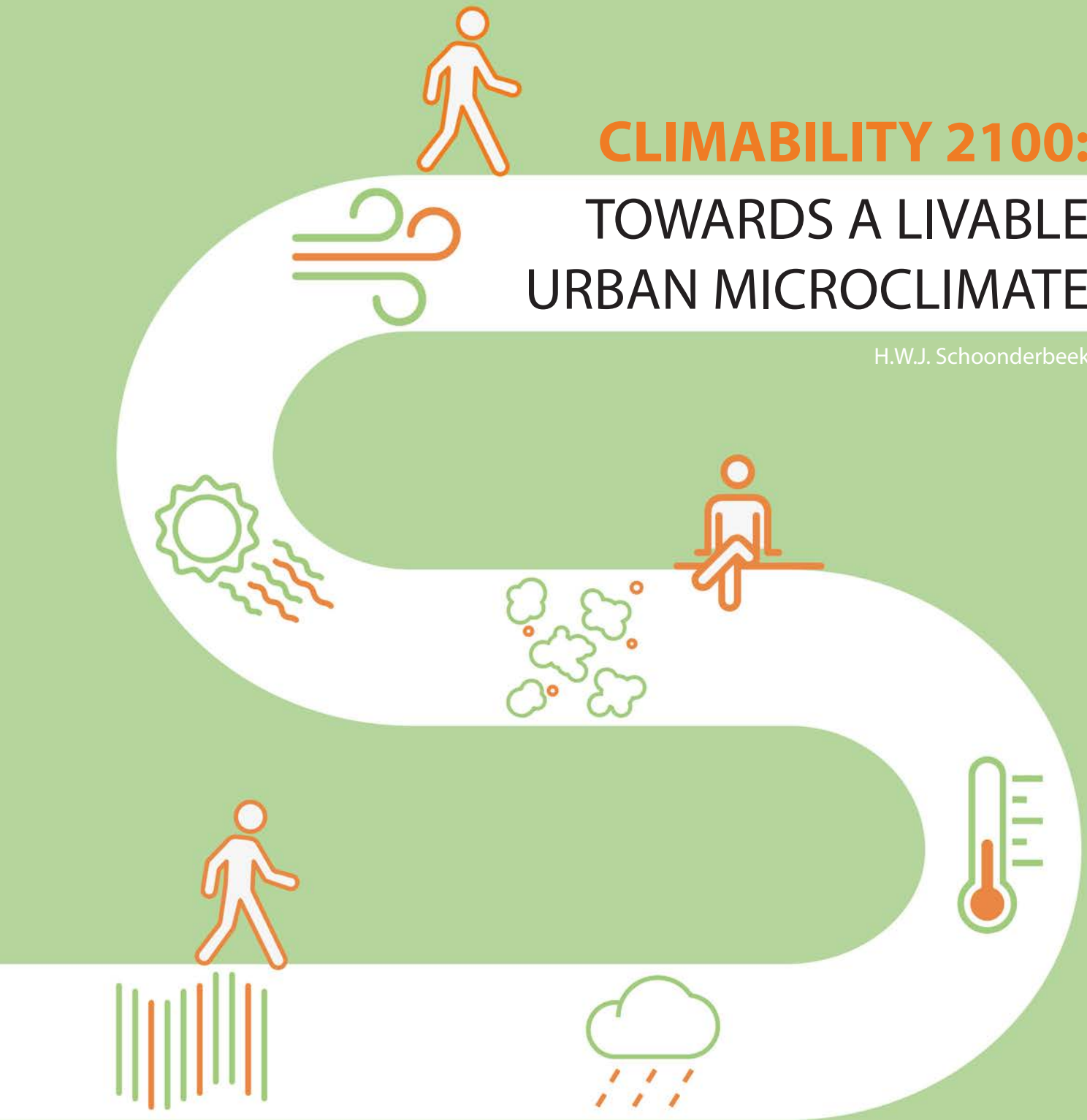
CLIMABILITY 2100:
TOWARDS A LIVABLE URBAN MICROCLIMATE

H.W.J. Schoonderbeek



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PREFACE

This graduation report is part of a series of reports for the graduation project in the master track of Urbanism at the Faculty of Architecture and the Built Environments at the TU Delft. This report will show the research that is done during this graduation year. The report contains the methodology, research and design strategies that show the problems and opportunities for the topics of climate change, liveability and urban development.

I want to thank Maurice Harteveld, Kristel Aalbers and Roberto Cavallo for the guidance in my graduation project and I think we had a successful and productive collaboration. Furthermore, I would like to thank Dipl. ing. U.D. Hackauf for the guidance of the methodology part of the report and Marjolein Pijpers-van Esch for sharing her knowledge of urban microclimate and guidance with a research method that I used. Last but not least I would like to thank my family and friends for all the support they gave me during this year.

Enjoy reading the thesis and if you have any questions you can always contact me or my mentors.

Rick Schoonderbeek
Msc graduation student Urbanism

Delft, July 2nd, 2020

Figure 1 Adaptation to climate conditions

Figure 2 Example of 'bad' design, Boston City Hall Square

STUDY MOTIVATION

During my work in practice at an Urban design office, I found that most of the time designs are made which are not really adaptive to future scenarios. We make designs for a time frame of 20 years for example, but not really looking into the far future. During the graduation project, I have given the chance to look further in the future. Research the 'what if' scenarios and see how we can deal with the conditions of these scenarios. Therefore I joined the cross-domain studio: City of the Future. Subsequently, my interest in climate change follows. It is one of the biggest threats the world is facing and we designers have the chance to work with it. With our designs we could help to reduce the climate effects, but more important is my interest in the adaptation to climate. Looking at climate problems in Europe I found some interesting articles about Milan. The articles were talking about Milan as a very grey city and that the city wants to change to a green city. At that point, I was really interested to do my graduation project in Milan. In addition to that, I thought it would be interesting to look for a collaboration with the Politecnico di Milano.

"People adapt to their surroundings and accept conditions that would appear to lie outside the established comfort range"

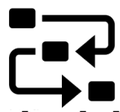
~ Erell et all. ~

Next to climate adaptation it is interesting for me to see how people adapt to the given conditions. Last summer I took a picture in Colombia at a place where temperatures were above 35°C, see figure 1. Walking through the streets of the city, we were always looking for places with shade. Besides, it was nice to see how the residents made the street very green while there is not much space in this narrow street. During the graduation project, I would like to get more knowledge about the adaptive behaviour of people in urban outdoor spaces. With this knowledge, I would like to see how urban designers can use that for future designs.

"It's hard to design a space that will not attract people. What is remarkable is how often this has been accomplished."

~ William "Holly" Whyte ~

For me, this quote says exactly why I always wanted to become a designer. Moving through the built environment I often see things that raise questions like: how did they come to this idea, because it doesn't work at all? An example of a bad urban design is the Boston City Hall Plaza, where I was last May. At his plaza, a lot of things went wrong. Firstly the accessibility is of bad quality, secondly, there is zero activity at the plaza and third, the whole plaza is paved. What you often see is that the result of the design is different than the ideas of the designer. Therefore I think it is important to steer a project until the last moment. In practice, I still see it every day. An idea drew on a piece of paper without analyzing the area first. They just draw something they have an idea about and if nobody does some good research about it, most of the time it will fail. There are more and more technologies to test if something will work, but often they forget about one thing: the people. The people, in the end, are the users of your design. Of course, the designers are the professionals, but the opinion of local people can be so much of worth. In my graduation project, I want to see how I can make a design for and with the people and also I want to see how urban designers can make sure that their ideas are performed well in the end.



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PART 1 METHODOLOGY

1 ABSTRACT

With a growing world population and changing climate conditions, cities have many problems to face in the future. The changing climate can affect the way we appropriate urban outdoor spaces which will affect the social sustainability in the city, so adaptation strategies in cities are necessary. Urban designers should create conditions to maintain the quality of life in these spaces and therefore the question is asked: "How can urban design improve the urban microclimate of- and (temporary) appropriation in urban outdoor spaces to make Milan sustainable towards 2100? This thesis is in search of urban design solutions for a social- and environmentally sustainable development of cities in the future. To achieve this the thesis will elaborate at first on temporary appropriation and the guidelines that urban designers should take into account to create (a) pleasant walkability, places for staying and soft edges. Secondly, it will elaborate on urban microclimate and it's guidelines. Thirdly, and most importantly, the relations between appropriation and urban microclimate will be explained. Through a strong analysis of the theoretical subjects and an analysis of Milan as a case study a vision and design strategy is developed. On different spatial scales, the projects show the opportunities and necessary actions that should be taken to create a sustainable living environment towards 2100. Design methods are used to research how urban designers can make the spatial translation of the theoretical guidelines and these solutions are shown in a handbook called: "Climability solutions for urban design". These solutions have been applied to multiple project locations in Milan where is shown how the solutions work, who is involved and which necessary actions are needed. After all, to create a sustainable environment towards 2100 interventions on different scale levels should be designed with great attention to the urban microclimate and appropriation of urban outdoor spaces. Designers should be more climate aware and should integrate choice in their design where people should have many opportunities to appropriate the space and to choose a microclimate that is pleasant for them. This research can be extended by site visits with interviews of residents and professionals in the fields of social- and environmental sustainability. Moreover, more extensive use of design tools, like ENVI-met, will give more insight into the design of urban microclimate and will improve the design ideas.

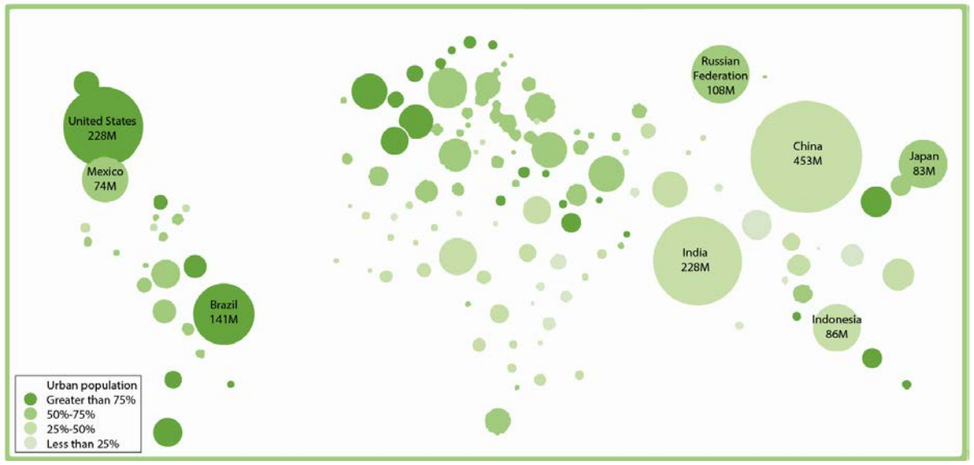

Figure 3 World population in 2000

Figure 4 World population in 2050

"there is a necessity for adaptation strategies in cities to cope with future weather conditions caused by climate change".

~ Tumini & Rubio-Bellido, 2016 ~

Figure 5 Residents rely on air-conditioning

2 PROBLEM FIELD

Nowadays we live in a world together with around 7.3 billion other people and our world is facing many problems. The biggest problem the world is facing is the growth of the world population which will rise to an expected number of 8.5 billion people in 2030, 9.7 billion in 2050 and 11.2 billion in 2100 (UN, 2019). This growing population, as shown in figure 3 and 4, is a result of an increasing number of people surviving to reproductive age together with big changes in fertility rates, growing urbanization and increasing migration (UN, 2019). With a growing population and the aim to protect rural areas governments think that the solution is to densify the cities, which is called urbanization. Urbanization is the process of global scale changing the social and environmental landscape on every continent. Urbanization is a result of population migration from rural areas in addition to natural urban demographic growth (WHO, 2012). These trends will have a big impact for future generations and cities will definitely have an important role in future development. "Urbanization can be critical for economic growth, for reduction of poverty, for stabilization of population growth and for long-term sustainability" (Martine, McGranahan, Montgomery, & Fernández-Castilla, 2008, p. 3). By 2050 68% of the world population will live in cities, while today that amount is 55% of the population (UN, 2018). These trends of growth will change the landscape of human settlement, with remarkable implications for the living conditions in cities, huge effects for the environment and development in different parts around the world (UN, n.d.).

With a growing population living in cities, the pressure on these cities and their environment will increase, see figure 6. More people in the same city will mean that more people have to share the same amount of space. This will have potential effects on the liveability in the city, like high levels of noise, limited space and the perception of overcrowding (Kennedy & Buys, 2010). Moreover, more people can increase the effects of climate change, because more people means more activity which leads to more urban heat which increases the climate effects. As mentioned by Tumini & Rubio-Bellido (2016) there is a necessity for adaptation strategies in cities to cope with future weather conditions caused by climate change. Global warming causes changes in climate conditions and this would have a significant effect on the urban microclimate and therefore the liveability (Tumini & Rubio-Bellido, 2016). The positive effects of the natural climate are much of the time ignored with urban development that causes residents to rely on air-conditioning for thermal and acoustic comfort and the low amenity of the urban outdoor space (Kennedy & Buys, 2010), see figure 5. So the liveability is directly related to population growth and has a strong connection related to the effects of climate change. This research project focuses on these climate effects and the influence on liveability with a study case in Milan, where multiple problems occur, which will be explained later.

Figure 6 Problem description of research projec

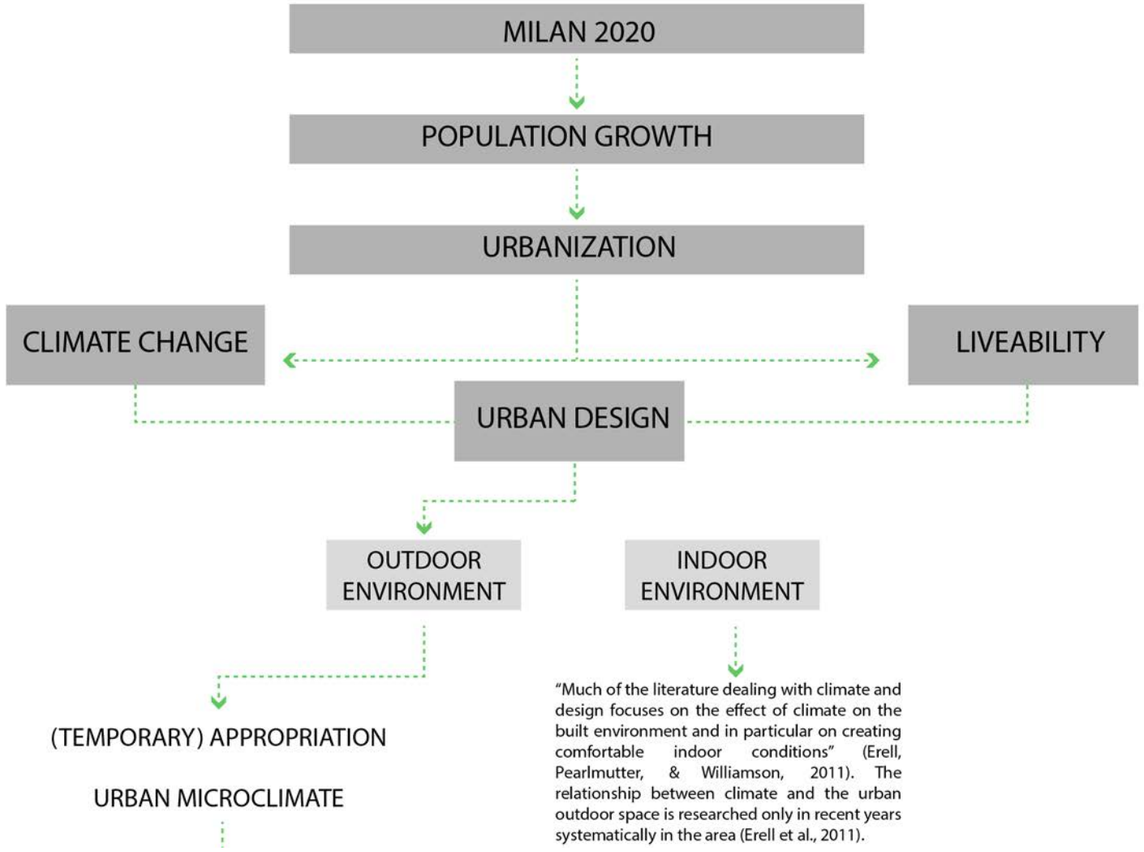

Figure 7 Problem field of research project

Figure 8 Traffic problems in Milan

2 PROBLEM FIELD

The design of urban areas affects the different elements of climate - temperature, wind patterns, humidity, precipitation, air quality – which in turn have direct consequences for the liveability in those places (Hebbert & Webb, 2012). Much of the literature dealing with climate and design focuses on the effect of climate on the built environment and in particular on creating comfortable indoor conditions" (Erell, Pearlmutter, & Williamson, 2011). There is less literature and research about the relation between climate and liveability in urban outdoor space, see figure 7. Because of climate change, there should be taken measures to increase this liveability.

> *"Climate is the main factor that determines the use of urban outdoor spaces.* ~ Santucci et al., 2019 ~

Climate change and liveability are two very broad terms that need some boundaries for this research project. Looking at the history of urban planning and development it can be seen that in the decades after 1950 city planning became less climate-aware (Hebbert & Webb, 2012).. As figure 8 shows, car lanes were widened and pedestrian paths, like sidewalks, narrowed which led to an increase in cars, and therefore a decrease of the outdoor air quality, and a decrease of the walkability in the city. At the same time, small city blocks became physically stronger and together with the construction of large-scale climate-controlled buildings the outdoor air circulation was blocked and wind tunnels were created. Moreover, there was an increase in the urban heat island effects, with a low thermal comfort for people, because there was a boost of high heat absorbed materials like asphalt and cement. These solid materials on buildings, streets and parking lots caused an increase of storm-water run-off and flood risk. The removal of trees led to the removal of pollution filters and exacerbated outdoor temperature extremes (Hebbert & Webb, 2012). The adverse climate trends will affect the outdoor liveability and these trends are well known by urban climatologists. The liveability is partly determined by the sustainability of the city. Combining climate, liveability and sustainability the phenomenon of temporary appropriation (TA) comes into play. TA of urban outdoor spaces is very important in the urban dynamics of a city. It is related to the resilience, both socially and environmentally, of urban outdoor spaces, where the design of these spaces has a great influence on TA (Lara-Hernandez & Melis, 2018).

According to Santucci et al. (2019) the dimensions and qualities of the environment can really have an effect on the way people will use and appropriate urban outdoor spaces. The outdoor comfort, also called the urban microclimate, is one of the main influencers on the use of urban outdoor spaces by people. It could be said that climate is the main factor that determines the use of urban outdoor spaces. In particular urban microclimate, which provides the condition that people experience all the time. So, the urban microclimate is fundamental in giving quality to urban life. To enhance the quality of life in the future we as urban designers can play an important role in the (temporary) appropriation of urban outdoor spaces by looking into the urban microclimate.

To research the problems of TA and urban microclimate this project will use a case study to analyze problems and test design solutions. For this project the city of Milan, Italy is chosen. In comparison with for example Asia, Europe is actually a shrinking continent looking at population numbers. However, there are cities in Europe that still attract people and therefore will grow in the future. Milan is one of these cities, where Milan is the 5th biggest city in Europe with a population of 5.1 million inhabitants (Eurostat, 2019), see figure 9. Looking at the history of Milan, figure 11 shows that till 1970 there was a huge increase which is somewhat flattened. This enormous increase was a result of immigration from people from the Italian south to the industrial north (Foot & Lecco, 2019). According to the UN (2018), the urban population in Italy will increase from 71% in 2020 to 81% in 2050, so the expectation is that the population will increase slightly in the future, while Milan is actually the only city in Italy which is still growing and attracting people, businesses and industries. This increase is caused mainly by immigration from abroad (Foot & Lecco, 2019). The expectation is that Milan will compete with cities such as London and Madrid in the future.

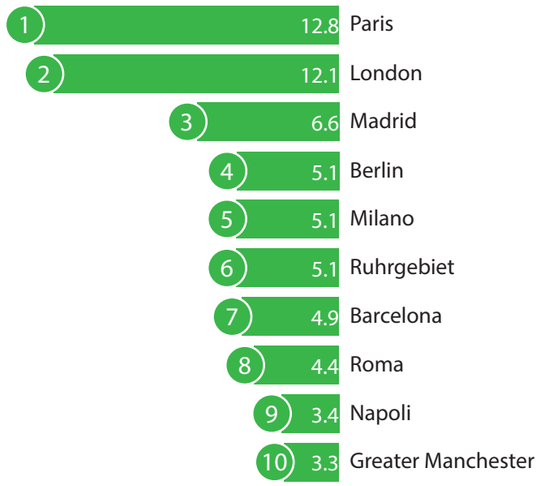

Figure 9 Population in European cities

Figure 10 Paved surfaces in Milan

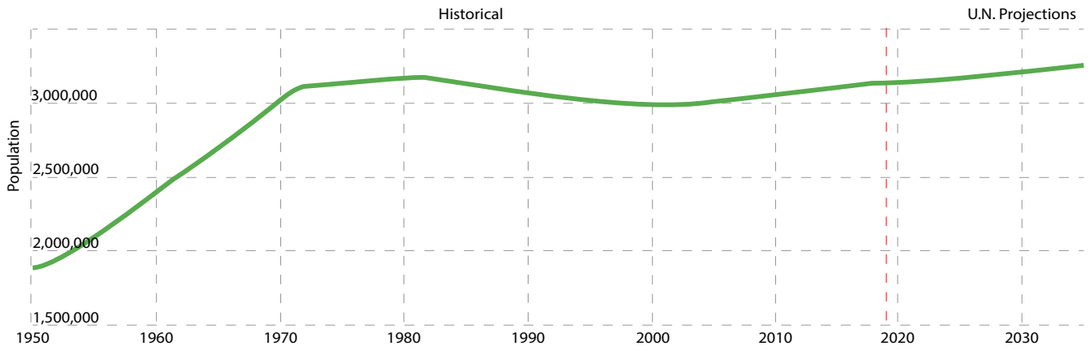

Figure 11 Milan, Italy Population 1950-2019

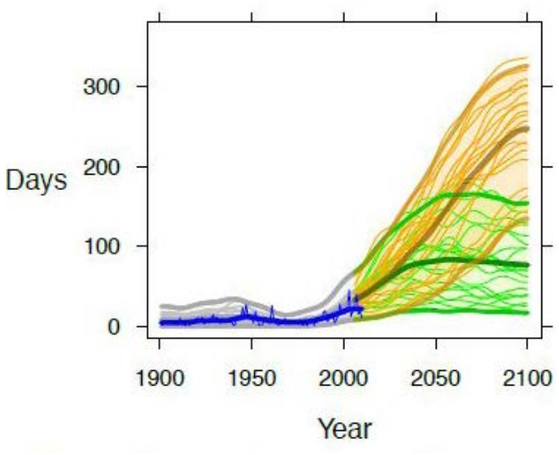

Figure 12 Days of heat waves in Italy

Figure 13 Flooding in Milan

2 PROBLEM FIELD

Regarding urbanization, liveability and the effects of climate change, there are some ingredients that make Milan an interesting location for this research project. First of all, it was shown earlier that Milan is still attracting people, businesses and industries and therefore there is a growing demand for supplies which gives increasing problems regarding liveability and climate change. However, Milan is only focussing on mitigation of the climate problems instead of looking at ways to adapt to the new conditions (Prasad, Ranghieri, Shah & Trohanis, 2009). Secondly, there are multiple elements that have a negative effect on liveability in Milan. Some parts of Milan are really dense, which have consequences for the liveability in those areas. Milan is also considered as a car-city where the cars are characterizing the streets and where pedestrians have little space to appropriate, see figure 10. Thirdly, there are multiple climate elements that give problems in Milan, now and in the future. The first problem that occurs is the temperature in the city which can be really high. During summer, temperatures above 40°C are not surprising anymore (Comune di Milano, 2018). The expectation is that temperatures will continue to rise in the future. As a result of urban heat island, the days with heatwaves also increases. With the worst-case scenario this can even reach above 300 days a year in Italy, see figure 12. One of the implications of these high temperatures is the decrease of the air quality. Regarding air quality, the northern area of Italy is the worst area in Europe (Agence France-presse, 2019). One of the reasons is the location close to the Alps. During summer the northern wind is blocked by the mountains, so there is not a lot of air movement in the city. Another problem that occurs more frequently in Milan are the heavy precipitation events. These precipitation events have led the last decades to multiple floods in Milan and there are some areas close to the city centre of Milan which have a high risk of flooding, see figure 13. All these elements of liveability and climate give enough motivation to take Milan as a location for the research project.

Climate change can affect the liveability in places which experience extreme climatic conditions (Kennedy & Buys, 2010). Climate reports show that these extreme climatic conditions will occur more frequently in Milan. If Milan wants to be truly sustainable they should give focus to these future conditions and their high-quality places where people want to live. According to (Kennedy & Buys, 2010) measures against the effects of climate also make cities more livable and therefore more attractive. So the main problem that this research project tackle is to make Milan a sustainable city towards 2100. In the project there will be research about the influence that urban designers can have to improve the (temporary) appropriation and urban microclimate. A description of an undesired scenario gives a picture of 2100 that will be the case if no measures are taken.

If there are not taken any measures regarding climate change and liveability the quality of life in Milan will decrease very fast. First of all, the temperatures will continue to rise, wherein urbanized areas the case would be even worse. These high temperatures lead to heatwaves, especially during the summer. Around 200 days a year there will be heatwaves in Milan. These extreme temperatures lead for example to health problems and a very low degree of thermal comfort in urban outdoor spaces where hot temperatures lead to heat stress, see figure 14 (Honjo, 2009). Secondly, the air quality will decrease very badly, because of an increase in people's activity and an increase of temperature (Papanastasiou, Melas & Kambezidis, 2015). At third, heavy precipitation events are the new standard. Because of more frequent events of heavy precipitation, the streets in Milan are frequently flooded. This will have consequences for the economy, society and liveability in Milan. With these problems, the question is raised if Milan will still be that attractive city for people, businesses and industries or that people will look for other places which are more attractive and safe to live.

Figure 14 Heat stress among the elderly

Figure 15 Opportunities of combination appropriation and microclimate in Milan

3 PROBLEM DEFINITION

PROBLEM STATEMENT:

The (temporary) appropriation of- and the climate conditions in urban outdoor spaces are decreasing because of the changing climate. If urban designers are not taking measures towards 2100 to stimulate the appropriation of and the urban microclimate in urban outdoor spaces quality of life will decrease more.

The problem statement builds up from the problems that are described in the problem field. The problem definition summarizes these problems. So, first of all, there is a trend of a growing population and urbanization in the world that will not stop in the upcoming decades and which is happening in Milan, Italy as well. This urbanization has some challenges for sustainable development in the future. From all these challenges this project focuses on two main effects of this urbanization: climate change and liveability. These topics will be researched in the context of urban outdoor spaces in Milan towards 2100. There can be seen that the quality of life is decreasing because of a change in the climate conditions and negative trends for the appropriation of urban outdoor space. There is a risk for cities that life on the streets will disappear because of changing climate conditions and the deterioration of urban outdoor spaces for people. While thermal comfort in indoor environments can be very well designed this is more difficult for the outdoor environment. When the outdoor conditions are poor people will look for pleasant indoor conditions. The urban microclimate is fundamental in giving quality to urban life. To enhance the quality of life in the future urban designers can play an important role in the (temporary) appropriation of urban outdoor spaces by looking into the urban microclimate. There is a lacking knowledge under urban designers about designing the urban microclimate. To bring in the perspective of the people urban microclimate is combined with (temporary) appropriation where the behaviour of people and use of spaces is considered. Talking about climate change often the big picture is taken in mind, however, the small scale climate is the one people perceive. The relation of urban design and architecture can show how designers and developers could collaborate to create sustainable city development.

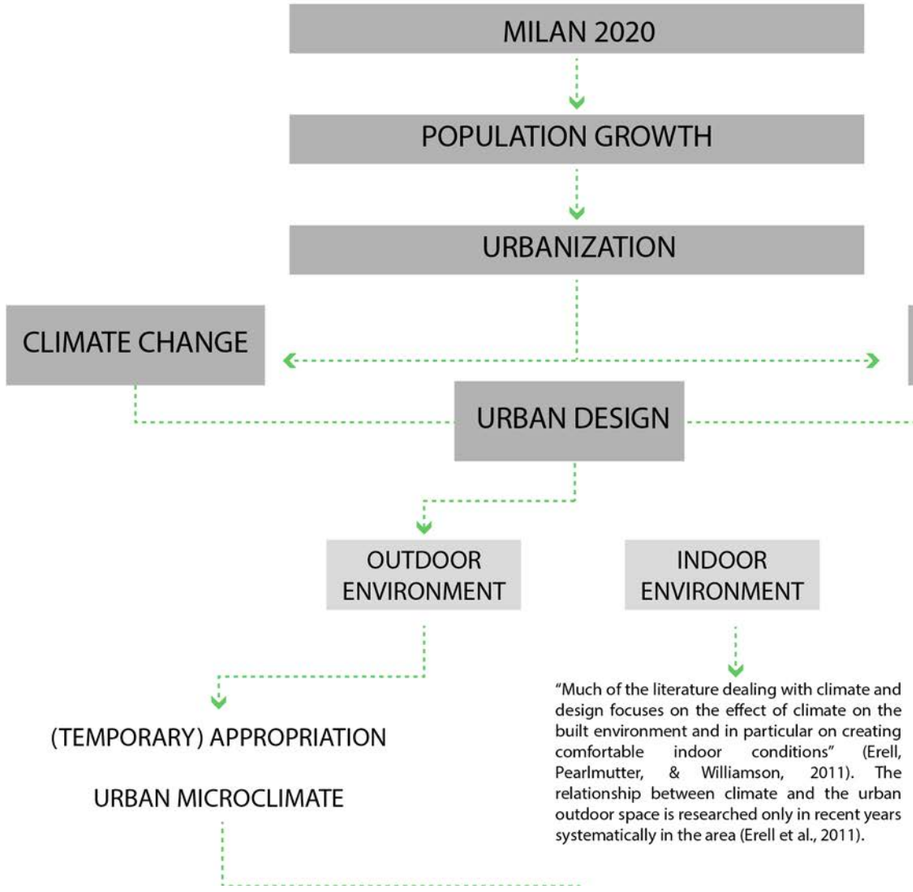

Figure 16 Research aim of the project

4 RESEARCH AIM

"the aim of the project is to explore how urban design can support the liveability in urban outdoor spaces regarding the climate conditions of 2100".

The general aim of the research project is to explore possible spatial interventions that increase or at least maintain the (temporary) appropriation of urban outdoor spaces in Milan towards 2100 by improving the urban microclimate, see figure 16. The project aims to add knowledge to the fields of liveability, urban microclimate and climate adaptation and will elaborate in this part why this addition is of use. First of all, research about climate and urban outdoor space is not something new. The relationship between climate and the urban outdoor space has researched in studies and discussions for at least one hundred years, for example where an urban heat island was identified in 1818 in London. However, most of the research is focussing on climate mitigation instead of adaptation. Only in recent years, the topic of climate adaptation is researched, however, Milan is not perceiving adaptive planning as an urgent topic (ECCA, n.d.). For this reason, it is interesting for this project to do research in this field.

Secondly, where much of the literature dealing with climate and design focuses on the effect of climate on the built environment and in particular on creating comfortable indoor conditions" (Erell, Pearlmutter, & Williamson, 2011) is the aim of this project to focus on the relation between climate and liveability in urban outdoor spaces. Because of climate change, there should be taken measures to increase this liveability.

Thirdly, urban climatology is one feature of the design of urban outdoor spaces. In order to create better environments for people, there is a necessity in understanding the urban microclimate so that designers may manipulate the spaces (Erell et al., 2011). So focussing on the urban outdoor spaces, the project aims to add knowledge to the field of liveability in urban outdoor spaces in relation to the urban microclimate. Therefore, for urban designers, it is interesting to conduct research on this topic to understand the conditions that have to be dealt with and how to respond to them by designing urban spaces. In other words, the general aim is to explore how urban design can support the liveability in urban outdoor spaces regarding the climate conditions of 2100, see figure 16. Research in literature will help to understand the topics we have to deal with and to give a strong body of knowledge that is necessary to design in these complex situations. In the first phase of the research project, the theory and the location will be explored. This is done to get a grip on the situation and to get an understanding of the topics.

Next to the general aim regarding climate change and liveability, the project contains also a site-specific aim. As shown in the problem field, Milan has some serious environmental problems which will be increased by climate change, like flooding and extreme temperatures. So the site-specific aim is to explore the possibilities to make Milan a resilient city towards 2100. It is interesting to explore the problems Milan has to face in the future and design sustainable solutions for those problems. As earlier mentioned, Milan is still only focussing on mitigation of the climate problems instead of looking at ways to adapt to the new conditions (Prasad et al., 2009). This gives the possibility for this project to add knowledge to the field of climate adaptation and give insights into ways to design climate-adaptive solutions. Climate adaptation is a quite new field where there is little information about the translation of adaptive systems into a design for urban outdoor spaces and makes those spaces livable by improving the urban microclimate. Design strategies will show how to implement climate principles that support the vision of Milan in 2100. This project is in search of new ways to adapt our living environment to the new climate conditions with spatial designs that take into account existing urban outdoor spaces.

"much of the literature dealing with climate and design focuses on the effect of climate on the built environment and in particular on creating comfortable indoor conditions"

~ Erell, Peralmutter, & Williamson, 2011 ~

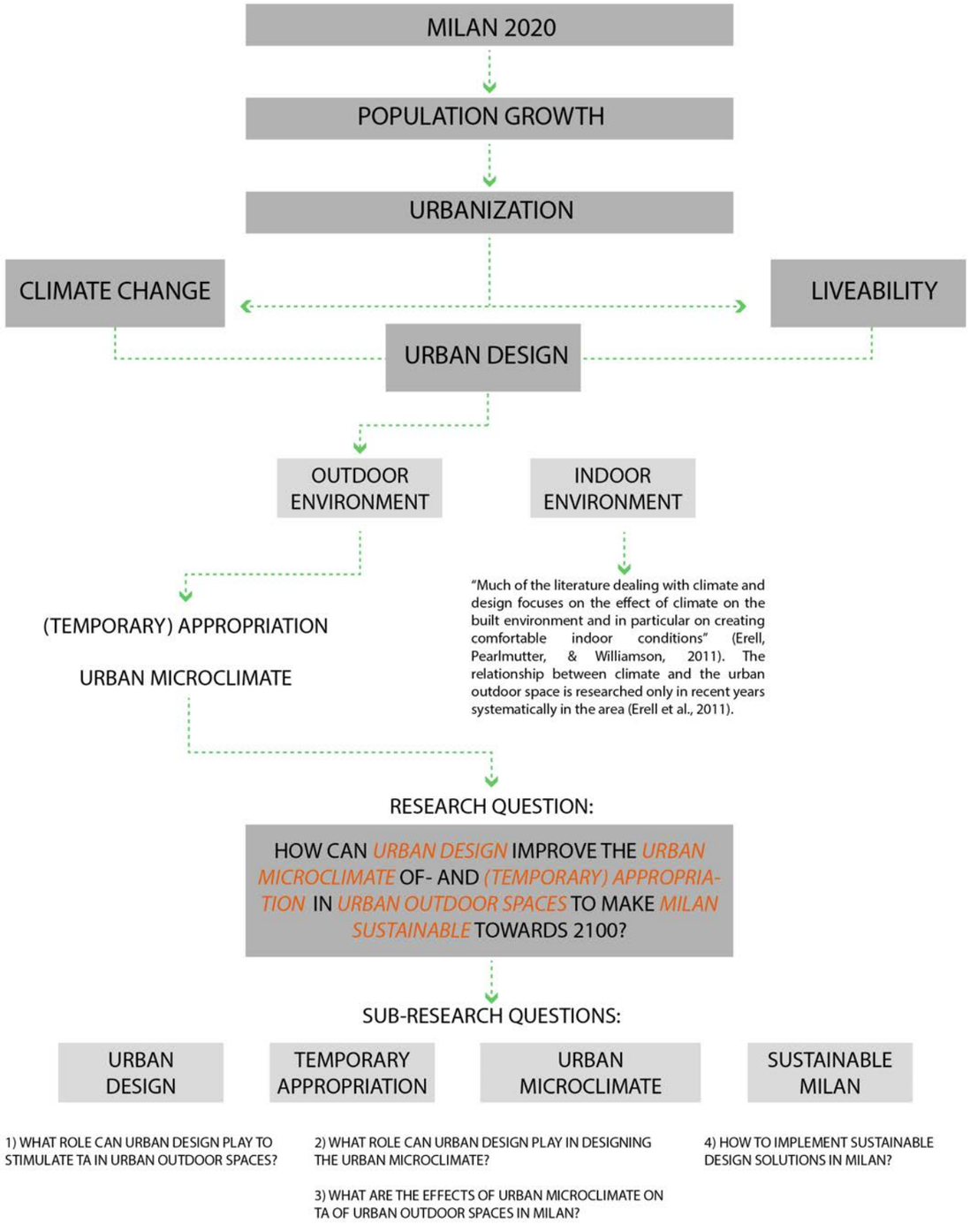

Figure 17 Conceptual framework

5 RESEARCH QUESTIONS

"How can urban design improve the urban microclimate of- and (temporary) appropriation in urban outdoor spaces to make Milan sustainable towards 2100?"?

The aim is to increase the liveability in Milan by improving the urban microclimate. Urban designers can play an important role to achieve this, so this leads to the following research question: How can urban design improve the urban microclimate of- and (temporary) appropriation in urban outdoor spaces to make Milan sustainable towards 2100?

This question contains multiple topics that need some explanation or research. So the sentence will be divided into parts and for these parts, sub-questions are formed to get a clear understanding of the problem.

1. What role can urban design play to stimulate TA in urban outdoor space?
2. What role can urban design play in designing urban microclimate?
3. What are the effects of urban microclimate on TA in urban outdoor spaces in Milan?
4. How to implement sustainable design solutions in Milan?

1. What role can urban design play to stimulate TA in urban outdoor space?
This question aims to give inside in the role that urban designers can have in stimulating TA in urban outdoor spaces. It is important that urban designers have knowledge about creating better environments for people and therefore knowledge about walkability, places for staying, transition zones and thermal comfort is needed. With this knowledge about TA urban designers can influence the outdoor spaces by creating the conditions which allow TA.

2. What role can urban design play in designing the urban microclimate?
This second question aims to give inside in the role that urban designers can have in the design process of urban outdoor spaces. It is important that urban designers have knowledge about creating better environments for people and therefore knowledge about the urban microclimate is needed. With this knowledge about urban microclimate, urban designers can influence the outdoor spaces in such a way that the spaces become pleasant to be. With this question inside, the microclimatic elements are given and it will show ways of designing with the microclimatic elements. For this question, a clear understanding of urban design, urban microclimate and the relation between them is needed.

3. What are the effects of urban microclimate on TA in urban outdoor spaces in Milan?
With the understanding of urban microclimate and TA, it is interesting for urban designers to see how one influences the other one. The relation between urban microclimate and TA will be researched, partly by theory as well as at a location in Milan. Here, design options will play an important role in showing elements that influence the urban microclimate which improve the TA. Design options can be evaluated by an assessment model that is made for this project.

4. How to implement sustainable design solutions in Milan?
This is an important question during a design process and I would like to gain knowledge about how urban designers can make sure that the proposed principles are implemented in the final design. The answer to this question will show which strategies can be used and which stakeholders are involved in the process.

6 RESEARCH METHOD

In this part, an overview is given of the sub-questions of the research project and the methods that will be used during the process. For each question, it is shown which kind of research method will be used during the project and of what importance this method is. The bigger the dot, the more important this method will be to get a grip on the sub-question. As figure (???) is showing there are sub-questions where theory is more important than design and there are other sub-questions where design plays a bigger role than theory. In this way, the project tries to have an interdisciplinary approach where each method gives different insights for the project. In the first period of the project, the focus will be on literature, case studies and mapping. This research will form a strong basis for the project. The theory will be used to get an understanding of urban microclimate and (temporary) appropriation. This theoretical part will form the basis for the design part. Research through design will be used to see how urban designers can influence urban microclimate and (temporary) appropriation. During the second period of the project, the focus will shift towards a design method. Case studies, for example, will be used for inspiration for design options.

Moreover, during the second period, professional designers in the field of urban design and climate adaptation will be interviewed to see how urban designers can make sure that the proposed principles are implemented in the final design.

For each sub-question, an overview is given where the research aim and the research methods are explained. There is an elaboration of what the methods should provide so that the sub-question can be answered. In the end, there is given insight into what the results of the research for each sub-question should be. During the research this will further be developed, however, this approach gives a strong backbone for the project.

		Literature	Case studies	Mapping	Interview/ survey	Design
THEORY	1. What role can urban design play to stimulate TA in urban outdoor spaces?	●	•			
	2. What role can urban design play in designing the urban microclimate?	●	•		•	
DESIGN	3. What are the effects of urban microclimate on TA of urban outdoor spaces in Milan?	●		●		●
	5. How to implement sustainable design solutions in Milan?		●			●

Figure 18 Overview of research methods

Subquestion 2: What role can urban design play in designing the urban microclimate?	
Aim	The aim is to get a clear understanding of urban design, urban microclimate and the relation between them and how urban designers can influence the urban mircoclimate.
Research method	Literature ● Case studies • Mapping Interview/survey ● Design
Literature	**What kind of literature?** Books, scientific papers, PHD research/master thesis **Key publications?** - *Design with urban microclimate* (Brown, 2010) - *Designing the urban microclimate* (Pijpers-van Esch, 2015) - *Urban microclimate: Designing the spaces between buildings* (Erell, Pearlmutter & Williamson, 2011) **What should it provide?** Through literature a clear definition of urban design and urban microclimate is given. The answer to this question should give ingredients for the design of the urban microclimate in Milan in the end. It is important to get a grip on the elements of urban microclimate and how to design with them.
Case studies	**What kind of case studies?** Focused on urban microclimate, **Key case studies?** - *Het klimaat past ook in uw straatje* - *De Straad* - *Kettingplein, Ghent* **What should it provide?** The case studies should provide a clear image of how to design with urban microclimate. The examples will show the translation of the theory into a design.
Interview	**Whom to interview?** Marjolein Pijpers-van Esch **What should it provide?** Marjolein did her PhD about designing the urban microclimate. Her PhD is already a good example for this project, however it can be helpfull to hear the knowledge from herself instead of my own interpretation of what she is writing.
Results	- clear overview of what is meant with urban design - clear overview of the scale of urban design - clear overview of the elements of urban microclimate - clear overview of ways to influence the urban microclimate with urban design - Guidelines / principles of designing the urban microclimate

Subquestion 1:
What role can urban design play to stimulate TA in urban outdoor spaces?

Aim	Set the boundaries of the term liveability in urban outdoor space that is important for this research project.
Research method	Literature (●) Case studies (●) Mapping Interview/survey Design
Literature	**What kind of literature?** Books, scientific papers **Key publications?** - *Measuring the livable city* (Southworth, 2003) - *Cities for people* (Gehl, 2010), *Life between buildings* (Gehl, 2011) - *What makes a public open space liveable?* (Dietrich & Kengyel, 2016) - *Temporary appropriation in cities* (Lara-Hernandez & Melis, 2018) **What should it provide?** Liveability is a broad term which is leaving a lof of space for different interpretations. Therefore it is important to make clear what is meant with liveability in this project. It is important to show what the project wants to achieve regarding liveability. Literature should show guidelines for urban designers regarding temporary appropriation in urban outdoor spaces.
Case studies	**What kind of case studies?** Focused on liveability in urban outdoor space **Key case studies?** - *Copenhagen* - *Kettingplein, Ghent* **What should it provide?** The case studies should provide a clear image where liveability is shown in urban outdoor spaces. The examples will show the translation of the theory about liveability into a design.
Results	- clear overview of the elements of temporary appropriation - clear overview of ways to influence appropriation with urban design - Guidelines / principles of designing appropriation of urban outdoor spaces

6 RESEARCH METHOD

Subquestion 3:
What are the effects of urban microclimate on TA of urban outdoor spaces in Milan?

Aim	Increase the liveability in urban outdoor spaces in Milan by improving the urban microclimate
Research method	Literature (●) Case studies Mapping (●) Interview/survey Design (●)
Literature	**What kind of literature?** Books, scientific papers, PHD research/master thesis **Key publications?** - *Life between buildings (Gehl, 2011)* - *Urban microclimate: Designing the spaces between buildings (Erell, Pearlmutter & Williamson, 2011)* - *Towards a Liveable Urban Climate: Lessons from Stuttgart* (Hebbert & Webb, 2012) **What should it provide?** An overview of the microclimate elements and their influence on the liveability in urban outdoor spaces. Moreover, with the knowledge from literature a criteria model is made to test the designs that are made.
Mapping	**What to look for?** With the knowledge from theory there should be looked for how outdoor spaces are used and how the influence of microclimate on the liveability is shown at the location. **What to document?** - Measure the current situation of urban outdoor spaces in Milan. I will look for elements or principles which respond to urban microclimate and appropriation that work in outdoor spaces.
Design	**What kind of design?** Design of the urban microclimate in urban outdoor spaces, new development and transformation **Purpose of design?** Explore different interventions in urban outdoor spaces. The designs should show the implementation of urban elements that have an influence on the microclimate and which improve the liveability in the area. A vision is made to show the ideas on a neighbourhood or city scale and design strategies will show how to implement the design principles that are made.
Results	- Vision for a climate adaptive Milan in 2070 - Design strategies that show how to improve the liveability by desgining the urban microclimate - The design strategies are tested by the criteria model - Design of new development project, tranformation project and a mixed project

Subquestion 4: How to implement sustainable design solutions in Milan?	
Aim	Provide knowledge about the implementation of design principles in a project design. Show the translation of the principles into a real design.
Research method	Literature · Case studies ● · Mapping · Interview/survey · Design ●
Case studies	**What kind of case studies?** Projects which shows the design principles that are made and how these can be seen in the final design of the project **Key case studies?** *- Het klimaat past ook in uw straatje* *- Bosco Verticale, Milan* *- De StraaD* *- Kettingplein, Ghent* **What should it provide?** The case studies should provide clear design principles of climate adaptation in urban outdoor spaces. The examples will show the translation of the principles into a design. Methods that are used can be work as an example for this project.
Interview	**Whom to interview?** Marjolein Pijpers-van Esch **What should it provide?** Professional designers have experience with design processes and therefore have knowledge about how to make sure the design principles are implemented in the final design. I want to know how to deal with the responsibility of projects. Who is resposible to ensure that the principles of a vision are et in the end?
Design	**What kind of design?** In the final design it is important to show the design principles that are made earlier. In the vision the principles are shown and design strategies will show how to implement the design principles that are made.
Results	- Overview of ways to implement the design principles - Timeline of interventions - Stakeholder actions

7 METHODOLOGICAL FRAMEWORK

First of all, a literature study will provide the required knowledge about the topics of urban design, urban microclimate and (temporary) appropriation. This knowledge will give a strong basis for the whole thesis and provide the possibility to always refer back to existing knowledge which will strengthen the arguments for problems and solutions. At the same time, the topics of urban microclimate and (temporary) appropriation are researched in a case study where problems and opportunities are spatially identified. This is important for urban designers because social- and environmental problems can be solved by spatial interventions. Not only Milan will be researched as a case study, but also other projects will be researched. These will be projects that have the same issues or provide solutions regarding urban microclimate and appropriation. With the knowledge of other projects interventions for these projects can be created and the aim is to prevent the same problems as in other projects.

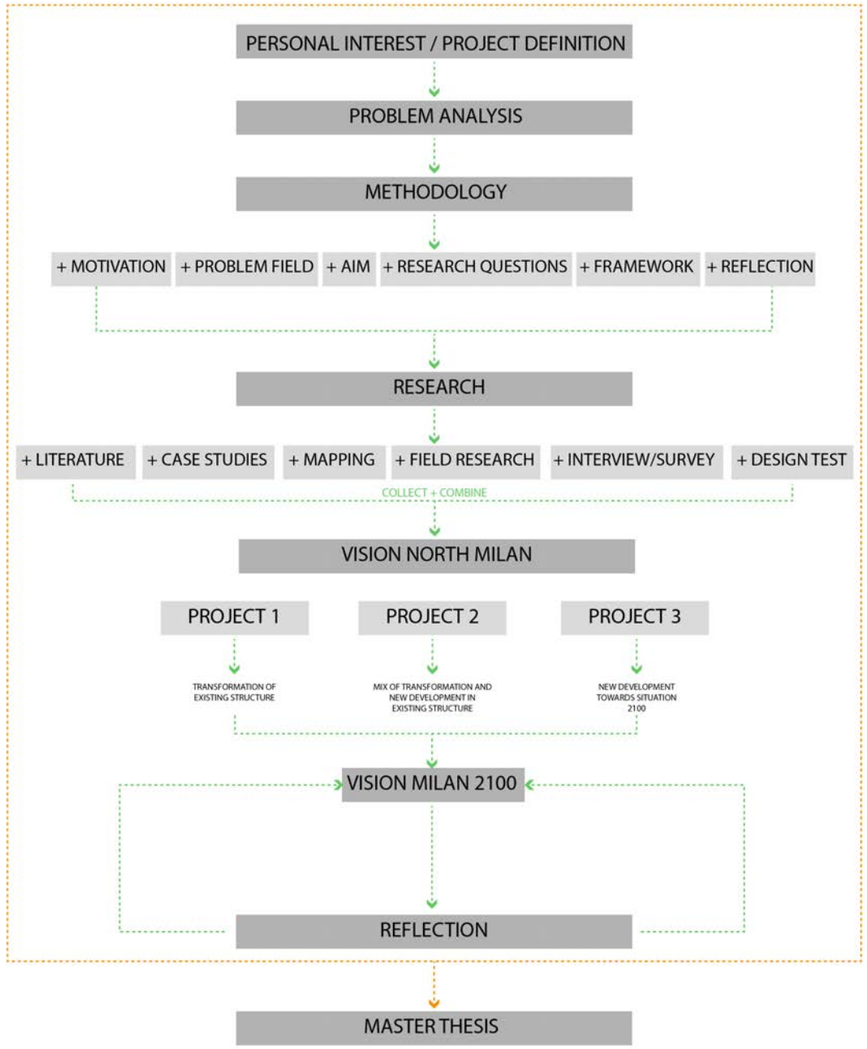

Figure 19 Methodological framework

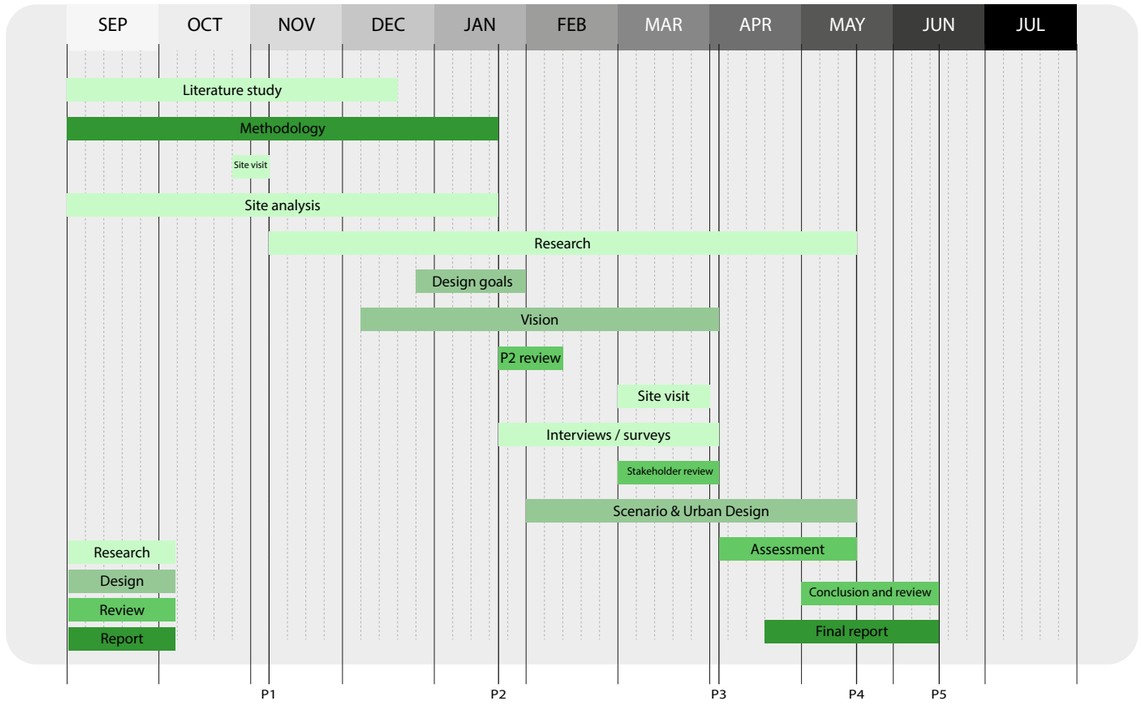

Figure 20 Planning of the graduation project

8 REFLECTION METHODOLOGY

8.1 Scientific relevance

As mentioned by Tumini & Rubio-Bellido (2016) there is a necessity for adaptation strategies in cities to cope with future weather conditions caused by climate change. Global warming causes changes in climate conditions and this would have a significant effect on the urban microclimate (Tumini & Rubio-Bellido, 2016). However, "much of the literature dealing with climate and design focuses on the effect of climate on the built environment and in particular on creating comfortable indoor conditions" (Erell et al., 2011). The relationship between climate and the urban outdoor space has researched in studies and discussions for at least one hundred years. However, only in recent years, the topic is researched systematically in the area (Erell et al., 2011). Therefore, for urban designers, it is interesting to research this recent topic to understand the conditions that have to be dealt with and how to respond to them by designing urban outdoor spaces. For this research, we will look at the case of Milan. Milan has some serious climate problems which they have to deal with, now and in the future. However, Milan has focused mainly on mitigation policies rather than on adaptation (Prasad et al, 2009). So, with increasing climate problems, the solution is not only to mitigate the effects but also to adapt the climate effects. There is almost no research done for climate adaptation in Milan and therefore this research project is relevant for the city, but also relevant for other cities because this project likes to show how to deal with climate change.

8.2 Societal relevance

Lenzholzer (2013) argues that for people the microclimatic environment is of life importance because our physiology function only in a relatively small range of temperature- and wind conditions. With the problem of climate change, it is very relevant to research what effects this change will have on people. Therefore research will be done about the behaviour of people in urban outdoor spaces to gain knowledge about the upper and lower limits to the range of 'acceptable' conditions for people (Erell et al., 2011). It is important to take the social part into account because people are the ones who are using public spaces in the end. It is possible that with climate change probably society will change too. Maybe life will be more inside than outside in the future, we don't know yet. So it is interesting to look for these changes and see what we can get out of it for making good public spaces in the future.

According to (Anglès et al., 2010) "The city is the place in which the human condition must be capable of self-recognition." Therefore this project will look through the eyes of the people and see what we as designers can learn from that. Hopefully, it will add knowledge to existing literature, for example to Cities for People, where a new relationship will be added, the relation of people and climate adaptation.

8.3 Ethical considerations

During the graduation project, some ethical considerations have to be made for the research. According to (Bryman & Bell, 2007) there are some principles regarding ethical considerations in research which I think are important for my research.

At first, misleading information must be avoided. It is important to present the collected data and information as clear as possible. Secondly, the communication related to the research should be honest and transparent. The research like to add knowledge to the scientific field, so information of the research project is open to everybody. Thirdly, the research data should be of an adequate level of confidentiality. When data is subjective instead of objective it is important to report that. The last important principle of the research is about respect for the privacy of research participants. Participants are not obliged to answer questions for example.

Furthermore, we as urban designers should keep in mind that everything we design could have a non-reversible effect. Once we have changed the urban fabric, our environment can not be the same as before. Every city is different, with different kinds of systems and with different kind of working patterns. This will mean that every space can develop in a lot of different ways given different conditions. In the end, the aim is to improve the quality of the space and make the space flexible, adaptable to future changes and so become sustainable. It is the task of urban designers to develop designs that have the least negative environmental impact. It is the role of urban designers to make sure that the designs are environment-sustainable, where the possible impacts for future generations are considered.

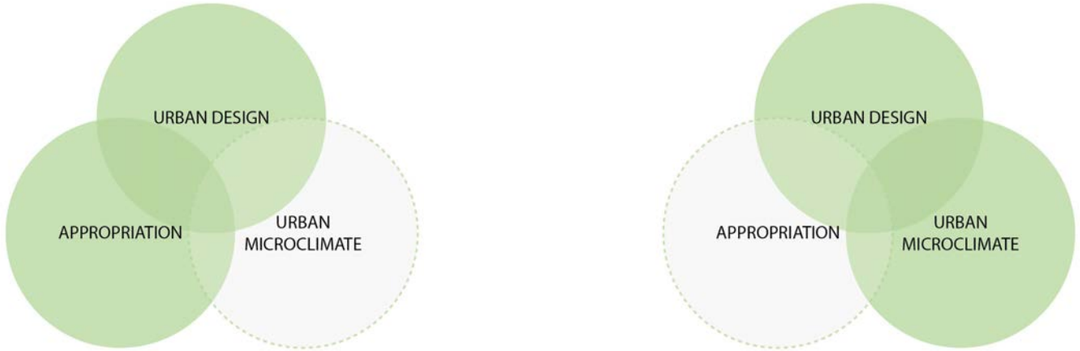

Figure 21 Theory concepts

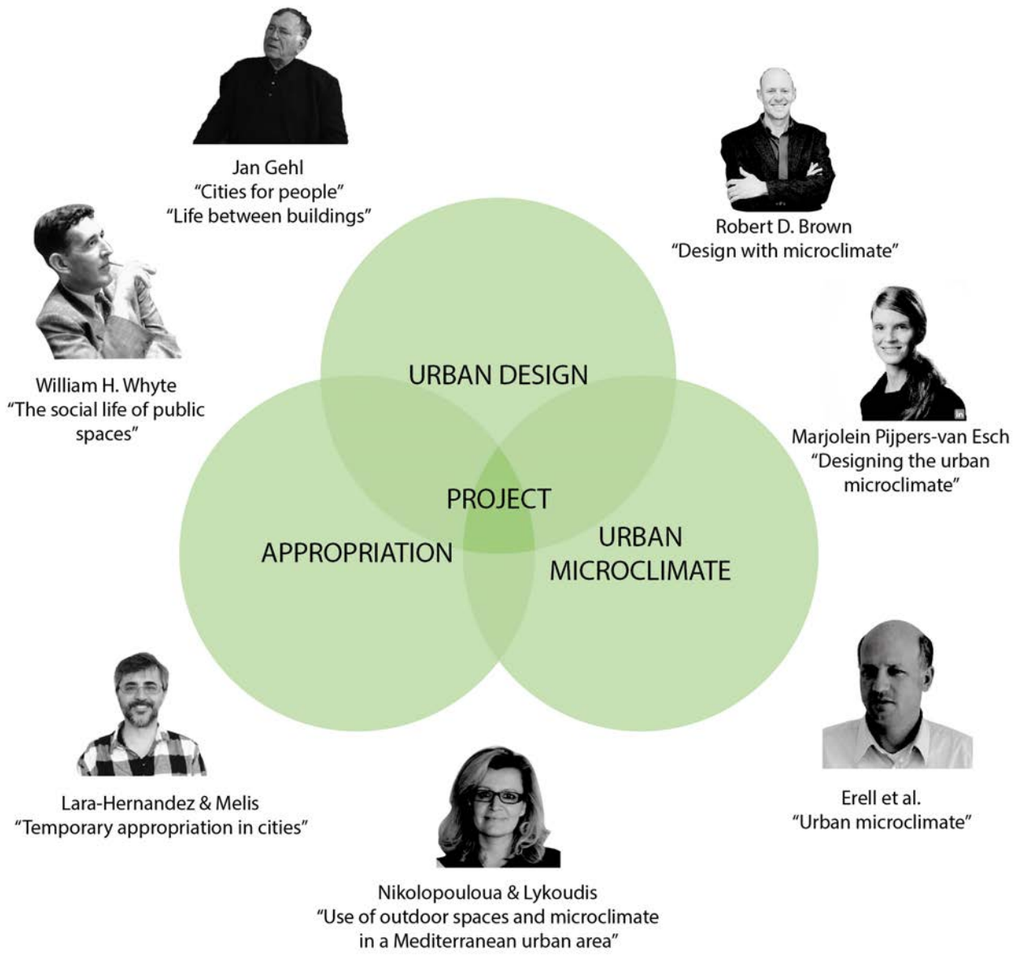

Figure 22 Literature review

9 THEORETICAL FRAMEWORK

Looking at the topics of appropriation, urban microclimate and the role of urban design in them it can be seen that there is a gap in the existing literature, as shown in figures 21 and 22. Before this gap will be explained there will be a short elaboration about the literature there is about the topics.

The topics of appropriation and urban microclimate are well described in the literature. For appropriation Melis and Lara-Hernandez show what this topic means in the context of the city. One of the most important issues they describe is social sustainability in cities with elaborations about social life on the streets and community resilience. What exactly the role of urban designers is or how we can design for appropriation is well described by William Whyte and Jan Gehl, however, this literature is a little outdated. Already in 1980, William Whyte described in "The social life of small urban spaces" important conditions for urban outdoor spaces. Later on, Jan Gehl gives his perspective about life in urban outdoor spaces in two of his books: "Cities for people" (2010) and "Life between buildings" (2011). There should be taken into mind that the books of Gehl are based on his findings and most of the time about places in Denmark. Nevertheless, it gives a clear overview of what urban designers should take into mind by designing urban outdoor spaces.

Regarding literature about urban microclimate, the book "Urban microclimate, designing the spaces between buildings" gives a strong basis to understand what urban microclimate is and what it consists of. However, the elaboration within the book is quite technical and this is not the point for this research. Looking further, much of the literature dealing with climate and design focuses on the effect of climate on the built environment and in particular on creating comfortable indoor conditions" (Erell, Pearlmutter, & Williamson, 2011). The last decades there is more attention given to the design of urban microclimate. This is done by Robert Brown with his book "Designing with microclimate" where he describes multiple aspects of the microclimate. Marjolein Pijpers van Esch adds multiple aspects to this field of knowledge, however, her PhD was focussing on the relation of urban microclimate and the physical well-being of people. What they both did to kind of summarize all the findings is that they make guidelines for designing the urban microclimate where they show what the influence of the urban environment is on climate elements.

Now the interesting point of this research comes into play. The relation between appropriation (liveability) and urban microclimate is not well described. One paper called: "Use of outdoor spaces and microclimate in a Mediterranean urban area" shows some examples of the relation between the topics. However, this is one of the few works of literature that is there about it. Especially there is a gap in the literature which can show the role of urban design in the relationship between appropriation and urban microclimate. Therefore this project will research this gap and show by design interventions the role of urban design in the process. The problems regarding appropriation and urban microclimate have not a visible direct relation, however, the microclimate influences the appropriation of urban outdoor spaces. The design of urban areas affects the different elements of climate - temperature, wind patterns, humidity, precipitation, air quality – which in turn have direct consequences for the liveability in those places (Hebbert & Webb, 2012).

In the next part, the main concepts of this project will be described to get an understanding of what fields this project aims to add knowledge.

Urban design

A lot of definitions are provided if it comes to urban design. The focus varies from the tasks of the urban designers to the scale of urban design or to the products of urban design and the process of that product. According to Pijpers-van Esch (2015) gave Barnett in 1982 a general definition of urban design: Urban design can be seen as the process of giving physical design direction to urban growth, conservation, and change. It consists of landscapes and buildings, in rural and urban areas. Another description of Barnett of urban design is the designing of cities without designing buildings (Pijpers- van Esch, 2015). Carmona et al. (2003) state that urban design is primarily concerned with the quality of the physical and socio-cultural public realm and focuses on the visual qualities and aesthetic experience of places. In other words, urban design is responsible for making places for people which they can enjoy and use.

Carmona et al. (2003) show seven objectives of urban design, as seen in figure 23. Regarding the scale of urban design Kevin Lynch (1981) states that urban design is working through different spatial scales rather than focussing on one scale.

7 objectives of urban design:

1 *Character*: a place with its own identity
2 *Continuity and enclosure*: a place where public and private spaces are clearly distinguished
3 *Quality of the public realm*: a place with attractive and successful outdoor areas
4 *Ease of movement*: a place that is easy to get to and move through
5 *Legibility*: a place that has a clear image and is easy to understand
6 *Adaptability*: a place that can change easily
7 *Diversity*: a place with variety and choice

Figure 23 Objectives of urban design

Liveability

Liveability, in general, is a relative concept. A few people in a narrow village street can be a good picture of a livable place, see figure 24. So it is not the number of people or the size of the place that matters, but the sense that a space is pleasant and popular that creates livable places (Gehl, 2010). A varied and complex city life creates a livable city. Therefore a mix of recreational and social activities is needed with pedestrian space and the opportunity for people to participate in urban life (Gehl, 2010). Southworth (2003) states that it is important for people to see how well the city is working, how comfortable it is and how enjoyable places are. Furthermore includes liveability different qualities such as a healthy environment, absence of crime and opportunities of life, like Gehl also stated. However, not only economic and social conditions are important for liveability. For example protection from hazards (flooding, wildfire, etc.) is important for urban life (Southworth, 2003). Hebbert & Webb (2012) state that the climatic variables - temperature, wind, humidity, precipitation and air quality - have direct effects for the liveability of urban spaces.

Figure 24 No life vs. life on the streets

9 THEORETICAL FRAMEWORK

Urban microclimate

To understand the meaning of the term 'urban microclimate' there should be an understanding of climate and the elements of climate. According to Encyclopaedia Britannica (2019, p. 1-3) "climate can be defined as the conditions of the atmosphere at a particular location over a long period of time; it is the long-term summation of the atmospheric elements (and their variations) that, over short periods, constitute weather. These elements are solar radiation, temperature, humidity, precipitation, atmospheric pressure, and wind".

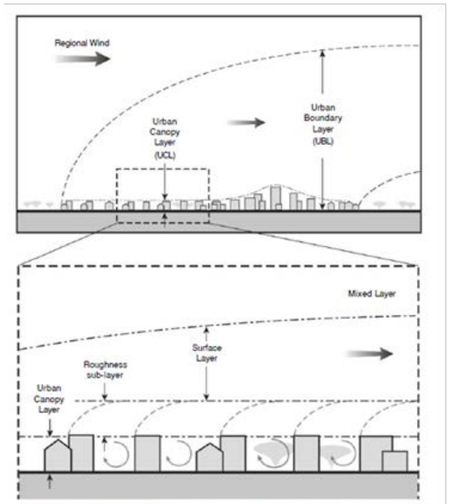

Figure 25 Schematic section of urban atmosphere

According to Brown (2010), the consideration of microclimate is crucial in designing and building urban outdoor spaces, yet microclimate is also the most difficult and challenging part in an outdoor space. Erell et al. (2011) state that microclimates are unique for each urban outdoor space, with indicators like air temperature, wind, radiation balance and others. It is important to define the scale level of urban microclimate. So, the micro-scale refers to this smallest realm, where each element, such as trees, influence the microclimate, which is in the end perceived by people (Erell et al., 2011). It is important to understand how the urban atmosphere has been built up, so figure 25 is showing the development. The lowest part is the urban canopy layer (UCL) where microclimates can be defined (Erell et al., 2011).

