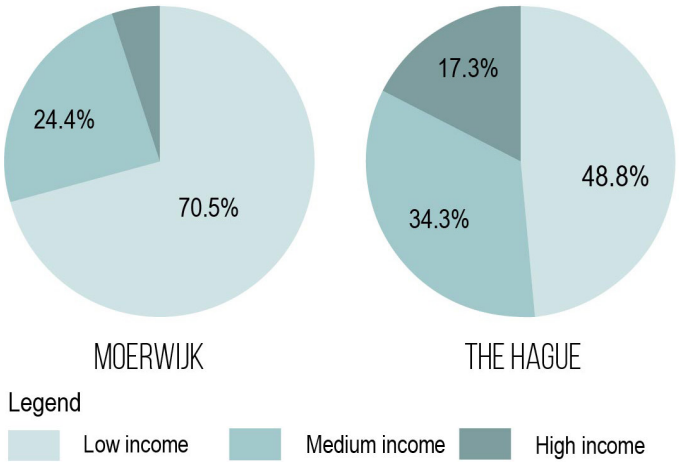


Fig 54 Distribution of income of residents in The Hague and Moerwijk.
Source: Reproduced by author (Gemeente Den Haag, 2018).

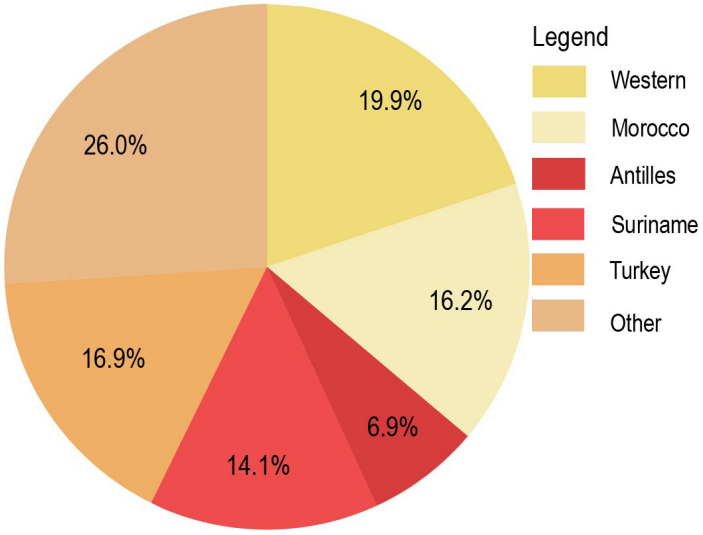


Fig 55 Migration background in Moerwijk.
Source: Reproduced by author (Allecijfers, 2021).

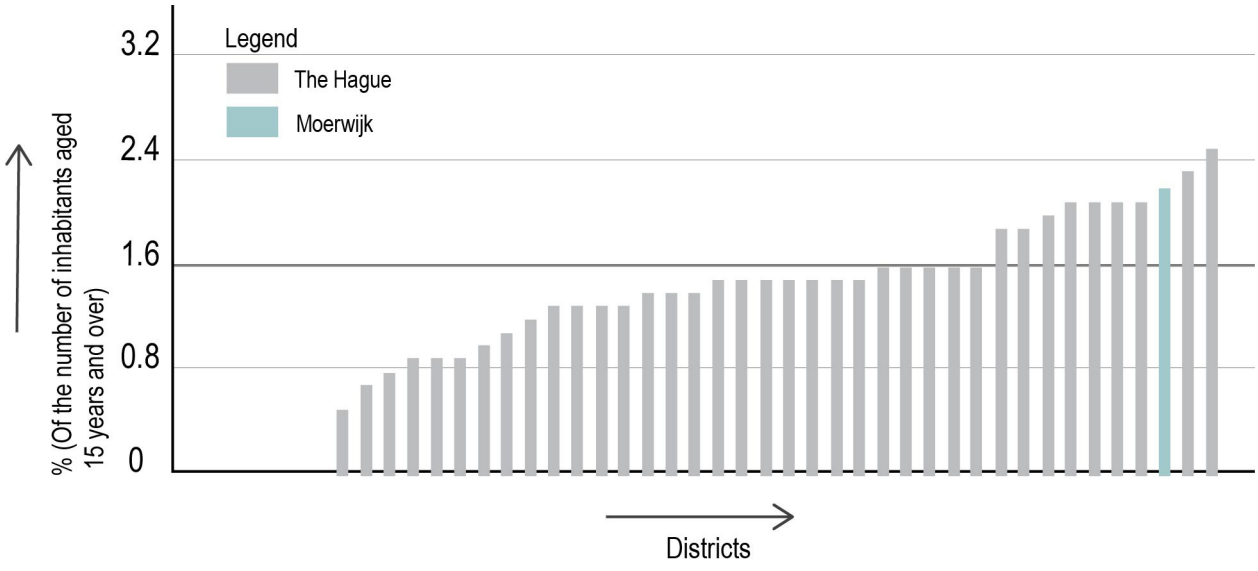


Fig 56 Share of persons receiving unemployment benefits.
Source: Reproduced by author (Gemeente Den Haag, 2020).

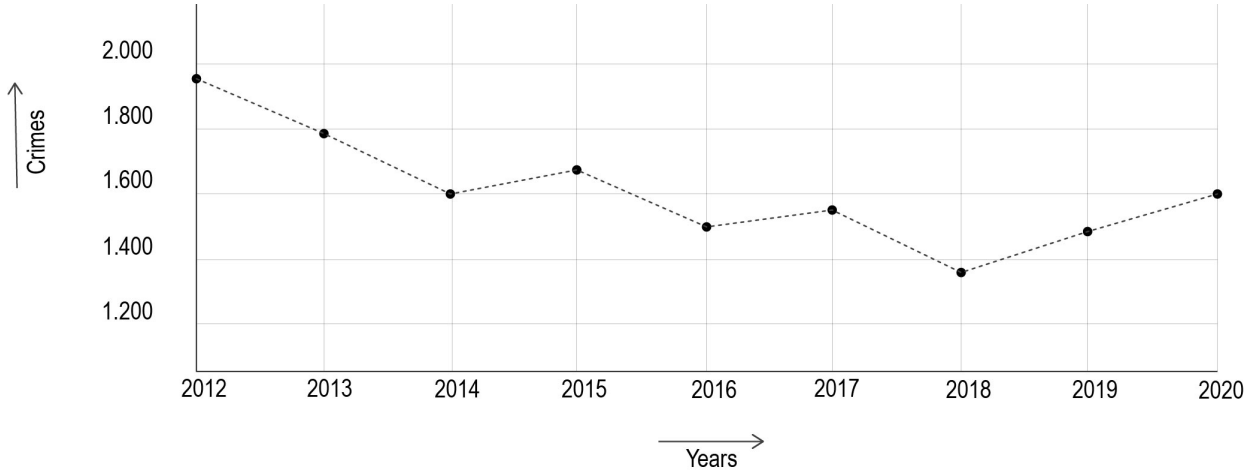


Fig 57 Development of total crimes in Moerwijk.
Source: Reproduced by author (Politie Haaglanden, 2020).

In 2020, there were 1,597 crimes and 2,231 reports of nuisance in Moerwijk. Compared to other neighbourhoods, this number is high (Politie Haaglanden, 2020). The housing cooperations are trying to reduce these crimes and the nuisance reports by completely sealing everything that belongs to the houses off from the public space. Residents try to shield themselves from the street by keeping the curtains closed. These interventions make the boundary between public and private space very strong.

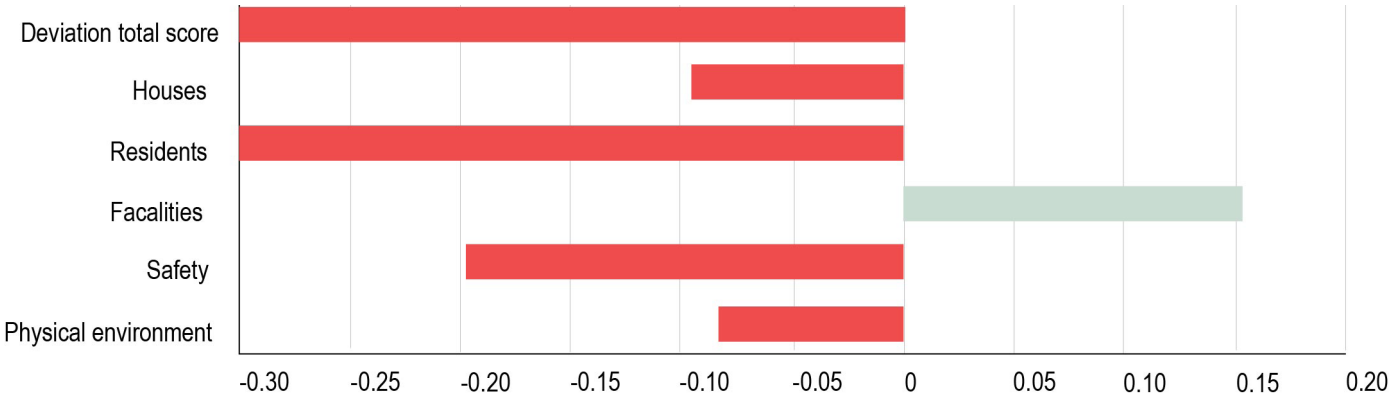


Fig 58 Leefbaarometer score of Moerwijk.
Source: Reproduced by author (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, n.d.-b).

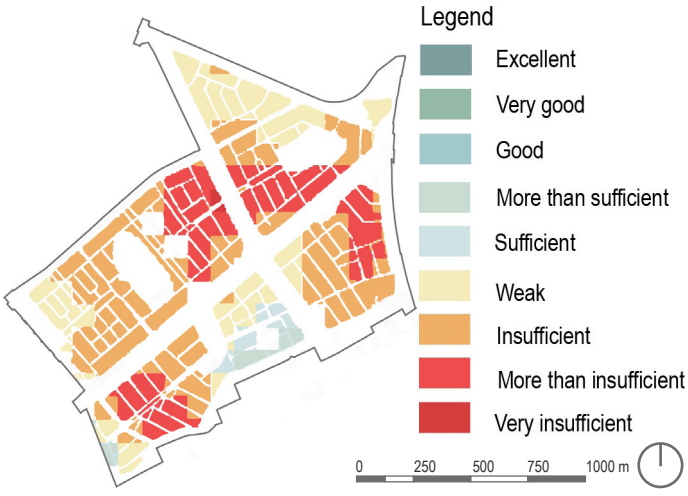


Fig 59 Leefbaarometer of Moerwijk.
Source: Reproduced by author (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, n.d.-b).

Based on the statistics, Moerwijk is a problem neighbourhood with a lot of potential for improvement. Figure 58 shows that residents also rate the neighbourhood negatively in terms of liveability. They score negatively on the components housing, residents, safety and physical environment.
The houses attract certain residents. There are currently no opportunities for advancement, residents who earn more money will have to leave the neighbourhood and low-income households will return. This puts the neighbourhood in a negative spiral.
The area that scores poorly on heat stress scores more than adequately on liveability. Safety, housing and the physical environment are better here than in the rest of Moerwijk and are more important for the residents of Moerwijk than their thermal comfort.

3.3 STAKEHOLDER ANALYSIS

The main stakeholders can be categorised in governance, the private sector and civil society. A distinction is also made here how important the stakeholders are in relation to the thesis.
The stakeholders and their relationship between the heat stress problem and the densification were also analyzed.

It is clearly visible that the private sector is mainly focused on densification and should therefore probably become more interested in the heat stress problem.
The primary and secondary stakeholders will be further explained with their needs and interests.

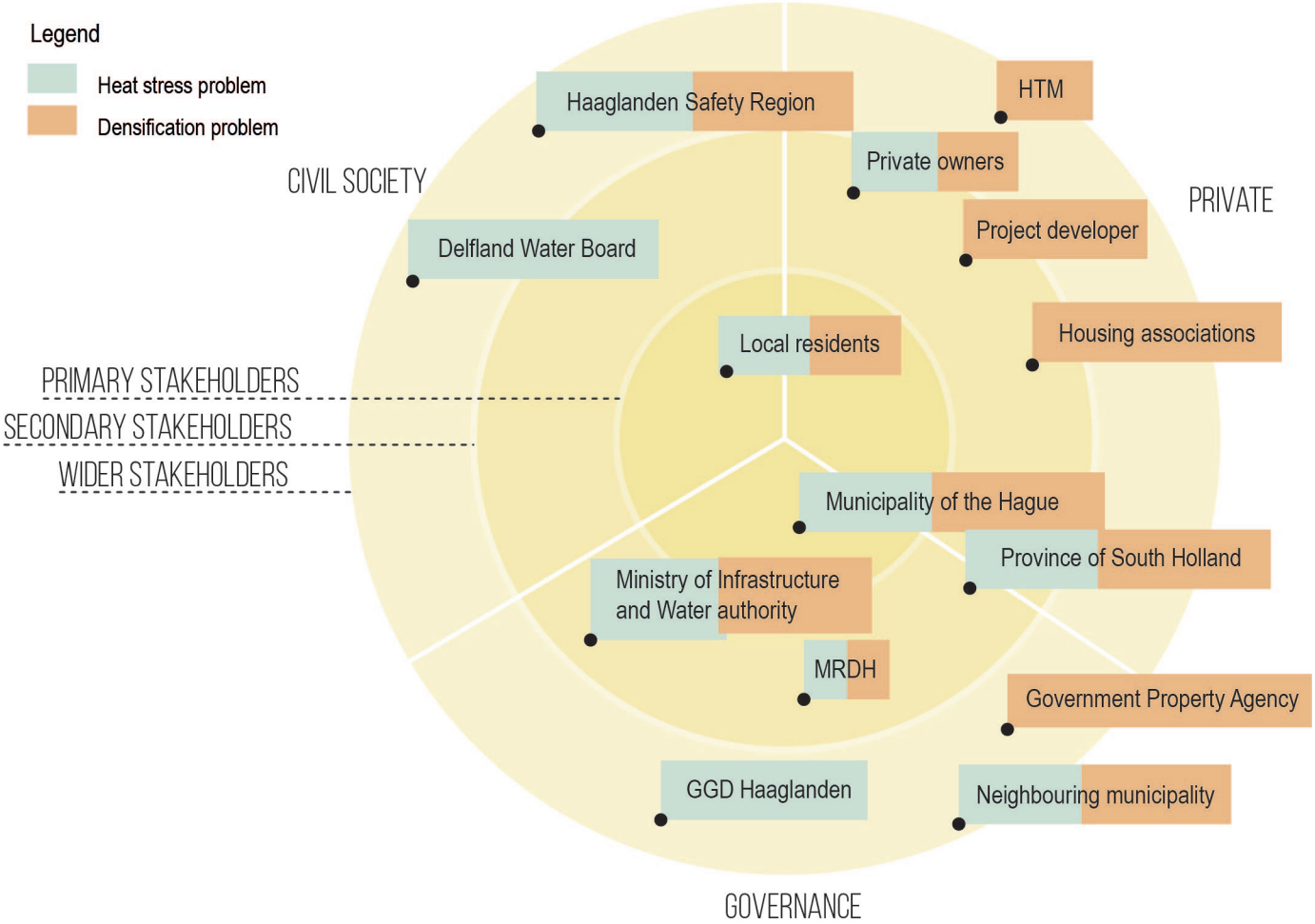


Fig 60 Stakeholder involvement diagram. Stakeholders were found by looking at reference projects of the municipality of The Hague on densification and area development.
Source: Produced by author (Cieraad et al., 2020) (Gemeente Den Haag, 2016b).

GOVERNANCE

THE MUNICIPALITY OF THE HAGUE

Service, education, culture and welfare (OCW)	Social affairs service and employment projects (SZW)	Public Affairs Department (DPZ)	City Management Department (DSB)
Urban Development Service (DSO)	Management service (DBV)	Administration (BSD)	Municipal accounts department (GAD)

Fig 61 The various departments of the municipality of The Hague.
Source: Produced by author (Gemeente Den Haag, 2021f).

THE MUNICIPALITY OF THE HAGUE

The municipality of The Hague is strongly involved in this project. The municipality of The Hague is a large organisation with many departments. When densifying a neighbourhood, nearly all departments have to work together with their own expertise. Currently, the Urban Development Department will have the largest share in this project (Gemeente Den Haag, 2021b).

Their interests are as followed:
- Strengthen spatial qualities in public spaces and buildings (Connekt, n.d).
- Increasing the supply of housing with a view to sustainability (Connekt, n.d).
- Improve accessibility to the region and European cities (Connekt, n.d).

MRDH

The MRDH is the metropolitan region of Rotterdam The Hague that consists of 23 municipalities to strengthen the economic climate for settlement and to improve accessibility. Some topics, such as living, working, digitalisation, traffic and sustainability, go beyond municipal boundaries (MRDH, n.d.).

Their interests are:
- Good accessibility by rail, road, water and innovative mobility services to continue to function as a transport region (MRDH, n.d.)
- Renewing the economy to boost employment (MRDH, n.d.)

MINISTRY OF INFRASTRUCTURE AND WATER AUTHORITY

This ministry is committed to an accessible, safe and liveable Netherlands. They ensure a good quality of water, soil and air and realise a circular economy (Rijksoverheid, n.d.).

Their interests are:
- Good accessibility by rail, road, water and air which has no negative impact on the quality of water, soil or air (Rijksoverheid, n.d.).

THE PROVINCE OF SOUTH HOLLAND

Computerisation and Automation department	Facility management department	Commissioning department	Audit and Advisory Unit
Financial and legal affairs department	Personnel and Organisation department	Communication department	Spatial Planning, Housing and Grounds department
Commissioning department	Development and land affairs department	Department of Administration	Society and economy department
Projects and programmes department	Infrastructure Management Service	Water and green space department	Mobility and environment department

Fig 62 The various departments of the province of South Holland (Pronvincie Zuid-Holland, 2020).
Source: Produced by author.

The province of South Holland, like the municipality of The Hague, is an organisation with a great many departments working together. The Department of Spatial Planning, Housing and Grounds will have the most input in this project .

Their interests are:
- Accelerating housing construction and enhancing the quality of space (Provincie Zuid-Holland, n.d.),
- Increasing green structures for a healthy and attractive settlement area (Provincie Zuid-Holland, n.d.).

PRIVATE

HOUSING ASSOCIATIONS

There are a total of 15 rental corporations operating in The Hague. The corporations are united in “Vereniging Sociale Verhuurders Haaglanden”. These corporations focus primarily on housing residents with low incomes (Sociale Verhuur Haaglanden, n.d.).

Their interests are:
- *Increasing the number of rental homes primarily for low-income residents (Sociale Verhuur Haaglanden, n.d.).*

PROJECT DEVELOPER

The project developer deals with the development and realisation of new building projects and is responsible for the entire process of building new homes and buildings. The process in which the developer is involved starts with the purchase of the land and ends with its completion (Qr-Quest, 2021).

Their interests are:
- *Increasing the supply of housing (Qr-Quest, 2021).*
- *Meeting the client’s requirements (Qr-Quest, 2021).*
- *Making a profit from the sale of the completed project (Qr-Quest, 2021).*

PRIVATE OWNERS

Private owners include all people who buy a house, shop or part of a building. That part of a building will be in their ownership. For this reason, these stakeholders often have the same interest as the residents explained below.

CIVIL SOCIETY

LOCAL RESIDENTS

The local residents are the residents of the neighborhood Moerwijk and mainly have interests in making the living environment and situation as pleasant as possible. The figures of the residents have shown that the residents mainly have little money, and have a migrant background (fig 53 & 54).
However, moving on within the district is difficult. Currently, 20% of the residents in Escamp’s social housing stock are living in too much space. To lower this percentage and create a balance, possibilities to move on will have to be created for residents (Gemeente Den Haag 2019a).
Residents shield themselves from the public space because they get an unsafe feeling because of the high crime rate and the poor maintenance of the houses. Residents also feel that the public space is in poor condition. The public areas are littered with food waste and the street is too unsafe for children to play in (Gemeente Den Haag 2016).

Their interests are:
- *Improving the physical and social living environment in terms of aesthetic, practical and sustainable aspects without having to make any investments (Gemeente Den Haag, 2016).*
- *Improving homes in terms of asthetics and safety without having to make any investments (Gemeente Den Haag, 2016).*
- *Offer flow-through opportunities for better housing (Gemeente Den Haag, 2016).*

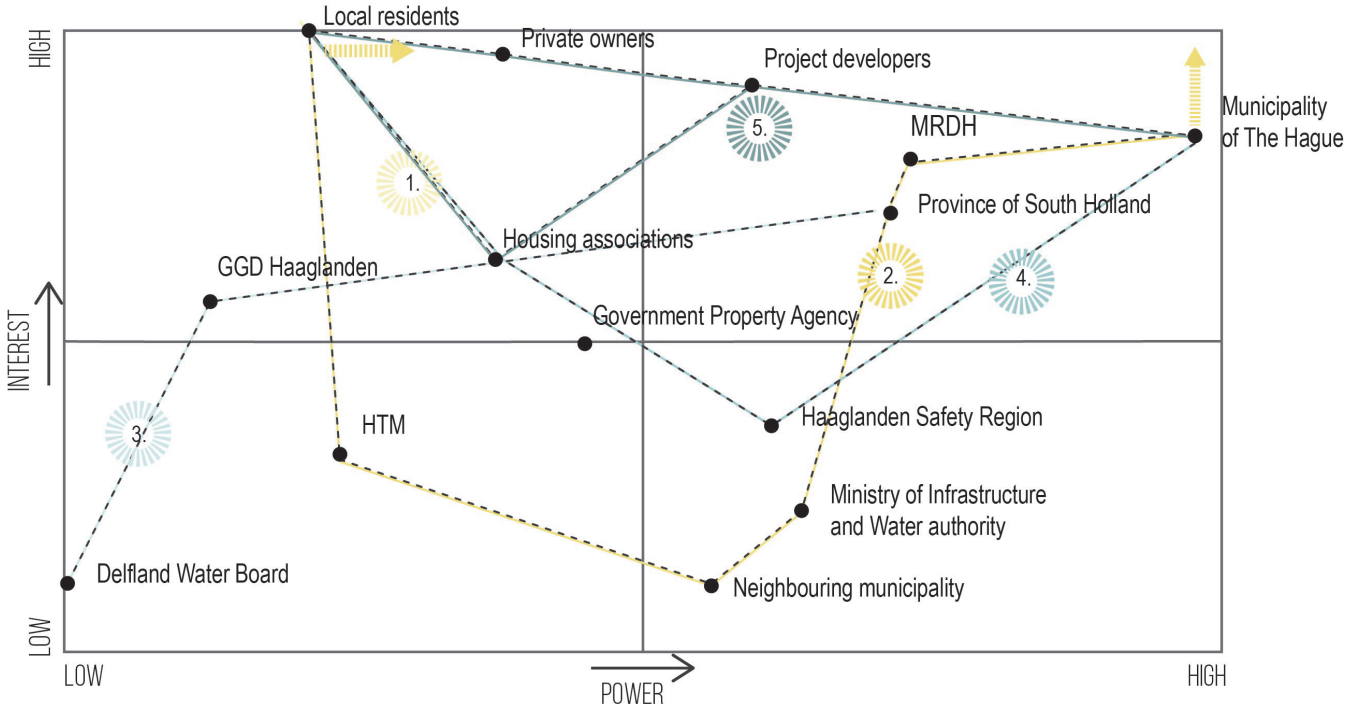


Fig 63 Stakeholders in power intest diagram.
Source: Produced by author.

POWER VS INTEREST

In power interest diagram (fig. 63) it can be seen that mainly the governance stakeholders are strongly involved in the project. It is therefore important to involve stakeholders with a high interest and a low power more in the project in order to achieve a better balance.
The two primary stakeholders are the local residents and the municipality of The Hague. The local residents are connected to many stakeholders but have little power to exert influence. While they are the stakeholder who ultimately experience the area development positively or negatively. The municipality of The Hague, on the other hand, has a lot of power to influence the development of the area. However, the municipality consists of many departments that operate independently of each other. As a result, not all departments are on the same wavelength, which affects the interest in the heat stress and densification problem. The municipality is also bound by legislation. And it only owns 30% of the land in The Hague, the rest is private and must therefore be discussed with other stakeholders (Information gathered from Jack Amesz from Municipality of the Hague). Based on the interest, there is also a relationship between different stakeholders.

1. Local residents and housing cooperatives both want a larger supply of cheaper housing. The municipality of The Hague has determined that 30 percent of newly built houses must be social housing (Gemeente Den Haag, 2019a). The supply of affordable housing in the Moerwijk neighbourhood is 74% social rent, which is already high. This gives current residents opportunity to move on to better houses in the neighbourhood.
2. For the governance stakeholders, maintaining the reputation as a transport region is important. In doing so, the accessibility with surrounding cities and areas must be improved. At district level, this means that public transport facilities and infrastructure have been realised in the district. This can have a negative effect on the thermal comfort due to the higher percentage of paved surfaces.
3. Thirdly, there are stakeholders who are more concerned with the liveable environment and the health of the residents. Green structures and an improved environment are key elements here. These green structures also contribute to the thermal comfort problem in the Moerwijk.
4. Local residents have indicated that they feel unsafe in the neighbourhood because of the high crime and nuisance rates. As a result, housing cooperatives have strongly closed off private spaces from the public domain. This has a negative effect on the reputation of the neighbourhood.
5. Due to the housing shortage, the municipality of The Hague, project developers and housing cooperations will have to discuss increasing the supply. Some of these houses will be sold on to private owners or will remain in the supply of the housing cooperative for social tenants.

Moerwijk scores poorly in certain areas. This photo illustrates the current image of the neighbourhood. A burnt down building that stands for poor quality housing, but an expensive scooter in front of the door, provides an interesting picture.

Fig 64 Picture of an an apartment building in Moerwijk.
Source: Photo taken by author.

4. DESIGN

SWOT

REFERENCE PROJECTS

PATTERN LANGUAGE

IMPLEMENTATIONS

PHASING

4.1 SWOT

The analysis is compiled in a SWOT. This contains the most important findings. Currently, there are more weaknesses in the district than strengths. This balance will have to be turned around by the design. Some points in the SWOT analysis cannot be influenced. These are mainly the opportunities and threats since the origin is external. Also the location of the district cannot be influenced. Some points in the SWOT analysis also have influence on other points. Making the housing supply more diverse will influence the value of the housing supply and the composition of the residents. The distance of the cooling locations, the shading facilities, and vegetation will also have a strong influence on the perceived temperature and heat stress. Ultimately, this will change the liveability of the neighbourhood.

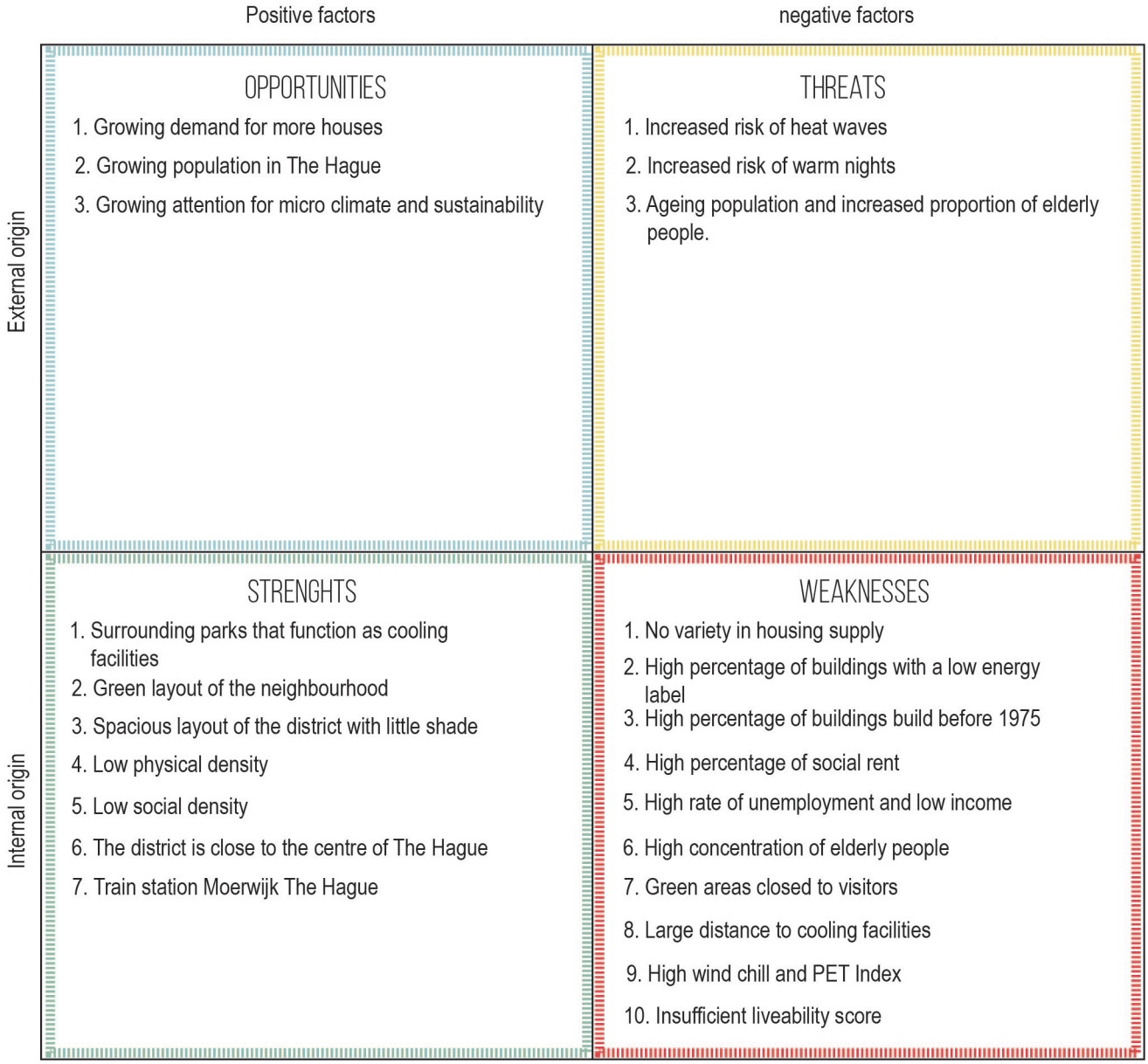


Fig 65 Conclusion of the analysis in a SWOT
Source: Produced by author.

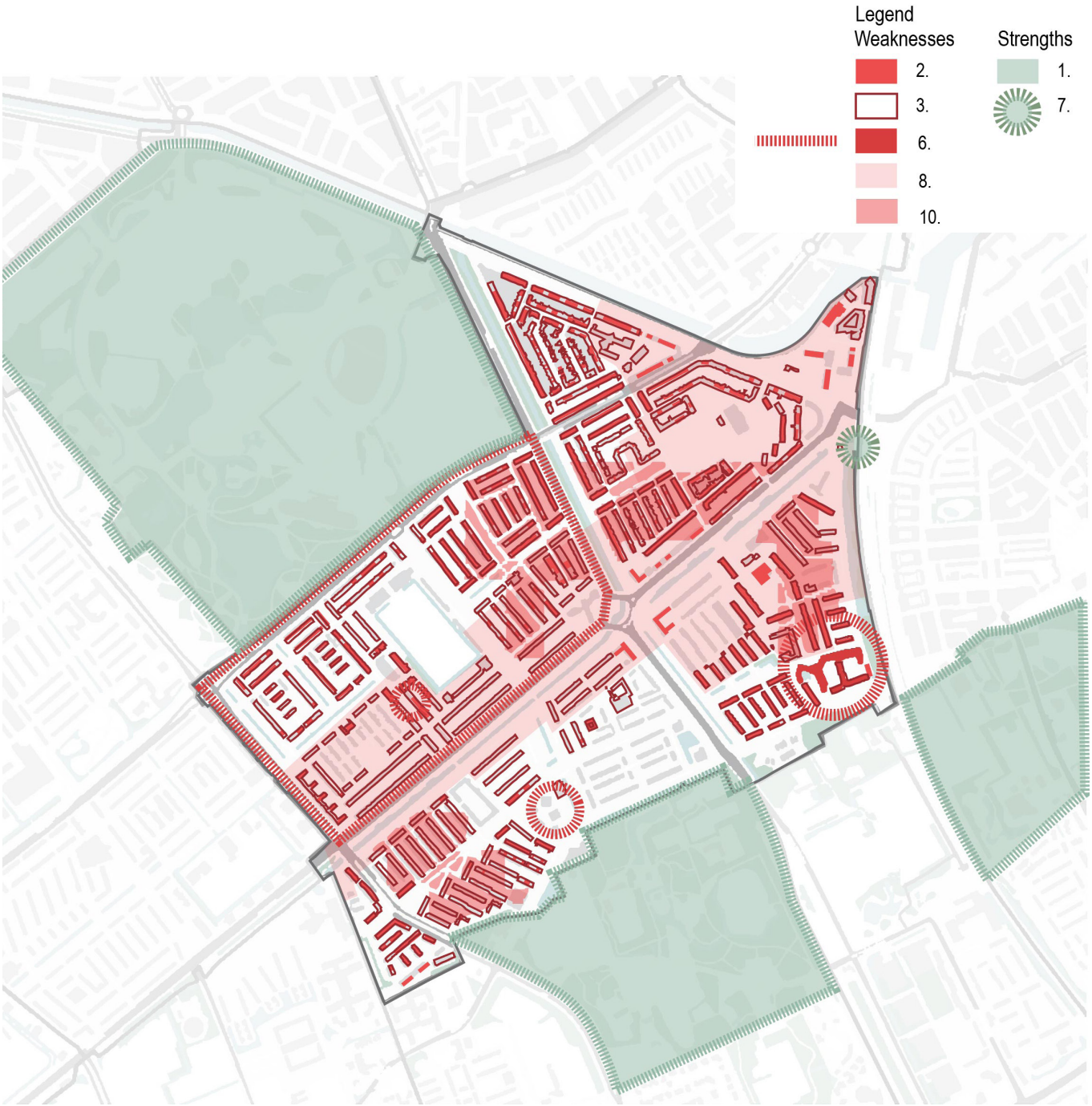


Fig 66 The physical elements in the SWOT are represented in a map
Source: Produced by author.

Not all aspects of the SWOT analysis are spatial. The opportunities and threats are not spatial and therefore cannot be represented in a map. Some of the strengths and weaknesses can be shown on a map. It is striking that the strengths of Moerwijk are mainly located outside the district. In terms of weaknesses, it can be seen that at certain locations in the district the liveability, concentration of the elderly and the energy label come together. These will be locations that deserve more attention in the design.

4.2 REFERENCE PROJECTS

PROFESSOR SCHOEMAKER PLANTAGE, DELFT

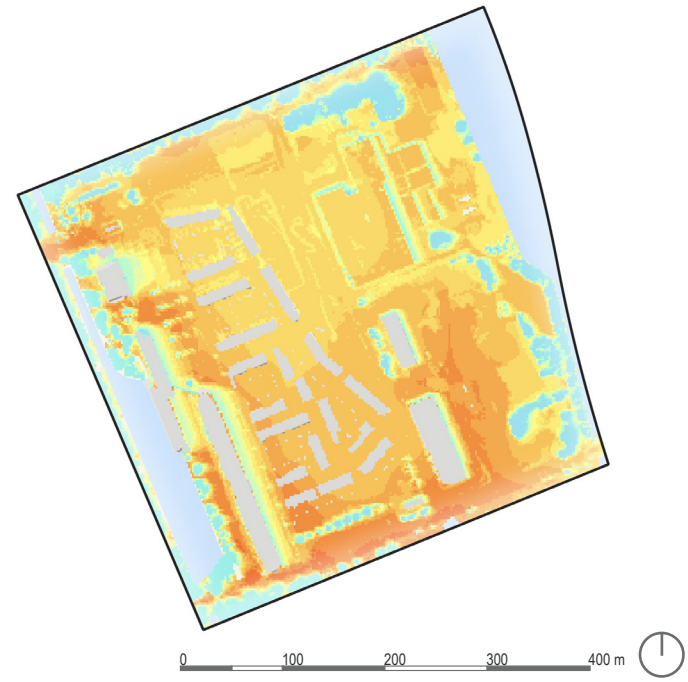


Fig 67 PET index of the Proffesor Schoemaker Plantage.
Source: Edited by author (Witteveen & Bos, 2020).

Fig 68 Guidelines against heat stress in the Professor Schoemaker Plantage.
Source: Produced by author (Bouw adaptief, n.d.).

The district focuses strongly on creating a climate-adaptive neighbourhood. The district has not yet been realised in its entirety, but already scores well on the PET-index.
The district is surrounded by water. This water cools the surrounding area and stores heat. This heat is released into the air at night, causing the city to warm up again (L. Klok & Solcerova, 2018). Figure 69 shows that the surface area of water in the future district is increased despite this disadvantage.
In the district, several interventions are made to combat water nuisance and heat stress, such as a wadi. However, this wadi will have an urban character in the district.

