How urban neighborhood design can support healthy and sustainable living

Master’s thesis
Tampere University
Faculty of Built Environment
The School of Architecture

Jieun Bae. April 2021

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Examiners / Supervisors

Assistant professor Sofie Pelsmakers, Tampere University

Postdoctoral researcher Laura Uimonen, Tampere University

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abstract

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The main aim of this thesis is to research **how urban neighborhood design can support and enhance health and well-being and more sustainable living**. Based on design principles that support and enhance sustainability and citizen's health and well-being, five design criteria are developed. Each criterion is further studied, and keynotes are taken away and act as a checklist for the neighborhood-scale plan.

For the case studies, three neighborhoods were selected based on similarity of context with Kalasatama, the chosen design area. The cases, which claim sustainable neighborhoods as their main aim, as well as the initial plan of Kalasatama are evaluated with five developed criteria. The aim is to make five criteria and related lessons that can be used for designers and developers to check as a precondition to design healthy and sustainable places which can promote people to have healthy and sustainable lives.

Finally, the design for the northern part of Kalasatama is suggested. The five criteria are used as an evaluation tool during the process, and the ultimate design is developed based on the result of this evaluation. The design process shows how these criteria can be used in the design phase and turn theory into practice.

This thesis suggests that neighborhood design should pursue health and well-being aspects and the inevitability of compromise for some sustainability criteria. The thesis also raises some questions and highlights issues about Finland's current prevalent housing typology. For example, one of the biggest problems turns out to be the distance between buildings, which does not consider the Finnish climate.

key words urbanization, health and well-being, housing neighborhoods, sustainability, living environments, urban planning

The originality of this thesis has been checked using the Turnitin Originality Check service.

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1.
introduction

1.1 the aim and purpose

The increase in the proportion of people living in urban areas, climate change which threatens our daily lives, combined with long-term sedentary lifestyles intrigue the interest in lifestyle illnesses variously called by health professionals as 'non-communicable diseases' (NCDs), 'avoidable-', and 'prevent-able illnesses'.

Urban planning is key to determine the built environment, natural surroundings, and social relationships which shape people's lifestyle. Planners and designers therefore should be responsible to make healthy places and healthy people. This thesis explores **how can urban planning and design support and enhance health and well-being and sustainable living environments.** The focus of this thesis is on urban neighborhood planning.

Based on design principles that support and enhance sustainability and citizen's health and well-being, five design criteria are developed. Each criterion is further studied throughout the literature review and keynotes are collected. After that, three neighborhoods that are selected based on similarity of context with the chosen design area are evaluated based on those five criteria. The thesis aims to develop and test five sustainable design criteria and related lessons that can be used for designers and developers to check as a precondition to design healthy places which can promote people to have healthy and sustainable lives. The design phase shows how these five criteria and checklists guide the design process in iterative stages. Computer simulation tools are used in order to get a better understanding of each case study and also the decision-making in the iterative design process of the new neighborhood design (e.g. solar shading, wind flow analysis).

1.2 defining the topic

In 2017, more than half of the world population (55%) live in urban settings. The number of inhabitants in the urban area keeps increasing and is expected to be more than two-thirds of the total world population by 2050 (Hannah & Max, 2018). However, the effect of **urbanization** is associated with a decrease in the quality of public spaces, courtyard, street, and indoor spaces as well, and this comes from the individuals' needs of getting the most of what is available (Strømann-Andersen & Sattrup, 2011; Pelsmakers & Saarimaa, 2020). Furthermore, reduced green areas, increased air pollutants and noise, and overcrowding are exacerbated by urbanization and add a burden to our health and wellbeing (Giles-Corti et al, 2016; Abraham et al, 2010; Maas et al, 2009; Evans, 2003).

It can be argued that the threat of **climate change** seems to have been overexposed, until recently we can experience the destruction of extreme weather events including intense rainfall events. Additionally, climate change does not mean simply warmer temperatures which are already harming environments enough to increase the global death rate (WHO, 2021), but it comes with other numerous cumulative effects such as an increase in energy consumption, air pollutants, and impaired water quality (Fraker, 2013).