Urban outdoor space

In this project, the term 'urban outdoor space' is used for a place of intervention. Therefore it is important to set boundaries for this term. In this project we take an urban environment instead of a rural environment and the project will focus on outdoor spaces instead of indoor spaces. Urban outdoor space is easily compared with public outdoor space, however, the project doesn't want to exclude the privately-owned spaces. All too often, the term 'urban outdoor space' is used without taking into account the real urban qualities that the term includes (Anglès, Carrera, & Torres, 2010). According to Gehl (2011), there are three broad requirements of urban outdoor spaces: (1) conditions for outdoor activities, (2) conditions for recreational activities and (3) conditions for social activities. According to Gehl (2011) optional outdoor activities, like recreational activities, are dependent on the quality of the outdoor spaces and that these activities will disappear when conditions are poor. When better city spaces are provided, use will increase, see figure 26. This is true for large city public spaces, for small street spaces down to a single element in urban outdoor space (Gehl, 2010).

Figure 26 Times square, New York, before and after

PART 2 RESEARCH

In this research part, the topics of appropriation and urban microclimate are explored and elaborated. Before the thesis will elaborate on urban microclimate there is something important to understand first. Not every climate problem can be solved when you design the urban microclimate. Oke (1987) made an overview of the spatial scales where climate phenomena occur. Together with information from Pijpers-van Esch (2015) an overview is made which can be seen in figure 27.

While designing the urban microclimate there should be focussed on multiple micro-scale problems. Problems like river flooding or tornadoes can't be solved directly. However, greenhouse gasses can be decreased by designing the urban microclimate. Therefore pollution at the ground level should be decreased. This will contribute to decreasing the ozone levels on the macro-scale. In this way solutions on the smallest scale can influence larger-scale levels.

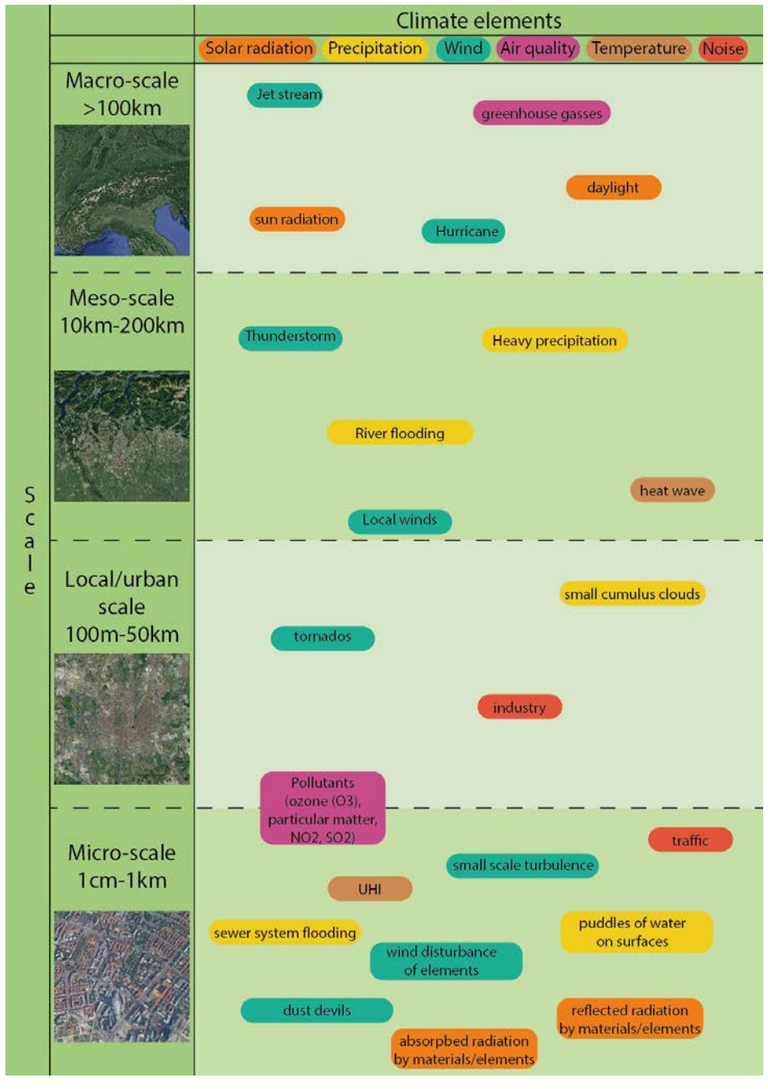

Figure 27 Spatial scales of climate elements

10 INTRODUCTION

To create some consistency within the thesis I will use the same type of icons over and over again. These icons are referring to the elements of appropriation and urban microclimate which will be elaborately explained in the next parts. These icons can be found in the literature study, analysis, vision and design strategies to make connections between theory and design.

This thesis will focus for appropriation on three elements; walkability, places for staying and edges public-private, while for urban microclimate the focus will be on solar radiation, temperature, wind, precipitation, air quality and noise.

WALKABILITY

PLACES FOR STAYING

EDGES PUBLIC-PRIVATE

SOLAR RADIATION

TEMPERATURE

WIND

PRECIPITATION

AIR QUALITY

NOISE

Figure 28 Activity level in the street

Figure 29 Appropriation of the sidewalk

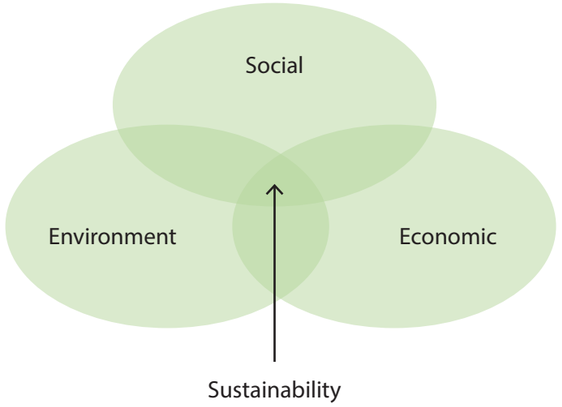

Figure 30 Urban social sustainability

Category	Economy		Leisure			Sacralisation
Description	Any activity in which a person or group use the public space in order to obtain an economic benefit directly or indirectly		Any activity in which a person or a group use the public space for leisure purposes			Any activity in which a person or a group use the public space for religious purposes
Sub-category	Work	Trade	Sports-games	Artistic expres-sions	Rest	
Individual or collective	Advertising or promoting services, waiting, engaging or attracting possible clients	Selling or buying products (food, handicraft, clothes, etc.)	Skateboarding, soccer, cards, marbles, hopscotch	Playing music, dancing, painting, acrobatics, reciting and singing	Eating, resting	Processions, praying, lighting candles and putting flowers

Figure 31 Activities of (temporary) appropriation

11 (TEMPORARY) APPROPRIATION

10.1 Introduction
There is a strong relationship between temporary appropriation (TA) and social sustainability. To illustrate this first the relation between TA and social sustainability will be explained where later the relation between TA and microclimate will be described. The phenomenon of TA of urban outdoor spaces is very important in the urban dynamics of a city. It is related to the resilience, both socially and environmentally, of urban outdoor spaces, where the design of these spaces has a great influence on TA (Lara-Hernandez & Melis, 2018). According to Lara-Hernandez & Melis (2018) Lefebvre argued in 1971 that appropriation is the goal of social urban life by saying that the domination of natural environment is way too big without the appropriation by people. Moreover they say that the appropriation of the urban environment can also be described as the interaction people have with the urban environment. This can be seen through all kinds of activities that are taking place in urban outdoor spaces. Appropriation of urban outdoor space that is time framed can be described as temporary appropriation. Urban design is necessary but not sufficient for temporary appropriation, because it also relies on the social life that takes place in the city (Lara-Hernandez & Melis, 2018). In this way there could be said that urban designers can not force people to use the urban outdoor space, but they can create the circumstances for people to use the urban outdoor spaces.

10.2 Temporary appropriation vs use of space
The relevance of TA within the urban context can be seen through the relationship between people and places. People appropriate urban outdoor spaces through activities that are taking place, see figure 29. There are different ways of looking at appropriation of urban outdoor spaces. Where some see walking and sitting already as appropriating space, others argue that identity plays a very important role in the appropriation of space (Lara-Hernandez & Melis, 2018). Fonseca Rodriquez described temporary appropriation as “the temporary act in which people use public spaces to carry out individual or collective activities other than the purpose that space was originally designed for” (Lara-Hernandez & Melis, 2018). This description gives the difference between the outdoor activities that are related to the appropriation of outdoor spaces and the simple use of these outdoor spaces. Not all activities that happen in urban outdoor spaces can be explained as TA. Therefore the activities of TA can be categorised into three kinds of activities, which can be seen in figure 31: economical activities, leisure activities (arts, sports, etc.) and sacralization activities. However, to give TA a relation to urban microclimate this project will focus on the most simple activities that take place in urban outdoor spaces. These activities will be described in paragraph 10.4, where directly a link with the urban design is made.

10.3 Temporary appropriation and social sustainability
The TA of urban outdoor spaces could be seen as one of the main aspects of social and environmental sustainability in cities. It is interesting to see how people interact with the urban environment and what effects human’s actions have on the environment (Lara-Hernandez & Melis, 2018). With social sustainability in cities, the aim is to combine the social and physical design that supports cultural and social life. To achieve this social equity and community sustainability are very important factors. Social equity is mostly about the accessibility to the human basic needs in a certain environment (Lara-Hernandez & Melis, 2018). Community sustainability is about the social interaction of people. The amount of attachment people feel to places has an influence on to which extent people interact with the urban outdoor spaces. Urban social sustainability includes environmental, social and economic aspects, see figure 30, where this project will look at the relationship between environmental- and social sustainability. According to Lara-Hernandez & Melis (2018) argues Musacchio that the urban environment is a constantly changing system. This is influenced by people’s needs, which are also constantly changing, and the actions, behaviour and values of people also influence the environment, both functionally and spatially, which can be seen as appropriation. Now we know how to describe appropriation and why it is important for social sustainability it is of importance to see how urban designers can deal with appropriation. Therefore in the next part, the influence of urban design on temporary appropriation is described. This should form the basis for the design part of the research project.




Figure 32 Pictures of walkability

11 (TEMPORARY) APPROPRIATION

10.4 Influence of urban design on temporary appropriation

10.4.1 Introduction

A Dutch architect called van Klingeren once said: "One plus one is three". By this, he means that when in an urban outdoor space something is happening this is because something is happening because something is happening. This process can also be negative when nothing is happening because nothing is happening (Gehl, 2011). A lesson from this is that it is important to create a variety of activities in urban outdoor spaces. In this way elderly come outside and appropriate benches to watch the children playing in the urban outdoor space.

For urban designers, it would be interesting to see how the design of urban outdoor spaces can enhance the temporary appropriation and therefore support social sustainability. To translate appropriation in something spatial this project will look into different aspects of appropriation: walkability, places for staying and the transition zones of public-private spaces. In this way urban designers aim to make temporary appropriation more quantitative measurable instead of qualitative. Appropriation demands space and comfortable climate conditions (Gehl, 2011). These are aspects that we as urban designers can influence, where we can decide the dimensions of the street and can influence the climate effects on people by taking into consideration some rules regarding walkability. The influence of urban microclimate on appropriation will be elaborated more in chapter 13.

10.4.2 Walkability

Walking is a way to get around, but also it's a way for being present in the urban outdoor space. According to Santucci et al. (2019) "walking is the primary way of appropriation" and cities are walkable when they are comfortable. According to Gehl (2011), it is not enough to design spaces where people only come and go. There should be conditions created for people to stay and make use of urban outdoor spaces. In this way, social and recreational activities can happen which add to the social sustainability of the place. Walking can be seen as a form of transport, where people go from point A to point B, but walking also gives the opportunity for many more activities (Gehl, 2010).

If urban outdoor spaces are pleasant to walk and sit, it will mean that all kinds of activities can develop in those spaces, like playing, sports activities and activities that support the community resilience (Gehl, 2011).

To create this walkability multiple aspects play a role. An important condition for pleasant and comfortable walkability in the city is the opportunity to walk freely without obstacles and being pushed away by other people. There should be room to walk, see top left of figure 32, without any interruptions and obstacles, where for example cars are prioritised above pedestrians, also for meaningless streets. Especially for the elderly, children and disabled persons, enough space to walk is very important (Gehl, 2010), see right bottom f figure 32. Another really important condition for walkability is the right surface material, because pedestrians and wheeled pedestrians are really sensitive to uneven ground surfaces, so stones or sand on pedestrian paths should be avoided (Gehl, 2011). The third condition for pleasant walkability is the time for waiting should be minimal. Pedestrians have most of the time a low priority and therefore they have to wait long at traffic lights and crossings (Gehl, 2010). An additional problem at places where people have to wait long periods is the creation of clumps (Gehl, 2010), see left bottom of figure 32. The sidewalks often have not enough space for this amount of people waiting at the corners of streets. By limiting the waiting time for pedestrians the natural flow of people is better and the gathering of people waiting is minimized. Furthermore, long, straight streets should be avoided, because these streets are not very interesting for pedestrians routes and most of the time these streets have more wind disturbance than curved streets. The last point for creating pleasant walkability is that differences in level should be avoided/minimized. It requires way more effort to walk upward and downward and stairs are even worse than a ramp (Gehl, 2011), see top right of figure 32. Stairs are not practicable for wheelchairs and baby carriages and with ramps the walking rhythm can be maintained (Gehl, 2010).

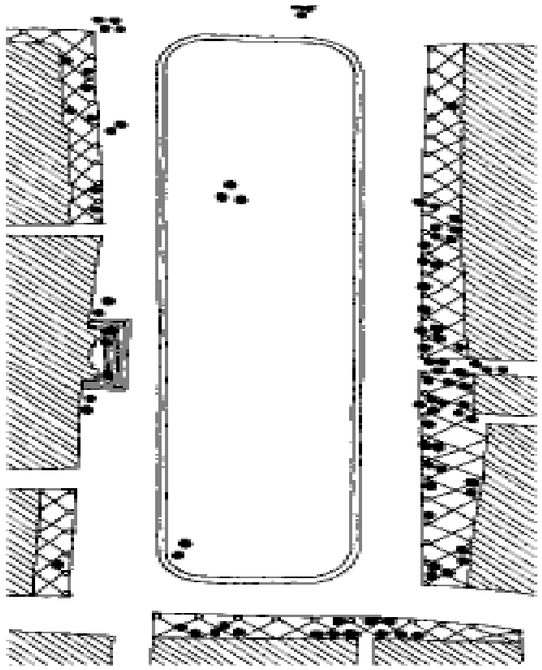

Figure 33 The edge effect

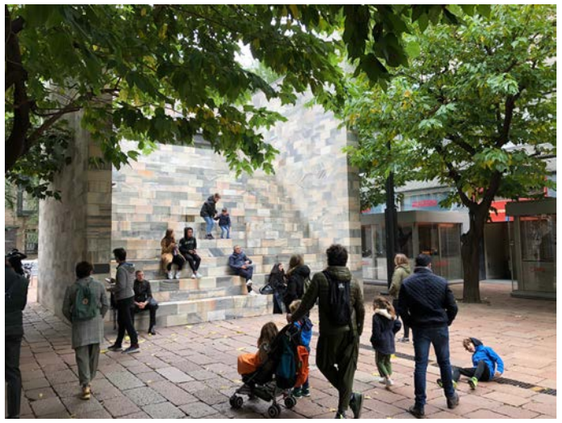

Figure 34 Steps as a place to stay

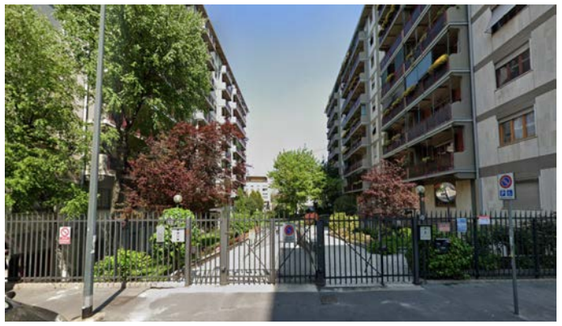

Figure 35 Edge zones in Milan

11 (TEMPORARY) APPROPRIATION

10.4.2 Staying

The second activity for the appropriation of urban outdoor spaces is staying in those spaces. Staying consists of standing and sitting and should be seen with respect to a real staying function: to enjoy the environment or to meet with someone, not to stop for a moment because of red light. To be able to enjoy the stay within the space the question is what makes a place pleasant to stay?
Popular places for staying can be found at the edge of spaces, as figure 33 shows. This can be explained through the fact that these places give the best positions for surveying the space and gives the best opportunity to keep distance from other people (Gehl, 2011). Direct contact with buildings gives the opportunity for staying, for example where activities on the ground floor have a direct connection with the street and invite people to stay for some time (Gehl, 2010). However, only edges are not enough, they should have niches for example. These niches provide something to lean on, give protection against weather conditions and offer a good view of the situation (Gehl, 2010).
When people want to spend more time in a space they tend to look for a place to sit. People are inclined to sit most where they are able to sit (Whyte, 1980) and besides sitting should be physically comfortable it is even more important that spaces should be socially comfortable. Social comfortability is created by choice: people can sit in the front or back of spaces, in the sun or in the shade and there should be a choice to sit in groups or alone (Whyte, 1980). The best way to create a choice is by making the urban features sittable, like ledges. Next to that benches and chairs can be added, but the most efficient way is to make use of the environment. A good example of a place to stay are steps. Steps are socially comfortable because people can sit at different heights, alone or together and watch the activities in the street from different perspectives (Whyte, 1980), see figure 34. Sitting places give even more choice when they are moveable. It gives flexibility and choice to people and by moving the elements around people can make the most out of the site, climate and view (Gehl, 2010). So we could say that orientation and view and the type of seating are important factors.

10.4.3 Soft edges

As earlier mentioned, the edges of spaces should be well designed and there is an important relation between inside and outside the building. Architecture and urban design emerge in these spaces. The idea exists that activities that are taking place in edges are mostly coming and going, however, research shows that this is only 10 per cent of the total activities. The other 90 per cent of the activities are stationary (Gehl, 2011). The type of buildings has an influence on the activities that take place in urban outdoor spaces. For example, with multistory buildings, it is too much effort for people to come down and appropriate the spaces. Besides, the spaces around multistory buildings have most of the time a quite impersonal character, in other words, more public, as shown in figure 35. Because it is too much effort for residents to carry their own furniture into urban outdoor space activities become very limited. To promote the appropriation of edges suitable places for staying should be put where they are most natural - at the entrance of buildings or at places where it is quite simple to enter and exit (Gehl, 2011). A sitting place next to the entrance which is protected against unpleasant weather conditions is a very good way to support the appropriation of urban outdoor spaces because the entrance is used during the whole day. Semi-private staying options, especially along the edges of urban outdoor space, can have an effect on the total activity level. People staying at the balconies of their house, in the terraces or front gardens show a picture of activity in the space and therefore stimulate other activities. The soft edges which are easily accessible and which people can decorate to give it a personal character are way more used than all other urban outdoor spaces. This is because the users of the space are well known and the option is right there which makes the effort to appropriate it low (Gehl, 2010). One important condition for soft edges is the ability for visual contact between inside and outside, especially on the ground floor and in the urban outdoor space in front (Gehl, 2010). Good connections between the indoor- and outdoor environment combined with good places to stay in front of the buildings should be created by urban designers. These extensions of opportunities for appropriation will be a valuable contribution to the quality of life at the scale of buildings, the street, the neighbourhood and in the city.

	WALKABILITY
1.	Walking demands space. Pedestrians should have enough space to walk freely through the urban outdoor space. Sidewalks should be wide and spaces like squares and parks should be created.
2.	For the surface material, stones, sand and an uneven ground surface are making walking more difficult, especially for wheeled traffic. Avoid these kinds of materials.
3.	Prevent obstacles, like dangerous traffic, traffic signs in the middle of the sidewalk or bus stops that cover the sidewalk. Also the unnecessary sidewalk interruptions with curb on, curb off should be avoided.
4.	Waiting time at traffic lights and crossings should be minimized to avoid the creation of clumps of people at these points. This can be done by giving the pedestrians higher priority.
5.	Create curved streets instead of long, straight streets. These streets are more interesting for pedestrians routes and most of the time these streets have less wind disturbance.
6.	Differences in level should be avoided if it comes to pedestrian routes. Movements upward or downward require more effort and an interruption in the walking rhythm. Stairs are even worse for wheelchairs and other wheeled slow traffic.
	PLACES FOR STAYING
7.	Edges should be well designed, because activities grow from here towards the middle. The relation with the buildings are therefore very important.
8.	Places for staying should be preferably placed along edges where they give social and environmental protection to the people. It gives an overview of all the activities on the street/square and gives protection against weather conditions.
9.	Orientation and view play an important role in the choice of a place to sit. Well-protected places to sit, with an unobstructed view of the surrounding activities, are always more popular than the places offering fewer advantages and more disadvantages.

11 (TEMPORARY) APPROPRIATION

10.5 Conclusion
To create/maintain social sustainability in the development of cities of the future the question is asked: What role can urban design play to stimulate (temporary) appropriation in urban outdoor spaces? Literature shows that temporary appropriation of urban outdoor spaces contributes to the social sustainability of places and therefore, urban designers should create conditions to stimulate this appropriation. This can be done by looking into the walkability of the area, by creating pleasant places to stay and design good edges and a visible connection between architecture and urban design.

The most important conclusion regarding social sustainability and appropriation is that designers should integrate choice in their design of urban outdoor spaces. People like to have many options that suit their preferences. Urban designers can provide these choices by analyzing urban outdoor spaces to see what they need and by critically planning sitting options, options to cross the street and to prioritize the pedestrians in the urban outdoor spaces.

10.	Create a wide variety of opportunities for sitting to provide all kinds of users inspiration and opportunity to stay. Primary seating, benches and chairs, should be provided and placed in strategically correct locations, in other words: the places with the most advantages.
11.	Secondary seating in the form of stairways, steps, boxes etcetera, are needed to offer extra sitting opportunities when this is needed. Steps are really popular, because it gives people many choices where to sit.
12.	Give people a choice where and how they can sit: in the front or back, in the sun or shade and in groups or alone. Choice should be integrated into the design of urban outdoor spaces
	SOFT EDGES
13.	Avoid non-active ground floors. In this case there is no direct connection between inside and outside. The street will be more public than private/semi private and will have an impersonal character.
14.	Create suitable places for staying at the entrance of buildings or at places where it is quite simple to enter and exit. In this way there is also something to talk about with your neighbours, pedestrians etc.
15.	Create semi private staying options at the edges of spaces. These can be balconies, terraces or front gardens, but all that have an opportunity for interaction with the street.
16.	Create visibility between the inside and outside of buildings, especially between the ground floor and the urban outdoor space in front. In other words: create open facades.

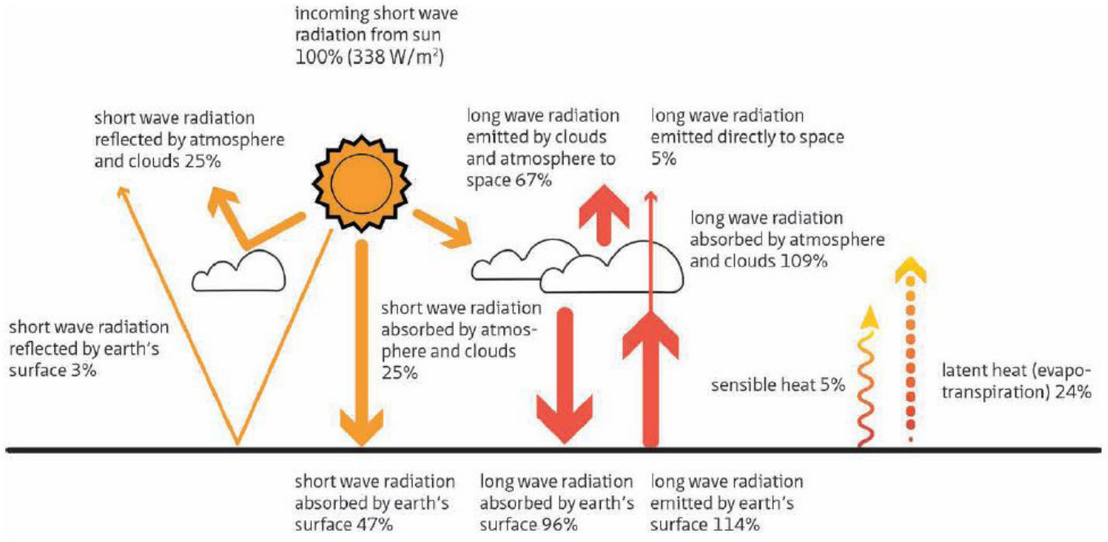

Figure 36 The earth's energy balance

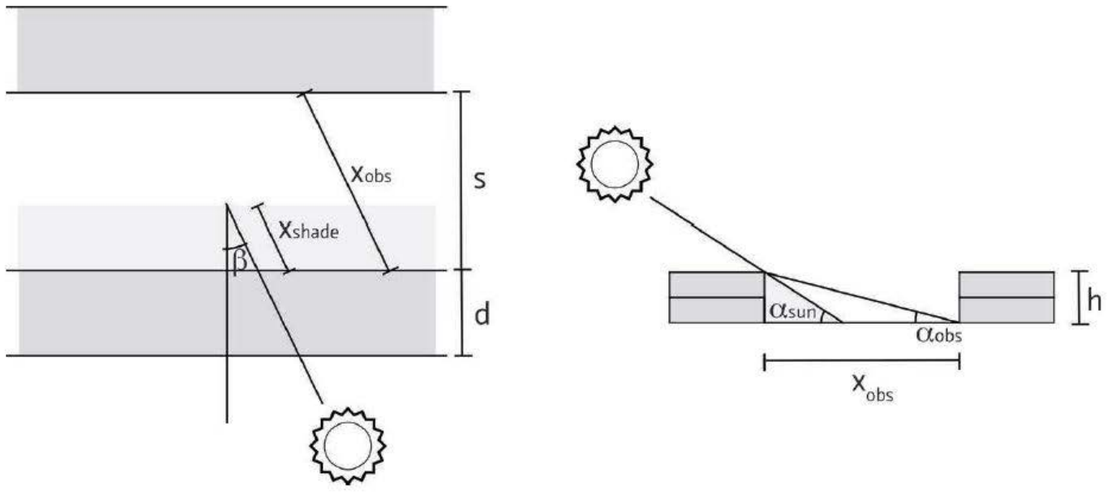

Figure 37 Direct perception of radiation

12 URBAN MICROCLIMATE

11.1 Introduction

As earlier said, urban design is responsible for making places for people which they can enjoy and use. In order to do that, urban design should modify the urban microclimate in such a way it is pleasant for people. According to Pijpers-van Esch (2015), the urban microclimate is highly influenced by morphology, materialization and landscaping of the urban environment. These are all elements that play a role in urban design, so it is important to take each of them into consideration. According to Brown (2010), every intervention to a place will have an influence on the microclimate in some way. However, the influence is different for each of the climatic elements. Therefore, in this part, the most important findings in the literature are given for each separate element and are explained with the principle of the urban canyon. "The urban canyon is defined as the (outdoor) space confined by facades, ground, roofs and the (imaginary) plain between the rooftops; and the air volume within this space" (Pijpers-van Esch, 2015, p.130). However, first, some main concepts of the urban microclimate are explained according to Brown (2010).

11.2 Main concepts

1. The main source of heating objects in an environment is the sun. The sun path is very predictable and the amount of heat is different for each location. This amount can be influenced by the design of the landscape and it is much easier to reduce the heat than to increase it.
2. The main source to cool warm objects in an environment is the wind. The wind direction is somehow predictable where the wind comes from some directions more than from other directions, which is called the prevailing wind. The amount of cooling can be influenced by the design of the landscape and it is much easier to lessen the cooling than to increase it.
3. It is very hard to modify the air temperature and humidity through the design of the landscape. However, in specific circumstances it is possible.
4. During summer, the design of the landscape can have the biggest influence on the microclimate where the absorption of solar radiation can be reduced. During winter, the design of the landscape can have the biggest influence on the microclimate where wind speeds can be reduced. During spring/fall, the design of the landscape can have the biggest influence on the microclimate by reducing the wind and not reducing the absorbed solar radiation.
5. Where the primary interest in the landscape is the thermal comfort of people, the radiation balance is most important: heat added to a person and the heat carried away from a person.

11.3 Climate elements

Urban microclimate is influenced by all kinds of climatic elements. This research will focus on the following elements: solar radiation, temperature, wind, precipitation, air quality and noise.

11.3.1 Solar radiation

Solar radiation comes in different wavelengths to the earth: as daylight, UV radiation and infrared radiation (heat) (Pijpers-van Esch, 2015). These various types of radiation have different effects when designing urban microclimate. This part will focus on heat radiation. Pijpers-van Esch (2015, p. 86) states: "Our thermal environment is created by the interplay of radiation coming from the sun and the reflection, absorption and re-emission of this radiation by the earth and its atmosphere". Figure 36 shows all the radiation that comes into play in an environment. The exchange of all the radiation is described as the Mean Radiant Temperature (MRT). The human thermal balance is influenced by four climate elements: radiation, air temperature, wind and relative humidity. Separately, the elements have not a clear influence on the thermal balance, however, the human body senses them all together as what is called "felt temperature" (Pijpers van Esch, 2015).

The solar radiation that is perceived by a surface, see figure 37 is highly dependent on the height to width ratio (H/W) of the street. This effect is very important during winter when the sun is lower than during summer. In general, in high-density areas, where buildings are high, there is less direct solar radiation on the street surface. One of the most important principles regarding solar radiation is the orientation of the streets. North-South oriented streets have a direct perception of the sun during winter and the building's facades will perceive sun during the morning and afternoon. East-West orientated streets have direct sunlight in the morning and afternoon

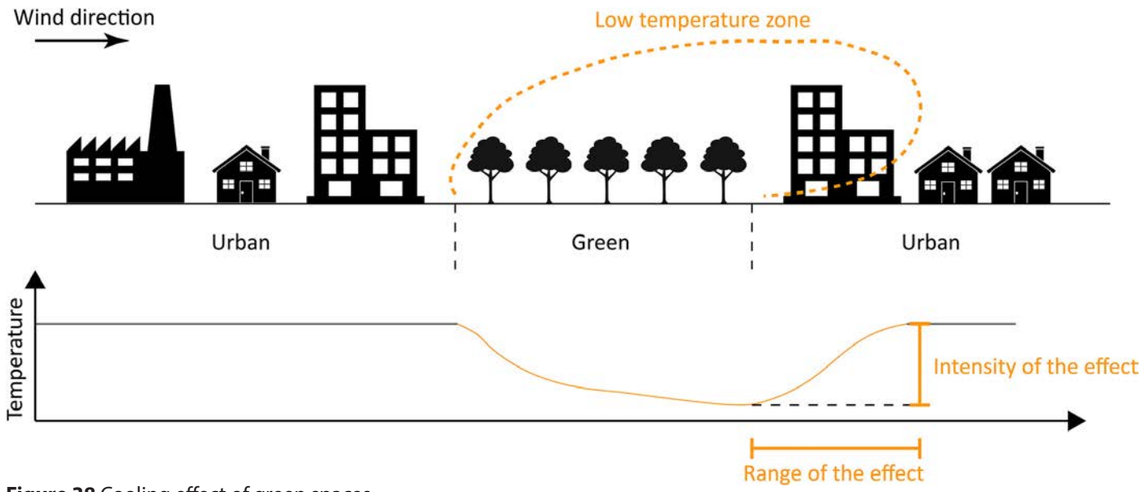

Figure 38 Cooling effect of green spaces

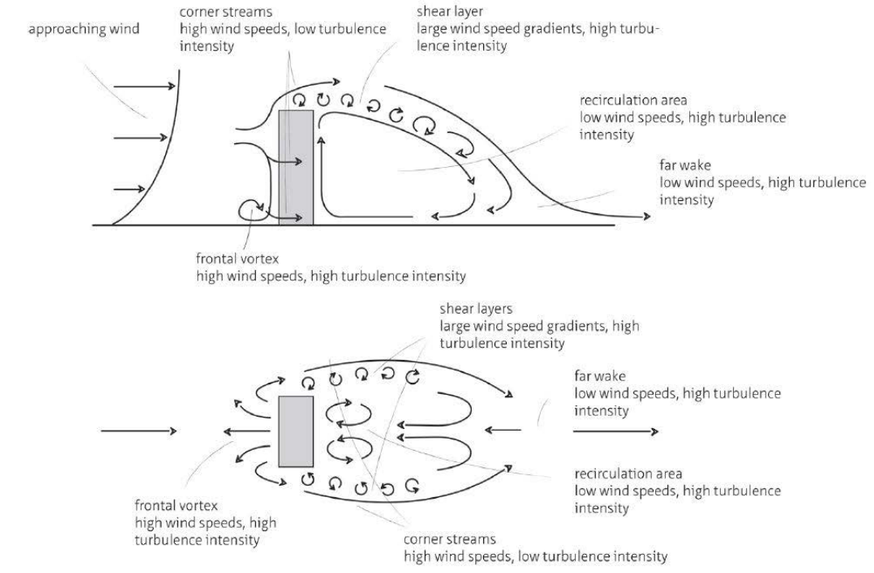

Figure 39 Flow pattern around a single building

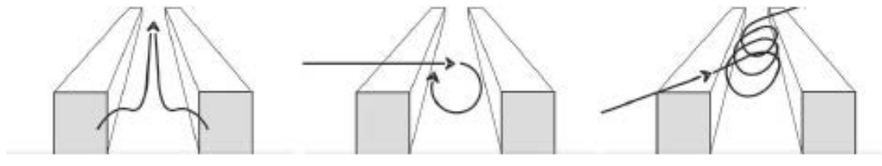

Figure 40 Flow patterns of wind in the urban canyon (a)

12 URBAN MICROCLIMATE

during summer and cause shade for comfort around noon (Pijpers-van Esch, 2015). Regarding the amount of radiation it is good to know that the more perpendicular position of the sun to a surface or element, the higher the intensity of radiation on that surface or element. This is because the radiation can be divided on a smaller surface. There is also more solar radiation absorbed by darker surfaces or elements, darker colours will get hotter and will reflect less solar radiation. This effect is reversed for light colours (Brown, 2010).

There are multiple ways to test the effects of urban design on solar radiation in urban outdoor spaces. The most important way to identify the effects is with a shadow-casting analysis. There are computer programs that can generate shadow diagrams or it is possible to do it by hand (Brown, 2010). The generation of solar energy is a very sustainable way of generating energy and therefore it is important to know where the most energy can be generated. This is mostly the case on roofs because these are the most perpendicular to the sun and have therefore a high amount of solar radiation. In warm climates, it is important to protect people against direct radiation, especially during summer. This can be created by providing elements that cause shade, like trees, trellises or overhanging roofs.

11.3.2 Temperature and relative humidity

As mentioned earlier, the human thermal balance is not influenced by air temperature alone (also by radiation, wind and humidity). These other elements have a higher influence on thermal comfort than air temperature (Brown, 2010). It was once measured that a surface, consisting of asphalt, was 20°C hotter in the sun than in shade, however, the air temperature at the same places at 1,5m above them was almost the same. So, it is very hard to modify the air temperature through the design of the urban environment. The same difficulty applies to relative humidity. However, in specific circumstances, it is possible to have an influence on air temperature and humidity. Brown (2010) points out one principle of air temperature and humidity to consider when designing the urban microclimate of urban outdoor spaces. The temperature of air exposed to the open sky can be much cooler and heavier than surrounding air and this air will flow down slopes and will be collected in low located areas. Moreover, air temperature near parks will be lower than surrounding concrete and asphalt in urban outdoor areas. This cooler air can influence the surrounding built areas where the wind can move this air, see figure 38. So, by creating green surfaces and elements the air temperature and humidity will be more pleasant for the thermal comfort of people.

11.3.3 Wind

Next to solar radiation, the wind is a climate element that can be influenced by the design of urban outdoor spaces. Differences in air pressure are causing wind and air pressure is influenced by temperature. Lower pressures are found in warm instead of cold air and therefore wind blows from high air pressure areas to low air pressure areas. High wind speeds are found by great pressure differences (Pijpers-van Esch, 2015). In general, to cool elements in urban outdoor spaces wind is the most effective tool. Wind can remove heat from elements until they have the same temperature as the wind (Brown, 2010). It is important to know that the wind direction in urban outdoor spaces is mostly variable. However, the wind comes from some directions more than from other directions, which is called the prevailing wind. The prevailing wind can be determined for every location and time, where it often changes with the seasons (Brown, 2010). For urban designers, there should be an extinction between wind flow around single buildings and wind flow in the urban canyon.

For a single building, there are two pressure systems regarding the wind flow pattern. The first one can be found on the windward side of the building. Wind bumps into the facade where it will push the pressure downwards and causes a frontal vortex which creates most wind discomfort. The higher the building, the higher the wind speeds (Pijpers-van Esch, 2015). The second pressure system can be found at the leeward side and at the corners of the building. At the leeward side, a recirculation area can be found and at the corners of the building, high corner streams are caused by air pressure. These corner streams cause high wind discomfort and therefore should be avoided.

For an urban canyon, there are three pressure systems regarding the wind flow pattern: parallel, perpendicular and at an angle. When the wind is parallel to the urban canyon the wind blows right through the canyon. With a wind direction (more

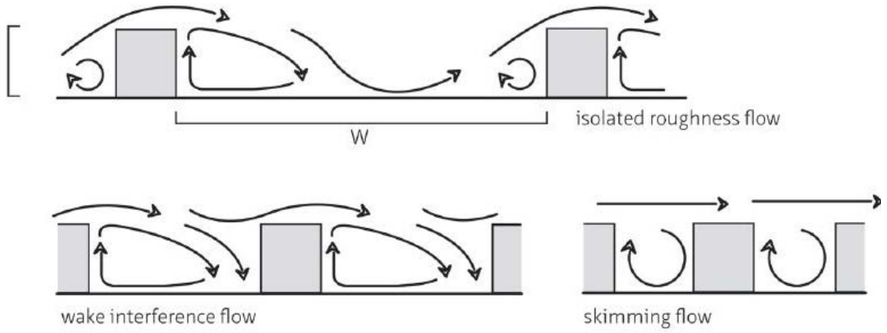

Figure 41 Flow patterns of wind in the urban canyon (b)

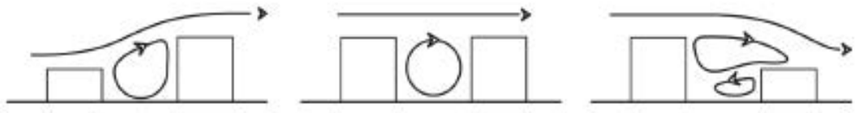

Figure 42 Flow patterns of wind in the urban canyon (c)

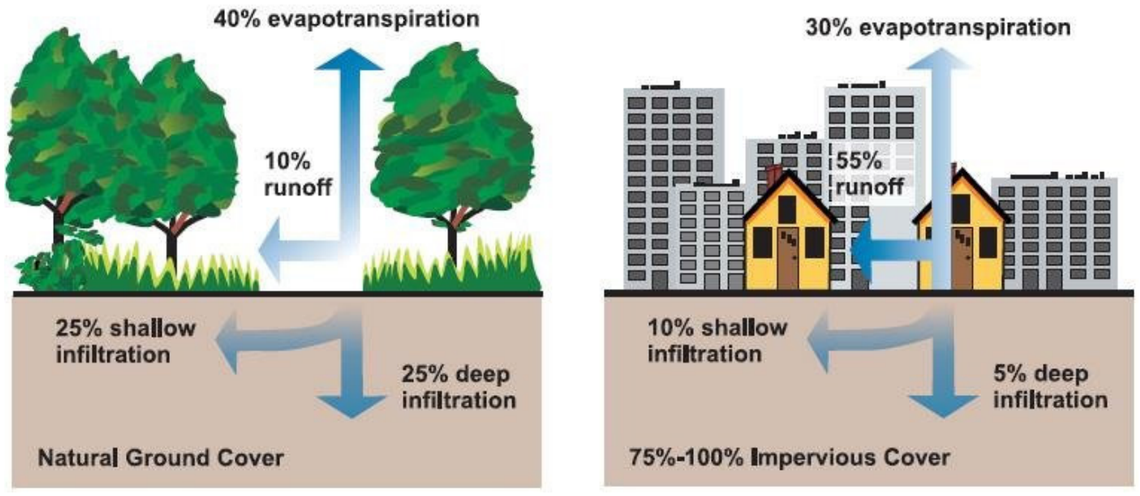

Figure 43 Infiltration of water

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or less) perpendicular, it will create different flow patterns within the canyon, as can be seen in figure 40. Next to the wind direction, the shape of the canyon plays a role, as can be seen in figure 41. Different wind patterns are created when the shape of the buildings is different, this can be seen in figure 42 (Pijpers-van Esch).

For urban designers it is important to take into account the wind patterns in the area. The prevailing wind is of high importance, but also the knowledge about single buildings, urban canyons and other elements is required. So the goal for a pleasant thermal comfort is to decrease the wind speeds in cold periods and to increase wind speeds in warm periods. In very warm areas people like to feel some air movement (Brown, 2010). Elements in the urban outdoor space can slow down the wind speeds and a very effective way to do that is the use of vegetation with a porosity of about fifty per cent. If the porosity is too high it will only create a small area of lower wind speeds and if it is too low it will not slow down the wind very much (Brown, 2010). Furthermore, urban designers should avoid high height differences between buildings and avoid pedestrian routes at the frontal vortex and corner streams of buildings. Enclosed spaces give high protection against wind discomfort, but again, frontal vortexes and corner streams should be avoided (Pijpers-van Esch, 2015).

10.3.4 Precipitation

Precipitation can be an issue in the life of people and the livelihoods in urban areas. According to Brown (2010), it is not the amount of rainfall, but the time and duration of the events that are most important for urban microclimate. Strategic planning can be anticipated in periods of heavy rainfall. People will search for sheltered places during precipitation and the urban environment can provide these sheltered places (Erell et al., 2011) However, the amount of rainfall is becoming more and more a problem within urban areas. The frequency of heavy precipitation events in urban areas is increasing and can lead to flooding.

Where precipitation can be a huge problem in urban areas it is very hard for urban designers to have an influence on precipitation at the microscale level (Pijpers-van Esch, 2020). If it is not possible to have an influence on precipitation urban designers should look at other ways to design with it and in this case adaptation is the keyword. If heavy precipitation events are happening there should be looked into areas or streets that have a high risk of flooding. The design of the urban space should do something with these vulnerable places Pijpers-van Esch (2020). Therefore I think it is important that urban design should integrate precipitation into the design of urban outdoor spaces, especially because heavy precipitation events are becoming more frequent. The design of the urban environment should look for possible solutions regarding heavy precipitation events. Most important is to manage the water movement in the area. During periods with a lot of rainfall, it is important to catch the rain, store it somewhere and diffuse the water during dry periods. For example, it can help to create height differences so that water can be stored at lower placed surfaces or water can be stored on roofs and on a later moment divided over the area. Furthermore it is important to look at the materialization where these should have enough infiltration possibilities. Within urban areas, this is most of the time a problem, see figure 43, and this can be solved by creating enough green/blue surfaces and elements so that water can infiltrate more easily. There should be a good network of sewer systems under the ground. Hollow streets can lead more water into these sewer systems where it can be drained and stored. In relation to the architecture, buildings should disconnect their sewer system from the public street. Buildings should store their own water and hold that for some time. In this case, the public systems are relieved a bit.

11.3.5 Air quality

A big issue in urban areas is air pollution. Exhaust from traffic and industry contribute by the creation of particles and gases into the air. The quality of the air is really important for the livability in urban outdoor space where low-quality air is really dangerous for the health of people (Pijpers- van Esch, 2015). The WHO has made guidelines for the maximum value of air quality, as shown in figure 45. The amount of air pollutants in the urban canopy is very related to the wind flow pattern. Air pollutants are transported by wind and are mixed with cleaner air by turbulence. Generally, air pollutants are trapped and/or deposited where wind speeds are low or where mixing with

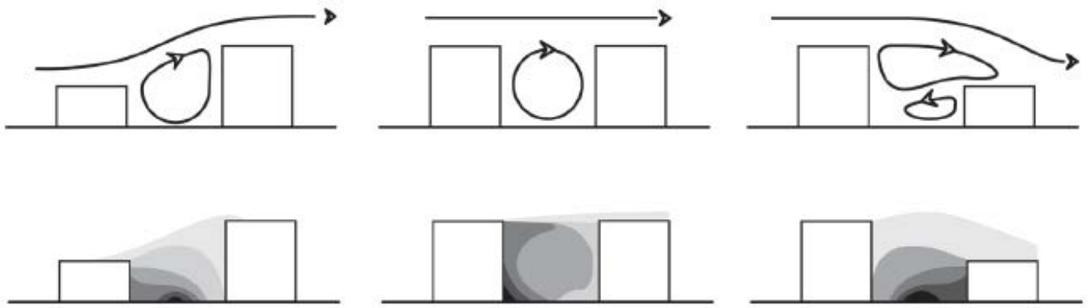


Figure 44 Pollutant concentration in urban canyon

Pollutant	Concentration	Averaging period
PM2.5	10 mg/m³	1 year
	25 mg/m³	24 hours
PM10	20 mg/m³	1 year
	50 mg/m³	24 hours
Sulphur dioxide	20 mg/m³	24 hours
	500 mg/m³	10 minutes
Nitrogen dioxide	40 mg/m³	1 year
	200 mg/m³	1 hour
Ozone	100 mg/m³	8 hours

Figure 45 WHO guidelines for air quality

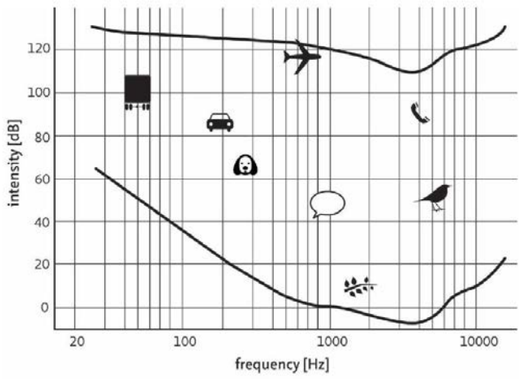


Figure 46 Sound sources

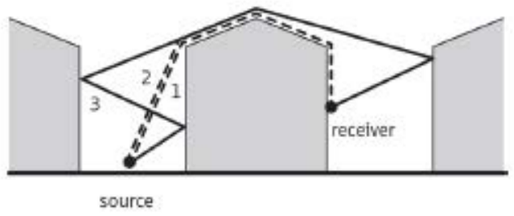


Figure 47 Diffraction and reflection in urban canyon

other air is limited (Pijpers-van Esch, 2015). With the wind perpendicular to the urban canyon, different concentrations of pollution can be found, as figure 44 shows. In general, the lowest concentration of pollution occurs along the windward facade where clean air comes into the canyon. Oppositely, the highest concentration of pollution will be on the leeward side of the urban canyon (Pijpers-van Esch, 2015). For urban designers, it is important to take into account that places for staying should be placed at a distance from heavily polluted sources. Slow traffic routes should be placed where at the lowest concentration of pollution, mostly at the windward side of the urban canyon. Along busy roads in the urban canyon, it is important to have enough openings to create ventilation and polluted air can be transported.

11.3.6 Noise

Within urban areas there is a lot of activity. These activities produce a lot of sounds, which can be annoying and causes stress for people. Regarding urban microclimate, these annoying and stress-producing sources are described as noise. Different types of noise sources produce a range in sound levels and will lead to a difference in the experience of annoyance (Pijpers- van Esch, 2015), see figure 46. People experience sounds from nature as positive, while noise from traffic is very annoying. Different modes of traffic are experienced differently: air traffic and road traffic are the most annoying where rail traffic is the least annoying (Pijpers-van Esch). Sound levels decline with distance and with time. The further a sound source from a point, the lower the sound level and the decline with time is dependent on the frequency of the sound. Sound reflection of surfaces is an important element in the urban canyon. Most of the urban canyons are diffusely reflective because of scattering facade and urban elements like outdoor furniture and trees (Pijpers- van Esch, 2015), see figure 47.
So, for urban design, it is important to protect recreational areas from noisy sources, because this is experienced by people as very annoying. Furthermore the materialization is of importance. In urban outdoor spaces, the sound is absorbed and reflected by surfaces and elements. The amount of absorption and reflection depends on the materialization.

11.4 Conclusion

The research question regarding urban microclimate was: What role can urban design play in designing the urban microclimate? Literature shows that the design of the urban environment highly influences the microclimate which is perceived by people. So, for each climate element different guidelines are important that urban designers should take into consideration, however, sometimes the guidelines are in contrast with each other. Therefore it is important to see what is really needed in that specific area, where we now know that the microclimate is different at each place in the city. Urban designers can use the maximization method where first the ideal situation for each climate element is drawn on the site after which compromises should be made to maximize the design of the urban microclimate. The knowledge of urban microclimate is there, the methods that help to design with microclimate are there and still in the developing process, so now urban designers should see how important an environmentally sustainable development of cities is in the future.

SOLAR RADIATION

17.	Functions which have a higher demand of heat should be placed higher than function with a lower demand
18.	The best design of urban structures is with buildings towards the south along a east-west directed street. With this structure the solar gain in the heating season is very high while it is low in summer. Moreover, this structure gives the best possibilities for a pleasant outdoor thermal comfort.
19.	Regarding the width of the streets it is preferable that east-west streets are wide and north-south streets narrow, because the H/W ratio has a bigger impact on east-west streets.
20.	In high density areas the roof is the most important source to gain solar radiation, while in low density areas it is possible that facades gain solar radiation because distances between buildings are bigger.
21.	For urban outdoor spaces other than streets (squares or parks e.g.) and meant for recreation, the north-south direction is the best orientation. The spaces should have a H/W ratio of 0.25 and smaller to have direct sunlight during winter. During summer there should be elements that provide shade.
22.	In dense urban areas, spaces like squares and parks should be placed at regular intervals to promote nocturnal long-wave radiation loss in summer. To avoid overheating, (flexible) shading should be provided.
23.	In warm climates it is preferable that the color of surfaces and objects are light so that it will absorb less and reflect more solar radiation.
24.	Type of trees provide different shades and allow different solar radiation to go through. In summer, deciduous and coniferous plants provide shade. In winter, deciduous plants allow solar radiation to go through and coniferous plants provide shade.
25.	Building- and urban elements (like trellis or overhanging roof) orientated to the south provide shade in summer and allow solar radiation to go through in winter.

TEMPERATURE

26.	There should be enough green surfaces and elements in the area to cool the surrounding built areas.

WIND

27.	Wind speeds can be slowed down through elements in the urban outdoor space. The most effective way to break the wind in urban outdoor spaces is with the use of vegetation. This vegetation is most effective with a porosity of about 50 percent. When windbreaks have a lower porosity it will generate turbulent air, which is an addition to the cooling effect of the wind.
28.	High buildings can create discomfort in urban outdoor spaces where high wind speeds will occur. This can be avoided by minimizing the difference in building height. Buildings that are two times higher or more than fifteen meters will create this discomfort of high wind speeds. If this can not be avoided the high buildings should have the long side of the building parallel to the main wind direction.
29.	Slow traffic routes or places for staying should not be placed at the frontal vortex and corner streams of high buildings.
30.	It is possible to build highly dense areas with much high-rise when all buildings in the area have somewhat the same height and buildings are placed less than 0.7 building heights from each other.
31.	A street grid aligned with the prevailing wind direction will have a combination of streets parallel to the wind with high wind speeds and streets perpendicular to the wind with many sheltered places. A street grid diagonal to the wind will have more general wind patterns in the streets.
32.	Streets parallel to the prevailing wind directions should not have a direct connection to open areas like rural areas or lakes.
33.	Squares and other small enclosed spaces are most protected against wind discomfort when corner streams, frontal vortexes and transverse flows are avoided.

PRECIPITATION

12 URBAN MICROCLIMATE

34.	By creating height differences water can be stored at lower placed surfaces so that higher placed surfaces will be dry.
35.	Materials of surfaces should have a high degree of infiltration so that water can be easily go into the ground and will not gather on the surface.
36.	There should be enough green/blue surfaces and elements in the urban outdoor space to store the precipitation during heavy events.
37.	Sewer systems of buildings should not be connected to the urban outdoor spaces. Buildings should store their own water (on the roof) and hold that water for some time. In this case there is less pressure on the water storage in urban outdoor space. An added value is that the stored water can be used during dry periods and can be used to flush toilets, vegetation in and on the building etc.
38.	Streets should be designed hollow instead of convexly. In this way more water can be stored and drained.
AIR QUALITY	
39.	Areas that cause a high amount of air pollution, like industry and harbours, should be placed downwind from residential areas.
40.	Spaces for staying, like squares or parks, should not be placed near heavy polluted sources like busy streets, because air pollution particles gather at these places.
41.	Foot and cycle ways along important streets are ideally put on the downwind side of the road, where generally clean air comes into the canyon from above and air pollution is hence the most minimal.
42.	Important streets ideally have intersections or side streets at short intervals as this creates ventilation. Air pollution is minimal in this case.
43.	Busy streets should be executed as step-up canyons (in case of perpendicular flow), as this configuration yields the lowest pollutant concentrations.

44.	If natural ventilation is used for buildings the street grids should be placed at an angle (at least 15 degrees) to the prevailing wind direction.
45.	Pitched roofs are not desired along streets with a high concentration of air pollution, because they prevent ventilation.
NOISE	
46.	It is not desired to place noisy functions immediately next to recreational areas or residential areas. Other functions should be placed in between.
47.	Parks / recreational green spaces should be located at a distance from noisy roads, because in green areas noise nuisance is perceived the most annoying.
48.	A homogeneous traffic system with an equal distribution of traffic will lead to higher noise levels than a system with hierarchy in the importance of streets.
49.	Along busy streets row of buildings is an important tool to protect the areas behind the buildings. Flat roofs, or even better, green roofs give extra protection against noise.
50.	The materialization of busy streets should be sound absorbing. This will give a reduction of the noise levels around the street and its surroundings.
51.	Along busy streets, a mix of different roof shapes is ideal, because this increases scattering
52.	A rectangle will have quieter areas than a square and will be more suitable for different functions
53.	Avoid specular surfaces (glass), because glass facades yield higher average sound levels and reverberation times.

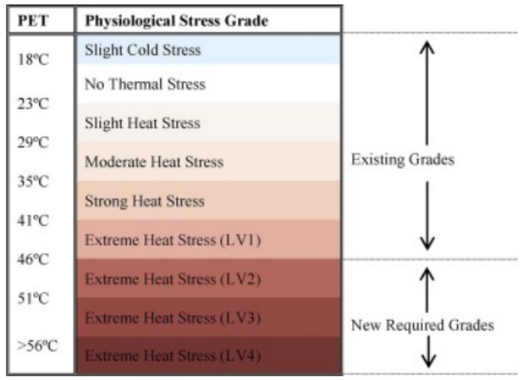


Figure 48 Heat stress

Figure 49 People adapt to climate conditions

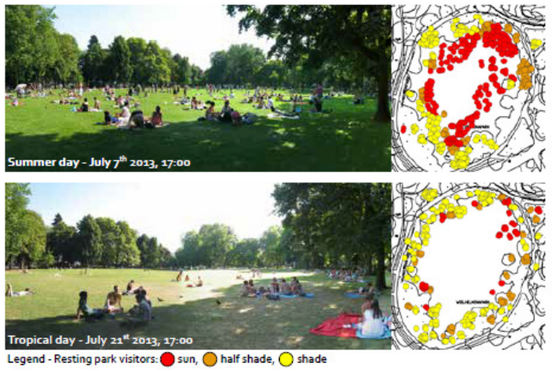


Figure 50 User patterns in parks

Figure 51 Greenery at different heights

Figure 52 Sidewalk and benches in sun or shade

13 MICROCLIMATE AND APPROPRIATION

12.1 Introduction

The design of urban areas affects the different elements of climate - temperature, wind patterns, humidity, precipitation, air quality – which in turn have direct consequences for the liveability in those places (Hebbert & Webb, 2012). In the decades after 1950 city planning became less climate-aware. Car lanes were widened and pedestrian paths, like sidewalks, narrowed which led to an increase in cars and therefore a decrease of the outdoor air quality. Small city blocks became physically stronger and together with the construction of large-scale climate-controlled buildings the outdoor air circulation was blocked and wind tunnels were created. There was an increase in the urban heat island effects because there was a boost of high heat absorbed materials like asphalt and cement. These solid materials on buildings, streets and parking lots caused an increase of storm-water run-off and flood risk. The removal of trees led to the removal of pollution filters and exacerbated outdoor temperature extremes (Hebbert & Webb, 2012). The adverse climate trends will affect the outdoor liveability and these trends are well known by urban climatologists.

According to Santucci et al. (2019), the dimensions and qualities of the environment can really have an effect on the way people will appropriate urban outdoor spaces. The outdoor comfort, also called the urban microclimate, is one of the main influencers on the appropriation of urban outdoor spaces by people. It could be said that climate is the main factor that determines the appropriation of urban outdoor spaces. In particular urban microclimate, which provides the condition that people experience all the time. So, the urban microclimate is fundamental in giving quality to urban life. In the part about appropriation, we could see that urban outdoor spaces are used in different ways where walking is of primary use (Santucci et al., 2019). Other ways to appropriate the urban outdoor space are sitting and doing activities.

According to Santucci et al. (2019) "cities are walkable - healthy, safe and vital - if they are comfortable." To address this comfortability urban microclimate comes into play. Urban microclimate has a primary effect on cities because it affects the walkability, comfort and health in urban outdoor spaces and therefore affects the quality of the public realm. Every day people experience the consequences of climate change which lead to a huge challenge of creating comfortable conditions in urban outdoor space. The challenge is made even bigger because the urban microclimate differs from place to place in the city (Santucci et al., 2019). It is crucial to understand the urban microclimate because outdoor thermal comfort is fundamental to people to appropriate urban outdoor spaces. Urban designers play an important role to achieve this because designing is one of the most powerful ways of affecting change.

In this part, the influence of the different climate elements on the appropriation of urban outdoor spaces is elaborated. This is partly done by some literature, but because there is a gap in this connection it is also done by my own observations in the case study of Milan.

12.2 Effect climate elements on appropriation

12.2.1 Effect of solar radiation and temperature on appropriation

Radiation from the sun is appreciated during the cooler season in Milan, however, in the summer the sun can create problems. At places with no shade fewer people will use the space, fewer people will sit down and the people that do so do that for a shorter period (Nikolopoulou, Baker, & Steemers, 2001). According to Spatial Adaptation Knowledge Portal (n.d.), people perceive physiological stress from heat. From 23°C slight heat stress and from 35°C strong heat stress occurs, as can be seen in figure 48. This would mean that heat is not good for people and therefore the liveability decreases when the temperature rises. A decrease in the liveability would mean people will appropriate the urban outdoor spaces less.

In Mediterranean urban areas, it is generally true that during summer, when air temperature increases, the number of people found in the sun is reduced. People prefer to sit or stand in shaded areas at higher air temperatures, see figure 49. However, as the high temperature is a factor contributing to discomfort, presence is reduced when the air temperature rises significantly. During winter the presence of people in the sun increases because temperatures are higher over there than in shadow areas (Nikolopoulou & Lykoudis, 2007). With this knowledge and the preferences regarding appropriation urban designers

Average wind speed [m/s]	Effects
5	Minor disturbance of hair and clothes, wind felt on face
10	Walking not easy, hair disturbed, fluttering of clothes, difficult to hold umbrella, frequent blinking of the eyes
15	Walking difficult to control, upper body bends windward, hair violently disturbed, impossible to hold umbrella, tears falling from the eyes
20	Walking very difficult, whole body bends windward, facial pain, ear-ache, headache, breathing difficult

Figure 53 Effects of wind

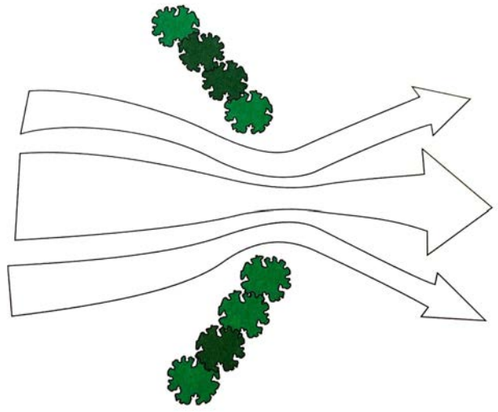


Figure 54 Channeling effect

Figure 55 Net providing shade and windbreak

Figure 56 Umbrella protection against sun and rain

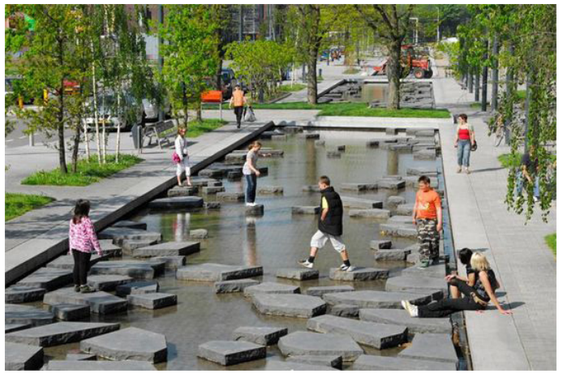


Figure 57 Urban waterway with stepping stones

13 MICROCLIMATE AND APPROPRIATION

should create options for people within urban outdoor spaces. This would mean that people can have a choice if they want to walk/sit in the sun or the shade, depending on their preferences. During summer it would be pleasant to have sitting options in the shade, for example under trees, while during winter people would appreciate the sidewalk or a bench in the sun, see figure 52. As earlier mentioned, a choice should be integrated into the design of urban outdoor spaces. This is also shown in a research done by Klemm (2018) where she shows that people enjoy the sun under certain temperatures, while with very high temperatures people appreciate the shadow more than the sun, see figure 50. For the edges of spaces, it is good to know that the presence of green creates a soft barrier between public and private, it can give shadow at certain moments of the day and lower the temperature at these places. It is therefore very suitable for these edge zones. Within a street, it is desired to create greenery at different heights to improve the thermal perception of pedestrians. The routes are in this case interesting, (semi) private zones can be protected and the microclimate is improved, see figure 51. As earlier mentioned, to prevent the city from overheating designers should add greenery, where green areas can have a cooling effect on their surroundings, on places where the wind can transport cool air from the green areas into the streets. In this case, it is important not to make the ventilation areas too dense with buildings or plants (Lenzholzer, 2013).

12.2.3 Effect of wind on appropriation

Sun and wind play a critical role in determining people's sense of comfort outdoors. Sun and wind both influence how warm or cold people feel, and winds, when too strong, can be a source of annoyance, and even physical harm (Bosselmann et al. 1984). During summer in Milan, the cooling effect of wind is desirable for a pleasant urban microclimate, while in winter cooling is creating discomfort (Pijpers-van Esch, 2015). The goal for wind regarding the thermal comfort of people is to decrease wind speeds in cold periods and to increase them in warm periods. Even in very hot conditions, people prefer some air movement (Brown, 2010). But people can also perceive the nuisance of wind. Research of Hunt, Poulton, & Mumford (1976) shows that the performance of everyday skilled tasks is getting worse when the wind speed increases from 4 to 8,5 m/s. The walkability in areas is already not easy with wind speeds of 10 m/s and gets worse when wind speeds increase, see figure 53. So, urban designers should think of where to put slow traffic routes in relation to the wind direction. Regarding places for staying, analysis on people sitting in the sun shows that wind appears to have a positive effect in the summer—when it is most welcome particularly by those sitting directly in the sun. The effect is negative in winter, reducing presence significantly since a sunlit position is, usually, also exposed to wind (Nikolopoulou & Lykoudis, 2007). For the edge zones of urban outdoor space, it can help to create niches where people can shelter if heavy winds are occurring. Facades can give that little protection for people that is needed. As earlier said, winding streets, especially pedestrian routes, are more interesting for people and avoid at the same time wind nuisance.

After a wind analysis urban designers should know which places should be protected against high wind speeds and which spaces should have some ventilation. Ventilation can be created by channelling the wind and therefore guide it to those spaces where ventilation is desired. This can be done with the use of buildings, trees and hedges where it can help use the cool airflows more efficiently (Lenzholzer, 2013), see figure 54.

12.2.4 Effect of precipitation on appropriation

Precipitation is a significant issue in many people's lives and livelihoods. In terms of microclimate, it isn't so much the amount of rainfall but, rather, the time and duration of precipitation events that are often of most interest to the users of public spaces (Brown, 2010). However, it is very hard to influence precipitation on the microscale of urban design. What we can do is make design measures that can adapt in relation to precipitation. First of all, it is very important that people are protected against precipitation and it is usually created at places where people have to wait, like bus and tram stops or train stations. However, people should also be protected against precipitation in shopping streets, on squares or walking routes (Lenzholzer, 2013). Solutions to create shade also can often provide shelter against precipitation, see figure 55 and 56. Dry feet is one of the most important conditions for people. Height differences play an important role in the temporary storage of water. With the use of sidewalks, pedestrian routes

Figure 58 Sidewalk protect against storm water

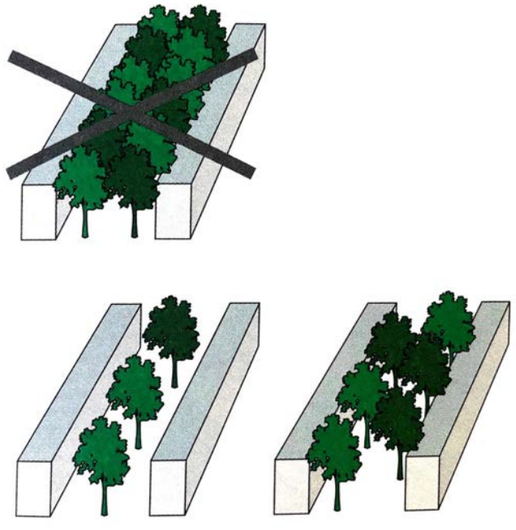


Figure 59 Avoid green tunnels

Figure 60 Squares are popular

13 MICROCLIMATE AND APPROPRIATION

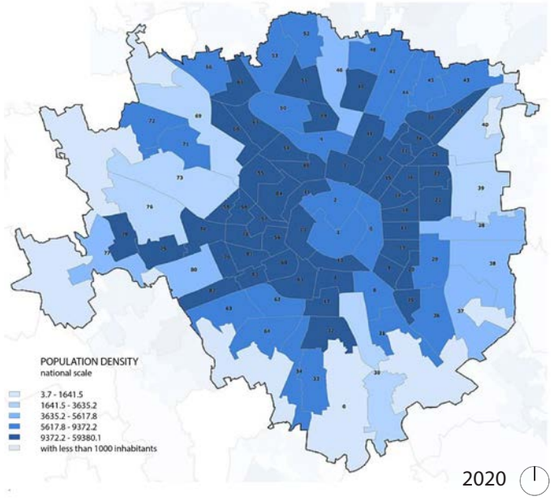
remained passable and residents remained dry, see figure 58. Curbs are not really friendly for wheeled slow traffic, however with strategically placed slopes, the accessibility is guaranteed (Rainproof Amsterdam, 2020). Canopies and deciduous trees are suitable for protection against precipitation, where they also can provide shade. However, for trees, during the winter they are less effective because they have lost their foliage (Lenzholzer, 2013).
As earlier said, cities can be cooled with green areas. However, there should be enough water available in the soil to support the evapotranspiration of the plants. In cities like Milan, it can be true that during heat waves there is not enough water, so it is important that sufficient irrigation is provided (Lenzholzer, 2013). Water is also an interesting element to combine with playing activities, like sprinklers or stepping stones, as shown in figure 57.