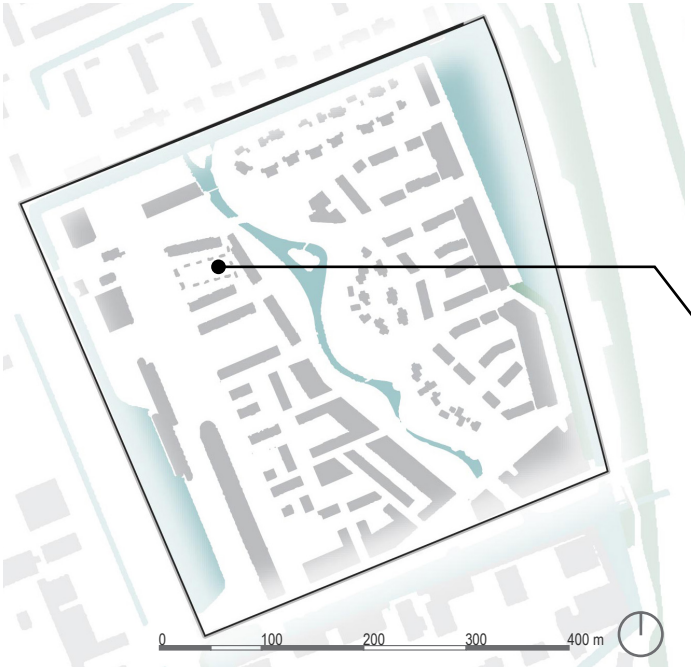


Fig 69 Layout of the Professor Schoemaker Plantage.
Source: Generated by author using GIS software, based on buildings, streets, water and green and edited by author (Bouw adaptief, n.d.).

Fig 70 Photo of a street in the Professor Schoemaker Plantage.
Source: Edited by author (Rosero, n.d.).

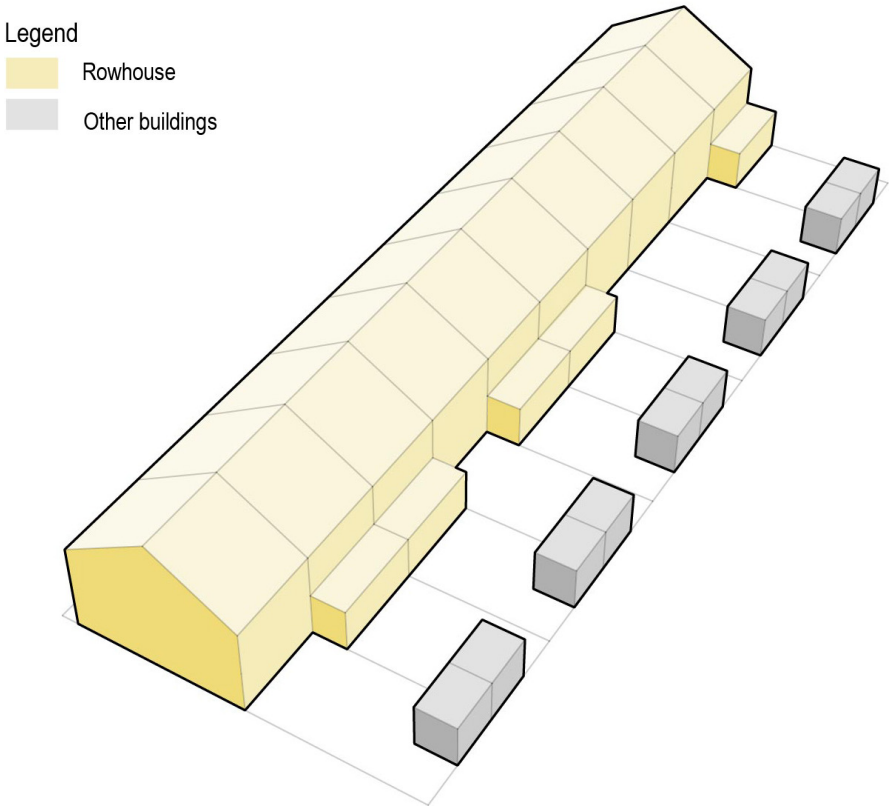


Fig 71 The housing type in the Professor Schoemaker Plantage.
Source: Produced by author.

The district consists mainly of row houses. There are some apartment buildings to increase the number of houses. The qualities of a terraced house such as the private garden can have a good effect on heat stress. However, this depends on the amount of greenery and orientation in the private back garden.

Figure 72 shows that measures have been taken against heat stress at the residential level, but also on a larger scale through surface water.

Fig 72 Photo of a part of the district of the Professor Schoemaker Plantage.
Source: Edited by author (Rosero, n.d.).

SLOTERDIJK CENTRUM, AMSTERDAM

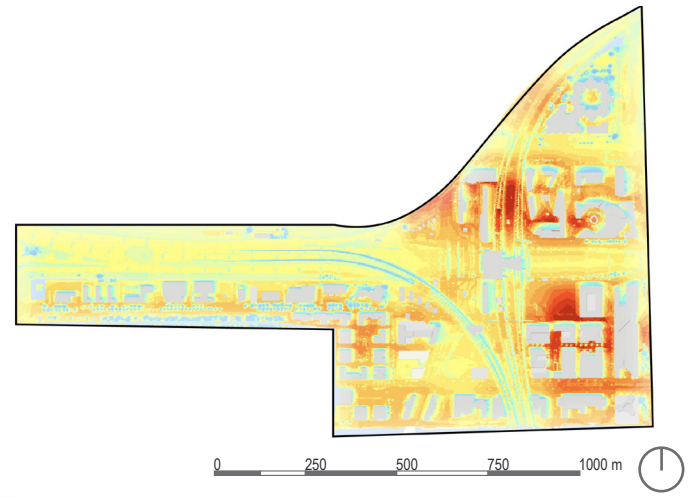


Fig 73 PET index of Sloterdijk Centrum.
Source: Edited by author (Witteveen & Bos, 2020).

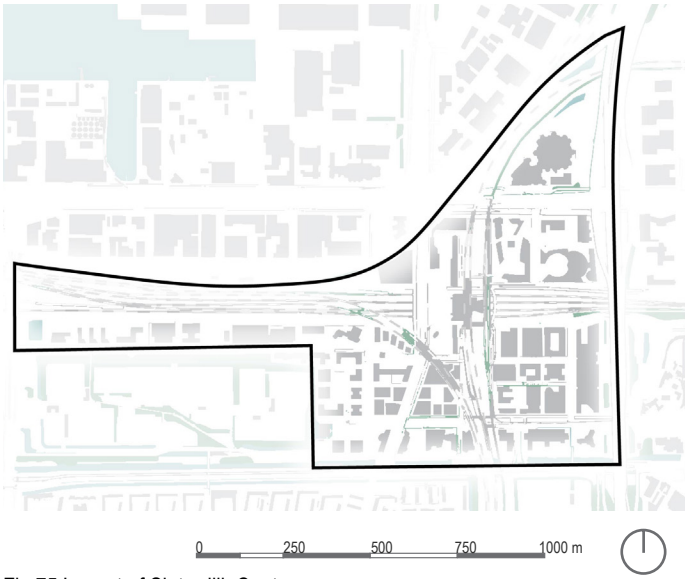


Fig 75 Layout of Sloterdijk Centrum.
Source: Generated by author using GIS software, based on buildings, streets, water and green and edited by author (Krabbenborg, 2018).

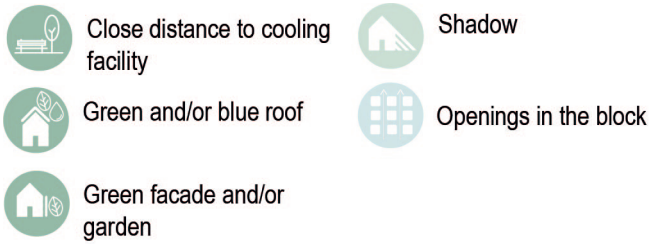


Fig 74 Guidelines against heat stress in Sloterdijk-Centrum.
Source: Produced by author.

Amsterdam Sloterdijk is to become a new centre for offices, housing and recreation in Amsterdam. The district will contribute to accessibility, greenery, sustainability, densification and completeness. Greenery will be the most important aspect of the district.
The district will therefore consist of various neighbourhoods, each with its own character. In these neighbourhoods, a mix of functions will be important in order to achieve a good balance between living and working.

Fig 76 Impression of the future in Amsterdam Sloterdijk.
Source: Edited by author (Vertical, n.d.)...

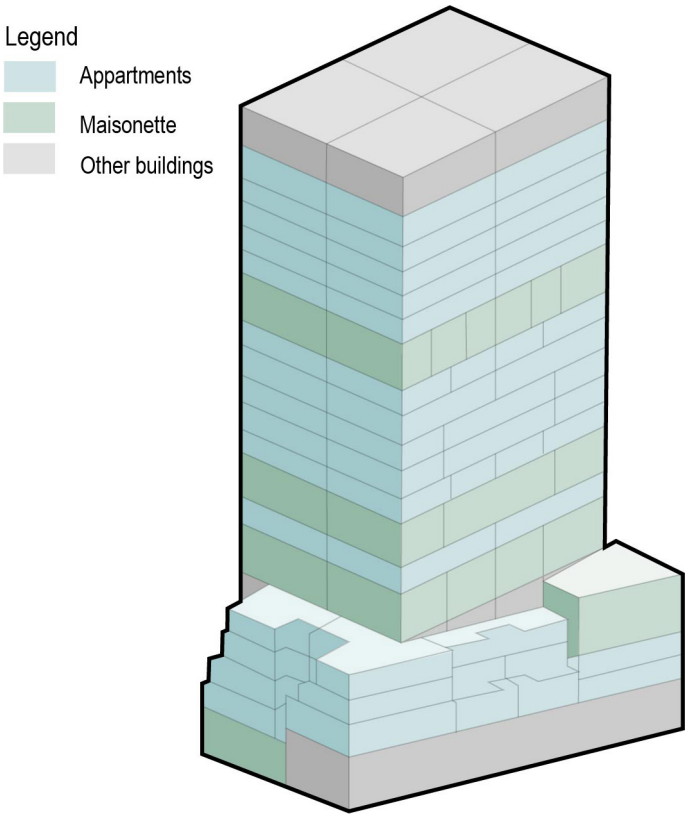


Fig 77 Building Vertical with several types of housing in 1 building. .
Source: Reproduced by author (Krabbenborg, 2018).

The neighbourhood consists of small blocks, which ensures that the wind can flow between the buildings, and because the high-rise stands on a platform, the microclimate on the ground floor remains pleasant.
The most important aspect of the new district is green space. Due to the high density of buildings, there is little room for greenery at ground level. For this reason, the buildings themselves are provided with greenery through green roofs and green facades.
The Vertical building has greenery on its roofs and facades, and because of the high-rise, this building provides a lot of shade at ground level. These interventions of the building ensure a lower heat stress level and a lower urban heat island effect. Another special aspect is the different housing types in the building (fig. 77). This building ensures that residents can live in a high-rise but still experience the qualities of a single-family home with a private garden (fig. 78). In this way, the public space is cooled by the buildings and not by the neighbourhood itself.

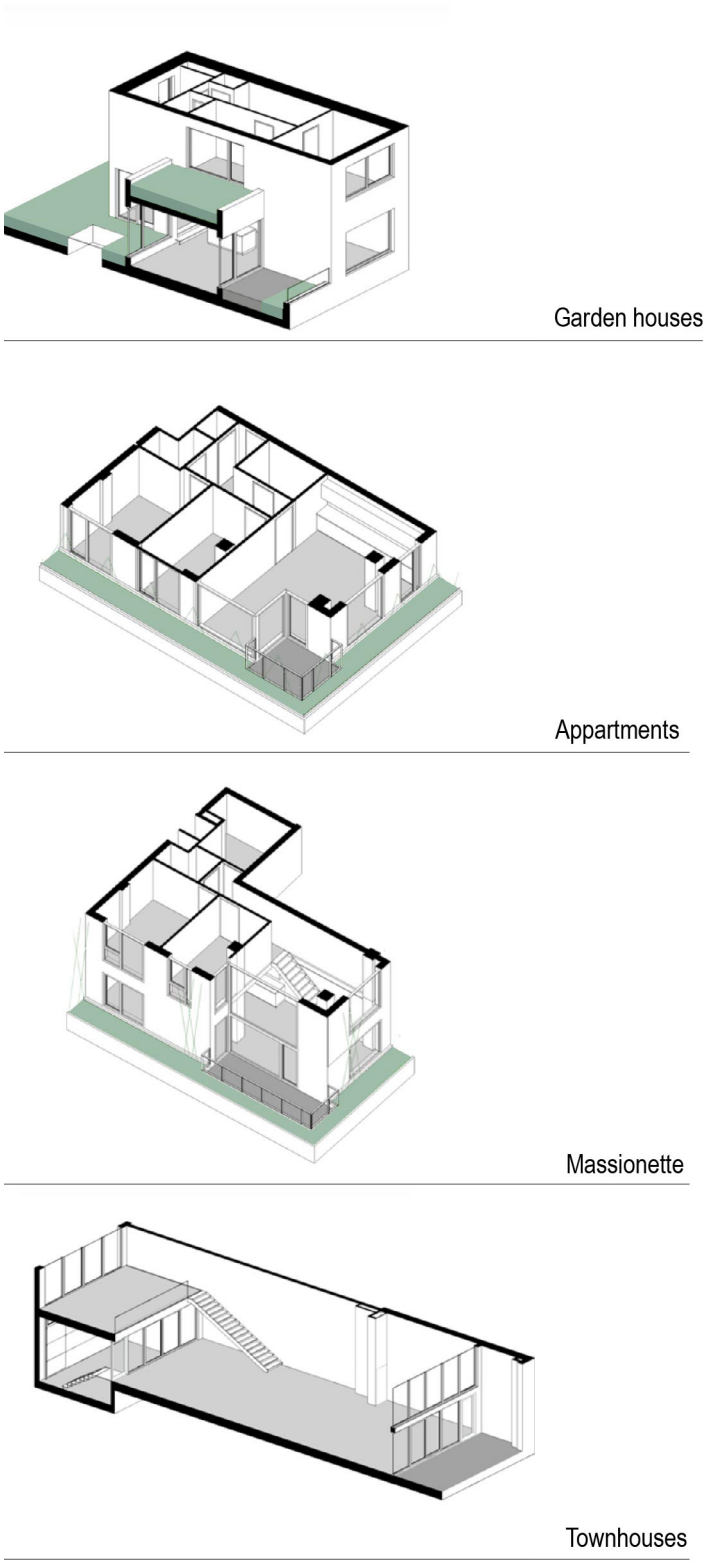


Fig 78 Different types of houses in the Vertical building.
Source: Edited by author (Krabbenborg, 2018).

SUPER BLOCK, AMSTERDAM

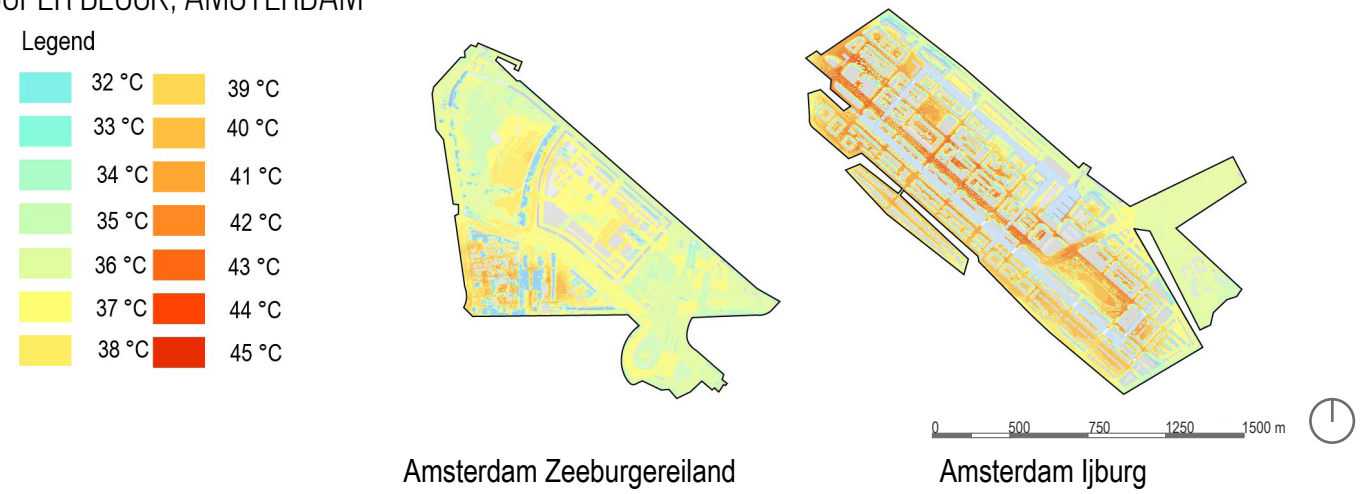


Fig 79 PET index of Amsterdam Zeeburgereiland and Ijburg.
Source: Edited by author (Witteveen & Bos, 2020).

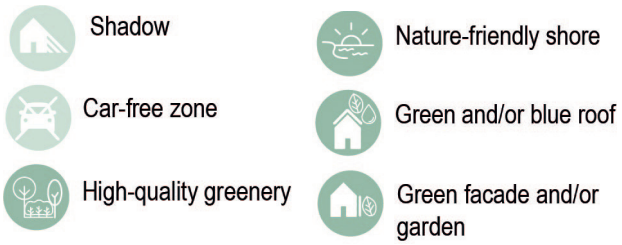


Fig 80 Guidelines against heat stress in the super block in Amsterdam.
Source: Produced by author.

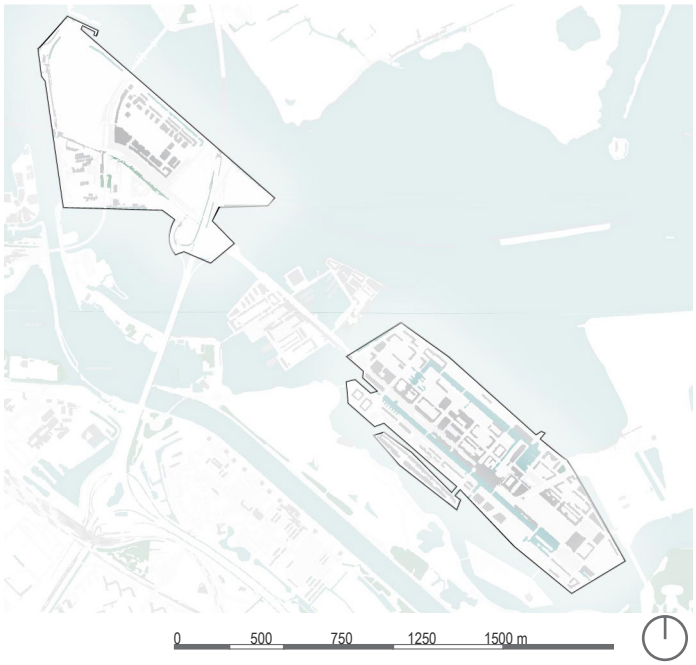


Fig 81 Layout of Ijburg en Zeeburgereiland.
Source: Generated by author using GIS software, based on buildings, streets, water and green.

IJburg and Zeeburgereiland are two islands on the edge of Amsterdam's city centre that use sustainability interventions to create a pleasant living environment. It can be seen that in figure 79, Zeeburgereiland certainly scores well on the PET index. In Amsterdam, the super block principle has been applied on IJburg and Zeeburgereiland. This principle has also been applied in Barcelona, where it has proven to be an effective intervention against heat stress. This was effective because this intervention is easy to combine with other interventions such as greenery. The space will no longer be accessible to cars, leading up to a lot of empty space that can be filled with other interventions.

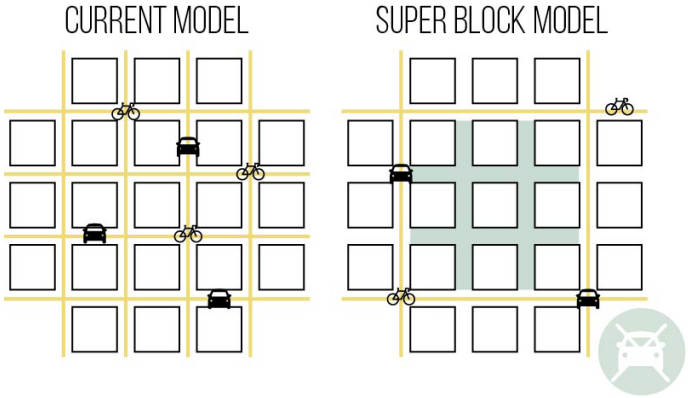


Fig 82 The principle of the super block in Barcelona.
Source: Reproduced by author (Ajuntament de Barcelona, 2014).

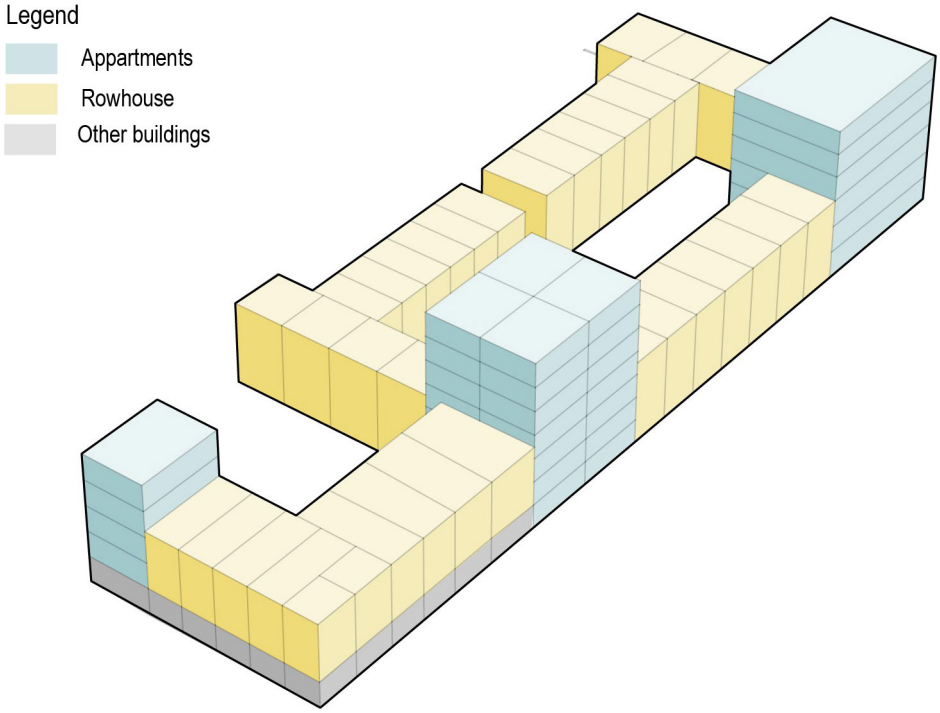


Fig 83 The housing type of a building in Amsterdam Ijburg.
Source: Produced by author.

In IJburg there are many closed building blocks that combine terraced houses and flats (fig. 83). Also, functions such as shops on the ground floor are combined with terraced housing above. The terraced houses on the ground floor have a private garden. The space between the private gardens is a communal garden. This creates a fine public space with different sizes of public and private interspersed.

In Zeeburgereiland, mainly flat houses are used with a lot of space between the flats (fig. 84). This can cause wind nuisance, but also a lot of public space for the residents.

Fig 84 Houses in Zeeburgereiland
Source: (Terrazza, n.d.).

INTERVENTIONS AGAINST HEAT STRESS

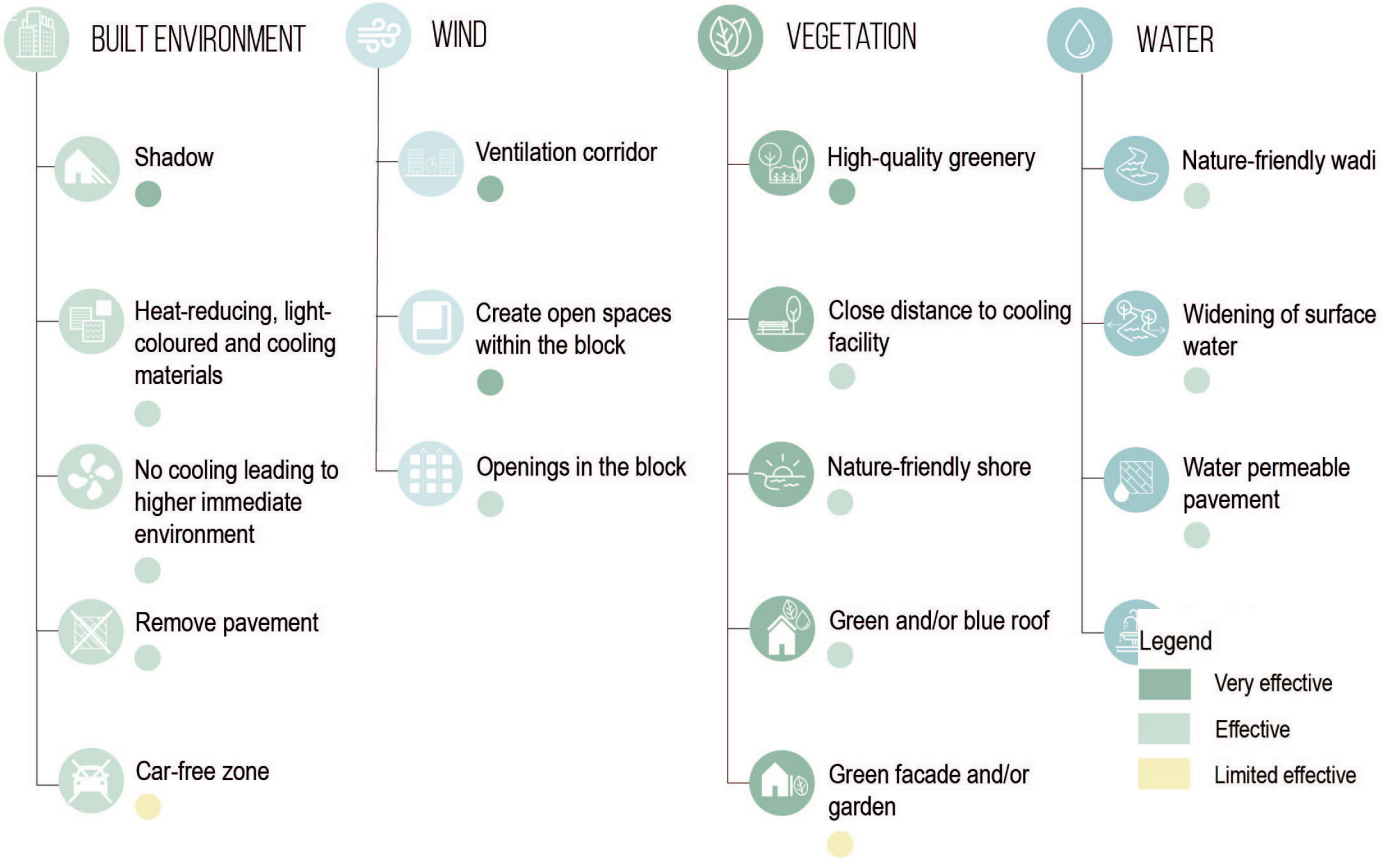


Fig 85 Design interventions against heat stress
Source: Produced by author using references and analys (Ajuntament de Barcelona, 2014), (Bouw adaptief, n.d.), (Kluck et al., 2020), (Krabbenborg, 2018), (Yang & Fu, 2019).

By combining the interventions from the references with new analysis, a list of interventions that help combat heat stress has emerged. These interventions have been categorised into four themes: the building environment, wind, vegetation and water. The interventions within the category have also been ranked in terms of their effectiveness. Interventions with a high effectiveness will therefore have a higher priority than interventions with a low effectiveness when making decisions.
The car-free zone and the private garden have been given a moderate effectiveness rating because these interventions can be very effective in combination with another intervention, such as high quality green space, but do not do much against heat stress on their own.

4.3 PATTERN LANGUAGE

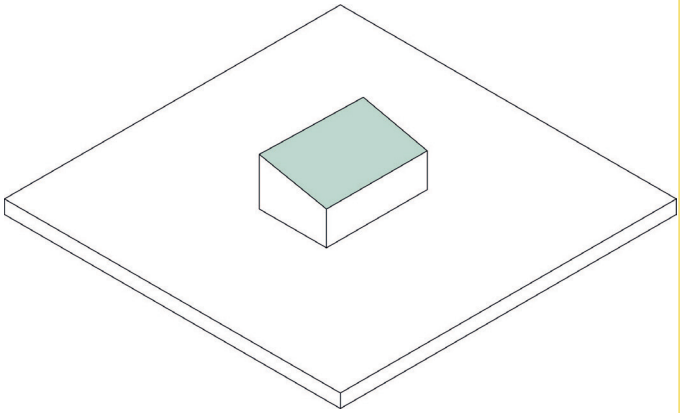
The pattern languages were chosen because it was difficult to make a smooth transition between analysis and design. The pattern languages is a method for bridging this gap between analysis and design, and for seeing relationships between different patterns. The relationship between patterns is important because patterns reinforce each other, weaken each other, can coexist or not (Croxford et al., 2020). The patterns emerged from the analysis of Moerwijk and the references of other neighbourhoods. These reference projects use interventions to combat heat stress. This has resulted in a list of heat stress interventions and this list has been transformed into patterns. Other patterns originate from a literature analysis (Pötz, 2016) (Yang & Fu, 2019).

An example for the pattern languages is figure 86. All patterns are listed in detail in the appendix. Each pattern consists of a title, diagram, hypothesis, context, practical implementations, relations, effectiveness and references. The diagram and the hypothesis show what the pattern is about with the context giving more background information.
Each pattern has several practical implementations which will be named later. This gives possibilities to apply certain patterns in different ways in practice, and to connect with other patterns by looking at the relations and making combinations.
To be able to make a choice in the priority of the patterns, effectiveness has also been applied here.

H. 3 HEAT REDUCING ROOFS

HYPOTHESIS

Intensive use of roofs to cool the indoor and outdoor climate.



CONTEXT

Due to the lack of space in cities, it is important that roofs are used intensively to improve the microclimate. Through the evaporation of water on roofs or their high reflective capacity, the roofs cool the outdoor space and the spaces under the roofs. This reduces the need for cooling in buildings. The roofs can also function as extra outdoor space by applying intensive green roofs.

PRACTICAL IMPLICATION

- Extensive green roof
- Intensive green roof
- Roofs with cool materials
- Water roof
- Tropical roof in combination with a collector roof

RELATIONS

H.2, H.4, H.5

REFERENCES

Pötz, H., & Bleuze, P. (2012). Groenblauwe netwerken voor duurzame en dynamische steden/Urban green-blue grids for sustainable and dynamic cities (1st ed.). Coop For Life.

EFFECTIVENESS

Heat stress / cooling effect:
Density:

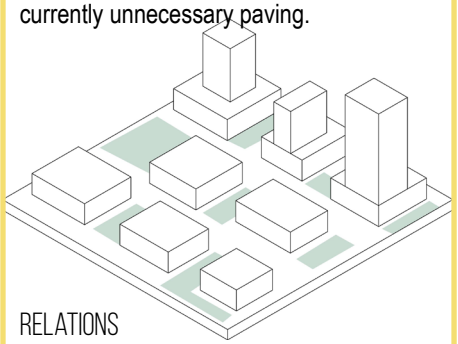
Fig 86 Example of the pattern language.
Source: Produced by author.

4.3.1 HEAT STRESS

The different patterns are split into two themes that have been seperated from each other throughout the entire process. “Heat stress” and “densification”.
These 17 patterns are based on the list of interventions that followed from the referencing projects and the literature analysis that was carried out (Pötz, 2016) (Yang & Fu, 2019).

H. 1 CREATING GREEN AREAS

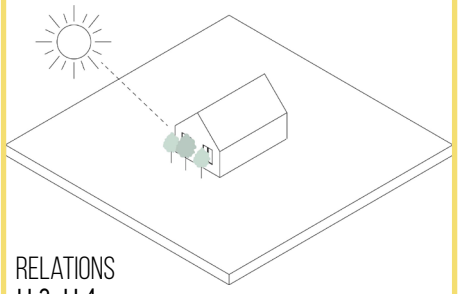
HYPOTHESIS
Increasing the percentage green spaces in the city by creating and improving small green areas in locations where there is currently unnecessary paving.



RELATIONS
H.6, H.7, H.8, H.9, H.16

H. 2 SUN PROTECTION THROUGH GREENERY

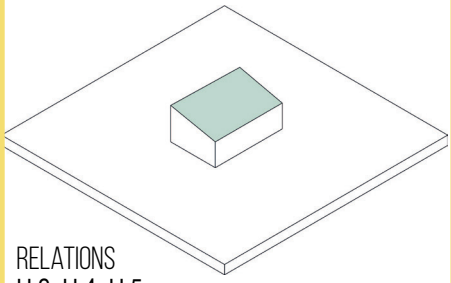
HYPOTHESIS
Strategically placed vegetation that function as sun protection.



RELATIONS
H.3, H.4

H. 3 HEAT REDUCING ROOFS

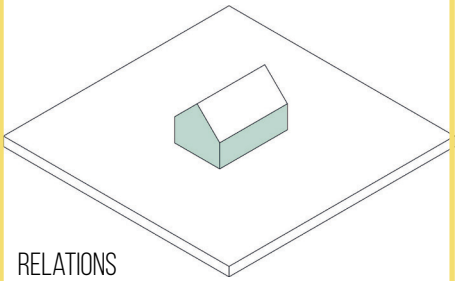
HYPOTHESIS
Intensive use of roofs to cool the indoor and outdoor climate.



RELATIONS
H.2, H.4, H.5

H. 4 GREEN FACADES

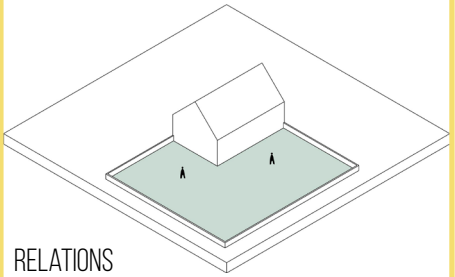
HYPOTHESIS
Intensive use of facades to cool the indoor and outdoor climate.



RELATIONS
H.2, H.3, H.5

H. 5 PRIVATE GREEN GARDENS

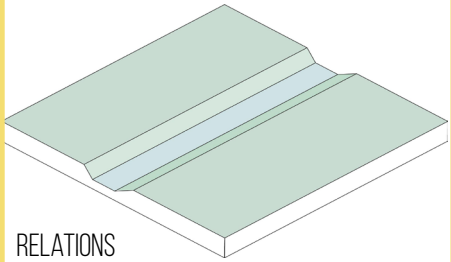
HYPOTHESIS
Private gardens with no more than 20% paving for a cool outdoor environment.



RELATIONS
H.3, H.4, H.8

H. 6 GREEN BANKS

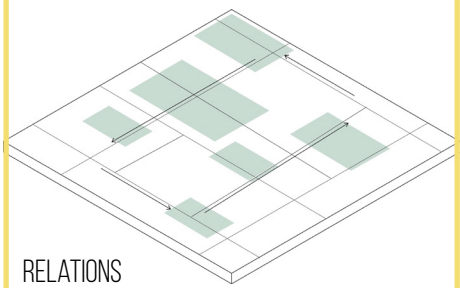
HYPOTHESIS
Nature- friendly banks that form a gradual transition from land to water and have a cooling effect on the surroundings.



RELATIONS
H.1

H. 7 GREEN GRID

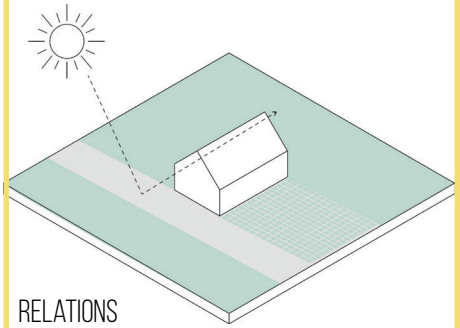
HYPOTHESIS
A grid of parks and small green areas that form pleasant cooling zones for surrounding residents.



RELATIONS
H.1, H.16

H. 8 COOL PAVING MATERIALS

HYPOTHESIS
Use of cooling hardening materials to reduce the ambient temperature.

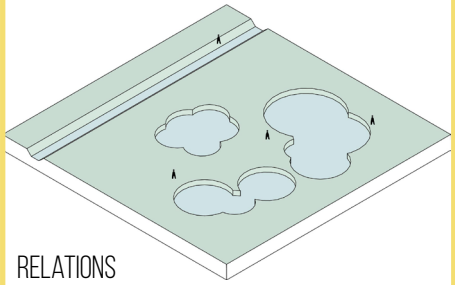


RELATIONS
H.1, H.5

Fig 87 Patterns for combating heat stress.
Source: Produced by author.

H. 9 COOLING WITH WATER

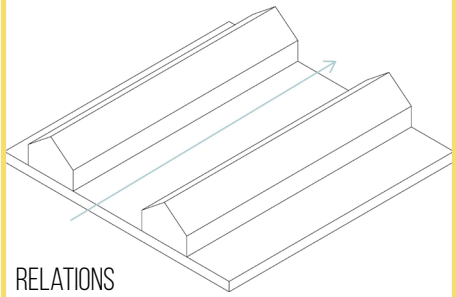
HYPOTHESIS
Evaporation of water that has a cooling effect on the immediate surroundings.



RELATIONS
H.1

H. 10 VENTILATION CORRIDOR

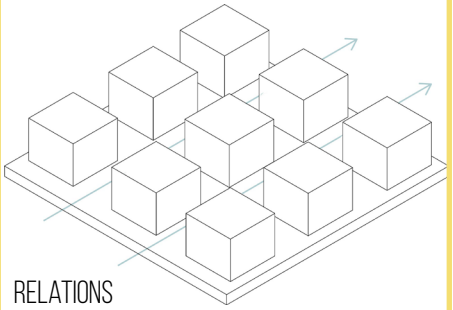
HYPOTHESIS
Large open spaces in the city can be cooled by the air flows of the wind.