Moreover, the development of technologies for **personal transportation**, remote communication, and workplace productivity has been related to much-reduced human energy-expenditure requirements. Too little exercise, as well as too much sitting, have received research attention showing a sense of urgency (Giles-Corti et al, 2016; Owen, 2012; Speck, 2018). Combined with the detrimental effects of pollution from automobile emissions and increased road traffic injuries (Tumlin, 2012), it has contributed to rethinking our transportation system.

As a result, cities face a myriad of public health challenges by increasing non-communicable diseases (NCDs), which are mainly the result of choices people have made, and the circumstances of their lives that have dictated them. The World Health Organization (WHO) reports that there is a shift in the burden of diseases from infectious disease to NCDs and announces **NCDs and road traffic injuries** as two of the biggest issues facing urban health.

Urban planning is key to determine the built environment, natural surroundings, and social relationships which shape our lifestyle. These environments can also affect our daily life choices (London, 2020; Dannenberg et al, 2011). It can encourage (or discourage) people to use a bicycle to school or work, to come across with neighbors and greet them, to take a walk around the neighborhood in their free time, and to have a good night without noise disturbance. Rethinking these environments which can help people to choose better decisions and lead to healthy lives is in need, and the urgency has been increasing more than ever.

In this thesis, the focus will be put on **the neighborhood-scale masterplan.** The neighborhood where people live can directly affect people's lifestyle, so that it is important to think about the opportunities of neighborhood-built environments. The wide determinants of health can be tackled through neighborhood development planning (Coyle, 2011; London, 2020) and it is necessary.

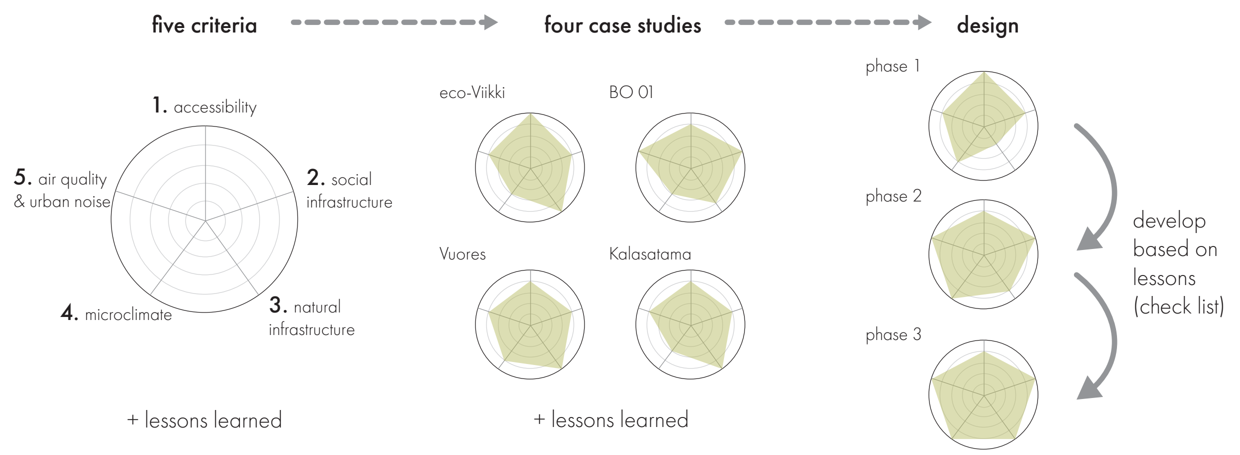
1.3 research method

This thesis uses literature reviews, design studies, and computer simulation. The literature review has been done with numerous books and articles. Among them, *Baker and Steemer's Healthy Homes: Designing with light and air for sustainability and wellbeing* is used for building up the structure of the thesis. The information on the case studies is publicly available data from the local city authorities, reports of the project, and internet pages of the projects and cities. Computer simulation is used for both case studies and the design phase to test sunlight hours and wind-flow comfort. The use of simulation tools helps to understand how the addition of new buildings affects the quality of the urban environment, the performance of the surrounding buildings as well as the city scale set-up by reassigning the natural element available at a place. This in turn affected the iterative design process whereby simulation results affected decision-making and design alterations to improve the comfort and sustainability outcome- i.e. evidence-based design.