12.2.5 Effect of air quality on appropriation
The presence of green in an urban environment is of high importance for air quality. Green absorbs pollutants and creates oxygen for people. However, for the design of the urban microclimate, the designers should know what kinds of green they can place at certain spaces. According to Brown (2010), some trees contribute to air pollution in an urban environment. Big offenders are trees like poplars and willows while oaks and maples are less offending, but generally, the presence of green improves the air quality. However, street trees should not be placed too close together, where they can form a roof, or green tunnel, where pollutants get stuck, see figure 59. There is not enough ventilation and therefore it creates an unhealthy environment for people walking alongside the street (Lenzholzer, 2013). In general, it is desired for places for staying and pedestrians routes to be placed at a distance from busy roads, because air pollutants gather at these places. To create pleasant walkability it is desired to place walking routes along important streets at the downwind side of the street. At this side, clean air comes into the canyon so air pollution is lowest at this side.

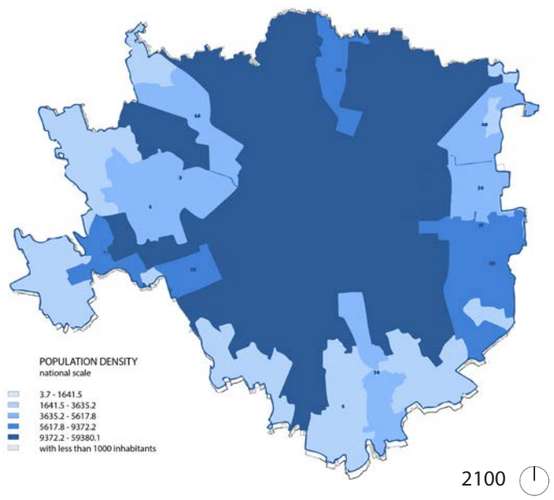
12.2.6 Effect of noise on appropriation
For appropriation of urban outdoor space it is important to hear music, people talking and have conversations with other people. The opportunity for a hearing is really valuable for the general ambience and physical and psychological well-being (Gehl, 2011). In busy streets it is almost impossible to have a nice conversation, so probably the appropriation for example sitting will be very low here. The border background noise for a normal conversation is possibly around 60 decibels. Above these amounts of decibels, it is really difficult to have a conversation (Gel, 2011). If we take walkability as the primary way of appropriation it is very important to have the ability to hear music, people talking and walking, because it makes the walk interesting and therefore enriching (Gehl, 2011). Squares and green areas are very suitable for places for staying because when they are placed at a distance from loud traffic they can create low noise levels in a city, which is really appreciated by people, see figure 60.

12.3 Conclusion
Urban microclimate has many different effects on the appropriation of urban outdoor spaces. Urban designers should aim for solutions that improve the urban microclimate on the one hand and the liveability on the other and there are many ways to do that. First of all knowledge about the microclimatic conditions of the area is needed and the behaviour of people according to those conditions. With that knowledge designers can create pleasant conditions in the urban outdoor space and the users can appropriate it in their way. Greenery, for example, has a lot of advantages for appropriation and microclimate. However, it is not so much about creating more green, it is more about creating effective green. Therefore a strong analysis of the site is needed and designers can create adaptable and flexible solutions for the problems and opportunities.

14 SITE ANALYSIS



2020



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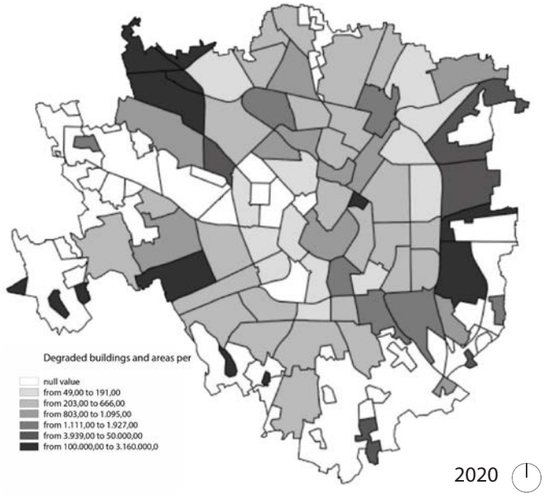
Density
Milan is one of the most dense cities in Italy. In Milan there are more than 7.500 people/sqkm living in the city. While the city center has a high building density, the neighbourhoods around the old city center can be very dense regarding population. The population in Milan is growing in the future. The amount of 7.500 people/sqkm living in the city will constantly grow. The densification probably will take place in every area of the city, however, neighbourhoods close to the city center will get very dense. These are areas with a good transportation system and lower prices than the city center. In these neighbourhoods the challenge is to make sustainable development and increase the density at the same time.



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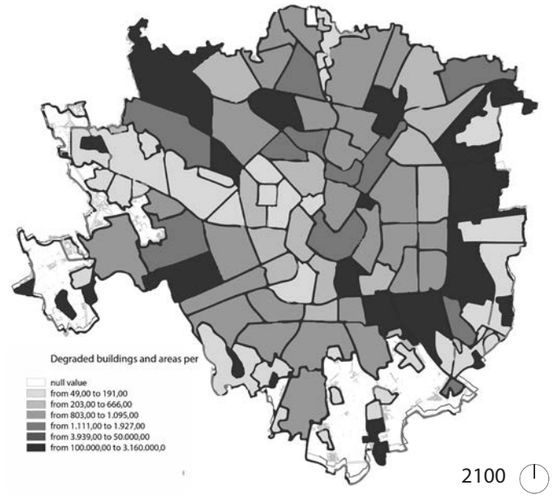

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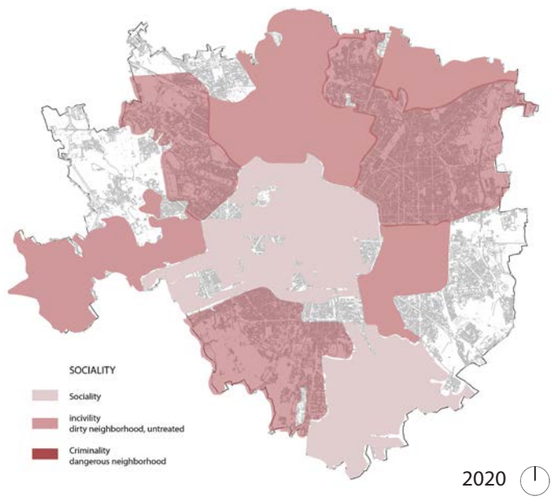
Degraded buildings and areas
Milan has quite some degraded buildings and areas. Most of them are located in the most peripheral areas of Milan. The most exemplary examples of degraded areas are the abandoned rail tracks across the city. With the challenge of densification these degraded areas are of high importance. These areas are well located in the city and have most of the time a lot of space available. Therefore there are already plans to transform these terminals into work-living areas. Looking into the future, city planners should look at the peripheral areas of the city, because these areas have multiple challenges to make.



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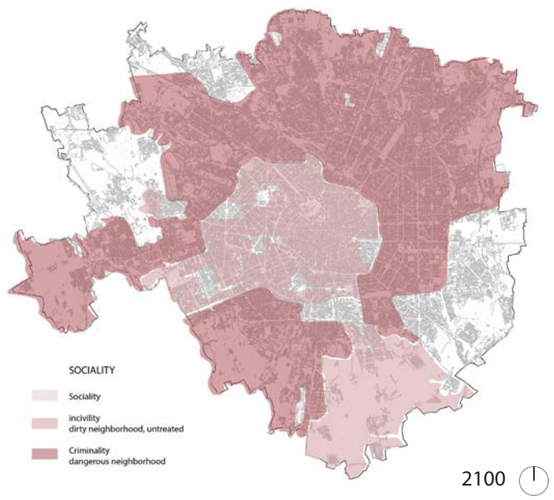

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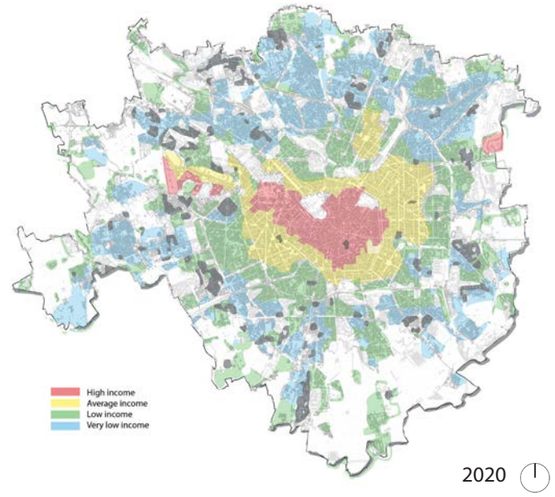
Sociality
Regarding the social aspects of the neighbourhoods in Milan the map shows that everything is good in the city center. In neighbourhoods further away from the center more problems occur. Neighbourhoods are less safe, maintenance of the neighbourhood is of low quality and people feel less concerned with their neighbourhood. On the one hand society is becoming more individual and on the other hand more community initiatives are upcoming. These trends have different influences on the social sustainability of the neighbourhood.



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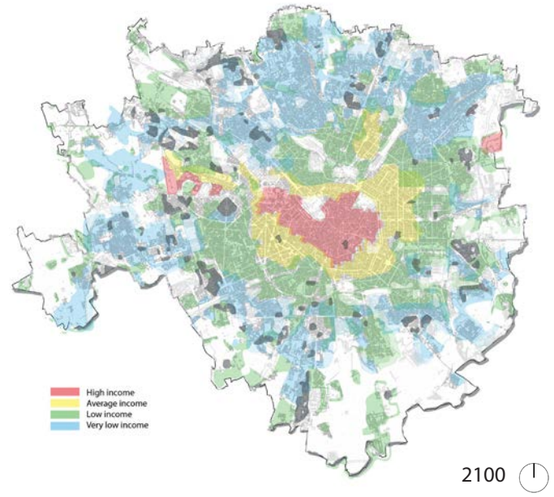

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Income
In Milan there is a growing social inequality which has influences on the liveability in the city. The city center is becoming more and more exclusive for the rich people, where prices are way too high for other people. At the same time there is a growing amount of homeless people. These people live on the street which affects the safety and liveability of public spaces. In peripheral areas the income is low which belongs to a certain type of people. These people have other needs and city planners should take this into account.

MILAN 2020

Factsheet population and society

Milan is the capital of Lombardy and the most important city in northern Italy. Regarding population numbers Milan is the second city of Italy, after Rome. However, Milan is the financial centre of the country and the most prosperous, industrial and commercial city of Italy. Because of its economic importance for the country Milan always attracted people, businesses and industries. Therefore Milan is a growing city, while the rest of Italy is shrinking (Lecco & Foot, 2019).

Population

3.250.315

1.378.689

Migration was always an important issue for Milan. After WWII there was a huge migration from people from the south of Italy. Since the 1970's there has been a lot of migration from outside Italy. Where it first were people from the african continent, nowadays it is mostly from eastern Europe (Lecco & Foot, 2019).

Total migration balance
+21.321

Migratory balance with foreign countries
+14.127

Population density
7.589 inhabitants / sqkm

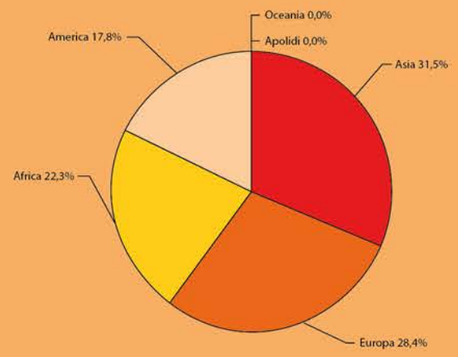
Foreigners % of population
14,5%

Society

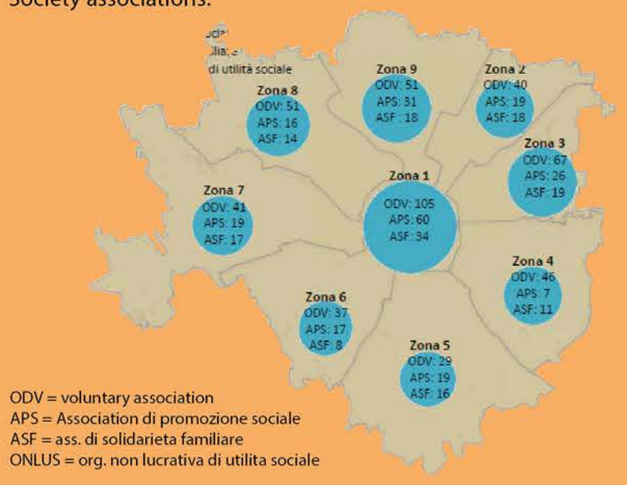
In Milan there is a social inequality. There is a small amount of people that are earning a lot of money in the business industries, while there is a big group of people where the salary is not very high. Moreover there are neighbourhoods outside the city centre which are not very safe and there are a lot of crime issues.

Average salary:
€34.302

Crime:
160.884 issues (2012)

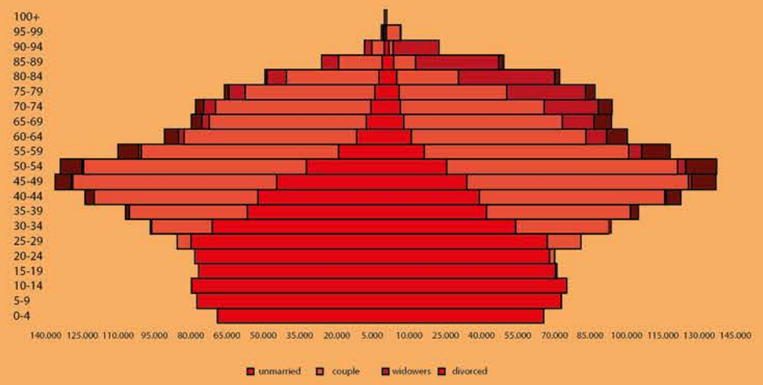


Society associations:



ODV = voluntary association
APS = Association di promozione sociale
ASF = ass. di solidarieta familiare
ONLUS = org. non lucrativa di utilita sociale

Residents per age
0-14 years: 13,5 %
15-64 years: 63,9 %
65+ years: 22,6 %



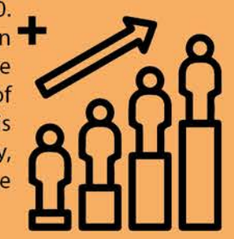
MILAN 2100

Factsheet population and society

This factsheet will show the trends towards 2100 that will have an influence on the appropriation of urban outdoor space in Milan. Population will keep growing and society will change. Milan is the biggest city of Italy, before Rome. Milan is the financial centre of the country and the most prosperous, industrial and commercial city of Italy.

Population +

Population is growing towards 2100. This is caused by a growing migration and immigration. Because of the strong economy and industry of Milan it will attract more people. This will have consequences for liveability, because people have to share the outdoor spaces with more people.



Trends:
Migration will increase, Milan will attract more Italians

Immigration will increase, Milan will attract more foreigners

Increase of population lead to decrease of quality of public spaces.

Society -

Society is changing towards 2100. It is hard to say how people will live in Milan by 2100, but from some trends we can make assumptions on the effect on appropriation of urban outdoor space.

Trends:
Society is becoming more individual. This decreases the feeling of responsibility of public space and therefore will lead to a decrease in appropriation of public space.

A growing social inequality leads to a decrease of appropriation of public space.

Growing demand for private security leads to a growth of privately owned space for public use. It is a way to appropriate the urban outdoor space, however usually it is closed to the public.

More community initiatives are upcoming. Community feeling is improving and this has a positive influence on the appropriation of public space.

Urban outdoor space -

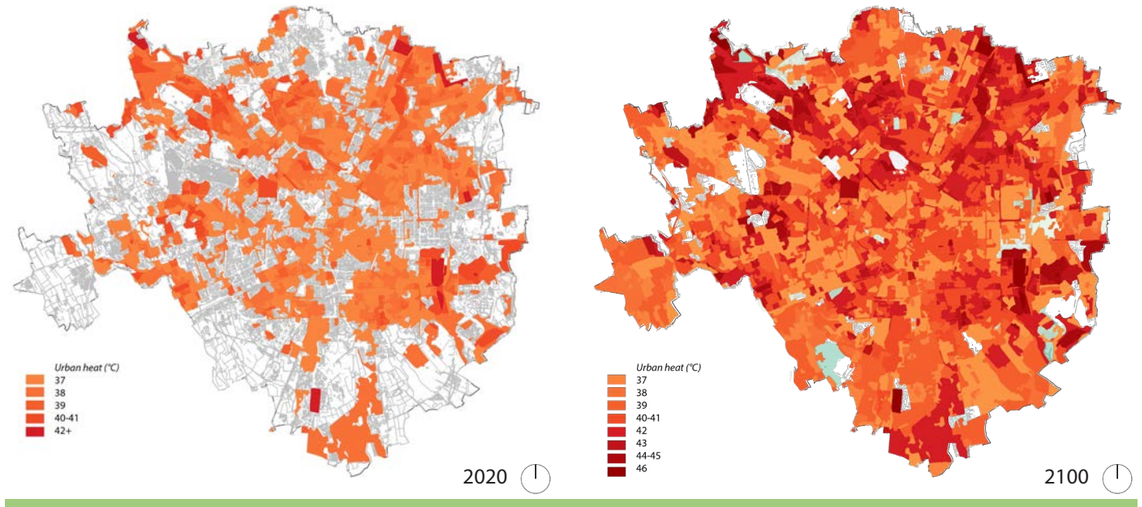
Urban outdoor spaces are constantly changing over time. In the modern time there was an increase in car use and a loss of quality of public spaces. Towards 2100 there was more and more attention given to urban outdoor space and their users.

Trends:
Widen car lanes and narrow sidewalks lead to decrease of appropriation of public space.

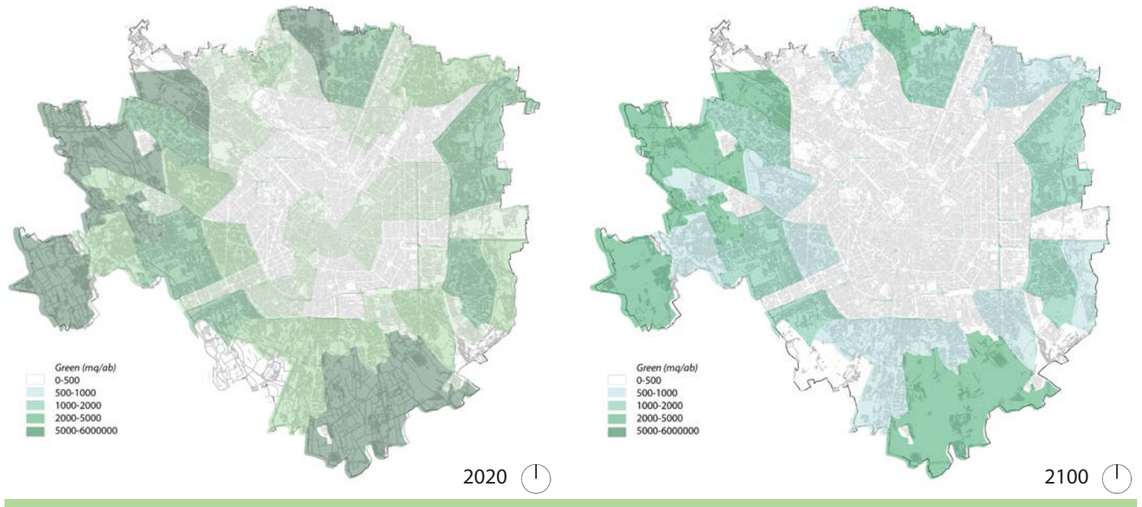
Removal of trees lead to decrease of appropriation of public space.

Increase of paved surfaces lead to decrease of appropriation of public space

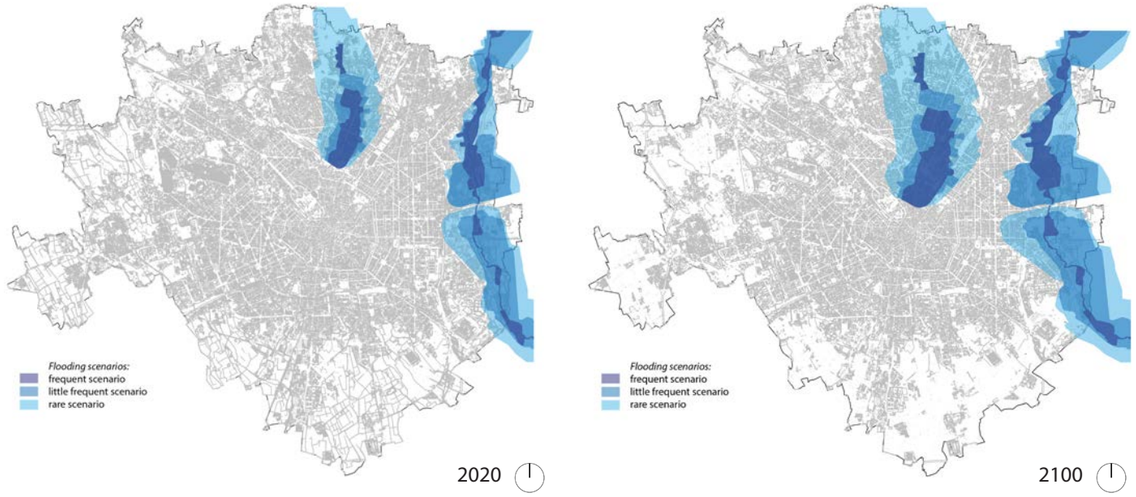
14 SITE ANALYSIS



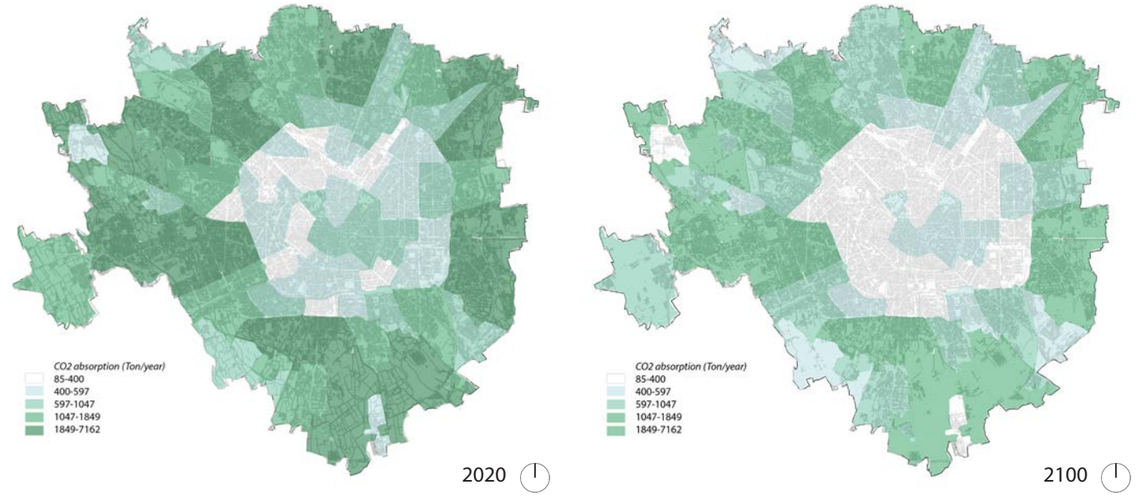
Temperature
As a result of the high amount of people, activities and buildings the temperature in the city can be very high. This map shows the urban heat in the city. High temperatures are all spread over the city, however the map shows that in general, the further away from the city centre, the lower the temperatures. The temperature is quite higher in the city centre than at the borders of the city. This is partly caused by the amount of green in the city centre, which we can see in the figures at the next page. High temperatures can be found along large infrastructural sites or at important transportation hubs like train stations or large distribution centers.



Green
As earlier mentioned, the high temperatures in the city are partly caused by the low amount of green in the city. This is something that can be seen in this map. This map shows a low amount of green in the city centre of Milan. In the areas around the city border the amount of green is higher, because these areas are less dense than the city center. The municipality already has plans to make the city more green, like planting three million trees before 2030 (La Republica, 2019) or large parks at abandoned train tracks, the scali projects.



Flooding
The map of flood risk also needs some elaboration. It is clear that the highest risk for flooding is located around the two rivers: Po and Seveso. The more close to the river the more frequent flooding will occur. Especially the flood risk area around the Seveso river can have enormous impacts. This is a very dense build area, as the map of density already showed, where the area around the Po river has more green areas around it. Therefore it is easier at this spot to make some space for the river to make it resilient in the future. In high dense areas solutions should be created to deal with future precipitation events.



CO2 absorption
The CO2 absorption has a strong relation with the amount of green in the city. It is known that trees absorb CO2 and therefore the air quality gets better. Also in this map it is clear that where there is a low amount of green there is a low amount of CO2 absorption of Milan. So around the city centre the absorption is way less than at areas further away from the city centre, with some exceptions like Parco Sempione. It is known that there is a lot of traffic in Milan, so it is important to have elements that absorb the emissions.

MILAN 2020

Factsheet climate

The current climate of Milan can be described as really hot during the summer and cold during winter. Especially the hot summers are getting more and more problematic. Since 1950 the climate has already changed a lot, where temperature increased by 1,4°C. More frequently heavy precipitation events occur which have led the last decades to multiple floods in the city.

Air quality **6 µg/m3**

The O3 amount in the air is 6 µg/m3. The northern are in Itlay is one of the worst aeras in Europe regarding air quality. There is a lot of industry in the region and the high amount of cars in the city are causing problems.

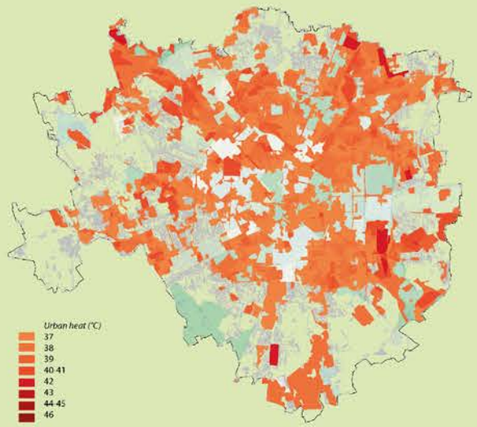
Precipitation

Heavy precipitation events have lead the last decades to multiple floods in Milan. Sewer systems can't handle the amount of rain and rivers from the mountains are flooded more frequently.

818 mm

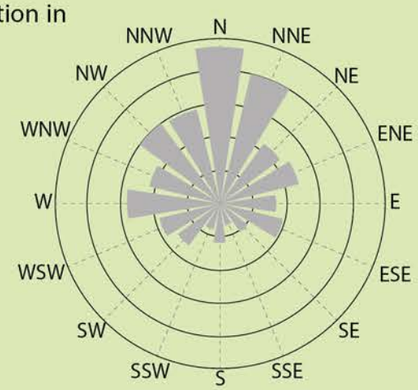
14,3 °C Temperature

During summer Milan has hot and dry summers. The air temperature is high and the humidity is low. These high temperatures are causing serious problems, for example for the health of people. During winter it can be very cold in Milan.



Wind **2,1 m/s**

The prevailing wind direction of Milan is north/north-east. However during summer, most of the wind from the north is blocked by the mountains of the Alps. This prevents ventilation in the city.



Solar radiation **174 W/m2**

All the paved surfaces in the city are causing high temperatures because the radiation on the dark surfaces will make it very hot. During summer shade is desired, while during the winter sitting in the sun is pleasant.

MILAN 2100

Factsheet climate

Predictions show that by 2050 Milan will have a climate like the current climate in Dallas, Texas. By 2100 this can even get worse towards the climate of Austin, Texas. The biggest difference that can be seen is the increase of temperature. The average temperature will increase, but more problematic will be the increase of temperature during the most warm months where there can be an increase of 7°C.

Air pollution -??%

It is difficult to say something about the future air pollution. Trends show different effects on the air quality. For example: O3 concentrations tends to increase. It has a strong relationship with precipitation. When it will rain more, there will be less poluted air.

Amount of air pollution:

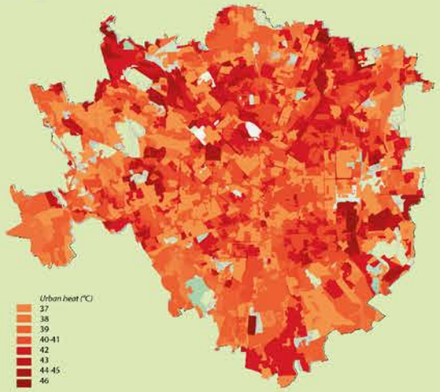
\+ ← Trends: Industry in the region will grow, industry will get cleaner

\- ← Car sharing will increase, so amount of cars en parking lots will decrease

\- ← Cars will get cleaner trough electric and hydrogen cars

18,5 °C (+4,2 °C) Temperature

The average temperature in 2100 will be 18,5°C where average maximum temperatures can reach 23,6 °C and average minimum 13,8°C. Overal this is an increase of more than 4,0 °C compared to 2020.



Trends: Urbanization is one of the main factors for climate change. Together with the loss of vegetation in the city this will lead to an increase of temperatures in the city.

Precipitation ++% Winter

-30% Summer

Heavy precipitation events are the new standard. Events with an amount of 30 litres per square meter per hour are already happening. This means that rain have lead the last decades to frequent flooding in Milan. On the other hand summers will be dryer and this can have significant effects for vegetation.

Trends: Higher temperatures lead to more evaporation. This can lead to more intense rainstorms. Intense rainstorms increase the risk of flooding. Much of the water runs of doing little to dampen soil and increases the risk of drought.

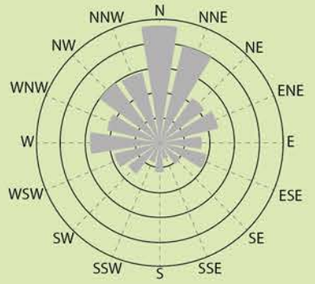
Solar radiation 184 W/m2 (+10 W/m2)

The solar radiation will slighty increase with 5,7%. This has a direct effect on heating the earth and atmosphere and indirectly by changing the cloud forming process.

Trends: Human activities causes a decrease in thickness of the ozone layer. This lead to an increase in solar radiation.

Wind 2,1 m/s (+0,0 m/s)

Wind patterns don't change a lot. It can be seen that the wind speed does not fluctuate a lot over time. However, it can be seen that there are more frequent heavy wind events (storms). Wind speed reaches 100 km/h or more during these heavy storms.



Trends: Temperature differences lead to air flows which lead to strong gusts of wind. Climate change causes more heavy wind events.

15 SITE SELECTION

The main objective of the site analysis is to define a project location where I as an urban designer can show the spatial translation of problems and solutions regarding appropriation and urban microclimate. By overlaying the different maps and previously acquired knowledge the most vulnerable and interesting parts of the city can be defined. Looking at the maps of liveability multiple problem areas in the northern part of Milan occur. This part of the city is known as an already dense area and this will get denser in the future. Low-rise buildings are replaced for high-rise buildings and this will have consequences in the future. In the northern part are some degraded areas where there is space for new development. These areas are very interesting for applying the ideas for urban microclimate and appropriation. Criminality is found in these areas and public security can be very low. For the climate problems in the city, the northern part is also interesting. The northern part has a high risk of flooding, mainly because of the Seveso river combined with heavy precipitation events. The city should adapt to these areas to avoid multiple floods in the future. Moreover, this area has high temperatures which are caused by the urban heat island. The high amount of paved surfaces, on streets and buildings, is causing these high temperatures, especially during summer. The northern part of Milan is known as a very high-density area with a low amount of green and little CO2 absorption because it is difficult to find space to make green areas and the municipality did not focus on the adaptation to the future climate conditions. In the next part, the northern area of Milan will be analysed further to get a clear understanding of the area and a more focused analysis regarding urban microclimate and (temporary) appropriation.

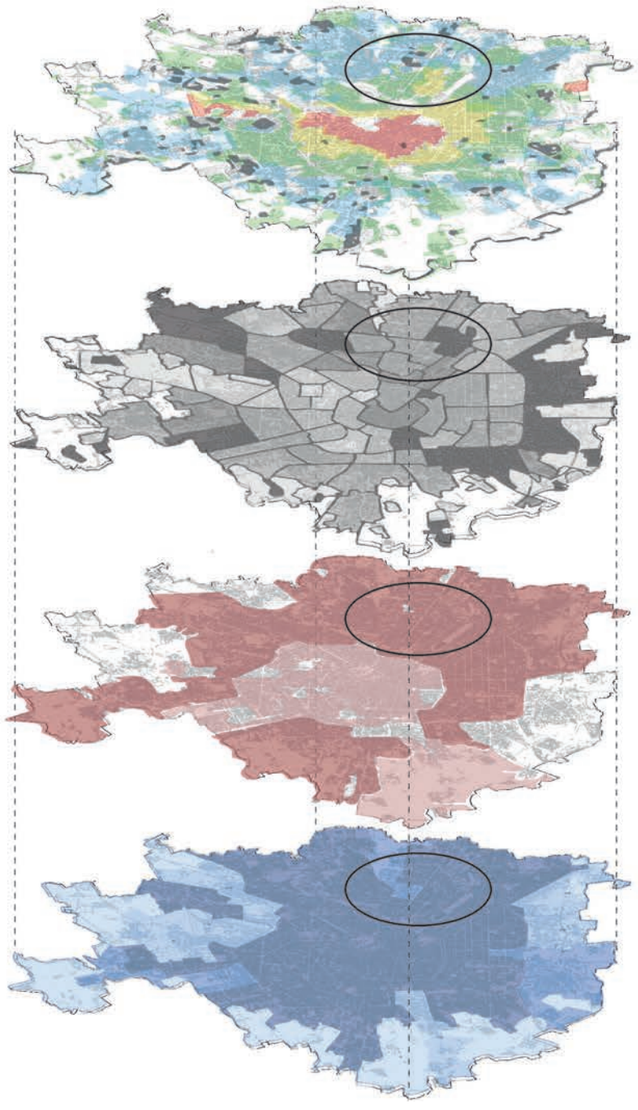


Figure 61 Overlay of social maps and site selection

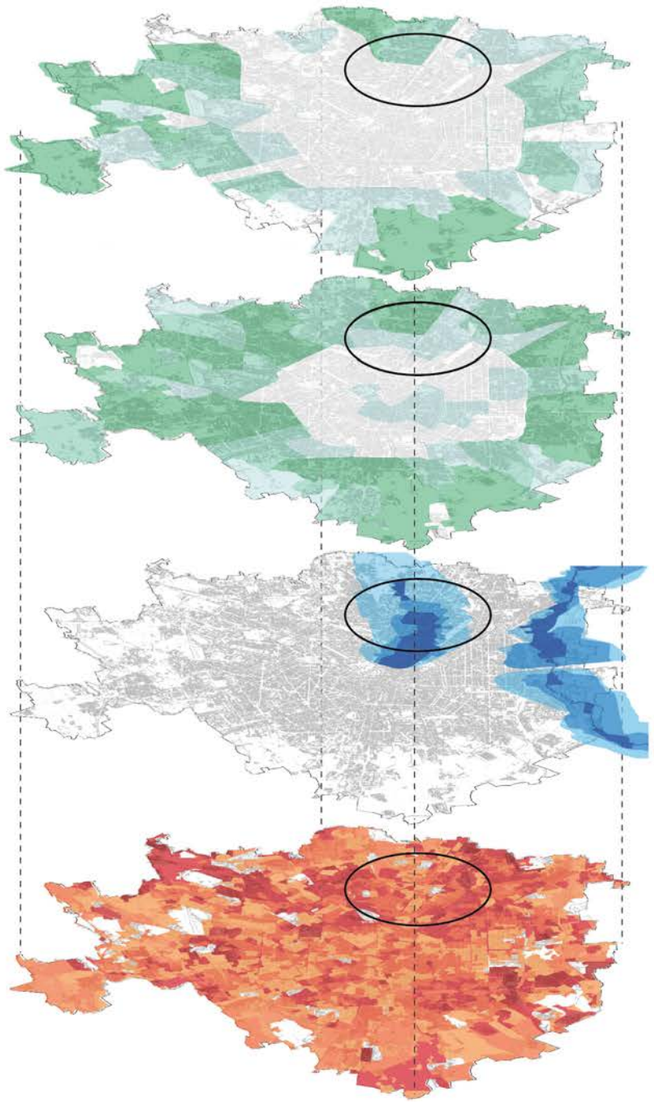
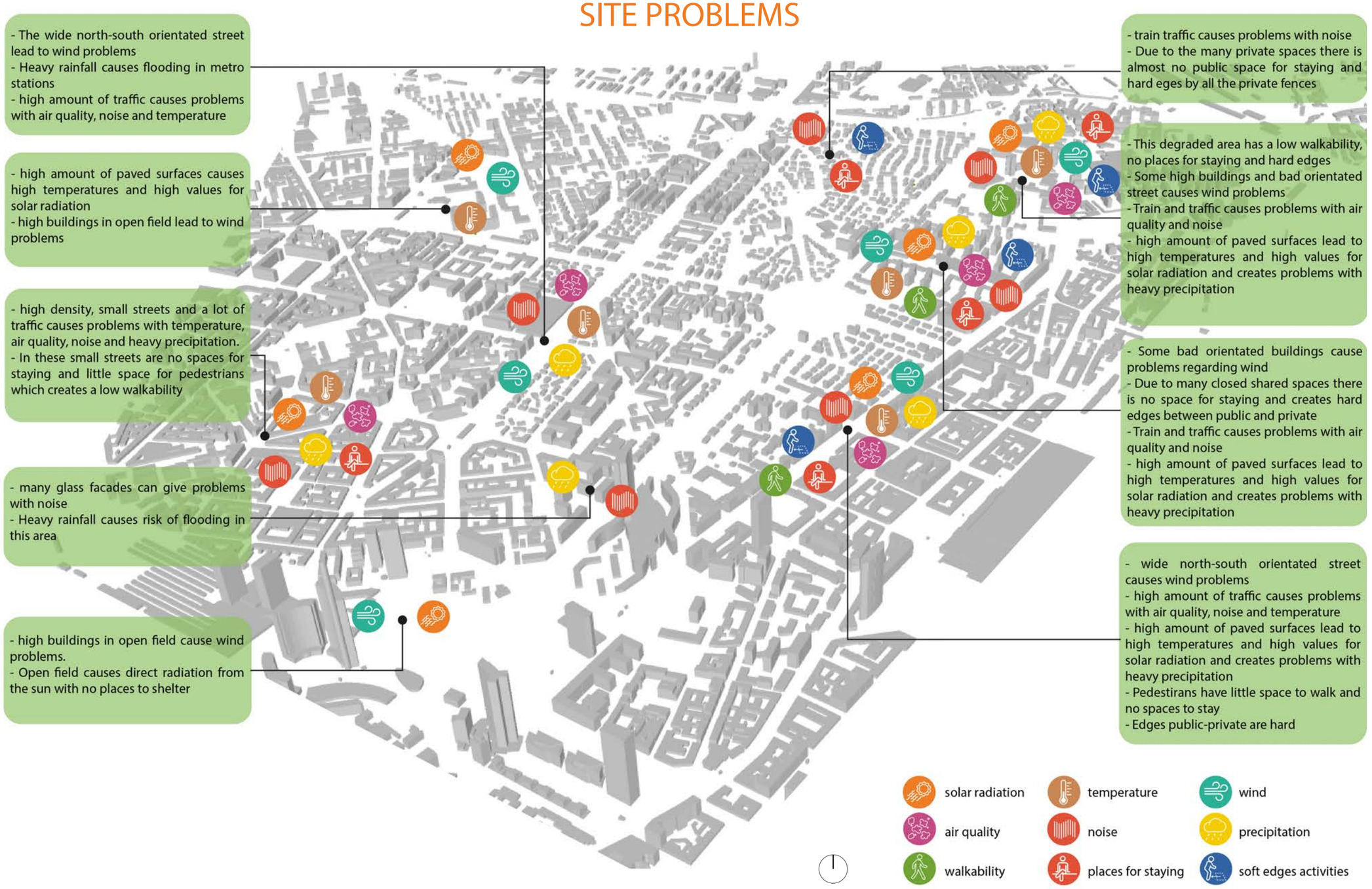


Figure 62 Overlay of environmental maps and site selection

SITE PROBLEMS



SITE OPPORTUNITIES

- cars get cleaner, so this will lead to cleaner air
- wide street profile provide opportunity for walkability, more green

- low building density gives opportunity for redesign of outdoor spaces and densification
- many paved surfaces could be transformed in more porous surfaces (parking lots)

- with such little space in outdoor spaces the walkability should be at least well designed
- if there is little space in the street, buildings can do a lot, for example facade greening

- green recreational areas should get an upgrade in terms of opportunities for staying
- hard edges can be transformed into soft edges

- New development will attract new people and businesses
- New technologies gives opportunities for the climate factors in the area.
- Park provides opportunity for recreation

- the many private properties gives the opportunity to do a lot of things on the smallest scale
- bottom-up initiatives will work here, top-down approach not

- school gives opportunity to add educational function about climate (climate garden e.g.)
- underused spaces give opportunity for new development
- low density provides opportunity for redesign of urban structure
- create ideas about energy-neutral development, water self-sufficient etc.

- Flat roofs gives opportunity to rethink their function
- right orientation should be used in redevelopment
- Monofunctional buildings gives opportunity to add something new
- remove of parking lots provide opportunity for walkability, places for staying, more green in street

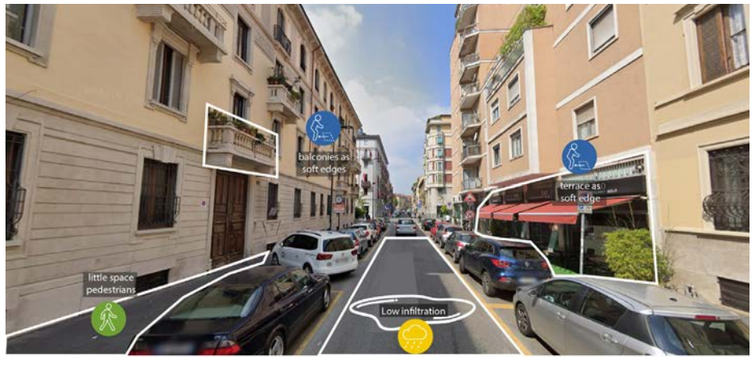
- wide street profile provide opportunity for walkability, more green
- Lot of space occupied by cars, so by the use of less cars the street profile can be redesigned.
- many paved surfaces could be transformed in more porous surfaces
- commercial functions on ground floor gives opportunity for appropriation of outdoor spaces

solar radiation
temperature
wind
air quality
noise
precipitation
walkability
places for staying
edge zone activities

16 NORTH MILAN ANALYSIS

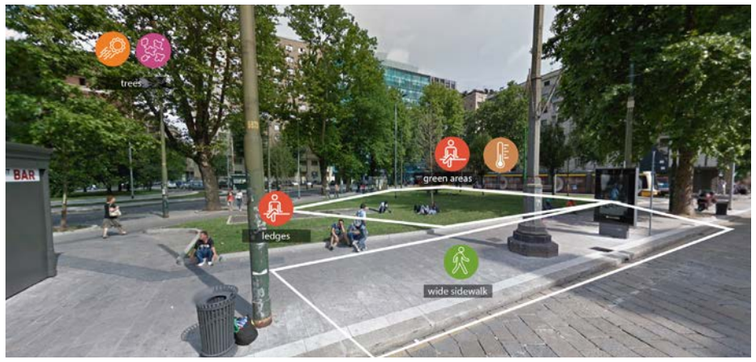
Now a project area is defined it is clear that the area is still quite large. To get in the end a design that shows interventions on the smallest scale there is again an analysis needed. This analysis will focus on the problems and opportunities for (temporary) appropriation and urban microclimate. First of all, a problem- and opportunity map will show which places could be interesting for the design strategies, after which analysis is done by a set of pictures of the site. It shows that North Milan has some problem areas where different challenges occur regarding appropriation and microclimate. However, there are also already well-functioning areas like Porta Nuova, a newer business district with some green areas like the library of trees. In dense areas like North Milan, it can be seen how much people appreciate and use the urban outdoor spaces that are available in the area. Green spaces with trees give the opportunity to stay in the sun or shadow, according to the preferences of people. For each site picture, some problems and opportunities are highlighted and a short elaboration will explain why these are problems and in which ways it can be used as an opportunity. The same icons are used to show to which topic of appropriation and urban microclimate the problems and opportunities belong to. Within the vision, which will be shown in the next chapter, three different key projects are chosen and this will be elaborated later.

This area, called Isola, is very dense and characterized by small streets. There is not much space: narrow sidewalks and very often restaurants claim a small piece of the sidewalk. Regarding urban microclimate, all the paved surfaces are causing high temperatures and it is difficult for precipitation to infiltrate.



This area is characterized by a high amount of cars and corresponding parking lots. These cause high amounts of air pollution, high temperatures, no protection against solar radiation and low infiltration of precipitation. The freestanding tall buildings can create high wind speeds at ground level, which causes wind nuisance to people.

Giardino Aldo Protti, a linear park above the train tracks. Orientated in line with the prevailing wind it can cause wind nuisance, however, the big trees give some protection. Moreover, the trees are causing shade, which is pleasant during the hot summers. The park gives many opportunities for appropriation, with benches and playgrounds.



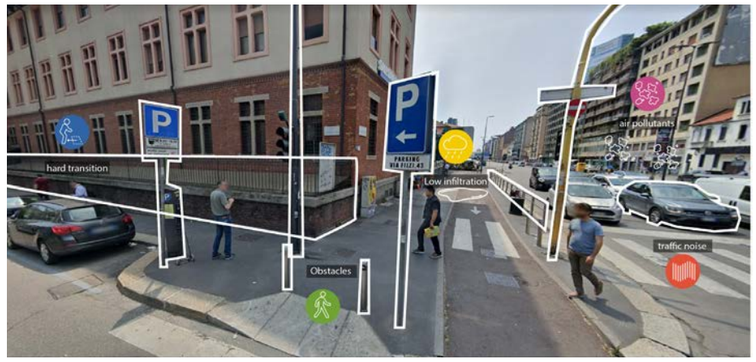
This place can be seen as an example of a good functioning area. The ledge around the grass area gives the opportunity to sit on and the wide sidewalks offer good walkability. The grass and trees have multiple advantages, like offering places to stay, better air quality and lower temperatures.

Villaggio Dei Giornalisti contains mostly residential villas and one of the most exclusive areas of the city. Due to all the privatized plots, edges are very hard, however with all the green the edge is made softer. The high amount of green is good for air quality, noise and precipitation. The wide sidewalks offer good walkability.

The ground floor is not very active and created a hard edge between public and private. It is separated by a fence and the sidewalk is narrow which leads to challenges for appropriation. The hIgh amount of paved surfaces gives problems with temperature and infiltration. The high amount of space for cars is causing problems with temperature and air quality.

16 NORTH MILAN ANALYSIS

Regarding appropriation, a lot of things are wrong in this figure. For pleasant walkability there should not be any obstacles on pedestrian routes. We can see over here a lot of traffic signs and -lights on the sidewalk. Moreover, we see a hard transition on the ground level of the building which makes it not a lively environment over here.



Elevated pathways are not pleasant for the walkability of chaired people. The parking lot gives multiple problems in this area. High temperatures, high radiation, low infiltration and a high amount of air pollution. The transition of the ground level is very hard with no activity on the ground floor and separation by a fence.

This is a place where a mix between challenges and opportunities can be seen. Pedestrians have the priority over here, as can be seen by wide sidewalks, safe crossing and a park in the back. Some green areas offer a good infiltration for precipitation, however, still, hard edges can be found and trees can give protection against solar radiation.

Parco Biblioteca Degli Alberi Milano is a large, modern park located next to Porta Nuova and Bosco Verticale. In this open space the wind can create a nuisance, however where people can stay, like a playground, the area is protected by trees. Infiltration is not a problem here with all the green surfaces and elements.

Walkability over here is poor. There are a lot of obstacles like traffic signs and the stairs towards the metro owns a lot of space. Also, a gap in the row of buildings can be seen. This gap can give problems regarding wind. All the paved surfaces lead to high temperatures and a low amount of infiltration of precipitation.

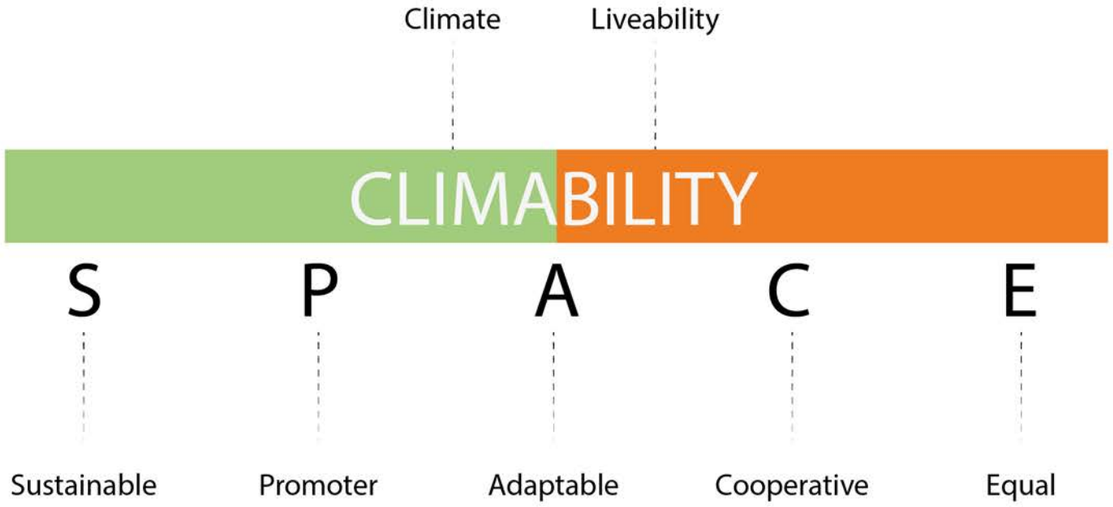
Pedestrian islands are not friendly for pleasant walkability. Pedestrians have to wait multiple times before they can cross the street. The high buildings in the open field give problems with high wind speeds. Also over here, all the paved areas give problems with temperature, radiation and infiltration of precipitation.

In this area, there are no places for staying. One reason for this is that the space between the buildings is all privatized through fences around. Pedestrians have little space to walk because cars appropriate a lot of space. The orientation of most of the buildings leads to high winds speeds because it is in line with the main wind direction.

This is a very degraded area with no quality of life on the streets. The only green that there is, is of a very low quality. There are a lot of paved surfaces causing high temperatures, high solar radiation and low amount of infiltration of precipitation. The train tracks in the back lead to high noise levels in the whole area.

PART 3 VISION

17 GOALS & OBJECTIVES



Sustainable:
- Aim for a sustainable development of cities towards the future. The development should be visible on different scale levels; from city to street.
- Promoting environmental sustainability by creating a pleasant urban microclimate resulting in enhancing quality of life in urban outdoor spaces.
- Promoting social sustainability by strengthening the (temporary) appropriation resulting in enhancing quality of life in urban outdoor spaces.

Promoter:
- Promote sustainable urban development and show solutions that contribute to this development
- Be a promoter of the new "green" architecture that enhance the qualities of urban microclimate and appropriation.

Adaptable:
- By focussing on the design of urban microclimate climate adaptive solutions should be developed to adapt to the future climate conditions.
- Create flexible and adaptable solutions in the urban outdoor space to support appropriation towards the future

Cooperative:
- Show the cooperation between architecture, urban- and landscape design with the new development and the transformation of the area
- Create cooperation between stakeholders: initiatives from local residents and big developments from the municipality

Equal:
- Find a balance between urban growth needs, climate adaptation and (temporary) appropriation of urban outdoor spaces
- Achieve a balance between human needs on the small scale and the cities needs on the large scale

18 VISION 2100

VISION STATEMENT:

IN THE YEAR 2100 MILAN WILL BE ENVIRONMENTAL- AND SOCIAL SUSTAINABLE BY PROVIDING CLIMATE ADAPTIVE SOLUTIONS FOCUSSING ON THE URBAN MICROCLIMATE THAT STIMULATE THE (TEMPORARY) APPROPRIATION OF URBAN OUTDOOR SPACES.

To create an environmental- and social sustainability Milan towards 2100 the interventions for (temporary) appropriation and urban microclimate should strengthen each other. By combining the positive effects of the interventions urban designers can create the conditions for quality of life regarding a pleasant urban microclimate and (temporary) appropriation. Climate conditions are well managed to ensure that people come outside, appropriate the urban outdoor spaces where they can interact with each other and in this way enhance social life on the streets. Managing the climate conditions should be seen as adapting urban outdoor spaces that provide choice to the users of the space. Milan should be the city that shows how to change from a very grey city with multiple climate and liveability problems to a sustainable city, environmental and social. Milan can be the promoter of sustainable urban development by showing the relations between urban design and architecture, where new "green" architecture and urban design projects are shown. Moreover, Milan should show how a city can adapt to changing conditions where mitigation alone is not the solution. By creating flexible interventions the spaces can adapt easily to future conditions to remain sustainable towards the future. This can only be achieved when cooperation is created. There should be cooperation between urban design and architecture, government and residents, planners/developers and residents. A sustainable city can only be created with the support of everybody involved. Urban designers can play an important role by showing interventions that translate the problems and opportunities into a design. Therefore interventions on different scale levels should be made where again the cooperation between stakeholders come into play. Small interventions can be created by residents, where all these small interventions can have a serious effect in the city. An additional benefit is that these small interventions can be created in a short time period, where large scale interventions are more focussed on the future. These large scale interventions require a lot of planning by the municipality but will have a big impact on the environment and social life.

The appropriation of urban outdoor spaces in North Milan is not fulfilling at the moment. Pedestrians are given a low priority, there are little staying opportunities and there is a hard boundary between the architecture and the urban outdoor spaces. By densifying the area in the future the urban outdoor spaces are pressured even more and with no attention given to its users the appropriation of urban outdoor spaces will decrease in the end. So to create a sustainable development the focus should also be at the social sustainability of the urban outdoor spaces. Therefore it is important to create comfortable walkability, pleasant places for staying and soft edges between public and private to incorporate the people in the area. Looking at the current situation and already planned developments the idea for North Milan is to create strong places for appropriation, mostly going from north to south. From the future development of Scalo Greco Breda towards Scalo Farini and Porta Nuova, it crosses some new projects like Gioia 22, Abitare in Maggiolina and three key projects that are chosen in this thesis where conditions are gonna be improved. From these strong projects, other directions can connect to this to spread the appropriation all over the area, see figure 63. With all the small scale interventions together a strong identity for appropriation can be created and a contribution given to a social sustainable development of Milan. Within the three key projects interventions for walkability, places for staying and soft edges are shown and elaborated. The projects will show how to create over time pleasant conditions for the appropriation of urban outdoor spaces.

Figure 63 Milan vision appropriation 2100

The urban microclimate in urban outdoor spaces in North Milan has some issues at the moment. High temperatures can be found during summer and because of heavy precipitation events, streets are flooded. This is mainly due to the high amount of hard surfaces on facades, roofs and street pavements. By densifying the area in the future, there will be more loss of green and the increasing activities will cause higher temperatures which lead to a decrease in the urban microclimate of outdoor spaces. To create a sustainable development the focus should also be on the environmental sustainability of places. Therefore it is important to create a pleasant urban microclimate with pleasant climate conditions regarding radiation, temperature, wind and precipitation. Air quality and noise should be considered as well. Looking at the current situation and already planned developments the idea is to create strong areas for urban microclimate gong from north to south. From the future development of Scalo Greco Bredo towards Scalo Farini and Porta Nuova, it crosses some new projects like Gioia 22, Abitare in Maggiolina and three key projects that are chosen in this thesis where conditions are gonna be improved. From these strong projects, other directions can connect to this to create a pleasant urban microclimate all over the area, see figure 64. With all the small scale interventions together a strong identity for urban microclimate can be created. At different locations, the focus for urban microclimate can differ, depending on the environment at those places. At some points, the focus will be on downsizing the noise levels and at other points, the focus will be more on decreasing the temperature. The projects will show spatial interventions that show the translation for urban microclimate to create over time pleasant conditions for urban outdoor spaces in Milan.

Figure 64 Milan vision microclimate 2100

18 VISION 2100

Figure 65 Milan vision 2100

Combining the two topics of appropriation and urban microclimate a strong basis for North Milan is created. The focus will be on creating a social- and environmentally sustainable development of the area. Interventions on different scale levels contribute to this and to show these interventions three key projects in the area are chosen. Three projects where multiple problems and opportunities occur are chosen because they have a high potential for showing the interventions for appropriation and urban microclimate, see figure 65.

1) Transformato Sondrio: a project of transformation. Through strategy, it will be shown what can be done in an existing situation.

2) Misto Maggiolina: a project of transformation and new development. By densifying through new development it is important that it relates to the existing structures.

3) Nuova Greco: a project of new development. In this case, the project shows how to optimize the design in relation to urban microclimate and (temporary) appropriation.

Rick Schoonderbeek • 4386272

PART 4 DESIGN STRATEGIES

DESIGN STRATEGIES

19 CLIMABILITY SOLUTIONS

CATEGORY	+	0	-
SOLAR RADIATION	The interventions have a positive effect. These will improve the thermal comfort with e.g. a decrease of the amount of W/m2, protection against direct radiation from the sun and opportunities to gain solar energy.	The interventions have not a significant effect, positive or negative. The situation will be kind of the same, so the same amount of W/m2 will appear and no improvement or decrease of protection against direct radiation.	The interventions have a negative effect. These will decrease the thermal comfort with e.g. an increase of the amount of W/m2, less opportunities to gain solar energy and more exposure to direct radiation.
TEMPERATURE	The interventions have a positive effect. These will lead to lower temperatures (°C). Urban heat island effects will decrease and some areas will be cooled due to the interventions.	The interventions have not a significant effect, positive or negative. The situation will be kind of the same, so the same temperatures (°C) will appear with the same urban heat island effects.	The interventions have a negative effect. These will lead to higher temperatures (°C) and urban heat island effects will increase.
WIND	The interventions have a positive effect. These will give protection against wind disturbane and high wind speeds (m/s). It gives protections against corner streams, frontal vortexes or can be used for cooling.	The interventions have not a significant effect, positive or negative. The situation will be kind of the same, so the same wind speeds will appear with the same problems of corner streams and frontal vortexes.	The interventions have a negative effect. These will give more problems regarding wind speeds (m/s), corner streams and frontal vortexes are created. The wind is not cooling the area.
PRECIPITATION	The interventions have a positive effect. These will give protection against heavy precipitation events. More water can be stored and re-used, water can easily infiltrate into the ground.	The interventions have not a significant effect, positive or negative. The situation will be kind of the same, so the same capacity of water storage is pressence, no improvement of infiltration of water.	The interventions have a negative effect. These will give more problems for heavy precipitation events. Less water can be stores, no re-use of water and more water on surfaces because bad infiltration.
AIR QUALITY	The interventions have a positive effect. The air quality is improved. This can be done by less pollutants in the area (ppm) or more absorption of the air pollutants.	The interventions have not a significant effect, positive or negative. The air quality is not improved nor decreased. Same amount of pollutants and same amount of absorption in the area.	The interventions have a negative effect. The air quality is decreased. There are more pollutants in the are (ppm) and there is less absorption of air pollutants.
NOISE	The interventions have a positive effect. The noise level is decreased. There is a lower amount of noise causers and more sound is absorpted in the area.	The interventions have not a significant effect, positive or negative. The noise level is not improved nor decreased. Same amount of noise causers and same amount of absorption in the area.	The interventions have a negative effect. The noise level is increased. There is a higher amount of noise causers and/or less sound is absorpted in the area.
WALKABILITY	The interventions have a positive effect. The walkability in the area is improved. Wider sidewalks, safe and frequently crossings, interesting routes etc.	The interventions have not a significant effect, positive or negative. The walkability is not improved nor decreased. Nothing is done to give pedestrians more space or higher/lower safety.	The interventions have a negative effect. The walkability in the area is decreased. Less space for pedestrians (smaller sidewalks), more unsafe crossings and a decrease in quality of routes.
PLACES TO STAY	The interventions have a positive effect. The amount of choice for places to stay is improved. More benches, elevations to sit on, choice to sit in the sun/shadow, alone/in groups etc.	The interventions have not a significant effect, positive or negative. The amount of choice for places to stay is not improved nor decreased. Same amount of benches and choice where to sit.	The interventions have a negative effect. The amount of choice for places to stay is decreased. Less benches, elevations to sit ons, choice to sit in the sun/shadow, alone/in groups etc.
TRANSITION SPACES	The interventions have a positive effect. The opportunity to appropriate the transition spaces is improved. More space to create soft edges between public and private.	The interventions have not a significant effect, positive or negative. The opportunity to appropriate the transition spaces is not improved nor decreased. Same space to create soft edges between public and private.	The interventions have a negative effect. The opportunities to appropriate the transition spaces is decreased. Less space to create soft edges between public and private.

From the guidelines from literature, a design toolkit is made where interventions are shown and assessed on the different categories for appropriation and urban microclimate. The interventions can happen at different scale levels, from district level to materialization. Most important is to show the interventions that combine the positive effects of appropriation and urban microclimate and to show the relations at different scale levels. Moreover, it is clear that buildings, and therefore architecture, play an important role in designing a better urban microclimate and stimulate the appropriation of urban outdoor spaces. That's what this studio makes the perfect fit; it shows the relations of urban design and architecture and ways of how they can make each other stronger. Each intervention in the toolkit is assessed on the different elements of appropriation and urban microclimate to give an idea of what the effects of the intervention would be. In the table on the left, there is made a distinction between three categories: positive effects, no significant effects, and negative effects. In short, there are given some examples of how the intervention could have a positive or negative effect. In the next part, the most important interventions for the combination of appropriation and urban microclimate are shown on different scale levels.

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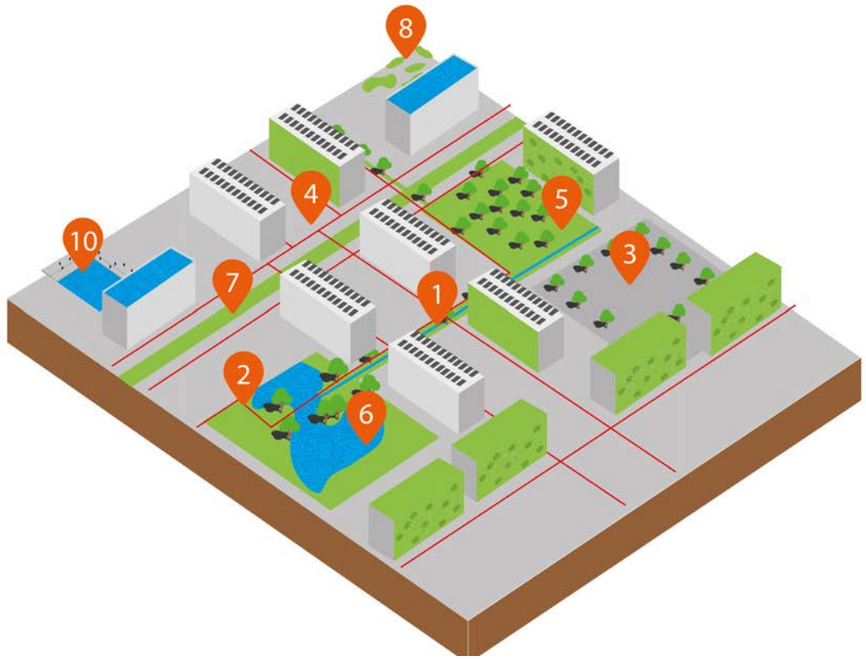
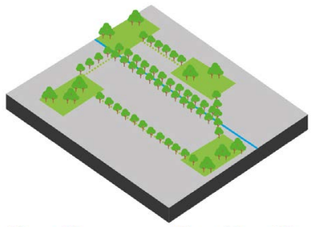
19 CLIMABILITY SOLUTIONS



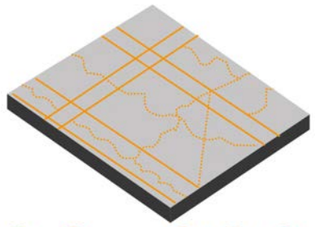
Large scale levels like the district scale are probably not the first spatial scale you think of talking about urban microclimate. However, to create sustainable development planning and interventions on different scale levels is needed. Not only the small scale is important for appropriation and urban microclimate. Planning on a large scale can have a great influence on smaller scale levels. On the district scale, the most important strategy is to create networks in the city. These can be networks for streets, water, green, internet, sewer systems, etc. Regarding appropriation and urban microclimate, the networks of green, blue, and squares are very important. To create pleasant walkability, planners should think of pedestrian routes through the city. A good example of how decisions on a large scale can have a major impact on urban microclimate is the orientation of streets and buildings. The orientation decides how solar radiation comes into the canyon and how the wind is perceived at the smallest scale. These large scale interventions/ strategies require a lot of planning and time, where most of the time the municipality should take the initiative.

1 Green/blue network



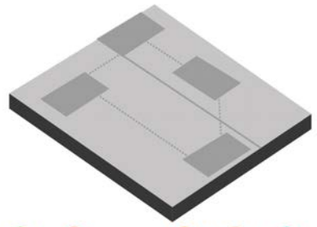
General information:
A green and blue network should be created troughout the city. The creation of these areas at regular intervals will have multiple advantages regarding appropriation and urban microclimate.