RELATIONS
H.11, H.15

H. 11 AIRFLOW CIRCULATION

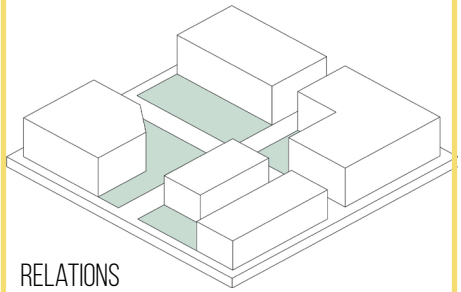
HYPOTHESIS
Small blocks provide a circulation path for wind to pass through for ventilation on a pedestrian level.



RELATIONS
H.10, H.12, H.15, H.16

H. 12 OPEN SPACES

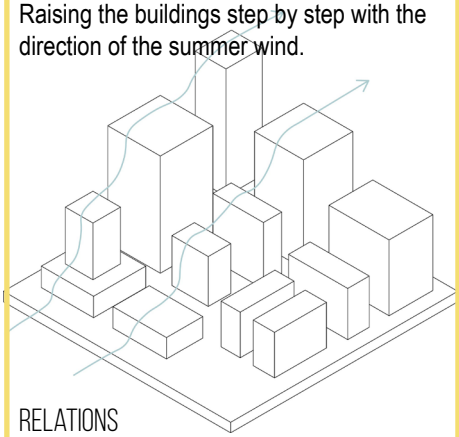
HYPOTHESIS
A maximum of 65% of the block can be built on, leaving open spaces. These open spaces must be placed so that airflow between the buildings is possible.



RELATIONS
H.11, H.15, H.16

H. 13 LADDER TYPE BUILDINGS

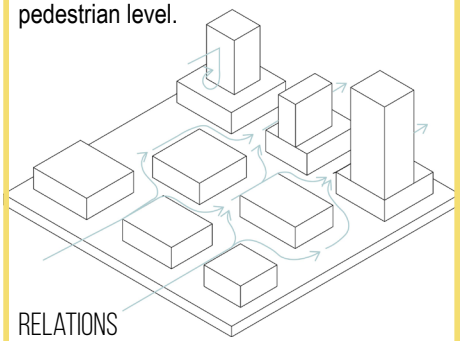
HYPOTHESIS
Raising the buildings step by step with the direction of the summer wind.



RELATIONS
H.14, H.17, D.1

H. 14 STAGGERED ARRANGEMENT OF BUILDINGS

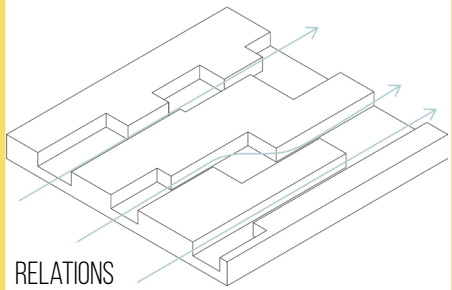
HYPOTHESIS
With staggered arrangement of buildings, and podiums, air flow can ventilate and provide a comfortable environment at pedestrian level.



RELATIONS
H.13

H. 15 VENTILATION GRID

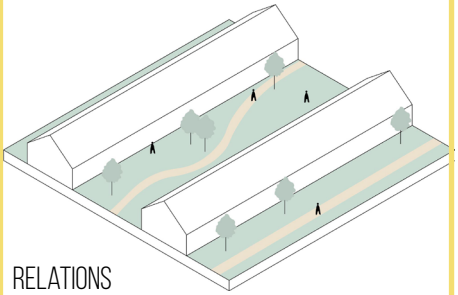
HYPOTHESIS
The orientation of buildings and open spaces allows the wind to ventilate at pedestrian level.



RELATIONS
H.7, H.10, H.11, H.12

H. 16 CAR FREE ZONES

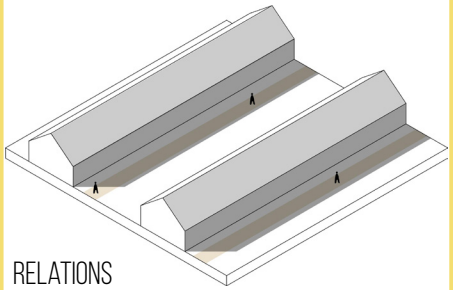
HYPOTHESIS
Use superblocks by increasing the size of the block to make streets accessible only to slow traffic, and create possibilites to combine it with other patterns



RELATIONS
H.1, H.11, H.12

H. 17 SHADOW

HYPOTHESIS
Shade to reduce surface during hot periods.



RELATIONS
H.2, H.13, D.1

Fig 88 Patterns for combating heat stress.
Source: Produced by author.

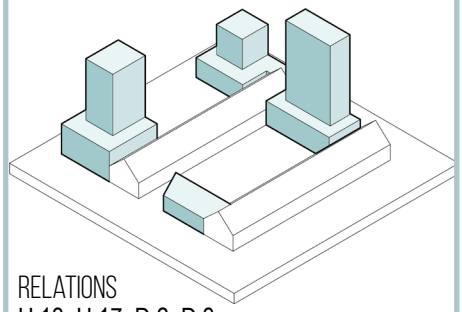
4.3.2 DENSIFICATION

For densification, it is mainly important that the wishes of future residents and current residents are taken into account.

D. 1 CREATING MORE HOUSES

HYPOTHESIS

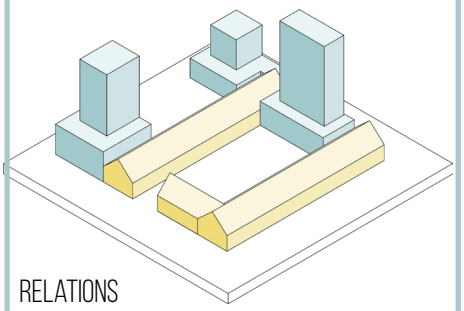
Realising more homes by densifying vertically on the same land area to increase the housingsupply.



RELATIONS
H.13, H.17, D.2, D.3

D. 2 VARIATY IN HOUSING SUPPLY

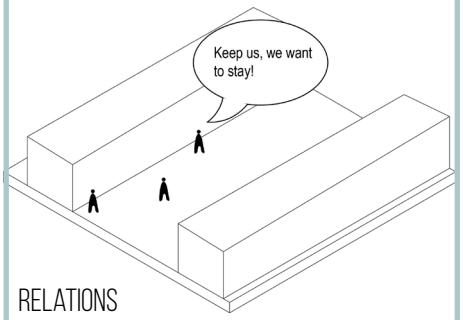
HYPOTHESIS
Create different types of housing to attract different types of residents.



RELATIONS
D.2, D.3

D. 3 RETAINING CURRENT RESIDENTS

HYPOTHESIS
The new interventions for densification and heat stress must not drive current residents away from the nieghbourhood.

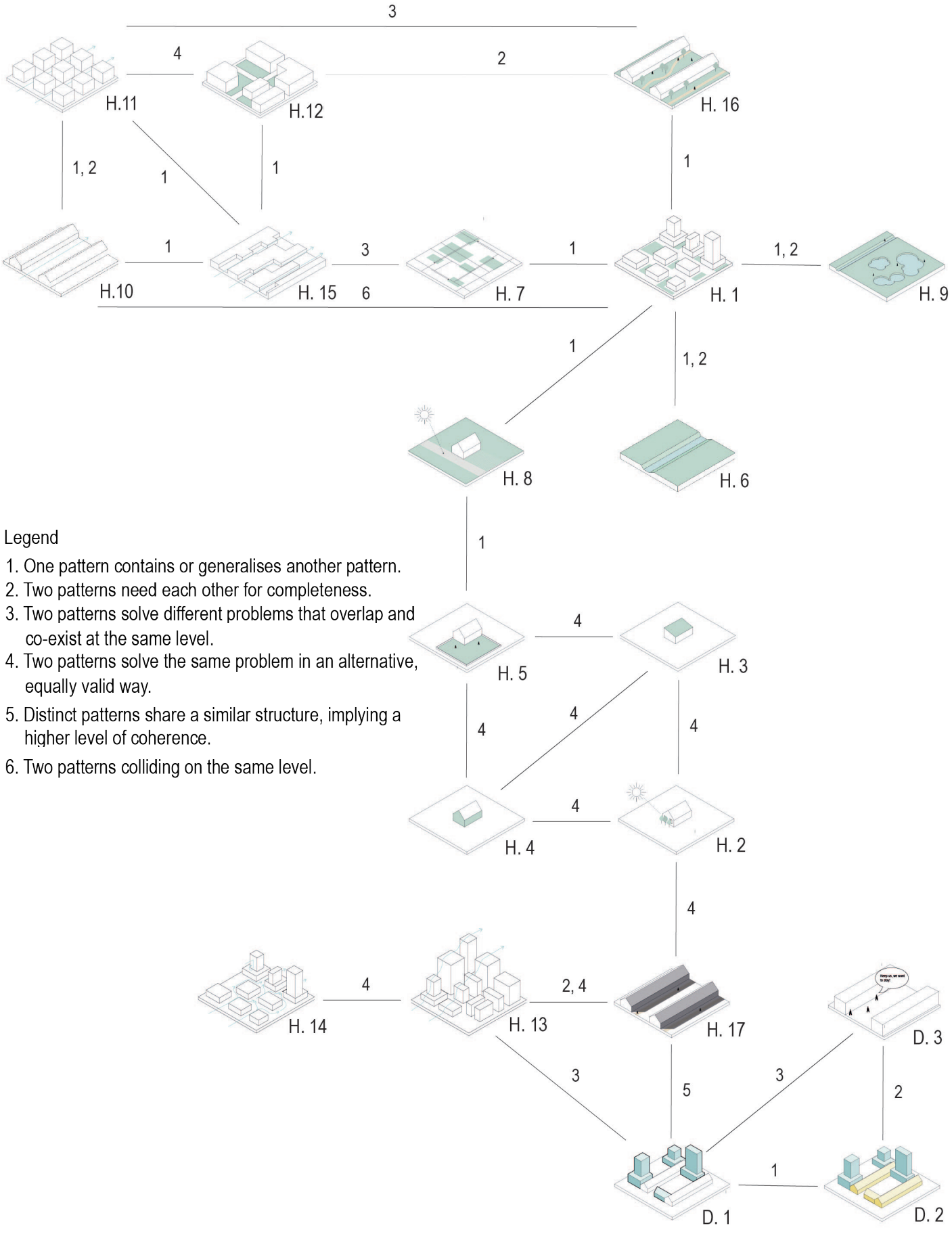


RELATIONS
D.1, D.2

Fig 89 Patterns for densification
Source: Produced by author.

4.3.3 RELATIONS

Between some patterns there is a relationship. This relationship can be very different from each other and there can also be several types of relationships between patterns (fig. 90) In this way, the design process can be helped by applying an intervention and directly shows what effect it has on other patterns.



Legend

1. One pattern contains or generalises another pattern.
2. Two patterns need each other for completeness.
3. Two patterns solve different problems that overlap and co-exist at the same level.
4. Two patterns solve the same problem in an alternative, equally valid way.
5. Distinct patterns share a similar structure, implying a higher level of coherence.
6. Two patterns colliding on the same level.

Fig 90 Relations between the patterns.
Source: Produced by author.

All patterns are also ordered by scale. The patterns with a large scale are often more difficult to implement than patterns with a small scale. For the implementation of the patterns in Moerwijk, first the large scale will be looked at, because this will have the most effect on the structure of a neighbourhood.

Many of the patterns are concrete, because they concern physical problems with physical solutions.
Because the patterns are too large to be placed close together, clusters have been made to show the correct position of the patterns.

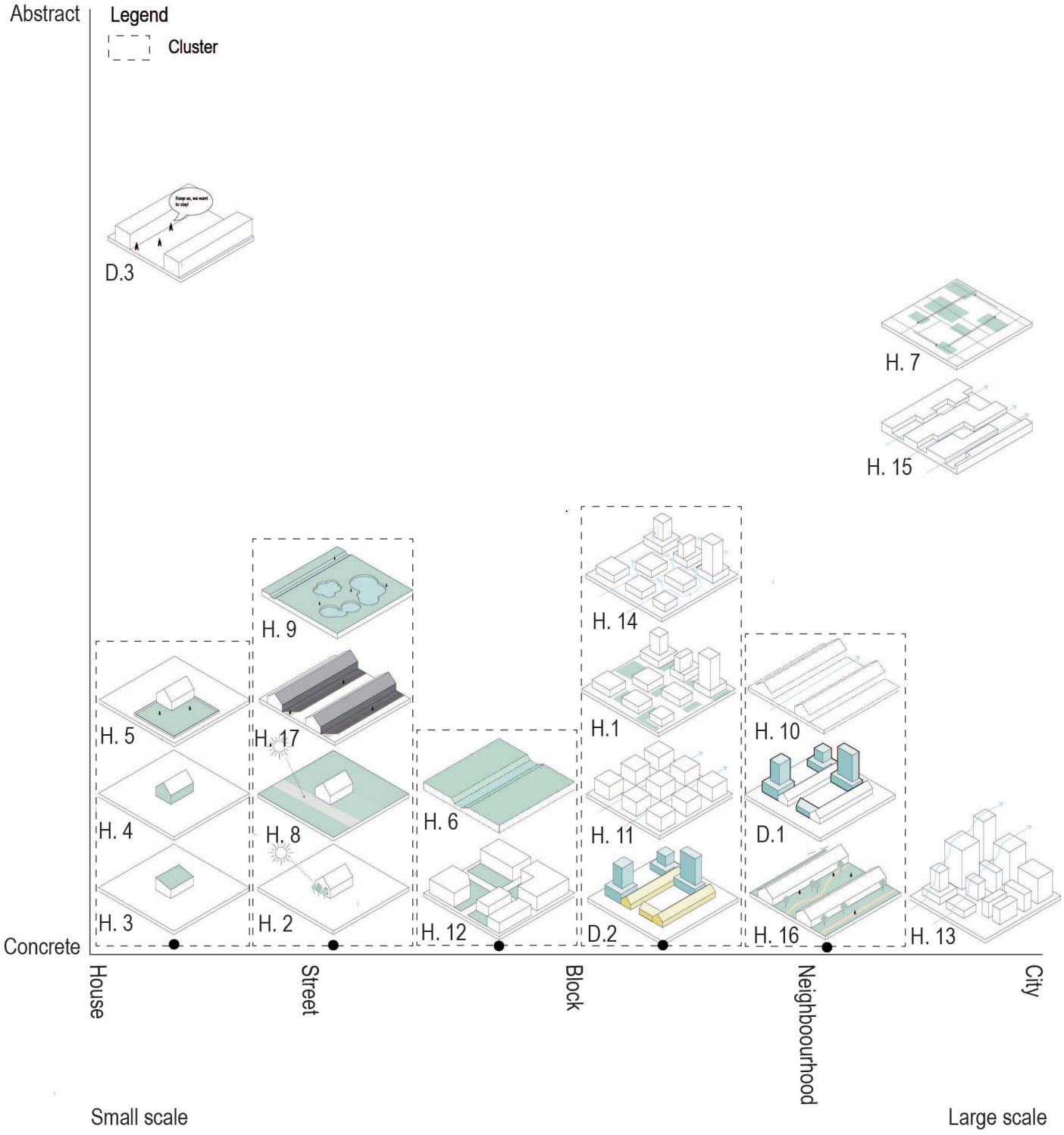


Fig 91 Patterns ordered by scale and degree of abstraction
Source: Produced by author.

4.3.4 POLICY AIMS

The patterns have been drawn up and form a good toolkit for the core actions that have recurred in the thesis in previous chapters or will recur in subsequent chapters. These core actions can be applied to all cities, neighbourhoods and areas, and can help municipalities and agencies to implement certain key actions. Each core action is tied to a group of patterns to help implement the core action in practice.

1. LIVABILITY

Creating an area that is seen as a fine, safe and comfortable living environment for all target groups.

Quality of life is a subject that has been discussed before and is sometimes difficult to express in physical terms. Although this subject is difficult to describe, it is no less important. A pleasant living environment where residents feel safe, comfortable and secure is valuable for the residents, but also has an effect on the value of the homes which is beneficial for other stakeholders who earn money from these homes. However, the various dimensions measured for liveability are physical. In this way, livability can also be improved.

Refer to patterns: H.1, H.2, H.3, H.4, H.5, H.7, H.9, H.16, H.17, D.1, D.2, D.3.

2. SUSTAINABILITY

Developing an area that takes into account the current wishes of residents, but which can also take care of the goals and wishes of future residents.

Sustainability is also a big concept that is difficult to grasp. The degree of sustainability is currently determined by the quality of life, the freedom that the future generation has to achieve their goals and the prosperity that the Netherlands has on the rest of the world. It is important that area development also looks to the future and how an area, neighbourhood or city can adapt to that future.

Refer to patterns: H.1, H.2, H.3, H.4, H.5, H.7, H.9, H.16, H.17, D.1, D.2, D.3.

3. THERMAL COMFORT

Creating a pleasant indoor and outdoor space for all target groups.

Sustainability is also a big concept that is difficult to grasp. The degree of sustainability is currently determined by the quality of life, the freedom that the future generation has to achieve their goals and the prosperity that the Netherlands has on the rest of the world. It is important that area development also looks to the future and how an area, neighbourhood or city can adapt to that future.

Refer to patterns: H.1, H.2, H.3, H.4, H.5, H.6, H.7, H.8 H.9, H.10, H.11, H.12, H.13, H.14, H.15, H.16, H.17.

4. DENSIFICATION

Efficient densification and improving the quality of the microclimate through the built environment.

There is a lot of pressure on the housing market and little space in the cities. It is important to densify in an efficient manner to create the maximum number of dwellings and increase opportunities for existing and future residents for there desired house.

Refer to patterns: D.1, D.2, D.3

5. BIODIVERSITY

Realising an outdoor space that is pleasant for all living organisms, and focusing on improving biodiversity in urban areas. .

More and more areas are being built on without paying attention to plants and animals. It is important during area development to take into account all the organisms that could possibly live there in order to create a good balance between humans, plants and animals. .

Refer to patterns: H.1, H.2, H.3, H.4, H.5, H.6, H.7 H.9, H.12, H.13, H.14, H.16.

6. FINANCING

Realising measures to achieve a better living environment that are feasible for stakeholders to pay for. .

During an area development, many stakeholders come together who are jointly responsible for the costs of the area development. Increasing the value of homes and creating more revenue opportunities can make area development more feasible. .

Refer to patterns: H.2, H.3, H.4, H.5, H.16, D.1, D.2

4.4 IMPLEMENTATIONS

The patterns are applicable to any city and are not location-specific. Together with the analysis, the patterns can be applied to a location. In this case, this is Moerwijk. The patterns will be used to realise more housing and reduce heat stress. The patterns will also have an effect on other themes and problems that were identified in the district during the analysis, such as liveability and biodiversity.

H.0 With this symbol the patterns are shown in the figures. To show exactly which patterns are applied at which location. The patterns are also treated as sub-chapters by placing the symbol in front of a paragraph.
In some cases, the patterns are not large enough for a whole paragraph. Then they are named in the text by means of (H.0).

H.15 To cool the district with the help of the wind, a ventilation grid has to be realised on a large scale. This ventilation grid consists of ventilation corridors (H.10) that let the wind flow through the district. The ventilation corridors should be placed in the direction of the summer prevailing wind or at an angle of maximum 30 degrees.

Perpendicular to these ventilation corridors, there will have to be streets for the air duct to make the ventilation flow better through the district. For this grid to be successful, some buildings will have to be demolished so as not to block the wind.

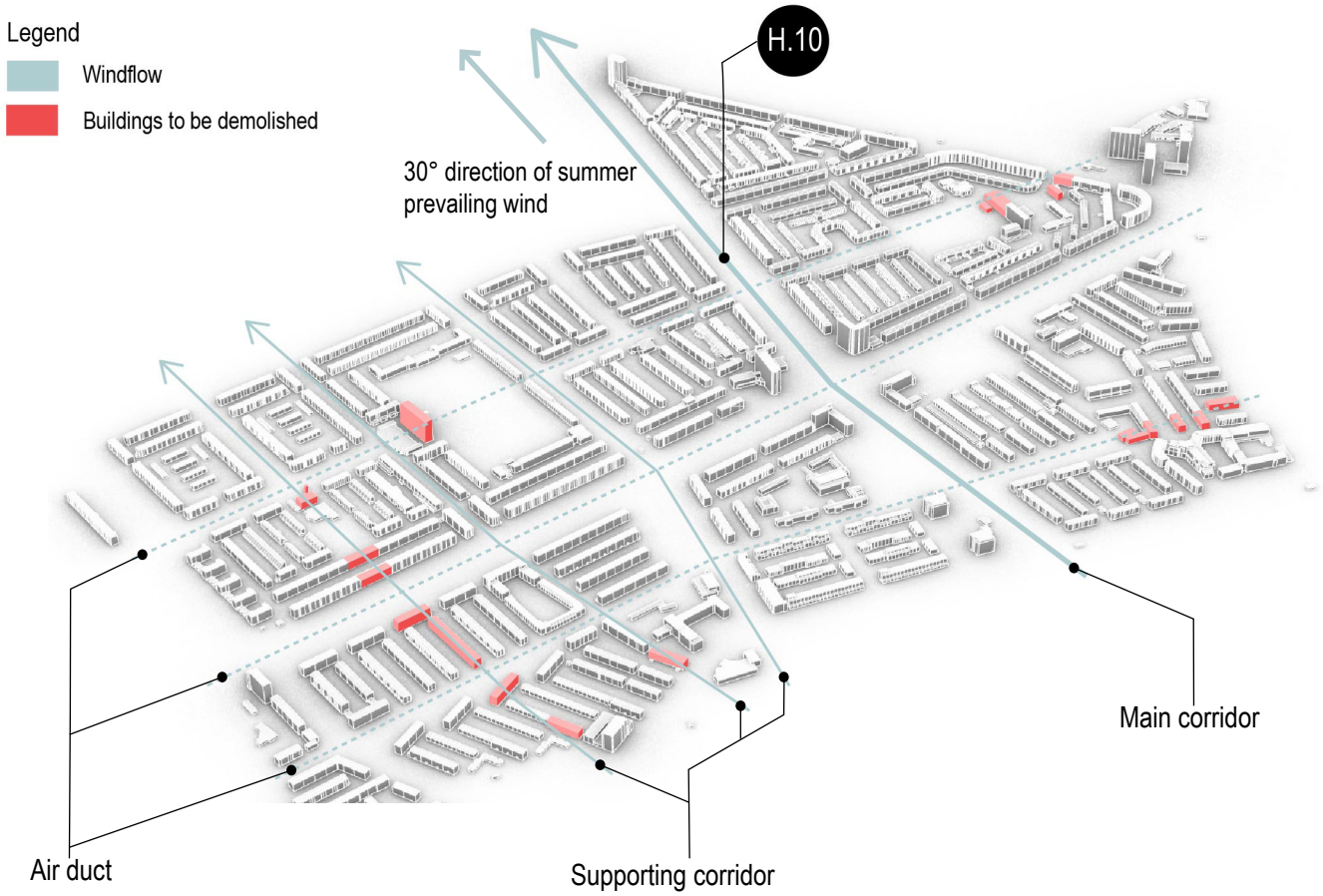


Fig 92 3D view of the ventilation grid
Source: Produced by author.

The ventilation grid of Moerwijk also affects the surrounding neighbourhoods and the structure of The Hague (fig. 93). The North-South connection for the ventilation grid fits in well with the current structure of The Hague. The East-West connection is certainly less effective in the East. To realise good ventilation on a large scale, the neighbouring district of Laakkwartier will also have to be adapted.

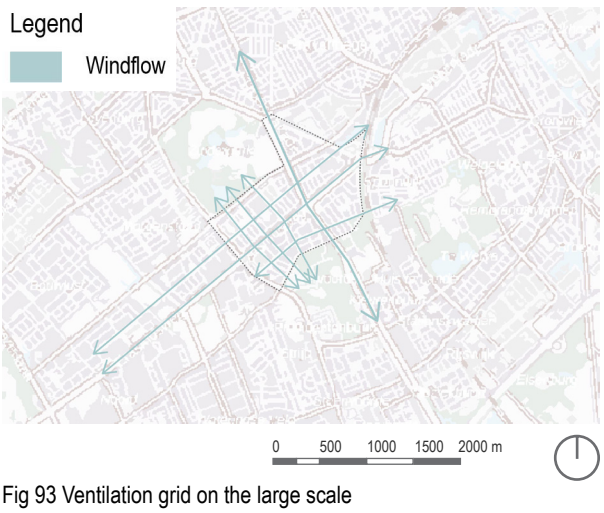


Fig 93 Ventilation grid on the large scale
Source: Generated by author using GIS software, based on buildings, streets, water and green.

H.10 In the neighbourhood there will be one large ventilation corridor shown in figure 92. For the wind corridor to work properly, space will have to be made in the street. Because of this, the trees in the middle of Moerweg have been moved to the side of the street. In practice, this will be difficult and new trees will have to be planted. At the edge of the street, the wind can be held back for a more pleasant feeling at pedestrian level and the trees provide shade at the locations where residents walk and relax. This information also lays the foundation for pattern H.2 where the trees provide shade and sun protection to the buildings in summer and are open in winter. Because the trees lose their leaves in the winter.

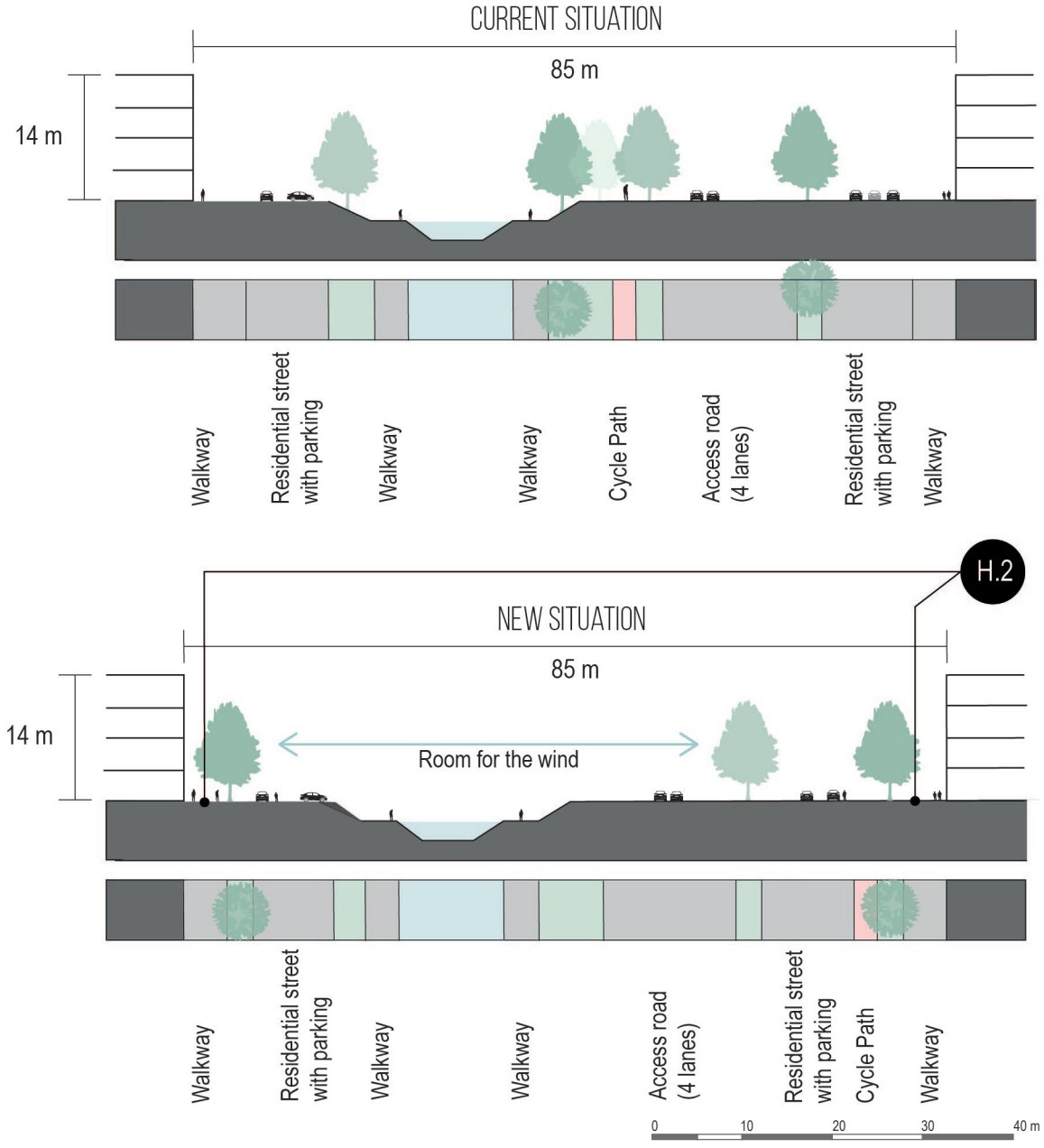


Fig 94 Wind corridor of the Moerweg
Source: Produced by author.

The ventilation and green grid will connect different nodes together each in a different way.

JUNCTIONS IN THE NEIGHBOURHOOD

There are a number of nodes in the neighbourhood where residents come together. These nodes often consist of shops. However, there are also hubs where the most vulnerable target group lives together. These are the elderly and care homes. Because this target group experiences the greatest consequences, this must be taken into account in the design.

H.15 VENTILATION GRID

The ventilation grid consists of ventilation corridors (H.10). Some lines of the ventilation grid are also located at the nodes. In this way, different nodes can be connected to each other.

H.7 GREEN GRID

The green grid will become a connecting element in the neighbourhood. The large parks with a high ecological value will be connected and the various centres in the district will be linked to each other. There is currently a paved square with a sports facility surrounded by shops. This square is recently redeveloped but can even be better with adjustments. This square has the potential to become a cooling facility in the district to minimise heat stress on a hot day (H.1).

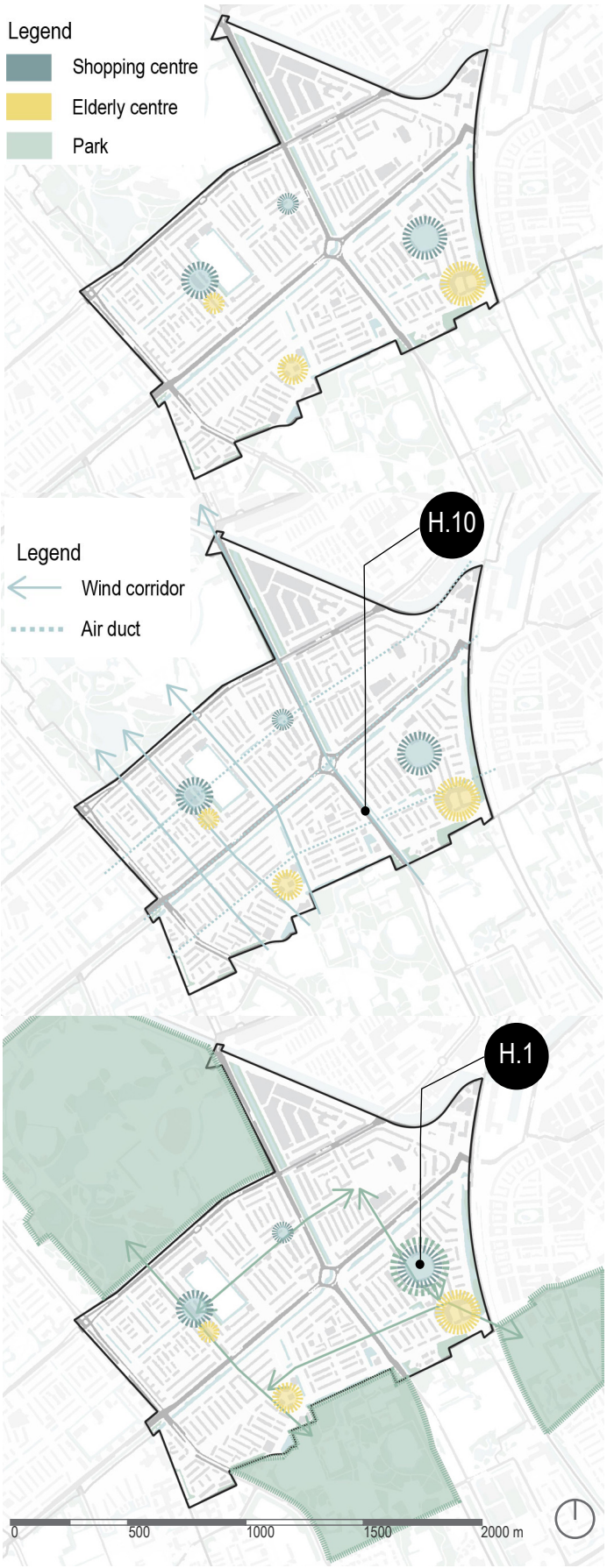


Fig 95 Map of the nodes, the ventilation grid, and the green grid.
Source: Generated by author using GIS software, based on buildings, streets, water and green.

Fig 96 Old situation for Heeswijkplein
Source: Produced by author

Fig 97 Current situation for Heeswijkplein
Source: Produced by author

H.1 This location will become part of the green grid in the future, and has recently been addressed by the municipality of The Hague. From a grey and paved square surrounded by trees, a square has been created with various functions for children and young people (fig. 97). This has greatly increased social cohesion in the neighbourhood. Nevertheless, there are some aspects that can be improved in the future with regard to heat stress and the micro-climate.

The materials used in the square can become extremely hot. The new design uses more grass, which has a cooling effect, but the playground is made on rubber mats. The football pitch that has been realised is made of artificial grass. If it is 30 degrees Celsius on a summer's day, this field quickly becomes 60 degrees.

The square is surrounded by a road. This wide road with its parking facilities creates a large separation between the square and the shops.

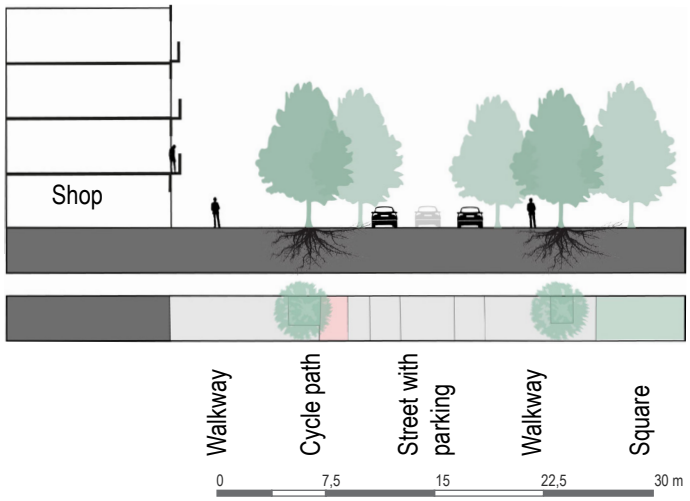


Fig 98 Section B street Heeswijkplein
Source: Produced by author

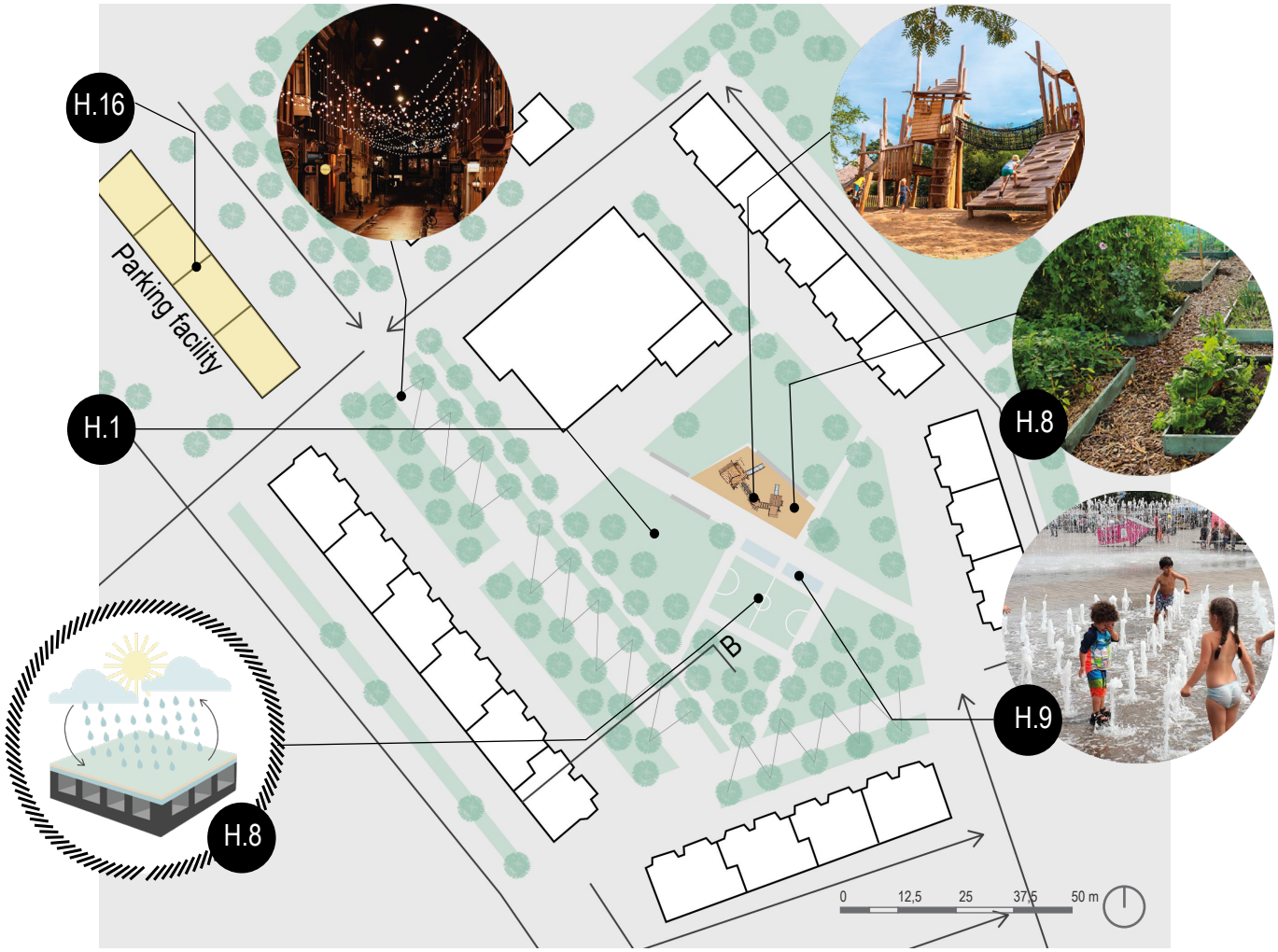


Fig 99 Improved situation for Heeswijkplein
Source: Produced and edited by author (Fonteintjes, 2019), (Het Koelste Kunstgrassportveld van Amsterdam, 2020), (Roest, n.d.), (Stadstuinieren, n.d.), (Uniek Speelprojecten, n.d.)