The process of thesis began with the leading NCDs and sustainable design aspects. To tackle health and well-being (including traffic injuries) in cities, the links between urban design features and the leading NCD risk factors are explored. According to them, **five criteria** are erected and further studied in chapter 3. In each criterion, key lessons are created as a checklist for neighborhood-scale planning.

Three sustainable villages (Eco-Viikki, Bo01, and Vuores) and the initial Kalasatama plan are analyzed as **case studies**. Eco-Viikki and Vuores are located in Finland, and Bo01 is built in Sweden, but all of them claim sustainable neighborhoods as their main aim. Each one is assessed whether it is designed in a way to encourage people to have healthy lives based on the five criteria.

In the end, the **design** of the northern part of Kalasatama is suggested. As described in Figure 1.1, key lessons from the five criteria are pursued as the main focus in the design. Several evaluations with the five criteria are also processed to refine and test the design iteratively. This process also shows the usability of the criteria for this thesis and other projects.



^ Figure 1.1 process of thesis

2.
background

2.1 Health and Well-being

The WHO separates true health from not being sick by defining health as 'a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity'. It provides rethinking of the level of health and well-being which urban planning needs to target.

The development of medicine has increased longevity worldwide, extending the average life expectancy from 66 to 73 between 2000 and 2019 (Roser et al, 2019). To fully enjoy our extended longevity, it is fundamental to check if people can enjoy a good quality of life in the additional years.

Major attention has been paid to identifying and treating the diseases, and it has brought immense value such as longer life expectancy. However, it can be supplemented by an approach that focuses on creating conditions that enable people to enjoy a wider sense of wellbeing and an enhanced quality of life. It is not immediately referred to as a matter of public health, but it has a powerful influence on avoiding illness.

2.2 Noncommunicable diseases (NCDs)

Diseases that cannot be received from another person are called 'non-communicable diseases'. They are the result of a combination of environmental and behavioral factors (WHO, 2018). NCDs are also referred to by health professionals as 'avoidable -', 'preventable diseases', implying the possibility of their prevention by proper environmental behavioral solutions.

As NCDs have overtaken infectious diseases as the leading cause of death and disability (WHO, 2018), it is important to understand what are leading NCDs and what are their causes. Including road traffic injuries, the links between leading NCDs and their causes are illustrated in Figure 2.1 and will be further explained in chapter 3.

	Leading NCDs and Road traffic injuries					
	Cardiovascular diseases	Type 2 diabetes	Cancer	Respiratory diseases including asthma	Mental illnesses	Transport related accidents
Sedentary lifestyle and physical inactivity	strong	strong	strong	weak		weak
Unhealthy diets	strong	strong	strong		weak	
Air pollutant			strong	strong		strong
Loneliness isolation	weak	weak	weak		strong	
Interaction of vehicles with cyclists and pedestrians			weak	strong		strong
Overcrowding noise	weak	weak	weak	weak	strong	weak

^ Figure 2.1
The links between leading NCDs and their lifestyle behaviors

- strong
- weak

2.3 Health and urban planning

The causes of health and wellbeing are such a complexity. It is characterized by multiple dimensions, including age, vulnerability, monetary situation, culture, healthcare system, environment, and behavior (Kuipers et al, 2011). **Providing a healthy place does not mean all will be healthy.** Even if the environment provides everything necessary to have healthier lives, the result can come differently depending on individuals' will and intention, which design can do nothing about. Figure 2.2 shows how people may react to the situations they are in.

1 Fortunate

The best situation, people enjoy their decisions such as walking to office or school, and those decisions benefit their health.

2 Sensible

They do not enjoy it, but still do it because they may understand the long-term benefit for their health.