2 Winding Pedestrian network



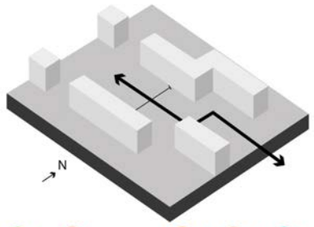
General information:
With the switch of prioritsing pedestrians instead of cars urban outdoor spaces are transformed into pedestirans friendly areas. Slow traffic will have the priority and the space for cars is downsized.

3 Square network



General information:
A network of squares should be created throughout the city. The creation of these areas at regular intervals will have multiple advantages regarding appropriation and urban microclimate.

4 Street orientation



General information:
Urban structures are important within a city. The street orientation has a big influence on the microclimate regarding wind and solar radiation and on appropriation regarding the walkability.

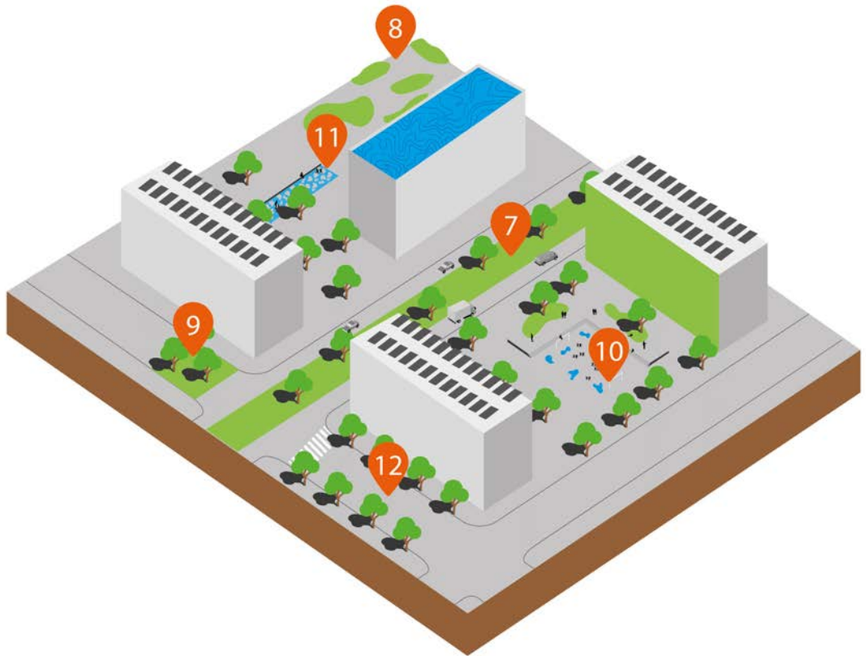
5 Urban forest

General information:
Urban forests have many functions within a city. They provide recreational spaces and have multiple advantages regarding urban microclimate. It is important to have larger green structures in a city like forests and parks.

6 Urban wetland

General information:
There are different kinds of wetlands within a city. Large water-rich natural areas around rivers outside the city or smaller urban wetlands like a rainwater garden. It differs from an urban forest, because of the high presence of water in the area.

19 CLIMABILITY SOLUTIONS



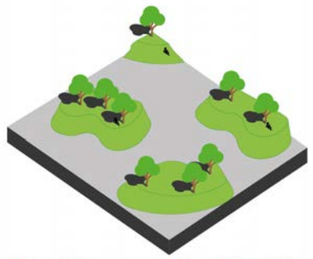
On the scale level of the neighbourhood, smaller interventions can be found that do not necessarily form a network through the whole district but are bigger interventions than you can find in the street. Decisions that are made for smaller intervention can have a big impact on a larger scale and it is important to see what kind of planning is needed for the interventions. Let's take for example the street park. One street park is an intervention on street level, however, it has implications on the whole neighbourhood.

The whole traffic system in the neighbourhood is changing and therefore it is an intervention at the neighbourhood level. Urban designers should think of the consequences of the intervention on the whole neighbourhood. Smart collaboration between the municipality, neighbourhood associations and residents is needed to create sustainable solutions for the neighbourhood. Therefore it depends on who should take the lead by creating such interventions.

7 Eco/social medians

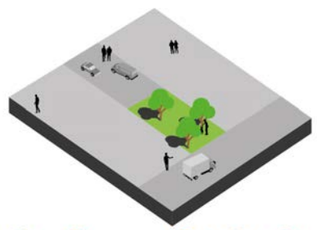
General information:
Eco/social medians can be created of different sizes. When there is enough width it could be linear parks, otherwise it can be used for traffic calming.

8 green hills



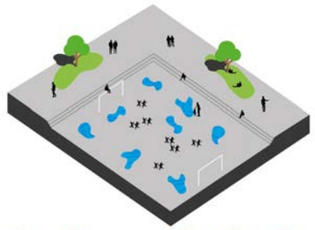
General information:
The creation of height differences in the form of hills provide many advantages regarding appropriation and urban microclimate.The hilly terrain invites people to appropriate the space.

9 street park



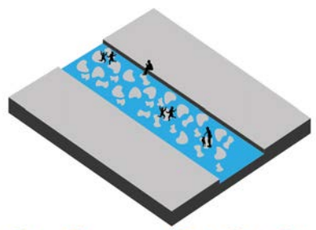
General information:
A street park is a permanent transformation where a less important street is transformed into a pocket park. It removes the space for cars and creates the opportunity for people to appropriate it for activities.

10 climate square



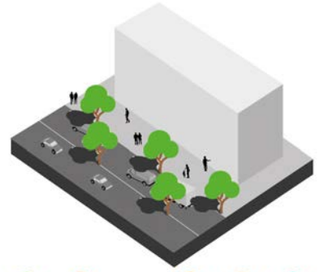
General information:
Climate squares are generally used in inner-city areas with little room for water buffers, where high groundwater levels make infiltration impossible and where green surfaces are desired.

11 urban water way



General information:
Open urban waterways provide a temporary water storage and drain the water. It is a nice aesthetic improvement for the city.

12 Street trees

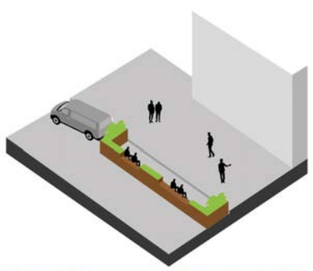


General information:
Trees have many advantages regarding appropriation and urban microclimate, however not every type of tree is beneficial. The type of tree should be chosen to suit the local moisture system.

19 CLIMABILITY SOLUTIONS

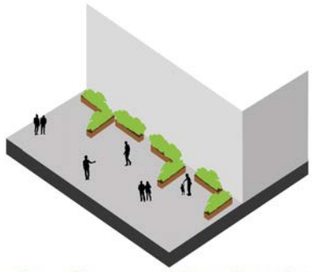
On the scale of the street, the solutions for appropriation and urban microclimate are probably the most prone. This is a scale where public life is happening each day and every time. At these spaces, a mix between large and small interventions can be found. Therefore it is also important that there is a collaboration between municipality and residents/ users. Smaller groups like a group of residents have an important role in these interventions. However, because the interventions are located in the street, which is most of the time owned by the municipality, the municipality should give great attention to this development. The most important concept at this scale is to give space back to pedestrians. Car space should be reduced to create pleasant walkability, enough space for soft edges and at the same time improve the urban microclimate. Sidewalks should be widened, crossings should be made safer and greenery should be created to improve the infiltration of water, air quality and temperature.

13 Parklet



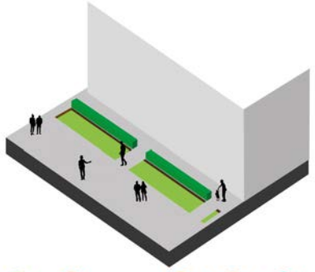
General information:
Parklets are a (temporary) transformation of parking spaces into pocket spaces along the sidewalk. It can be seen as sidewalk extensions with the purpose of creating places for staying.

14 Outdoor planters



General information:
Outdoor planters are there in many ways, according to the preferences of the residents. This makes it very suitable for appropriation. Plants have many advantages for the urban microclimate.

15 infiltration strip



General information:
Infiltration strips are lower placed, green surfaces next to paved surfaces where rainwater can be (temporary) stored and slowly infiltrated.

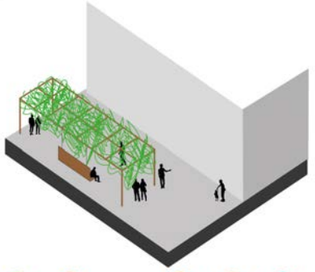
16 Greenery with ledge

General information:
At certain places a tree can be combined with more functions. By adding a ledge or a bench it provides options to sit.

17 curb bulb

General information:
A curb bulb is an extension of the curb. It is a strategy that is used to widen the sidewalk at important locations to create a safer pedestrian environment.

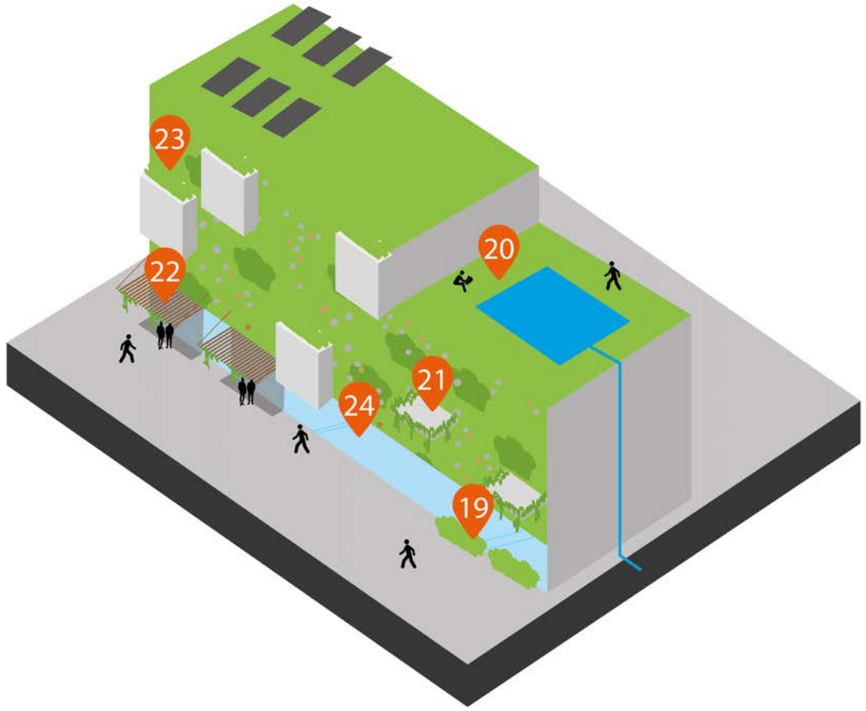
18 Trellis / pergola



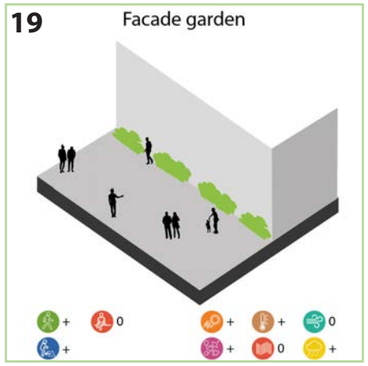
General information:
A trellis/pergola is a construction where plants can grow on. Mostly it is used as a roof above a terrace or path to provide shade.

DESIGN STRATEGIES

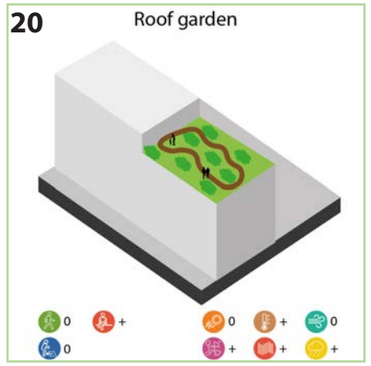
19 CLIMABILITY SOLUTIONS



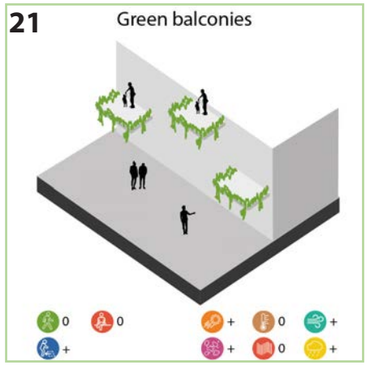
When designers aim to improve the conditions of urban outdoor spaces they should not only look at the space itself but buildings surrounded can play a very important role by achieving the goals for appropriation and urban microclimate. There is a clear connection between the building and the outdoor space, so designers should also look at opportunities that the architecture can offer, especially in dense areas, where outdoor space is often limited. It is more and more clear that the facade and roofs of buildings can offer many advantages for appropriation and urban microclimate. By adding green elements to them they contribute to a better urban microclimate and for example, balconies create a visible connection with the street, which improves the appropriation and therefore the quality of life on the street. Interventions are not only focussed on how to reduce the negative effects of urban microclimate and appropriation, but it is also about adapting to the conditions. An example is the distribution of the functions of buildings where they can optimize it regarding solar radiation.



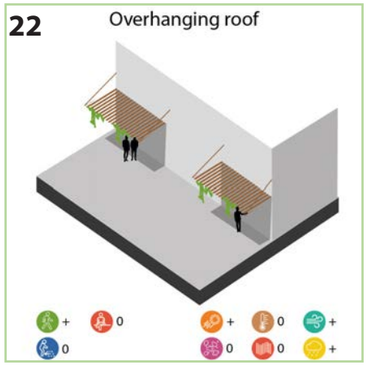
General information:
With a facade garden the residents remove a row of tiles along the facade at the side of the street and create a little garden. It has some advantages regarding appropriation and urban microclimate and it contributes to a green scenery in the street.



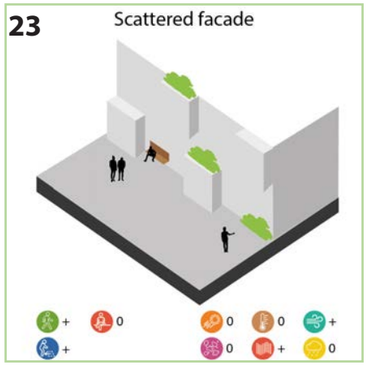
General information:
A roof can have multiple functions, like having solar panels, green vegetation or even better a green garden. In this case the green on the roof is given an additional function, a (semi)private space for residents.



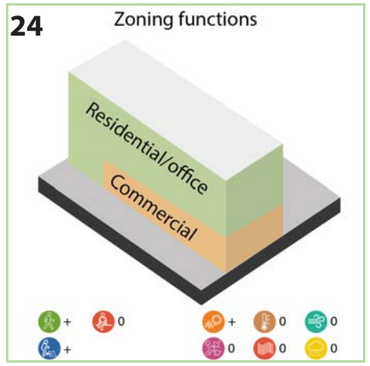
General information:
A balcony provides opportunities to grow all kinds of plants and herbs. It creates spaces between public and private and when made green it has mutliple microclimatic advantages.



General information:
An overhanging roof, protruding outwards from the building mostly functions as weather protection. It can also function to define the entrance of a building.



General information:
An irregular facade is more interesting than a regular facade. A large variation in function, materialization and details gives high quality to the architecture.



General information:
Different functions in a building should have some planning. Commercial functions on the ground floor with residents/ offices on top of it. Restaurants and shops create a lot of activity on the ground floor.

20 INITIATIVES & COOPERATION

For each development different stakeholders can contribute to it. Most of the time, for bigger developments the municipality should take the lead, while for smaller measurements the market or residents can be the initiators. In the end, municipality, market and residents corporate with each other and initiatives should be combined. It is good to know that residents can take initiative because they like to have a livable street. Small interventions like facade garden, benches, meeting spots or communal gardens are good examples of local initiatives where the municipality only should support these initiatives by giving the residents the space they need.

On the left part of the figure, the initiative is at the municipality. The municipality does a lot of big and small developments to guarantee the livability in the city. It will be beneficial to look for opportunities for cooperation between municipality, market and residents. At the right part of the figure, the initiative is at the market and residents. The municipality can facilitate in this case, because the municipality should be involved in the process, but is not responsible for the development. It is beneficial for the municipality to subsidize and promote local initiatives that contribute to their own goals. The municipality allows innovation where the market can look for new products and services.

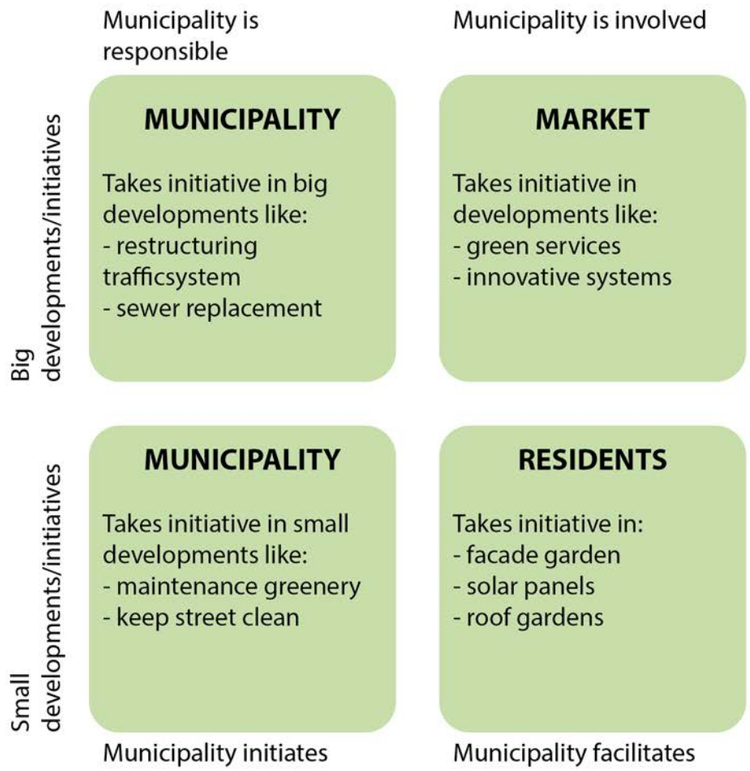


Figure 66 Stakeholders initiatives

To really make changes towards sustainable development it is important to create support among residents. Therefore, urban designers should cooperate with residents. Urban designers should tempt others to join and to let others take measures that enhance the quality of life. However, there are many types of people and these different people have different desirables and need different strategies to involve them in the design process, see figure 67. There are people who are conservative and don't like change. Others are willing to help and take initiatives to join the movement. For the municipality and urban planners, it is helpful to know where these different types of people live. With this information, they can decide which ways of communication work in which area. Different ways to approach and inform residents are residents meetings, webpages with information, local newspapers, social media or neighbourhood events. Also, there should be thought about the moments to involve residents, for example during seasonal changes and during big reconstructions of areas.

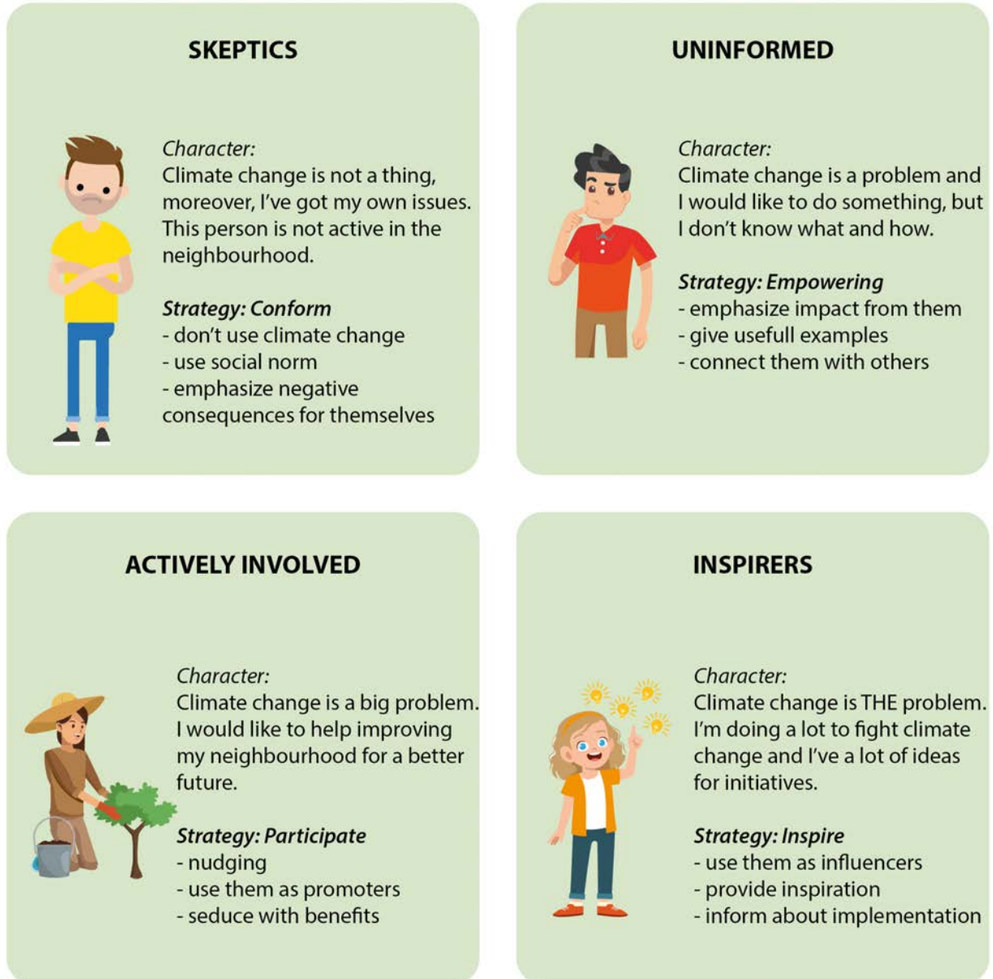


Figure 67 Types of residents

20 INITIATIVES & COOPERATION

It is a good thing that there are already a lot of initiatives going on regarding climate change and social cohesion. However, in Milan, it is difficult to find such events or initiatives. Therefore, on this page, there are some events and initiatives shown which can be an example of how to approach this change in different ways. For example, there is an app and website called "Huisje Boompje Beter", where all kinds of measurements are shown which are applicable by residents. Another example is the initiative of "1000 geveltuinen" where the sidewalks in the city are transformed into small gardens. Within this project, there are different ways to support this initiative. A good example in Milan is "BING", where all kinds of activities are happening. Around a vacant plot in the city are now activities happening like a community garden, sports events and workshops. These kinds of communities are opportunities to involve in the change we like to make.

DESIGN STRATEGIES

21 CONTEXT KEY PROJECTS

Project 2: Nuovo Greco

- Overlapping area of Greco and Cassina de Pomm
- Area sandwiched between multiple train tracks and Via Melchiorre Gioia
- Low density area, almost no residents
- Architecture build around 1970
- In the area: school, hotels, swimming pool, cultural center, bars
- Next to a big supermarket

GRECO

MAGGIOLINA

CASSINA DE POMM

PALAZZO LOMBARDIA

GIOIA 22

PORTA NUOVA

Project 1: Transformato Sondrio

- car boulevard directed from northeast to southwest
- connection of Porta Nuova to Greco
- intersection of Via Melchiorre Gioia and Viale Sondrio
- Architecture build around 1920
- Until 1960's flanked by a canal
- Some new architecture like: Palazzo Lombardia and Gioia 22
- Metro station Sondrio opened in 1991
- Metro line sometimes flooded
- Average building height: 30m
- Alongside residential neighbourhood build in 1922 with 9m high alone standing buildings

Project 2: Mixo Maggiolina

- Part of Maggiolina neighbourhood
- Residential neighbourhood, all apartments
- Sandwiched between Via Melchiorre Gioia and Viale Evaristo Stefini with traintracks
- High population density
- Architecture build around 1965
- Energy label F or G, very low
- Multiple underground parking garages
- Average building height: 30m
- Small local shopping center

Figure 68 Context of three key projects

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22 TRANSFORMATO SONDRIO

22.1 CURRENT CONDITIONS

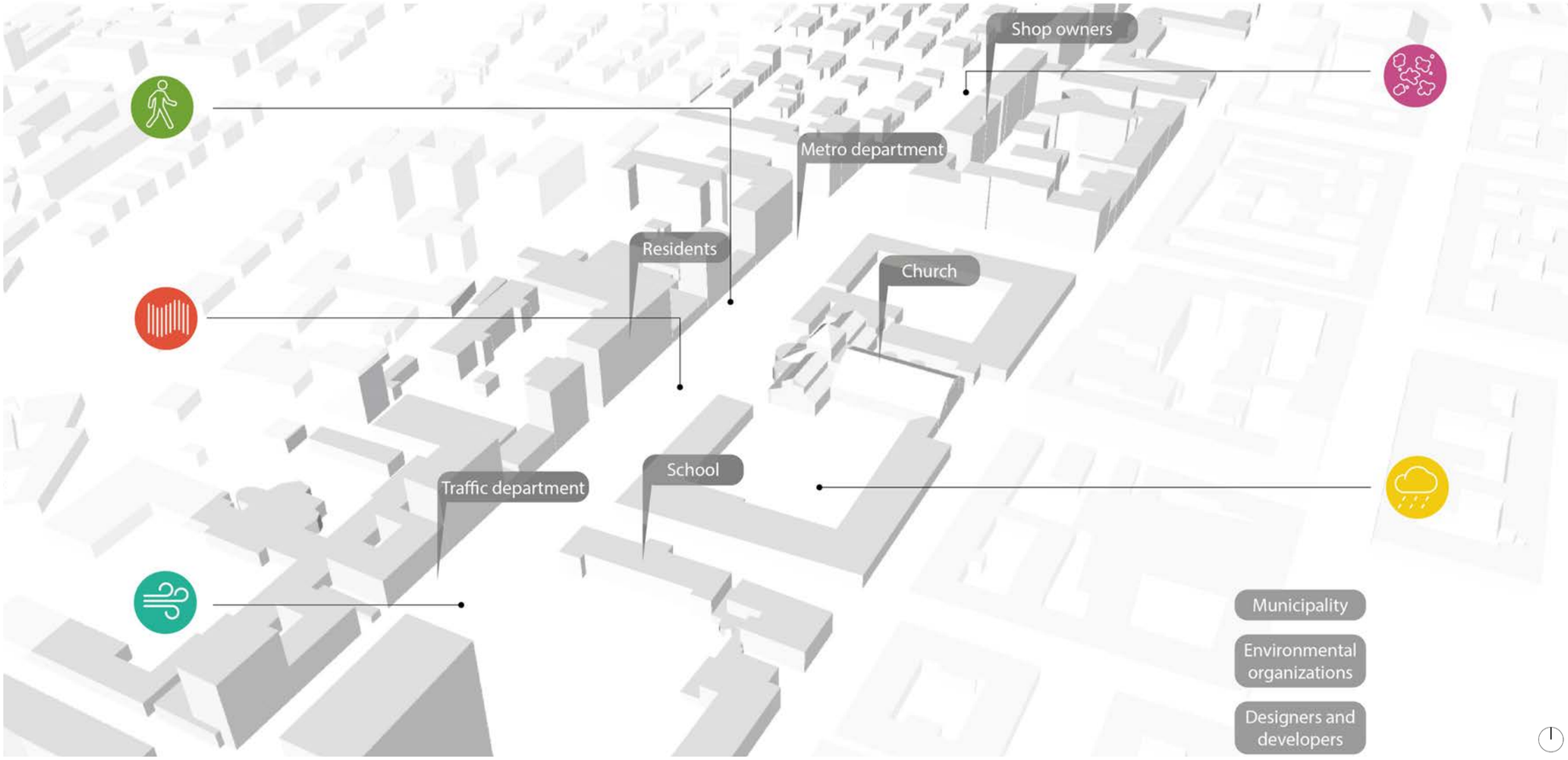

Figure 69 View of current conditions

Figure 70 Section of current conditions

This area is occupied by cars and therefore pedestrians have very little space. There are limited possibilities to cross the street and sidewalks are narrow.

Pedestrians experience wind nuisance because the orientation of the street is the same as the prevailing wind direction and there are no elements to protect pedestrians from the wind.

Because of all the paved surfaces and the absence of green surfaces and elements water can't be stored during heavy precipitation events.

Traffic is causing a lot of air pollution and there are no elements to absorb this pollution.

Traffic is causing a lot of noise which leads to nuisance regarding conversations and places for staying.

TRAFFIC

POOR WALKABILITY

ALL PAVED SURFACES

DESIGN STRATEGIES

22 TRANSFORMATO SONDRIO

22.2 URBAN PLAN

1:2000

Figure 71 Urban plan 2100

The first key project is about the transformation of an existing urban outdoor space in Milan. This project is chosen to show which interventions can be done in a single street. In this case, it is an important boulevard directed from north to south. The boulevard is occupied by cars and characterized by paved surfaces, on the street but also on the facades of the building. The pedestrians have a low priority, this can be seen through the narrow sidewalks and little opportunities to cross the street, which lead to low-quality walkability. Towards 2100 the street profile should be changed. Outdoor space should be given back to pedestrians. Moreover, the area is made more green to fight urban heat island and to improve water runoff. In this project, the relation of urban design and architecture is shown with the facade and roofs of buildings. Overall this project focuses on the urban outdoor space where most of the changes are happening in the street profile. Additional changes are made in the inner areas along the boulevard. For example, the paved playground from the school is transformed into a playground with greenery and there is a possibility for a climate square. Depending on the orientation, the roofs of buildings will have different functions. Orientated to the south it will produce solar by solar panels, while buildings in line with the boulevard will have green roofs. This projects should be an example of how to reduce space for cars and what can be done with that free space to contribute to the social- and environmentally sustainable development of cities.

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Figure 72 Design strategy 2030

Figure 73 Design strategy 2050

Figure 74 Design strategy 2100

22 TRANSFORMATO SONDRIO

22.3 PHASING AND STAKEHOLDERS

On the next four pages, the phasing and stakeholders of the project can be found. It would be smart to connect the climability interventions with other investments in the city. By looking into the replacement periods of different street elements a clear overview can be made to see where connecting opportunities are. This will not mean that in the first couple of years nothing can be done. Small (temporary) interventions can be made, like parklets and greening of facades and balconies. Together with the interventions, it is important to know who is involved in the project. Urban designers can inform and steer stakeholders to participate in the design process. Residents and shop owners can contribute to the design by greening their balconies and creating small facade gardens. These projects can be promoted by initiatives like 1000facadegardens or "Huisje Boompje Beter". Large transformations and interventions should be done by developers or the municipality. The street is most of the time owned by the municipality while adjacent properties are privately owned. Therefore a public-private collaboration is needed to maintain the quality of life in the street.

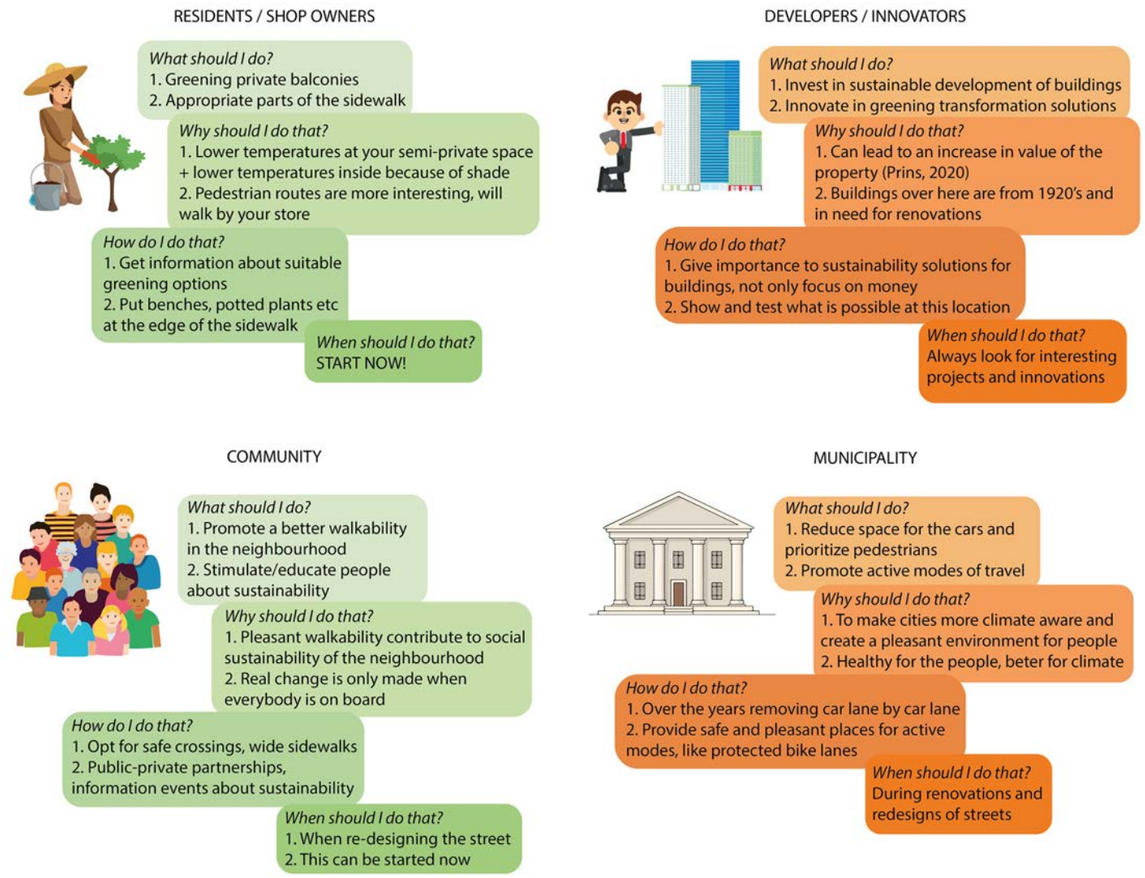

Figure 75 Actions stakeholders

DESIGN STRATEGIES

22 TRANSFORMATO SONDRIO

22.3 PHASING AND STAKEHOLDERS

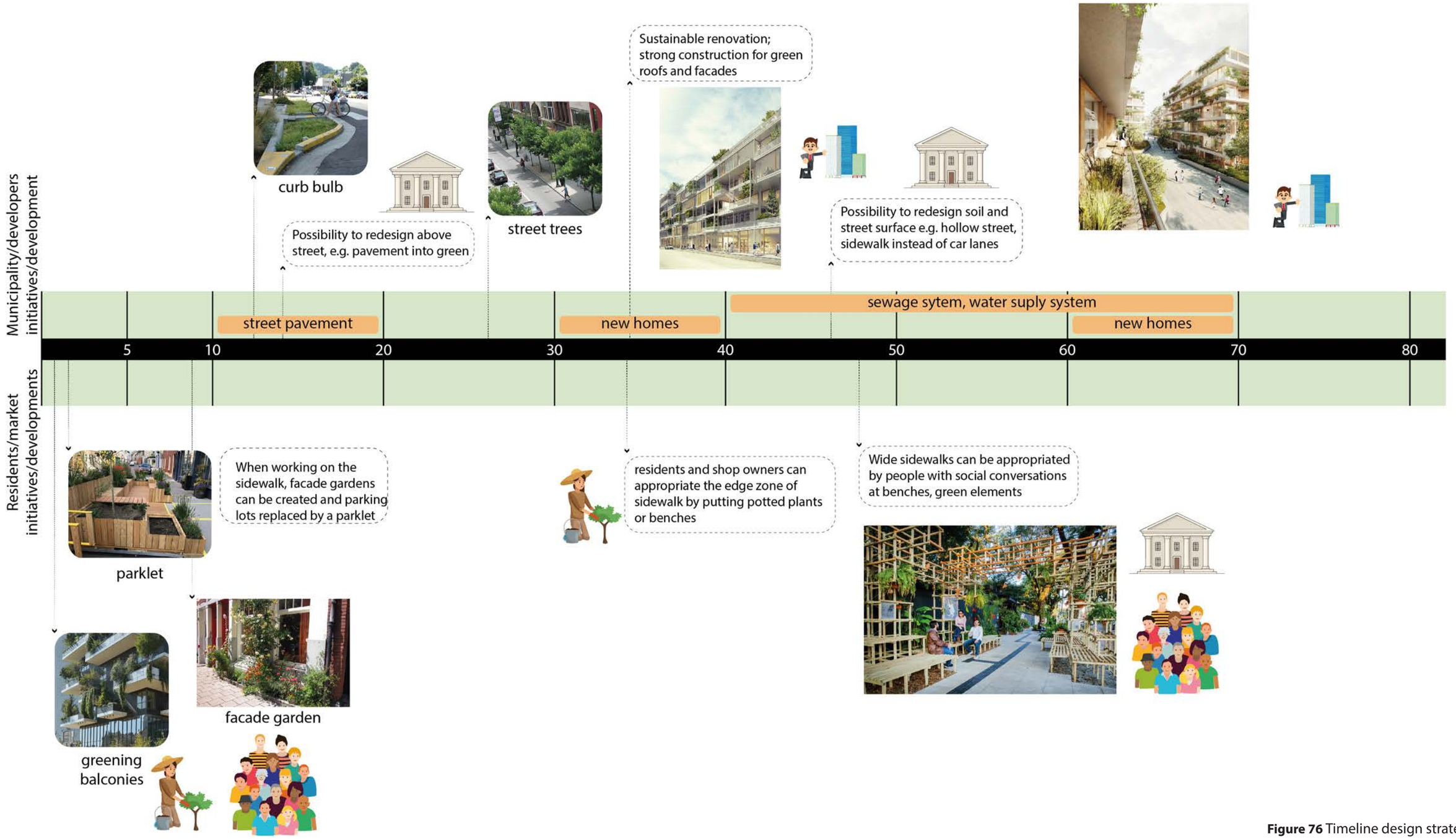

Figure 76 Timeline design strategy

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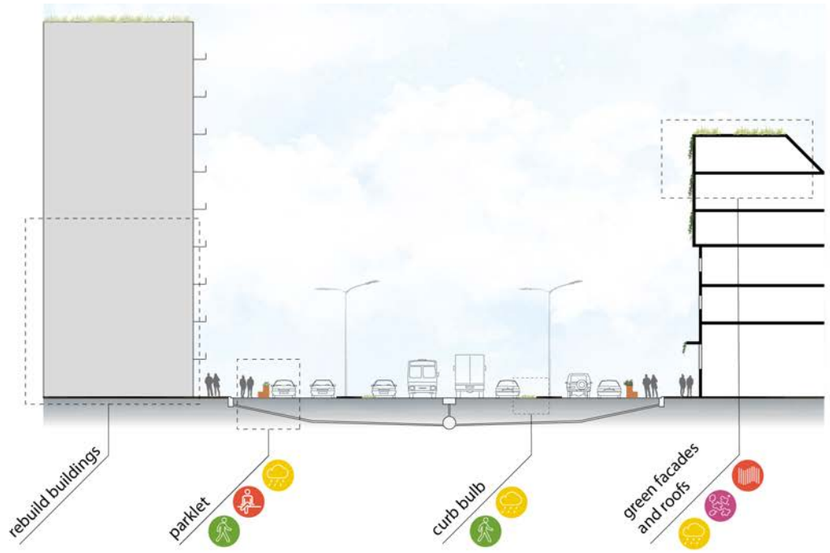

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Figure 77 Section A-A' design strategy 2030

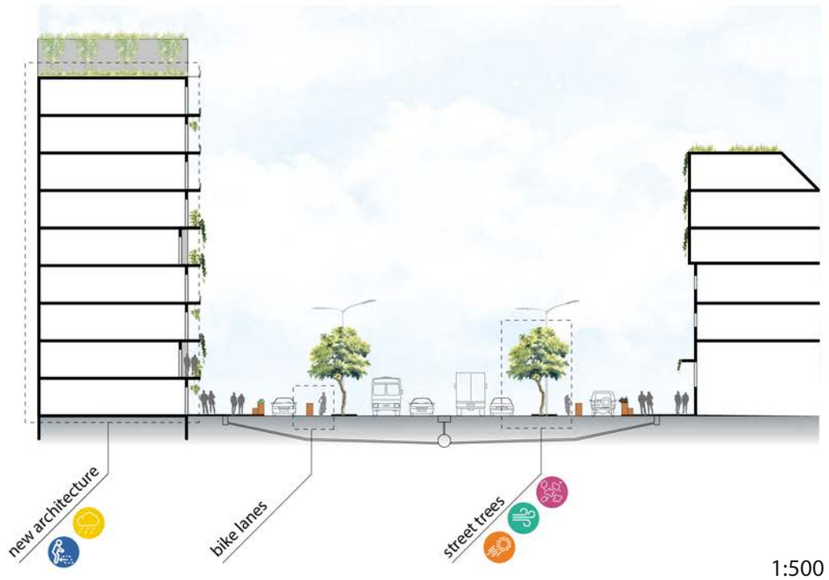

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Figure 78 Section A-A' design strategy 2050

22 TRANSFORMATO SONDRIO

22.4 IMPLEMENTATION

These sections show which interventions can be applied and how this will look like. Within the first 10 years, small interventions can be made, like parklets and curb bulbs and a start is made on greening the facade and roofs. (Temporary) parklets are implemented. When these parklets are well used they can be made permanent in a later stadium. Some low, bad quality buildings are removed which can later be rebuilt. Towards 2050 most of the parking spaces should be gone. Therefore instead bike lanes and wide sidewalks are created. The greening of the street is progressing through the planting of street trees. New buildings will have the same height as the surrounding buildings, however, these new buildings will be very sustainable, with green on the facade and an active ground floor. With balconies, a stronger connection with the street is provided. Towards 2100 the total transformation of the street should be done.

Instead of 10 car lanes in 2020, 4 car lanes are still there, but slow traffic has appropriated the space. The wide sidewalks and connection with the architecture will provide lots of opportunity for social interaction. Trees provide shade and protection against wind on the sidewalk to make pedestrian routes pleasant during summer and winter. Rainwater can be stored and infiltrated at different places: roof, facade and at green surfaces in the street. The drainage in the street is rearranged by the creation of a hollow street instead of a convex street. A collaboration between municipality, communities and residents resulted in a pleasant environment for everyone. In further detailed sections, there is also explained who should take responsibility and who should maintain the area. In addition, feedback was provided to literature to substantiate the interventions.

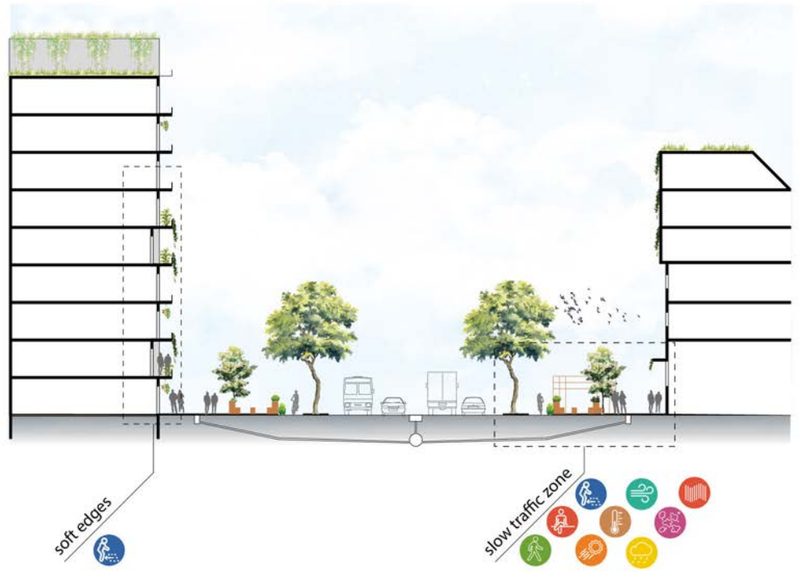

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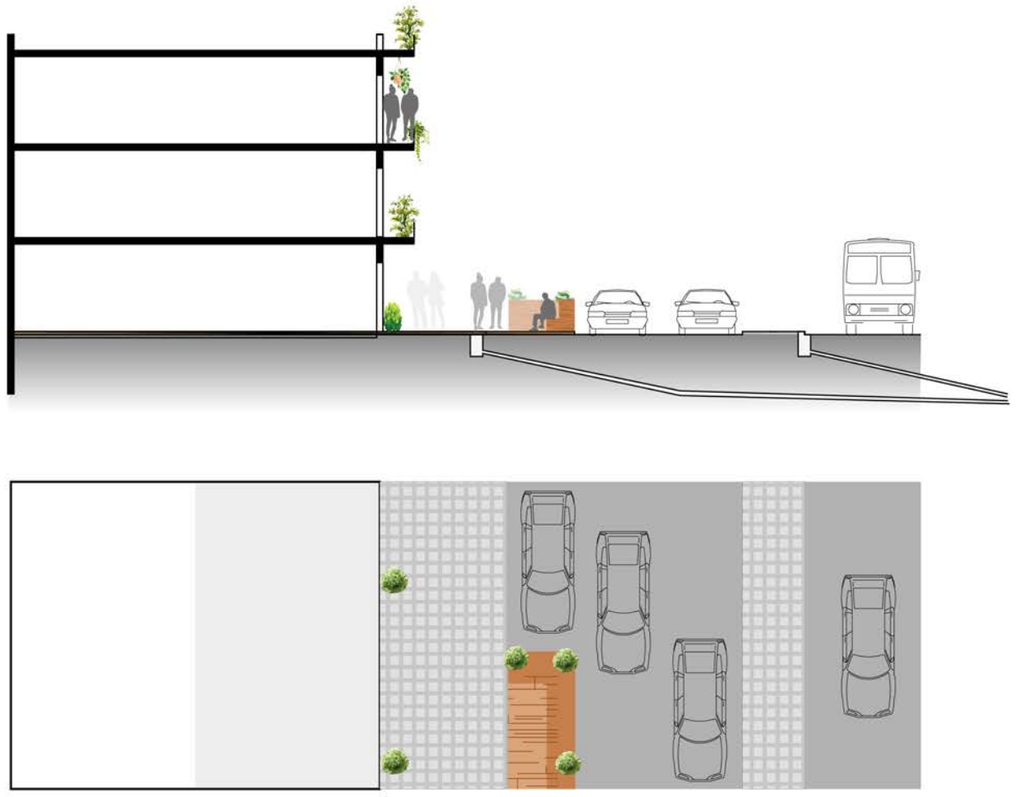
Figure 79 Section A-A' design strategy 2100

22 TRANSFORMATO SONDRIO

22.4 IMPLEMENTATION



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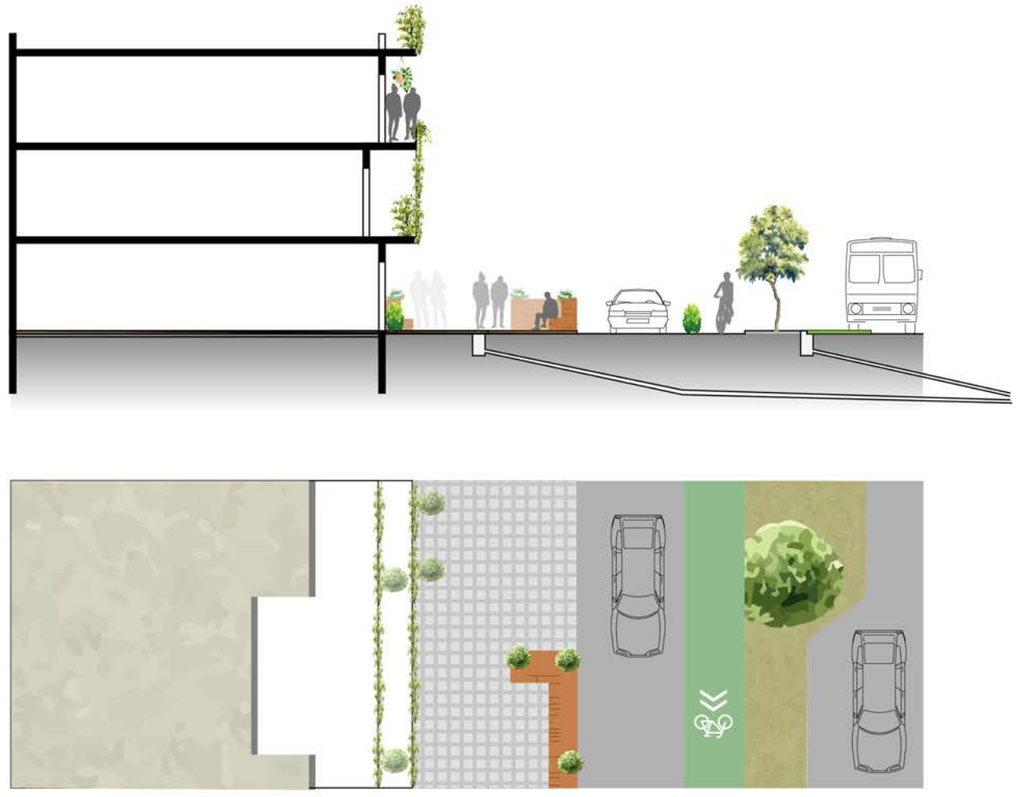
Residents can start with greening their balconies and from ground level facade gardens or outdoor planters can be placed by shop owners.

The first important step is to replace multiple parking lots by parklets which are placed strategely at restaurants and cafés. This is done by shop owners with cooperation with municipality

Figure 80 Detailed section 2030



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New sustainable architecture provides constructions for green roofs and facades. Developers are responsible for the buildings, but municipality can make rules for green facades and baconies.

The municipality is responsible for the redesign of the street. Curb bulbs are created for safe pedestrian crossings, streets trees are planted and car lane is replaces by bike lane

Figure 81 Detailed section 2050

DESIGN STRATEGIES

22 TRANSFORMATO SONDRIO

22.4 IMPLEMENTATION

Facade green and planted balconies are lowering the temperature, absorb water, air pollutants and noise

There is a lot of space for pedestrians. Because of the wide sidewalks at a distance from traffic a safe walking environment is created. The edges of the sidewalk can be appropriated by shop- and restaurant owners

Walking is the primary way of appropriation. The wide sidewalk contribute to the comfortability and will increase the appropriation (Santucci et al., 2019; Gehl, 2011)

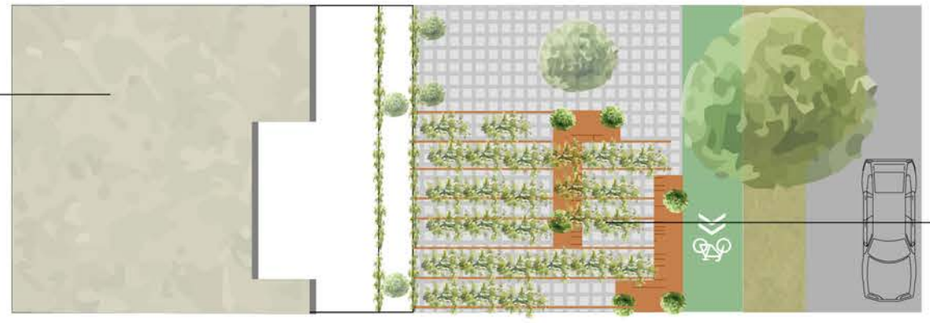
People maintaining the facade gardens or green balconies show a picture of activity which will have a positive influence on the appropriation as a whole (Gehl, 2010)

Residents / shop owners create facade gardens. It will lead to a soft edge and social conversations can happen. Multiple microclimate elements are improved.

Trees provide shade, act as a windbreak, allow water to infiltrate and improve the air quality

Sewer system can be replaced and hollow streets are created for better drainage of storm water.

Green roofs can offer semi-private staying options, are lowering temperatures, can store water and give extra protection against noise



1:200

This wooden structure act as a pergola and offer sitting opportunities. Therefore it protects against solar radiation, give protection against wind and absorb water and air pollutatns.

The choice to sit in the sun or in the shade from the pergola will increase the appropriation, because a choice is given (Whyte, 1980)

The last carlane is removed and a whole new walking environment is created. A wooden structure works as a pergola which is connected to the architecture. Municipality is responsible for the maintanence, but with a public-private partnership with shop- and restaurant owners maintenance can be caried out.

Figure 82 Summary of design strategy

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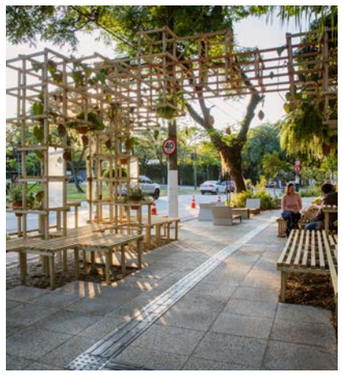
22 TRANSFORMATO SONDRIO

22.5 VISUALIZATION OF ELEMENTS



Architecture
LTR: Ray Nice stadium redevelopment project Vinci Immobilier; London National Park City; COWORKING, Munich



Sidewalk
LTR: All color sidewalk, Sao Paulo; Podium eilanden; East Union Mixed-used Apartments

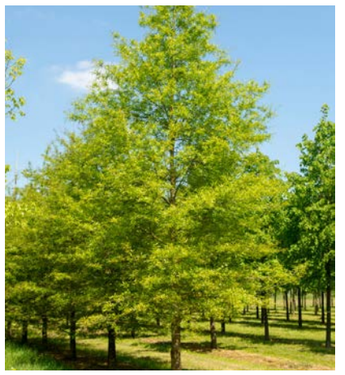


Semi-private zones
LTR: Magic Breeze Sky Villas; Caixas de vidro x País tropical; Porte des Ternes, Paris

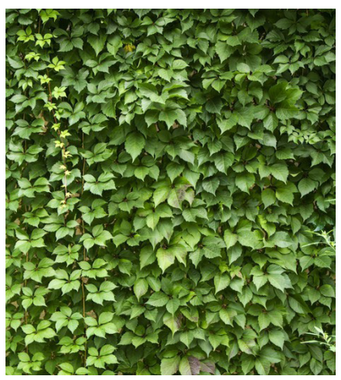


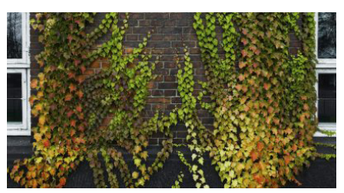

Street furniture
LTR: All color sidewalk, Sao Paulo; The Peoples Parklet (top); ParKIT, Gensler (bottom); Non-Stop Forest, Penoyre & Prasad





Trees
LTR: Tilia cordata 'Greenspire', Quercus ilex 'holly oak', Quercus phellos 'Willow oak'






Vegetation
LTR: Hedera Helix, Virginia Creeper (top), Boston Ivy (bottom), Virginia Creeper vine.

22 TRANSFORMATO SONDRIO

22.6 SITE IMPRESSIONS

Towards 2100 the designers should give space back to the pedestrians. Milan is already looking for opportunities to increase the number of bicycle lanes and reduce the space for the cars. Instead of a wind tunnel and little opportunities to walk in the shade, people are now protected against the wind by the porous greenery and trees will provide shade. The edge between buildings and outdoor space is made softer by the use of green.

There are not a lot of opportunities to cross the busy street, so extra crossings are created to give pedestrians higher priority. By the use of curb bulbs traffic should slow down and these green curb bulbs also provide temporary water storage. The high amount of pavement is reduced by the use of green, in the street, on the facades and the roofs.

23 MISTO MAGGIOLINA

23.1 CURRENT CONDITIONS

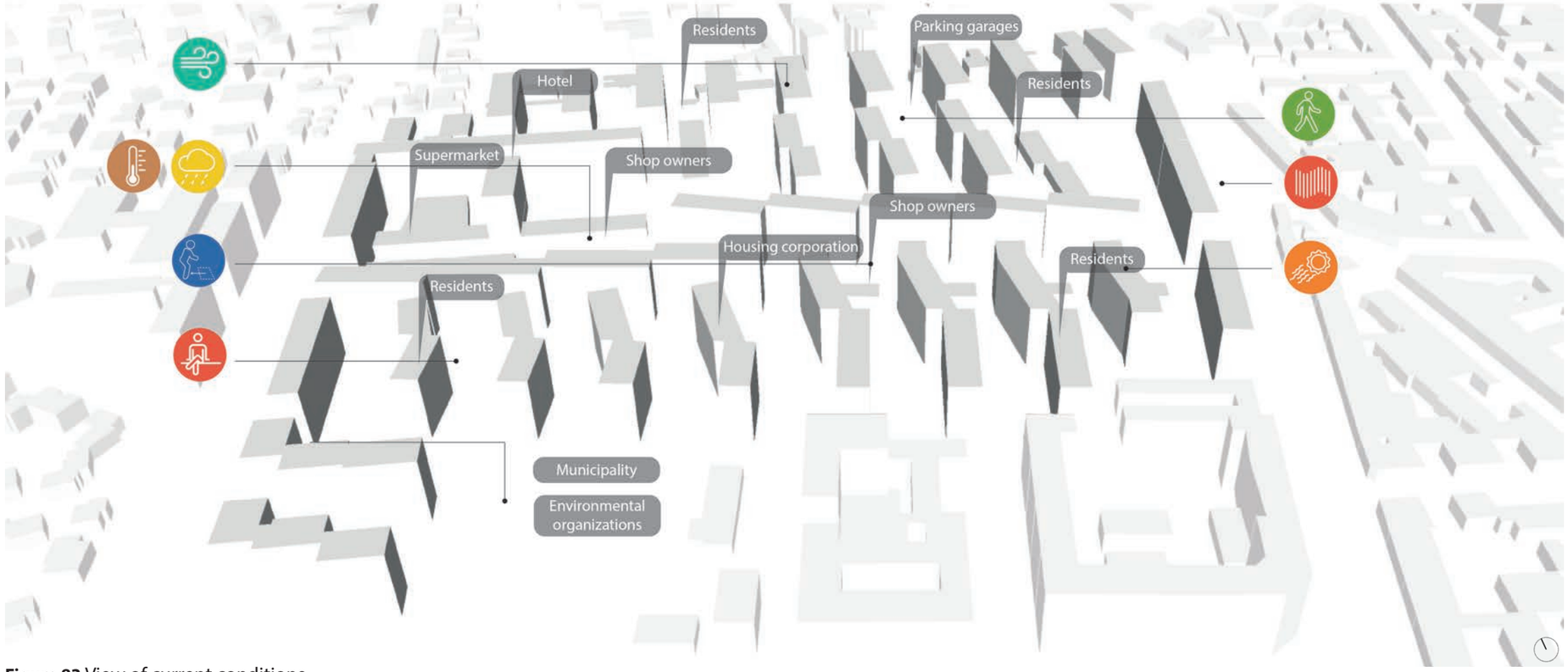


Figure 83 View of current conditions

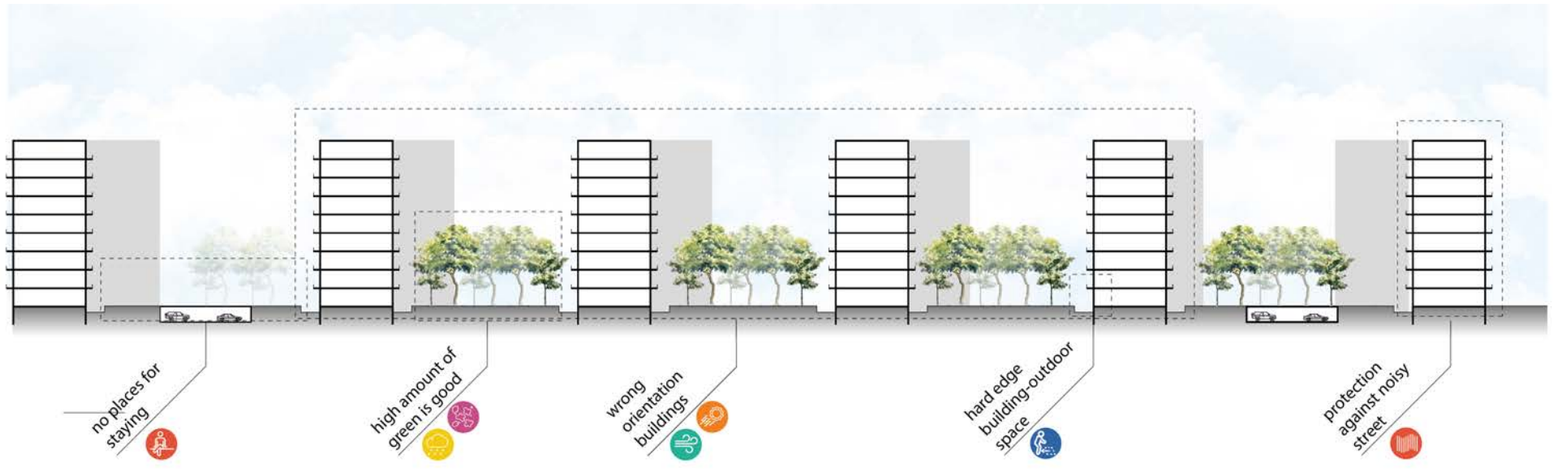


Figure 84 Section of current conditions

1:1000

This area is occupied by cars and therefore pedestrians have very little space and sidewalks are narrow.

All the spaces between the buildings are closed by a fence and have no real functions for staying.

The typology of the buildings ensures that there is a hard edge between the residents and the outdoor spaces.

Because of the orientation of the buildings, multiple tunnels are created and high wind speeds create wind nuisance.

Because of all the paved surfaces water can't be easily stored during heavy precipitation events.

Traffic is causing a lot of noise which leads to nuisance regarding conversations and places for staying.

BUILDING ORIENTATION

PAVED SURFACES

CLOSED OUTDOOR SPACES

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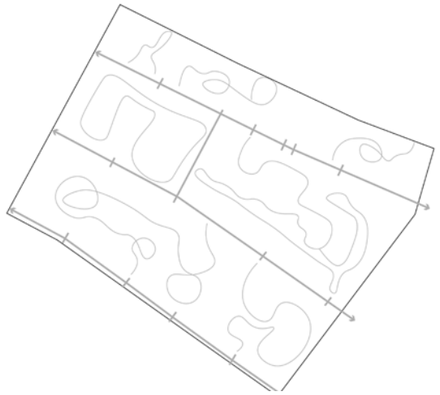
23.2 MAXIMIZATION METHOD

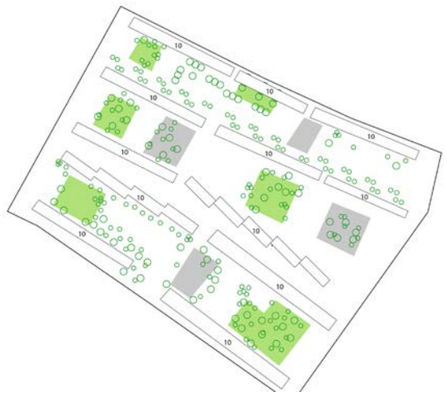
For this site, the Environmental Maximization Method is used in different ways. First of all, it is used as an analysis method. For each element of appropriation and urban microclimate, the site has been assessed. The method helps to analyze which specific opportunities and problems there are in an area. In the design process, the Maximization Method is used to get a foundation for an urban development plan. The first figures show the maximum result and the guidelines regarding each element of appropriation and urban microclimate. The next step is to overlay the maps and make compromises for an urban plan. The specific design rules coming from the Maximization Method are shown in thematic maps on pages 136-137. The rules show with the icons to which elements it is applied. For buildings, it is desired to change the orientation and to remain somewhat the same building height. (Green) outdoor spaces should be connected through the whole neighbourhood and should have different functions to address different target groups in the area. Within the streets, there should be enough space for pedestrians.

WALKABILITY



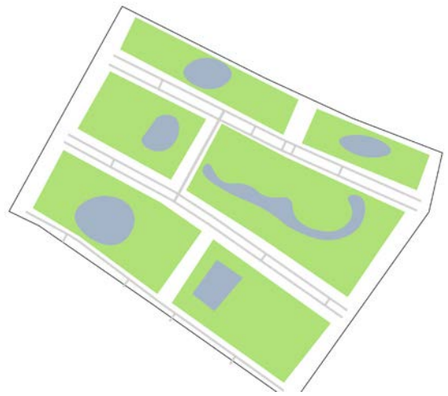
- Wide sidewalks
- Many safe pedestrian crossings
- Curved pedestrian routes

WIND



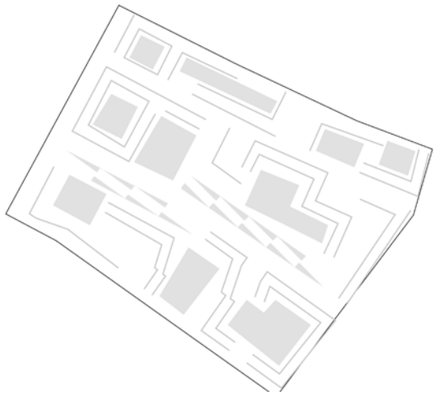
- Create vegetation to slow down the wind
- High wind speeds can be avoided by a building orientation towards the south
- To create some ventilation parks and squares are created
- Buildings have somewhat the same building height to avoid high wind speeds

PRECIPITATION



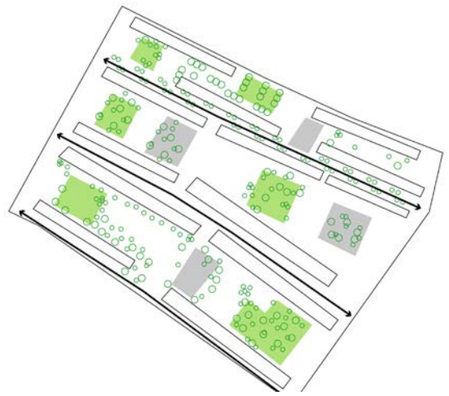
- Create height differences, like sidewalks, to provide dry feet at higher placed surfaces
- Create green/blue surfaces to store water and provide a good infiltration

PLACES FOR STAYING / SOFT EDGES



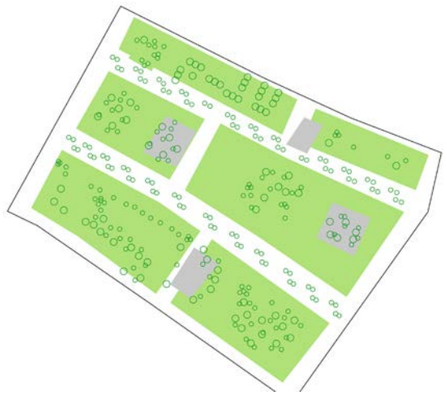
- Wide variety of outdoor activities
- Wide variety of sitting options
- Good edges around squares/parks
- Active ground floors
- Visibility between inside-outside
- Semi-private staying options at edges

SOLAR RADIATION/TEMPERATURE



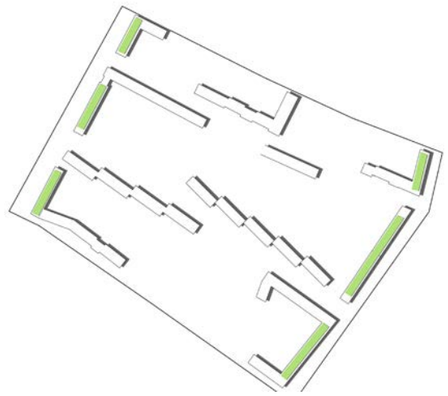
- Buildings towards the south along the wide east-west directed street
- create squares and parks
- provide shade options

AIR QUALITY



- Outdoor stying areas are placed at a distance from heavily polluted streets
- Create ventilation by creating intersections at short intervals
- Provide green elements to absorb air pollutants

NOISE



- Inner areas should be protected from noisy streets. This can be done by buildings with a green roof

- A row of buildings should protect the inner outdoor spaces from noise from busy streets
- Buildings are orientated to the south along an east-west street. The solar gain is very high and tunnel effects for wind are avoided.
- Minimize the height differences in building height. Avoid buildings that are two times higher or more than 15 meters high.