Despite the fact that this square has recently been redeveloped, the situation with regard to heat stress can be improved by some measures. By enlarging the building block and parking at the edge of the block in a garage, more space is created for pedestrians and greenery (H.16). The street behind the square will remain accessible for the car, also for any supply of products from the shops. For this reason, the renewed green structure will be extended outwards (H.1).
The playground will be changed into a natural playground with wood chips as a base, which can collect more water than the plastic underlayer what can lead into more evaporation for cooling the surroundings.
The artificial turf of the football pitch will be replaced by cooled artificial turf where water can be stored under the artificial turf to cool the grass during hot days (H.8).
As an extra element, fountains will be added where people can have direct contact with water, which can be refreshing (H.9).

More grass will be added to the street and lights will be hung between the trees to create a cosy and pleasant feeling that draws the shops and the square together.

Fig 100 Section B street Heeswijkplein
Source: Produced by author

H.16 In order to remove the car from the street the district will be organised into super blocks. By enlarging the building blocks the streets within these blocks can be filled with different patterns to combat heat stress. The streets will no longer be accessible for cars, but only for slow traffic and emergency services. This means that parking will have to be provided outside the block, creating a new parking facility. Each building block will provide enough parking spaces sunk underneath the new building to meet the parking requirement (fig. 101). According to the municipality of The Hague, parking facilities must be available within a radius of 500 metres from the home. In order to take into account residents with reduced mobility and shopping facilities that require a 100-metre walk, four additional parking facilities are required (Gemeente Den Haag, 2011).

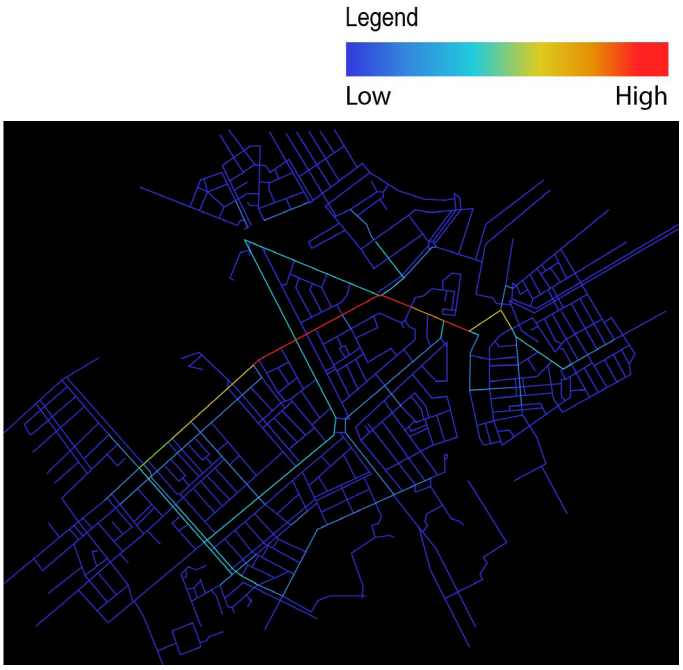
In the future, we will be less dependent on the car and will travel more by public transport, shared cars or bicycle. As a result, parking spaces can already be reduced at some locations. The Moerwijk train station is located on the outskirts of the district, which means that 25% fewer parking spaces need to be realised within a radius of 500 metres around this station.

With an eye to the future, parking spaces can be allocated to shared cars so that residents with lower incomes also have the option of a car. Since Moerwijk is not entirely in a regulated area, 10% of the parking demand may consist of shared cars. It is assumed here that 4 households make use of a shared car (Gemeente Den Haag, 2021c).

Fig 101 A map of the super blocks and parking facilities in Moerwijk.
Source: Generated by author using GIS software, based on buildings, streets, water and green.

The space syntax analysis was performed to analyse the pressure on the movement in the streets. This analysis was the basis for the super block pattern. Figure 102 shows that the pressure on the streets to move through is minimal for the streets in the district. Only the main roads and the access roads are coloured red and yellow and will therefore have to be retained. This analysis has therefore shown that it is possible to enlarge the building block.

By enlarging the housing block, it is no longer possible to park in the housing block (H.16). The building block will only be accessible to slow-moving traffic and the emergency services. The parking standard is currently between 0,66 and 1,5 parking spaces per dwelling and, together with the densification, this amounts to 233 parking spaces (Gemeente Den Haag, 2020b). Currently, parking is already provided on two sides around the block. In order not to have too many cars in the street, this will be changed to one side of the road so that there is more room for greenery (fig. 103). The parking areas outside will be fitted with open clinkers to incorporate greenery into the street (H.8). Furthermore, a two-storey car park will be built under the new building, with one storey sunk into the ground. This was done to create a pleasant transition to fewer parking spaces since many current residents are likely to be dissatisfied with the changed parking situation.



CURRENT SITUATION, NORMAL BLOCKS

Fig 102 Space syntax analysis of pressure on the streets of Moerwijk.
Source: Generated by author using Space Syntax software.

	Rental	Sale
Appartment 70/100 m²:	0,66	0,8
Rowhouse 100/160 m²:	1	1,5
Parking spots needed:		233
Parking spots created outside:		229

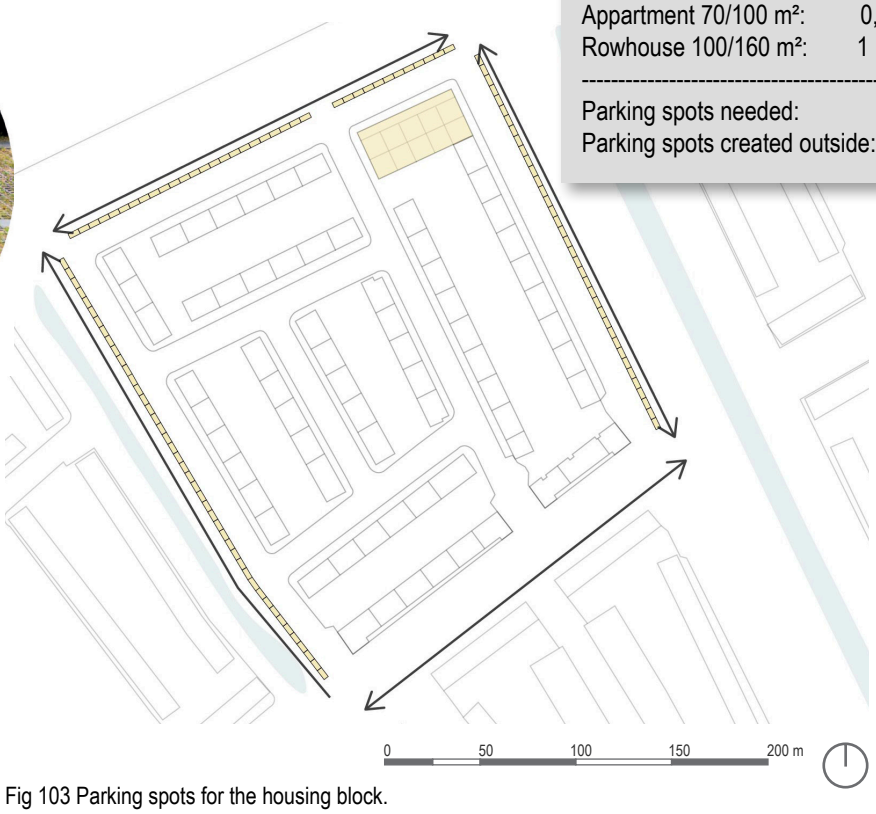


Fig 103 Parking spots for the housing block.
Source: Produced and edited by the author (Rosero, n.d.).

H.13 To allow the wind to flow properly through and over the buildings in the whole neighbourhood, the height of the buildings must be taken into account. There are already more high-rise buildings in the north of the district and around the Moerwijk railway station. In these locations the buildings have little or no negative effect of the other buildings because of any shadows, as these buildings are adjacent to a major road or park. The distribution is as shown in Figure 104.

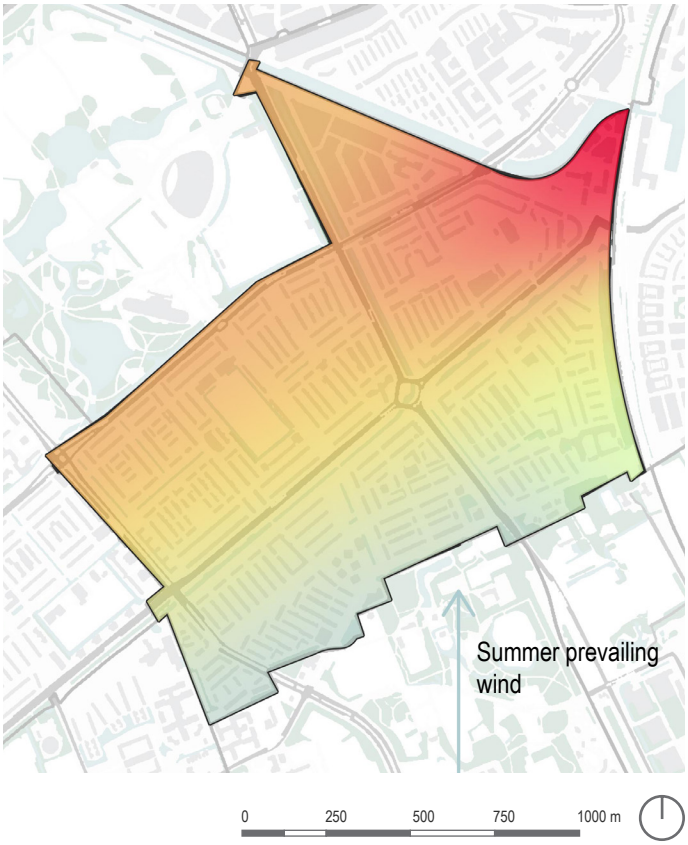


Fig 104 Map showing in zones the height of the buildings in Moerwijk.
Source: Produced by author

Furthermore, zones have been created that indicate the height of the buildings.

Zone 1: Low-rise, ground-level housing between 1 and 3 floors.
Zone 2: Medium-high-rise, buildings of 3 - 5 floors.
Zone 3: High-rise buildings, buildings from 5 - 10 storeys.
Zone 4: Extreme high-rise buildings, buildings of 10 storeys and more.

The high buildings provide a lot of shade at pedestrian level, which cools down on a hot summer day (H.17).

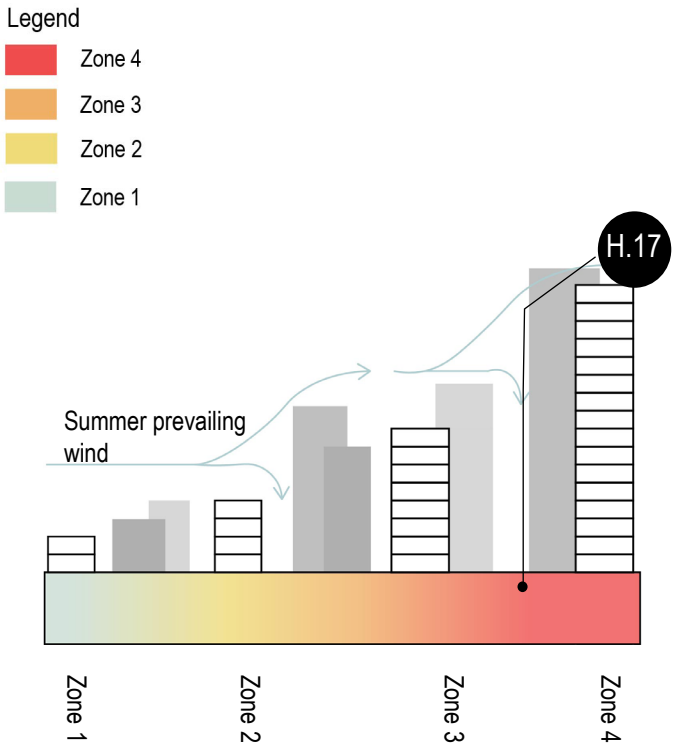
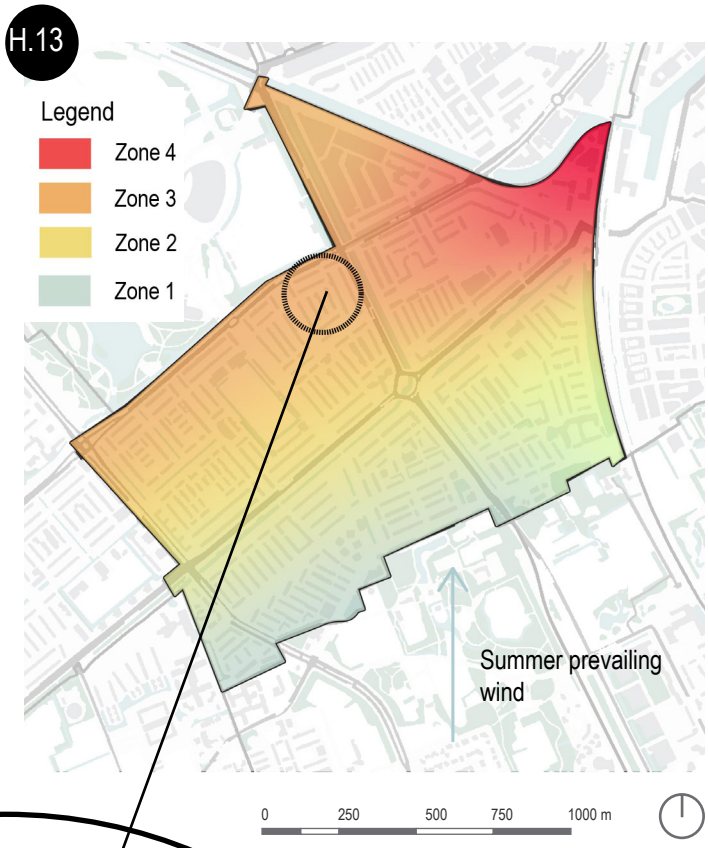


Fig 105 Section of the zones and the height of the buildings.
Source: Produced by author

BLOCK

H.11 The building block used as an example is located at the edge of the district and at the edge of the Zuiderpark. This building block is mainly located in zone 3. To stimulate the airflow in the building block, houses will have to be demolished, transformed and added. This way, the wind can flow through the building block. In addition, higher building elements will be placed at the north of the block to direct the wind upwards. These building elements also stand on podiums for extra space and a pleasant climate at pedestrian level (H.14).



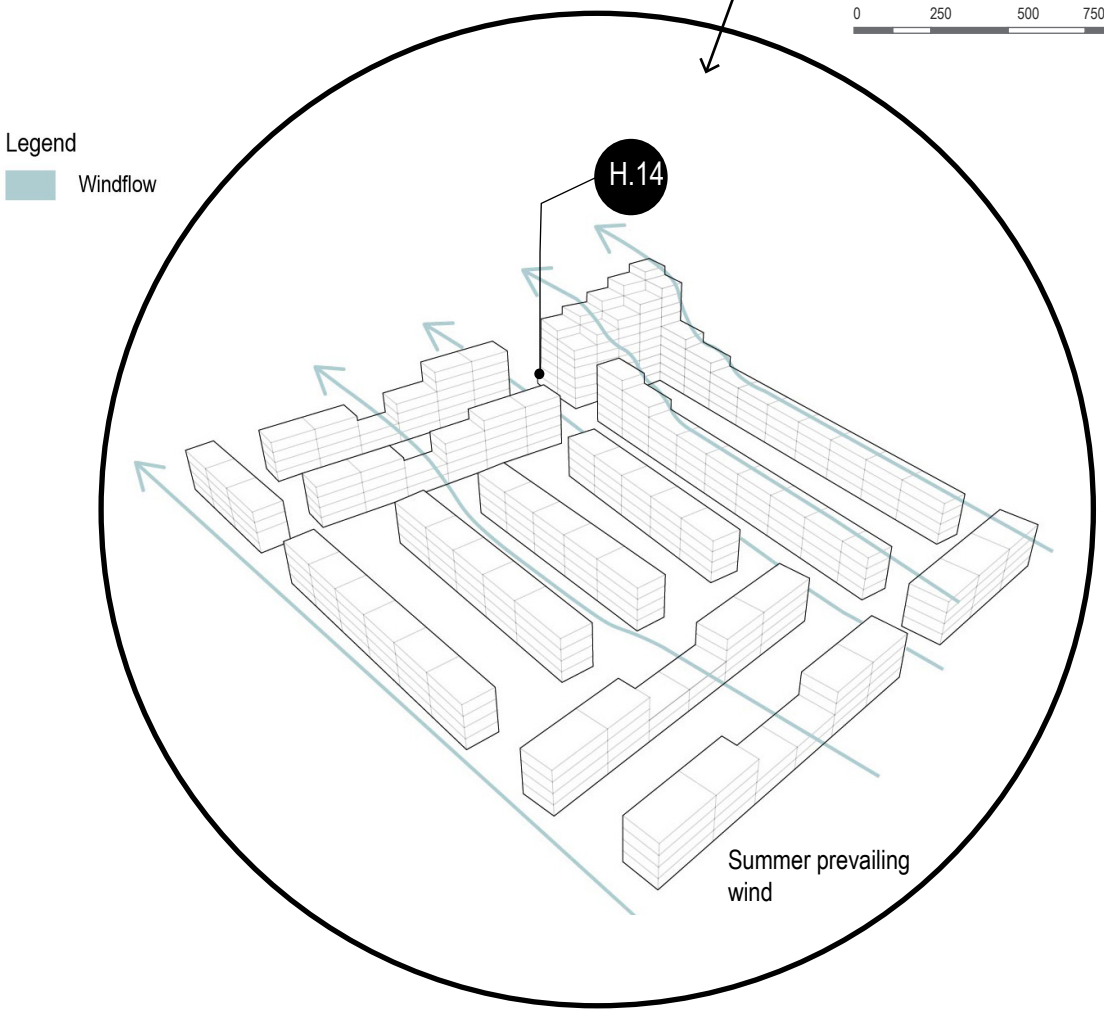


Fig 106 The airflow in the building block.
Source: Produced by author

D.1 Due to the set height for densification, densification can be done in various ways. Each way deals with the present built-up area differently. Two ways have been listed:

Intervene: Make use of the existing buildings by topping them up, splitting them and extending them.
Restructuring: Demolishing the current buildings and creating new ones.

In Moerwijk, a total of 1800 homes will have to be built. This leads to a densification of approximately 75 dwellings per building block.

Due to the wind orientation and the location of the building block, the highest densification will occur mainly in the north of the building block. The Hague Municipality's want to densify towards the Zuider Park. They believe that the green structure of the city has the most potential for densification (Information gathered through contact with the Municipality of The Hague). Despite the fact that the thinking is different, the highest densification location is the same

Densification for Moerwijk:	+1800 dwellings
Densication for each block:	+75 dwellings
Current number of dwellings:	210 dwellings

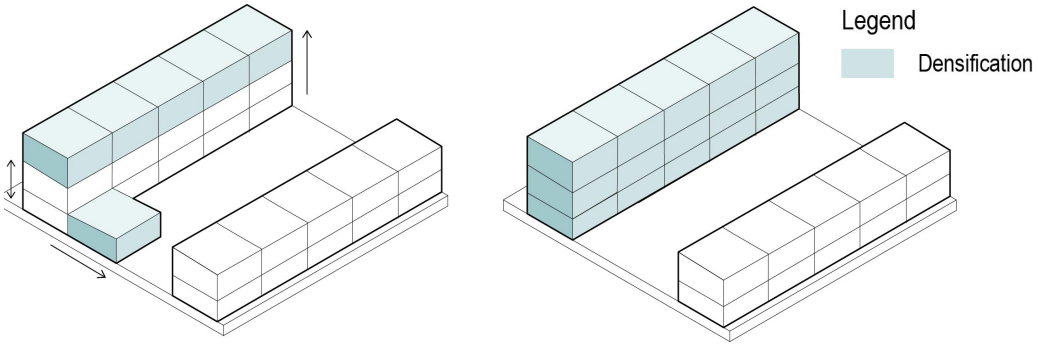


Fig 107 Possible ways to densify
Source: Produced by author

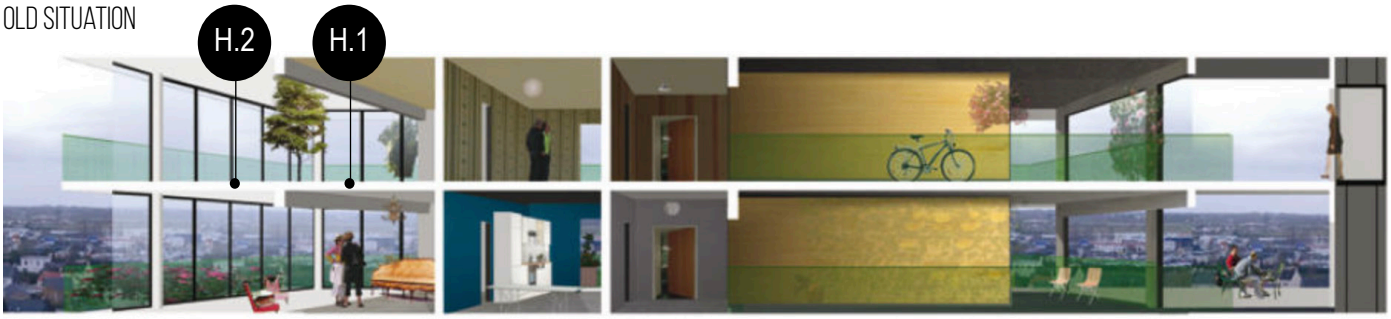
A new building volume will be constructed for the restructuring. "Poppies Buiksloterham" have been used as a reference for this volume (fig. 108). The project in Buiksloterham is part of the open building approach, which involves building in a flexible manner in order to increase the resilience of the neighbourhood. The shell and the installation system are separated, which means that the shell can be used much longer.
In terms of the microclimate, this project is focussed on creating public green spaces on a higher level. In Buiksloterham it is interesting that the space between the shell and the built-in system will provide an extra outdoor space that can be filled with plants (H.1). Placing this façade on the south wall will also prevent direct sunlight from entering the houses (H.2), which will keep the indoor climate more pleasant (Knudsen, 2020).

Fig 108 Reference project "Poppies Buiksloterham"
Source: Edited by author (Marc Koehler Architects, 2018).

OLD SITUATION

NEW SITUATION

OLD SITUATION



NEW SITUATION

Fig 109 Reference project “PLUS - Les grands ensembles de logements”
Source: Edited by author (Druot, Lacaton & Vassal, 2004).

A project like “Poppies Buiksloterham” focuses mainly on more expensive housing and may be too expensive in a neighbourhood like Moerwijk. As the houses would then become too expensive to pay for, there would be a big difference between the new residents and the current residents (D.3). Demolition and realisation of new buildings is more expensive than transformation. Transformation can also be more efficient, economical and of better quality. This is why we also looked at a reference project that is cheaper and offers opportunities for social rental and other cheaper housing. The reference project “PLUS” focuses (fig. 109), just like “Buiksloterham”, on a nice outdoor space for each house. Therefore more outdoor space is realised on each floor by a second facade. Because of a lot of natural light, the transformed building and large outdoor space, the quality is better and the living space is increased, making the house suitable for larger households. Many houses will be added and, if possible, part of the restructured building can be transformed (Druot, Lacaton & Vassal, 2004).

The existing buildings in Moerwijk will also be tackled. Many of the buildings in Moerwijk resemble houses such as “Panelák” in Slovakia (fig. 110). This concrete building will be renovated and compacted by placing one or more extra floors on top.
Like the “Klarenstraat”, a project in Amsterdam (fig. 111). They are adding balconies and a garden to the buildings. Residents appreciate their home more with the possibility of their own outdoor space (H.5). By adding extra greenery, it is possible to cool down the outdoor area (H.1). Together with good parking facilities, this will make the homes even more attractive to users (DASH, n.d.).

Fig 110 Reference project “Panelák”
Source: Edited by author (gutgut architects, 2014).

Fig 111 Reference project “Klarenstraat”
Source: Edited by author (Vanschagen Architecten, 2014).

For densification, the wind, the current structure and the resident's perception are mainly taken into account. This leads to the demolition of dwellings on the top floor of some buildings to provide an additional opportunity for the wind to flow through the building block (fig. 112).
Some dwellings will be transformed into new types of housing in order to achieve greater diversity in the housing supply (D.2).
For densification purposes, dwellings will naturally be added (D.1). This will be done mainly by adding on and restructuring one building.
The height of the neighbourhood is in the corner, since there is a large road behind this block and it therefore does not cast an undesirable shadow on the surrounding building blocks.

Current number of dwellings:	210 dwellings
Realised number of dwellings:	316 dwellings
Densification:	106 dwellings
Dwellings to be demolished:	-18 dwellings
Dwellings to be transformed:	+- 44 dwellings
Dwellings to be renovated:	148 dwellings

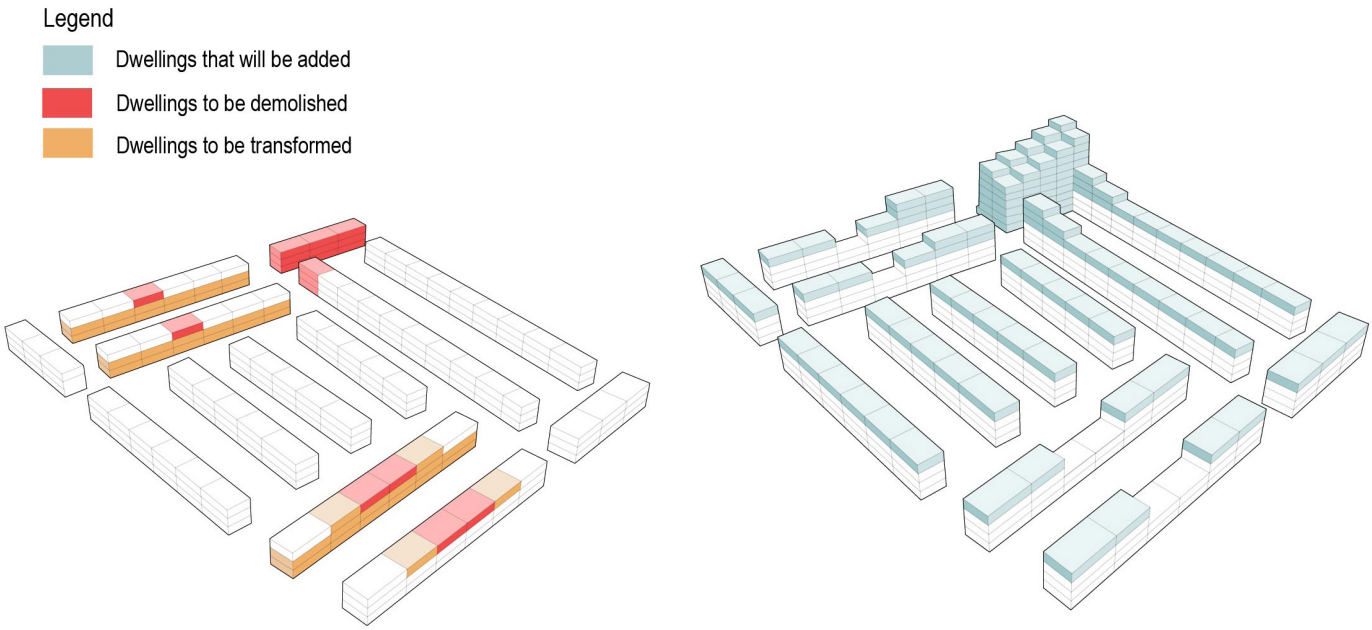


Fig 112 Houses to be demolished for wind circulation and densification.
Source: Produced by author

D.2 The residents of the appartments that will be demolished and transformed will be given new social housing (D.3). This leaves 73 newly built apartments for new residents. Half of these will be for sale and a quarter will be for private rent in order to offer more diversity in the neighbourhood. This will leave 20 apartments for the housing cooperative to compensate for the costs incurred in realising the project.
There will also be rowhouses and massionette homes. These houses have a large surface area and, for this reason, will mainly be for sale and will be privately rented, in accordance with the demand from residents identified in the analysis.
In the building block there will be a varied housing supply in order to introduce new residents to the neighbourhood, to create opportunities for growth for current residents and improve the reputation of the neighbourhood.

Appartments:
Current social rent: 148 dwellings
Replacing demolished/tranformed: +62 dwellings
Newly built apartments: +80 dwellings
---
230 dwellings for social rent
20 dwellings for private rent
40 dwellings for sale

Rowhouses/massionettes:
Transformed row houses: +18 dwellings
Newly built massionettes: +8 dwellings
---
12 row houses for sale
6 row houses for private rent
8 massionettes for sale

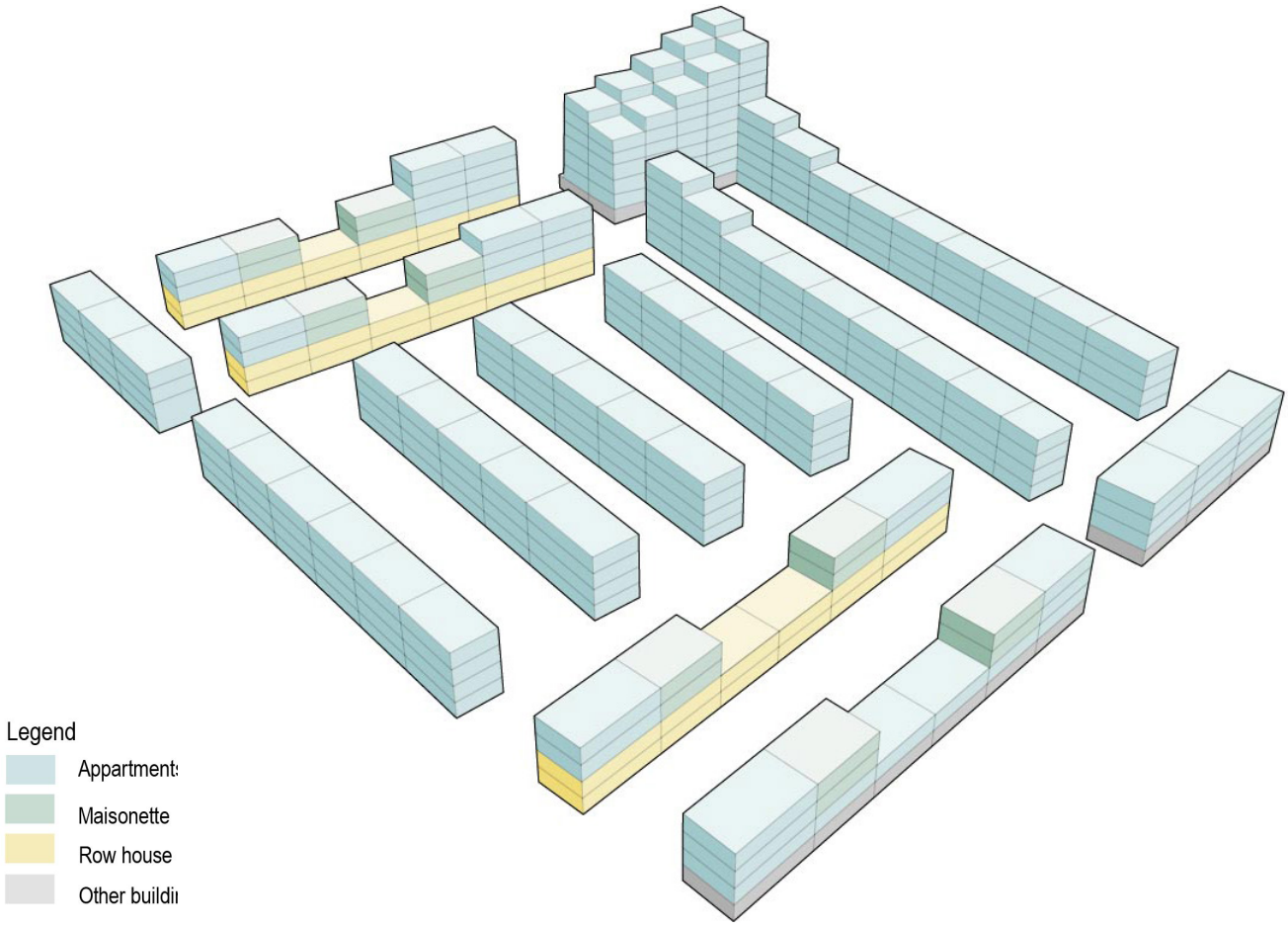


Fig 113 Varied housing supply in the building block.
Source: Produced by author.

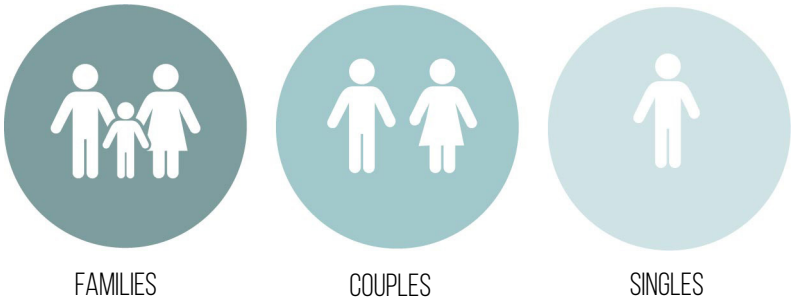


Fig 114 Target groups of the building block.
Source: Produced by author

Because different types of housing are being built for different income groups, there will be a focus on different target groups. For the terraced houses and massionettes, the focus will be on families and for the appartments, the focus will be on couples and singles. The flats with a second facade will be larger and therefore also possible for large households. The design of the public space also takes these target groups into account. This results in the public space in figure 115. Although the street is not accessible by car, it is considered possible in connection with the emergency services.