Or because it is convenient or effective. For example, people may choose public transportation over their car because it brings them to the destination faster or is cheaper.

3 Your choice

It can happen simply because they are not willing to do so.

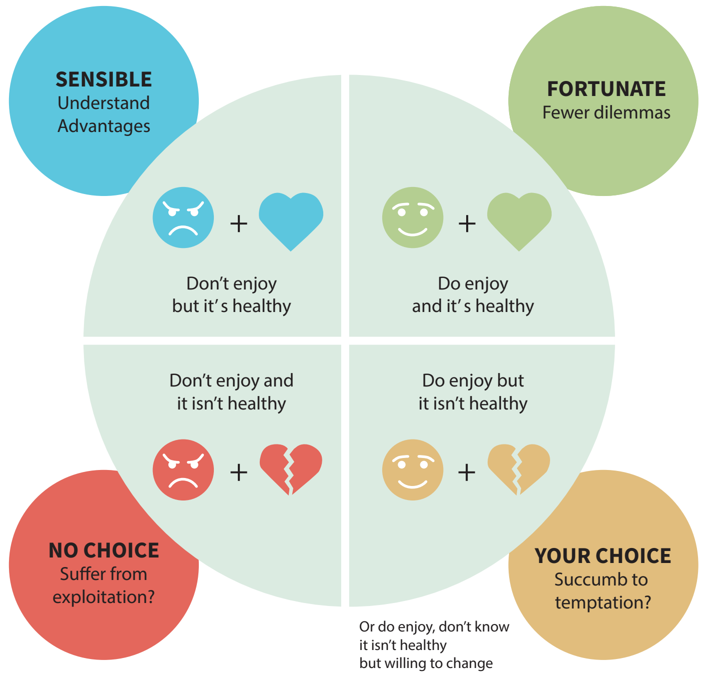
Or because people do not realize it is unhealthy.

4 No choice

The Last category may mean that situation needs extra support. Perhaps living or working in a polluted environment.

Risk factors for NCDs and road traffic injuries are influenced by the urban environment, and the built environment has the potential to create the condition in which barriers to healthy lives are low and to lead to better decisions for one's health as well as the environment (London, 2020; Dannenberg et al, 2011).

Moreover, well-designed and appropriate urban design interventions, which are integrated into people's daily lives, can drive these decisions even without awareness of people and reduce poor health which is unconsciously created by lifestyle (Giles-Corti et al, 2016; Kent & Thompson, 2019). There is a broader responsibility for planners and designers to make healthy alternatives available and to encourage their use.



^ Figure 2.2
Life's choice (London, 2020)

2.4 five criteria

According to the leading NCDs and sustainable design principles, **five criteria; Accessibility, Social infrastructure, Natural infrastructure, Microclimate, and air quality and urban noise** are constructed. Combined with climate change, five criteria are illustrated in Figure 2.3. Every criterion, directly and indirectly, addresses potential health impacts.

v Figure 2.3
How the five criteria address the causes
● primary effect
○ secondary effect

	Five criteria				
	1. Accessibility	2. Social infrastructure	3. Natural infrastructure	4. Microclimate	5. Air quality & Urban noise
Sedentary lifestyle and physical inactivity	● (Owen, 2012)	● (Mehta, 2007)	○ (Nielsen & Hansen, 2007)	● (Sim & Gehl, 2019; Moonen et al, 2012; Martins et al, 2016)	● (Giles-Corti et al, 2016)
Unhealthy diets	● (Kent & Thompson, 2019)		● (Teig et al, 2009)		
Air pollutant	● (Giles-Corti et al, 2016)		● (Speck, 2018; Tumlin, 2012)	● (Strømann-Andersen & Sattrup, 2010)	● (Giles-Corti et al, 2016)
Loneliness isolation	○ (Yamaguchi et al, 2020)	● (Yamaguchi et al, 2020)	● (Maas et al, 2009; Susan, 2007; Sugiyama & Thompson, 2007)	● (Chen & Ng, 2012; Tavares & Swaffield, 2017)	
Interaction of vehicles with cyclists and pedestrians	○ (Speck, 2018)	○ (Speck, 2018)			● (Woodcock et al, 2009)
Overcrowding noise	● (Sturm & Cohen, 2004)		○ (Evans, 2003; Gidlöf-Gunnarsson & Öhrström, 2007)		○ (Gidlöf-Gunnarsson & Öhrström, 2007)
Climate change	○ (London, 2020)		● (Brown & Mijic, 2019)	○ (Moonen et al, 2012; Lenzholzer, 2015)	● (Woodcock et al, 2009)