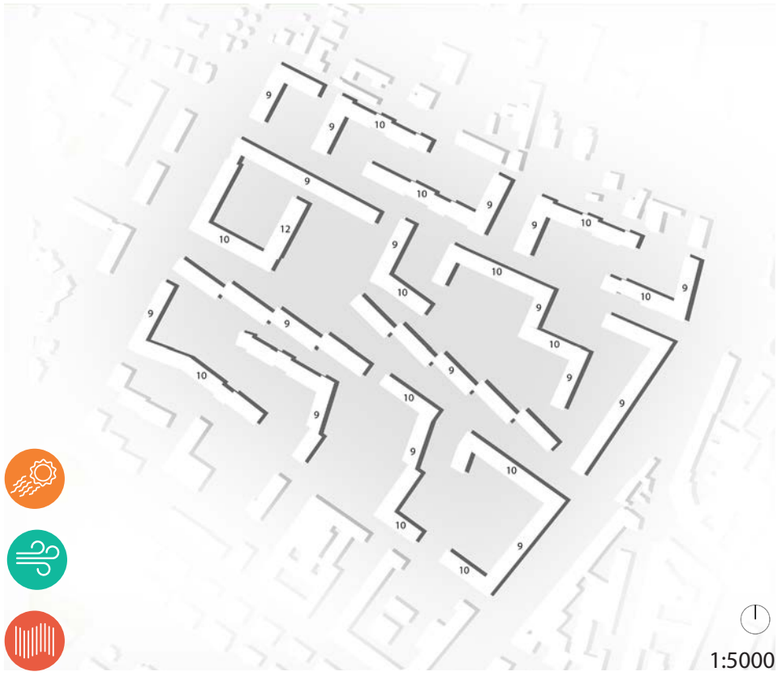


Figure 85 Building design rules

- Create a network of green spaces in the neighbourhood. Different green spaces can be connected by green elements in the streets.
- Add green at places where problems occur regarding high temperatures, bad infiltration of water

Figure 86 Green design rules

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23.2 MAXIMIZATION METHOD - DESIGN RULES

Figure 87 Outdoor spaces design rules

- Open up the urban outdoor spaces and make it accessible to everyone.
- Create different kinds of functions in the urban outdoor spaces

Figure 88 Street design rules

- Create wide east-west streets and narrow north-south ones.
- Close roads where they are not necessary to give that space back to the pedestrians
- Give priority to the pedestrians in the street. This means: wide sidewalks, enough possibilities to cross the street, safe crossings

23 MISTO MAGGIOLINA

23.3 URBAN PLAN

The second key project is about a mix of transformation and new development. This project is chosen to show how an existing area can be transformed into a sustainable environment. The orientation-, the typology of the buildings and the outdoor spaces are the key elements in this project. This project is chosen to show what urban designers can do to improve an existing neighbourhood with a very characterizing structure. This project aims to remain the specific character of the morphology and typology where changes have an addition to the neighbourhood. In this case, the large character of the buildings has been preserved, however, better connections with the street and outdoor space is made. There is a transition from closed outdoor spaces to spaces which are fully accessible by everyone. These outdoor spaces are connected with each other through the whole neighbourhood but they all have a different character or function. In this case, we can find smaller pocket parks, a climate square which can be the central point of the neighbourhood, hilly terrain between buildings or a playground aimed at a younger target group. This variation in outdoor spaces ensures that the neighbourhood is interesting for all kinds of groups. The area had already a quite green character and this is even made stronger while it is made more publicly accessible. The orientation of buildings is changed because this is more favourable regarding solar radiation and wind. Moreover, the ground level of buildings is made more active contributing to better walkability and a safer environment. With balconies and semi-private areas, interaction with the street is created which will increase the social cohesion in the neighbourhood. This projects should be an example of how to transform low-quality outdoor spaces to interesting and lively outdoor spaces that contribute to the social- and environmentally sustainable development of cities.

1:2000

Figure 89 Urban plan 2100

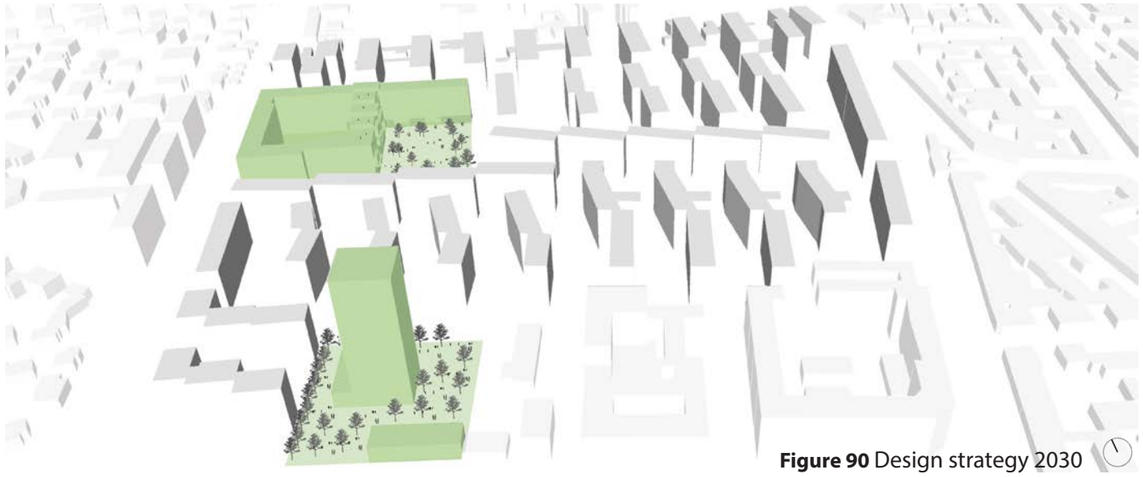

Figure 90 Design strategy 2030

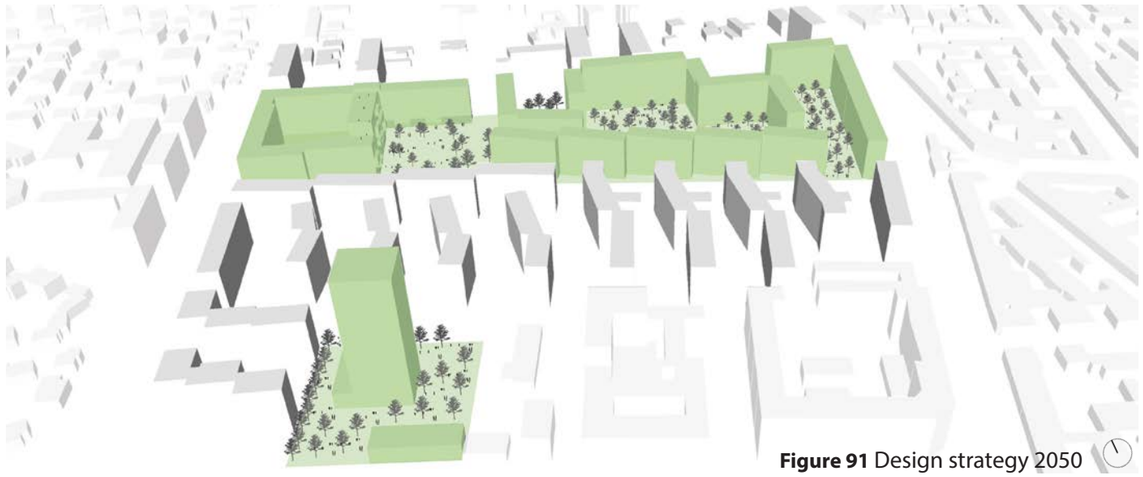

Figure 91 Design strategy 2050

Figure 92 Design strategy 2100

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23.4 PHASING AND STAKEHOLDERS

In the first phase of the strategy, some small interventions and one big development are made. The small interventions form a basis for further development in phases towards 2100. The first big development of the climate square with some new architecture should activate the neighbourhood. Because in the existing situation there is no publicly accessible outdoor space, the climate square could be the example of a sustainable urban outdoor space and work as a catalysator for the neighbourhood.
Towards 2050 further large developments are made in the centre part of the neighbourhood. The orientation of buildings is changed, from north-south to east-west, and the ground level is full of activities. In this case, the solar gain is very high and the tunnel wind effect is avoided. Outdoor spaces are combined and given a function for different groups.
From 2050-2100 the rest of the neighbourhood can be changed. The orientation of buildings is changed, outdoor spaces are given different qualities and the walkability is improved. Also in this project, it is valuable to look for connecting opportunities within urban outdoor elements. The municipality looks for opportunities with developers and housing associations to redesign buildings and give more quality to urban outdoor spaces. With collaboration between stakeholders, support is created for the interventions, like community gardens which are maintained by local residents. This will increase the social cohesion in the neighbourhood.

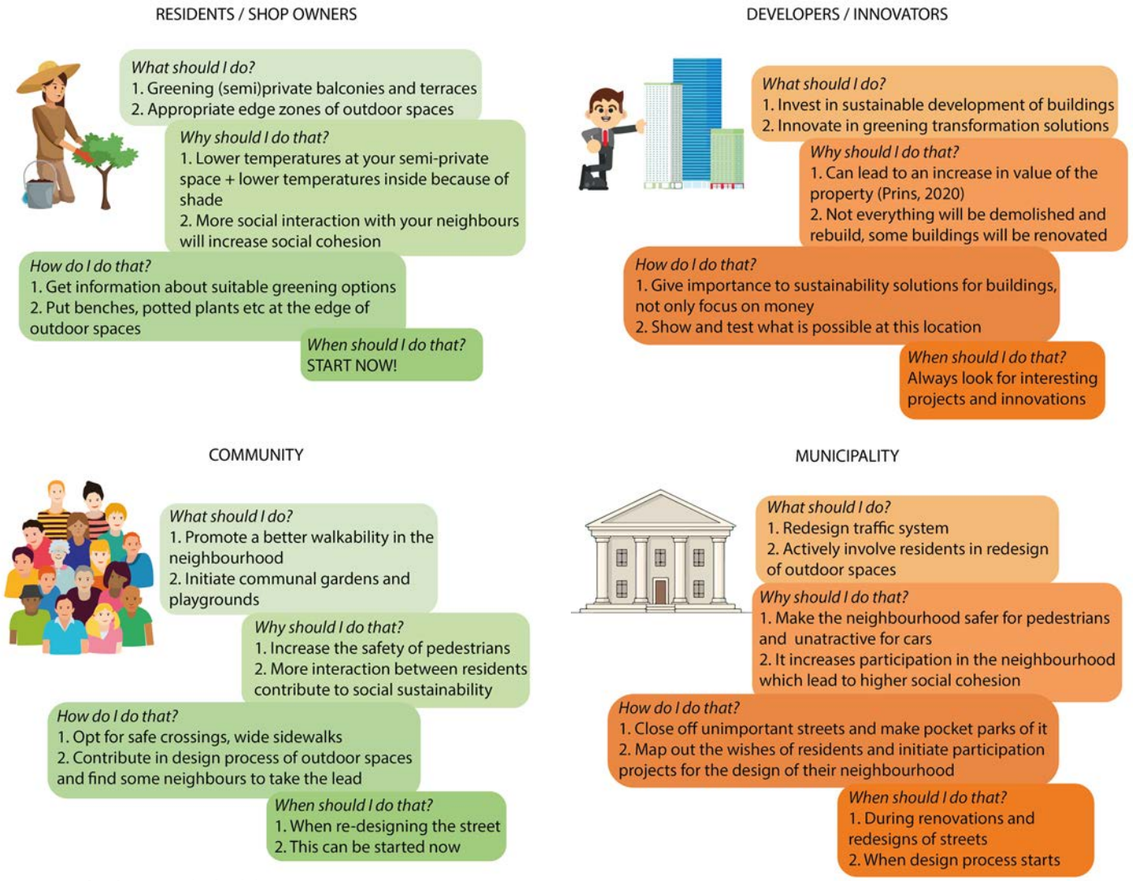

Figure 93 Actions stakeholders

23 MISTO MAGGIOLINA

23.4 PHASING AND STAKEHOLDERS

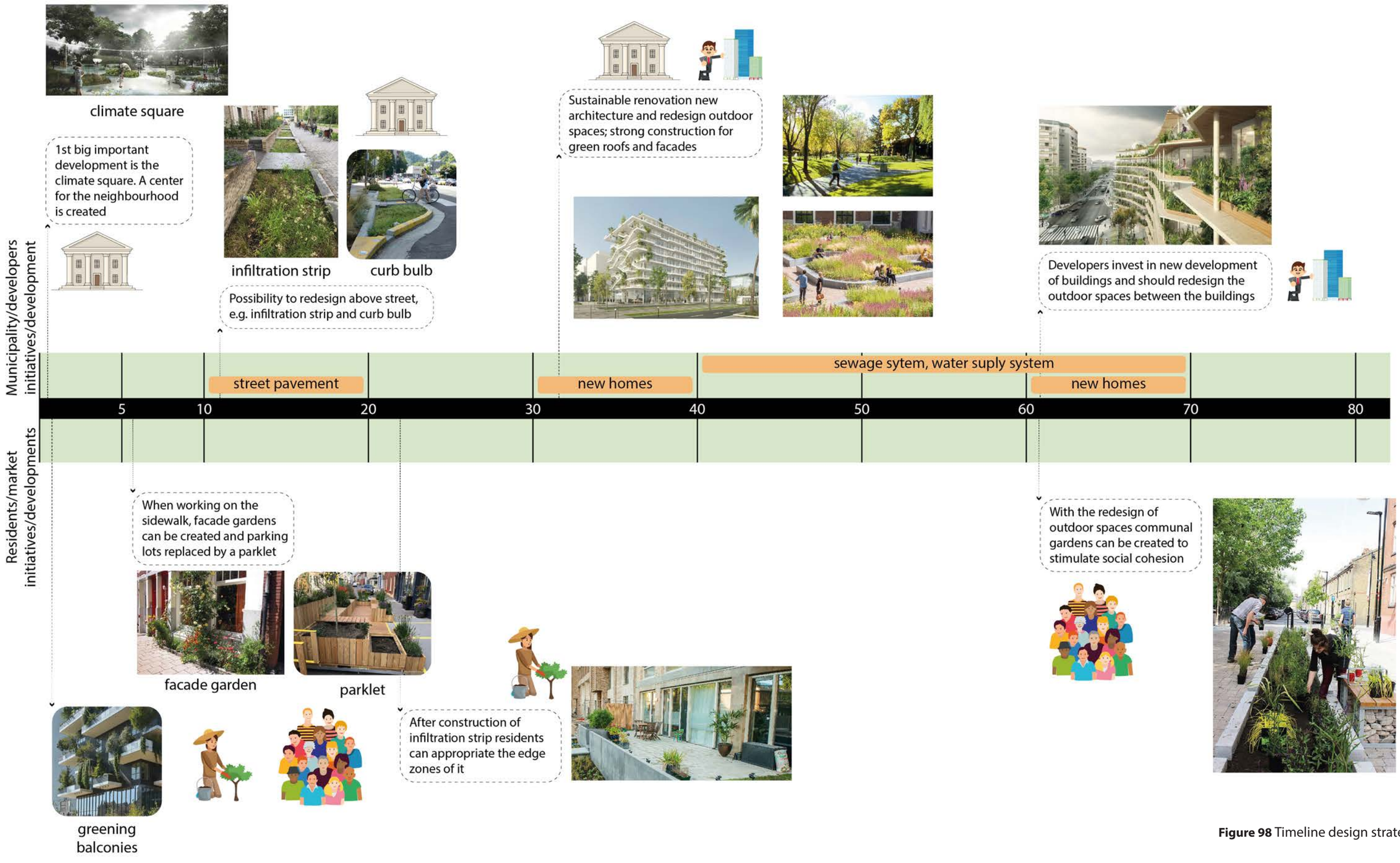

Figure 98 Timeline design strategy

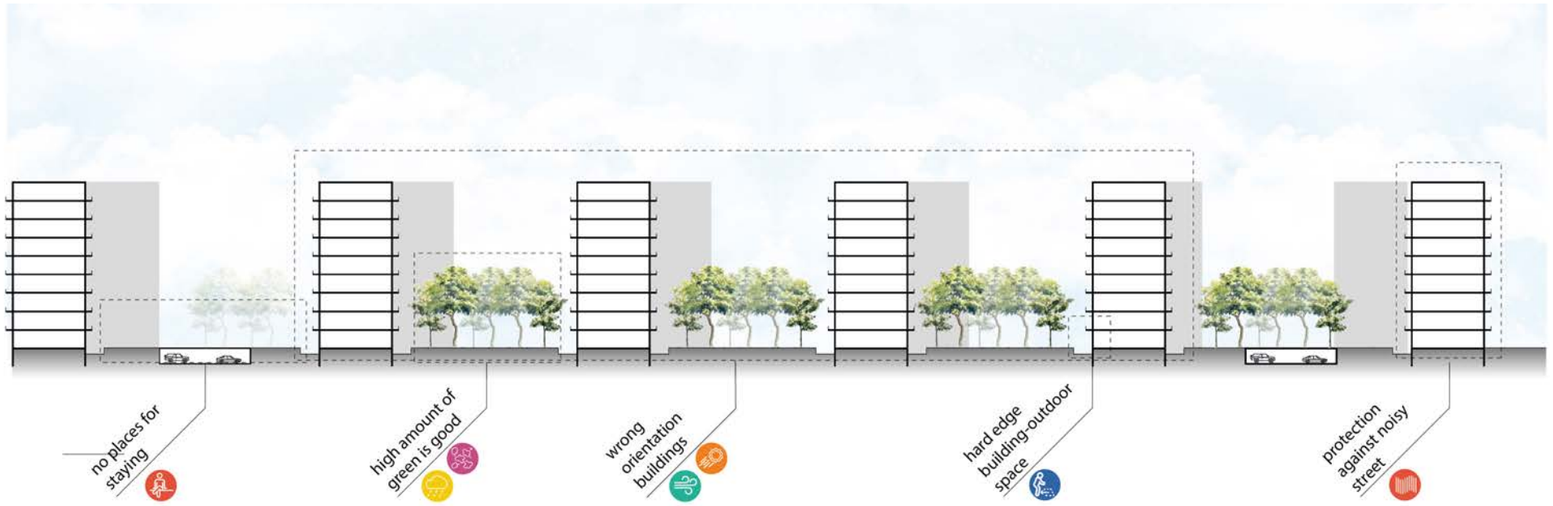

Figure 94 Section A-A' existing

1:1000

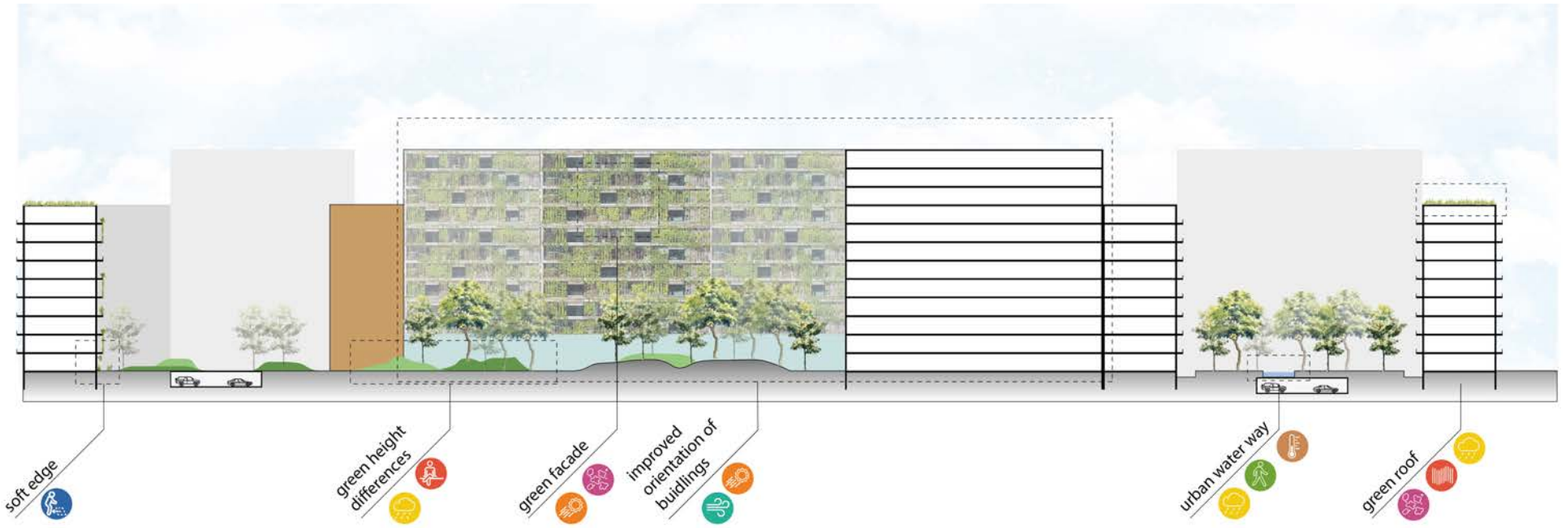

Figure 95 Section A-A' new

1:1000

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23.5 IMPLEMENTATION

The sections A-A' show the transformation of the architecture and outdoor spaces of the neighbourhood. Where in the existing situation the green areas between the buildings had only microclimatic functions, like infiltration of water, avoiding high temperatures and acting as a windbreak, in the new situation the outdoor spaces have given more function. They are accessible to everyone and each space is different instead of all the same kind of green spaces. A better connection between architecture and outdoor space is made by creating an active ground floor with a visible connection between inside and outside.

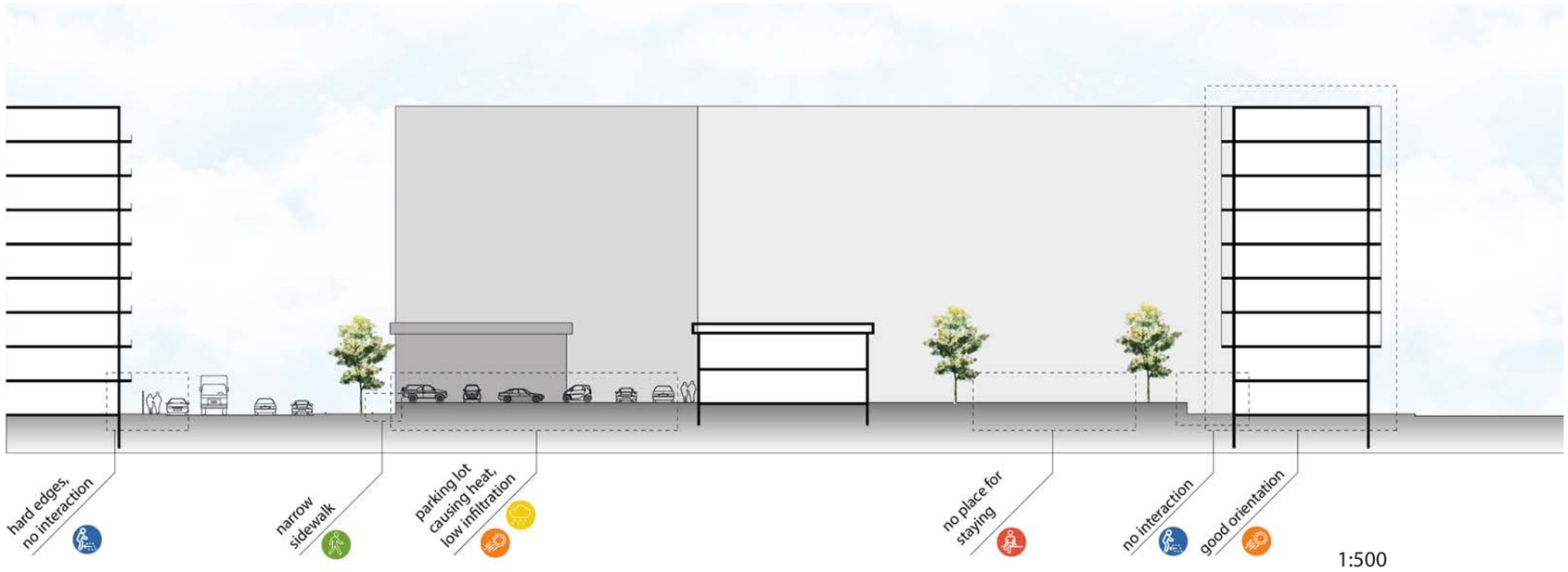

Figure 96 Section B-B' existing

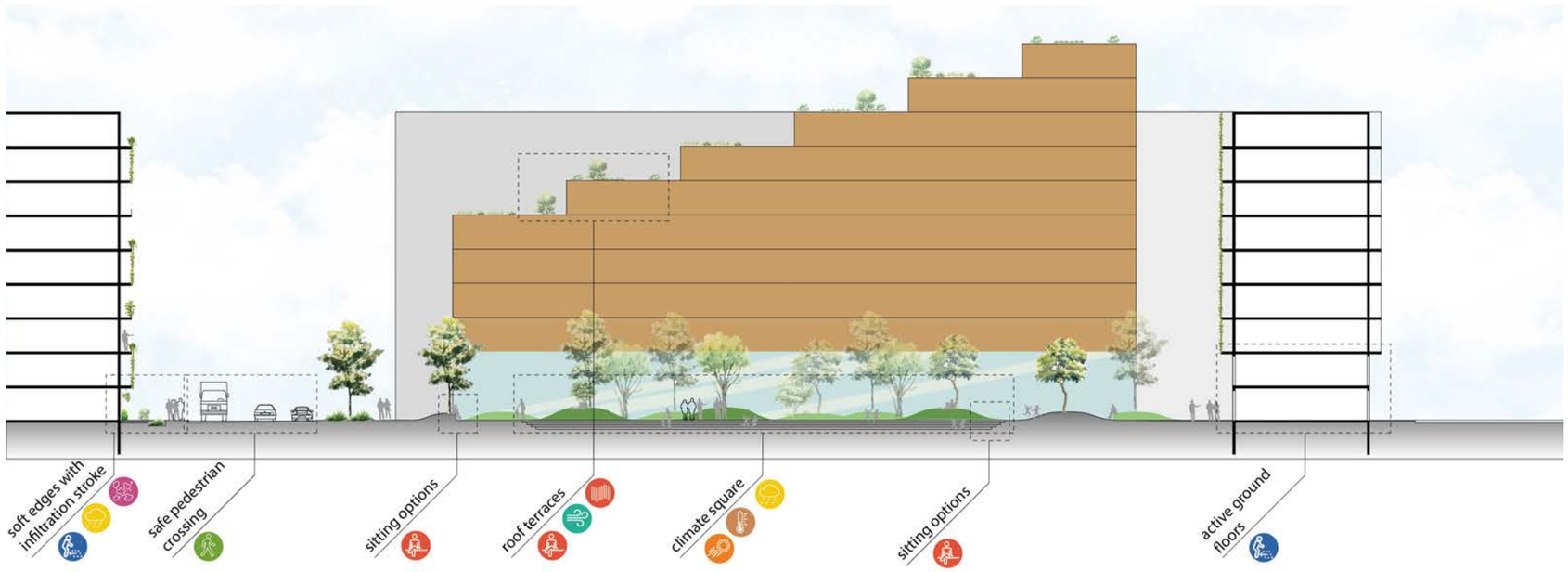

Figure 97 Section B-B' new

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23.5 IMPLEMENTATION

Section B-B' show the transformation of the area in the first phase. A parking lot and some low buildings are removed and a climate square with some new architecture has replaced it. Terraces, orientated to the south, on the roof of the new building create new (semi)private zones which improve the appropriation and create a visible connection with the outdoor space. Sidewalks are widened and made more interesting by the intervention of infiltration strips. By connecting the sewer system of the building to this infiltration strip the problem of water storage in the area can be solved. In further detailed sections, there is also explained who should take responsibility and who should maintain the area. In addition, feedback was provided to literature to substantiate the interventions.

DESIGN STRATEGIES

23 MISTO MAGGIOLINA

23.5 IMPLEMENTATION

Semi-private staying options with a lot of green provide interaction with the outdoor space and improves the air quality and temperature

Green spaces contributes to the quality of life, because they invite social interaction and activities. People meet each other, or join hands to maintain a green playground in the neighbourhood. (Greencities, 2018)

Greening the south facade lowers the temperature (inside and outside), improves the air quality and absorb noise

Trees provide shade, act as a windbreak, allow water to infiltrate and improve the air quality

Buildings can protect the inner areas from wind nuisance cause by high wind speeds and high noise levels caused by traffic

All the green elements and surfaces in the area are causing a lower air temperature.

Drainage of buildings is connected to water bassin in the outdoor space.

1:200

Secondary seating, like steps, offer many opportunities for staying. Steps are really popular because people can sit at different heights, alone or in groups and offer a good lookout point. (Gehl, 2011)

Deepened central square provide temporary water storage and secondary seating options

Combining the green height differences with ledges provide seating options which people can appropriate

Wide sidewalks, interaction between inside and outside, and a lot of detail on ground level are causing an interesting and safe walkability. Residents can move chairs and tables around the site.

Movable chairs and tables provide comfortability and flexibility and increase the appropriation, because residents can make the most of the site, climate and view (Gehl, 2010)

Figure 99 Summary design strategy

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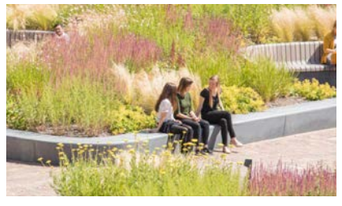
Architecture
LTR: Porte des Ternes, Paris; ANIS office building; Abitare in Maggiolina




Semi-private spaces
LTR: Kop Zuidas (top); Abitare in Maggiolina (bottom); Rebel, Studioninedots; Magic Breeze Sky Villas



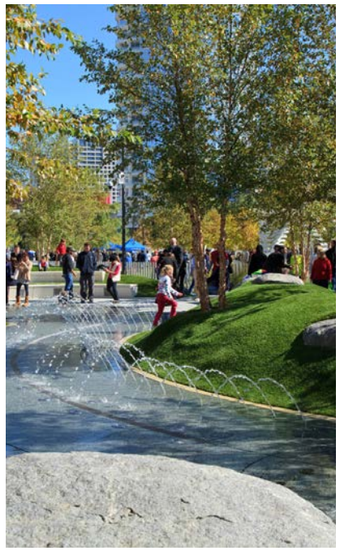


Street furniture
LTR: Cobra Bench System (top), Delfland water authority, Mecanoo (bottom); Winkelcentrum Heyhoef, Tilburg; Climate adapted neighbourhood, Tredje Natur (bottom); New Poznan town hall

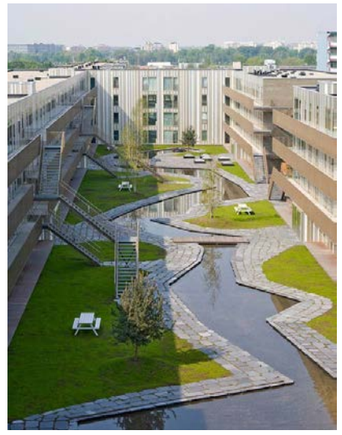
23 MISTO MAGGIOLINA

23.6 VISUALIZATION OF ELEMENTS








Types of outdoor spaces
CW: Roombeek, Enschede; Puddle jumping Welcome; Klyde Warren Park, Dallas; Jo Malone's Fragrance Garden; Climate adaptive neighbourhood, Tredje Natur; De Kameleon; Foothill college, PWP landscape; Water Square, Tiel; Oxford House Pocket Park (center)

A better connection between the architecture and outdoor spaces is created. The hard edge by a fence is replaced by a green zone where water can infiltrate and green is added to the facade. By allowing the residents to appropriate the space behind the infiltration stroke a better connection is created to the urban outdoor space.

23 MISTO MAGGIOLINA

23.7 SITE IMPRESSIONS

The parking lot and a low-quality green area are transformed into a climate square. At this place, people from the neighbourhood can come together and enjoy the green hills and water square. During heavy precipitation events, this square can store a lot of water while during summer it will be a pleasant area to stay.

DESIGN STRATEGIES

24 NUEVO GRECO

24.1 CURRENT CONDITIONS

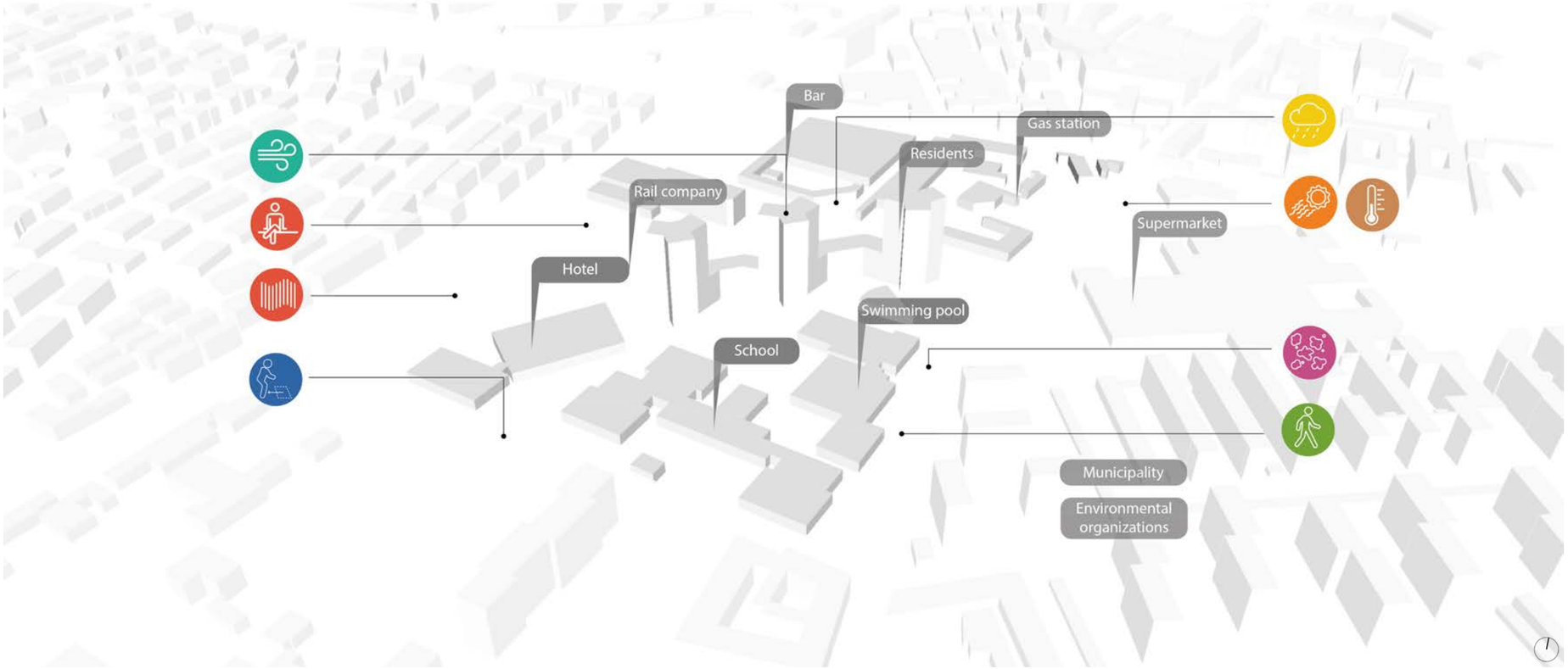


Figure 100 View current conditions

Sidewalks are narrow or not even present in the area. Traffic islands are causing problems for the walkability.

There is no quality in the urban outdoor spaces regarding staying. This area contains multiple degraded spaces.

There is a hard edge between the architecture and the outdoor spaces. It is a very degraded area.

Because of all the paved surfaces temperatures are really high. There are no elements in the area to protect people from solar radiation.

Some alone standing high buildings can create high wind speeds and therefore wind nuisanc.e

Because of all the paved surfaces water can't be easily stored during heavy precipitation events.

Cars in the busy street and at the parking lot of the supermarket are causing air pollution. There are no elements to absorb this pollution.

Train tracks are causing a lot of noise which leads to nuisance regarding conversations and places for staying.

BAD WALKABILITY

NO PLACES FOR STAYING

HARD EDGE ARCHITECTURE

PAVED SURFACES

WIND DISCOMFORT

NOISY TRAIN TRACK

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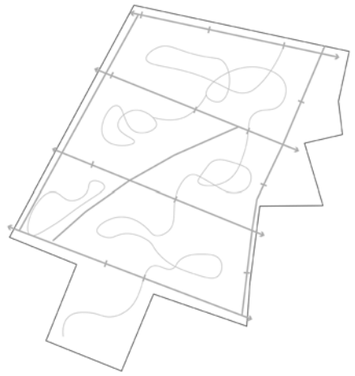
24 NUEVO GRECO

24.2 MAXIMIZATION METHOD

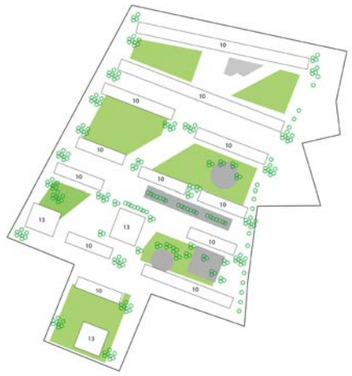
For this site, the Environmental Maximization Method is used during the design process to get a foundation for an urban development plan. For the elements of appropriation and urban microclimate the most desired situation is drawn. In this situation, there are some overlapping similarities, for example regarding green areas. However, there are some issues where the maximization method does not agree, for example with solar and noise. It is desired to place buildings along east-west directed streets but with all the train tracks causing a lot of noise it is also desired to place buildings in a north-south direction to protect the inner areas from noise. So, at this point design decisions should be made by making compromises to get the best design possible given the situation. The specific design rules coming from the Maximization Method are shown in thematic maps on the next pages. This project aims to maximize the design for appropriation and urban microclimate in a very degraded area. It gives the designer a lot of freedom to design according to the principles learned in literature because the area can be considered empty and design can be made from scratch.

WALKABILITY



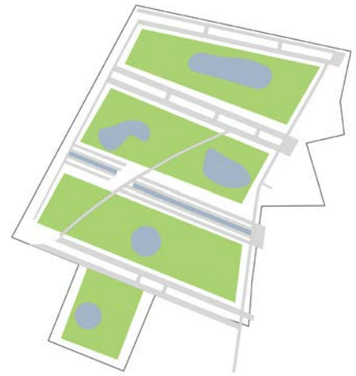
- Wide sidewalks
- Many safe pedestrian crossings
- Curved pedestrian routes

WIND



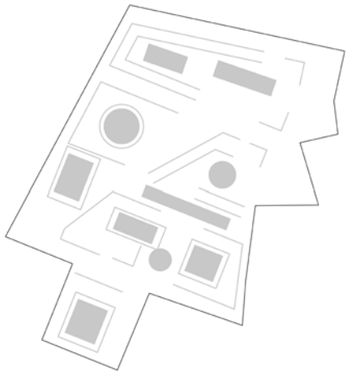
- Create vegetation to slow down the wind
- High wind speeds can be avoided by a building orientation towards the south
- To create some ventilation parks and squares are created
- Buildings have somewhat the same building height

PRECIPITATION



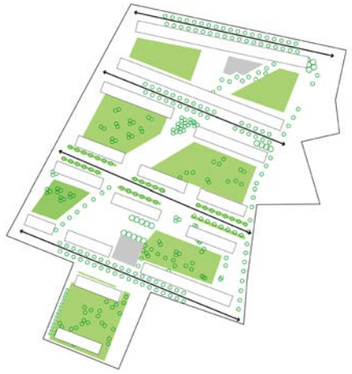
- Create height differences, like sidewalks, to provide dry feet at higher placed surfaces
- Create green/blue surfaces to store water and provide a good infiltration

PLACES FOR STAYING



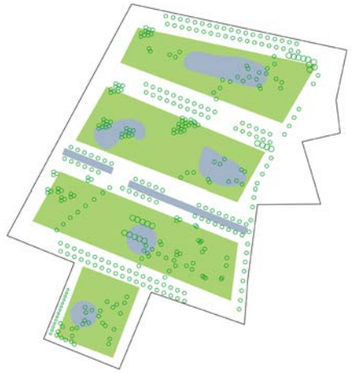
- Wide variety of outdoor activities
- Wide variety of sitting options
- Good edges around squares/parks
- Active ground floors
- Visibility between inside-outside
- Semi-private staying options at edges

SOLAR RADIATION/TEMPERATURE



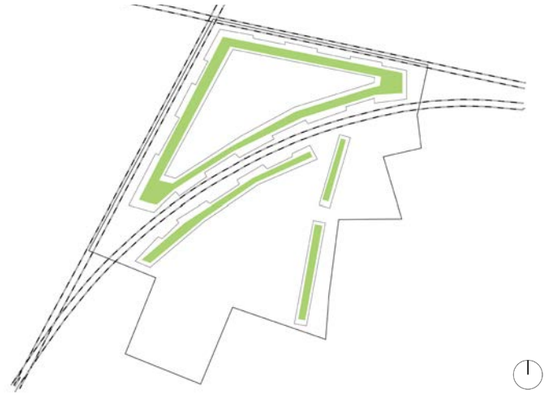
- Buildings towards south along wide east-west directed street
- create squares and parks
- provide shade options

AIR QUALITY



- Outdoor stying areas are placed at a distance from heavy polluted streets
- Create ventilation by creating intersections at short intervals
- Provide green elements to absorb air pollutants

NOISE



- Inner areas should be protected from noisy streets. This can be done by buildings with a green roof

24 NUEVO GRECO

24.2 MAXIMIZATION METHOD - DESIGN RULES

- Row of buildings should protect the inner outdoor spaces from noise from busy streets
- Buildings are orientated to the south along an east-west street. The solar gain is very high and tunnel effects for wind are avoided.
- Minimize the height differences in building height. Avoid buildings that are two times higher or more than 15 meters high.

Figure 101 Building design rules

- Create a network of green spaces through the neighbourhood. Different green spaces can be connected by green elements in the streets.
- Add green at places where problems occur regarding high temperatures, bad infiltration of water

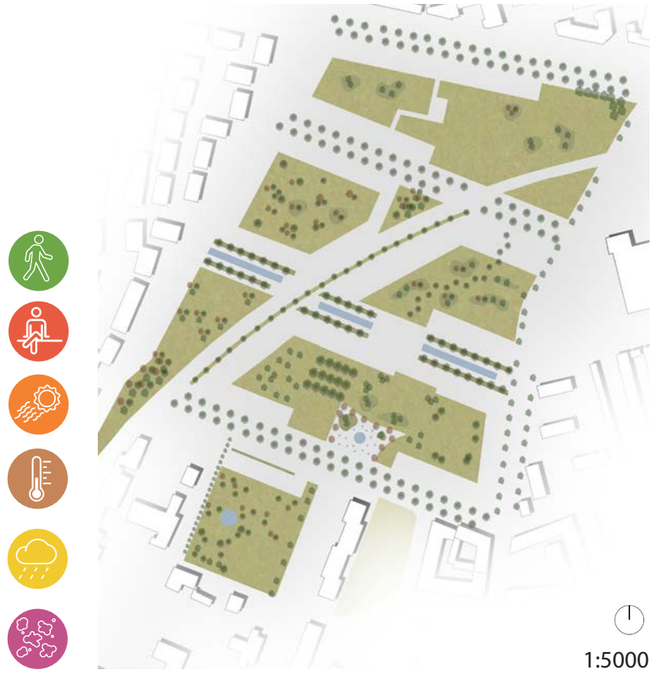


Figure 102 Green design rules

Figure 103 Outdoor spaces design rules

- Open up the urban outdoor spaces and make it accessible for everyone.
- Create different kinds of functions in the urban outdoor spaces

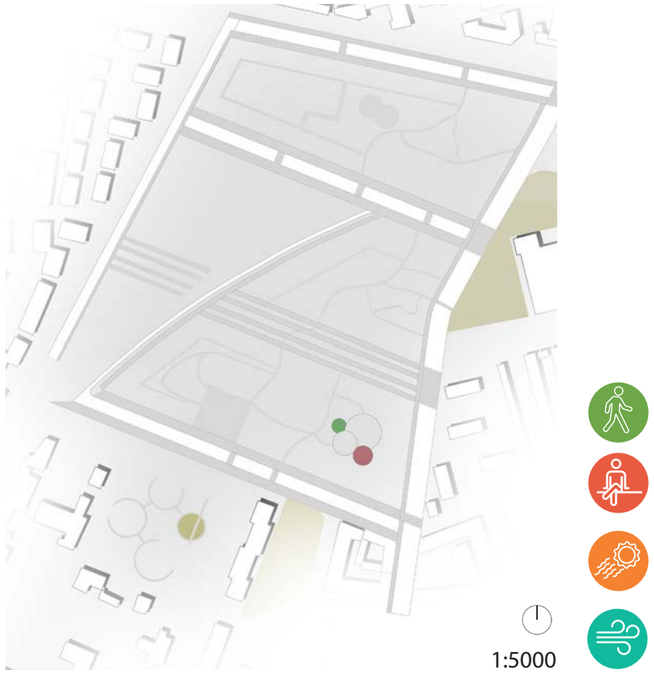


Figure 104 Street design rules

- Create wide east-west streets and narrow north-south ones.
- Close roads where they are not really necessary to give that space back to the pedestrians
- Give priority to the pedestrians in the street. This means: wide sidewalks, enough possibilities to cross the street, safe crossings

DESIGN STRATEGIES

24 NUEVO GRECO

24.3 URBAN PLAN

1:2000

Figure 105 Urban plan 2100

This third project is about a totally new development in a very degraded area in the city. This project is chosen to show how to design a sustainable living area from scratch, except for some important elements like the train tracks. With the knowledge that the city will grow more in the future, it is important to look for opportunities to densify degraded areas in the city. Together with the densification of the area sustainable outdoor spaces should be created. With the help of the guidelines, maximization method and 'climability' design solutions the aim is to create an urban plan for the future which is social- and environmentally sustainable. It is a large area, so I limit myself to initiating urban planning principles. In a real project, the area is divided into sub-areas where the detailed design of the sub-areas should be done by a team of urban- and landscape designers and architects, executors etc. In the area some standard street profiles can be found; a pedestrian street, north-south directed street and east-west directed street. North-south directed streets should be narrow to avoid overheating and provide shade during the summer. These streets are close to the train tracks and therefore less pleasant to stay for a longer time. East-west streets can be wide and space for green elements should be created in these streets. During summer these green elements can provide shade and improve local temperatures, where in winter they allow solar radiation to come through. The wide profile gives the pedestrians a lot of freedom for activities and this will enhance the social cohesion. To densify the area there is chosen for a mix between large building blocks and towers. This allows a high population density and offers a lot of urban outdoor space. These outdoor spaces should be very green and should have different opportunities for appropriation. An important factor in the area is the presence of the train tracks. These can produce a lot of noise, which is unpleasant for the microclimate and therefore the appropriation. In this project, there is an opportunity to show the relation between urban design and architecture. With a typology of high building blocks and towers, there is a danger of little connection with the outdoor space. In the section on page 168-169, a solution to that is shown.

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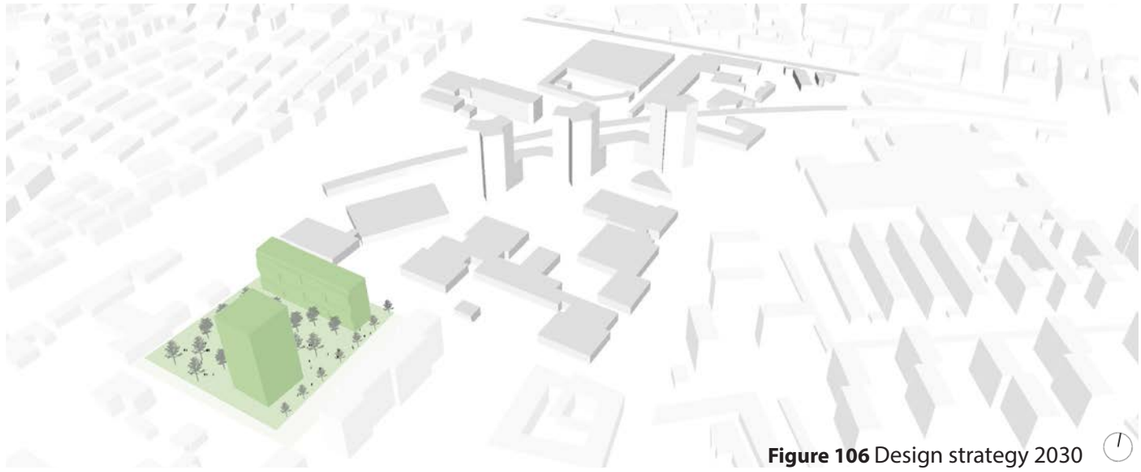

Figure 106 Design strategy 2030

Figure 107 Design strategy 2050

Figure 108 Design strategy 2100

24 NUEVO GRECO

24.4 PHASING AND STAKEHOLDERS

In the first phase of the strategy, the project "Abitare in Maggiolina" is executed. This project is already started and fits well within my vision. A combination of building block and a tower on a big plot gives a lot of urban outdoor space where a green character is given to that space. A fountain is a central point where social life will be formed. In the second phase, the most degraded part of the area is transformed. Between the train tracks, a combination of building blocks and towers is created where the architecture protects the outdoor spaces from noise so that social life is very pleasant in those outdoor spaces. Opportunities for roof terraces are created to provide a new kind of semi-private space for the residents. These semi-private spaces contribute to the activity level on the street and offer opportunities for social interaction. From 2050-2100 the rest of the area can be changed where there is also the transformation of the school. This gives the opportunity to educate children and parents about climate change and liveability by creating a climate playground next to the school. Also in this project, it is valuable to look for connecting opportunities within urban outdoor elements. The municipality looks for opportunities with developers and housing associations to redesign buildings and give more quality to urban outdoor spaces. With collaboration between stakeholders, support is created for the interventions, like community gardens which are maintained by local residents. This will increase the social cohesion in the neighbourhood.

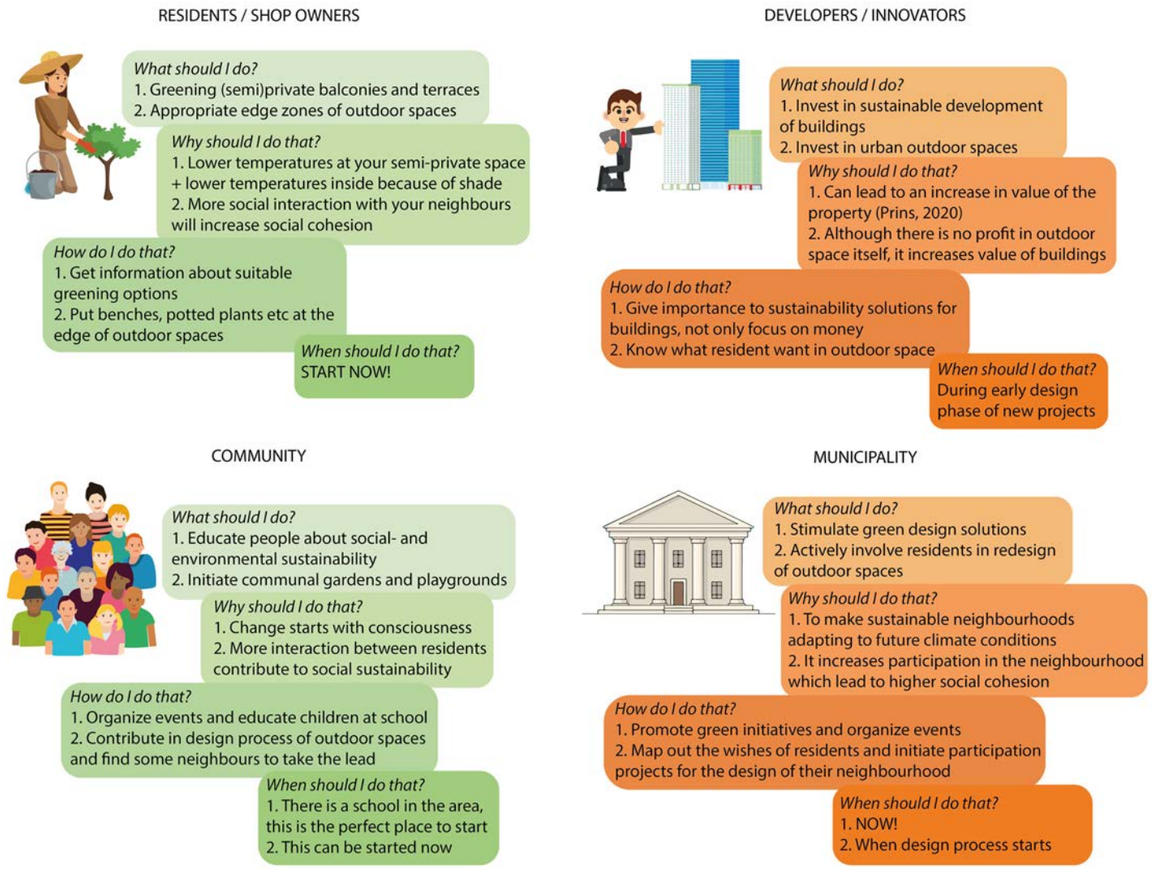

Figure 109 Actions stakeholders

DESIGN STRATEGIES

24 NUEVO GRECO

24.4 PHASING AND STAKEHOLDERS

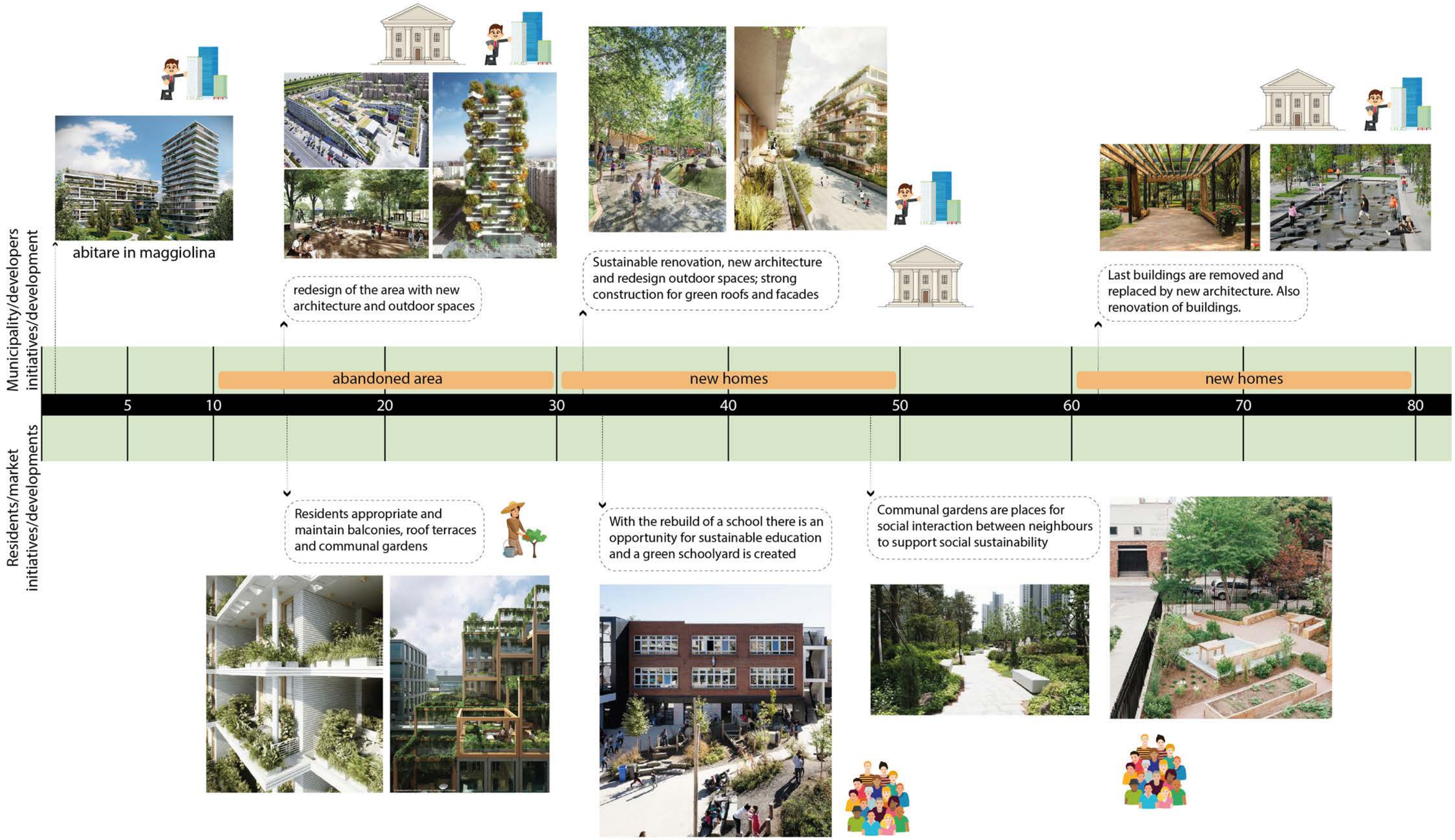

Figure 110 Timeline design strategy

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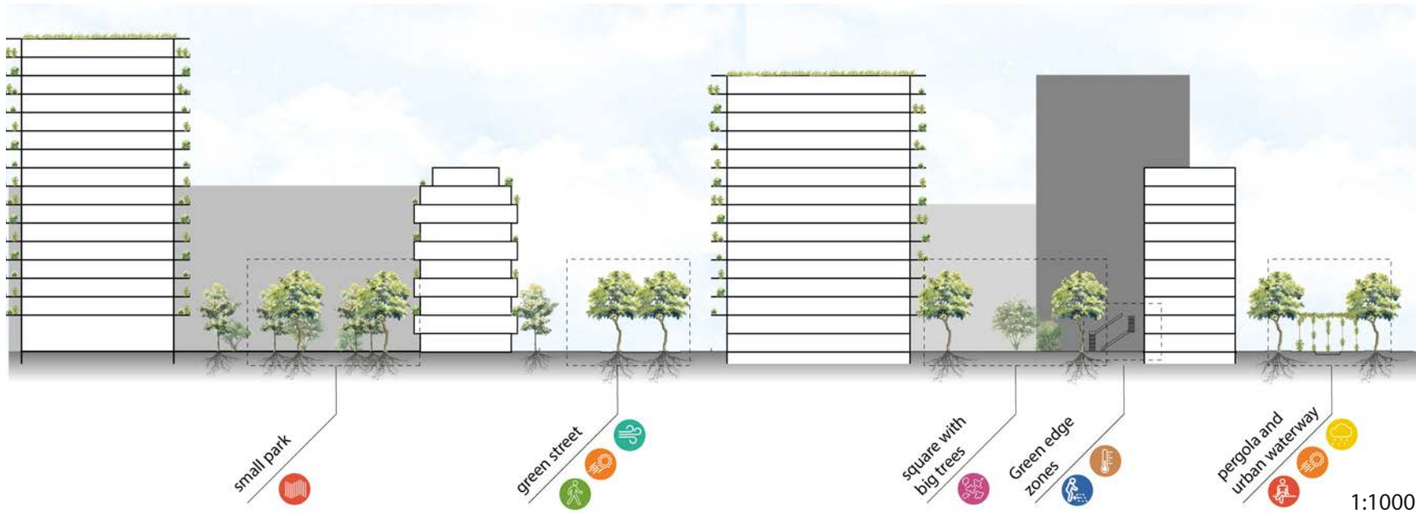

Figure 111 Section A-A'

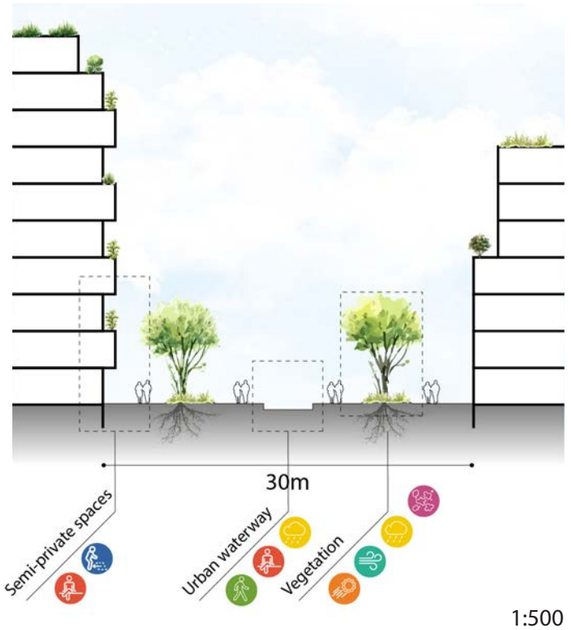

Figure 112 Street profile pedestrian zone

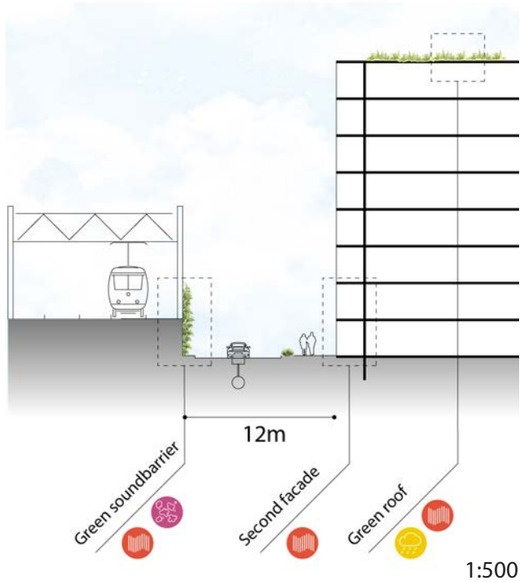

Figure 113 Street profile along train tracks

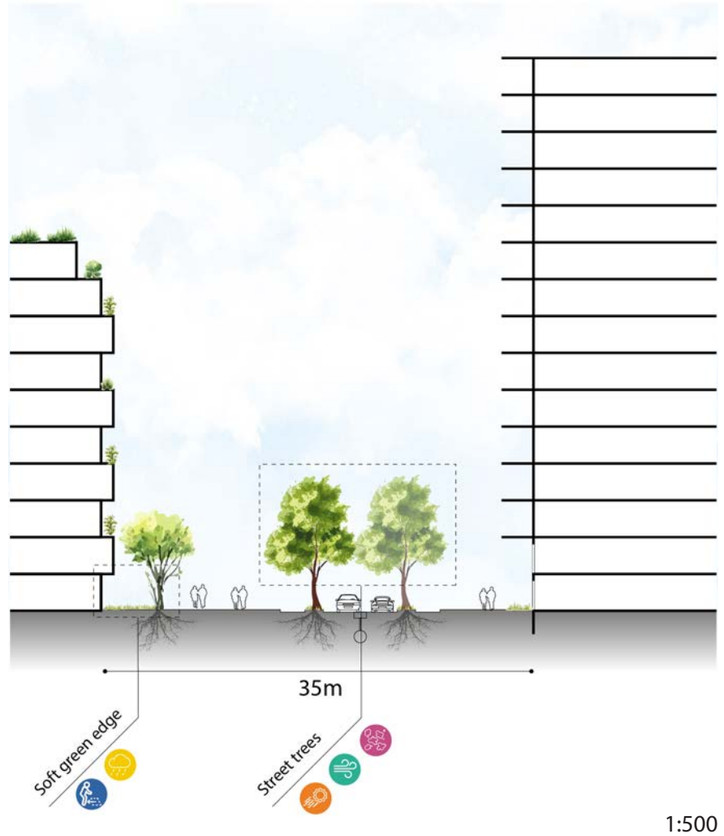

Figure 114 Street profile east-west street

24 NUEVO GRECO

24.5 IMPLEMENTATION

The sections show the different street profiles that are created and section A-A' shows the elements and qualities of the architecture and outdoor spaces. The icons show to which elements the solutions are applied. In the detailed section on page 168-169, an elaboration of the relation of architecture and urban design is shown. An active ground floor should provide a visible connection with the outdoor space and for residents placed higher in the building a fast connection with the outdoor space can be created by providing stairs directly into the outdoor space. In addition, feedback was provided to literature to substantiate the interventions.

DESIGN STRATEGIES

24 NUEVO GRECO

24.5 IMPLEMENTATION

Variation in greenery, big and small, high and low, and in different colours enhances the experience of the pedestrian routes and therefore increases the appropriation (Klemm, 2018).

Green elements and surfaces in the area provide shade and lower temperatures, improves water infiltration, and air quality and can give protection against wind.

To promote appropriation around multistory buildings in residential areas places for outdoor stays are placed at places where it is easy to enter and exit, in this case at the staircases (Gehl, 2011)

Staircases that enter the outdoor space provide a faster and better connection between architecture and outdoor space. This will improve the social cohesion and make that people feel more responsible to the space.

Outdoor spaces meant for recreation are places at a distance from noisy sources like busy roads and are protected from sound by architecture and vegetation.

People staying in their semi-private zones show a picture of activity in the area and will promote activities in the outdoor space. When these spaces are made green it improves the temperature and air quality

1:200

Benches placed at different locations along pedestrian routes improve the walkability and offers a choice to people where to sit, e.g. in the shade of trees.

"Edge zones to which users have easy accss and can furnish and fit our are used more intensivvely than all the other staying options in the city. The user group is well defined and the option is right at hand" (Gehl, 2010).