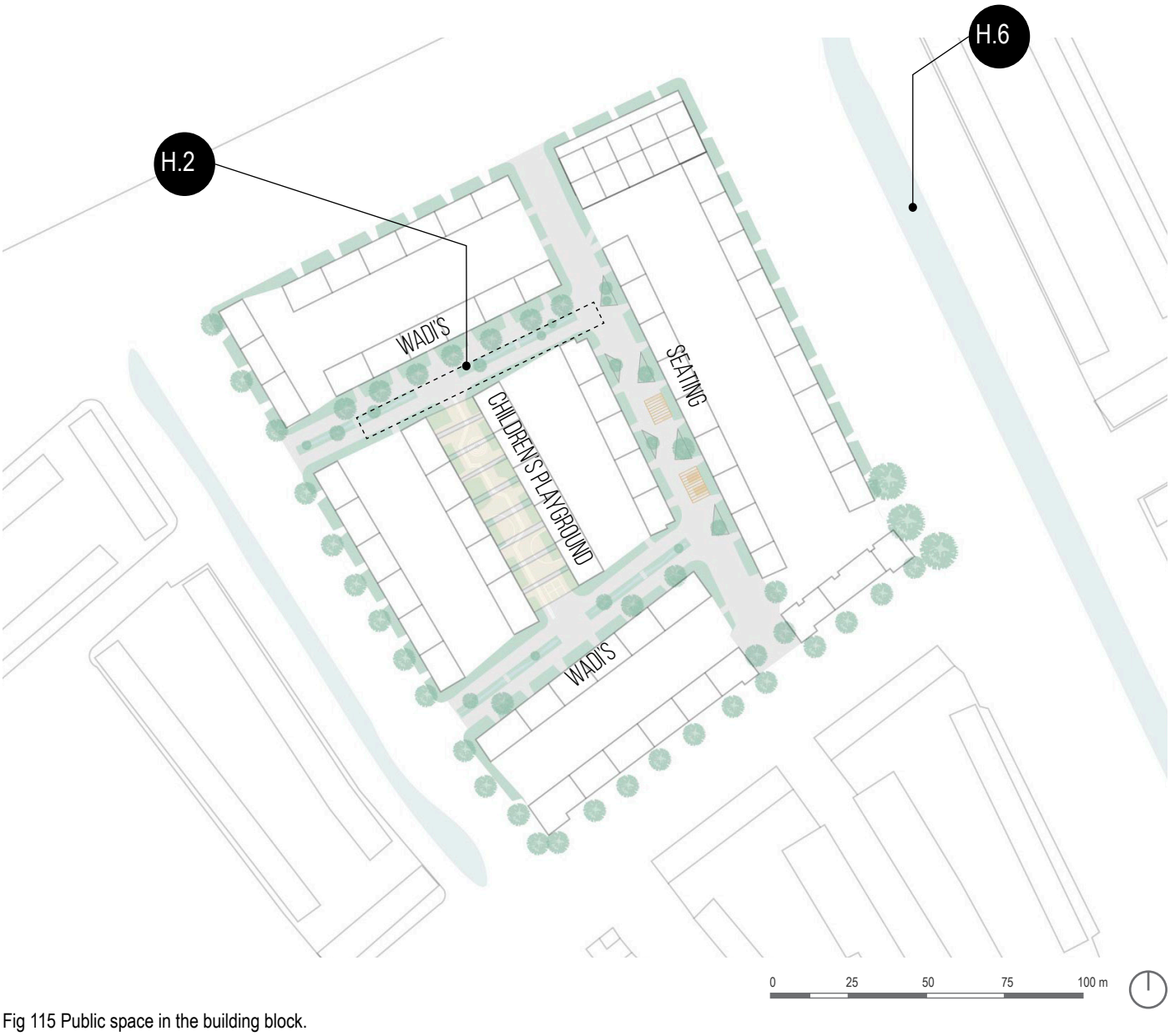


Fig 115 Public space in the building block.
Source: Produced by author

SEATING

This street is the longest street in the residential block and will mainly be used for moving around. To make this space more pleasant, the street will be screened off with planters. Between the planters, seating will be realised. The frame will be planted with plants that will provide cooling to the surroundings through evaporation, but will also provide shade for the seats (H.17), so that the residents can relax here on a hot summer day. In this way, the way people perceive the street will different. The street becomes a place to stay rather than a place to move.
A disadvantage of these seating areas may be that they are used by possible loitering youths who cause a nuisance. However, many windows face the public space, so there will be a lot of social control, which makes this less obvious.
The trees in the public space are at a fairly small size as the space for the roots under the ground is limited in the public space.

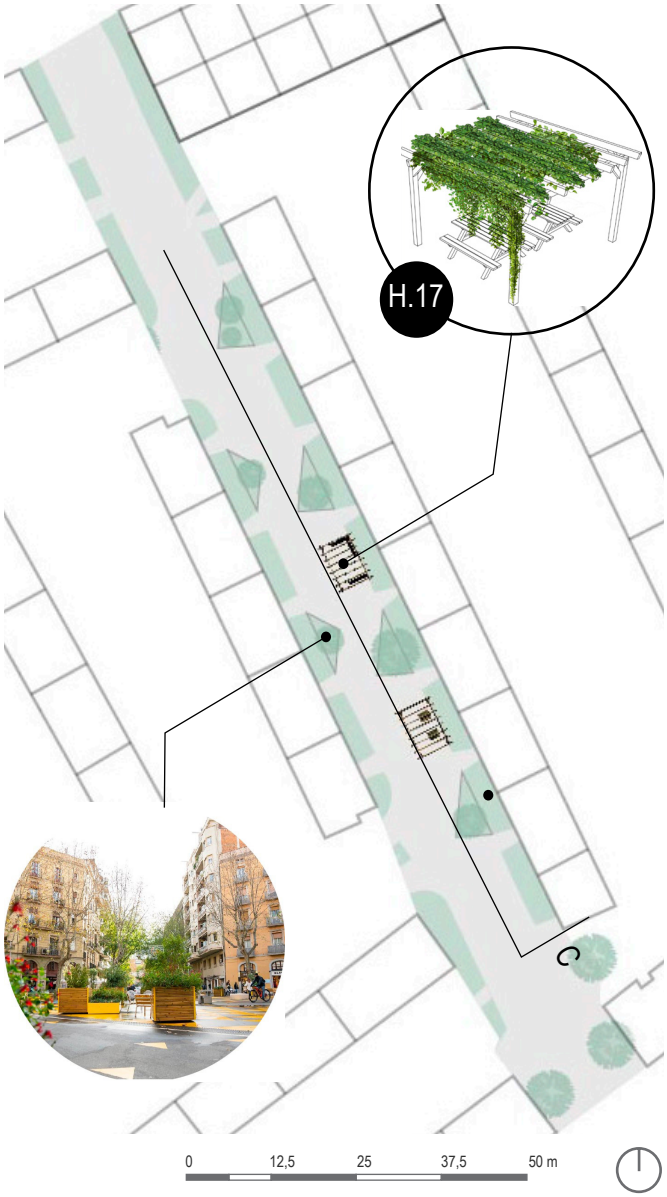


Fig 116 The seating area in the public space.
Source: Produced and edited by the author (Ajuntament de Barcelona, 2014)

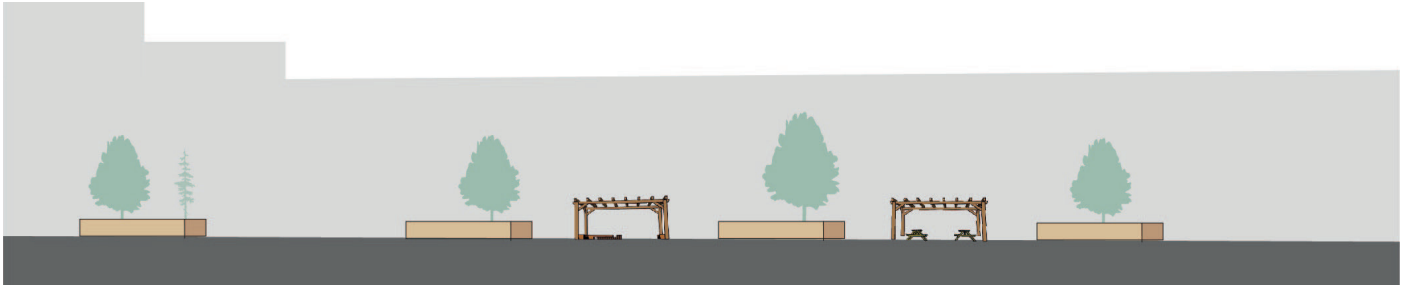


Fig 117 Section C of seating area in the public space
Source: Produced by author

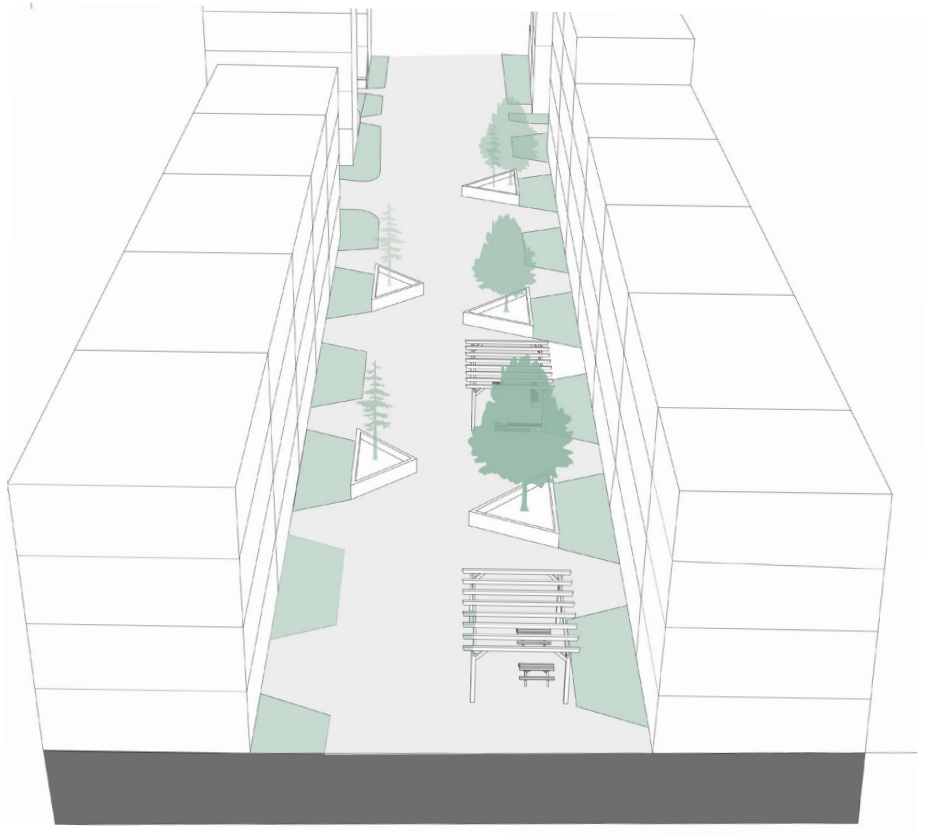


Fig 118 3D section the seating are in the public space.
Source: Produced by the author

By making the transition from a moving space to a residence space, the street becomes more enclosed. However, it is important that any emergency services can still reach the street, so that the street is also still possible to pass by car.

The grass that currently borders the houses will be changed into high-quality greenery with planting and wild flowers. This is shown in the impression, in practice, this will mean less bloom for much of the year.

Fig 119 Impression of the seating area in the public space
Source: Produced by the author by using lumion (CGaxis, n.d.), (Google, 2021), (MrCutout.Com, n.d.), (Nonscandinavia, n.d.), (PNGEgg, n.d.).

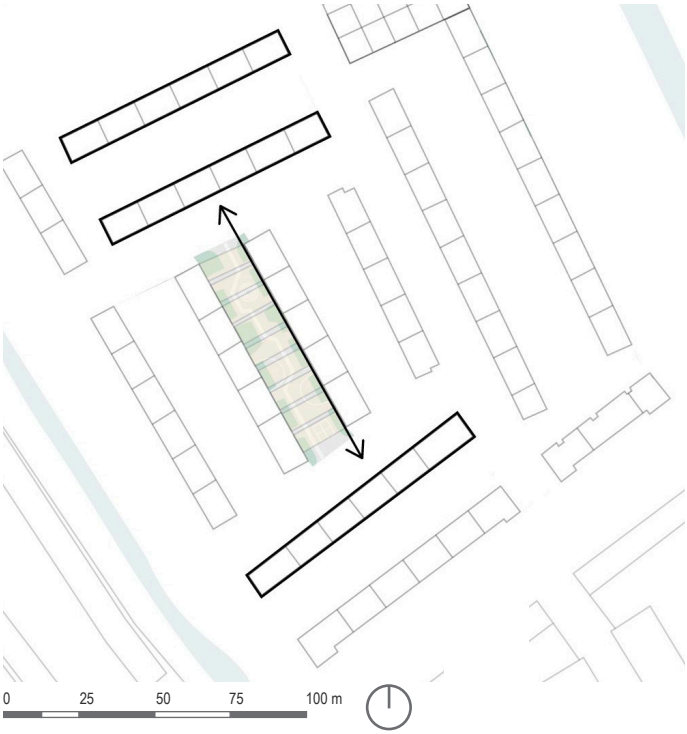


Fig 120 The playground in the public space.
Source: Produced and edited by the author (Bravo, 2017)

CHILDREN'S PLAYGROUND

One of the public spaces is the street that lies between the terraced houses. Because children often play together within a building block, this street is used as a connector. In the design of the outdoor space, children are the focus of attention by furnishing the space with games on the ground, as is done with the superblocks in Barcelona.
A disadvantage is that when children play games with each other and there is a lot of interaction, this can cause noise pollution during the day. This may disturb fellow residents in the street. Since working from home is becoming more common.
Also, games are chosen that are timeless and have been played by children for many decades, but unfortunately this is not flexible and the children may not use the games on the ground.

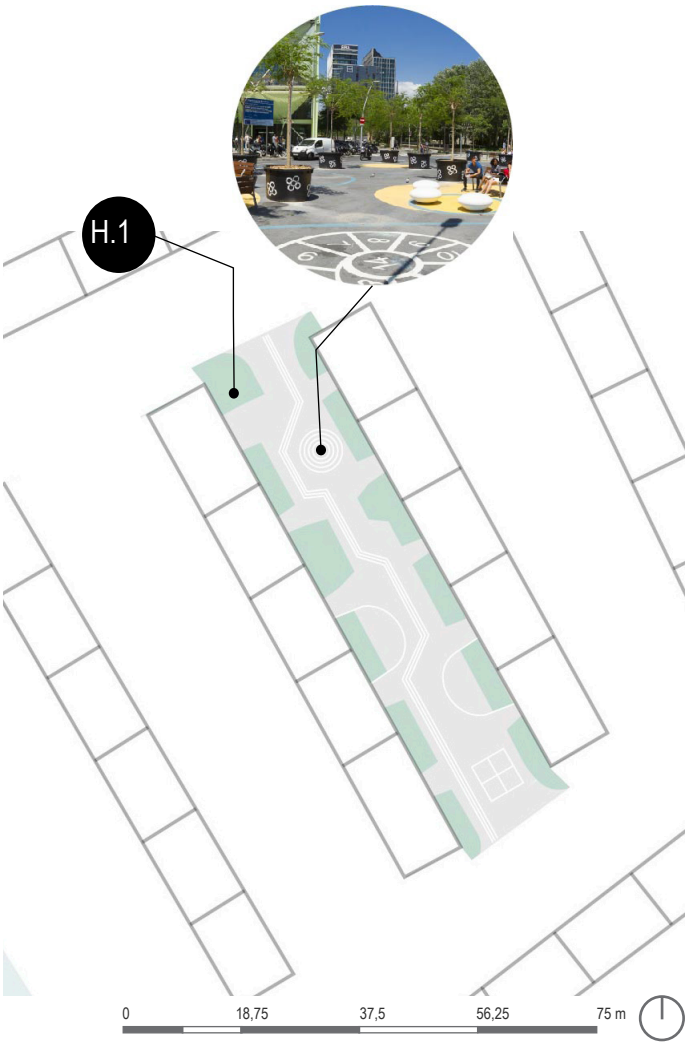


Fig 121 Zoomed in version of the playground in the public space.
Source: Produced and edited by the author (Calle Larios, n.d.)

The paving can become very hot if no measures are taken to prevent this, so sunshades are used in the summer to keep it pleasant (H.17). In winter, these can be removed to provide a pleasant outdoor space all year round. These measures are already applied in cities where it can get many degrees warmer in summer.
The cloths not only have a sun protection function, but also close off the room more. This gives a cosy and safe feeling.
The cloths are white and still allow a lot of sunlight through, which means that it does not become a dark and unpleasant space. Ultimately, this creates a light and spacious passage that brings residents closer together.

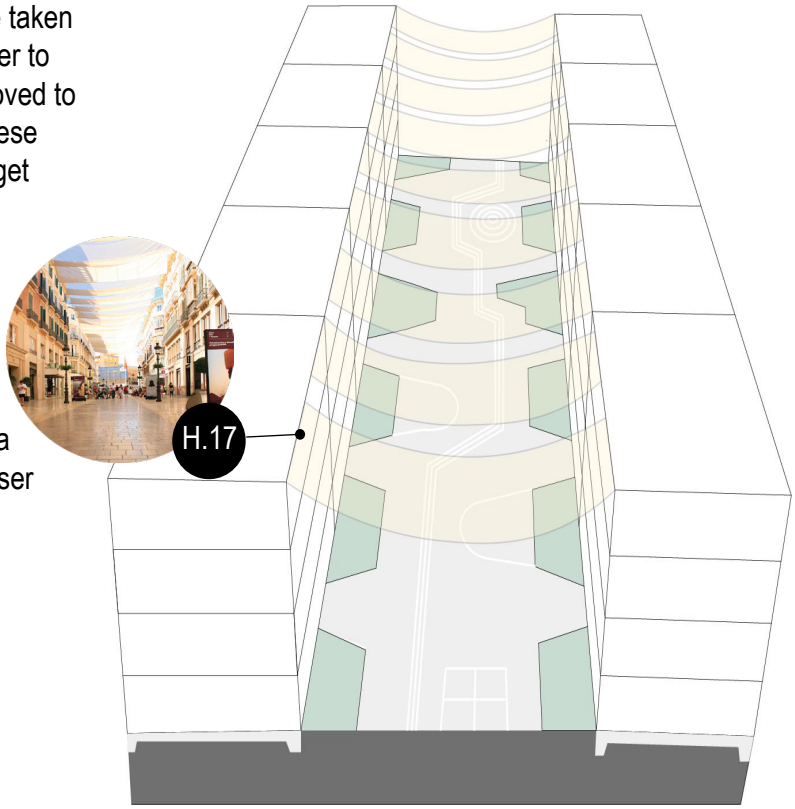


Fig 122 3D section of the children's playground in the public space.
Source: Produced by the author

Fig 123 Impression of the playground in the public space
Source: Produced by the author (CGaxis, n.d.), (Google, 2021), (MrCutout.Com, n.d.), (Nonscandinavia, n.d.), (PNGEgg, n.d.), (Shoppen in Malaga, n.d.)

The public space is separated by a wadi. These wadis will help the rainwater to infiltrate easily and, in combination with greenery and the evaporation of the water, it can cool the street (H.9). The wadi is interrupted in the middle to make the street accessible and the wadi can be crossed with the use of stepping stones. The street to the north has houses that face south. To cool down these houses, trees will be placed in front of them which will serve as sun blinds (H.2).

Fig 124The wadis in the public space.
Source: Produced and edited by the author (Rosero, n.d.)

In a wadi, rainwater flows slowly to lower lying green spaces. Here, most of the water will infiltrate into the top layer of the soil. There, it can also end up in the groundwater. When there is a lot of rainfall, the water can be directed to the surface water by means of a drain. These slokops are usually situated at the side of the wadi as shown in figure 125 (Boogard, 2020).
The wadi consists mainly of grass but will also be enriched with small trees for possible shade (H.17). The roots of these trees will grow more to the sides of the wadi in connection with the construction of the wadi.

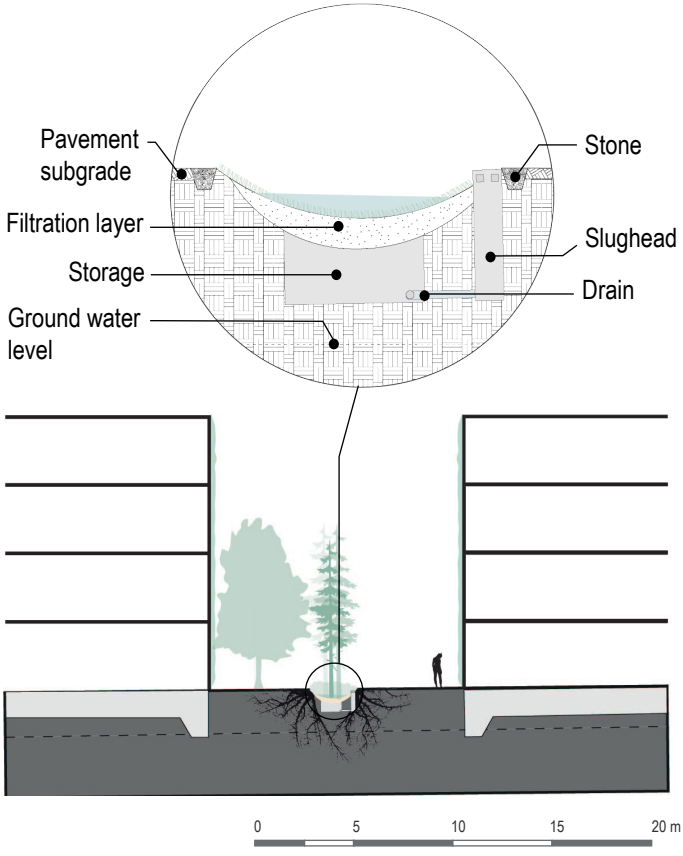
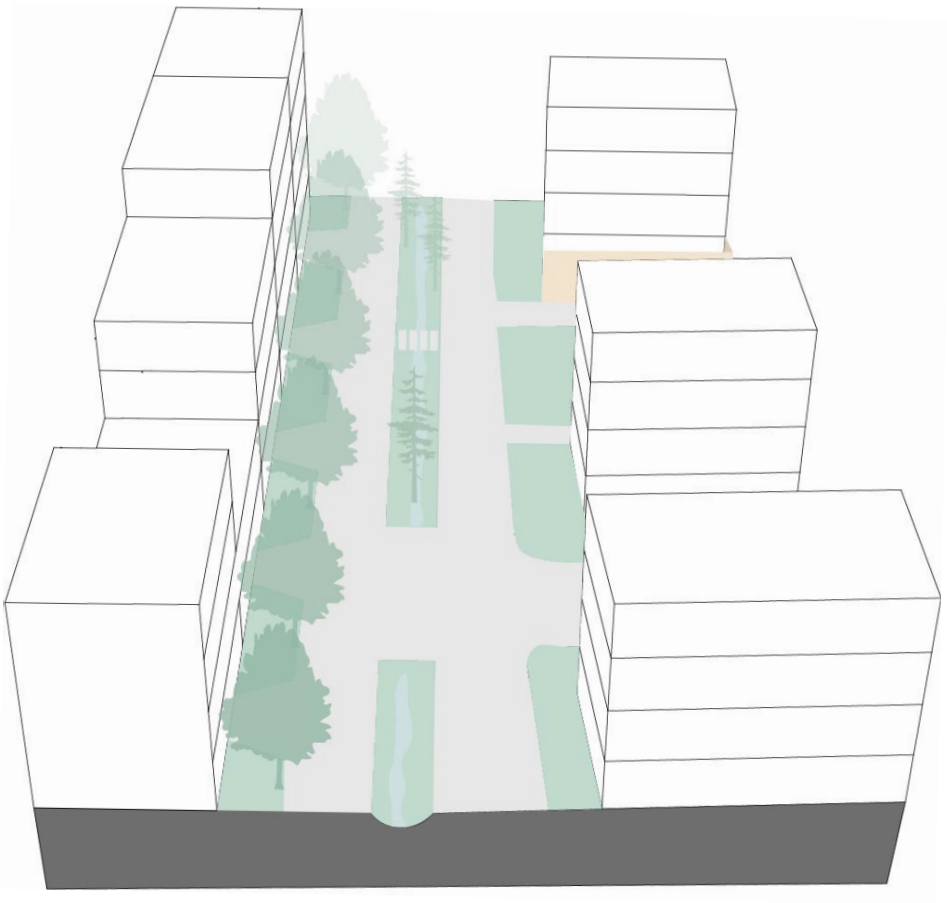


Fig 125 Section of the wadi system and a detail section.
Source: Produced and edited by the author (Boogard, 2020)



Some houses have the front facade facing south. This means that the façade can become very hot during hot periods, and by placing trees in front of the façade, shade is created on the façade that can cool the houses (H.2). In the winter, this is not necessary and the leaves will fall from the trees so that this effect will disappear.
There is currently already a plot of green space for each house. This plot will be retained, but enriched with more diverse planting to attract more different kinds of animals (H.1).
Incorporating green into the streetscape improves physical and mental health, social cohesion, biodiversity and the WOZ value of the homes (van Hattum et al., n.d.).

Fig 126 3D section of the wadi in the public space.
Source: Produced by the author

Fig 127 Impression of the wadi in the public space
Source: Produced by the author (CGaxis, n.d.), (Google, 2021), (MrCutout.Com, n.d.), (Nonscandinavia, n.d.), (PNGEgg, n.d.), (Praxis, n.d.)

H.5 In the current situation, the boundary between the public space and private is very strong. To give people a safer feeling, this boundary will be blurred. By providing a private garden, the boundary of the home is shifted to give a safer feeling. The private garden ends in the semi-public space and this leads to the public space. In this way, the boundary goes smoothly from private to public.

Fig 128 Section D, slow transition from private to public.
Source: Produced by author.

The renovation projects have shown that a private public space is often desirable and positively influences the quality of the house. The analysis also showed that residents cut themselves off from the public space to feel safer, and that the public space is hardly used. By placing private gardens of 5 metres deep on the ground floor, the residents will get a safe feeling. Residents also feel responsible for their own gardens, which leads to better maintenance.

Fig 129 Green private gardens in the building block.
Source: Produced by author.

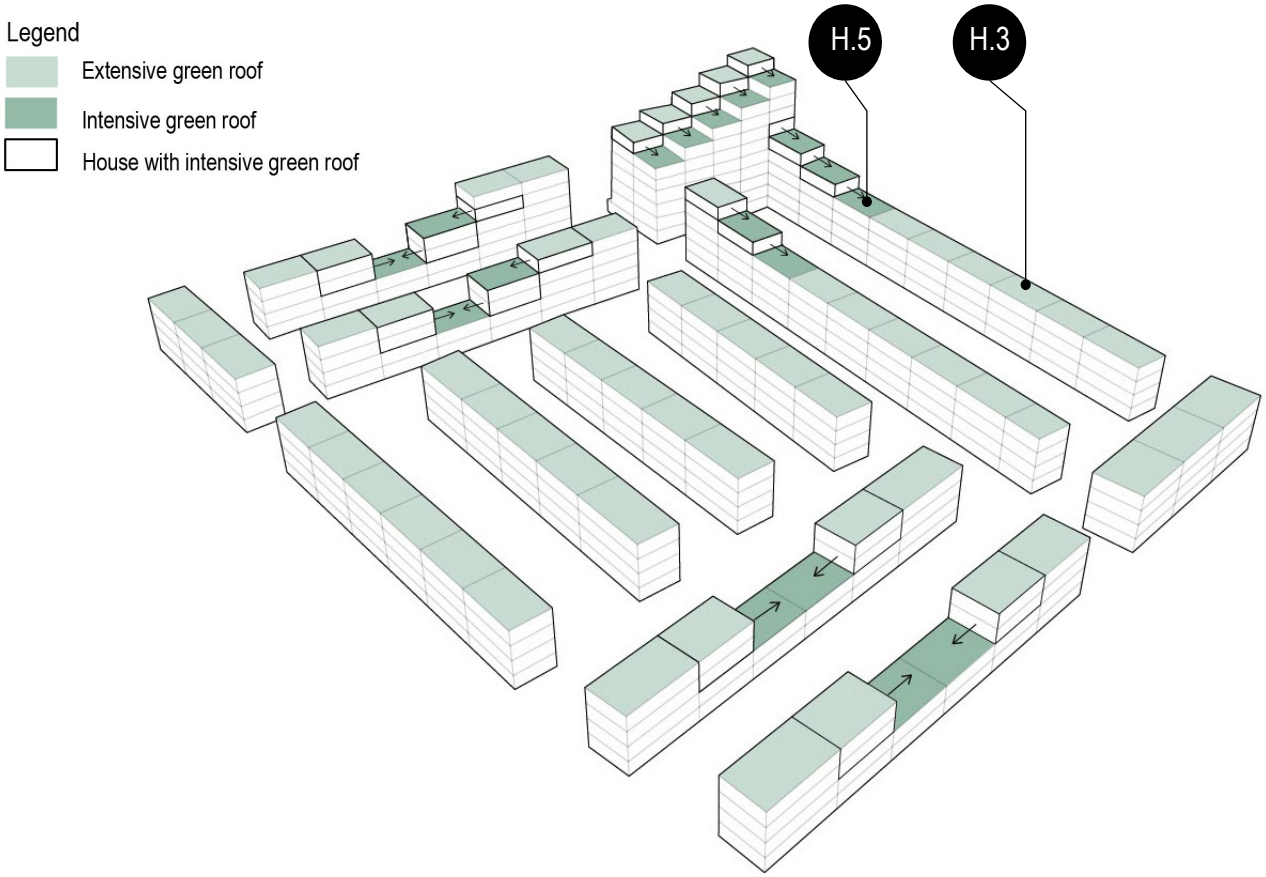


Fig 130 Green roofs in the building block.
Source: Produced by author.

H.5 Gardens will also be realised on some of the roofs of houses for the effective use of space. These gardens are private or shared with another dwelling, and can be split by two or shared together. The rest of the roofs will be an extensive green roof to cool the outdoor space and the dwellings under the roof.

H.4 Not only the ground floor but the roofs will also be greened. But in order to achieve the maximum situation, facades are also being made greener. Facades with few large openings are the best facades for greening and for this reason all the side facades will be greened. The other facades have large windows and balconies, which makes it difficult to add plants to these facades.

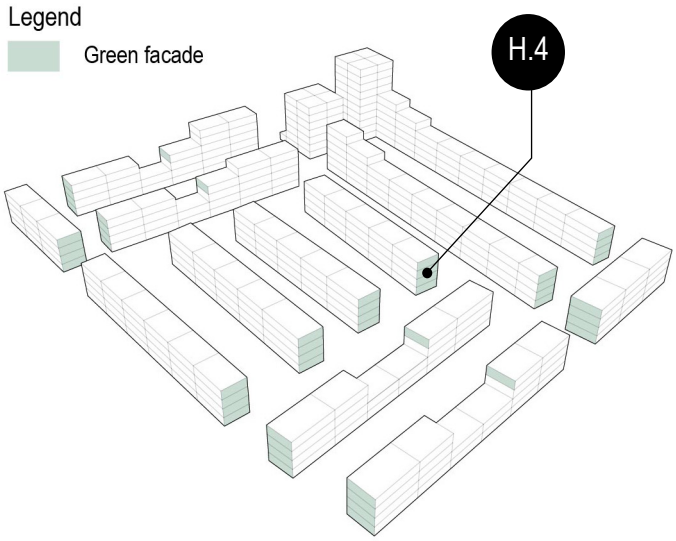
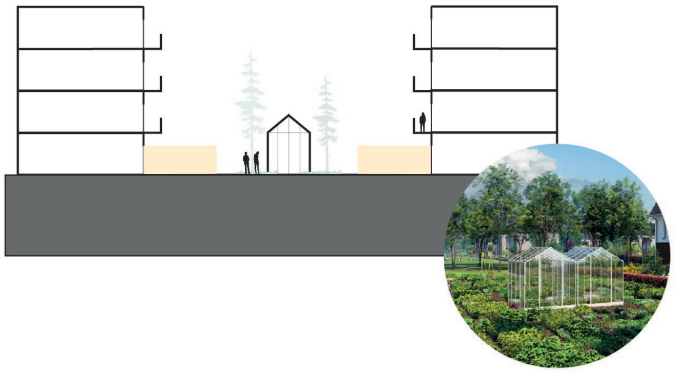


Fig 131 Green facades in the building block.
Source: Produced by author.

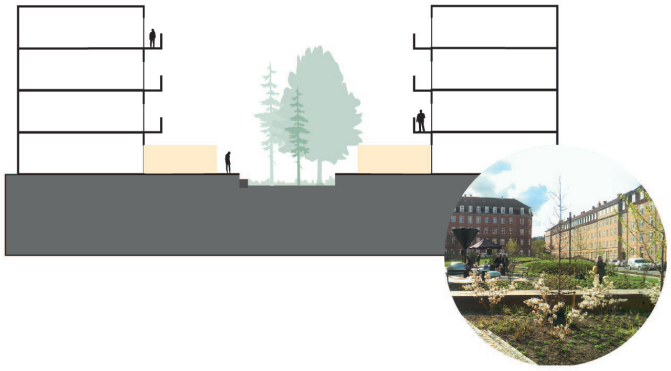
These in-between spaces will be equipped with many trees and greenery. In this way, most of the trees that are currently present will be retained. But to make these spaces attractive, they will also be given a function. To keep the housing blocks interesting and flexible, four possible infills for the spaces in between were designed. The vegetable gardens promote social cohesion among residents and can bring different types of residents together. The vegetable gardens also have an educational function and provide direct contact with the greenery

VEGETABLE GARDEN



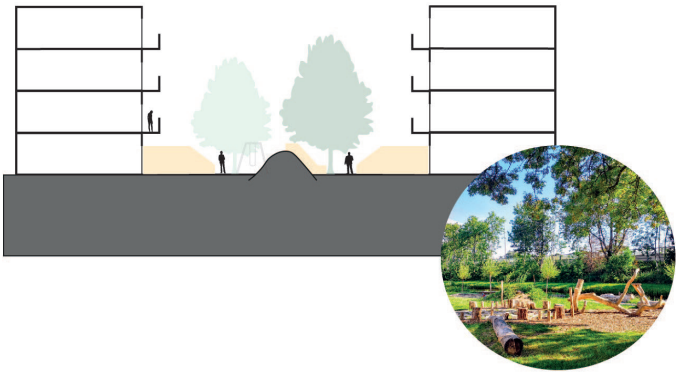
The second interpretation is a natural landscape that is imitated. By placing the greenery slightly lower than the paths, there is no direct contact with the greenery. But by combining this with seating, an oasis of peace can be created.

NATURE



In many places in the Netherlands, nature and playgrounds already go well together. By combining play equipment with greenery and trees, and through the car-free zone, the perfect location for the child is created. By lowering the fences of the private garden here, it is possible for parents to keep an eye on the children from the private garden.

CHILDREN'S PLAYGROUND



If the private garden is too small, it is nice to be able to relax in the semi-public space. It is important to create seating areas for this purpose. It is also important to create meeting places for residents. By combining this with pergolas for shade (H.17), these spaces remain cool during warm periods.

SEATING

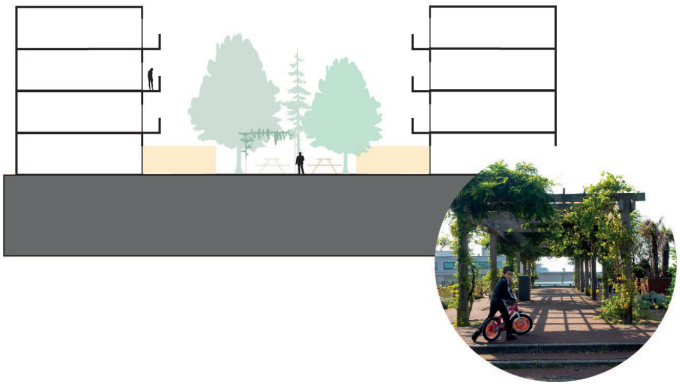


Fig 132 Infill semi public space
Source: Produced and edited by author by author (Dakpark Rotterdam, 2021), (De Buurtschap, n.d.), (Sustainia, 2018), (Wooning Berkhuizen, 2020)

Fig 133 Infill of the semi-public spaces
Source: Produced by author.

This semi-public space is flexible because of the various options for its use. This infill depends on the houses and the residents who live there. The distribution of the semi-public space is shown in figure 133.
The children's playground will be located in the semi-public areas where the terraced houses are, as families with children are likely to live here. This will allow children to play in a safe space with parents who can supervise them.
The nature variant is placed in the new construction and renovation where appartments are placed. This area is mainly oriented towards couples and singles to relax. Clusters of trees, in combination with seating areas under pergolas (H.17), make it possible to relax in the shade on a hot summer day.
Because the paths are slightly higher than the plants, it is also possible to sit at the edge of the paths and enjoy the greenery.
The great social value of the vegetable gardens in bringing together different types of residents ensures that this variant is placed in the middle of the block. In this way, the vegetable gardens are easily accessible for everyone in the block.
This block will be the test site. If a certain function does not have the desired outcome, this can be taken into account in the development of the other building blocks and this infill can be omitted.

CHILDREN'S PLAYGROUND

The semi-public area of the playground consists of 3 large pieces of equipment with a natural look. The equipment is made of sustainable wood. Children have a preference to play in nature and by using natural materials this can be imitated. The central play element also has a water element. This creates direct contact with water, allowing children to cool down. The entire semi-public area will consist of grass, after the play elements that have sand as a substrate and the paths that consist of normal paving and open clinkers for extra green.
Each play element is also equipped with seating facilities for parents to supervise the children.

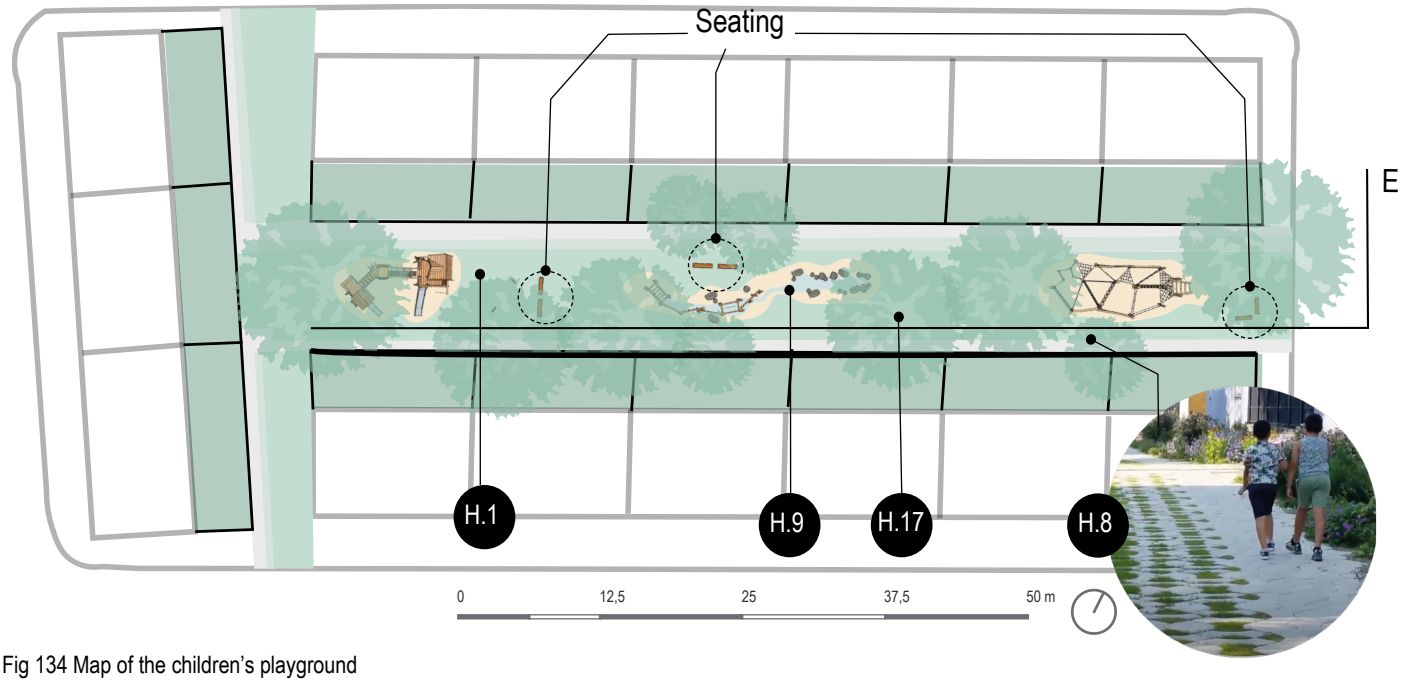


Fig 134 Map of the children's playground
Source: Produced and edited by author (Sluijsmans, 2021)

Fig 135 3D section of the playground in the semi public space
Source: Produced and edited by author (Acacia-Robinia Nederland BV, n.d.), (Paalman, 2018), (Uniek Speelprojecten, n.d.).