It must be pointed out that adjustment to the urban structure requires integrated approaches, and it can address several health issues at once. For example, better versions of streets can make them more friendly to walk and cycle, improve air quality, make the public realm safer and more attractive, and raise the number of people getting more exercise in daily life (Dannenberg et al, 2011). It would generate an increase in the social interaction that helps to unite communities, enhance our sense of wellbeing, and this will bring a good chance of boosting local economies (Kent & Thompson, 2019). This indicates that each of the criteria is separated but interconnected with each other. Separately, none of these criteria will bring about the desired outcome, but their combined approaches contribute to environments that produce the conditions for people to pursue healthy lives.

"Health is no more a personal issue than sustainability or traffic safety is. It is a cross-sector job, where different stakeholders need to work together in order to create a healthy city. Only in the space between city planners, architects, politicians, healthcare professionals, and other vital societal arenas can we create cities that are truly for people." - Gehl

3.
five criteria

1. accessibility

The first criterion is accessibility which has a huge influence on public health by dominating people's daily choices including transportation mode (Giles-Corti et al, 2016; Tumlin, 2012), health-related lifestyle behaviors (Baker & Steemers, 2019; London, 2020), and their diet choices (Dannenberg et al, 2011; Kent & Thompson, 2019). It is therefore related to every leading NCDs, implying that offering good accessibility can bring enormous value to the environment and public health.

Walking and cycling are not solely for transportation but also serve recreational purposes with positive effects on climate and health. These environmentally compatible transport modes reduce the dependence on private cars, thus decreases noise and air pollution, and promote activities in daily settings (Giles-Corti et al, 2016; Dannenberg et al, 2011; Abraham et al, 2010). It is also associated with the quality of public spaces. With little or no interference of automobiles, the public realm becomes safer and more attractive (Brown et al, 2007; Lorinne, 2007; Lund, 2002; Mehta, 2007), promoting interaction between people through a high social density (Macdonald, 2005; Zhang & Lawson, 2009). It can increase the number of people getting exercise in daily life and give a good chance of boosting local economies (Owen, 2012; Living Streets, 2014).

House is the place where people start their journey. It is important to offer a neighborhood that is friendly to walk, bike, and use public transportation.

Qualified density

Qualified density planning helps to reduce land consumption, as well as minimize the need for transport people, products, and energy. Through efficient transport systems and shared infrastructures, density is considered as one strategy for sustainable development. To increase the compactness of activities and developments, this suggests that future urban developments should be planned near the existing urban structure, and it also involves developing previously undeveloped urban land, and redeveloping existing buildings or sites (Jabareen, 2013; Strømann-Andersen & Sattrup, 2011).

Transit is one strategy to use urban space efficiently. While individual cars require extra space for parking lots which consume more space than building itself, public transport takes less space compared to private cars and can deliver a lot of people at once (Giles-Corti et al, 2016). When a city does not have enough density, it is difficult to arrange economic and effective public transport system which serves the whole area equally (Ecocity, 2005). It does play an important role when people choose their transportation, while a poor public transportation system fosters dependence on private automobiles (Tumlin, 2012).

Figure 3.1.1 >
Average Daily Trips vs Density (Tumlin, 2012)
As density increases, pedestrian and transit increase, and vehicle trips decrease.