1:100

Figure ??: Section A-A'

Figure 115 Summary design strategy

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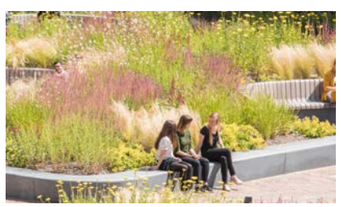
Architecture
LTR: Tirana vertical forest; Abitare in Maggiolina (top); Hangzhou Duolan Complex (bottom); Housing ZAC croissant


Semi-private spaces
LTR: Kop Zuidas (top); Abitare in Maggiolina (bottom); Rebel, Studioninedots; Magic Breeze Sky Villas





Street furniture
CW: Cobra Bench System; Donghu Park; New Poznan town hall; Climate adapted neighbourhood, Tredje Natur; Delfland water authority, Mecanoo

24 NUEVO GRECO

24.6 VISUALIZATION ELEMENTS

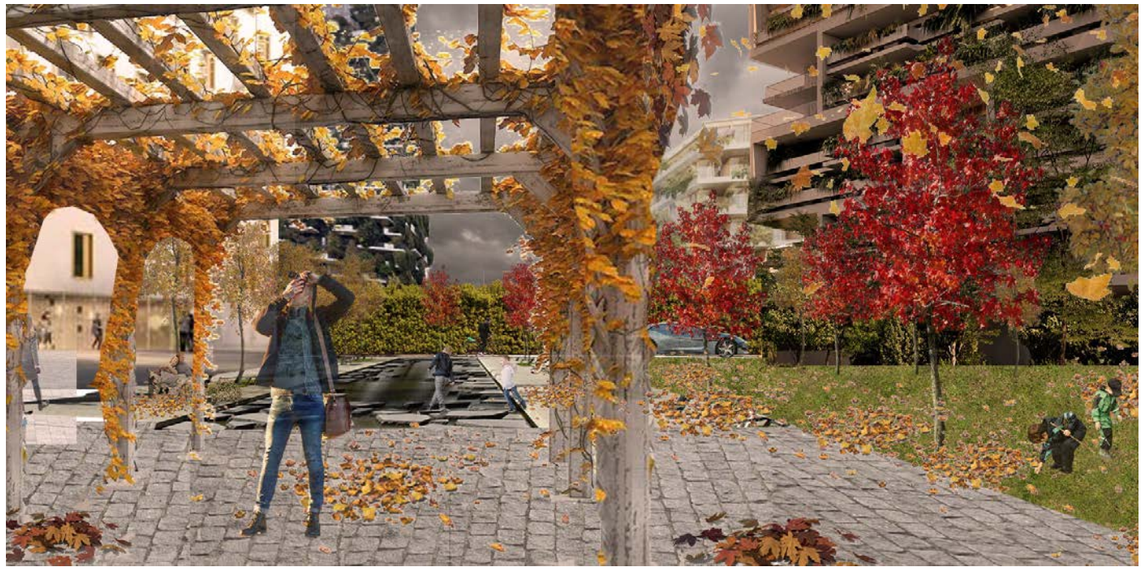






Types of outdoor spaces
CW: Tokyo Plaza Omotesando Harajuku; The Healthy Urban Life Data and Knowledge Hub; Foothill college, PWP landscape; Roombeek, Enschede; Gateway fountain; I'm Viadukt, Zürich; Abitare in Maggiolina; Sint Lutgardis

In this pedestrian zone, multiple qualities can be found in urban outdoor spaces. The space under the train tracks is transformed into shops and creative businesses from the old situation are moved here. The green character invites people to come outside and appropriate space. Architecture in the context of 'Bosco verticale' improve the area and have multiple advantages regarding climate.



In this pedestrian zone multiple qualities can be found in the urban outdoor spaces. The most important element in this east-west orientaded pedestrians street is the urban waterway. Along the waterway benches and trees are places to offer different places for staying. The pergola offers protection to the sun during the hot summers.

24 NUEVO GRECO

24.7 SITE IMPRESSIONS

The exact designs of this project should be created by an integral team of architects, urban- and landscape designers, civil engineers, climate experts, etcetera. Together a sustainable environment is created with attention to the social- and environmental sustainability. These impressions show what the area could look like. The whole area should have a green character, where green in the street and on the buildings have multiple advantages regarding appropriation and urban microclimate. By showing the impressions in different seasons the project aims to get an understanding of the solutions. The projects should be inviting, interesting and flexible during day and night, in spring, summer, fall or winter and for everybody accessible. Target groups should be clear to create outdoor spaces for their preferences, like a water square with sprinklers where children can play and enjoy while the parents watch and have conversations with other parents. In this way, the project aims to address the problems of climate change and liveability and aims to preserve the qualities that Milan has to offer.

A square with different fountains offers a lot of activities in the area. Surrounded by greenery with benches people can appropriate the space and watch children playing in the water. The architecture is well connected to the area by creating green balconies with a view on the square.

PART 5 CONCLUSION AND REFLECTION

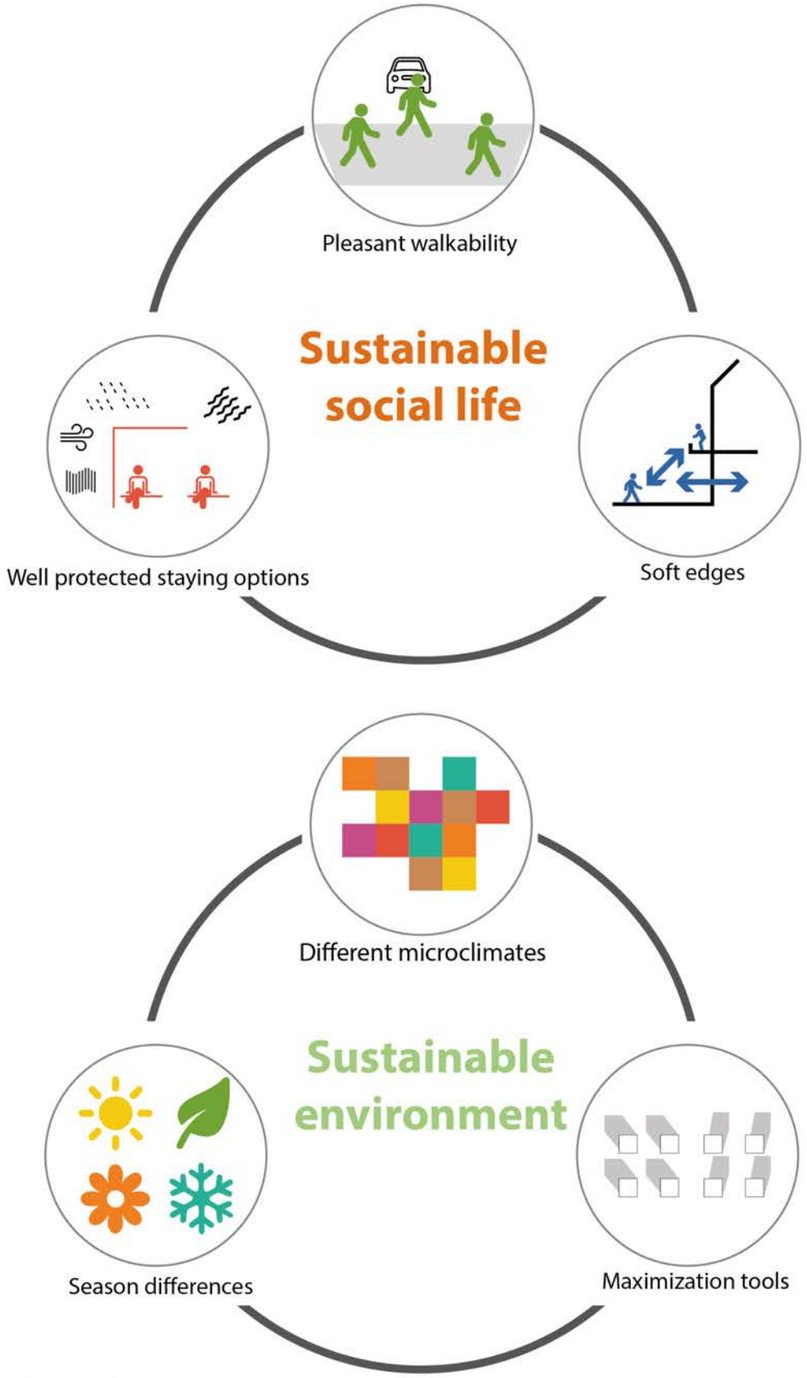


Figure 116 Conclusion drawings

25 CONCLUSION

To research the sustainable development of cities towards 2100 the following research question was developed: **How can urban design improve the (temporary) appropriation and the urban microclimate in urban outdoor spaces to contribute to a sustainable Milan towards 2100?**

There is no one answer to this question, where sustainable development can be achieved in many different ways. However, to answer this question in the context of this research project different topics were researched where urban design guidelines were made from. These guidelines are spatially translated in a toolkit that shows interventions which improve both appropriation and urban microclimate and which is called "climability solutions for urban design". These solutions are applied to three projects in Milan to show how the transition for sustainable development is made.

23.1 Stimulate (temporary) appropriation

Literature shows that temporary appropriation of urban outdoor spaces contributes to the social sustainability of places and therefore, urban designers should create conditions to stimulate this appropriation (Lara-Hernandez & Melis, 2018). This can be done by looking into three different categories of appropriation: walkability, places for staying and soft edges of urban outdoor spaces. For the walkability of an area, the most important aspect is to create space for pedestrians (Gehl, 2010). Pedestrians should have a higher priority in urban planning. Urban designers can create pleasant conditions for pedestrians by designing wide sidewalks and safe crossings, interesting pedestrian routes and avoid obstacles like height differences or elements on pedestrian routes (Gehl, 2010). Pleasant walkability will contribute to the quality of spaces and in that way to the appropriation of urban outdoor spaces. To stimulate the appropriation in terms of staying, urban designers should create well-protected places to stay. Moreover, urban designers should create a wide variety of opportunities for sitting and this means a combination between primary seating, like benches, and secondary seating, like stairways or ledges (Whyte, 1980). A good design of edges of urban outdoor spaces stimulates the appropriation of those spaces. (Semi)private options, like balconies or front gardens, create an opportunity for interaction in the street and therefore contribute to the social sustainability of urban outdoor spaces (Gehl, 2010; Lara-Hernandez & Melis, 2018). Regarding edges, the relation with the architecture is very important because a connection between inside and outside improves the activity level. The most important conclusion regarding appropriation in the context of social sustainability is that designers should integrate choice in their design of urban outdoor spaces. People like to have many options that suit their preferences. Urban designers can provide these choices by analyzing urban outdoor spaces to see what is needed and by critically planning sitting options, options to cross the street and to prioritize the pedestrians in the urban outdoor spaces. When people feel comfortable in the space they will appropriate it, and for a longer period of time, which in turn will stimulate others to appropriate the space and so on. In this way, the activities support the social life and social sustainability of the urban environment.

23.2. Design the urban microclimate

Literature shows that the design of the urban environment highly influences the microclimate which is perceived by people (Pijpers-van Esch, 2015). So, for each climate element different guidelines are important that urban designers should take into consideration. However, sometimes the guidelines are in contrast with each other. Therefore it is important to see what is really needed in that specific area, where we now know that the microclimate is different at each place in the city (Brown, 2010). Important to know is that the presence of the sun is appreciated during the cold winter, while it should be avoided during the hot summer. So urban designers should create places with the opportunity to walk or sit in the shade. Regarding wind, high wind speeds should be avoided, while during the summer a cool breeze is very welcome (Brown, 2010). Urban designers should take more often the heavy precipitation events into their design, so places to store the water should be created. There are tools that urban designers can use for designing the urban microclimate, where it can be difficult to apply all the guidelines for each climate elements. Digital programs can help to analyze the site and can improve the design when it is used during the design process. Moreover, urban designers can use the maximization method where first the ideal

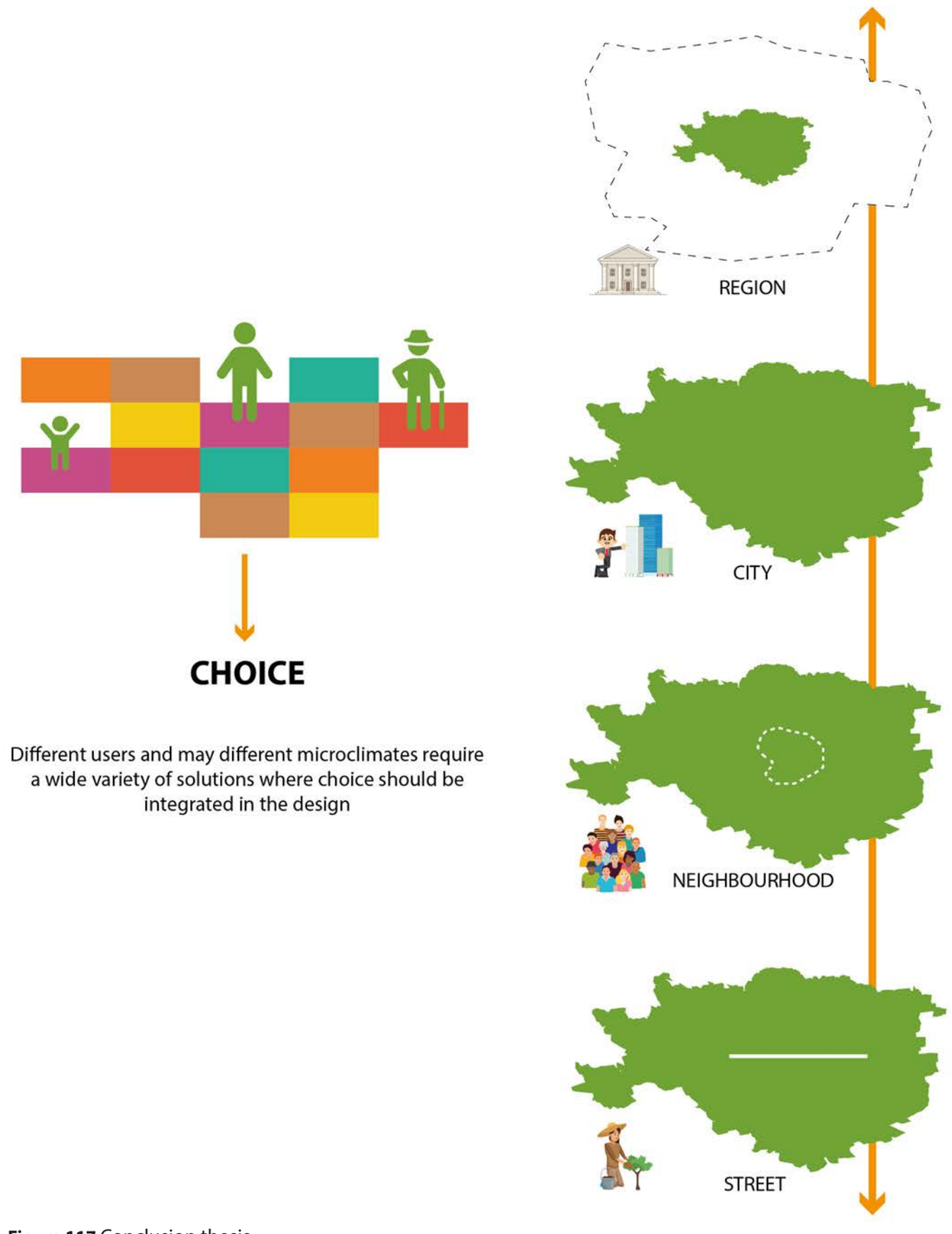


Figure 117 Conclusion thesis

25 CONCLUSION

situation for each climate element is drawn on the site after which compromises should be made to maximize the design of the urban microclimate. The knowledge of urban microclimate is there, the methods that help to design with microclimate are there, and still in the developing process, so now urban designers should see how important an environmentally sustainable development of cities is in the future. In other words, cities should become more climate aware to enhance the quality of life in urban outdoor spaces.

3. Climability of urban outdoor spaces

Urban microclimate has many different effects on the appropriation of urban outdoor spaces. Urban designers should aim for solutions that improve the urban microclimate on the one hand and the liveability on the other and there are many ways to do that. First of all knowledge about the microclimatic conditions of the area is needed and the behaviour of people according to those conditions. With that knowledge designers can create pleasant conditions in the urban outdoor space and the users can appropriate it in their way. Greenery, for example, has a lot of advantages for appropriation and microclimate. However, it is not so much about creating more green, it is more about creating effective green. Therefore a strong analysis of the site is needed and designers can create adaptable and flexible solutions for the problems and opportunities. The most important lesson urban designers should take from appropriation and urban microclimate is that choice should be integrated into a design. Many different people are appropriating urban outdoor spaces and all these people have different preferences. In general, elderly people prefer to sit in the shade where other people do like a bench in the sun. To make cities sustainable interventions for appropriation and urban microclimate are needed and for the implementation of the design solutions, this should work at different scale levels. The interventions should take place at the scale of the district towards the building. This will mean that each intervention has different time periods for implementation, different stakeholders and costs. So it is important for urban designers to know which stakeholders they should integrate into the process to make an intervention successful. Therefore a good collaboration between actors should be integrated into the design process. The municipality can make improvements on the large scale, while residents can make differences on the smallest scale. It is possible that small scale interventions are easily created, cheap and possible with only the cooperation with residents, while large scale interventions require a lot of planning, participation between a lot of stakeholders and cost more. Urban designers can steer a bit in this process. They can create the conditions in urban outdoor spaces so that the residents can fill it in like they prefer while the desired outcome is accomplished. In the end, designers should create choices for people. In this way, users can make the most of the space, socially and environmentally (Gehl, 2010).

4. Recommendations

The most important recommendation for urban designers is to go to the place of the project and feel what this place is like and to interview people in the neighbourhood to understand their needs and ideas about sustainability. The residents are in the end the users of the outdoor spaces, so it is important to know how they experience the microclimate and what they think will help to enhance the social cohesion in the neighbourhood. By involving residents, support is created which will help the successful development of the city. To optimize the design regarding climate an analysis of activities in the space should be done in different seasons of the year: summer, fall, winter and spring. Next to interviewing residents, the knowledge of professionals in the fields of social- and environmental sustainability will help, especially professionals with knowledge about the project area.
My second recommendation is to research the topics more in-depth. There is so much knowledge to gain about the way urban designers design outdoor spaces. Moreover, it would be good to research other elements of climate problems, like drought and flooding.
My third recommendation would be to use digital tools for designing urban microclimate. In this research, for example, ENVI-met was used to analyze the key projects on their performance of climate. However, it would be really informative to use this tool also in the design process. It will be time-consuming, but the results of the design would be more precise.
My last recommendation is to look for collaborations between professional experiences. Because urban development requires knowledge about buildings, infrastructure, vegetation, social issues and many more topics, it is very valuable to find the collaboration between urban- and landscape designers, architects, civil engineers, climate experts etcetera.

The current Milan is characterized by paved surfaces, cars and is challegging very warm summers. Through strategis prjocts within the urban landscape of Milan, the city will create a pleasant outdoor comfort where people appropriate the urban outdoor spaces under pleasant climate conditons. Milan has created a sustanable and resilient living environment throught the whole city. All these sustainable developments are connected with eachother to form one network of environmental and social sustainability. Milan is a sustainable city made by a strong collaboration between municipality, advisers and it's residents.

Societal relevance
Climate change potentially affects multiple issues of a sustainable society, where it can have an effect on developments of health, equality, housing and liveability (WHO, 2011). It is shown that climate change and extreme weather events influence different parts of the life of people, where it affects, for example, the basic requirements for health - clean air and a safe sheltered place - or it causes emergency events (flooding, drought or extreme heat waves) (WHO, 2011). Moreover, Lenzholzer (2013) argues that for people the microclimatic environment is of life importance because our physiology functions only in a relatively small range of temperature- and wind conditions.
Looking into the future, there is a risk for cities that life on the streets will disappear because of changing climate conditions and the deterioration of urban outdoor spaces. A potential effect is that society will change too because public life will be more inside than outside when the outdoor conditions are poor. Thermal comfort in indoor environments can be very well designed, so when the outdoor conditions are poor people will look for pleasant indoor conditions. However, almost 80% of the city consists of urban outdoor space (streets, parks etc) and social life is part of those urban outdoor spaces. It is not desired that social life will disappear in urban outdoor spaces because of the poor climate conditions. Especially in the context of Milan, where very high temperatures occur during summer and this will get worse if nothing is done.

So it is of high importance that a livable and pleasant environment will be created for people. With the problem of climate change, research about the effects of this change on people is relevant where knowledge about the upper and lower limits to the range of 'acceptable' conditions for people is welcome when designing comfortable urban outdoor spaces (Erell et al., 2011). Urban designers should know what conditions people feel comfortable in urban outdoor spaces.
Therefore it is relevant to conduct research about these changing conditions and how urban designers can play a role to enhance the quality of life in urban outdoor spaces, where environmental and social sustainability should be created. The social part is in this story very important because people are the ones who are using urban outdoor spaces in the end.

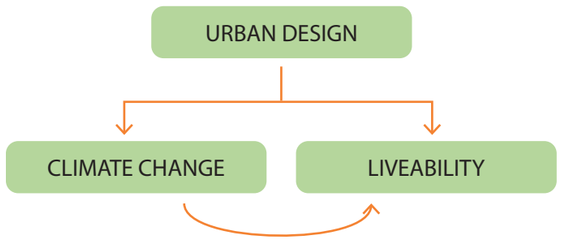


Figure 118 Research relevance

Relation research and design
Urban design is in my opinion about the spatial translation of problems we find at different scale levels, like the city scale or neighbourhood scale. These problems can be researched in different ways, theory- or design-based. Theory-based research is important to get an understanding of the problems to be addressed. Design-based research shows the spatial problems and opportunities that belong to the topic. In this project both theory- and design-based research is used. In the first part of the research, the topics of appropriation and urban microclimate were studied with literature, aiming to learn the basics and see how designers can translate theory into a design. In the second part of the research project, research through design was used as a research method. By applying the knowledge from theory into the design and reflecting on it the aim was to make the design better. With design solutions test can be made to show if ideas will work or not. The role of the mentors in this process was really important. My mentors tried to give me the advice to bring the graduation project to the next level. The mentors have certain knowledge about literature appropriate to the topic and have skills regarding designing urban environments. Through the whole project, my ability to make a sufficient project was ok, however, my mentors helped me to make the project even better by giving advice and suggestions and this shows that teamwork leads to better projects.

Already in the '70s and '80s, the relationship of urban microclimate and the appropriation of outdoor spaces is described by Jan Gehl and William Whyte. They are talking about ways to enjoy the weather or about ways to protect people from bad weather. However, what they don't really describe is how

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design interventions can both contribute to social and environmental sustainability at the same time and how these solutions can be applied and performed by the stakeholders, this is elaborated on pages 184-185. In my graduation project, I have tried to build on their ideas and add new knowledge to it. For example, green places improve the adaptation to climate conditions by providing a cooling effect and improve the water storage capacity during extreme rainfall. At the same time, these green places invite social interaction and therefore improve the quality of life. Residents maintain a green playground in their community which will lead to social interactions (Green cities, 2018).

Advantages and limitations of the chosen methodology
The chosen methodology is strongly based on literature. This will have some advantages and limitations. Advantages are for example that results from the research can be made scientific by reflecting it back to literature. Literature gives a strong basis for the whole project, where it will be easy to refer to the literature to make your point stronger. However, research-based on literature will have some limitations. For example, the impression is made that other perspectives are limited and eliminated. This should not be the case. The use of literature should always be placed in perspective and the researcher can reflect on the use of it. The choice for making a design toolkit also has some advantages and limitations. Limitations, for example, are that the tools that are given can be interpreted and used in different ways. There are different ways of using the design toolkit, which can also be an advantage. The toolkit should work as an urban design basis where architecture and landscape design can develop from. Overall the chosen methodology shows the design process in a clear way where design strategies are developed from a vision all the back towards literature.

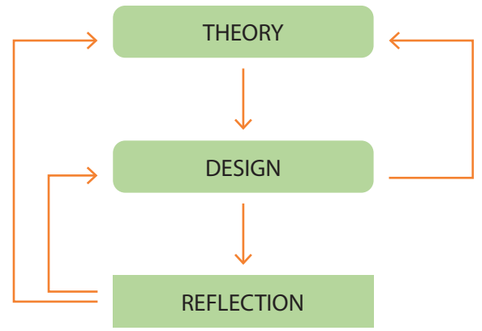

Figure 119 Relation research and design

Discussion on problems during data collection
The first problem with the data collection was about general information about Milan. I had not really an idea of what was going on in Milan, except that they have struggles regarding the climate effects. For data about climate I had to search very deeply, but in the end, I was able to give a clear overview of the situation. Looking at trends I was also able to describe a situation for 2100, however, this is really uncertain. The problem for data collection was way bigger for the social part of this research. In the Netherlands, there is a lot of information about resident groups, types of buildings, neighbourhood communities etc. but for Milan, I struggled a lot with retrieving data. I contacted the municipality and Politecnico Milano, however, I had no response or said that the numbers they have available are from around 10 years ago. To overcome this problem I tried to use the same method as for climate by giving an info sheet for now and 2100. This partly succeeded, however, this one is less precise and way more difficult to predict than for climate. A solution for data collection about the neighbourhood would be to go to the location and interview the people living there and look for ways to get that information. But then the situation in the world changed dramatically. During the graduation period, the world was facing the problem of COVID-19. Because my project is located in Milan some changes had to be made. It was not possible for me to do a second site visit and this had multiple consequences. First of all, I was not able to get to the site and have an experience of the location. I was not able to take good pictures to work with and as related to appropriation it would have been interesting to interview people at the location. Moreover, I could not see how people were using the spaces, which is a very important topic in my research. In this way, I could not have the chance to get a good feeling of

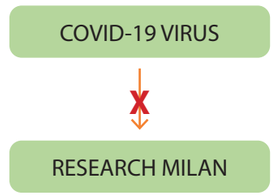

Figure 120 Problems data collection

how the neighbourhood works. To compensate these problems I focussed more on the theory that explained people's behaviour in relation to climate and changed the focus a bit by analyzing and designing the location with the help of ENVI-met. Later, when also the faculty was closing and I was not able to continue with ENVI-met I had to make use of design guidelines regarding appropriation and urban microclimate. For further research, it would be valuable to continue the research with methods that I was not able to do, as explained in the recommendation on page 177.

Discussion of possibilities to generalise results

The results that are gained from research in Milan probably is not something that can't be applied in different cities. Of course, designers have to look at the different climate regions, but for Mediterranean cities, the same principles can be applied as the ones in Milan. For appropriation the results can also be applied in a different context. Every city needs space for pedestrians, give choice to people and create that quality of life people like to have. In the short way the message for cities is simple: create sustainable development. However, for each city, for each neighbourhood and for each building

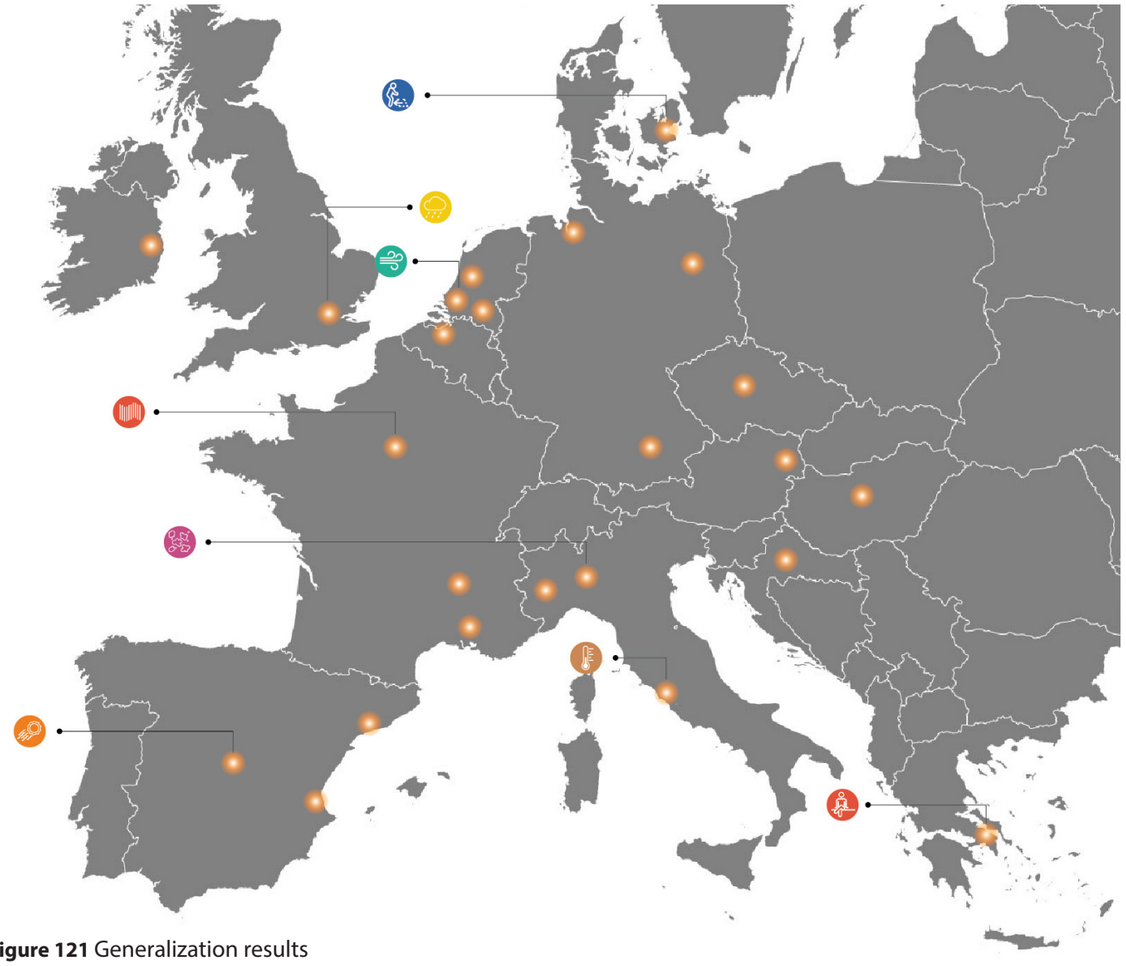

Figure 121 Generalization results

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different actions are asked. One should give more focus to water problems while another project should focus on the creation of greenery which helps for temperature and air quality for example. My results can be set in relation to the studio topic of 'cities of the future' where solutions for environmental- and social sustainable development of cities add to the knowledge about our future cities. The environmental and social issues, and the solutions that are made for that, can be placed in the perspective of urbanism/ architecture studies where we as designers are always looking for the spatial translation of certain problems that are occurring in huge fields like the environmental and social problems within cities. The results of this project add knowledge to the field of urban design, climate change and liveability which can be applied in different cities around the world.

Regarding the climability solutions that I made, there is something people should understand. The interventions in the design toolkit are not the only possible solutions. It gives an idea about what can be done to address the problems of appropriation and urban microclimate. On the other hand it is not true that if designers are applying all the interventions the problems are gone. You don't want to apply the same thing all the time, because this is not interesting and each situation is different. People should see it as a recipe: the ingredients and strategy are explained, but the results will most of the time differ depending on the designers (cook), taste, stakeholders etc. So in this project the elaboration of the key project are

Figure 122 Interpretation solutions

examples of how it could look like. If the area is really transformed, architects, urban designers, landscape designers etc should work it out in detail, where they should work integrally with each other. I have seen that for example, the orientation for buildings has consequences for the climate inside and outside the building. So urban designers and architects should work together. Moreover, when it comes to trees, landscape architects have way more knowledge about those elements, so together they should look at which tree and at which place it should be placed. In my case, there was no time for that and there was chosen for a strategy of 3 projects instead of one project in detail.

Reflection on ethical issues and dilemmas

We as students are really open-minded and do not have many restrictions in our designs towards a better future. During a festival about the future of our cities, I saw a totally different discussion for making a sustainable environment in our world. Professional designers/planners have different questions about climate adaptation. They were mostly talking about who should take the lead to fight climate, who is responsible for implementing the ideas and who is gonna pay for it? From this, I think we as students have a unique opportunity to think in different ways about our future cities. My research project should not exclude other ideas about sustainable development. For example, where I show many solutions with greenery it could be that there are problems with drought and there is not enough water to maintain the green solutions. Therefore research about drought should be added to the field of climate change in cities.

Due to the corona crisis, everyone should ask themselves the question: do I need to live the way I lived before the crisis? Because everyone was asked to work from home multiple problems occur, but also opportunities in my opinion. Do we need to travel that much to work for meetings etc? Do we need the car that much? During the corona crisis streets became empty, especially the number of cars really reduced. We should reduce the space for cars and with this space, we can do a lot. We can give it back to the people so that appropriation can increase and we can create more green which will help to fight the climate.

"Work with climate and climate protection concentrates on three levels of climate: macro-, local and micro-".
I've seen that interventions that contribute to social and environmental sustainability indeed work on different sales in the city and even regional.

"In countries with strong sun and high temperatures, city structure features shady narrow streets and buildings with thick walls and samll openings".
Although these structures are favorable for climate conditions in mediteranean area I doubt if this is still the case with new development. There is a trend of vertical buildings with larger urban outdoor spaces around it.

"Lengthy outside stays mean lively cities"
To maintain this designers should look for new ways to adapt to future conditions

Jan Gehl, theories since the 1960's

"There is a lot than can be done. This does not require large investments but rather precise requirements and a great deal of consideration".
Still applicable, but he doesn't say what should be done and how we do this. With my interventions and strategies I am building on this idea

"Cafés already providing good microclimate, because it increases economic value. There are good economic arguments for ensuring that café chairs can be used as man hours per day and per year as possible".
Designers can use these shops and restaurant to improve the neighbourhood, for example the soft edges of spaces

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Most surprising findings
I would like to conclude this reflection with my most surprising findings from this graduation project. First of all it was a brightening for me to see that urban design is always working on different scale levels, even with the topic of urban microclimate. Here it is not only about the microscale, because we can see that decisions on a larger scale can have a huge impact on the microscale. For example, the orientation of buildings and streets determine the wind speeds and the amount of solar radiation people feel on the smallest scale. It never occured to me that this is of high importance. Furthermore the most surprising element of the results is what kind of solutions can be done even at places where there is almost no space for improvements. For example the re-design of sidewalks where in the beginning it looks like not a lot of transformation can be made, but it appeared that even small interventions can have a huge difference for the urban microclimate or appropriation of those spaces. So I think that urban designers not only should think about big developments and big transformation where also with limited possibilities differences can be made.

"Create as much sun as possible".
With the higher temperatures because of the climate change people are looking more and more for shaded areas. We could say that we now have to create as much as shade as possible.

William H. Whyte, theories from 1980

"The pressence of water: very pleasant, but it should be made more accessible".
Because the warming climate people look for cooling elements in the city. With water sprinklers and fountains the appropriation and microclimate improves.

"Trees and sitting spaces should be combined. People feel safe under trees, however on the ledge around trees are fences for example, so not accessible".
Make it accessible, people are looking for a sitting space in the shade and a tree provide this.

"It's not only about indoor or outdoor, but the inbetweens and semi outdoors".
This theory is still applicable + it increases social cohesion in neighbourhoods. Activities in the semi-private spaces will increase the total appropriation

PART 6 BIBLIOGRAPHY

A
Agence France-Presse. (2019, April 4). *Air pollution hotspots in Europe* [Illustration]. https://www.ednh.news/air-pollution-hotspots-in-europe/
Anglès, M., Carrera, J., & Torres, R. P. (2010). *In Favour of Public Space: Ten Years of the European Prize for Urban Public Space.* ACTAR.

B
Brown, R. D. (2010). *Design With Microclimate* (2nd ed.). Island Press.
Bryman, A., & Bell, E. (2011). *Business Research Methods.* Oxford University Press.

C
Carmona, M., Heath, T., Oc, T., & Tiesdell, S. (2003). *Public Places, Urban Spaces: The Dimensions of Urban Design.* Architectural Press.
Comune di Milano. (2018). *Aggiornamento del Piano di Governo del Territorio del Comune di Milano.* https://www.comune.milano.it

D
E
ECCA. (n.d.). *Climate Change and Territory: Towards the Adaptation Plan for the Metropolitan City of Milan – ECCA 2019.* Retrieved 4 January 2020, from https://www.ecca2019.eu/climate-change-and-territory-towards-the-adaptation-plan-for-the-metropolitan-city-of-milan/
Elke druppel telt | Amsterdam Rainproof. (2020). Amsterdam Rainproof. https://www.rainproof.nl/
Encyclopaedia Britannica. (2019, May 22). *Climate | meteorology.* https://www.britannica.com/science/climate-meteorology
Erell, E., Pearlmutter, D., & Williamson, T. J. (2011). *Urban Microclimate: Designing the Spaces Between Buildings.* Washington, United States: Taylor & Francis Group
Eurostat. (2019, March). Statistics on European cities. Retrieved 21 October 2019, from https://ec.europa.eu/eurostat/statistics-explained/index.php/Statistics_on_European_cities

F
Foot, J., & Lecco, A. (2019, November 26). *Milan*. https://www.britannica.com/place/Milan-Italy

G
Gehl, J. (2010). *Cities for People* (2nd None ed.). Island Press.
Gehl, J. (2011). *Life Between Buildings* (6th ed.). Island Press.

H
Hebbert, M. & Webb, B. (2012). Towards a Liveable Urban Climate: Lessons from Stuttgart. *Liveable Cities: Urbanising World* (ISOCARP 07).
Honjo, T. (2009). Thermal Comfort in Outdoor Environment. *Global Environmental Research, 3*, 43–47.
Hunt, J. C. R., Poulton, E. C., & Mumford, J. C. (1976). The effects of wind on people; New criteria based on wind tunnel experiments. *Building and Environment, 11*(1), 15–28. https://doi.org/10.1016/0360-1323(76)90015-9

I
J
K
Kennedy, R. J. & Buys, L. (2010) Dimensions of liveability : a tool for sustainable cities. In *Proceedings of SB10mad Sustainable Building Conference*, Madrid.
Klemm, W. (2018). *Clever and Cool.* Amsterdam University Press. https://doi.org/10.18174/453958

L
Lara-Hernandez, J. A., & Melis, A. (2018). Understanding the temporary appropriation in relationship to social sustainability. *Sustainable Cities and Society, 39*, 366–374. https://doi.org/10.1016/j.scs.2018.03.004
Lenzholzer, S. (2013). *Het weer in de stad* (1st ed.). Nai010 Uitgevers/Publishers.
Lynch, K. (1981). *A Theory of Good City Form* (First Edition). The MIT Press.

27 TEXT REFERENCES

M
Martine, G., McGranahan, G., Montgomery, M., & Fernández-Castilla, R. (2008). *The New Global Frontier* (illustrated edition). London: Earthscan

N
Nikolopoulou, M., Baker, N., & Steemers, K. (2001). Thermal comfort in outdoor urban spaces: understanding the human parameter. *Solar Energy, 70*(3), 227–235. https://doi.org/10.1016/s0038-092x(00)00093-1
Nikolopoulou, M., & Lykoudis, S. (2007). Use of outdoor spaces and microclimate in a Mediterranean urban area. *Building and Environment, 42*(10), 3691–3707. https://doi.org/10.1016/j.buildenv.2006.09.008

O
Oke, T. R. (1987). *Boundary Layer Climates*. Routledge.

P
Papanastasiou, D. K., Melas, D., & Kambezidis, H. D. (2015). Air quality and thermal comfort levels under extreme hot weather. *Atmospheric Research, 152*, 4–13. https://doi.org/10.1016/j.atmosres.2014.06.002
Pijpers-Van Esch, M. (2015). *Designing the urban microclimate* (1st ed.). Tu Delft Open.
Prasad, N., Ranghieri, F., Shah, F., Trohanis, Z. (2009). Climate resilient cities : a primer on reducing vulnerabilities to disasters - Milan, Italy (English). Washington, DC: World Bank. http://documents.worldbank.org/curated/en/758591468039836222/Climate-resilient-cities-a-primer-on-reducing-vulnerabilities-to-disasters-Milan-Italy

Q
R
S
Santucci, D., Chokhachian, A., & Auer, T. (2019). Temporary Appropriation of Public Spaces: The Influence of Outdoor Comfort. In A. Melis, J. A. Lara-Hernandez, & J. Thompson (Eds.), *Temporary Appropriation in Cities* (pp. 117–126). https://doi.org/10.1007/978-3-030-32120-8_7
Spatial Adaptation Knowledge Portal. (n.d.). Voorbeeld PET-hittekaart overdag voor Wageningen [Example PET-heatmap during the day for Wageningen]. Retrieved 11 January 2020, from https://ruimtelijkeadaptatie.nl/stresstest/bijsluiter/hitte/informatie-maat/voorbeeld-pet-hittekaart/
Social Cohesion. (2018, October 8). Green Cities. https://uk.thegreencity.eu/themas/social-cohesion/
Southworth, M. (2003). Measuring the Liveable City. *Built Environment (1978-), 29*(4), 343-354. Retrieved from www.jstor.org/stable/23288885

T
Tumini, I., & Rubio-Bellido, C. (2016). Measuring Climate Change Impact on Urban Microclimate: A Case Study of Concepción. *Procedia Engineering, 161*, 2290–2296. https://doi.org/10.1016/j.proeng.2016.08.830

U
UN. (n.d.). Urbanization. Retrieved 15 October 2019, from https://www.un.org/en/development/desa/population/theme/urbanization/index.asp
UN. (2018, May 16). 68% of the world population projected to live in urban areas by 2050, says UN | UN DESA | United Nations Department of Economic and Social Affairs. Retrieved 15 October 2019, from https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html
UN. (2019, September 16). Population. Retrieved 15 October 2019, from https://www.un.org/en/sections/issues-depth/population/

V
W
WHO. (2011). *The social dimensions of climate change.* Retrieved from https://www.who.int/globalchange/publications/social-dimensions-climate-change/en/
WHO. (2012, October 25). Urbanization and health. Retrieved 15 October 2019, from https://www.who.int/globalchange/ecosystems/urbanization/en/
Whyte, W. H. (1980). *The social life of small urban spaces.* Ingram.

X
Y
Z

Page 4
Brussat, D. (2015). Save the bad public spaces! [Photograph]. Retrieved from https://architecturehereandthere.com/2015/04/01/april-fool-project-for-public-spaces-national-trust-preservation/

Page 11
Duomo Di Milano Visto Dallalto. (n.d.). [Photo]. Musikterbaruaje. https://musikterbaruaje.blogspot.com/2019/12/duomo-di-milano-visto-dallalto_97.html

Page 12
Goldberg, M. (2015, June 3). What Air Conditioners Can Teach Us About International Development [Photo]. Global Dispatches. https://www.globaldispatchespodcast.com/what-air-conditioners-can-teach-us-about-international-development/
Wilson, M. (2018). By 2050, 70% Of The World's Population Will Be Urban. Is That A Good Thing? [Illustration]. Retrieved from https://www.fastcompany.com/1669244/by-2050-70-of-the-worlds-population-will-be-urbanis-that-a-good-thing

Page 14
Redazione. (2019, August 29). Vaibilità, via Melchiorre Gioia riaperta al traffico [Photo]. Milano Today. http://www.milanotoday.it/cronaca/melchiorre-gioia-aperto.html

Page 16-17
Figure by author based on: Eurostat. (n.d.). Statistics on European cities - Statistics Explained [Illustration]. Retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php/Statistics_on_European_cities
Macrotrends LLC. (n.d.). Milan, Italy Population 1950-2020 [Graph]. Retrieved from https://www.macrotrends.net/cities/21571/milan/population
Seveso esondazione a Milano: allagati quartieri di Isola e Niguarda. (2014). [Photograph]. Retrieved from https://www.ilfattoquotidiano.it/2014/07/08/maltempo-a-milano-esonda-il-seveso-allagati-quartieri-isola-e-niguarda/1053066/
Wanted in Milan. (2018b). Milan launches heat-wave relief programme [Photograph]. Retrieved from https://www.wantedinmilan.com/news/milan-launches-heat-wave-relief-programme.html
World Health Organization & United Nations. (2018). Climate and health country profile - Italy. Retrieved from https://apps.who.int/iris/handle/10665/260380.

Page 34-35
Erell, E., Pearlmutter, D., & Williamson, T. J. (2011). Urban Microclimate: Designing the Spaces Between Buildings. Washington, United States: Taylor & Francis Group.
Figure by author based on: Carmona, M., Heath, T., Oc, T., & Tiesdell, S. (2003). Public Places, Urban Spaces: The Dimensions of Urban Design. Oxford, United Kingdom: Architectural Press.
Gehl, J. (2010). Cities for People (2nd None ed.). Washington DC, United States: Island Press.
New York City Department of Transportation. (2013). Before and After: Broadway- Times Square [Photograph]. Retrieved from https://www.flickr.com/photos/nycstreets/9138010840

Page 40-44
Gehl, J. (2010). Cities for People (2nd None ed.). Washington DC, United States: Island Press.
Gehl, J. (2011). Life Between Buildings (6th ed.). Washington DC, United States: Island Press.
Google. (n.d.). 117 Via Melchiorre Gioia. Retrieved from: https://www.google.com/maps/@45.4925774,9.2044166,3a,70.3y,219.76h,90.75t/data=!3m6!1e1!3m4!1swZGfzYl3TS_nVa1QniaLZA!2e0!7i16384!8i8192
Google. (n.d.) Milan. Retrieved from: https://www.google.com/maps/place/Milaan,+Itali%C3%AB/
Google. (n.d.). Via Tonale. Retrieved from: https://www.google.com/maps/@45.4895168,9.2012539,3a,75y,197.09h,77.34t/data=!3m6!1e1!3m4!1sdn8knB00u10eKRKxmzP6Lw!2e0!7i16384!8i8192
Lara-Hernandez, J. A., & Melis, A. (2018). Understanding the temporary appropriation in relationship to social sustainability. Sustainable Cities and Society, 39, 366–374. https://doi.org/10.1016/j.scs.2018.03.004

Page 48-54
Pijpers-Van Esch, M. (2015). Designing the urban microclimate (1st ed.). Delft, The Netherlands: TU Delft.
US Environmental Protection Agency. (n.d.). Green stormwater infrastructure [Illustration]. MACC. http://www.the-macc.org/stormwater/green-infrastructure-suitability/

28 FIGURE REFERENCES

Page 60-64
Buro Sant en co. (n.d.). Roombeek [Photo]. Buro Sant En Co. https://www.santenco.nl/nieuws/project-roombeek-en-schede-voorbeeld-voor-programma-klimaatactieve-stad-kas/
Commercial 95 340. (n.d.). [Photo]. Gale Pacific. https://www.galecommercial.com/en_na/product/commercial-95-340
Dearsley, B. (n.d.). Historic Haarlem [Photo]. Planetware. https://www.planetware.com/netherlands/amsterdam-surroundings-nl-nh-asurr.htm
Getty Images/Uxo Rivas. (n.d.). Águeda's Umbrella Sky Project [Photo]. Architecturaldigest. https://www.architecturaldigest.com/gallery/most-beautiful-streets-in-the-world
Introducing Cobra Bench System. (2018, March 28). [Illustration]. Artform. https://www.artformurban.co.uk/news/introducing-cobra-bench-system.html
Klemm, W. (2018, November 19). Initial results of user patters in the Wilhelminapark [Illustration]. In Clever and cool Generating design guidelines for climate-responsive urban green infrastructure.
Lenzholzer, S. (2013). Het weer in de stad [Weather in the city] (1st ed.). Rotterdam, The Netherlands: Nai010 Uitgevers/Publishers.
Matzarakis, A., Mayer, H., & Iziomon, G. M. (1999). Applications of a universal thermal index: Physiological equivalent temperature. International Journal of Biometeorology, 42(2), 76–84.
Michon, M. (n.d.). Van Hallstraat [Photo]. Rainproof. https://www.rainproof.nl/toolbox/maatregelen/herintroductie-van-het-trottoir
Pijpers-Van Esch, M. (2015). Designing the urban microclimate (1st ed.). Delft, The Netherlands: TU Delft.
Rosselli, P., & Cionci, L. (2015). Bosco Verticale [Photo]. ArchDaily. https://www.archdaily.com/777498/bosco-verticale-stefano-boeri-architetti

Page 110-111
1000 geveltuinen. (2020, May 25). [Illustration]. Awesome Rotterdam. https://awesomerotterdam.org/1000geveltuinen/
Atelier Groenblauw. (2014, October 14). Huisje Boompje Beter [Illustration]. Rainproof. https://www.rainproof.nl/nieuws/de-huisje-boompje-beter-app-live
BinG Binari Greco. (n.d.). [Illustration]. Facebook. https://www.facebook.com/bingbinarigreco/
Green Cities. (n.d.). [Illustration]. Green Cities. https://uk.thegreencity.eu/
Festival del verde. (2018, May 18). [Illustration]. NAm. https://www.namecodesign.it/il-festival-dedicato-al-verde-e-al-paesaggio-allauditorium-parco-della-musica-di-roma/
Organic Terrace & Balcony Garden Workshop. (n.d.). [Illustration]. EventsHigh. https://www.eventshigh.com/detail/bangalore/bdd918705828be705c98a7cd52e55939-organic-terrace-balcony-garden-workshop
Zimmer, L. (2015, December 5). A rolling garden on wheels recently popped up in the middle of Milan [Photo]. Inhabit. https://inhabitat.com/public-garden-project-transforms-a-milan-square-into-an-urban-oasis/
Page 128-129
Archilovers. (2016, July 22). Magic Breeze Sky Villas [Photo]. Archilovers. https://www.archilovers.com/projects/187913/magic-breeze-sky-villas.html
Boomkwekerij Ebben B.V. (n.d.). Boomkwekerij Ebben. Retrieved 25 June 2020, from https://www.ebben.nl/nl/
Caixas de vidro x País tropical. (n.d.). [Photo]. Mondoarq. https://mondoarq.wordpress.com/2015/07/27/caixas-de-vidro-x-pais-tropical/
David. (2019, July 11). The Peoples Parklet [Photo]. Benchspacecork. https://benchspacecork.ie/author/david/page/2/
Eiko, S. (n.d.). All colors Sidewalk [Photo]. ArchDaily. https://www.archdaily.com/912060/all-colors-sidewalk-zoom-urbanismo-arquitetura-e-design-plus-lao-engenharia-and-design
Ferrier Marchetti Studio. (n.d.). Porte des Ternes, Paris [Illustration]. Ferrier Marchetti Studio. https://ferriermarchetti.studio/project/a-generous-and-open-project-transforms-a-ring-road
Gardenia. (n.d.). Parthenocissus quinquefolia (Virginia Creeper) [Photo]. Gardenia. https://www.gardenia.net/plant/parthenocissus-quinquefolia
Grant, B. L. (2020, July 4). Boston ivy [Photo]. Gardening Know How. https://www.gardeningknowhow.com/ornamental/vines/ovgen/covering-brick-walls-with-vines.htm
grimschitz, J. (n.d.). Hedera Helix [Photo]. Pixers. https://pixers.nl/fotobehang/hedera-helix-gemeenschappelijke-klimop-44846297
Limburg, C. (2015, July 18). ParKIT [Photo]. Cindrea. http://www.cindrea.nl/2015/07/#3813919683726701458
Maslovarić, T. (n.d.). COWORKING [Illustration]. Michels Architekturbüro Köln Berlin. https://mic-arc.de/de/projekte/1728
Nice. (2020). [Illustration]. Even Conseil. http://www.even-conseil.com/portfolio-items/nice-projet-de-reamenagement-du-stade-du-ray-nice-vinci-immobilier/

Non-Stop forest. (n.d.). [Photo]. Pinterest. https://nl.pinterest.com/pin/322711129553002258/
Streetlife. (n.d.). Podium eilanden [Photo]. Streetlife. https://www.streetlife.nl/nl/producten/podium-isles
Weinstein AU. (n.d.). East Union Mixed-Use Apartments [Illustration]. Weinstein AU. https://weinsteinau.com/projects/east-union/
WATG. (n.d.). London National Park City [Illustration]. WATG. https://www.watg.com/tag/london-national-park-city/

Page 130-131
Google. (n.d.). Via Melchiorre Gioia. Retrieved from: https://www.google.com/maps/place/Milaan,+Itali%C3%AB

Page 150-151
Abitare in Maggiolina. (n.d.). [Illustration]. Abitare in Maggiolina. https://abitareinmaggiolina.com/progetto.html
Archilovers. (2016, July 22). Magic Breeze Sky Villas [Photo]. Archilovers. https://www.archilovers.com/projects/187913/magic-breeze-sky-villas.html
ATELIER STARZAK STREBICKI. (n.d.). Former Jesuit monastery, new Poznan town hall [Photo]. ATELIER STARZAK STREBICKI. http://www.starzakstrebicki.eu/en/project/former-jesuit-monastery-new-town-hall-poznan-poland/
Buro Sant en co. (n.d.). Roombeek [Photo]. Buro Sant En Co. https://www.santenco.nl/nieuws/project-roombeek-en-schede-voorbeeld-voor-programma-klimaatactieve-stad-kas/
Dillion Diers Photography. (n.d.). Klyde Warren Park [Photo]. ArchDaily. https://www.archdaily.com/298385/klyde-warren-park-the-office-of-james-burnett
Ferrier Marchetti Studio. (n.d.). Porte des Ternes, Paris [Illustration]. Ferrier Marchetti Studio. https://ferriermarchetti.studio/project/a-generous-and-open-project-transforms-a-ring-road
Furuto, A. (n.d.). Climate adapted neighbourhood [Illustration]. ArchDaily. https://www.archdaily.com/266077/climate-adapted-neighborhood-tredje-natur
Grijsen. (n.d.). Tilburg, Winkelcentrum Heyhoef [Photo]. Grijsen. https://www.grijsen.nl/tilburg-winkelcentrum-heyhoef/
Holmes, D. (2016, July 14). Water Square Tiel [Photo]. WLA. https://worldlandscapearchitect.com/water-square-tiel-opens/#.XvS4kSgzZPY
Introducing Cobra Bench System. (2018, March 28). [Illustration]. Artform. https://www.artformurban.co.uk/news/introducing-cobra-bench-system.html
Jo Malone's Fragrance Garden. (2015, February 24). [Photo]. Gardenista. https://www.gardenista.com/posts/rehab-diary-jo-malones-fragrance-garden-in-brooklyn/
Jongejeugd, D. (2019, February 26). Watervertragende groenstrook Kop Zuidas [Photo]. Rainproof. https://www.rainproof.nl/watervertragende-groenstrook-kop-zuidas
Kramer, L., & van der Burg, M. (2012). De Kameleon [Photo]. ArchDaily. https://www.archdaily.com/255095/de-kameleon-nl-architects
Mecanoo. (n.d.). Delfland Water Authority [Photo]. Mecanoo. https://www.mecanoo.nl/Projects/project/210/Delfland-Water-Authority?t=5
Oxford House Pocket Park. (n.d.). [Photo]. Pinterest. https://nl.pinterest.com/pin/338121884518200118/
PWP landscape. (n.d.). Foothill college [Photo]. Pinterest. https://nl.pinterest.com/pin/322711129553559563/
Roussel, L. (n.d.). Offices with terraces [Illustration]. Arch2o. https://www.arch2o.com/offices-terraces-laisne-roussel/
Studioninedots. (n.d.). Rebel [Illustration]. Studioninedots. https://studioninedots.nl/project/rebel/
Stunning Stormwater Park Concept. (n.d.). [Illustration]. Pinterest. https://nl.pinterest.com/pin/322711129553228014/

Page 152-153
Google. (n.d.). Via Giovanni Cagliero. Retrieved from: https://www.google.com/maps/place/Milaan,+Itali%C3%AB
Google. (n.d.). Via Eugenio Pellini. Retrieved from: https://www.google.com/maps/place/Milaan,+Itali%C3%AB

Page 170-171
Abitare in Maggiolina. (n.d.). [Illustration]. Abitare in Maggiolina. https://abitareinmaggiolina.com/progetto.html
Archilovers. (2016, July 22). Magic Breeze Sky Villas [Photo]. Archilovers. https://www.archilovers.com/projects/187913/magic-breeze-sky-villas.html
ATELIER STARZAK STREBICKI. (n.d.). Former Jesuit monastery, new Poznan town hall [Photo]. ATELIER STARZAK STREBICKI. http://www.starzakstrebicki.eu/en/project/former-jesuit-monastery-new-town-hall-poznan-poland/
Block, I. (2019, March 1). Tirana vertical forest [Illustration]. De Zeen. https://www.dezeen.com/2019/03/01/tirana-vertical-forest-albania-stefano-boeri-architetti/
Buro Sant en co. (n.d.). Roombeek [Photo]. Buro Sant En Co. https://www.santenco.nl/nieuws/project-roombeek-en-schede-voorbeeld-voor-programma-klimaatactieve-stad-kas/
De Cleene, M. (n.d.). Sint Lutgardis [Photo]. Studio Basta. https://www.studiobasta.be/projecten/semi-publiek/sint-lutgardis
Furuto, A. (n.d.). Climate adapted neighbourhood [Illustration]. ArchDaily. https://www.archdaily.com/266077/climate-adapted-neighborhood-tredje-natur
Grijsen. (n.d.). Tilburg, Winkelcentrum Heyhoef [Photo]. Grijsen. https://www.grijsen.nl/tilburg-winkelcentrum-heyhoef/
Grozdanic, L. (2014, July 24). Labyrinthine Green-Roofed Hangzhou Duolan Complex [Photo]. Inhabitat. https://inhabitat.com/labyrinthine-green-roofed-hangzhou-duolan-complex-combines-a-mall-with-urban-homes-in-china/
Housing ZAC croissant. (n.d.). [Illustration]. Pinterest. https://nl.pinterest.com/pin/842525042778899806/
Introducing Cobra Bench System. (2018, March 28). [Illustration]. Artform. https://www.artformurban.co.uk/news/introducing-cobra-bench-system.html
I'm Viadukt. (n.d.). [Photo]. Zuerich.Com. https://www.zuerich.com/en/visit/attractions/zurich-west?location=null
Jongejeugd, D. (2019, February 26). Watervertragende groenstrook Kop Zuidas [Photo]. Rainproof. https://www.rainproof.nl/watervertragende-groenstrook-kop-zuidas
maakif. (2008, April 20). Gateway fountain [Photo]. PBase. https://www.pbase.com/image/95866970
Mecanoo. (n.d.). Delfland Water Authority [Photo]. Mecanoo. https://www.mecanoo.nl/Projects/project/210/Delfland-Water-Authority?t=5
Mecanoo. (2020, May 16). Data and Knowledge Hub Healthy Urban Living [Illustration]. Mecanoo. https://www.mecanoo.nl/News/ID/504/Mecanoo-joins-Data-and-Knowledge-Hub-Healthy-Urban-Living
PWP landscape. (n.d.). Foothill college [Photo]. Pinterest. https://nl.pinterest.com/pin/322711129553559563/
Studioninedots. (n.d.). Rebel [Illustration]. Studioninedots. https://studioninedots.nl/project/rebel/
Tokyu Plaza Omotesando Harajuku. (2012, September 17). [Photo]. Archilovers. https://www.archilovers.com/projects/65554/tokyu-plaza-omotesando-harajuku.html

Climability solutions for urban design

District scale
BLVD. (n.d.). Sichuan Renshou Urban Wetland Park [Illustration]. BLVD. http://www.blvd.com.cn/en/Project-show-proid_216-lanmuid_2.html
Buenos Aires. (n.d.). [Photo]. ITDP. https://www.itdp.org/2020/01/27/buenos-aires-1985-and-today/peds/
Cidade linear. (n.d.). [Photo]. Megatimes. https://www.megatimes.com.br/2019/03/urbanismo.html
Funkia Landskapsarkitektur. (n.d.). Square of Jan Stenbeck [Photo]. Scandinavian Architects. https://www.scandinavian-architects.com/en/funkia-landskapsarkitektur-stockholm/project/the-square-of-jan-stenbeck
Landezine. (n.d.). Television Centre [Photo]. Landezine. https://landezine-award.com/television-centre/
landscape architecture. (n.d.). [Photo]. Pinterest. https://pl.pinterest.com/pin/487514728417726768/
Mecanoo. (n.d.-b). Scali Milano [Illustration]. Mecanoo. https://www.mecanoo.nl/Projects/project/196/Scali-Milano-Catalysts-for-sustainable-living?d=3&t=0
OMA. (n.d.). Scalo Farini [Illustration]. OMA. https://oma.eu/projects/scalo-farini
SeiMilano. (2018, May 14). [Illustration]. Urbanfile. https://blog.urbanfile.org/2018/05/14/milano-sella-nuova-via-bisceglie-nuovi-rendering-di-seimilano/
Ott, C. (2019). Usaquén Urban Wetland [Photo]. ArchDaily. https://www.archdaily.com/912462/usaquen-urban-wetland-cesb-obraestudio
Urbancek, N. (n.d.). People walking on street [Photo]. Unsplash. https://unsplash.com/photos/Q6AKY4isj1w

Neighbourhood scale
admin. (2015, October 13). Enghaveparken [Illustration]. Tredje Natur. https://www.tredjenatur.dk/en/2015/10/lecture-about-enghaveparken/
Buro Sant en co. (n.d.). Roombeek [Photo]. Buro Sant En Co. https://www.santenco.nl/nieuws/project-roombeek-en-schede-voorbeeld-voor-programma-klimaatactieve-stad-kas/
Cidade linear. (n.d.). [Photo]. Megatimes. https://www.megatimes.com.br/2019/03/urbanismo.html
Furuto, A. (n.d.). Climate adapted neighbourhood [Illustration]. ArchDaily. https://www.archdaily.com/266077/climate-adapted-neighborhood-tredje-natur
Introducing Cobra Bench System. (2018, March 28). [Illustration]. Artform. https://www.artformurban.co.uk/news/introducing-cobra-bench-system.html
Kramer, L., & van der Burg, M. (2012). De Kameleon [Photo]. ArchDaily. https://www.archdaily.com/255095/de-kameleon-nl-architects

28 FIGURE REFERENCES

BIBLIOGRAPHY

28 FIGURE REFERENCES

Marritz, L. (2011, November 5). Trees Are a Tool for Safer Streets [Photo]. Deeproot. https://www.deeproot.com/blog/blog-entries/trees-are-a-tool-for-safer-streets
Oxford House Pocket Park. (n.d.). [Photo]. Pinterest. https://nl.pinterest.com/pin/338121884518200118/
PWP landscape. (n.d.). Foothill college [Photo]. Pinterest. https://nl.pinterest.com/pin/322711129553559563/
SLA. (n.d.). The South Boulevard [Photo]. SLA. https://www.sla.dk/en/projects/sonderboulevard/
Stunning Stormwater Park Concept. (n.d.). [Illustration]. Pinterest. https://nl.pinterest.com/pin/322711129553228014/
Walker, J. (2014, August 22). Derbyshire Street Pocket Park [Photo]. Flickr. https://www.flickr.com/photos/wirewiping/15284371916

Street scale
AARP livable communities. (n.d.). [Illustration]. Pinterest. https://nl.pinterest.com/pin/368450813242948147/
David. (2019, July 11). The Peoples Parklet [Photo]. Benchspacecork. https://benchspacecork.ie/author/david/page/2/
Dearsley, B. (n.d.). Historic Haarlem [Photo]. Planetware. https://www.planetware.com/netherlands/amsterdam-surroundings-nl-nh-asurr.htm
Eiko, S. (n.d.). All colors Sidewalk [Photo]. ArchDaily. https://www.archdaily.com/912060/all-colors-sidewalk-zoom-urbanismo-arquitetura-e-design-plus-lao-engenharia-and-design
Groenjournalistiek. (2014, June 20). Delft [Photo]. Groenjournalistiek. http://www.groenjournalistiek.nl/2014/06/delft_hofjes/
Hoboken. (n.d.). Stormwater curb extension [Photo]. Nacto. https://nacto.org/publication/urban-street-stormwater-guide/stormwater-elements/green-infrastructure-configurations/stormwater-curb-extension/
Holmes, D. (2019, July 18). Donghu Park [Photo]. WLA. https://worldlandscapearchitect.com/donghu-park-shanghai-china-dlc/#.XveaRigzZPY
Introducing Cobra Bench System. (2018, March 28). [Illustration]. Artform. https://www.artformurban.co.uk/news/introducing-cobra-bench-system.html
Jongejeugd, D. (2019, February 26). Watervertragende groenstrook Kop Zuidas [Photo]. Rainproof. https://www.rainproof.nl/watervertragende-groenstrook-kop-zuidas
Limburg, C. (2015, July 18). ParKIT [Photo]. Cindrea. http://www.cindrea.nl/2015/07/#3813919683726701458
Mecanoo. (n.d.-a). Delfland Water Authority [Photo]. Mecanoo. https://www.mecanoo.nl/Projects/project/210/Delfland-Water-Authority?t=5

Building scale
admin. (2015a, March 29). Geveltuintjes hoe zit het precies [Photo]. De Groene Stad. https://degroenestad.nl/geveltuintjes-hoe-zit-het-precies/
Archilovers. (2016, July 22). Magic Breeze Sky Villas [Photo]. Archilovers. https://www.archilovers.com/projects/187913/magic-breeze-sky-villas.html
Bakker. (n.d.). Vigne-vierge 'Veitch Boskoop' rouge [Photo]. Bakker. https://www.bakker-belgique.com/products/vigne-vierge-veitch-boskoop-rouge
Maslovarić, T. (n.d.). COWORKING [Illustration]. Michels Architekturbüro Köln Berlin. https://mic-arc.de/de/projekte/1728
MVRDV. (n.d.). Valley [Illustration]. MVRDV. https://www.mvrdv.nl/projects/233/valley
Pelli Clarke Pelli Architects. (n.d.). PORTA NUOVA GARIBALDI [Photo]. Modulo.Net. https://modulo.net/en/realizzazioni/unicredit-headquartes-porta-nuova-garibaldi
Rosselli, P., & Cionci, L. (2015). Bosco Verticale [Photo]. ArchDaily. https://www.archdaily.com/777498/bosco-verticale-stefano-boeri-architetti
Schulz, D. (2014, August 4). Pacific Park Brooklyn [Illustration]. 6sqft. https://www.6sqft.com/greenland-forest-city-partners-selects-cookfox-and-thomas-balsley-for-pacific-park-brooklyn/
Studioninedots. (n.d.). Rebel [Illustration]. Studioninedots. https://studioninedots.nl/project/rebel/
Verschillende niveaus. (n.d.). [Photo]. Pinterest. https://nl.pinterest.com/pin/322711129531420097/
Wongwan, K. (2015). Kurve 7 [Photo]. ArchDaily. https://www.archdaily.com/644945/kurve-7-stu-d-o-architects
zanderrotharchitekten. (n.d.). th62 [Illustration]. Zanderrotharchitekten. https://www.zanderroth.de/en/projekte/th62/

PART 7 APPENDIX

29 AR3U023 THEORIES OF UPD

Human behaviour in urban outdoor spaces: the effect of urban microclimate

AR3U023 Theories of Planning and Design
Msc Urbanism, Delft University of Technology

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Abstract
This paper describes the relationship between the urban microclimate and the behaviour of people in urban outdoor space. Urban microclimate can be understood as the distinctive climate in a small-scale urban area and is constituted by the influence of the built environment and on the larger scale by climatic elements. The elements which are described in this paper are: temperature, precipitation, and wind. The different factors that influence the human perception of microclimate can be divided in three clusters, the individual physical and physiological factors, the external factors, and the third cluster is formed by psychological factors. For the influence of temperature on people's behaviour it is clear that warm conditions and presence of sunlight are important factors in the use of public space. It is important that people have a wide choice of spaces to sit, under different conditions, so a variety of spaces with sun and shade. For the relation between precipitation and behaviour it isn't so much the amount of rainfall but, rather, the time and duration of precipitation events that is often of most interest to the users of outdoor spaces. Wind appears to have a positive effect in the summer— when it is most welcome particularly by those sitting directly in the sun and the effect is negative in winter. For the relationship between urban microclimate and people's travel behaviour it is generally clear that warm and dry weather provide ideal conditions for outdoor leisure activities and active open-air transport modes, whereas rain, snow, windy and cold weather result in switches to sheltered transport modes. Not only react people to weather, people also adapt to their surroundings and accept conditions that would appear to lie outside the established comfort range. Moreover people are comfortable in a wide range of environments as they respond to the complex situations encountered in their daily lives.