Fig 136 Section E of the playground semi public space
Source: Produced by author

There is little height difference in the semi-public area. In connection with the water, it is a little later and a small hill has been built to interrupt the long space.

By using different plants, trees and natural materials such as wood, a natural playground for children can be created. The perfect situation is imitated for children by bringing nature, water and different heights together in one design. Parents will feel more secure that children can play easily under their supervision. Figure 137 give an idea of what this might look like.

Fig 137 Impression of the playground in the semi-public space
Source: Produced by the author by using lumion (Google, 2021), (MrCutout.Com, n.d.), (Nonscandinavia, n.d.), (PNGEgg, n.d.), (Praxis, n.d.)

NATURE

The semi-public space consists mainly of a variety of plantings with paths in between. For this reason, enough shaded seating areas are provided to enjoy the greenery. The pergolas provide shade and the clusters of trees have a shadow function (H.17). The paths of the crossovers will consist of permeable pavement for excess rainwater and evaporation to cool the path (H.8).
Along the gardens, as in any semi-public space, there is a path with partly open paving stones for more water drainage that also has a cooling effect (fig. 139). This creates a transition from regular paving to semi-green and semi-paved ground to complete greenery.
Since the plants are 2 metres lower than the paths, the water will also flow in here during wet periods due to the slopes. Residents will enjoy the space and greenery here, which has a positive effect on the physical and mental state of the visitor.

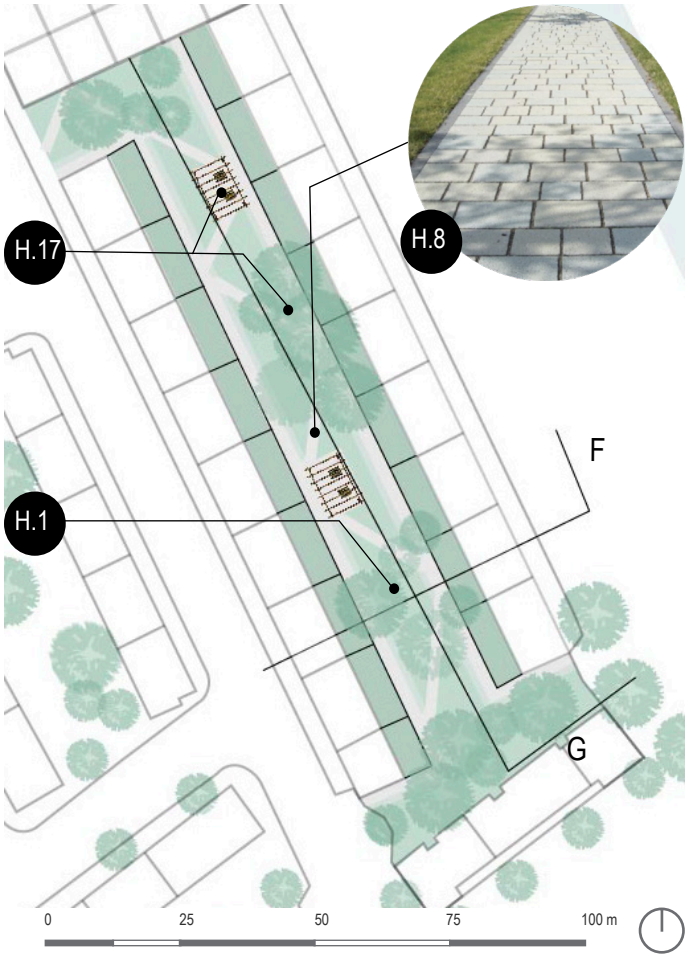


Fig 138 Map of the nature in the semi public space
Source: Produced and edited by author (de Smet, 2019).

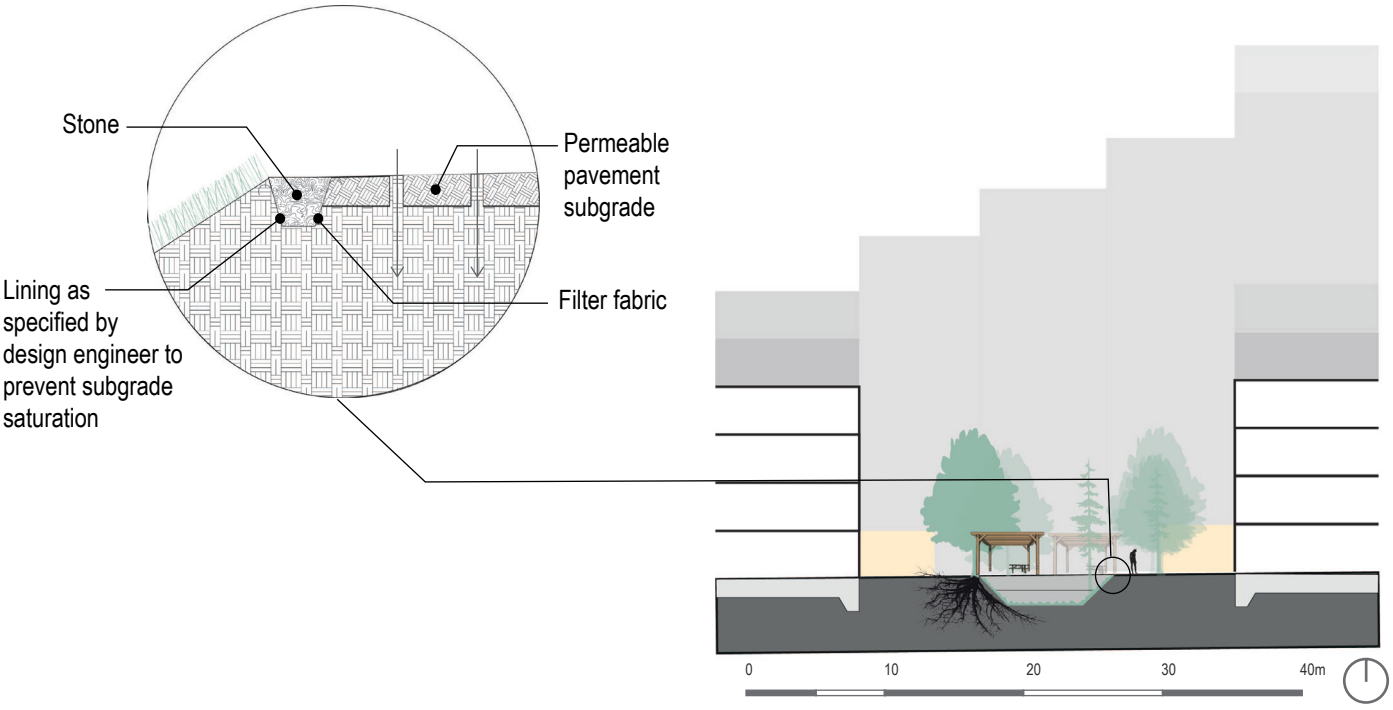


Fig 139 Section F of the playground in the semi public space and a detail section.
Source: Produced by author.

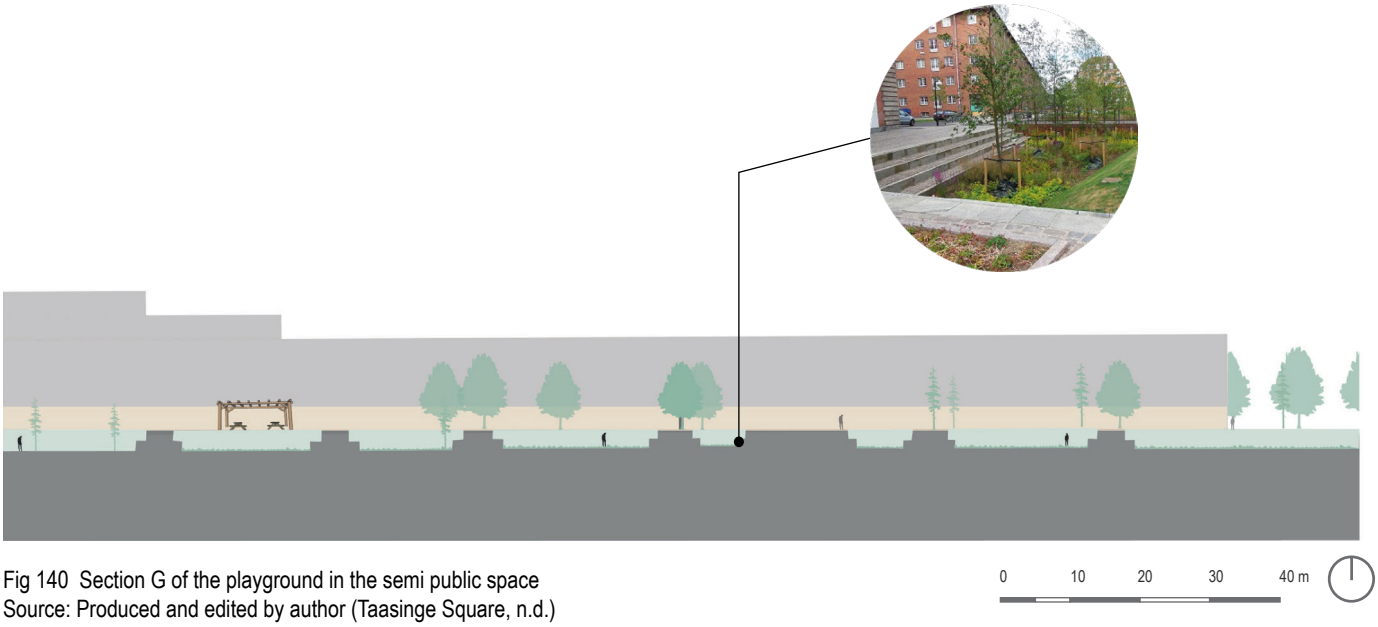


Fig 140 Section G of the playground in the semi public space
Source: Produced and edited by author (Taasinge Square, n.d.)

There are large steps along the paths to make the greenery accessible. These steps also provide the opportunity to sit along the paths and enjoy nature. Between these large steps, there will also be normal steps to make nature more accessible.

The impression shows that the greenery has been given an interpretation, but that it also offers the freedom for flexible use. In this way, this semi-public space can adapt itself more to possible future scenarios.

Fig 141 Impression of the nature area in the semi-public space
Source: Produced by the author by using lumion (CGaxis, n.d.), (Google, 2021), (MrCutout.Com, n.d.), (Nonscandinavia, n.d.), (PNGEgg, n.d.). (Praxis, n.d.)

VEGETABLE GARDEN

The vegetable garden focuses on the social aspect to bring different types of people in the neighbourhood together. The semi-public area consists of 2 small greenhouses in which different types of plants can be grown. This is expanded by plant boxes in front of and behind the greenhouses. The current trees in the semi-public space will be retained in connection with the shadow effect these trees provide.
In many projects, vegetable gardens have a desirable effect and bring together several target groups. It is of course possible that the residents make little or no use of the vegetable garden, in which case this will be changed into another use.

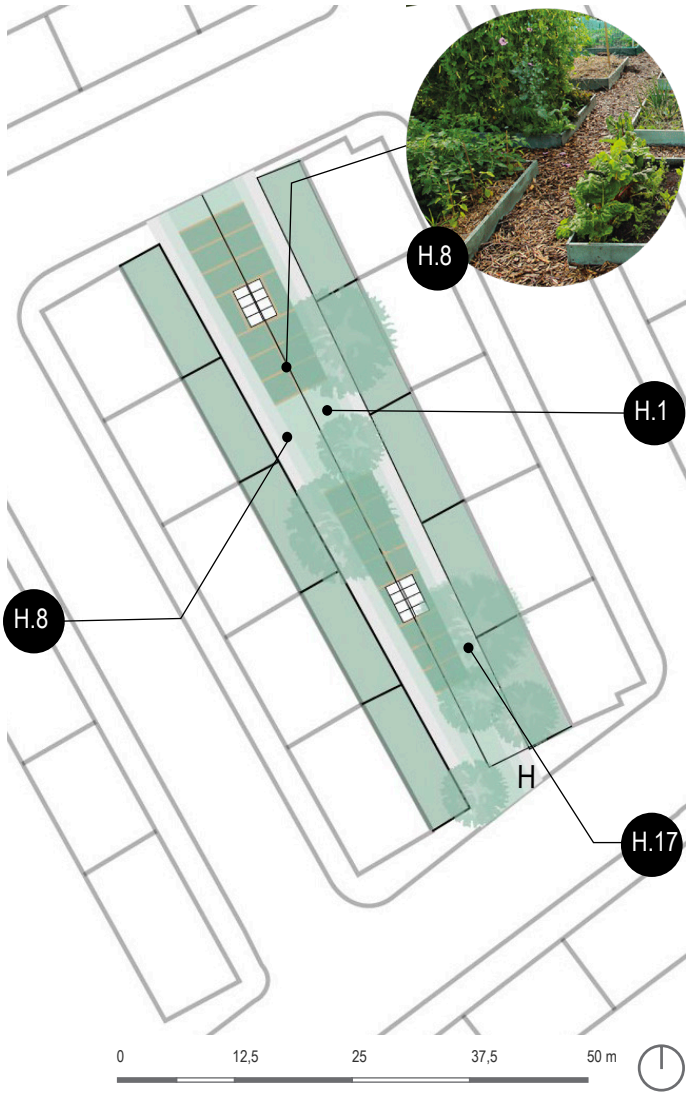


Fig 142 Map of the vegetable garden in the semi public space.
Source: Produced by author.

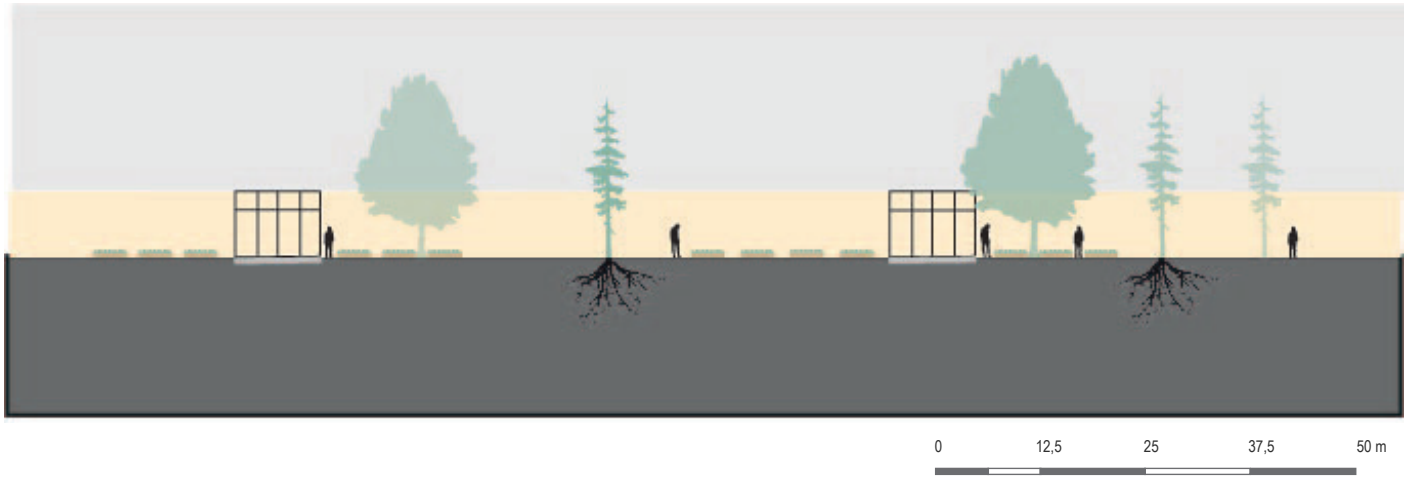


Fig 143 Section H of the vegetable garden in the semi public space
Source: Produced by author.

Fig 144 3D section of the vegetable garden in the semi public space
Source: Produced by author.

Between the small greenhouses and the plant boxes, narrow paths have been made so that all the plants are easily accessible. These paths are made of wood chips. Wood chips are used to keep the plants healthy, preferably hard wood. These wood chips are placed between the different beds of the vegetable garden. This will allow the path to retain more water, which can be evaporated, keeping the plants in good condition for longer and cooling the environment.

Fig 145 Impression of the vegetable garden area in the semi-public space
Source: Produced by the author by using lumion (Canopia by Palram, n.d.), (CGaxis, n.d.), (Google, 2021), (MrCutout.Com, n.d.), (Nonscandinavia, n.d.), (PNGEgg, n.d.). (Praxis, n.d.), (Simons, n.d.),

Fig 146 Map of the whole building block.
Source: Produced by author.

By combining all public and semi-public spaces, a building block with a lot of green and diversity in function, target group and biodiversity is created. People experience this space as a place to stay or as a place to be with a specific function (fig. 146).

However, this is different for animals. Animals do not see functions or different spaces. Animals see places where they can find food, reproduce or seek protection. For animals, the city is a large landscape (fig. 147) (van Stiphout, 2020).

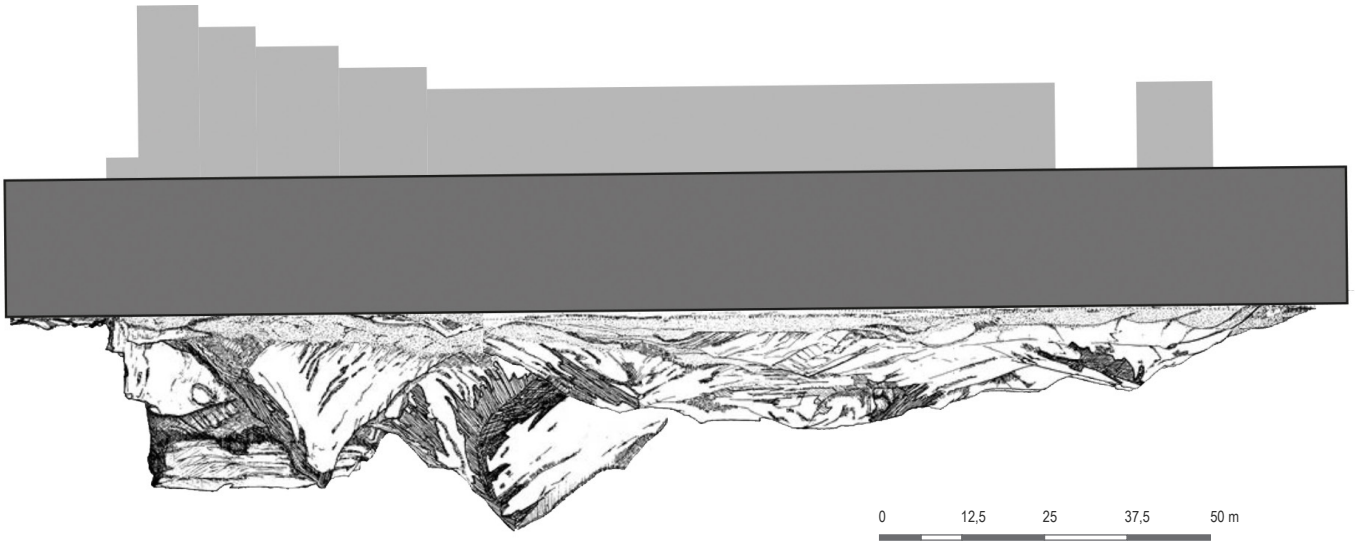
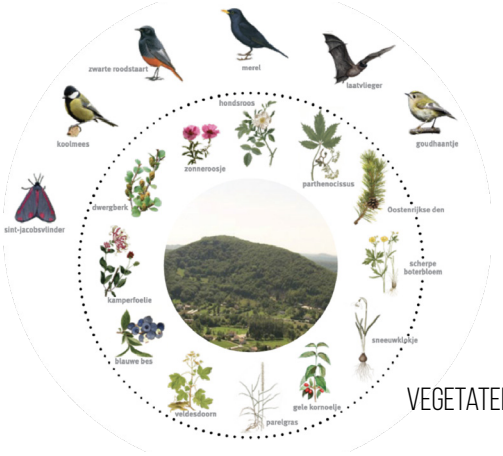


Fig 147 Section of the buildings elements in the neighbourhood.
Source: Produced and edited by author (van Stiphout, 2020)

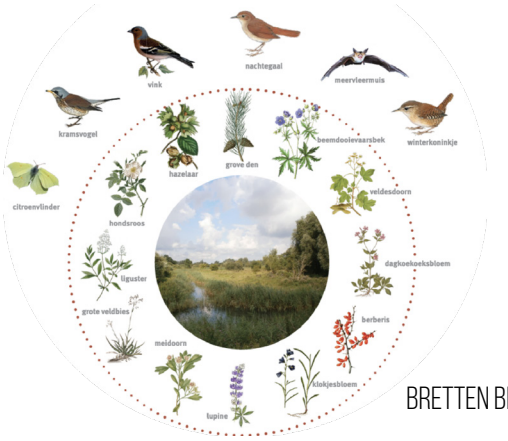
GARDEN BIOTOPE

Urban gardens are important for food, protection and breeding sites. Aesthetics is an important factor here, but the different types of plants with lots of nectar can also contribute to biodiversity (van Stiphout, 2020).



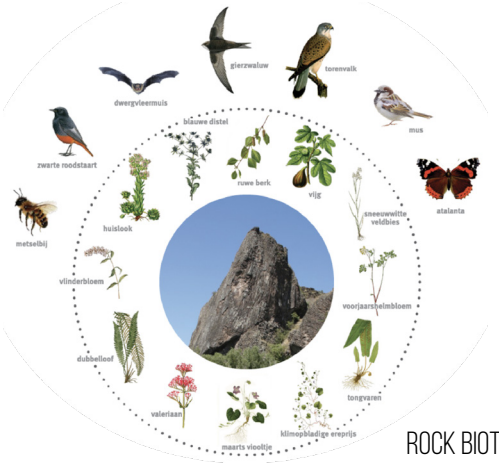
VEGETATED HILLSIDE BIOTOPE

Roof terraces, green facades and planters are seen as an overgrown steep hill for an animal. With all the different plants, this provides good nesting ground for birds (van Stiphout, 2020).



BRETTEN BIOTOPE

The Bretten biotope is based on the landscape of the Bretten. In the city, this can be found on flat roofs of about 4 to 5 storeys high and in public spaces. By arranging many public spaces and roofs in this way, a gorge park is created in which animals can move safely through the entire biotope (van Stiphout, 2020).



ROCK BIOTOPE

High buildings, pavement and infrastructure are considered the rock biotope for an animal. The animals that find their food in this biotope can find good nesting space and protection in the cracks and holes of walls (van Stiphout, 2020).

Fig 148 Different biotopes in the city.
Source: Produced and edited by author (van Stiphout, 2020)

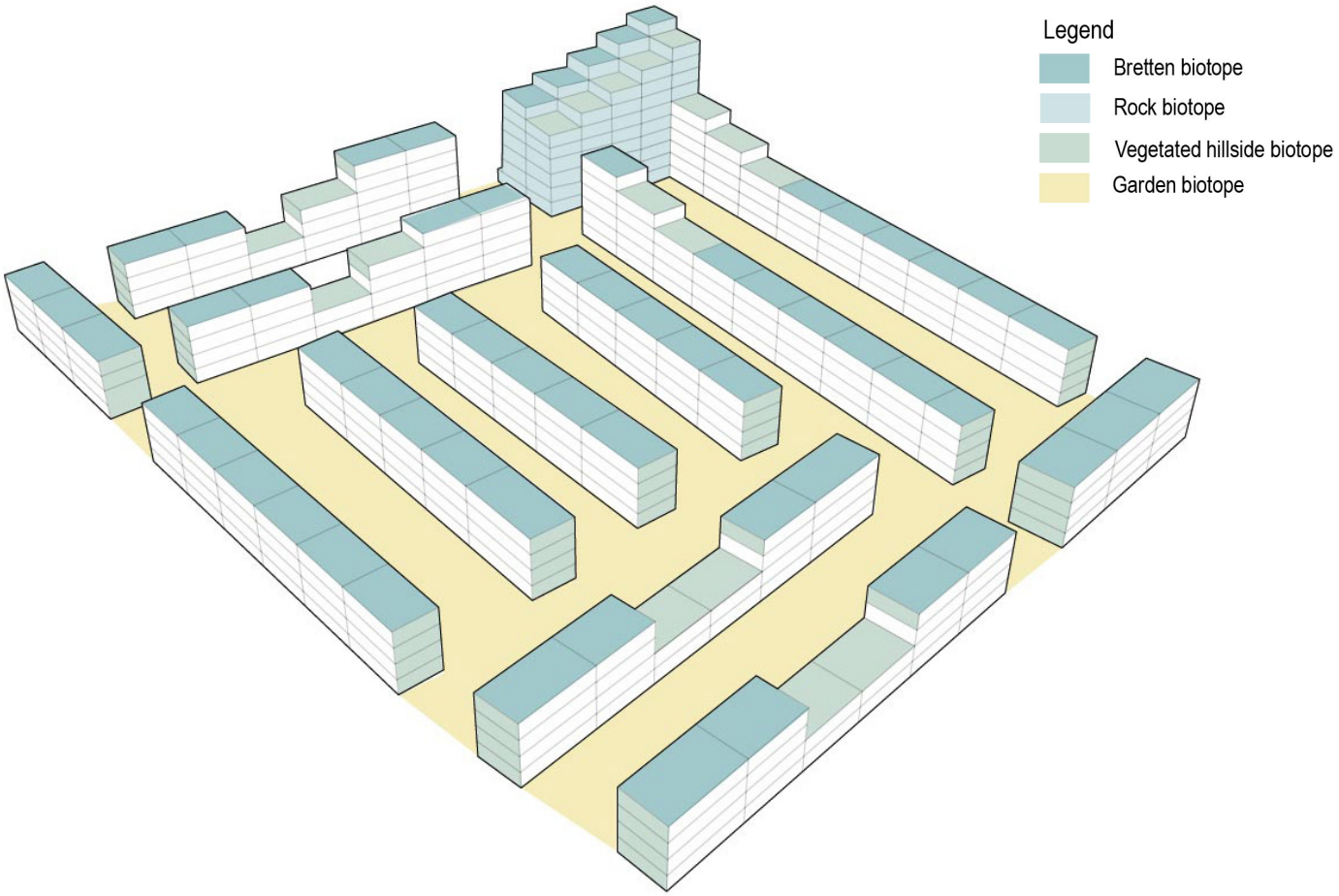


Fig 149 Different biotopes in the building block.
Source: Produced by author.

There are different biotopes that come together in the building block (fig. 149). Each biotope has its own space in the block and may overlap with each other in practice, because the boundaries are not rigid, of course. This creates a great diversity of animals.

In the entire neighbourhood, the wind has created large height differences, so that a lot of space can be created in the buildings for many different kinds of insects and birds. This is done by means of gaps and holes in the facades that offer protection and breeding places for these animals (fig. 150). This increases biodiversity in the city.

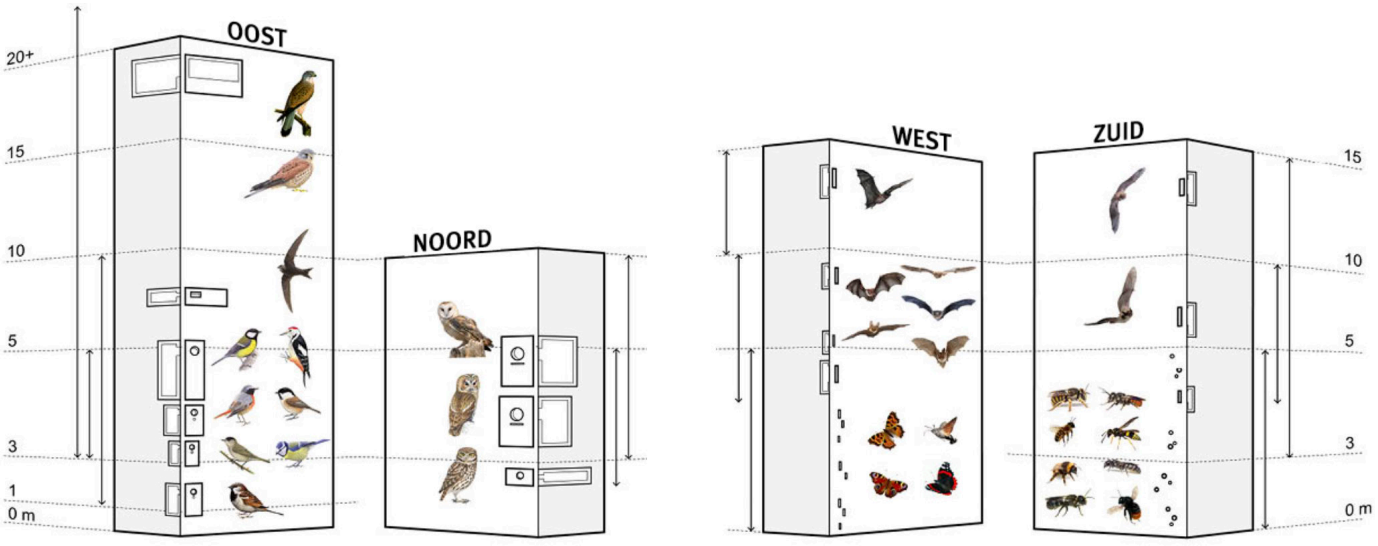


Fig 150 Different animals that can be implemented in the buildings.
Source: (van Stiphout, 2020)

POSSIBILITIES FOR THE USE OF TREES

Trees are very important in combating heat stress. Trees cool through evaporation and by creating shade. Evaporation can cool the air temperature on a large scale. Because the water in the leaves evaporates and allows the leaf to cool down because of the air flowing past it, the air will also cool down. This phenomenon cannot be felt directly, but it does have an effect on a large scale (Rahman en Ennos, 2016).
Shadow does provide local cooling for residents and buildings. This mainly affects the wind chill factor of the places in the shade. The PET index can be lowered by 12 to 19 °C (Klok et al., 2019). Shading the façade of a house in the shade of a tree can also lower the indoor temperature (Rahman en Ennos, 2016).
Not every tree has the same effect. Large trees with dense tree canopies cause more shade. Heat waves are often accompanied by long periods of drought. Due to drought, trees may lose their leaves, reducing the shading effect (Hirons and Sjörman, 2018). This makes it important to look for trees with a high drought tolerance.

Native trees with dense tree canopies and high drought tolerance are (Green Cities, 2019):

- Field maple or Spanish aak (Acer campestre ‘Elsrijk’)

- Small-leaved lime tree (Tila cordata ‘Greenspire’ or ‘Rancho’)

- Japanese caucasian alder (Alnus spaethii)

- European nettle tree (Celtis australis)

Fig 151 Different types of trees that work against heat stress.
Source: Produced and edited by author (Japans Kaukasische Els, n.d.), (Van den Berk Boomkwekerijen, n.d.), (Veldesdoorn, n.d.), (Winterlinde, n.d.)

4.5 PHASINGS

The phasing is based on the patterns that have been drawn up to indicate which patterns can be applied at what time and which stakeholders should implement these patterns (fig. 152). A lot of patterns are related to mulitple stakeholders. These stakeholders are linked to the patterns by their interest, which is determined in the stakeholder analysis. Some of the patterns are also linked to ownership.
Because not everyting has the same priority or can not be realised in the same period three phases are created in which the patterns are realised.

Phase 1:
This phase consists of investments that are already equipped with the means to execute the patterns. These patterns are often on a small scale and easy to implement in space (Cieraad et al., 2020).
Duration: 3 to 5 years.

Phase 2:
This phase consists of patterns that are feasible and need to be set up in the short term in order to be realised in phase 2. These patterns require more resources and costs to implement, but have high priority for densification and microclimate improvement (Cieraad et al., 2020).
Duration: 5 to 7 years.

Phase 3:
This phase consists of patterns that require a lot of resources to realise. These patterns are often on a large scale and connected to many other flows of the district, which makes these patterns more difficult to implement. These patterns can be implemented during a large-scale restructuring of the district.
Many patterns from phase 3 follow from patterns from phase 2 and can therefore only be executed in the longer term (Cieraad et al., 2020).
Duration: >10 years.

Some patterns can be applied in multiple phases..
For the realisation of more green areas, the entire process will have to take into account unnecessary paving, unused public spaces where new cooling locations can be created.
These patterns will all affect the existing housing market, and new homes in the district. These patterns cost money and the housing corporation, project developer and municipality has to pay these costs. The housing cooperation and project developer will recover these cast from there residents. This will increase the rent and there is a chance that the residents will have to leave. It is important to protect these existing residents by using pattern D.3. The current residents will be taken into account throughout the entire process in order to prevent this effect as much as possible.

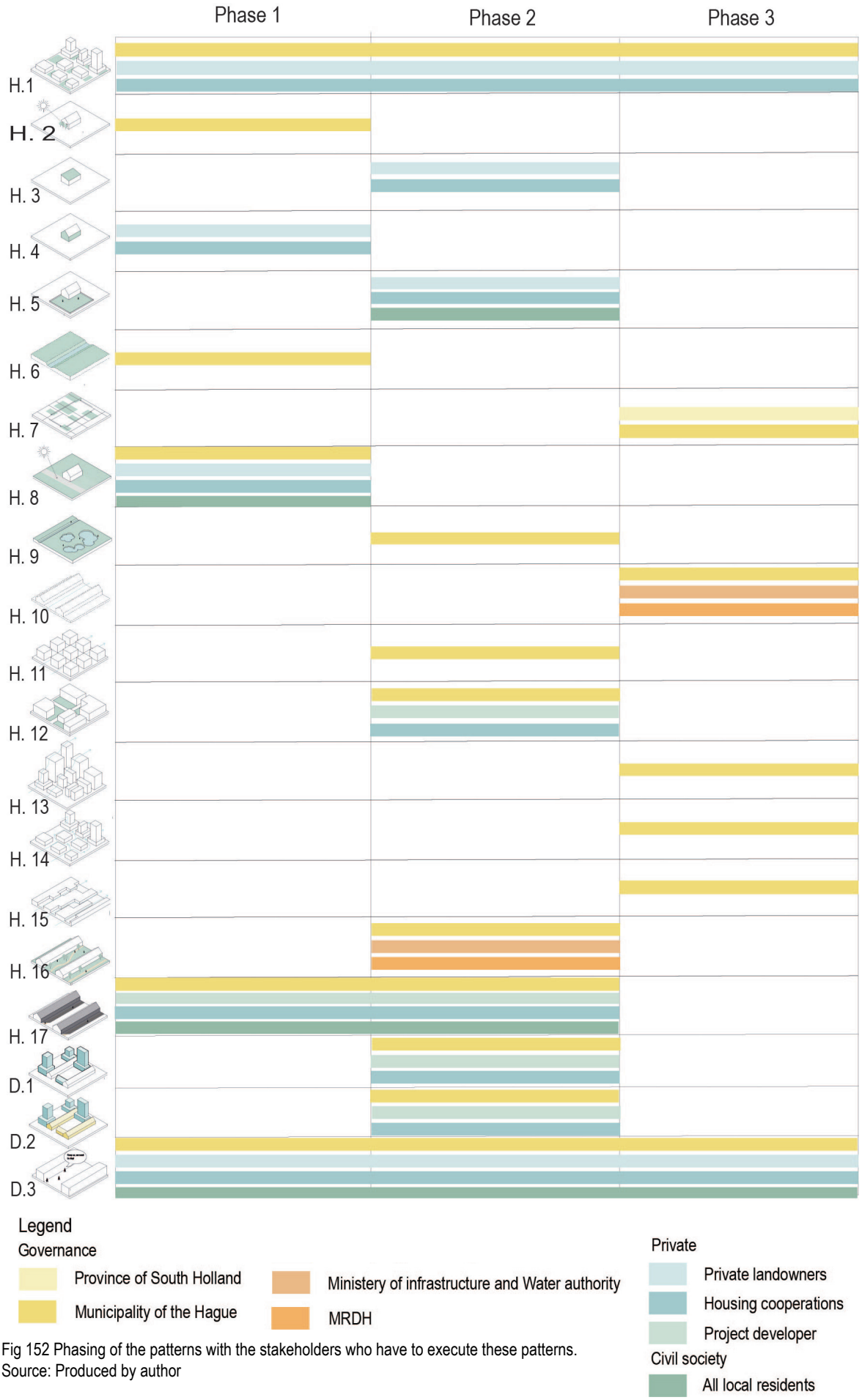


Fig 152 Phasing of the patterns with the stakeholders who have to execute these patterns.
Source: Produced by author

Fig 153 Property distribution in the block.
Source: Produced by author.