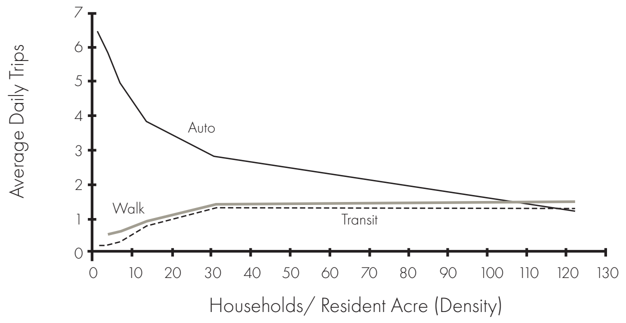
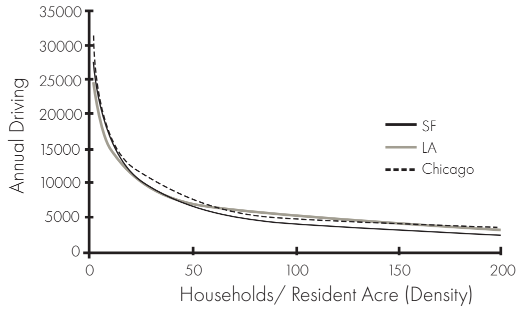


Figure 3.1.2 >
Driving vs Residential Density (Tumlin, 2012)
This shows the same thing. As density increases, vehicle trips decrease.



Mixed land use

Mixed land use refers to the diversity of functional land uses. It allows people to have close proximities between their daily living destinations such as residential, commercial, industrial, and transportation (Jabareen, 2013). To promote people to walk rather than use their cars, urban planning needs to ensure people travel with the shortest possible distances to fulfill their demands of everyday life (Aghaabbasi et al, 2018; Speck, 2018).

Other than the distance, it is important to make the street **pleasant for pedestrians**. For this, the owner of the street should be a pedestrian, not a car. Streets need to be perceived as safe for every user, and cars always should be ready to allow them. Streets can be kept safe with regulations such as limiting the car speed, placing bollards and lighting, while protecting sidewalks from cars and car crashes with trees (Aghaabbasi et al, 2018).

It is also important to make the street interesting. People like to have a comfortable overview of a place, and with **human scale**, it is easy to promote intimacy and sociability (Sim & Gehl, 2019). It does not mean all buildings need to be a single floor mass. Because of a unique feature of human eyes which has a longer vision in the horizontal direction than vertical, constantly changing on the ground floor is enough to give new stimuli. What humans can see during walking is limited with the ground floor of buildings, the pavement, and street space itself (Macdonald, 2005; Gehl, 2011).

To make **cycling** an attractive transportation choice for people of all ages and abilities, safety is vital (Winters et al, 2011), and the safety of bicycles is in numbers. When there is greater number of cyclists on roads, more car drivers pay attention to them (Robinson, 2005). It is fundamental to encourage non-cyclist to start cycling. According to surveys of commuters, distance and safety issues are listed as top reasons why they do not use a bike as their commute transport. Other than that, there are lack of storage space, weather condition, and interactions with motor vehicles (Transport Canada, 2008). It is critical to physically separate cyclists and motor vehicles, and carefully consider how they interact at intersections. Clear signs and design will develop the perception of safety and bring real safety to cyclists. Other than that, urban planning can address some arrange of weather conditions with proper interventions (Tumlin, 2012; Coyle, 2011).