Key words
Urban microclimate, People's behaviour, travel behaviour, adaptation, climate change

1. Introduction
As a result of the growing population cities are more exposed to the risk of climate change impacts, now and especially in the future. As mentioned by Tumini & Rubio-Bellido (2016) there is a necessity for adaptation strategies in cities to cope with future weather conditions caused by climate change. Global warming causes changes in climate conditions and this would have a significant effect on the urban microclimate (Tumini & Rubio-Bellido, 2016). "Much of the literature dealing with climate and design focuses on the effect of climate on the built environment and in particular on creating comfortable indoor conditions" (Erell, Pearlmutter, & Williamson, 2011). The relationship between climate and the urban outdoor space has researched in studies and discussions for at least one hundred years. However, only in recent years the topic is researched systematically in the area (Erell et al., 2011). Therefore, for urban designers it is interesting to conduct research in this recent topic to understand the conditions that have to be dealt with and how to respond to them by designing urban spaces. Lenzholzer (2013) argues that for people the microclimatic environment is of life importance, because our physiology function only in a relative small range of temperature- and wind conditions.
So, the main research question of this paper is: *what is the influence of urban microclimate on the behaviour and experience of people?* To answer this question the paper will first give a clear definition of urban microclimate. After that an overview of the behaviour of people in urban outdoor spaces in relation to urban microclimate is given. The effect of urban microclimate on people's travel behaviour will also be elaborated. The last part will be about the ability of people to adapt to the conditions in the urban microclimate. The paper will be concluded in the conclusion and results will be discussed. Moreover some recommendations will be made for further research.

2. Urban microclimate
To understand the meaning of the term 'urban microclimate' there should be an understanding of climate and the elements of climate. According to Encyclopaedia Britannica (2019, p. 1-3) "climate can be defined as the conditions of the atmosphere at a particular location over a long period of time; it is the long-term summation of the atmospheric elements (and their variations) that, over short time periods, constitute weather." These elements are solar radiation, temperature, humidity, precipitation, atmospheric pressure, and wind. Not all of the elements are equally relevant for studying the relationship between behaviour and urban microclimates. To elaborate more into depth this paper will focus on three elements instead of all of them in a general way. The elaborated climatic elements are: temperature, precipitation and wind.

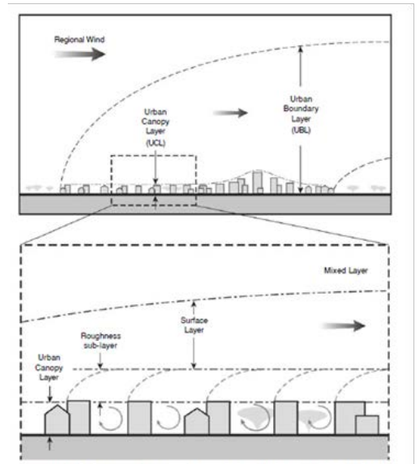


Figure 1: Schematic section of the urban atmosphere, showing the development of the urban boundary-layer (UBL) relative to the urban canopy-layer (UCL) (Erell et al., 2011, p. 16).

To get a grip on the scale of urban microclimate an overview of the layers within the urban atmosphere is given in figure 1. In an urban area, the lowest part of the atmosphere – which is called the urban boundary-layer (UBL) – is affected by the built up terrain. The UBL can be divided into sub-layers, and the difference between the sub-layers is fundamental to urban climate (Erell et al., 2011). For this paper it is not necessary to elaborate all of the sub-layers, so figure 1 shows a schematic section of all the sub-layers and only the lowest part will be elaborated more. "The very lowest part of the urban atmosphere is the urban canopy-layer (UCL), which extends from ground level to the height of buildings, trees and other objects" (Erell et al., 2011, p. 17). Due to the specific heterogeneity of the UCL, a unique microclimate has emerged within any given urban space. "The microclimate is affected by air temperature, wind flow, radiation balance and other climatic indicators and is being determined by the physical nature of the immediate surroundings as well as by the urban and regional environment" (Erell et al., 2011, p.17). The dimensions of the space, the material of the space and features around it, and the vegetation in spaces are all design parameters that have an effect on the climate at this smallest scale. Because urban design may have small, but effective impacts on outdoor thermal comfort, the microclimate of urban outdoor spaces is also considered an architectural issue (Erell et al., 2011). However, in my opinion an urban design should be an integrated and interdisciplinary process where the effect of an intervention should be tested to the different fields of urban design, architecture, but also transport and infrastructure to seek for the best solution.

Urban microclimate can be understood as the distinctive climate in a small-scale urban area, which is formed by climatic conditions on the large scale and constituted by the influence of the built environment. The elements of climate which are important for the urban microclimate are: solar radiation, temperature, humidity, precipitation, atmospheric pressure, and wind. It is important to note that the atmospheric variables in a microclimate can differ substantially from the conditions in a larger area.

3. Urban microclimate and people's behaviour
In considering people's preferences for climatic elements – air temperature, radiation, air movement and humidity – it is important to have information on an optimal value for thermal conditions or in other words to know the upper and lower limits to the range of 'acceptable' conditions (Erell et al., 2011). "The concept of acceptability is particularly important in urban design, as it establishes the boundaries of the climatic conditions which should be achieved. The acceptance of these conditions, and of less extreme climatic conditions, can best be understood by reference to the cultural, social, economic, temporal and physical contexts in which they occur" (Erell et al., 2011, p. 135). Looking more closely to people's preferences, research is showing that most of the time people choose a certain microclimatic environment within the outdoor environment, even though that is unconscious (Lenzholzer, 2013). People choose, depended on their need for microclimate, for a place or route in the sun or shadow, in the wind or protected

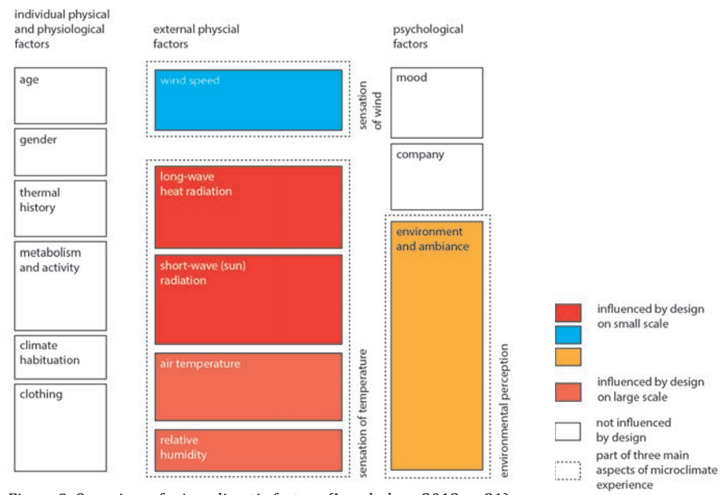


Figure 2: Overview of microclimatic factors (Lenzholzer, 2013, p. 21).

against it (Gehl, 2011). Furthermore the ambiance plays a role in the perception of microclimate, in other words if we perceive a place as 'warm' or 'cold'. The perception of microclimate helps people to search for places which fulfil their needs, physically and psychologically (Lenzholzer, 2013). Moreover, expectation play an important role for thermal environment in two ways. Firstly they may have an influence on the choice people make for their clothing which will affect their actual thermal sensation. Secondly, due to 'psychological preparation' expectations may have an influence on people's interpretation of that sensation as dissatisfaction (Nikolopoulou et al., 2001).
The different factors that influence the human perception of microclimate can be divided in three clusters, see figure 2. The first cluster is formed by the individual physical and physiological factors. These can't be influenced by urban design. The second cluster includes the external factors, the physical incentives for the human sensation of temperature and wind. Especially the sensation of temperature and wind can be influenced by design measures. The third cluster is defined by psychological factors, which can be partly manipulated by urban design (Lenzholzer, 2013). In the next part an overview is given of the influence of temperature, precipitation and wind on people's behaviour in urban outdoor spaces.

Temperature
The air temperature shows minimal differences in urban outdoor space at a scale level of a few meters. However, the air temperature differs during the day (Lenzholzer, 2013). With urban planning interventions the air temperature can be influenced to a limited extent, however multiple small interventions together can have a big influence (Lenzholzer, 2013). Referring back to the 'optimal' conditions of urban outdoor space, research in Cambridge showed thermal neutrality was found to vary from 7.5°C in winter to 27°C in the summer, a range of 19.5°C, whereas in earlier research Humphreys found the range in the indoor environment of 13°C (Nikolopoulou, Baker, & Steemers, 2001). This means that the outdoor climatic conditions are easier to accept for people and that they have a more strict preference for indoor conditions.
In Mediterranean urban areas it is generally true that during summer, when air temperature increases, the number of people found in the sun is reduced. People prefer to sit or stand in shaded areas at higher air temperatures. However, as high temperature is a factor contributing to discomfort, presence is reduced when air temperature rises significantly. During winter the presence of people in the sun increases, because temperatures are higher over there than in shadow areas (Nikolopoulou & Lykoudis, 2007). For a city like Milan, in my case, this information can be of high importance for urban designers, especially related to climate change.
It is clear that warm conditions and presence of sunlight are important factors in the use of public space. The average number of people sitting in the space increasing as global temperature increases. It is important that people have a wide choice of spaces to sit, under different conditions, so a variety of spaces with sun and shade (Nikolopoulou et al., 2001).

Precipitation
First of all there are differences in the kind of precipitation. The temperature near the ground will determine whether we experience the precipitation as rain, snow, sleet, or hail (Brown, 2010). Precipitation is a significant issue in many people's lives and livelihoods. In terms of microclimate it isn't so much the amount of rainfall but, rather, the time and duration of precipitation events that is often of most interest to the users of public spaces (Brown, 2010). With the other main form of precipitation, snowfall, we are more concerned about the amount of snow and the direction and speed of the wind during snow events. There is actually a lack of research in this field of microclimate. Where there is some research about the travel habits of people, which will be elaborated later, for the general behaviour of people there is only knowledge that people will search for sheltered places during precipitation (Erell et al., 2011). For Milan the topic of precipitation should get more research, because the frequency of heavy precipitation events is increasing. For urban designers it would be interesting to know how interventions can respond to the behaviour of people during these events.

Wind
Also the movement of air plays an important role in people's perception of microclimate (Lenzholzer, 2013). When temperature differences are high, such as a person's skin exposed to winter winds, the amount of heat carried away from the person's body is high, while in summer, when the air temperature can be almost the same as the body temperature, the amount of heat carried away is very low (Brown, 2010). This phenomenon works also inversed, when air temperature is higher than the body temperature, it can actually add temperature to the person, making him or her warmer. When the air is the same temperature as a the body temperature, then no heat is carried away (Brown, 2010). This shows why the wind is way more effective in cooling people in cold weather than in warm or hot weather. The goal for wind regarding to the thermal comfort of people is to decrease wind speeds in cold periods and to increase them in warm periods. Even in very hot conditions, people prefer some air movement (Brown, 2010).

Average wind speed (m/s)	Effects
5	Minor disturbance on hair and clothes, wind felt on face
10	Walking not easy, disturbance on hair, frequent blinking, fluttering of clothes
15	Walking difficult to control, violently disturbance on hair, impossible to open eyes continuously, fluttering of clothes
20	Walking very difficult, violently disturbance on hair, impossible to face wind, facial pain, violent fluttering of clothes

Figure 3: Overview of the effects of wind speeds (Murakami & Deguchi, 1981, p. 293).

But people can also perceive nuisance of wind. Research of Hunt, Poulton, & Mumford (1976) shows that the performance of everyday skilled tasks is getting worse when the wind speed increased from 4 to 8,5 m/s. The subjective assessments, (eyes, noise, pleasantness, etc.) showed that people perceive wind more above a speed of 6 m/s. A survey undertaken at La Defence, a tall building with a huge gap in it, located in Paris, has shown that the changes in wind speed around the base of the building are the most unwanted (Hunt et al., 1976). Figure 3 shows an overview of wind speeds and the effect people perceive from that. Urban designers can influence the microclimate by considering the wind in the design. For example, "if a windbreak is too dense, it will create only a small area of low wind speed, while a barrier that is too porous creates a large area with barely discernible wind reduction. The optimum porosity is somewhere near 50 percent" (Brown, 2010, p. 77-78).
To conclude the effects of wind on people's behaviour, analysis on people sitting in the sun, wind appears to have a positive effect in the summer— when it is most welcome particularly by those sitting directly in the sun. The effect is negative in winter, reducing presence significantly since a sunlit position is, usually, also exposed to wind (Nikolopoulou & Lykoudis, 2007).

So what makes a space successful from a climate point of view? William Whyte used time-lapse photography to study how people used urban outdoor spaces in New York. He documented the comings and goings, the rituals, the rhythms of encounters and basically what made some spaces 'work' and others not. He found that significant elements in the success of places related to the effects of sun, wind, trees and water (Erell et al., 2011). Besides, most authors offer the observation that throughout history one purpose of building houses has been to provide shelter from the often hostile conditions occurring outside, caused by a combination of temperature, wind, rain and sun (Erell et al., 2011). A conclusion from different studies is that people are always looking for sheltered areas to protect themselves against wind, rain and sun.

4. Urban microclimate and people's travel behaviour

People have different purposes to travel. They can make commuting (work, school) trips, shopping trips or leisure trips. A person's individual weather perception can lead to last-minute changes in routes and departure time, while other forecasting information has impact on the planning of activities and travel, like destination and mode choice (Dijst, Böcker, & Kwan, 2013). In this part the three climate elements of temperature, precipitation and wind are also related to people's behaviour, however this time on the travel behaviour of people, in other words, on the mode choices people make, see appendix for results of a research of Cools et al. (2010).

Temperature
"According to an extensive study of walking speed factors, an increase of speed was observed not only while people go down the slope but also up the slope, which brings us to conclusion that people speed up to pass the stressing/disrupting areas faster" (Melnikov, Krzhizhanovskaya, & Sloot, 2017, p. 188). The conclusion that is made here is supported by a study performed in Canada. At this study higher walking speeds were observed at a temperature of -15 °C, compared to the walking speeds observed at 15 °C (1.43 m/s versus 1.23 m/s). For temperatures above 15 °C, the walking speed increased to 1.28 m/s, measured at a temperature of 25 °C. So, people walk faster when the temperature lays outside their comfort range. People walk faster to escape the uncomfortable area as soon as possible and get to more comfortable areas (Melnikov et al., 2017). Furthermore people can perceive a temperature difference very precisely. A difference of 0.005 °C can be sensed by arm, and even a smaller difference by forehead. This perceived difference can lead pedestrians to diverge from a straight pathway towards a cooler area. This will result in a curved path, instead of the shortest, straight line (Melnikov et al., 2017).
Research in Toronto implies that with temperatures above 15°C travelling by bike becomes insensitive to temperature, while for temperatures below 15°C the utility of cycling decreases. Furthermore walking is only sensitive to temperatures of 1-5°C (Saneinejad, Roorda, & Kennedy, 2012). However, it is not clear if this is the case for different climate zones. For example, according to Böcker, Dijst, & Prillwitz (2013) hot weather (above 25–30°C) often result in a switch from open-air to sheltered transport modes and decrease the number of visits to outdoor destinations. Moreover, for the same category of temperature, cycling is affected by cold temperatures twice as much as walking (Saneinejad et al., 2012).
Besides, according to Cools, Moons, Creemers, & Wets (2010)extreme temperatures (both cold and warm) appear to have the least impact on commuting travel behaviour. This can be related to what Gehl (2010) is calling the degree of necessity. At the one end of the scale you have the necessary activities (going to work or school) and at the other end of the scale there is the recreational activities. So, because people have to go to school or work, temperatures will not affect this fact that they have to go.

Precipitation
Although precipitation has a small effect on mode choice for commuting trips, people are reluctant to shift to other modes of transportation. During extreme precipitation there is shown a small change from cycling to car mode, where snow strongly reduces the use of public transport because of the delays and unreliability of the travel time. According to Cools et al. (2010) for commuting trips snow has the biggest impact. People will postpone or even cancel their trip with heavy precipitation. For recreational trips there is a high chance people will choose the car above walking or cycling, however during snow events there is an increase of walking and cycling and the car mode decreases (Sabir, 2011). Heavy rain appear to have an effect mainly on the timing of the trip: people appear to postpone their trips until more favourable weather con

ditions apply (Cools et al., 2010). From my own experience I support this claim, because before I leave my house I always check the weather application for the weather forecast. On a rainy day I will look for the most favourable time to leave. However, only if this is possible, which refers to the necessity of trips of Gehl (2010).
Looking at the difference of effect between transport modes, research have shown that the negative effect of precipitation on cycling is two times bigger than on walking, where there is a slight difference between rain and heavy rain (Saneinejad et al., 2012). However, for walking the effect of rain becomes positive, which suggest that walking increases in rainy conditions. An explanation for this effect is that people may switch from cycling to walking in rainy conditions (Saneinejad et al., 2012).

Wind
There are different perceptions of wind in relation to the travel habits of people. For example, a strong wind during hot weather may be evaluated as pleasant and stimulating for walking and cycling, whereas the same wind during cold weather may be perceived as highly uncomfortable, especially in combination with precipitation (Dijst et al, 2013).
According to Cools et al. (2010) it appears that storm has an effect mainly on the timing of the commuting trip. People appear to postpone their trips until more favourable weather conditions apply. The effects of heavy winds or storms are striking: about 50% of the respondents postpone their trips during stormy periods, whereas 45% cancel their trips (Cools et al., 2010). Looking at differences between walking and cycling Saneinejad et al. (2012) conclude that the negatively effect of wind speed on cycling is two times bigger than on walking.

It is clear that changes in travel behaviour in response to weather conditions are dependent on the type of weather condition and that behavioural changes are strongly dependent on the trip purpose (Cools et al., 2010; Gehl, 2010) . Generally, warm and dry weather provide ideal conditions for outdoor leisure activities and active open-air transport modes, whereas rain, snow, windy and cold weather result in switches to sheltered transport modes. Most studies also agree on a higher relative impact of weather on recreational compared with utilitarian trips.

5. Urban microclimate and people's adaptation

The paper has provided an overview of the effects of the elements of microclimate on the behaviour of people. To add one more interesting topic to this framework of knowledge the paper will elaborate on the ability of people to adapt to their environment.

From research it is known that people take action to improve their comfort. People modify their clothing and metabolic rate, and take 'adaptive' actions. "Separating thermal sensation from thermal satisfaction, it was further demonstrated that 'adaptive opportunity' (the degree to which people can adapt to their environment) is important for their satisfaction with the space" (Nikolopoulou et al., 2001, p. 228). Furthermore, field surveys consistently show that people are able to adapt to their surroundings and will accept conditions that lie outside their comfort range. Researchers undertaking field studies acknowledge the importance of environmental factors and the researchers claim that people are actually comfortable in a wide range of environments. This is because people respond to the complex situations encountered in their daily lives (Erell et al., 2011). For example research of Nikolopoulou & Lykoudis (2007) show that during working days the use of spaces can be very different. The morning use is lower than the evening when open spaces are much cooler places to stay than the indoor environment. However the morning use is higher than the use during midday when the air temperature rises. In the evening the use is increasing again, because the outdoor spaces are cooler than the indoor environment.
It is also worth to point out the effect of psychological adaptation. For example, where normally air temperatures of 30-32°C are experienced as warm for outdoor activities, research shows something interesting. When the previous days had high air temperatures, people are used to it and know what actions to take to improve their comfort. This explains why air temperature of 30°C is regarded as relatively cool when maximum air temperature reached 35°C earlier that day (Nikolopoulou & Lykoudis, 2007). This has similarities with a statement of Erell et al. (2011) where they claim that the acceptance of climate conditions, and of less extreme climatic conditions, can best be understood by reference to the cultural, social, economic, temporal and physical contexts in which they occur (Erell et al., 2011).

6. Conclusion and discussion

Urban microclimate can be understood as the distinctive climate in a small-scale urban area, and is constituted by the influence of the built environment and on the larger scale by climatic conditions. The elements of climate which are important for the urban microclimate are: solar radiation, temperature, humidity, precipitation, atmospheric pressure, and wind, where this paper elaborated on temperature, precipitation and wind as the main factors.
So, the main research question of this paper was: *what is the influence of urban microclimate on the behaviour and experience of people?* . It is hard to answer this question, because we now know that the urban microclimate is influenced by multiple climatic elements and each of these elements has a different relation with the behaviour of people. What we do know is that most of the time people choose a certain microclimatic environment within the outdoor environment, even though that is unconscious. Furthermore, the different factors that influence the human perception of microclimate can be divided in three clusters, the individual physical and physiological factors, the physical incentives for the human sensation of temperature and wind and the psychological factors. For the behaviour of people and temperature it is clear that warm conditions and presence of sunlight are important factors in the use of public space, although this differs for each climate zone. So, it is important that people have a wide choice of spaces to sit, under different conditions, so a variety of spaces with sun and shade. For the relation between precipitation and behaviour it isn't so much the amount of rainfall but, rather, the time and duration of precipitation events that is often of most interest to the users of outdoor spaces. Wind appears to have a positive effect in the summer— when it is most welcome particularly by those sitting directly in the sun. The effect is negative in winter, reducing presence significantly since a sunlit position is, usually, also exposed to wind.
For the relationship between urban microclimate and people's travel behaviour it is generally clear that warm and dry weather provide ideal conditions for outdoor leisure activities and active open-air transport modes, whereas rain, snow, windy and cold weather result in switches to sheltered transport modes. Most studies also agree on a higher relative impact of weather on recreational compared with utilitarian trips.
Not only react people to weather, people also adapt to their surroundings and accept conditions that would appear to lie outside the established comfort range. Moreover people are comfortable in a wide range of environments as they respond to the complex situations encountered in their daily lives.

From research it is still very hard to compare results with each other, because there are multiple influences related to weather, where location is the biggest issue. It would be interesting to have more research about people's behaviour during weather conditions. Especially in Mediterranean cities, because most of the research is about North European-, American- or Australian cities. Also, there is a lot of knowledge about temperature and to a lesser extent about wind, but for the behaviour of people during precipitation there is not a lot of research. It is hard and time consuming to measure this relationship, but it definitely can help designers understand the elements that influence the microclimate.

7. References

- Böcker, L., Dijst, M., & Prillwitz, J. (2013). Impact of Everyday Weather on Individual Daily Travel Behaviours in Perspective: A Literature Review. *Transport Reviews, 33*(1), 71–91. https://doi.org/10.1080/01441647.2012.747114
- Brown, R. D. (2010). *Design With Microclimate* (2nd ed.). Washington DC, United States: Island Press.
- Cools, M., Moons, E., Creemers, L., & Wets, G. (2010). Changes in Travel Behavior in Response to Weather Conditions. *Transportation Research Record: Journal of the Transportation Research Board, 2157*(1), 22–28. https://doi.org/10.3141/2157-03
- Dijst, M., Böcker, L., & Kwan, M. P. (2013). Exposure to weather and implications for travel behaviour: introducing empirical evidence from Europe and Canada. *Journal of Transport Geography, 28*, 164–166. https://doi.org/10.1016/j.jtrangeo.2013.01.004
- Encyclopaedia Britannica. (2019, May 22). Climate | meteorology. Retrieved 13 November 2019, from https://www.britannica.com/science/climate-meteorology
- Erell, E., Pearlmutter, D., & Williamson, T. J. (2011). *Urban Microclimate: Designing the Spaces Between Buildings*. Washington DC, United States: Taylor & Francis Group.
- Gehl, J. (2010). *Cities for People* (2nd None ed.). Washington DC, United States: Island Press.
- Gehl, J. (2011). *Life Between Buildings* (6th ed.). Washington DC, United States: Island Press.
- Hunt, J. C. R., Poulton, E. C., & Mumford, J. C. (1976). The effects of wind on people; New criteria based on wind tunnel experiments. *Building and Environment, 11*(1), 15–28. https://doi.org/10.1016/0360-1323(76)90015-9
- Lenzholzer, S. (2013). *Het weer in de stad [Weather in the city]* (1st ed.). Rotterdam, The Netherlands: Nai010 Uitgevers/Publishers.
- Melnikov, V., Krzhizhanovskaya, V. V., & Sloot, P. M. A. (2017). Models of Pedestrian Adaptive Behaviour in Hot Outdoor Public Spaces. *Procedia Computer Science, 108*, 185–194. https://doi.org/10.1016/j.procs.2017.05.006
- Murakami, S., & Deguchi, K. (1981). New criteria for wind effects on pedestrians. *Journal of Wind Engineering and Industrial Aerodynamics, 7*(3), 289–309. https://doi.org/10.1016/0167-6105(81)90055-6
- Nikolopoulou, M., Baker, N., & Steemers, K. (2001). Thermal comfort in outdoor urban spaces: understanding the human parameter. *Solar Energy, 70*(3), 227–235. https://doi.org/10.1016/s0038-092x(00)00093-1
- Nikolopoulou, M., & Lykoudis, S. (2007). Use of outdoor spaces and microclimate in a Mediterranean urban area. *Building and Environment, 42*(10), 3691–3707. https://doi.org/10.1016/j.buildenv.2006.09.008
- Sabir, M. (2011). *Weather and Travel Behaviour* (Thesis). Retrieved from Amsterdam
- Saneinejad, S., Roorda, M. J., & Kennedy, C. (2012). Modelling the impact of weather conditions on active transportation travel behaviour. *Transportation Research Part D: Transport and Environment, 17*(2), 129–137. https://doi.org/10.1016/j.trd.2011.09.005
- Tumini, I., & Rubio-Bellido, C. (2016). Measuring Climate Change Impact on Urban Microclimate: A Case Study of Concepción. *Procedia Engineering, 161*, 2290–2296. https://doi.org/10.1016/j.proeng.2016.08.830

8. Appendix

TABLE 2 Changes in Work and School Trips

Change	Frequency (%)	Cold (%)	Snow (%)	Rain (%)	Fog (%)	Warm (%)	Storm (%)
Mode change	Never	93.8	75.8	84.8	94.6	81.6	86.8
	1–25	4.4	14.6	7.9	3.7	10.5	8.1
	26–50	0.9	2.6	1.4	0.1	4.4	0.9
	>50	0.9	7.0	5.9	1.6	3.5	4.2
Time-of-day change	Never	89.5	47.8	70.3	74.0	94.4	74.9
	1–25	6.0	23.7	17.0	13.7	2.8	14.9
	26–50	2.5	9.2	6.9	6.9	1.5	4.7
	>50	2.0	19.3	5.8	5.4	1.3	5.5
Location change	Never	96.6	86.6	94.4	97.5	97.0	93.3
	1–25	2.2	8.4	3.3	1.3	2.0	4.1
	26–50	0.6	3.0	1.0	0.5	0.8	1.1
	>50	0.6	2.0	1.3	0.7	0.2	1.5
Trip cancellation	Never	96.2	75.4	93.8	95.3	89.0	92.6
	1–25	3.4	19.4	5.0	4.3	10.1	6.1
	26–50	0.4	4.1	0.2	0.4	0.9	0.7
	>50	0.0	1.1	1.0	0.0	0.0	0.6
Route change	Never	90.5	56.4	85.0	85.4	96.4	87.1
	1–25	6.3	26.7	9.9	10.0	2.4	8.4
	26–50	1.8	9.8	2.5	1.5	0.9	2.7
	>50	1.4	7.1	2.6	3.1	0.3	1.8

TABLE 3 Changes in Shopping Trips

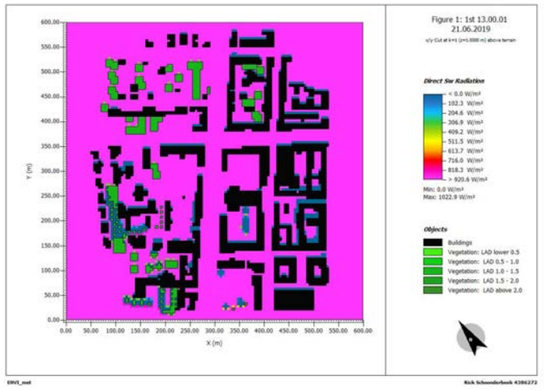
Change	Frequency (%)	Cold (%)	Snow (%)	Rain (%)	Fog (%)	Warm (%)	Storm (%)
Mode change	Never	91.5	78.2	85.6	91.9	79.7	86.8
	1–25	5.2	11.2	6.0	4.4	10.2	6.5
	26–50	1.4	3.4	2.2	0.8	4.9	1.6
	>50	1.9	7.2	6.2	2.9	5.2	5.1
Time-of-day change	Never	80.2	29.4	41.8	59.9	80.0	47.7
	1–25	13.1	28.2	24.1	19.2	13.0	22.8
	26–50	3.9	16.9	13.6	11.4	4.2	13.7
	>50	2.8	25.5	20.5	9.5	2.8	15.8
Location change	Never	86.8	54.0	68.4	72.2	83.7	69.3
	1–25	7.4	20.6	12.6	11.9	10.5	13.7
	26–50	2.8	9.4	10.7	8.8	2.6	10.0
	>50	3.0	16.0	8.3	7.1	3.2	7.0
Trip cancellation	Never	86.7	31.9	48.4	64.4	82.6	55.0
	1–25	7.1	33.7	29.3	20.4	13.3	23.3
	26–50	3.0	14.5	11.6	8.8	2.7	11.6
	>50	3.2	19.9	10.7	6.4	1.4	10.1
Route change	Never	93.1	58.8	81.7	80.6	93.3	81.7
	1–25	4.5	23.2	11.0	11.3	4.7	10.7
	26–50	1.4	10.3	3.7	4.8	0.5	4.6
	>50	1.0	7.7	3.6	3.3	1.5	3.0

TABLE 4 Changes in Leisure Trips

Change	Frequency (%)	Cold (%)	Snow (%)	Rain (%)	Fog (%)	Warm (%)	Storm (%)
Mode change	Never	89.9	74.4	83.9	87.3	77.3	85.6
	1–25	7.7	13.5	8.9	8.1	11.7	8.7
	26–50	1.2	3.8	3.1	3.5	6.4	3.0
	>50	1.2	8.3	4.1	1.1	4.6	2.7
Time-of-day change	Never	85.3	35.1	54.3	61.8	85.3	58.6
	1–25	10.5	30.9	26.1	21.3	11.5	20.1
	26–50	2.0	15.0	12.7	9.2	2.0	13.0
	>50	2.2	19.0	6.9	7.7	1.2	8.3
Location change	Never	83.3	70.9	75.1	81.5	83.9	74.1
	1–25	9.9	14.1	11.3	9.3	10.0	13.1
	26–50	2.8	6.5	6.3	5.3	3.3	6.5
	>50	4.0	8.5	7.3	3.9	2.8	6.3
Trip cancellation	Never	79.3	35.6	56.1	66.1	82.2	55.3
	1–25	14.4	34.0	24.2	20.2	13.9	23.5
	26–50	4.1	13.8	9.6	8.0	3.0	12.1
	>50	2.2	16.6	10.1	5.7	0.9	9.1
Route change	Never	92.8	55.1	76.4	78.6	94.3	76.9
	1–25	4.4	24.4	13.9	13.5	3.6	12.4
	26–50	2.1	11.9	5.9	4.5	1.2	6.9
	>50	0.7	8.6	3.8	3.4	0.9	3.8

Cools, M., Moons, E., Creemers, L., & Wets, G. (2010). Changes in Travel Behavior in Response to Weather Conditions. *Transportation Research Record: Journal of the Transportation Research Board, 2157*(1), 22–28. https://doi.org/10.3141/2157-03

Radiation



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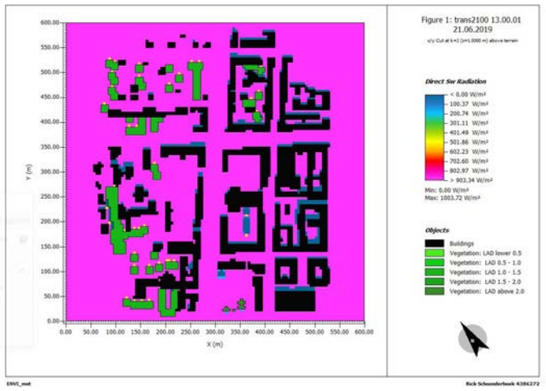

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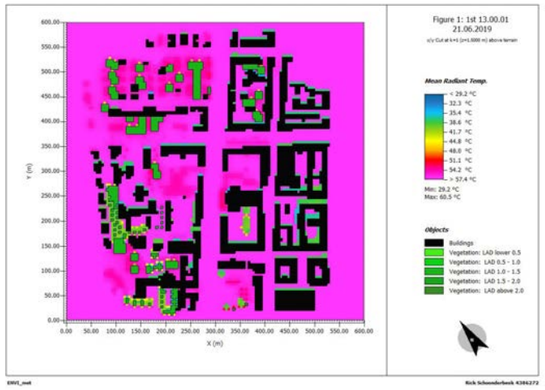

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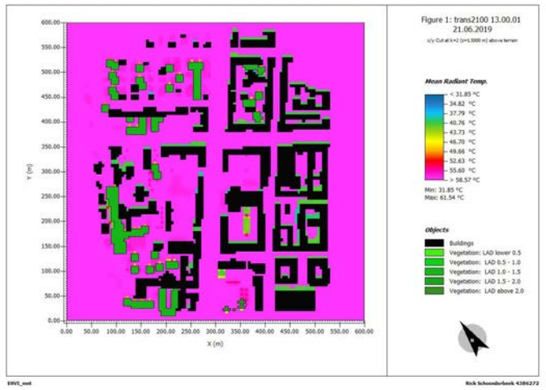

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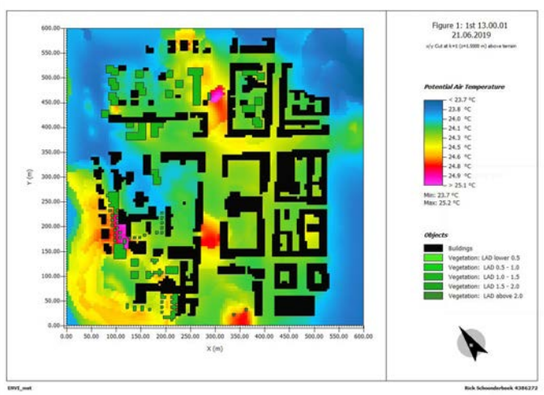
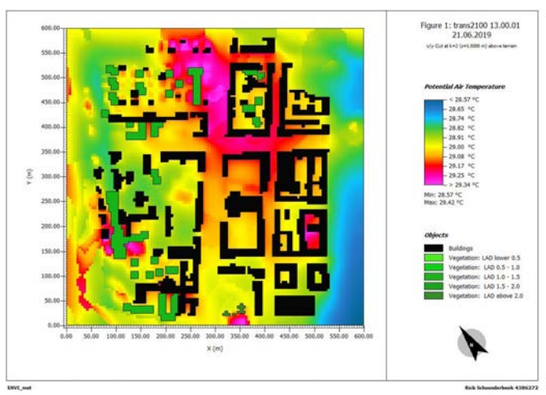
Air temperature



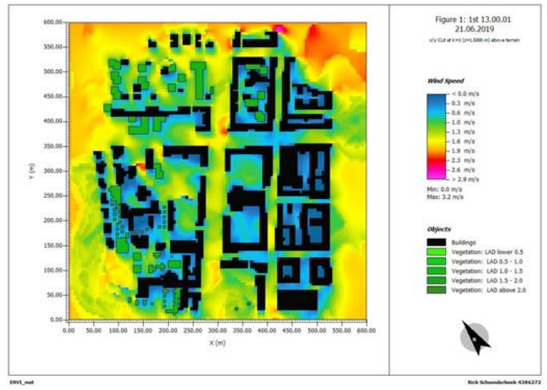
Air temperature situation 2019



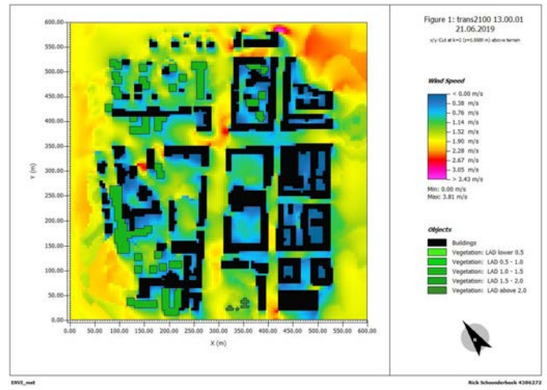
Air temperature situation 2100

30 ENVI-met

Wind

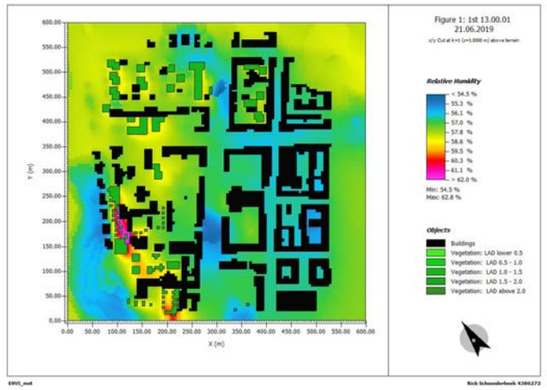


Wind speed situation 2019

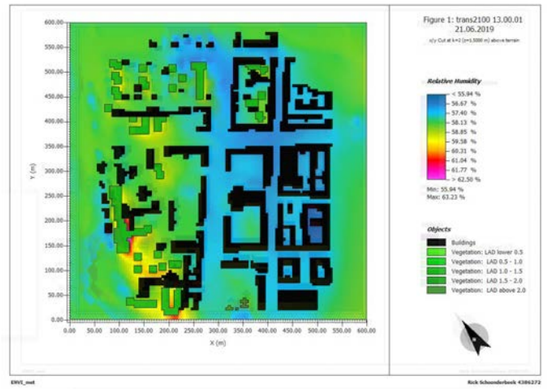


Wind speed situation 2100

Humidity

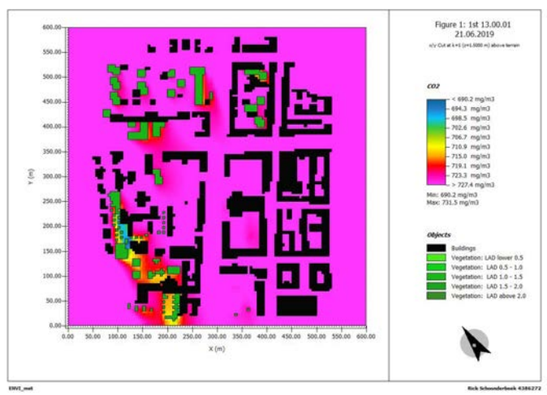


Relative humidity situation 2019

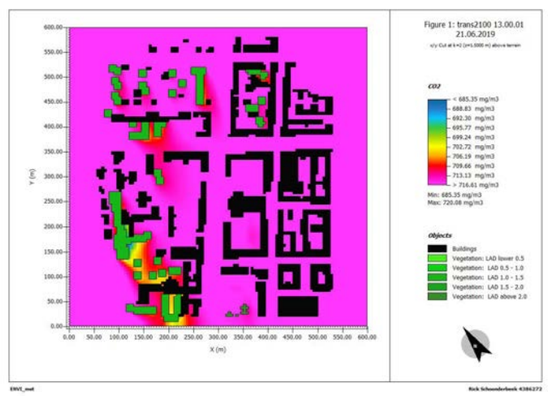


Relative humidity situation 2100

Air quality



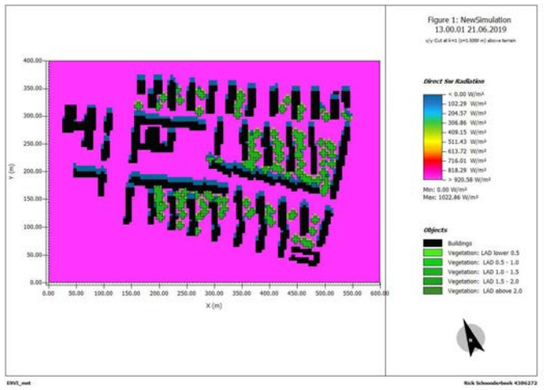
CO2 situation 2019



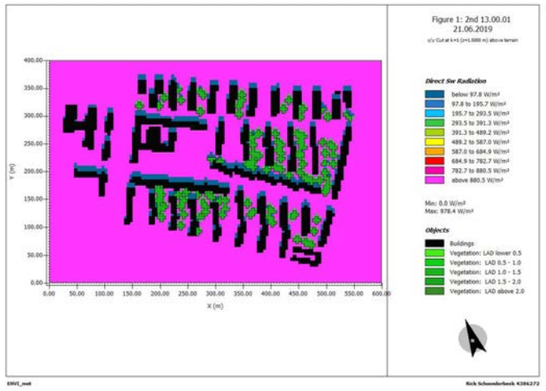
CO2 situation 2100

30 ENVI-met

Radiation

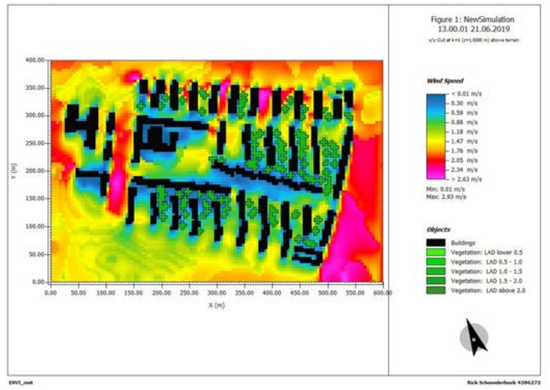


Direct radiation situation 2019

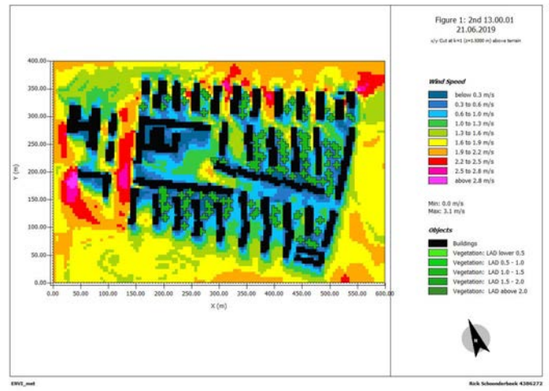


Direct radiation situation 2100

Wind

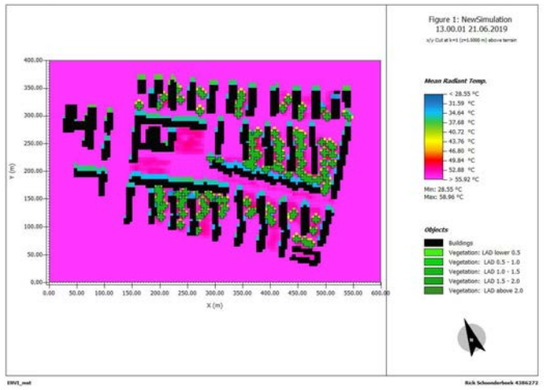


Wind speed situation 2019

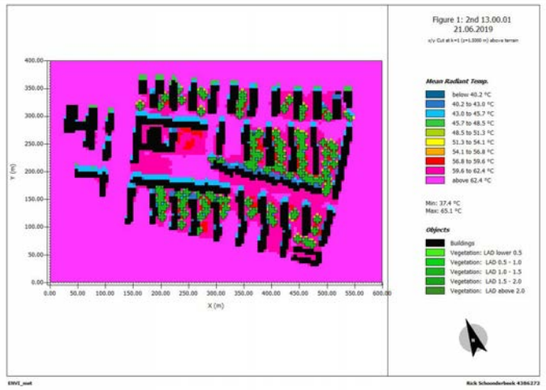


Wind speed situation 2100

Temperature

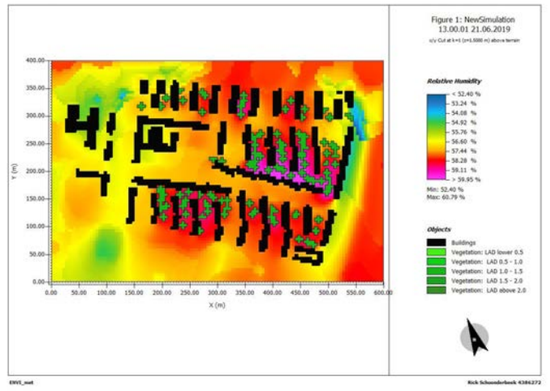


Mean radiant temperature situation 2019

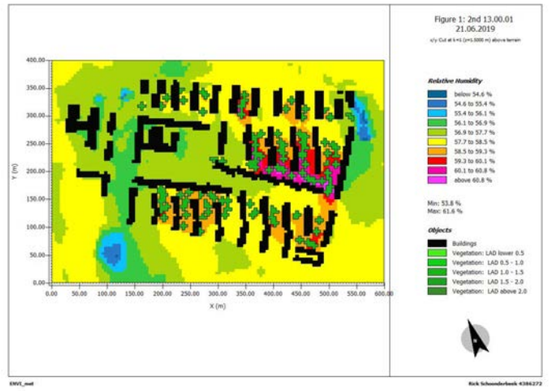


Mean radiant temperature situation 2100

Humidity

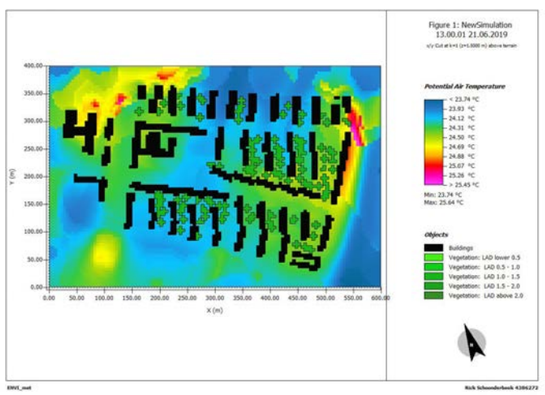


Relative humidity situation 2019

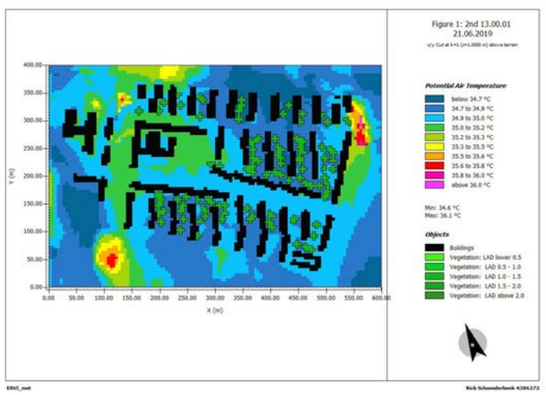


Relative humidity situation 2100

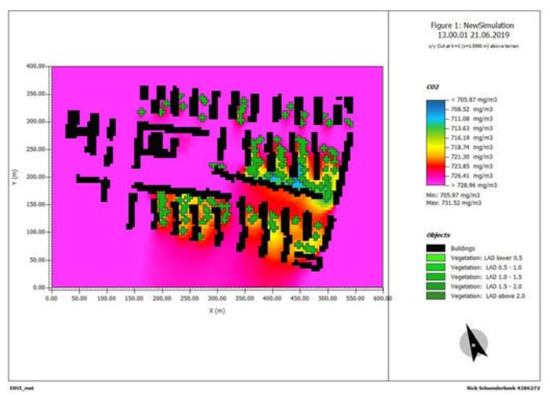
Air quality



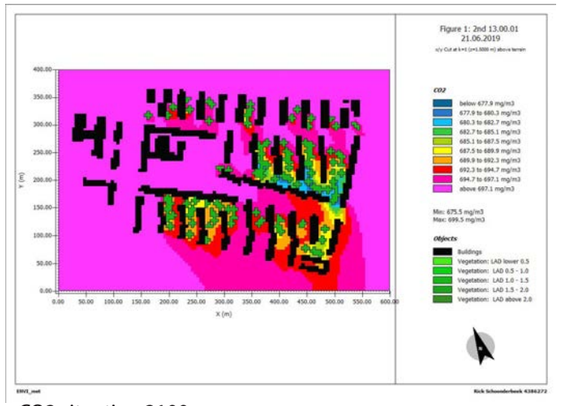
Air temperature situation 2019



Air temperature situation 2100



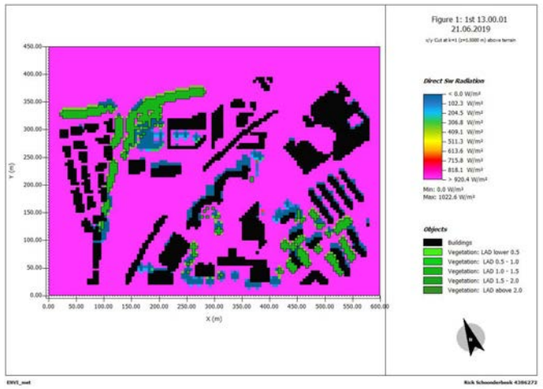
CO2 situation 2019



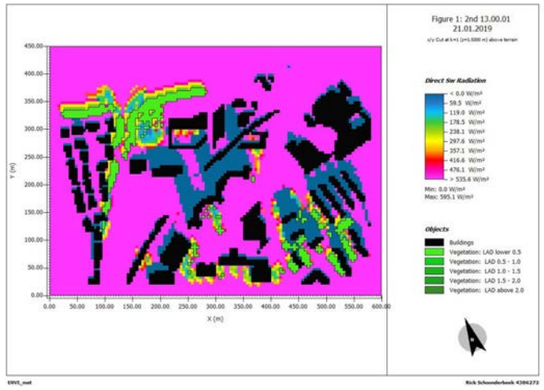
CO2 situation 2100

30 ENVI-met

Radiation

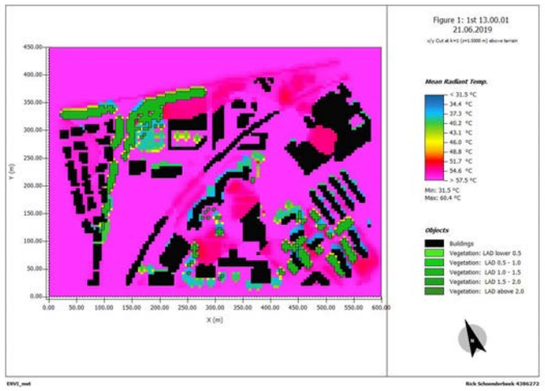


Direct radiation situation 2019

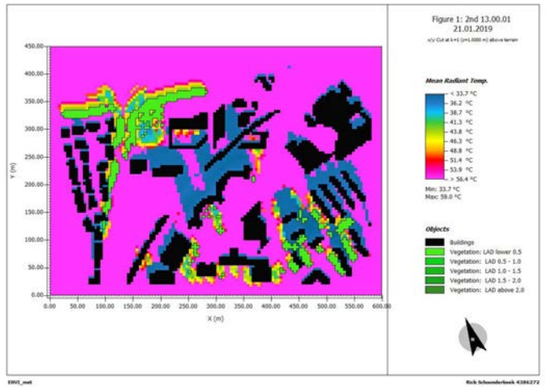


Direct radiation situation 2100

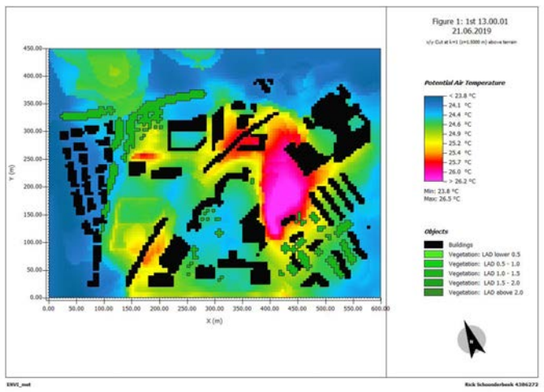
Temperature



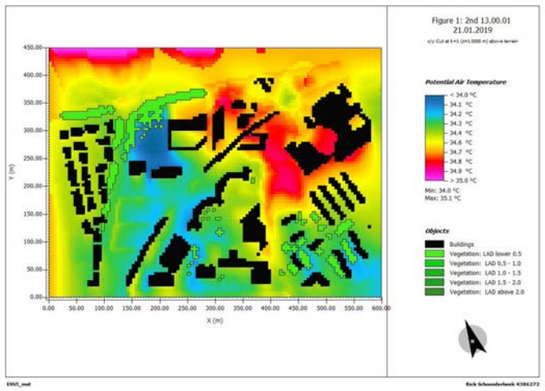
Mean radiant temperature situation 2019



Mean radiant temperature situation 2100

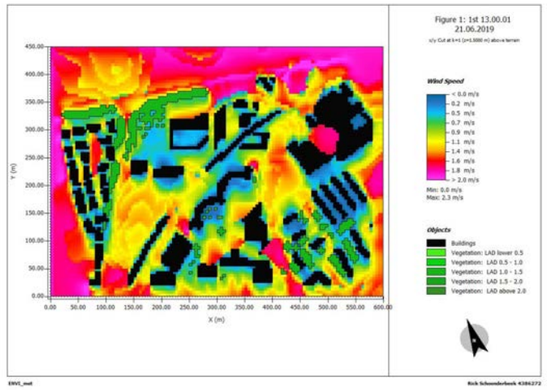


Air temperature situation 2019

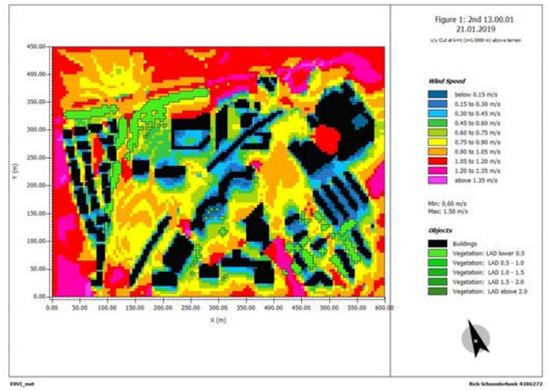


Air temperature situation 2100

Wind

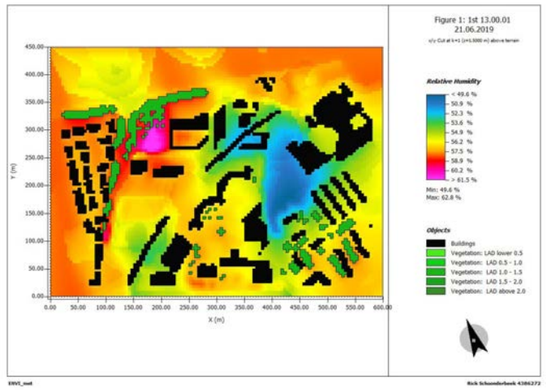


Wind speed situation 2019

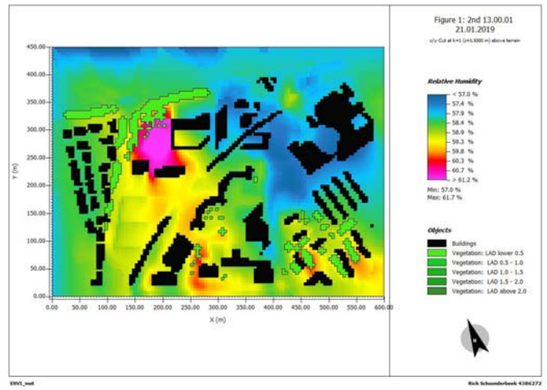


Wind speed situation 2100

Humidity

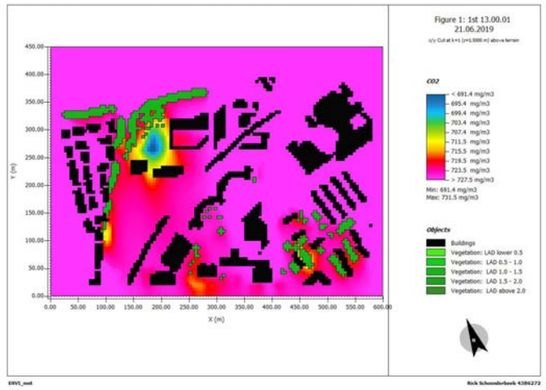


Relative humidity situation 2019

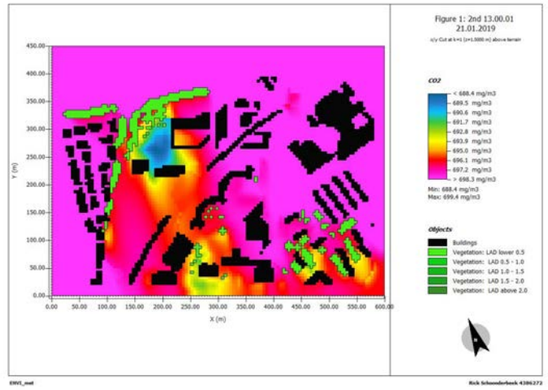


Relative humidity situation 2100

Air quality



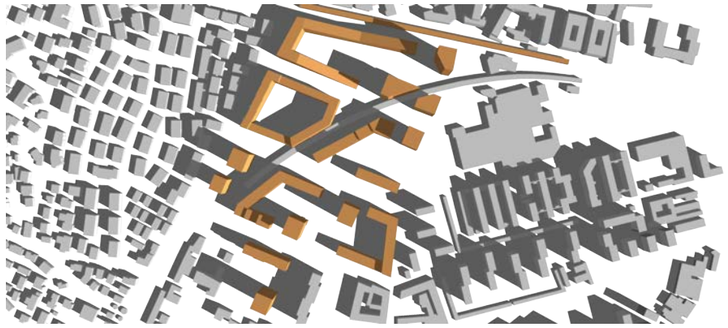
CO2 situation 2019



CO2 situation 2100

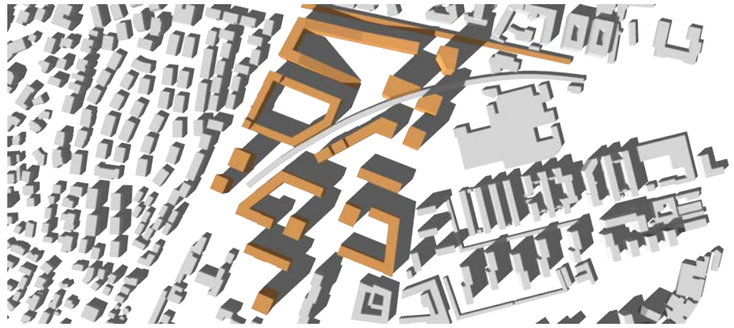
31 SOLAR ANALYSIS

21 march 2020 10.00u

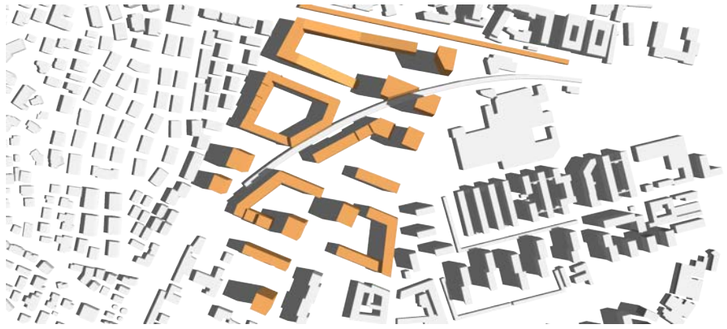


21 march 2020 13.00u

21 march 2020 16.00u



21 june 2020 10.00u



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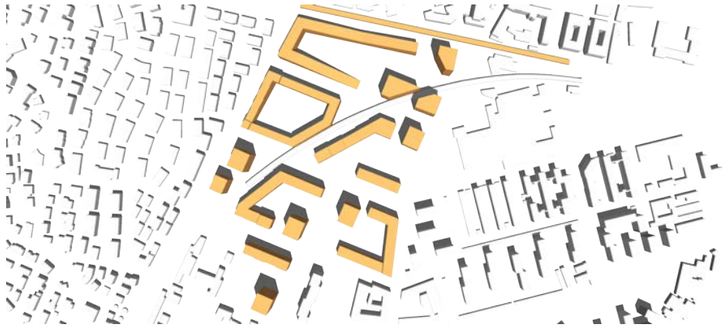

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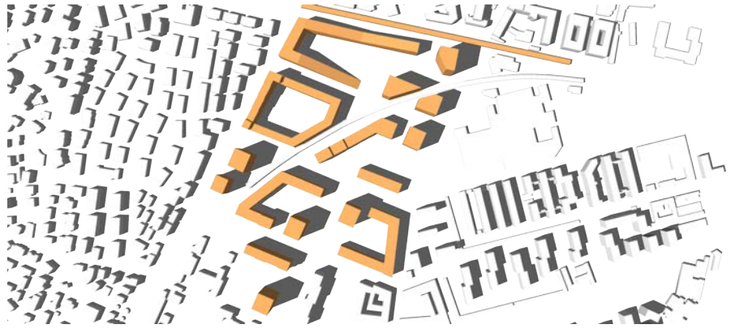

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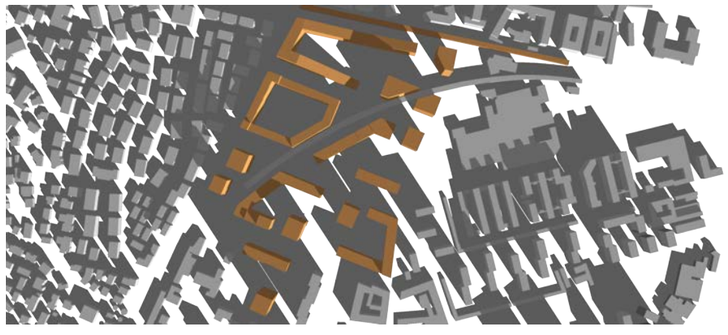

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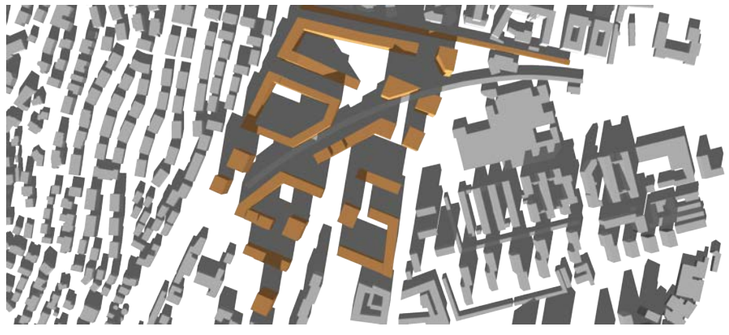

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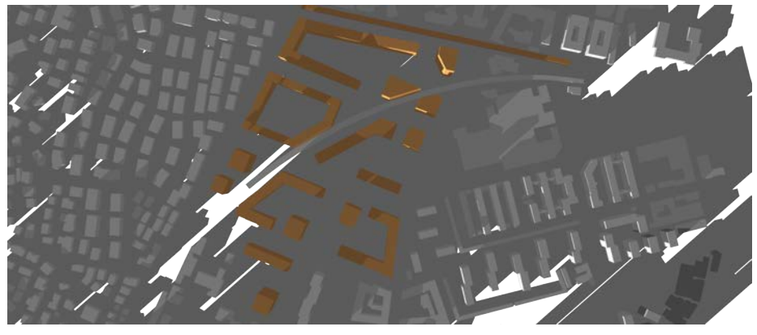
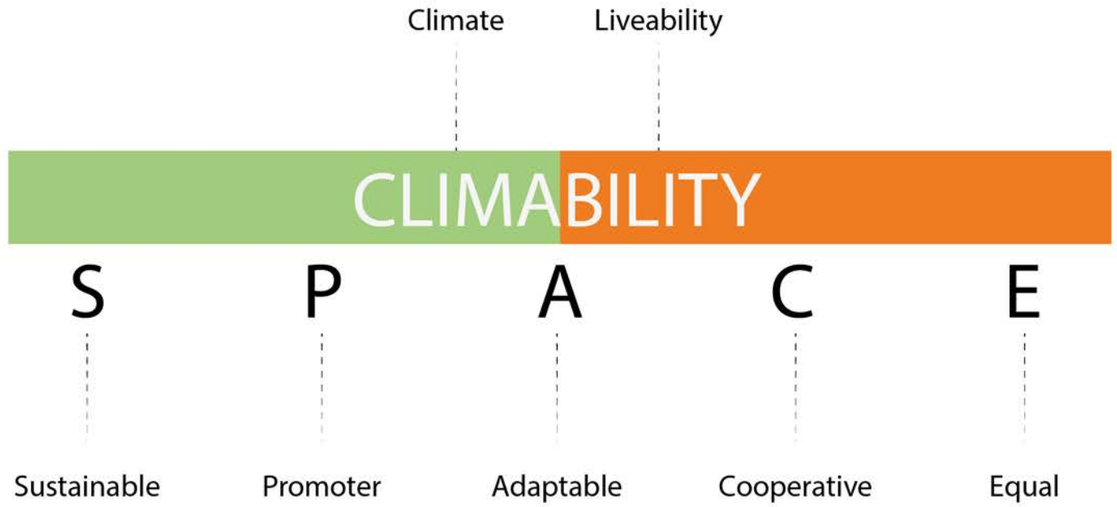


CLIMABILITY SOLUTIONS FOR URBAN DESIGN

H.W.J. Schoonderbeek



Sustainable:
- Aim for a sustainable development of cities towards the future. The development should be visible on different scale levels; from city to street.
- Promoting environmental sustainability by creating a pleasant urban microclimate resulting in enhancing quality of life in urban outdoor spaces.
- Promoting social sustainability by strengthening the (temporary) appropriation resulting in enhancing quality of life in urban outdoor spaces.

Promoter:
- Promote sustainable urban development and show solutions that contribute to this development
- Be a promoter of the new “green” architecture that enhance the qualities of urban microclimate and appropriation.