It is important to know who is responsible for the costs of redevelopment. For the public space, the municipality will have to pay the costs as the streets are owned by the municipality (fig. 153).
For the buildings and the semi-public space, the situation is more complicated. The houses and semi-public spaces are owned by the Vestia housing corporation (fig. 153).
To prevent as much as possible that Vestia will raise the rent of the houses and that some residents will not be able to pay this, Vestia will get 20 extra houses for social rent. Since more houses than these 20 will be realised, a project developer will be added as a stakeholder who will realise private rental and owner occupied houses and sell them to private individuals.

Vestia will therefore be able to receive extra money from the sale of land to the project developer in order to build terraced houses, maissionettes and appartments.
At some locations in the building block, several stakeholders are connected. The stakeholder who will own the ground floor will have to pay for the garden as this will affect the value of the property on the ground floor. The remaining space of the semi-public space will have to be paid for by all stakeholders connected to the surrounding buildings. These will mainly be private individuals and the housing association.

4.6 CONCLUSION DESIGN

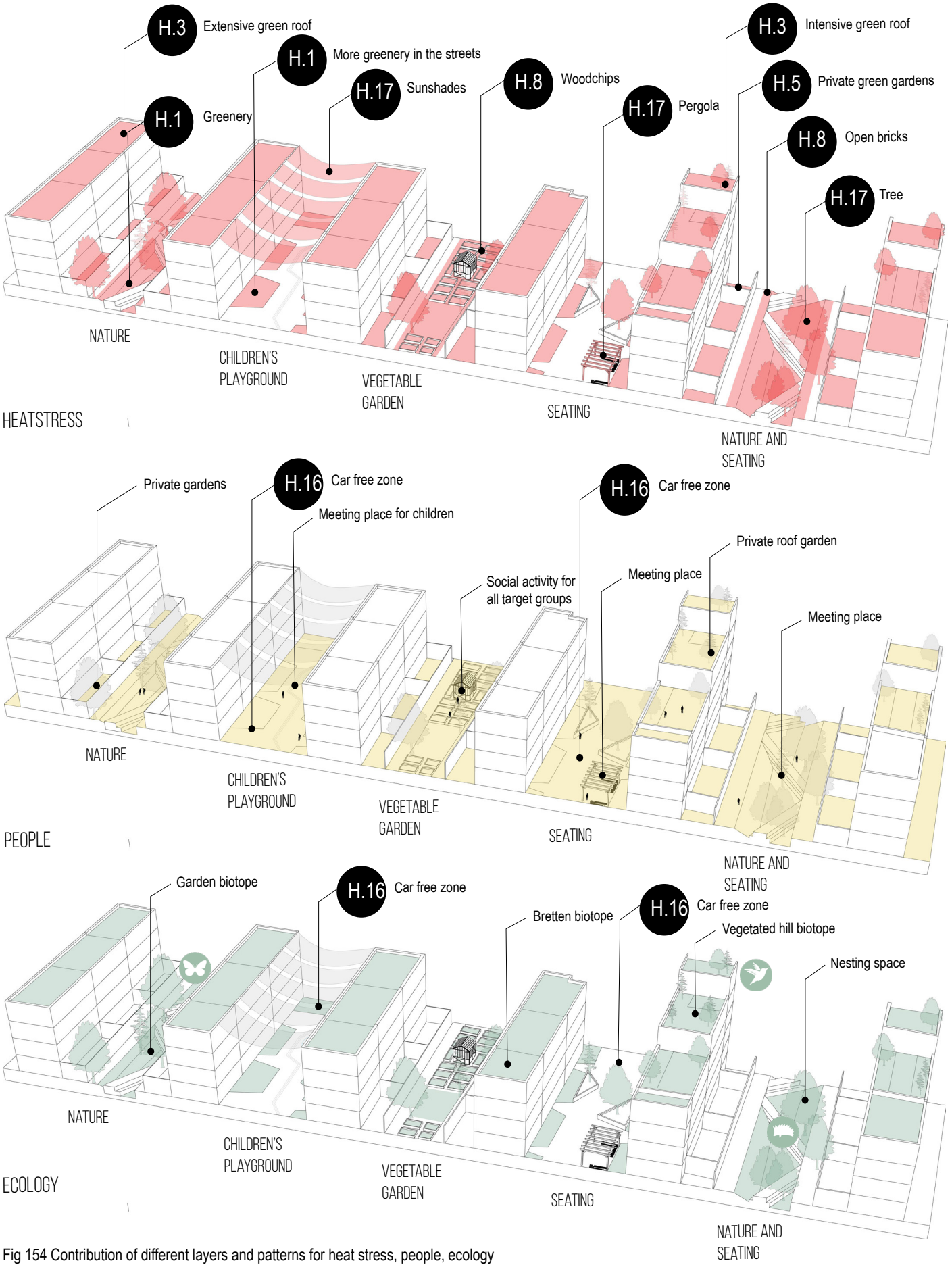


Fig 154 Contribution of different layers and patterns for heat stress, people, ecology
Source: Produced by author.

HEATSTRESS

In the building block, many patterns are used on different layers of the building block to lower the perceived temperature outside and inside. There are patterns that have a direct effect on this temperature such as shading and patterns that lower the ambient temperature on a large scale such as green roofs.
Patterns are also used that can be applied in different ways such as creating shade and greenery. In this way, pleasant places for residents and visitors are created and the quality of living is increased. This also has a positive effect on the value of the homes in the residential block.

PEOPLE

Lowering the PET index has a positive effect on the liveability of the residential block. Residents will now experience a more pleasant temperature inside and outside during warm periods, reducing the consequences of heat stress. By enlarging the block and creating car free zones, there is more room to redesign the public space. By giving the semi-public and public areas different functions, several target groups will be addressed. In this way, the aim is to make more use of the outdoor spaces so that there is more interaction between residents.
If people do not want to interact with their fellow residents for a while, private outdoor spaces have also been created as much as possible in the form of balconies, gardens and roof gardens.

ECOLOGY

The car-free zones have also created a nice living environment for animals that live on the ground such as hedgehogs that can take refuge in the bushes.
These many green areas with different types of planting will attract various insects and butterflies that will have a positive effect on biodiversity.
Furthermore, there is a large difference in height in the neighbourhood due to the wind, which means that various birds will be present in the neighbourhood. By creating gaps and holes in the facades, these birds will have hiding places and nesting places or they can nest in one of the many trees that are present in the district. In this way, the neighbourhood is not only pleasant for people, but also for animals.

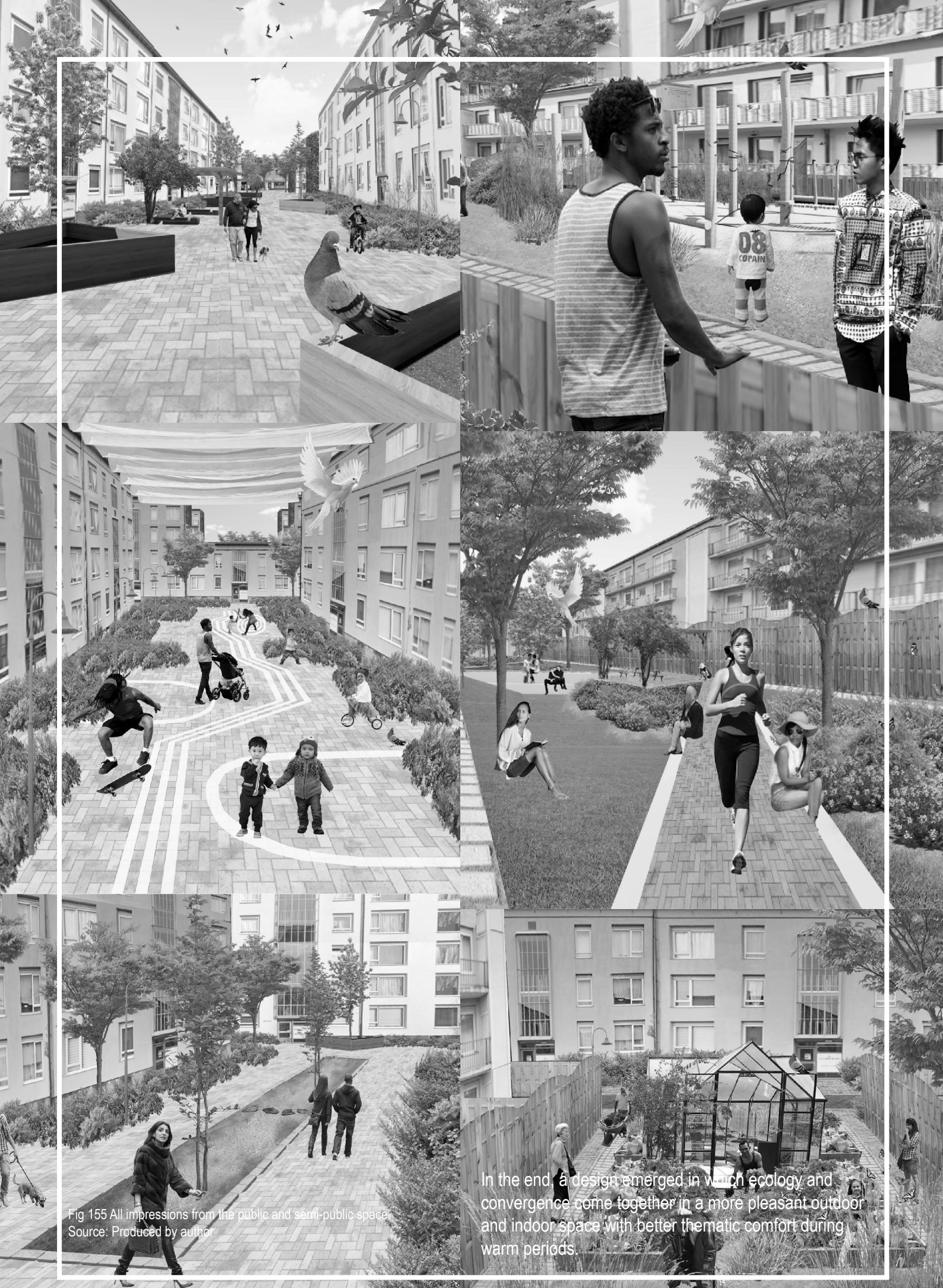


Fig 155 All impressions from the public and semi-public space
Source: Produced by author

In the end, a design emerged in which ecology and convergence come together in a more pleasant outdoor and indoor space with better thematic comfort during warm periods.

5. Conclusion

TRANSFERABILITY

CONCLUSION / DISCUSSION

REFLECTION

REFERENCES

5.1 TRANSFERABILITY

How easy can the interventions, patterns and designs be applied in other neighbourhoods? The pattern languages provide the patterns that will combat heat stress and provide opportunities for densification. These patterns are general and can be applied to any neighbourhood.
Patterns, however, respond to the existing elements of a neighbourhood and these differ for each neighbourhood, so the implementation will also differ in each neighbourhood. Some patterns respond to specific elements such as surface water, structure or height of buildings. Other patterns depend on external factors like the wind and sun orientation.
In a final design, not only the improvement of the micro climate is taken into account, but also social and financial layers.
Every neighbourhood is already different, so it is not possible to use a single solution to densify all the neighbourhoods in the same way to reduce heat stress. However, there are neighbourhoods that are similar to Moerwijk in terms of structure or density.

THE EARLY POST-WAR NEIGHBOURHOOD

The early post-war neighbourhoods were built at the same time as Moerwijk, so they have many similarities. These districts often have the same structure in which living, working, infrastructure and recreation are strongly separated and the collective is central. This is expressed in the 3 to 4-storey house construction with large collective green spaces in the district. These urban patterns that emerge are repeated in stamps throughout the district, which creates a lot of monotony. This way of setting up a new district ultimately leads to the same problems in the districts as in Moerwijk.
The green qualities in the district are therefore present, but due to poor maintenance and management, these values are hardly used and appreciated (Lörzing et al., 2008).
Here are some examples of neighbourhoods that are similar to Moerwijk, where densification can be done in a similar way and also improve the microclimate.

Agreements:

+ Monotone residential buildings
+ Stamping building blocks
+ Collective green areas
+ Separation between living, working and recreation
+ The public space filled with cars
+ High percentage social rent
+ High percentage of low income residents

Differences:

- Stakeholder composition

Presikhaaf, Arnhem

This district consists of stamped urban structures with an alternation of flats and row houses. In this district, there is a large collective green space for recreation and, on a small scale, the public space is arranged in the same way as in Moerwijk, whereby the home is split from the public space (which is filled with the car) by a small semi-public space.

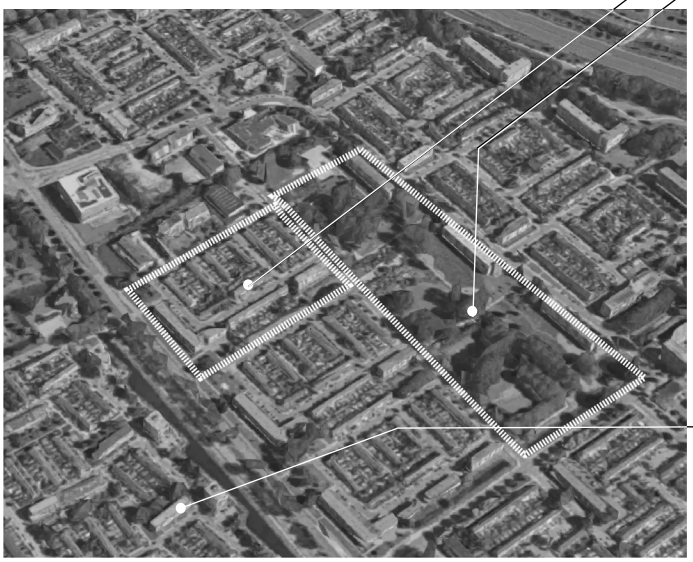


Fig 156 Early post-war Presikhaak district in Arnhem.
Source: Edited by author (Google, 2022).

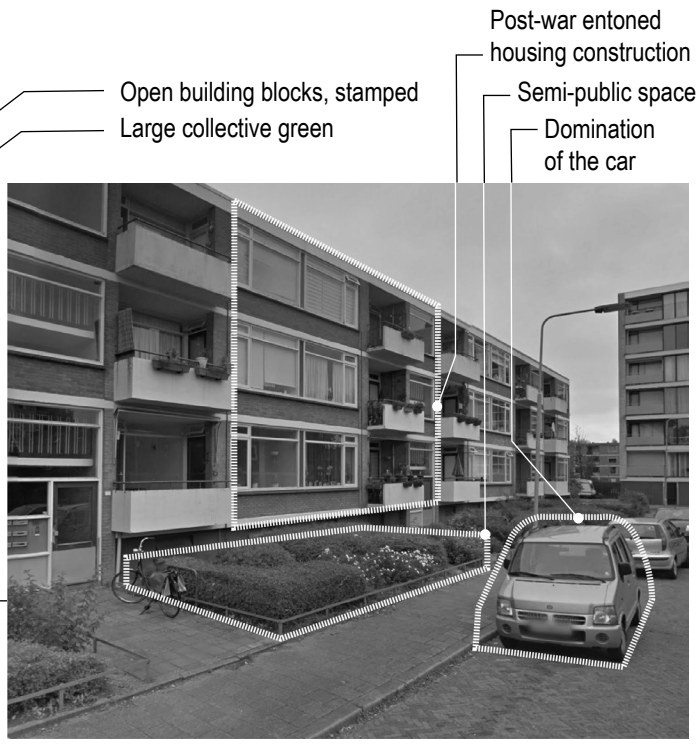


Fig 157 Early post-war housing in Presikhaak.
Source: Edited by author (Google, 2022).

Crabbehof, Dordrecht

Dordrecht has a neighbourhood with houses similar to those in Moerwijk. This district is also stamped but with somewhat larger building blocks. In the blocks there is a lot of collective green which has no function and is therefore not used.

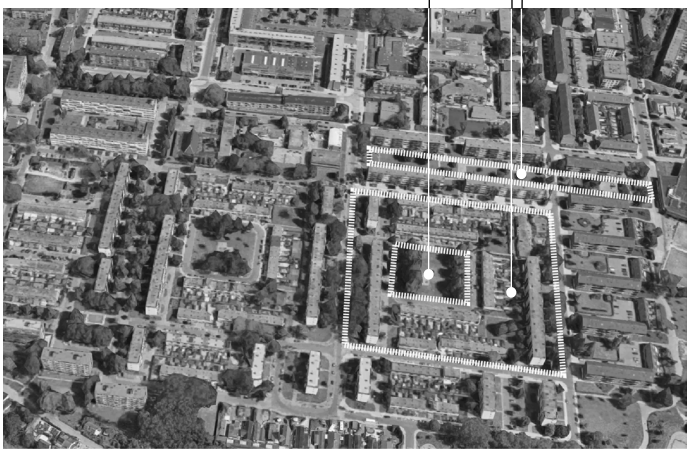


Fig 158 Early post-war Slotermeer district in Amsterdam.
Source: Edited by author (Google, 2022).

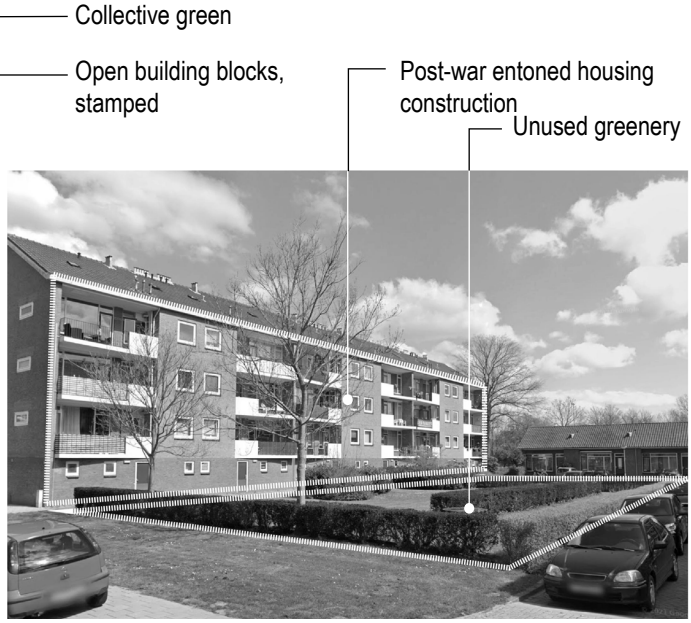


Fig 159 Early post-war Slotermeer district in Amsterdam.
Source: Edited by author (Google, 2022).

Slotermeer, Amsterdam

Many of the urban planning patterns consist of open building blocks that have potential for reducing heat stress. These patterns are therefore repeated several times and ultimately a variety of different stamps are repeated in the district. As in Moerwijk, there is collective green space between the houses that is hardly used. And the public space is filled with cars.

Fig 160 Early post-war Slotermeer district in Amsterdam.
Source: Edited by author (Google, 2022).

Fig 161 Early post-war Slotermeer district in Amsterdam.
Source: Edited by author (Google, 2022).

1970S AND 1980S NEIGHBOURHOOD

These neighbourhoods have been selected on the basis of density. Moerwijk has an average density of:

GSI: 0.39
FSI: 1.24

The 70's/80's neighbourhood is often called a cauliflower neighbourhood and is characterised by its green layout with many dead-end paths. The same green lay out can be a reason of the similarity in density, but because they are built in a different timeframe the structure of the neighbourhood is different. Also, the architecture of the houses has many similarities with the houses in Moerwijk, but with a modern twist.
The houses are built monotonously. The neighbourhoods are also monotonous in structure, so that every street looks the same (M3H Architecten, 2012).

Agreements:

+ Architecture of the buildings
+ Collective green areas
+ The public space filled with cars
+ High percentage social rent
+ High percentage of low income residents
+Density

Differences:

- Structure of the neigbourhood
- Morphology of the buildings

Venserpolder, Amsterdam

Venserpolder is a district with closed building blocks that are placed next to each other in a structured way. These building blocks are nevertheless stamped on a small scale.Collective greenery has been placed in these buildingblocks, like in Moerwijk.

The patterns can also be applied to this. In this way, the neighbourhood has the potential to enlarge the building blocks and open up the street to slow traffic. The blocks will also be opened up for possible wind ventilation.

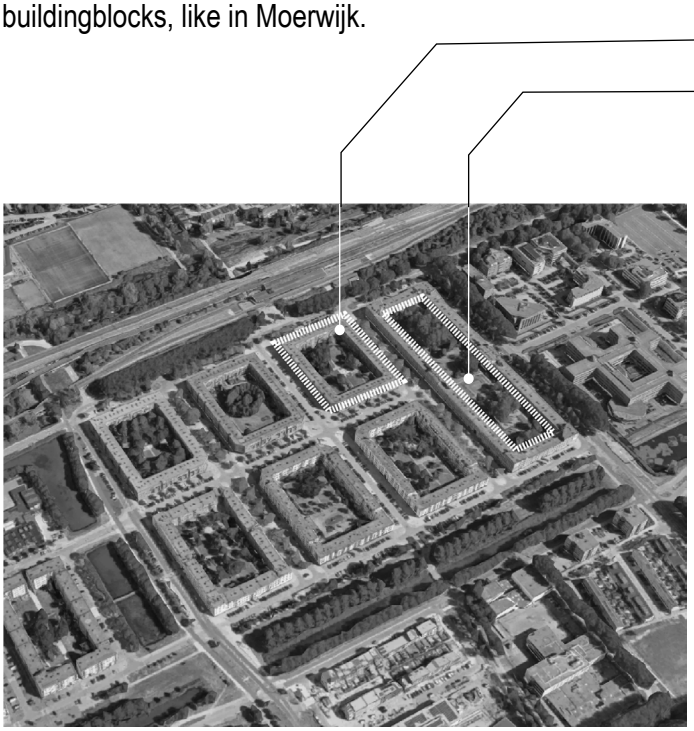


Fig 162 1980s neighbourhood Venserpolder in Amsterdam.
Source: Edited by author (Google, 2022).

Fig 163 1980s neighbourhood Venserpolder in Amsterdam.
Source: Edited by author (Google, 2022).

Holendrecht, Amsterdam

Holendrecht has a strict division between the collective green and the public space. This district separates the car from the green space, leaving plenty of room for slow traffic. The structure of the district has elements of the traditional cauliflower district.

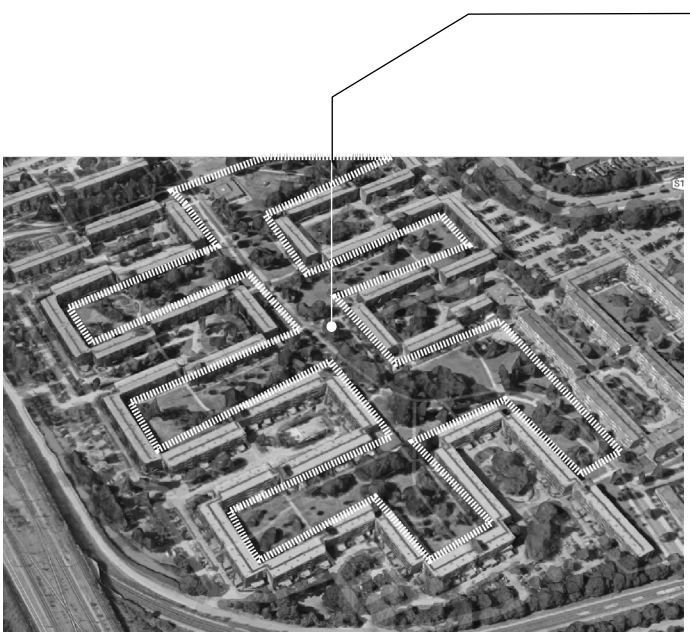


Fig 164 1980s neighbourhood Holendrecht in Amsterdam.
Source: Edited by author (Google, 2022).

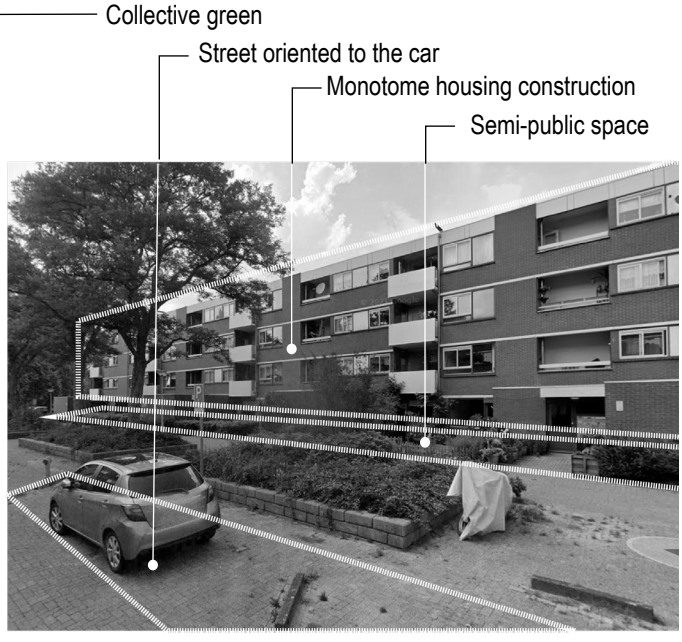


Fig 165 1980s neighbourhood Holendrecht in Amsterdam.
Source: Edited by author (Google, 2022).

5.2 CONCLUSION

The aim of this research was to develop a method for densifying in an efficient way to prevent and possibly reduce heat stress. The main research question was therefore:

How to densify in The Hague in order to mitigate and prevent heat stress and the urban heat island effect to improve the livability of the city and the health of its inhabitants?

To answer this question, this project first answers the sub-questions summarised below:

CONCEPTUAL BACKGROUND:

1. **How can densification provide an opportunity for the integration of a better living environment?**

The literature has shown that the best way to increase densification for the living environment and thermal comfort is high-rise. High-rise buildings provide a lower GSI, with more space for other facilities and greenery. Higher buildings also provide more shade, improving thermal comfort during hot periods.

2. What is the relation between heat stress and the urban heat island effect?

The urban heat island effect is one of the indicators of heat stress and therefore the two elements are dependent of each other. The difference between the two terms is that heat stress focuses on body temperature and the effect is felt outside during the day and inside at night. The urban heat island effect focuses on the heat storage of materials and is most pronounced at night. This effect is therefore more often experienced indoors.

ANALYSIS:

3. In what way is the heat stress and the urban heat island effect manifesting in The Hague?

The urban heat island effect is worst in the centre of The Hague and in Scheveningen. As a result, most heat stress occurs at these locations. But if nothing is done to change the area around The Hague, the heat will linger for at least two to three weeks after a hot day in the future.

4. What is a physical density typology in The Hague?

The analysis showed that density is greatest in the centre and in Scheveningen. Due to the lack of space in the city, buildings here are taller and closer together than in the neighbourhoods around them. The neighbourhood that ultimately emerged as the focus location is a typical early post-war residential area in which low-rise dwellings have been built. These dwellings are functionally laid out and are usually 3 to 4 storeys high. The houses have the same structure but each has its own layout. In this district, the percentage of social housing is high and the quality of the houses is low.

5. In what way is the heat stress and urban heat island effect affected by different morphologies and densities?

In The Hague it is clear that density is linked to thermal comfort. This is particularly true of the density of the GSI. The locations with the highest GSI in The Hague, such as the city centre and Scheveningen, are also those where the urban heat island effect is most pronounced. Because the urban heat island effect is an indicator of heat stress, these locations will also be the locations where heat stress occurs most often.

6. In which locations are people most affected from heat stress and the urban heat island effect?

The analysis showed that the elderly over 80 experience much greater effects of heat stress than younger people. The mechanisms of the elderly can no longer adapt easily to warm temperatures, and these people have a higher risk of even dying from heat stress.
The concentration of elderly people is greatest in the districts of Waldeck, Loosduinen, Scheveningen, Moerwijk, Bouwlust and Vredelust.

7. Which stakeholders are most important in the densification process, and how can their interests and needs be met?

The most important stakeholders are the Municipality of The Hague and the residents of the neighbourhood. Both stakeholders are interested in improving the aesthetics and functionality of the public spaces and in improving the quality of the existing housing and creating more housing. The difference between these stakeholders lies in the fact that the residents do not have the possibility to pay for this. There is another stakeholder that has a lot of power in the building block. This is the housing cooperative. They own almost all the buildings and for this reason the municipality, together with the housing association, must decide who is responsible for which interventions.
These choices will be made according to the interests and ownership of the stakeholders. By showing a detailed and working design, parties can discuss what is feasible and what is possible in the long term.

8. Which spatial interventions against heat stress and the urban heat island effect can be applied in a densified The Hague?

The pattern languages shows all the interventions that can be applied to reduce and prevent heat stress and the urban heat island effect. These patterns focus on themes such as wind, building environment, water and green. These interventions then depend on external factors such as wind and sun orientation and the underlying layers of the area. The patterns will differ from implementation due to the current situation of the area.

9. To what extent are the interventions in a typical neighbourhood in The Hague transferable to other cities?

The patterns of the pattern language that have been drawn up can be applied to any district in any city and country, perhaps in a different form than in The Hague. Yet there are many similar districts in the Netherlands where the same kind of structure and problems prevail and the same interventions can be applied as in Moerwijk with slight modifications.

The answers to the sub-questions provide the means to answer the main question:

How to densify in The Hague in order to mitigate and prevent heat stress and the urban heat island effect to improve the livability of the city and the health of its inhabitants?

For densification, it is important to keep the GSI low so that there is plenty of room for facilities at pedestrian level to combat heat stress and the urban heat island effect using the patterns in the pattern languages. This will have a positive effect on thermal comfort. The improved public space and a good microclimate will also improve the liveability and health of the residents.
In order to achieve sufficient densification, the lack of space means that the houses will be stacked higher. , which will provide shade, which is also positive for thermal comfort.

5.3 REFLECTION

This graduation project has the aim of understanding the relationship between the density and heat stress. To this extent, the main objective is to investigate how urban densifications and interventions can mitigate heat stress in The Hague.
As an addition to make the translation step into designs and provide new insights into mitigating heat stress the reflection consists of five parts. The first three parts, focus on the process of the thesis. The fourth and fifth part deals with the content of the thesis, the outcome of the thesis and the limitations. The last part of the reflection is a personal reflection

5.3.1 THE RELATION BETWEEN RESEARCH AND DESIGN

As mentioned before, much has been written about heat stress and the urban heat island effect. General tools are often given for this to solve the problem, but this is not incorporated in a design. This research has shown that the snap to a design is necessary because the microclimate strongly depends on external factors that are placespecific. To address this missing link, together with the housing shortage and the enormous demand for densification, the relationship between research and design is a lot stronger.
The research consists of two topics, heat stress and densification. First, general research was conducted into liveability and sustainability, which is a very broad subject. This ensures that the knowledge remains limited.
Further on in the research, we look more closely at different densities, the relationship between density and open space and the demand for certain types of housing. This shows that there is also a strong relationship between density and heat stress.
Heat stress is also researched for this purpose and knowledge is collected about heat waves, indicators of heat stress, the locations where heat stress occurs, external factors such as the wind, and the vulnerable target groups. Due to the limited time for the research and the lack of information about wind, it is difficult to find location-specific information about possiblities for cooling by wind.
For further analysis, research is carried out on the entire city of The Hague and a location is chosen by selecting various aspects. The location depends on the aspects chosen and these can vary per study.
Ultimately, an analysis is made of the Moerwijk district and the figures show that the district scores very poorly in certain areas. Conclusions are also drawn from a field trip, but the field trip focuses on the experience of the space and is personal. In further research, multiple experiences can be compared through interviews.
Here, the transition is made from analysis to design and the two elements take place more side by side. The design choices are underpinned by the research that has been carried out, so that the relationship in the project becomes more pronounced.
The process makes a clear transition from research to design, but in the entire process there is also an interaction between the two elements.

5.3.2 ADVANTAGES AND LIMITATIONS METHODOLOGY

The methods chosen should help answer the research questions and the main question of the study.
The approach was clearly structured with an interaction between the different steps in the process. However, during the process, it had become clear that some methods were no longer appropriate to the project and did not help answer the questions or contribute to the thesis in any way.
In the beginning of the process, methods are taught that can be useful during the thesis. The main focus was on stakeholder analysis and the maximisation method.
Both methods are not focused on the transition between analysis and design, which made the transition more difficult than expected. Ultimately, by using reference projects and the pattern languages, a smooth transition was made between analysis and design. From this the design emerged and by maximising the situation for heat stress the maximisation method was applied. However, the intention was to apply multiple maximisations and eventually make an optimisation but this did not turn out to be the right method.
To evaluate the maximisation, the DCBA method was intended to be used. This turned out not to be the best way for the thesis, because the interventions could not be evaluated with labels.
The stakeholder analysis made in the beginning of the process felt like a floating part in the thesis for a long time. By finally making an overall phasing and linking it to the stakeholders, the analysis and the design come together

through this method.
The process is not a linear line and trail and error method is unconsciously a big part in the thesis. Methods should help the project and not limit you.

5.3.3 THE RELATION BETWEEN THE GRADUATION STUDIO AND PROJECT

The graduation studio focuses on the spatial environment problems of the 21st century by integrating design, science and technology. The approach mainly looks at the interaction between different flows and morphologies to improve human and environmental well-being. By using systemic design, which is central to the studio, a clear picture is formed of the complexity of the many flows in the microclimate and these flows can be transformed into a design.
The thesis has the same focus and approach, and focuses mainly on the micro climate where flows in and out also influence the wellbeing of people.
In the beginning of the process, the studio will provide a lot of support and guidance to start with the analysis, methods and subject formulation of the project.

5.3.4 OUTCOME

A general toolkit for combating heat stress was created and this was incorporated into a design for Moerwijk. A design was eventually created for 1 building block of Moerwijk. This building block is the example for the other building blocks, but flexibility and variation is important for this design. Due to the lack of time, it is not possible to work out every building block. Which could possibly be better organized in further research.
In the building block, the situation for densification and combating heat stress is maximized. However, this does not take into account the economic consequences of this situation. The interventions carried out to improve the heat stress situation cost money. Since the neighbourhood is mainly owned by the housing cooperative, and the compensation of 20 additional homes will be too small. The costs will therefore be partially recovered from the residents. This ensures that the rent will get higher, as a result of which many residents will no longer be able to pay the costs and need to leave the neighborhood.
Due to the theoretical and drastic approach to maximize the situation external parties are not taken into account. The buildings are often owned by different parties with different agendas, which means that interventions are not always possible.
Some interventions that have a high impact, are expensive and adapt the structure of the neighborhood, will be difficult to implement and difficult to implement in practice.

5.3.5 EXPLORATION FURTHER RESEARCH

Although much research has already been done on heat stress, there are still opportunities for further research. This research developed a method of densification to combat heat stress. The pattern languages that have been developed are still fairly general and can be expanded through further research.
It also looks at densification in Moerwijk and other post-war neighbourhoods, but further research can look at other types of neighbourhoods and densities. We can even look at international cities where heat stress is a greater problem than in the Netherlands and the temperature differences between day and night are many times greater, which may require a different degree of densification.
As mentioned earlier, there are many stakeholders involved in densification, each with its own agenda, which are not considered in this thesis. In an additonal study it would be interesting to involve stakeholders more in order to develop a more realistic design.

5.3.6 PERSONAL REFLECTION

I would like to end the reflection with a personal note. In this way, I can share what I have learned in the past year. First of all, I have learned a great deal about heat stress, densification and The Hague. My interest in the micro-climate has only grown with this, and this is definitely something I want to take into my future career.
I have developed more tools and methods in this year to do my own research. I learned that it is sometimes good to let go of the structure of a report and that it is important to look at previous work and reference projects.
There is so much to learn from others and it is unnecessary to invent something yourself that has already been thought of.
This has also taught me how good it is to study at the faculty of Architecture and the Built Environment. There is so much to learn from fellow students and teachers.

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This apartment complex was realised recently and is currently one of the few locations that is a pleasant and good quality residential area in the neighbourhood. Together with the design for the rest of Moerwijk, this quality can be applied throughout the district to provide every current and future resident with a pleasant and cooling living environment.
By means of the pattern language, this level of quality can also be achieved in other districts and cities.

Fig 166 Picture of new apartment buildings where the private space is closed off from the street.
Source: Photo taken by author.

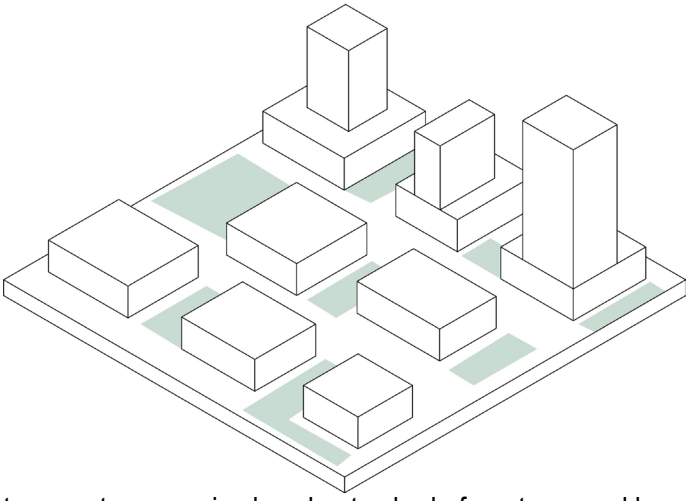
6. APPENDIX

PATTERN LANGUAGE

H. 1 CREATING GREEN AREAS

HYPOTHESIS

Increasing the percentage green spaces in the city by creating and improving small green areas.