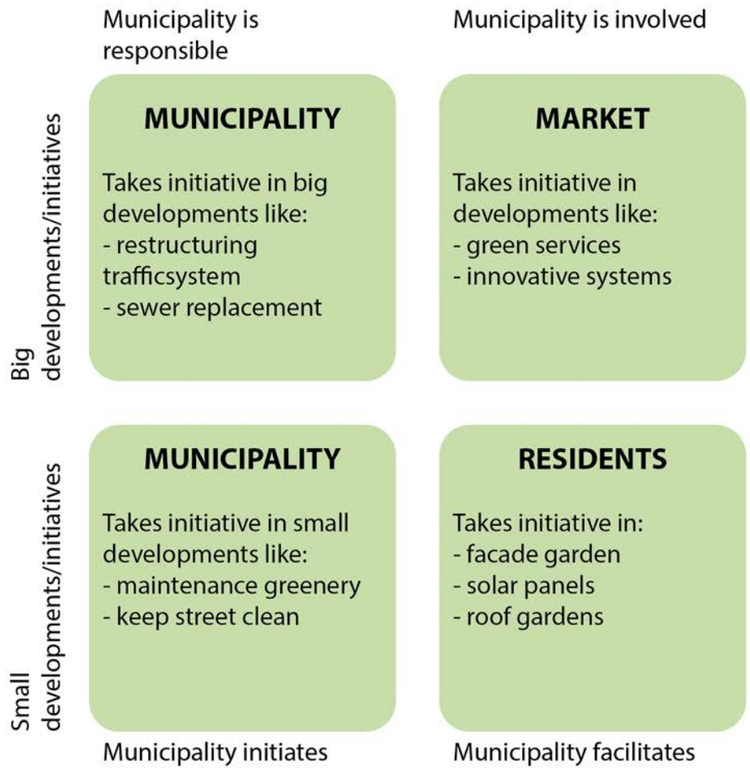
Adaptable:
- By focussing on the design of urban microclimate climate adaptive solutions should be developed to adapt to the future climate conditions.
- Create flexible and adaptable solutions in the urban outdoor space to support appropriation towards the future

Cooperative:
- Show the cooperation between architecture, urban- and landscape design with the new development and the transformation of the area
- Create cooperation between stakeholders: initiatives from local residents and big developments from the municipality

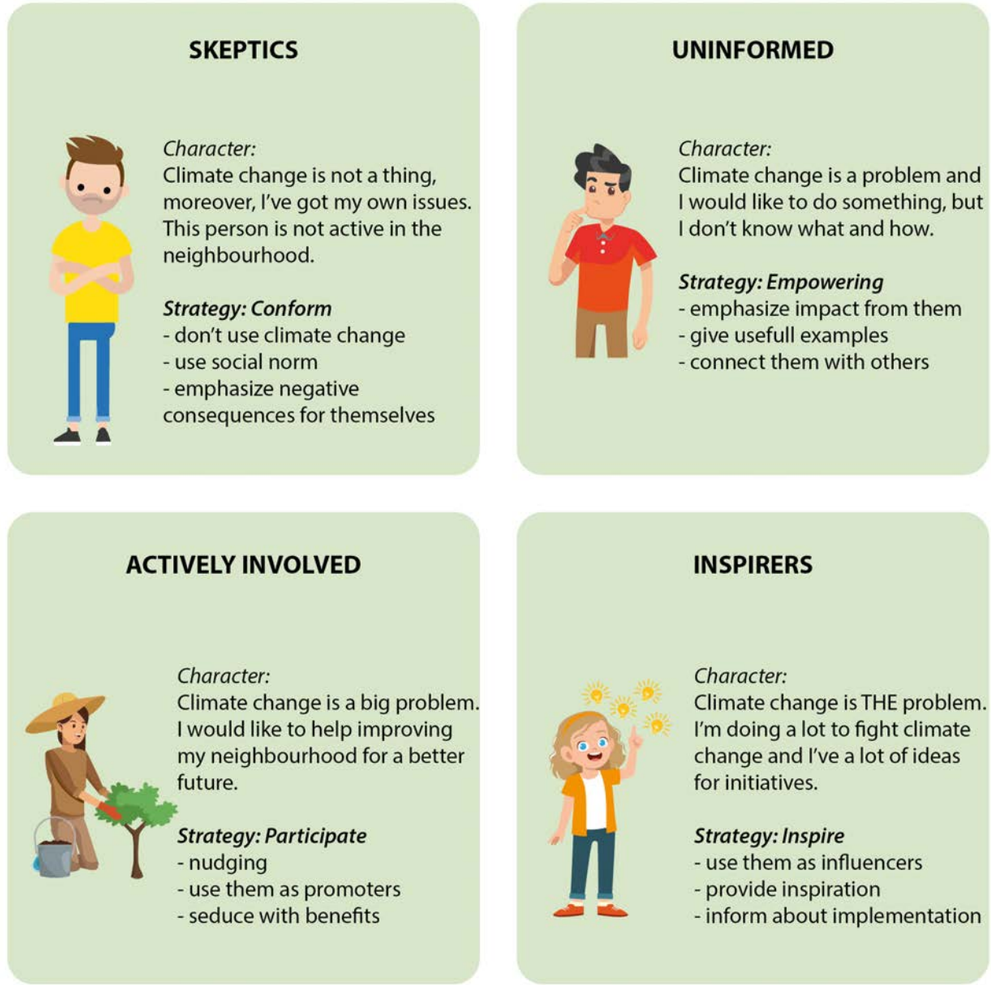
Equal:
- Find a balance between urban growth needs, climate adaptation and (temporary) appropriation of urban outdoor spaces
- Achieve a balance between human needs on the small scale and the cities needs on the large scale

For each development different stakeholders can contribute to it. Most of the time, for bigger developments the municipality should take the lead, while for smaller measurements the market or residents can be the initiators. In the end, municipality, market and residents corporate with each other and initiatives should be combined. It is good to know that residents can take initiative because they like to have a livable street. Small interventions like facade garden, benches, meeting spots or communal gardens are good examples of local initiatives where the municipality only should support these initiatives by giving the residents the space they need.

On the left part of the figure, the initiative is at the municipality. The municipality does a lot of big and small developments to guarantee the livability in the city. It will be beneficial to look for opportunities for cooperation between municipality, market and residents. At the right part of the figure, the initiative is at the market and residents. The municipality can facilitate in this case, because the municipality should be involved in the process, but is not responsible for the development. It is beneficial for the municipality to subsidize and promote local initiatives that contribute to their own goals. The municipality allows innovation where the market can look for new products and services.

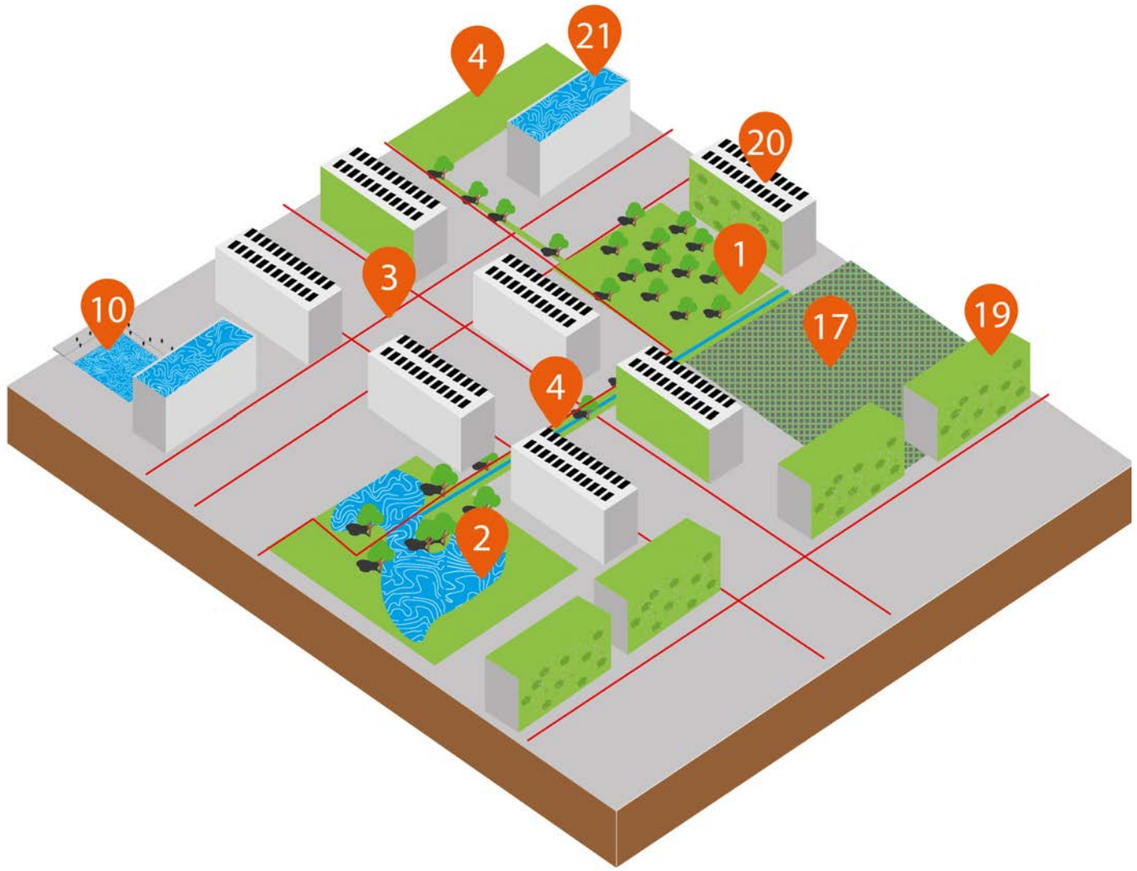


To really make changes towards sustainable development it is important to create support among residents. Therefore, urban designers should cooperate with residents. Urban designers should tempt others to join and to let others take measures that enhance the quality of life. However, there are many types of people and these different people have different desirables and need different strategies to involve them in the design process, see figure 67. There are people who are conservative and don't like change. Others are willing to help and take initiatives to join the movement. For the municipality and urban planners, it is helpful to know where these different types of people live. With this information, they can decide which ways of communication work in which area. Different ways to approach and inform residents are residents meetings, webpages with information, local newspapers, social media or neighbourhood events. Also, there should be thought about the moments to involve residents, for example during seasonal changes and during big reconstructions of areas.

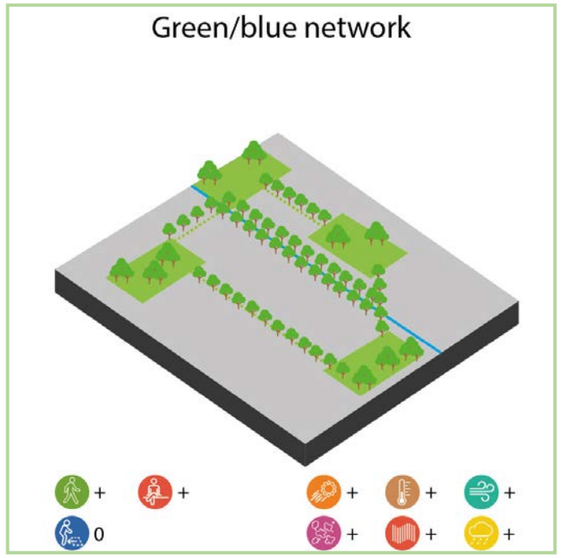


CATEGORY	+	0	-
SOLAR RADIATION	The interventions have a positive effect. These will improve the thermal comfort with e.g. a decrease of the amount of W/m2, protection against direct radiation from the sun and opportunities to gain solar energy.	The interventions have not a significant effect, positive or negative. The situation will be kind of the same, so the same amount of W/m2 will appear and no improvement or decrease of protection against direct radiation.	The interventions have a negative effect. These will decrease the thermal comfort with e.g. an increase of the amount of W/m2, less opportunities to gain solar energy and more exposure to direct radiation.
TEMPERATURE	The interventions have a positive effect. These will lead to lower temperatures (°C). Urban heat island effects will decrease and some areas will be cooled due to the interventions.	The interventions have not a significant effect, positive or negative. The situation will be kind of the same, so the same temperatures (°C) will appear with the same urban heat island effects.	The interventions have a negative effect. These will lead to higher temperatures (°C) and urban heat island effects will increase.
WIND	The interventions have a positive effect. These will give protection against wind disturbane and high wind speeds (m/s). It gives protections against corner streams, frontal vortexes or can be used for cooling.	The interventions have not a significant effect, positive or negative. The situation will be kind of the same, so the same wind speeds will appear with the same problems of corner streams and frontal vortexes.	The interventions have a negative effect. These will give more problems regarding wind speeds (m/s), corner streams and frontal vortexes are created. The wind is not cooling the area.
PRECIPITATION	The interventions have a positive effect. These will give protection against heavy precipitation events. More water can be stored and re-used, water can easily infiltrate into the ground.	The interventions have not a significant effect, positive or negative. The situation will be kind of the same, so the same capacity of water storage is pressence, no improvement of infiltration of water.	The interventions have a negative effect. These will give more problems for heavy precipitation events. Less water can be stores, no re-use of water and more water on surfaces because bad infiltration.
AIR QUALITY	The interventions have a positive effect. The air quality is improved. This can be done by less pollutants in the area (ppm) or more absorption of the air pollutants.	The interventions have not a significant effect, positive or negative. The air quality is not improved nor decreased. Same amount of pollutants and same amount of absorption in the area.	The interventions have a negative effect. The air quality is decreased. There are more pollutants in the are (ppm) and there is less absorption of air pollutants.
NOISE	The interventions have a positive effect. The noise level is decreased. There is a lower amount of noise causers and more sound is absorpted in the area.	The interventions have not a significant effect, positive or negative. The noise level is not improved nor decreased. Same amount of noise causers and same amount of absorption in the area.	The interventions have a negative effect. The noise level is increased. There is a higher amount of noise causers and/or less sound is absorpted in the area.
WALKABILITY	The interventions have a positive effect. The walkability in the area is improved. Wider sidewalks, safe and frequently crossings, interesting routes etc.	The interventions have not a significant effect, positive or negative. The walkability is not improved nor decreased. Nothing is done to give pedestrians more space or higher/lower safety.	The interventions have a negative effect. The walkability in the area is decreased. Less space for pedestrians (smaller sidewalks), more unsafe crossings and a decrease in quality of routes.
PLACES TO STAY	The interventions have a positive effect. The amount of choice for places to stay is improved. More benches, elevations to sit on, choice to sit in the sun/shadow, alone/in groups etc.	The interventions have not a significant effect, positive or negative. The amount of choice for places to stay is not improved nor decreased. Same amount of benches and choice where to sit.	The interventions have a negative effect. The amount of choice for places to stay is decreased. Less benches, elevations to sit ons, choice to sit in the sun/shadow, alone/in groups etc.
TRANSITION SPACES	The interventions have a positive effect. The opportunity to appropriate the transition spaces is improved. More space to create soft edges between public and private.	The interventions have not a significant effect, positive or negative. The opportunity to appropriate the transition spaces is not improved nor decreased. Same space to create soft edges between public and private.	The interventions have a negative effect. The opportunities to appropriate the transition spaces is decreased. Less space to create soft edges between public and private.

From the guidelines from literature, a design toolkit is made where interventions are shown and assessed on the different categories for appropriation and urban microclimate. The interventions can happen at different scale levels, from district level to materialization. Most important is to show the interventions that combine the positive effects of appropriation and urban microclimate and to show the relations at different scale levels. Moreover, it is clear that buildings, and therefore architecture, play an important role in designing a better urban microclimate and stimulate the appropriation of urban outdoor spaces. That's what this studio makes the perfect fit; it shows the relations of urban design and architecture and ways of how they can make each other stronger. Each intervention in the toolkit is assessed on the different elements of appropriation and urban microclimate to give an idea of what the effects of the intervention would be. In the table on the left, there is made a distinction between three categories: positive effects, no significant effects, and negative effects. In short, there are given some examples of how the intervention could have a positive or negative effect. In the next part, the most important interventions for the combination of appropriation and urban microclimate are shown on different scale levels.



District scale



SQUARE NETWORK

General information: A green and blue network should be created throughout the city. The creation of these areas at regular intervals will have multiple advantages regarding appropriation and urban microclimate. Moreover these areas should be connected to make a network instead of loose parts.
Appropriation: Different green/blue areas in the city will provide multiple and pleasant places for staying. Within the green areas it would be pleasant to walk and to stay. More advantages are created when these areas are well connected with each other. In this case it provides interesting and pleasant pedestrian routes alongside these routes in different green areas.
Urban microclimate: Multiple green/blue areas will help to reduce the temperature in the city. The cooling effect of green spaces apply over here. Moreover green areas will provide storage for heavy precipitation events.
Leadership: To create such a network of green/blue spaces a lot of planning should be done. Therefore the municipality should take the lead in this.
Costs: €€€
Maintenance: Municipality

KEY ASPECTS

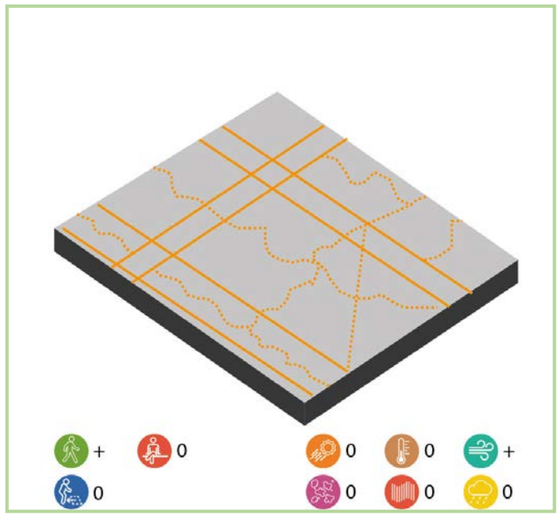
- **Providing recreational spaces**
- **Inviting social interaction and activities**
- **Cooling effect**
- **Water storage during heavy precipitation events**

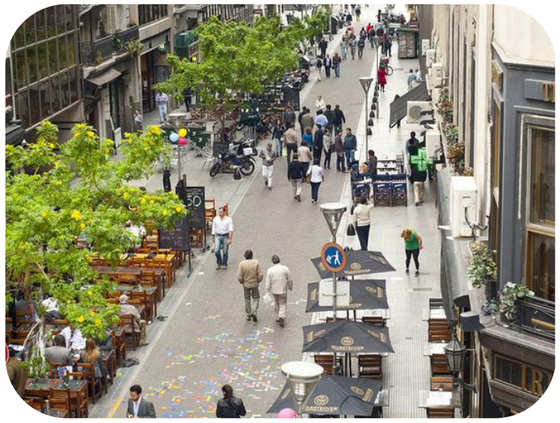
STAKEHOLDERS

- **Municipality**
- **Environmental organizations**
- **Parks and recreational organizations**
- **City residents**

WINDING PEDESTRIAN NETWORK

General information: With the switch of prioritising pedestrians instead of cars urban outdoor spaces are transformed into pedestrians friendly areas. Slow traffic will have the priority and the space for cars is downsized.
Appropriation: The walkability in the areas is very safe and interesting. At crossings pedestrians should not wait too long by giving them priority above the cars. Moreover, pedestrians are protected against these dangers. Between major roads winding pedestrian routes are created
Urban microclimate: Winding pedestrian routes have the advantage of avoiding wind discomfort. Wind will not reach high speeds because of straight canyons, but will be broken by the winding structures.
Leadership: The municipality should create conditions to prioritise the pedestrians. However, the pedestrians decide which routes are in the end taken, because the people are always looking for the shortest routes towards their destination.
Costs: €-€€€
Maintenance: Municipality



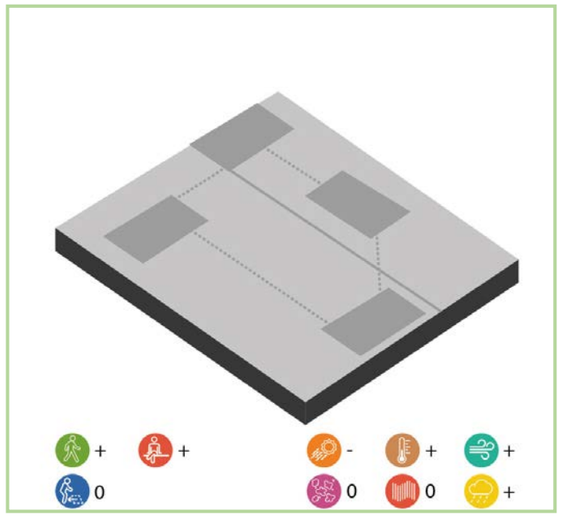


KEY ASPECTS
- Prioritize pedestrians
- Interesting pedestrian routes
- Avoiding wind discomfort

STAKEHOLDERS
- Traffic department
- Recreational organizations
- City residents
- Adjacent shops/restaurants

SQUARE NETWORK

General information: A network of squares should be created throughout the city. The creation of these areas at regular intervals will have multiple advantages regarding appropriation and urban microclimate. Moreover these areas should be connected to make a network instead of loose parts.
Appropriation: squares create possibilities for people to stay or to appropriate activities. When placed at regular intervals it provides a pleasant walkability where people can walk from open space to open space.
Urban microclimate: squares at regular intervals can promote long-wave radiation loss at night during the summer. To avoid overheating, shading at these squares should be provided.
Leadership: To create such a network of square spaces a lot of planning should be done. Therefore the municipality should take the lead in this.
Costs: €€€
Maintenance: Municipality

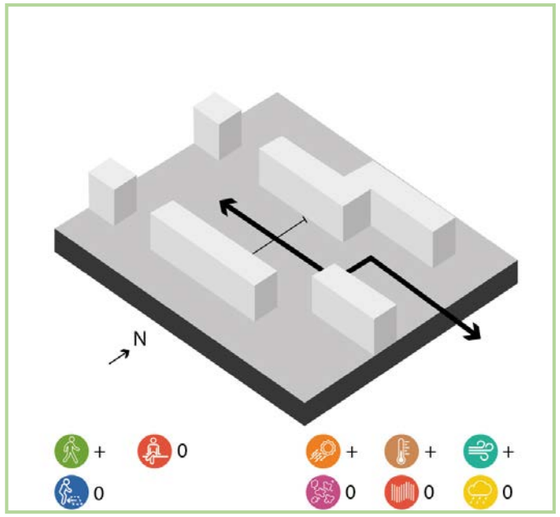


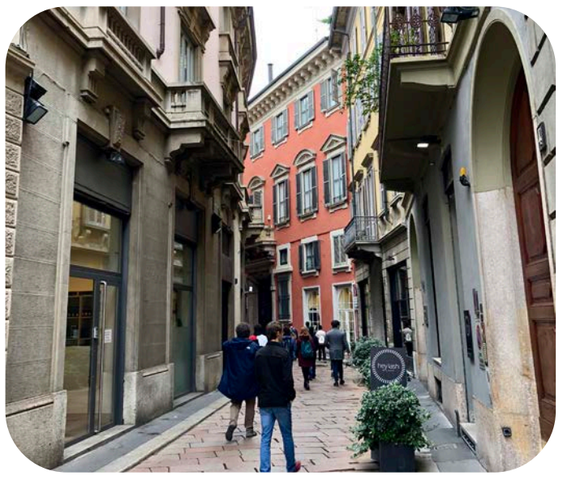
KEY ASPECTS
- Differentiated squares
- Place for activities
- Promote radiation loss
- Avoid overheating

STAKEHOLDERS
- Municipality
- Adjacent property owners
- Cultural sector
- Restaurants/cafes/shops
- City residents

STREET ORIENTATION

General information: urban structures are important within a city. The street orientation has a big influence on the microclimate regarding wind and solar radiation and on appropriation regarding the walkability.
Appropriation: curved streets are preferable for a pleasant walkability. It is more interesting for pedestrians and it avoids wind nuisance.
Urban microclimate: streets parallel to the prevailing wind direction can give problems with wind nuisance, because the wind can easily be channelled. Moreover east-west streets should be wide and north-south streets narrow, because the H/W ratio has a bigger impact on east-west streets. This structure gives the best possibilities for a pleasant outdoor thermal comfort.
Leadership: Street grid in a city requires planning and designing on a large scale. Therefore the municipality should take the lead.
Costs: -
Maintenance: Municipality



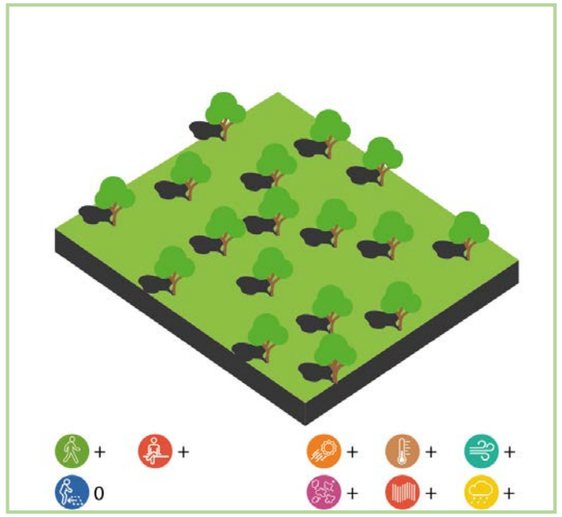


KEY ASPECTS
- No long straight streets
- Prevailing wind direction vs pedestrian routes
- H/W ratio

STAKEHOLDERS
- Municipality
- Traffic department
- Developers
- City residents

URBAN FOREST

General information: Urban forests have many functions within a city. They provide recreational spaces and have multiple advantages regarding urban microclimate. It is important to have larger green structures in a city like forests and parks.
Appropriation: Urban forests and parks provide recreational space in a city. A pleasant walkability is created in these green areas and they give many opportunities for staying.
Urban microclimate: urban forests contribute to a reduction in heat stress and therefore the city's air temperature. Moreover they provide islands of clean air within urban areas. The green character of the spaces provide water storages in a dense city.
Leadership: Large green spaces require a lot of city planning and is therefore the task of the municipality. Small pocket parks can also be initiatives from smaller groups.
Costs: €€
Maintenance: Municipality

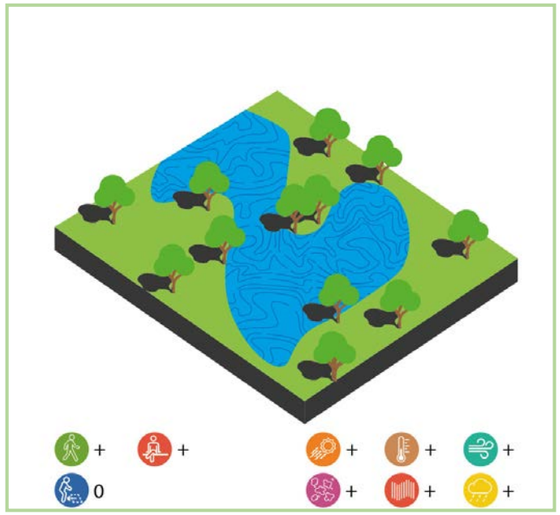


KEY ASPECTS
- Recreational spaces
- Social interaction and activities

STAKEHOLDERS
- Municipality
- Green space management
- Parks and recreational organizations
- City residents

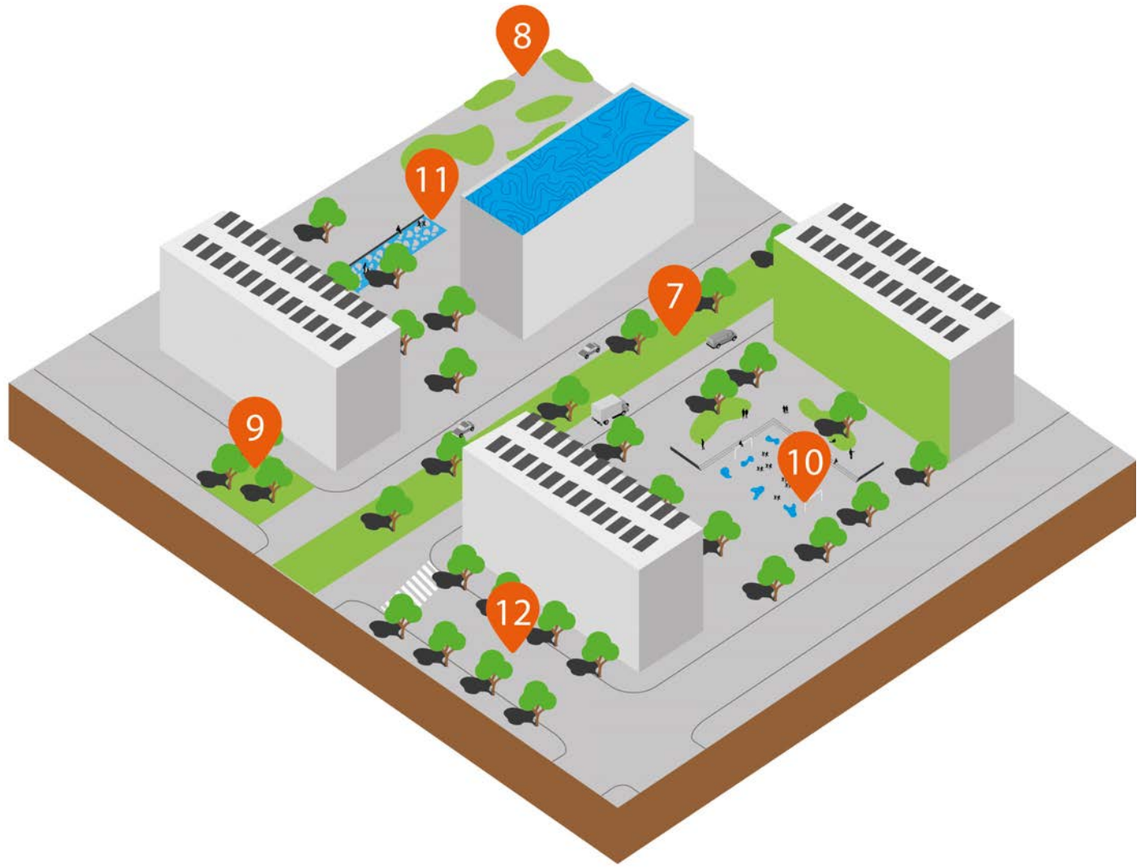
URBAN WETLAND

General information: There are different kinds of wetlands within a city. Large water-rich natural areas around rivers outside the city or smaller urban wetlands like a rainwater garden. It differs from an urban forest, because of the high presence of water in the area.
Appropriation: urban wetlands provide many opportunities for staying and connected with a pedestrian network it creates a pleasant walkability.
Urban microclimate: urban wetlands provide a great contribution to the water storage in a city. The wetlands help to reduce the heat in the city and they improve the air quality when combined with certain types of plants.
Leadership: Large wet spaces require a lot of city planning and is therefore the task of the municipality. Small urban wetlands can also be initiatives from smaller groups and designed by landscape designers.
Costs: €-€€
Maintenance: Municipality



KEY ASPECTS
- **Recreational spaces**
- **Water storage for the city**

STAKEHOLDERS
- **Municipality**
- **Water management**
- **Parks and recreational organizations**
- **City residents**



Neighbourhood scale

ECO/SOCIAL MEDIAN

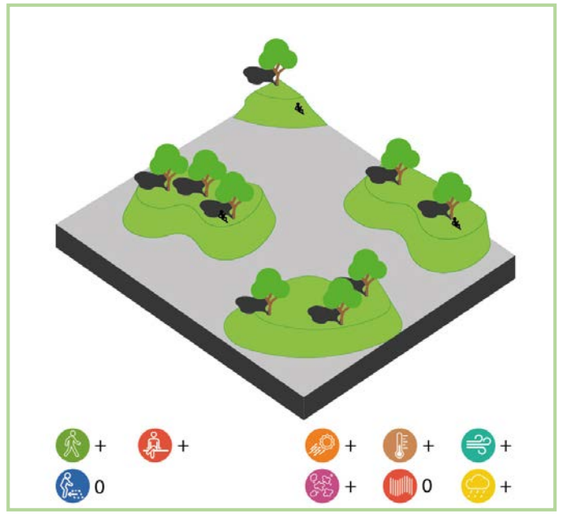
General information: Eco/social medians can be created of different sizes. When there is enough width it could be linear parks, otherwise it can be used for traffic calming.
Appropriation: When used as traffic calming it creates a safer walkability in the street. As linear parks it provides places for staying and new pedestrian routes.
Urban microclimate: The presence of greenery improves the temperature and air quality. Within dense, paved areas the medians provide water storage during heavy precipitation events.
Leadership: Bigger projects like linear parks should be initiated by the municipality. Smaller interventions in the street can come from residential initiatives.
Costs: €-€€
Maintenance: Municipality

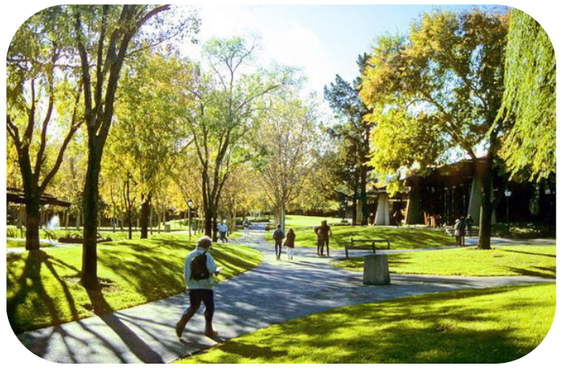
KEY ASPECTS
- Pedestrian routes
- Width of the street
- Green environment
- Impact on traffic system

STAKEHOLDERS
- Traffic department of municipality
- Parks and recreation
- Community organizations

GREEN HILLS

General information: The creation of height differences in the form of hills provide many advantages regarding appropriation and urban microclimate.The hilly terrain invites people to appropriate the space.
Appropriation: The height differences provide choice to the people where and at which height they want to stay. At the same time, pedestrian routes through the hills create a pleasant and interesting walkability.
Urban microclimate: Water runoff can be steered towards lower placed surfaces. The hills combined with trees offer places in sun or shade, improve the air quality, give protection against wind and provide water storage during heavy precipitation events.
Leadership: Mostly the intervention is quite a large intervention in the public space, so the municipality owns the space and should commission the design.
Costs: €€
Maintenance: Municipality



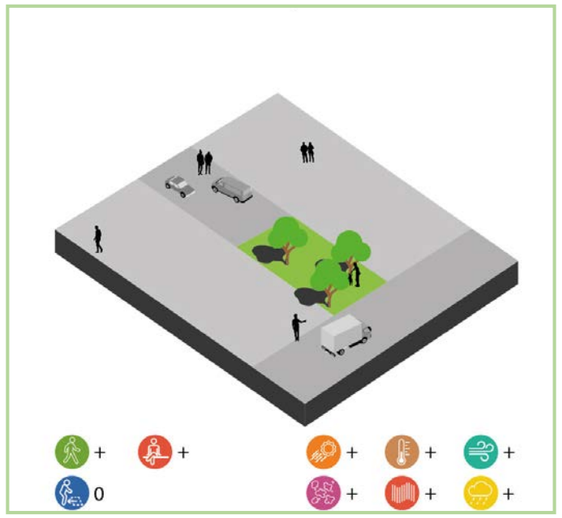


KEY ASPECTS
- Height differences
- Multiple sitting options
- Stormwater run-off and temporary water storage

STAKEHOLDERS
- Municipality
- Landscape designers
- Community organizations
- Residents

STREET PARK

General information: A street park is a permanent transformation where a less important street is transformed into a pocket park. It removes the space for cars and creates the opportunity for people to appropriate it for activities like playing, urban farming or community activities.
Appropriation: Streets are made safer by the removal of cars and thus improves the walkability. Moreover it creates spaces for staying.
Urban microclimate: When the pocket parks are combined with greenery like trees and plants it has multiple advantages regarding the climate. Local temperatures are improved, water can be stored and air quality is improved.
Leadership: A collaboration between the municipality and neighbourhood associations should lead this intervention.
Costs: €-€€
Maintenance: Community associations and residents

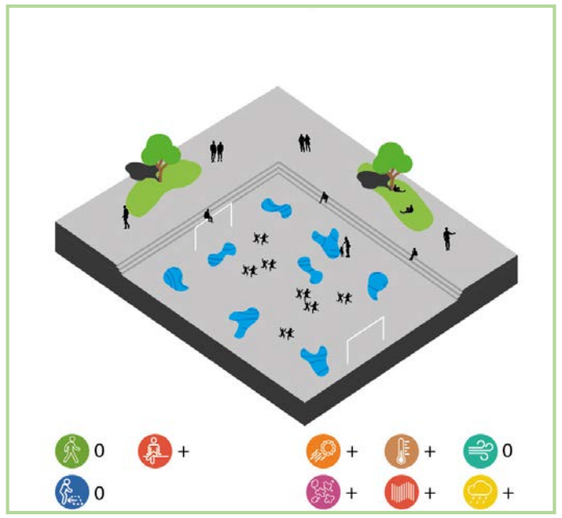


KEY ASPECTS
- Unimportant residential streets
- Impact on traffic flow in neighbourhood
- Community support
- Greening of streets

STAKEHOLDERS
- Initiatives from residents
- Community associations
- Municipality

CLIMATE SQUARE

General information: climate squares are generally used in inner-city areas with little room for water buffers, where high groundwater levels make infiltration impossible and where green surfaces are desired.
Appropriation: Climate squares provide many opportunities for appropriation. People can sit around green elements, at the stairs around the water square and undertake many activities. A water square can be combined with other public urban functions, like green spaces, and therefore result in a climate square.
Urban microclimate: The water square works as a water buffer where the lowest part fills up first and the water remains the longest. Green elements around the water square provide shade and improve the air quality.
Leadership: It is a big development and requires a lot of maintenance and management, so the municipality should be responsible.
Costs: €€€
Maintenance: Municipality

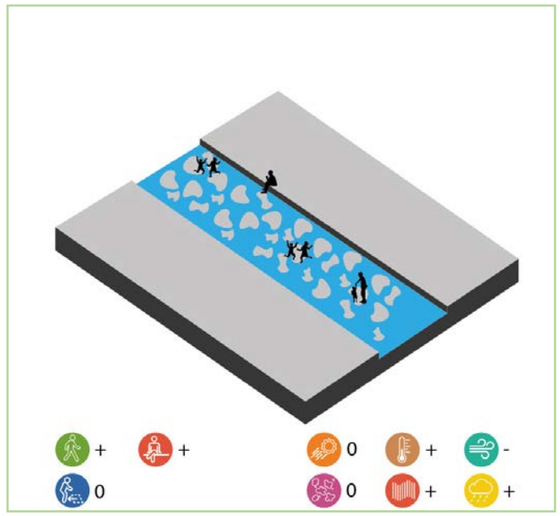


KEY ASPECTS
- Many sitting options
- Lots of activities
- Water buffer

STAKEHOLDERS
- Municipality
- Landscape designers
- Community organizations
- Schools

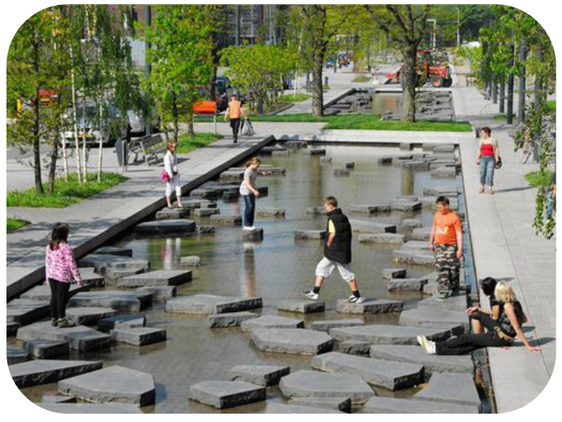
URBAN WATERWAY

General information: open urban waterways provide a temporary water storage and drain the water. It is a nice aesthetic improvement for the city.
Appropriation: urban waterways provide places for staying when alongside the water gentle banks or astepped quay is made. Moreover, stepping stones invite people to play at the waterway.
Urban microclimate: The most important advantage is the water storage that the waterway provides. The temperature also improves a bit.
Leadership: There are different sizes of waterways. Mostly the municipality combined with the water department should take the lead.
Costs: €€
Maintenance: Municipality



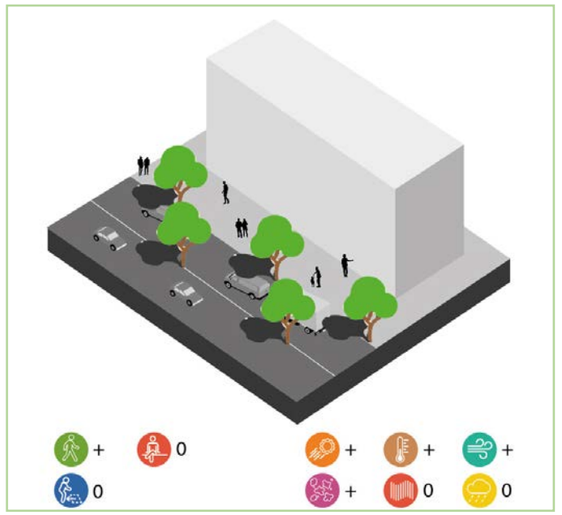
KEY ASPECTS
- Water buffer
- Cooling effect
- Contribute to playing activities

STAKEHOLDERS
- Municipality
- Water department



STREET TREES

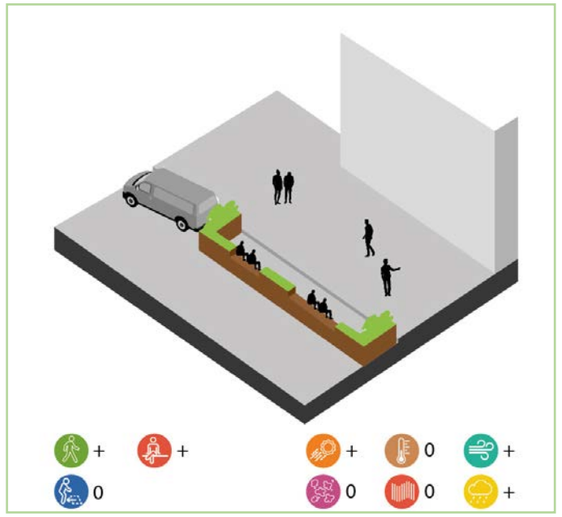
General information: Trees have many advantages regarding appropriation and urban microclimate, however not every type of tree is beneficial. The type of tree should be chosen to suit the local moisture system.
Appropriation: Most of the time street trees remove some space for pedestrians and are therefore negative for appropriation. However it also provides shade for pedestrians and at places where people can sit and it can work as a windbreak and therefore protect people from wind nuisance.
Urban microclimate: Trees provide shade and evapotranspiration and therefore have a cooling effect in the street. At busy roads the trees should not be too dense, because it prevents ventilation of air pollutants. Trees absorb water, which is an advantage for precipitation.
Leadership: The municipality should make a tree plan and maintain the trees.
Costs: €-€€
Maintenance: Municipality



KEY ASPECTS
- Types of trees
- Providing shade on sidewalk

STAKEHOLDERS
- Municipality
- Landscape designers

Street scale



PARKLET

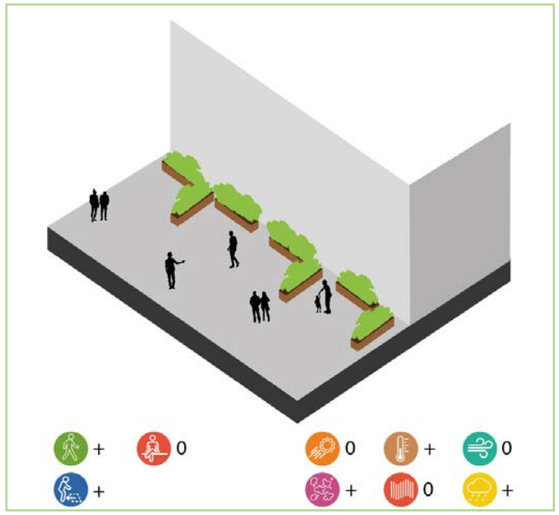
General information: Parklets are a (temporary) transformation of parking spaces into pocket spaces along the sidewalk. It can be seen as sidewalk extensions with the purpose of creating places for staying.
Appropriation: It creates places for staying in areas where the most activities are about movement. The walkability is improved and more interesting and sitting options are created. When the temporary intervention works it can be made permanent.
Urban microclimate: When the design of the parklet includes plants, small trees or green surfaces it helps to improve the microclimate. It can infiltrate water, improve the air quality and provide places with shade.
Leadership: Public-private collaboration between municipality and community sponsor.
Costs: €
Maintenance: Local businesses

KEY ASPECTS
- (Temporary)
- Accessible for everybody
- Maintenance plan
- Weather and seasonal use

STAKEHOLDERS
- Department of transport
- Investors
- Community organizations
- Residents/shop owners

OUTDOOR PLANTERS

General information: Outdoor planters are there in many ways, according to the preferences of the residents. This makes it very suitable for appropriation. Plants have many advantages for the urban microclimate.
Appropriation: Residents can claim a piece of the sidewalk by putting their plants on it. It will create a softer edge between public and private. A mix between high and low green elements in the street make it very attractive for pedestrians, so the walkability improves.
Urban microclimate: Rainwater can be stored in the green elements. It will lead to lower temperatures in the street and the air quality will improve.
Leadership: bottom up initiatives by the residents can make this work
Costs: €
Maintenance: Residents / shop owners

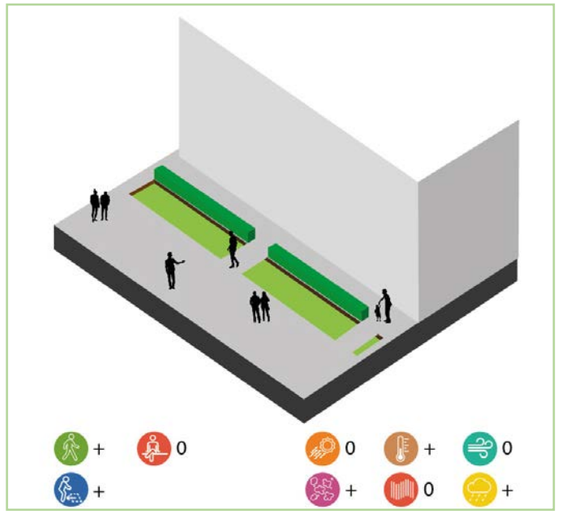


KEY ASPECTS
- Appropriation of edges
- Greening of streets
- Cooling effect
- Water storage

STAKEHOLDERS
- Building residents / shop owners
- Municipality
- Community associations

INFILTRATION STRIP

General information: Infiltration strips are lower placed, green surfaces next to paved surfaces where rainwater can be (temporary) stored and slowly infiltrated.
Appropriation: When the strips are placed at edge zones between public-private it works as a soft edge. Certain distance between public space and (semi) private zones is created.
Urban microclimate: It works very well as (temporary) water storage. Moreover it improves the local temperature and air quality because of the plants.
Leadership: It should be a collaboration between municipality and private owners of buildings, like housing associations.
Costs: €-€€
Maintenance: Residents / Residential associations

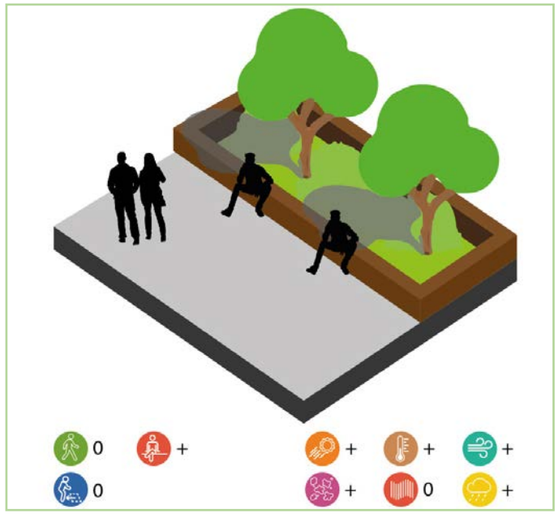


KEY ASPECTS
- Soft edge public-private
- (Temporary) water storage
- Improved air quality

STAKEHOLDERS
- Residents
- Housing associations
- Municipality
- Community associations

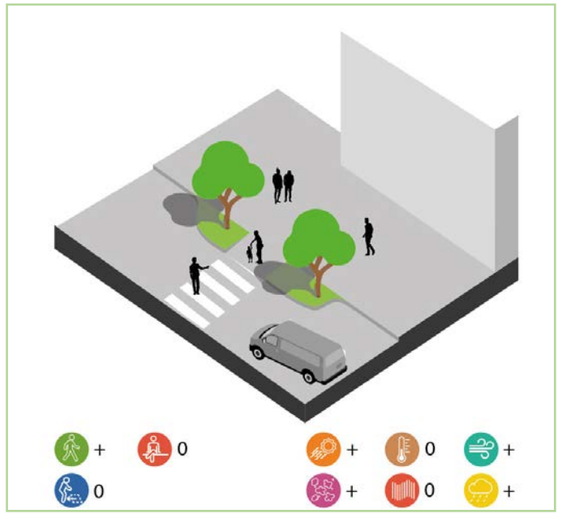
GREENERY WITH LEDGES

General information: At certain places a tree can be combined with more functions. By adding a ledge or a bench it provides options to sit.
Appropriation: The ledge or bench provide sitting options and therefore improves the places for staying. People like to sit under trees, because they feel protected.
Urban microclimate: Trees provide the choice to sit in the sun or in the shade. Multiple trees can work as a windbreak to protect pedestrians. Trees have a cooling effec on the area and improve the air quality.
Leadership: Municipaltiy
Costs: €-€€
Maintenance: Municipality



KEY ASPECTS
- Protected sitting options
- Pleasant urban microclimate
- Social comfortability

STAKEHOLDERS
- Municipality
- City residents



GREEN CURB BULB

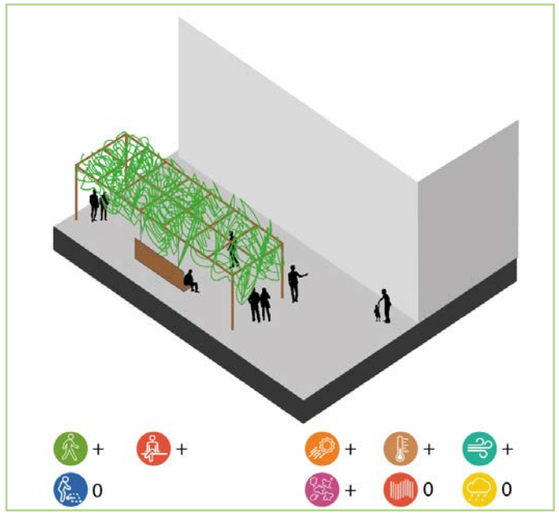
General information: A curb bulb is an extension of the curb. It is a strategy that is used to widen the sidewalk at important locations to create a safer pedestrian environment.
Appropriation: A curb bulb at intersections, like pedestrian crossings, improves the safety, because of narrowing the street and cars will slow down.
Urban microclimate: When a curb bulb is combined with green surfaces it also has advantages for the microclimate. It provides water storage, improves the air quality and trees can provide shade.
Leadership: The transportation department plays a very important role and community associations can participate in the process to decide the functions of the curb bulb.
Costs: €-€€
Maintenance: Municipality

KEY ASPECTS
- Safe pedestrian crossings
- Impact on traffic volume
- Water storage

STAKEHOLDERS
- Municipality
- Department of transportation

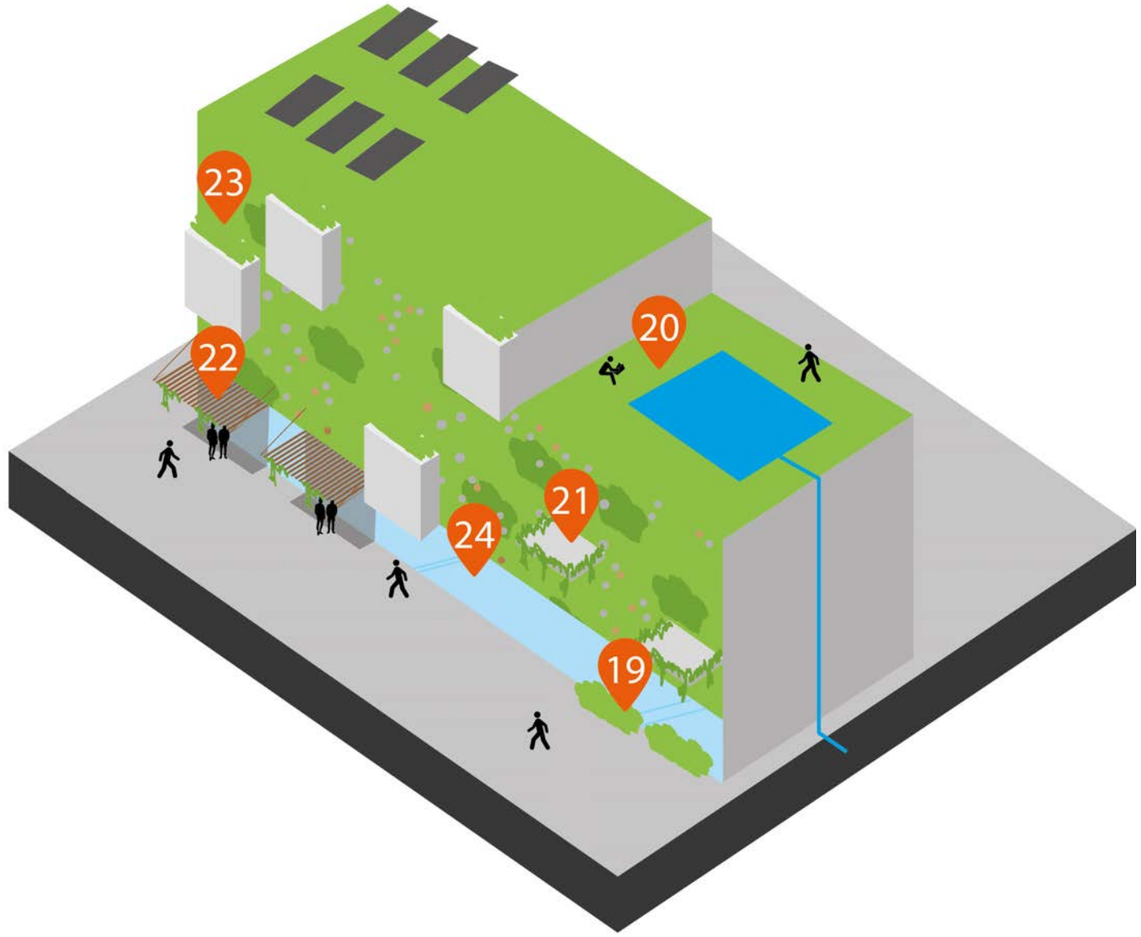
PERGOLA

General information: A trellis/pergola is a construction where plants can grow on. Mostly it is used as a roof above a terrace or path to provide shade.
Appropriation: A pergola offers the possibility to walk in the shade, which improves the walkability. When a pergola is combined with sitting options it creates a pleasant environment for staying also.
Urban microclimate: It provides shade during the summer and allows solar radiation to go through in winter. The plants on the pergola improve the air quality and can work as a windbreak to protect the pedestrians from wind nuisance.
Leadership: Pergola on a public street is part of the municipality where smaller constructions can be made by smaller groups.
Costs: €-€€
Maintenance: Municipality



KEY ASPECTS
- **Social comfortability**
- **Protected walkability**
- **Protection against sun**
- **Protection against wind**

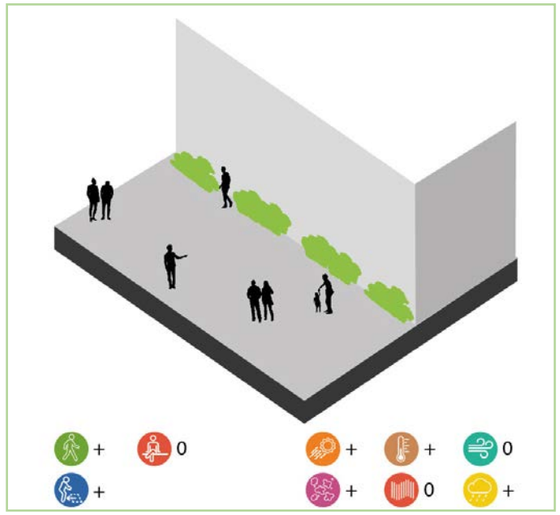
STAKEHOLDERS
- **Municipality**
- **Adjecent shops/restaurants**
- **Residents**
- **Community associations**

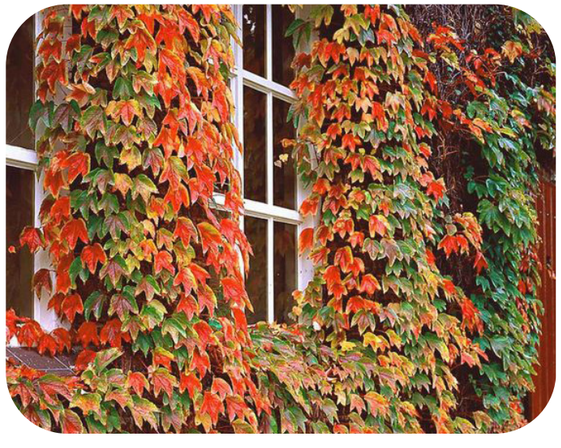


Building scale

FACADE GARDEN

General information: With a facade garden the residents remove a row of tiles along the facade at the side of the street and create a little garden. It has some advantages regarding appropriation and urban microclimate and it contributes to a green scenery in the street.
Appropriation: Residents can appropriate a little piece of the sidewalk and make it their own. A softer edge is created and when residents are doing some maintenance conversations on the street start to emerge.
Urban microclimate: Water from the facade can infiltrate in the facade garden. Moreover the plants contribute to lower temperatures in the street. The facade behind the plants heats up less and gives off less heat to the street at night. Air quality improves a little bit.
Leadership: residents should create this intervention where municipality can stimulate the use of it.
Costs: €
Maintenance: Residents



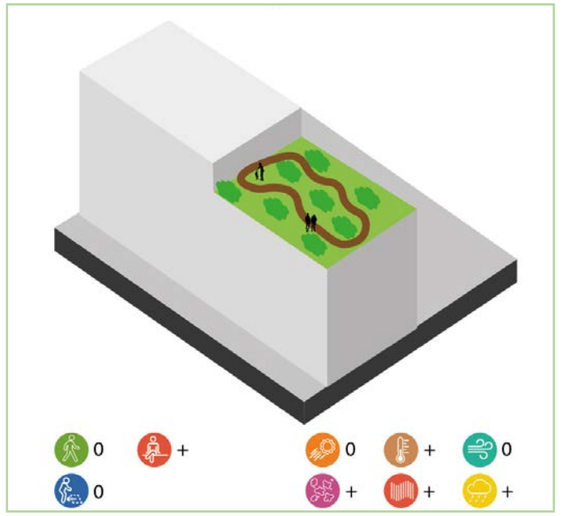


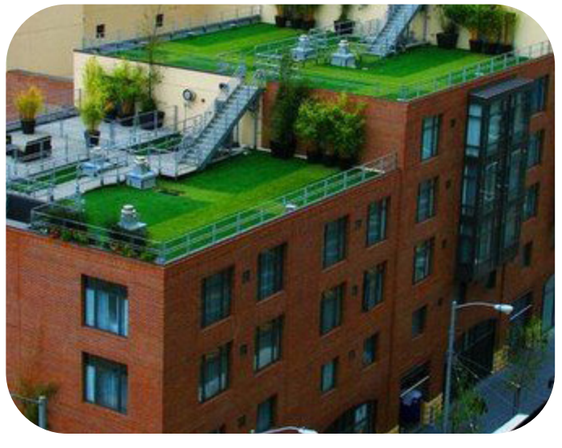
KEY ASPECTS

- **Social conversations during maintenance**
- **Own identity**
- **Low temperatures, better infiltration**

STAKEHOLDERS

- **Residents**
- **Community associations**
- **Municipality**





GREEN ROOF TERRACE

General information: A roof can have multiple functions, like having solar panels, green vegetation or even better a green garden. In this case the green on the roof is given an additional function, a (semi) private space for residents.
Appropriation: By giving the green roof an intensive function like a garden or terrace it provides new options for residents to appropriate. When there is not so much space at ground level, a roof garden is a good alternative.
Urban microclimate: Roof gardens contribute to water storage and temperature control. Moreover green on the roof causes a reduction of noise and absorbs pollutants.
Leadership: residents and building owners should create this intervention
Costs: €-€€
Maintenance: Residents / housing associations

KEY ASPECTS

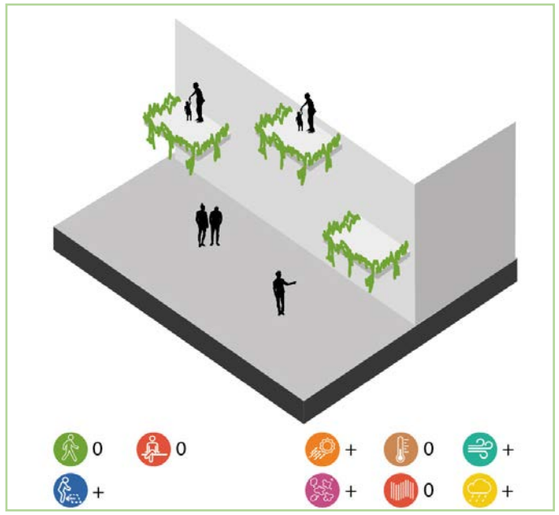
- **(Semi)private staying options**
- **Water storage**
- **Lower temperatures**

STAKEHOLDERS

- **Housing associations**
- **Residents**

GREENING BALCONIES

General information: A balcony provides opportunities to grow all kinds of plants and herbs. It creates spaces between public and private and when made green it has multiple microclimatic advantages.
Appropriation: Balconies are (semi)private staying options that have the opportunity for interaction with the street. A soft edge is created by the visual interaction between public and private.
Urban microclimate: Plants and herbs on the balcony improve the air quality and temperatures on the balcony itself. Plants can work as a windbreak to protect the residents on the balconies.
Leadership: residents should create their own space on their balconies
Costs: €
Maintenance: Residents

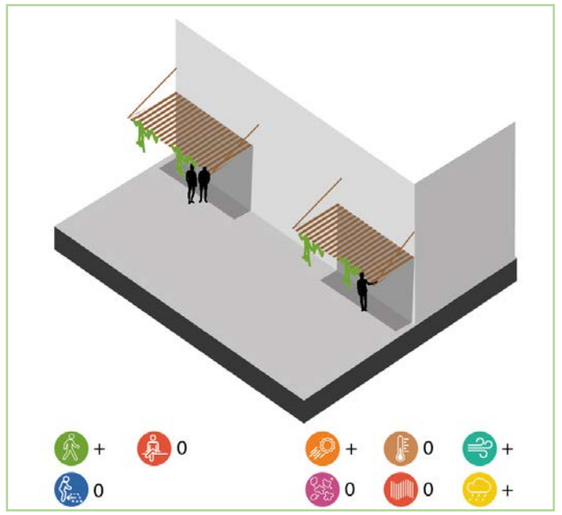


KEY ASPECTS
- (Semi)private staying options
- Soft edge
- Lower temperatures
- Improvement air quality
- Residents involvement

STAKEHOLDERS
- Residents
- Housing associations
- Community associations

OVERHANGING ROOF

General information: An overhanging roof, protruding outwards from the building mostly functions as weather protection. It can also function to define the entrance of a building.
Appropriation: It provides protection for pedestrians and therefore contributes to a better walking environment.
Urban microclimate: Protection against solar radiation, precipitation and wind is provided. When it is combined with plants the air quality is improved too.
Leadership: shop owners, building owners
Costs: €
Maintenance: Shop owners / housing association

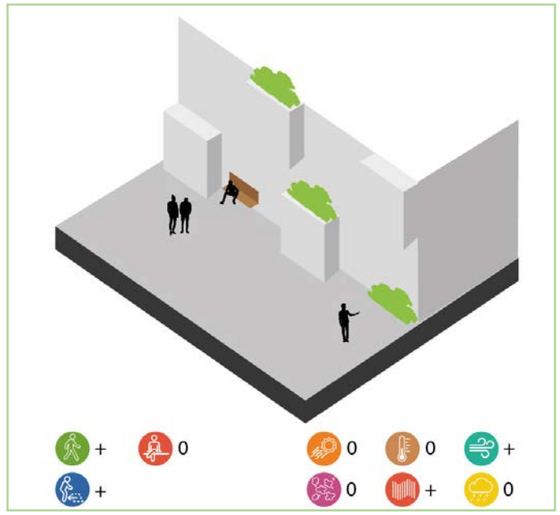


KEY ASPECTS
- Weather protection
- Entrance of buildings
- Pedestrian routes

STAKEHOLDERS
- Shop owners
- Housing associations
- Developers
- Municipality

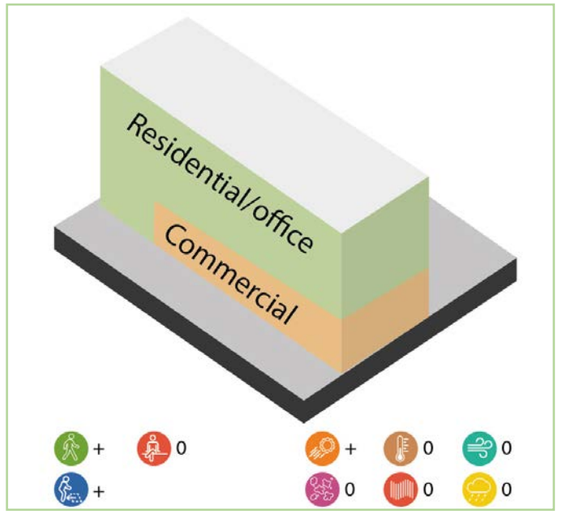
FACADE RELIEF

General information: An irregular facade is more interesting than a regular facade. A large variation in function, materialization and details gives high quality to the architecture.
Appropriation: Facade relief contributes to an active ground floor and therefore a pleasant walkability. All the edges can give pedestrians protection.
Urban microclimate: An irregular facade increases scattering, and therefore lower noise levels. Moreover it can work a little bit as a windbreak.
Leadership: building owner
Costs: -
Maintenance: Housing associations / residents



KEY ASPECTS
- High level of detail
- Active ground floor
- Scattering of noise
- Opportunities for appropriation

STAKEHOLDERS
- Developers
- Housing associations
- Shop owners
- Residents



FUNCTION ZONING

General information: Different functions in a building should have some planning. Commercial functions on the ground floor with residents/offices on top of it. Restaurants and shops create a lot of activity on the ground floor.
Appropriation: Functions on the ground floor should have interaction with the street to improve the walkability and to make the transition between inside and outside softer.
Urban microclimate: Functions which have a higher demand of heat should be placed higher than functions with a lower demand.
Leadership: buildings owners, however municipality can make certain rules regarding the ground floor.
Costs: -
Maintenance: Municipality

KEY ASPECTS
- Optimal zoning of functions
- Active ground floor
- Residential on top

STAKEHOLDERS
- Municipality
- Developers
- Housing associations
- Shop owners