CONTEXT

Greenery in the city is suppressed by paving and buildings. There are many unexploited opportunities for small-scale green spaces in the city. Small green areas in the city reduce the city's air and surface temperature. The temperature remains low due to shade from trees and less heated unpaved surfaces. In the ideal situation, the green areas are filled with grasslands, shrubs and a loose tree planting.

PRACTICAL IMPLICATION

- Grass between tram tracks
- Unused paved surfaces in the street
- Pavement in front of houses.

RELATIONS

H.6, H.7, H.8, H.9, H16

EFFECTIVENESS

Heat stress / cooling effect: ●●●
Density:

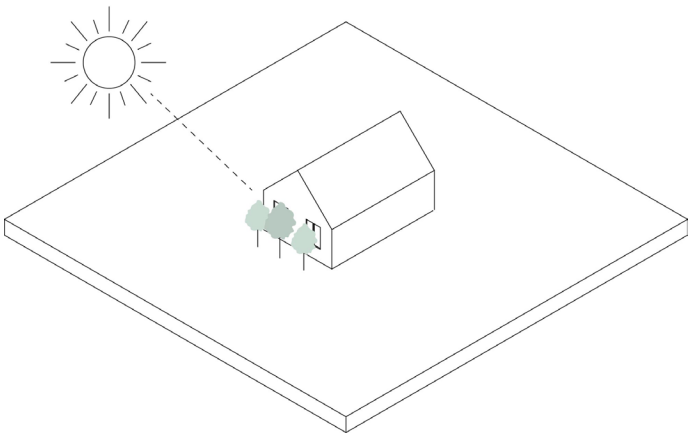
REFERENCES

Pötz, H., & Bleuze, P. (2012). Groenblauwe netwerken voor duurzame en dynamische steden/Urban green-blue grids for sustainable and dynamic cities (1st ed.). Coop For Life.

H. 2 SUN PROTECTION THROUGH GREENERY

HYPOTHESIS

Strategically placed vegetation that function as sun protection.



CONTEXT

Strategically placed vegetation in front of the façade and façade planting can function as sun protection for the indoor climate of the building. Deciduous trees function as blinds to keep out the summer sun but let in light in the winter.
Non-leaved cladding will reduce transmission loss in winter by providing an additional insulating layer and reducing heat radiation.

PRACTICAL IMPLICATION

- Deciduous trees in front of the south facade.
- Non-leaved cladding on the facade.

RELATIONS

H.3, H.4, H.17

EFFECTIVENESS

Heat stress / cooling effect: ●●●
Density:

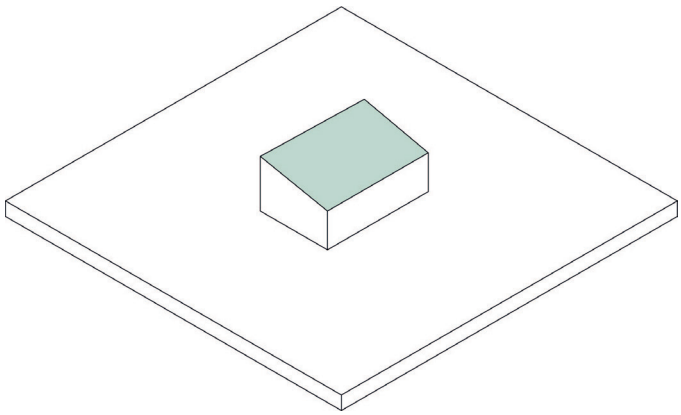
REFERENCES

Pötz, H., & Bleuze, P. (2012). Groenblauwe netwerken voor duurzame en dynamische steden/Urban green-blue grids for sustainable and dynamic cities (1st ed.). Coop For Life.

H. 3 HEAT REDUCING ROOFS

HYPOTHESIS

Intensive use of roofs to cool the indoor and outdoor climate.



CONTEXT

Due to the lack of space in cities, it is important that roofs are used intensively to improve the microclimate. Through the evaporation of water on roofs or their high reflective capacity, the roofs cool the outdoor space and the spaces under the roofs. This reduces the need for cooling in buildings. The roofs can also function as extra outdoor space by applying intensive green roofs.

PRACTICAL IMPLICATION

- Extensive green roof
- Intensive green roof
- Roofs with cool materials
- Water roof
- Tropical roof in combination with a collector roof

RELATIONS

H.2, H.4, H.5

EFFECTIVENESS

Heat stress / cooling effect:

Density:

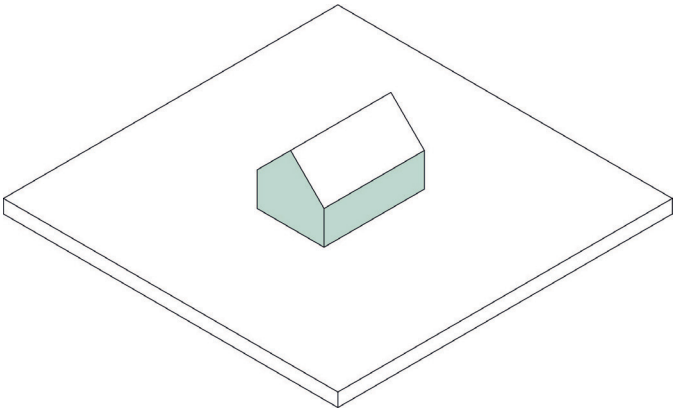
REFERENCES

Pötz, H., & Bleuze, P. (2012). Groenblauwe netwerken voor duurzame en dynamische steden/Urban green-blue grids for sustainable and dynamic cities (1st ed.). Coop For Life.

H. 4 GREEN FACADES

HYPOTHESIS

Intensive use of facades to cool the indoor and outdoor climate.



CONTEXT

Due to the use of greenery and space in the city, greenery must be applied to elements in the city that are already present. The green cladding shields the façade from direct solar radiation. This absorbs less heat and the plants evaporate water, cooling the surrounding space. In winter, the cladding provides an extra layer of insulation. This reduces energy consumption for cooling and heating throughout the year.

PRACTICAL IMPLICATION

- Self-climbing plants
- Climbing plants with a distance from the wall construction.
- Hanging plants in pots connected to the roof or balcony
- Green facade gardens

RELATIONS

H.2, H.3, H.5

EFFECTIVENESS

Heat stress / cooling effect: ●●●
Density:

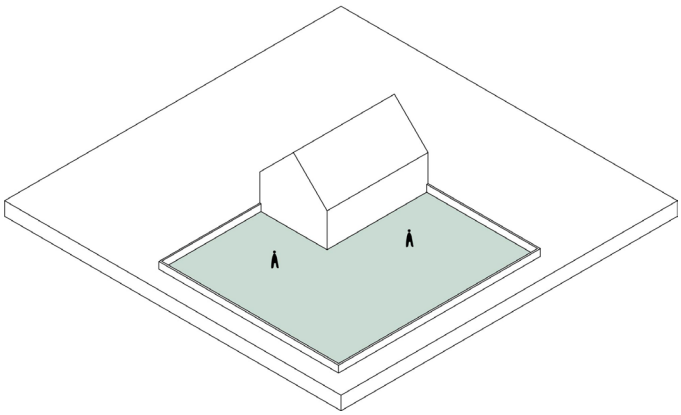
REFERENCES

Pötz, H., & Bleuze, P. (2012). Groenblauwe netwerken voor duurzame en dynamische steden/Urban green-blue grids for sustainable and dynamic cities (1st ed.). Coop For Life.

H. 5 PRIVATE GREEN GARDENS

HYPOTHESIS

Private gardens with no more than 20% paving for a cool outdoor environment.



CONTEXT

In the current situation, 75% of the private gardens are paved for the most part. This has a negative effect on the microclimate. The shading and evaporation provided by vegetation in private gardens cools the outdoor area. In the future, regulations will have to be introduced that motivate the construction of green gardens. A green garden consists of 80% vegetation and only 20% paving.

PRACTICAL IMPLICATION

- Green gardens

RELATIONS

H.3, H.4, H.8

EFFECTIVENESS

Heat stress / cooling effect:

Density:

REFERENCES

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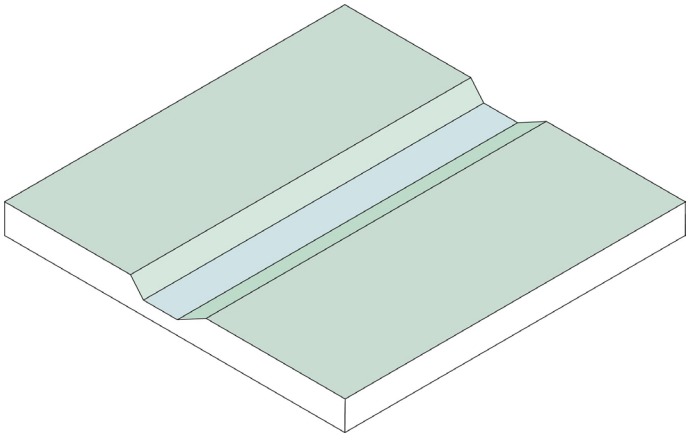
H. 6 GREEN BANKS

HYPOTHESIS

Nature-friendly banks that form a gradual transition from land to water and have a cooling effect on the surroundings.



CONTEXT

Normal banks have hard separations between water and land. These hard separations contain little greenery, so the cooling effect is minimal. Nature-friendly banks are the habitat for various plants and animals. The variation of greenery and water has a cooling effect on the environment.

PRACTICAL IMPLICATION

- Nature friendly banks

RELATIONS

H.1

EFFECTIVENESS

Heat stress / cooling effect: ●●
Density:

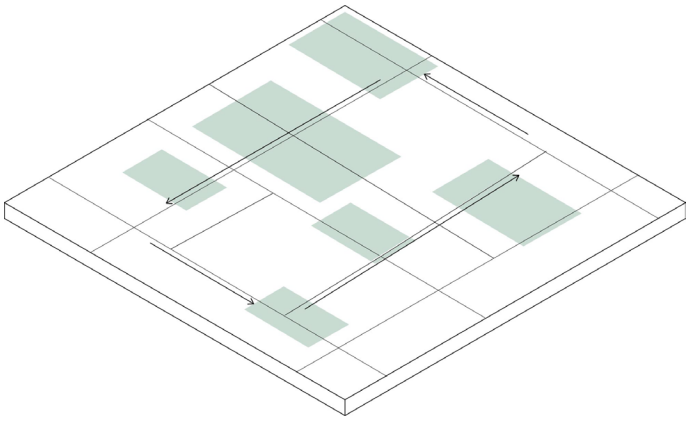
REFERENCES

Pötz, H., & Bleuze, P. (2012). Groenblauwe netwerken voor duurzame en dynamische steden/Urban green-blue grids for sustainable and dynamic cities (1st ed.). Coop For Life.

H. 7 GREEN GRID

HYPOTHESIS

A grid of parks and small green areas that form pleasant cooling zones for surrounding residents.



CONTEXT

A grid of parks and green areas have a cooling effect on the microclimate, but together they also form a better city climate. During hot periods, this network forms pleasant residential areas for residents to cool down in. These recreational areas should be loosely planted to allow for wind flow in the grid.

PRACTICAL IMPLICATION

- Grid of parks and small areas of vegetation

RELATIONS

H.1, H.16

EFFECTIVENESS

Heat stress / cooling effect: ●●●
Density:

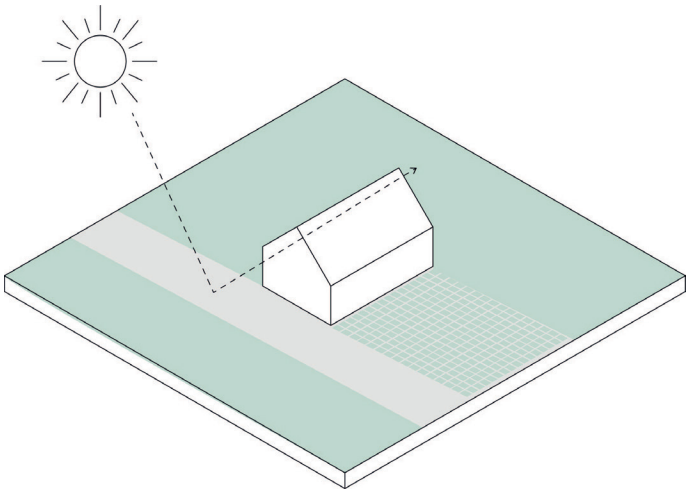
REFERENCES

Pötz, H., & Bleuze, P. (2012). Groenblauwe netwerken voor duurzame en dynamische steden/Urban green-blue grids for sustainable and dynamic cities (1st ed.). Coop For Life.

H. 8 COOL PAVING MATERIALS

HYPOTHESIS

Use of cooling hardening materials to reduce the ambient temperature.



CONTEXT

The use of cooling pavement materials reduces air and surface temperatures in the city. Heat is stored in materials and transferred to the subsurface and, during summer rains, to rainwater that flows over the pavement into surface water. The lower the temperature of the materials, the lower the temperature of the environment.

PRACTICAL IMPLICATION

- Light-coloured materials
- Semi-paved

RELATIONS

H.1, H.5

EFFECTIVENESS

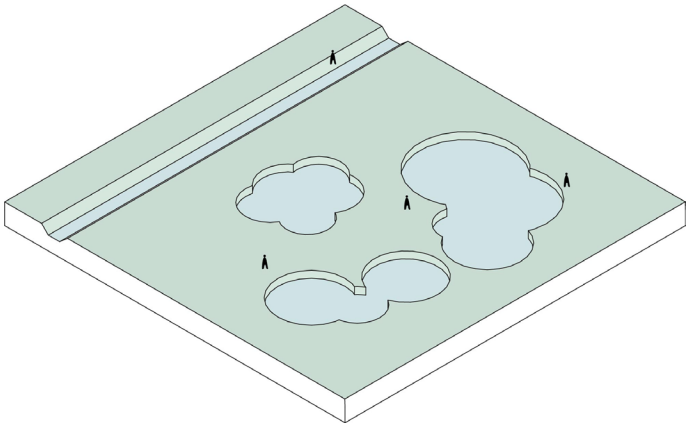
Heat stress / cooling effect: ●●●
Density:

REFERENCES

H. 9 COOLING WITH WATER

HYPOTHESIS

Evaporation of water that has a cooling effect on the immediate surroundings.



CONTEXT

In the Netherlands, it is customary to design with water. Water can be used during heat waves for cooling. Water causes evaporation and absorption of heat, which has a cooling effect on the immediate surroundings.
However, the cooling effect of water on the sensation temperature is small when you are not on or in the water. So the contact with water cools you down, but the effect on the air temperature of the environment is at most 1 degree.

PRACTICAL IMPLICATION

- Fountains
- Wadi
- Sprinkling
- Surface water

RELATIONS

H.1

EFFECTIVENESS

Heat stress / cooling effect: ●●
Density:

REFERENCES

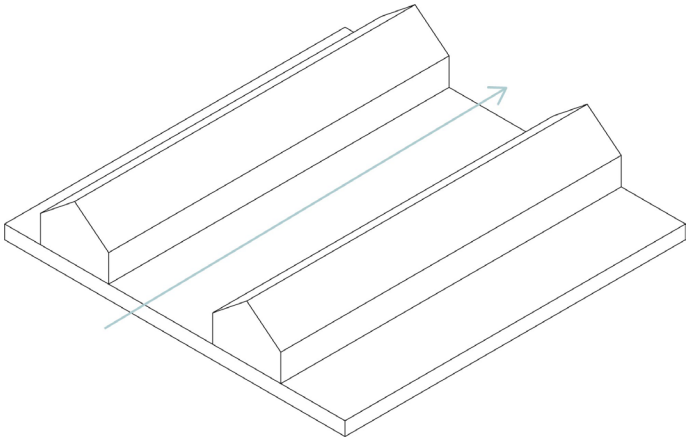
Klok, L., & Solcerova, A. (2018, December 18). Water: een koelelement in de warme stad? Klimaatadaptatie. Retrieved 17 March 2022, from https://klimaatadaptatienederland.nl/actueel/actueel/interviews/interview-klok-sol/

Pötz, H., & Bleuze, P. (2012). Groenblauwe netwerken voor duurzame en dynamische steden/Urban green-blue grids for sustainable and dynamic cities (1st ed.). Coop For Life.

H. 10 VENTILATION CORRIDOR

HYPOTHESIS

Large open spaces in the city can be cooled by the air flows of the wind.



CONTEXT

The ventilation corridor cools the outdoor area through air flows. Enough space is needed for this, which is why there must also be sufficient unbuilt space. The main corridor should be 150 metres wide, the secondary corridor 80 metres wide and the smallest corridor at least 30 to 50 metres wide. The length should be at least 500 metres. The corridor should be oriented towards the summer prevailing wind and the public space can be protected by the winter prevailing wind.

PRACTICAL IMPLICATION

- Main roads
- Continuous recreational spaces
- Urban landscaping spaces
- Non-constructed land
- Buillding setback spaces
- Low-rise building areas
- Vegetation corridor

RELATIONS

H.11, H.15

EFFECTIVENESS

Heat stress / cooling effect:

Density:

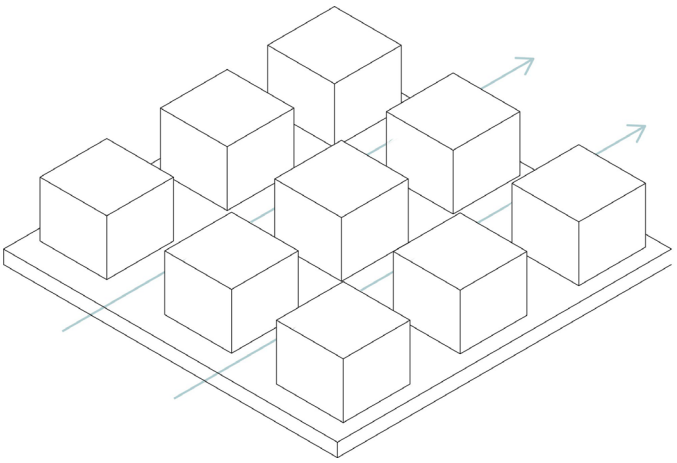
REFERENCES

Yang, J., & Fu, X. (2019). Optimization Strategy of Wind Environment in Urban Central Area. The Centre of City: Wind Environment and Spatial Morphology, 167–186. https://doi.org/10.1007/978-981-13-9690-8_6

H. 1 1 AIRFLOW CIRCULATION

HYPOTHESIS

Small blocks provide a circulation path for wind to pass through for ventilation on a pedestrian level.



CONTEXT

In the cities, the space is built up as much as possible. However, small blocks and short streets provide the opportunity for summer prevailing winds to ventilate the streets. The orientation of the blocks and streets must also be taken into account.

PRACTICAL IMPLICATION

- Small closed building blocks
- Shortening of streets

RELATIONS

H.10, H.12, H.15

EFFECTIVENESS

Heat stress / cooling effect:
Density:

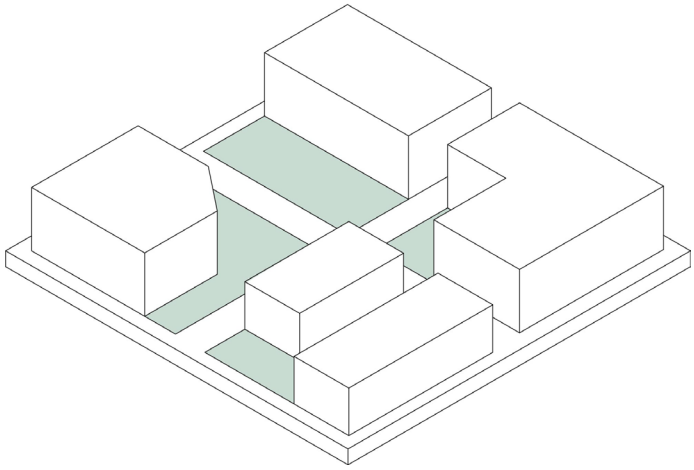
REFERENCES

Yang, J., & Fu, X. (2019). Optimization Strategy of Wind Environment in Urban Central Area. The Centre of City: Wind Environment and Spatial Morphology, 167–186. https://doi.org/10.1007/978-981-13-9690-8_6

H. 12 OPEN SPACES

HYPOTHESIS

A maximum of 65% of the block can be built on, leaving open spaces. These open spaces must be placed so that airflow between the buildings is possible.



CONTEXT

Due to the lack of space in cities, there are few open s paces. It is important to keep open spaces in the block for air circulation that cools the streets. The building percentage in the block should not exceed 65%. In high-density areas, larger open spaces can be created by pulling the buildings back. This makes the streets wider, allowing more air to circulate at pedestrian level.

PRACTICAL IMPLICATION

- Square
- Main roads
- Continuous recreational spaces
- Urban landscaping spaces
- Non-constructed land
- Buillding setback spaces

RELATIONS

H.11, H.15, H.16

EFFECTIVENESS

Heat stress / cooling effect:
Density:

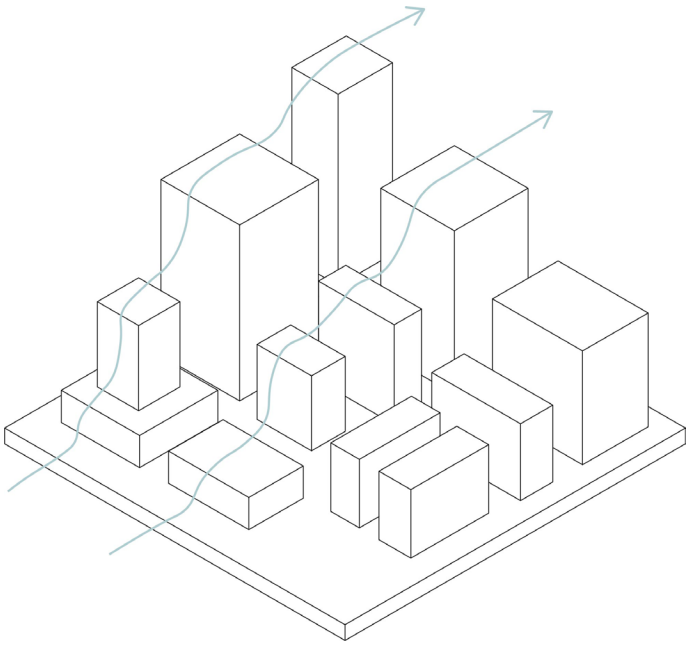
REFERENCES

Yang, J., & Fu, X. (2019). Optimization Strategy of Wind Environment in Urban Central Area. The Centre of City: Wind Environment and Spatial Morphology, 167–186. https://doi.org/10.1007/978-981-13-9690-8_6

H. 13 LADDER TYPE BUILDINGS

HYPOTHESIS

Raising the buildings step by step with the direction of the summer wind.



CONTEXT

The height variation allows the direction of the wind to be changed and prevents the airflow from being stranded. By doing this incrementally, the ventilation of buildings is improved. The wind should gradually decrease where the summer prevailing wind comes from.

PRACTICAL IMPLICATION

- Ladder type buildings

RELATIONS

H.14, H.17, D.1

EFFECTIVENESS

Heat stress / cooling effect:

Density:

REFERENCES

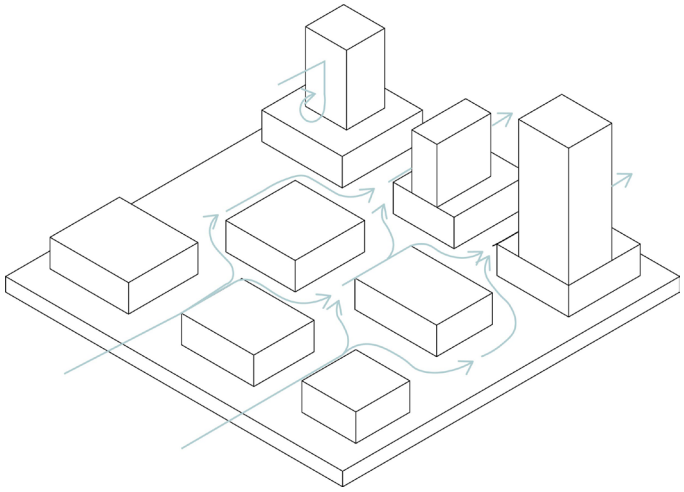
Krautheim, M., Pasel, R., Pfeiffer, S., & Schultz-Granberg, J. (2014). City and Wind. Macmillan Publishers.

Yang, J., & Fu, X. (2019). Optimization Strategy of Wind Environment in Urban Central Area. The Centre of City: Wind Environment and Spatial Morphology, 167–186. https://doi.org/10.1007/978-981-13-9690-8_6

H. 14 STAGGERED ARRANGEMENT OF BUILDINGS

HYPOTHESIS

With staggered arrangement of buildings, and podiums, air flow can ventilate and provide a comfortable environment at pedestrian level.



CONTEXT

The staggered layout of buildings along the summer prevailing winds allows for air flow at pedestrian level between the buildings. Podiums of high rise building have a regulating role in directing the wind at pedestrian level ensuring a comfortable environment.

PRACTICAL IMPLICATION

- Staggered lay out
- Podiums of high rise buildings

RELATIONS

H.13

EFFECTIVENESS

Heat stress / cooling effect:
Density:

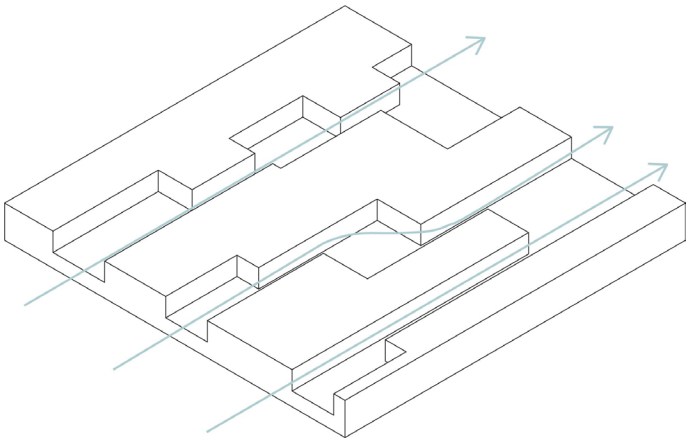
REFERENCES

.Yang, J., & Fu, X. (2019). Optimization Strategy of Wind Environment in Urban Central Area. The Centre of City: Wind Environment and Spatial Morphology, 167–186. https://doi.org/10.1007/978-981-13-9690-8_6

H. 15 VENTILATION GRID

HYPOTHESIS

The orientation of buildings and open spaces allows the wind to ventilate at pedestrian level.



CONTEXT

The wind needs room to drop and vent at pedestrian level. Here, non-built-up areas and a good orientation towards the summer prevailing wind are needed.

PRACTICAL IMPLICATION

- Ventilation corridors
- Staggered lay out
- Ladder type buildings
- Small blocks
- Open spaces

RELATIONS

H.7, H.10, H.11, H.12

EFFECTIVENESS

Heat stress / cooling effect:

Density:

REFERENCES

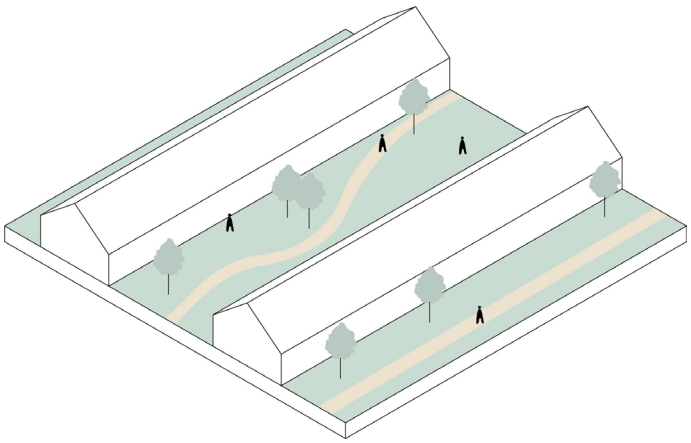
Krautheim, M., Pasel, R., Pfeiffer, S., & Schultz-Granberg, J. (2014). City and Wind. Macmillan Publishers.

Yang, J., & Fu, X. (2019). Optimization Strategy of Wind Environment in Urban Central Area. The Centre of City: Wind Environment and Spatial Morphology, 167–186. https://doi.org/10.1007/978-981-13-9690-8_6

H. 16 CAR FREE ZONES

HYPOTHESIS

Use superblocks by increasing the size of the block to make streets accessible only to slow traffic, and create possibilites to combine it with other patterns



CONTEXT

Many neighbourhoods are designed for the car, which makes for an unattractive public space that can heat up considerably on a hot summer day. By creating so-called 'super blocks' with public spaces that are only accessible to slow traffic, there is room for heat stress measures.

PRACTICAL IMPLICATION

- Super blocks
- Car-free zones

RELATIONS

H.1, H.12

EFFECTIVENESS

Heat stress / cooling effect:
Density:

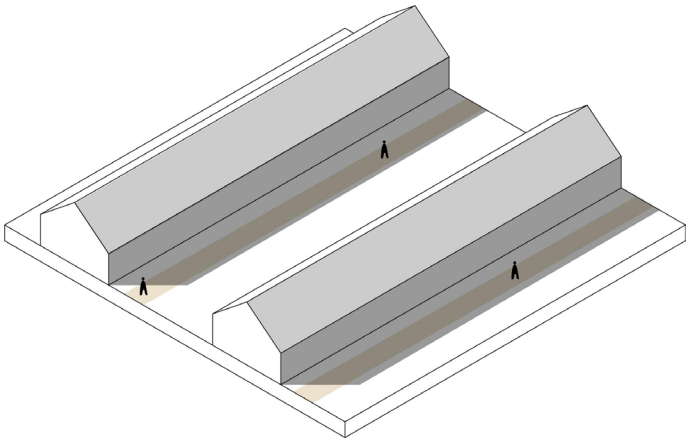
REFERENCES

Polonyi, T. (2021, October 15). Superblocks – the Spanish Idea That Is Conquering European Cities. CityChangers. Org – Home Base for Urban Shapers. Retrieved 17 March 2022, from https://citychangers.org/superblocks/

H. 17 SHADOW

HYPOTHESIS

Shade to reduce surface during hot periods.



CONTEXT

Shade keeps surfaces cool and ensures that materials do not absorb much heat. This also lowers the perceived temperature. It is important that there is 40% shade in the walking routes when the sun is at its highest.

PRACTICAL IMPLICATION

- Buildings
- Trees
- Pergolas
- Cloths

RELATIONS

H.2, H.13, D.1

EFFECTIVENESS

Heat stress / cooling effect:

Density:

REFERENCES

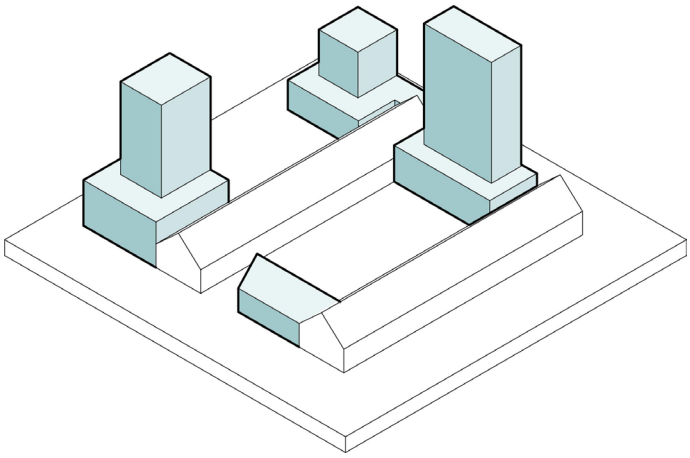
Kluck, J., Klok, L., Solcerová, A., Kleerekoper, L., Wilschut, L., Jacobs, C., & Loeve, R. (2020, May). De hittebestendige stad (No. 978–94-92644-80–0). Hogeschool Amsterdam.

Kluck, J. (2020, May 28). Groen en schaduw helpen beste tegen hitte in de stad. Klimaatadaptatie. Retrieved 18 March 2022, from https://klimaatadaptatienederland.nl/actueel/actueel/interviews/hittebesten-dige-stad/#:%7E:text='Om%20de%20gevoelstemperatuur%20te%20verlagen,van%20bomen%20of%20van%20gebouwen.

D. 1 CREATING MORE HOUSES

HYPOTHESIS

Realising more homes by densifying vertically on the same land area to increase the housing supply.



CONTEXT

In the cities, there is a lack of space while there is also a shortage of housing. For this reason, more homes will have to be built on a smaller surface area. The Municipality of The Hague wants to realise 10,000 more houses in The Hague South-West.

PRACTICAL IMPLICATION

- High rise buildings
- Closed building blocks
- Adding on existing buildings

RELATIONS

H.13, H.17, D.2, D.3

EFFECTIVENESS

Heat stress / cooling effect:

Density:

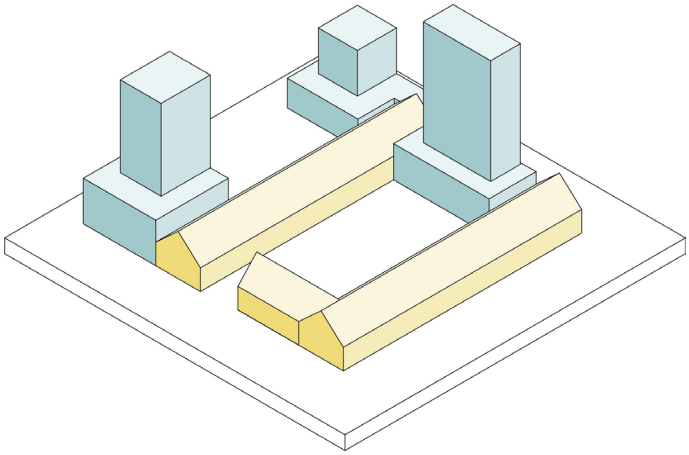
REFERENCES

Gemeente Den Haag. (2019, February). Woonagenda 2019–2023. https://denhaag.raadsinformatie.nl/document/7443591/1/Woonagenda_2019-2023#:~:text=Van%20alle%20woningen%20die%20in,vrijkomen%2C%20worden%20verloot%20onder%20starters.

D. 2 VARIATY IN HOUSING SUPPLY

HYPOTHESIS

Create different types of housing to attract different types of residents.



CONTEXT

Due to lack of space, mainly flats are built. However, residents have no preference for flats. Several types of housing must be realised to promote the flow of residents within the neighbourhood and to make more residents happy.

PRACTICAL IMPLICATION

- Appartments
- Row houses
- Semi-detached houses
- Freestanding houses

RELATIONS

D.1, D.3

EFFECTIVENESS

Heat stress / cooling effect:
Density:

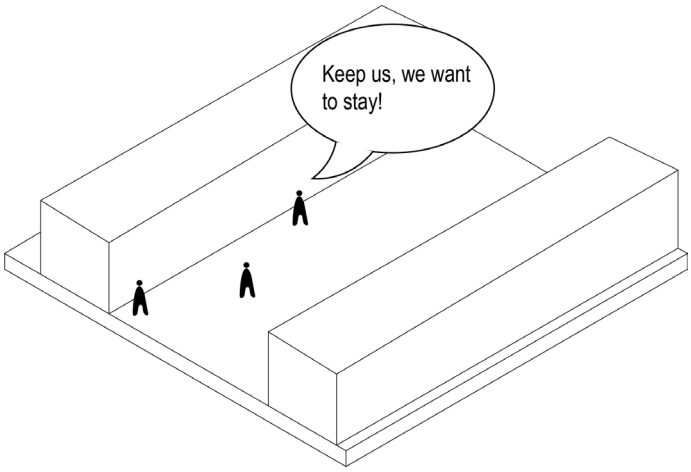
REFERENCES

de Zeeuw, F., & Keers, G. (2020, May 26). En tóch moeten we meer eengezinswoningen bouwen. Gebiedsontwikkeling.nu. Retrieved 8 February 2022, from https://www.gebiedsontwikkeling.nu/artikelen/en-t%C3%B3ch-moeten-we-meer-eengezinswoningen-bouwen/

D. 3 RETAINING CURRENT RESIDENTS

HYPOTHESIS

The new interventions for densification and heat stress must not drive current residents away from the neighbourhood.



CONTEXT

The redevelopment should still make the current residents feel at home in the neighbourhood. Major redevelopment and renovation costs money. This money has to be earned back and landlords often take it away from the residents by allowing the landlord to increase the rent. This can lead to residents no longer being able to pay the rents and having to leave the neighbourhood.

PRACTICAL IMPLICATION

- New affordable homes
- Renovating the current homes
- Realising growth opportunities within the district

RELATIONS

D.1, D.2

EFFECTIVENESS

Heat stress / cooling effect:
Density:

REFERENCES

Ministerie van Algemene Zaken. (2021, November 26). Gaat de huur omhoog na renovatie? Rijksoverheid.nl. Retrieved 7 April 2022, from https://www.rijksoverheid.nl/onderwerpen/woning-huren/vraag-en-antwoord/gaat-de-huur-omhoog-na-renovatie