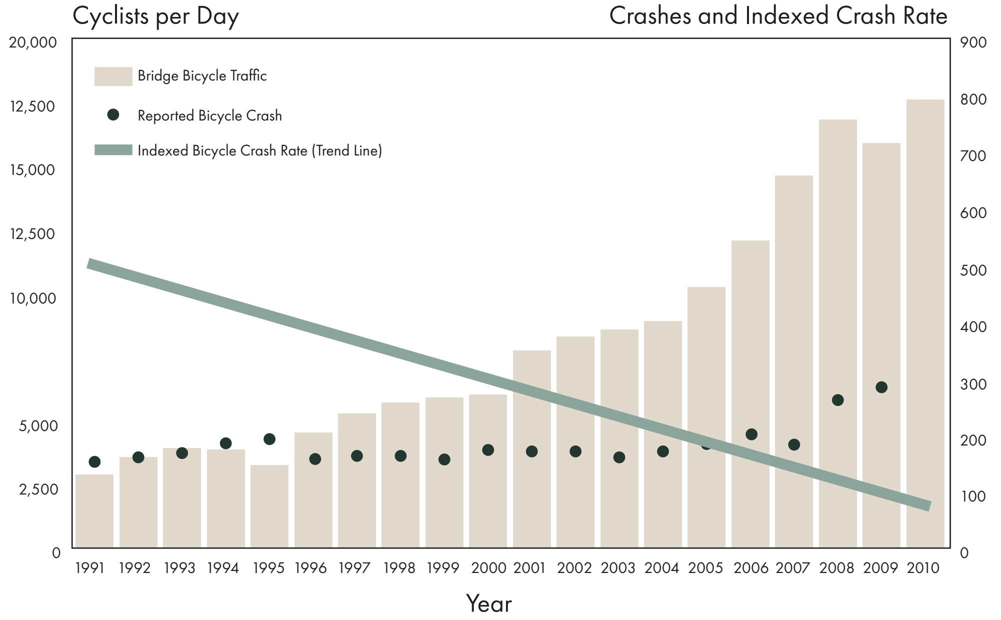


Figure 3.1.3 >

The more, the safer (City of portland, 2010)

As cycling increased, the crash rate has declined sharply.

	Lesson learned
Qualified density	a. Qualified density b. Public transport stops should be located at an acceptable distance from every resident unit. c. Active travel modes should be well design on bigger scale planning.
Mixed land use	d. Every unit should be well connected to pedestrian and cycle road and have a short distance to daily destination. e. Safe and interesting streets to walk and cycle (special attention on ground floor regarding human scale). f. Address weather condition with proper interventions (e.g trees for windbreaker or shadow). g. Carefully design pedestrian-centered streets. h. Enough storage spaces for bike

Special attention needs for sedentary lifestyle and diets. Sedentary behavior involves little or no physical activity including time spent in cars or watching television. Increased automobile manufacturing and development of network intrigue automobile- and screen-dependent urban environment, and bring about dominant sedentary lifestyles (Owen, 2012). The problem of a sedentary lifestyle is distinct from a lack of physical activity. Even among those who reported high levels of moderate-to-vigorous physical activity (more than 7h per week), the sedentary lifestyle with sitting for 10h or more per day increases health risks (Giles-Corti et al, 2016).

In cities, non-communicable diseases such as diabetes and obesity are rapidly increasing (Schuff & Risom, 2018; Cities Changing Diabetes, 2020), and this is highly relevant to both the food people are consuming and their lifestyle. At the same time, one-quarter of man-made greenhouse gas emission is caused by the food system (Vermeulen et al, 2012). To truly make a healthy place, a food system should be considered.

1. Sedentary lifestyle

Appropriate urban planning can attribute to reduce sitting time. Particularly by giving sustainable active travel, residents can exercise in their daily lives. There is further evidence from Koohsari et al (2015). Those living in large urban areas spend less time sitting than those living in smaller towns or cities. It indicates that large urban areas with extensive public transport infrastructures and walkable destinations encourage citizens to spend less time sitting in private vehicles and do utilitarian physical activities in their daily routine.

Locating parks, trails, and recreation facilities are associated with greater use of them and more recreational physical activity (Dannenberg et al, 2011). The accessibility and high quality of recreation facilities are important contributors to higher recreational activity. However, recreation facilities themselves may not be enough to lead to an increase in use. Safety and aesthetics of facilities, as well as proper activity programs with considering culture and context, may also be needed (Kent & Thompson, 2019; Klinenberg, 2018).

2. Healthy food

There are diverse factors that affect to individual's diet and the built environment can influence them directly or indirectly, and urban planning cannot directly restrict individuals' diets or access to fast-food restaurants. However, just as well-organized transportation can promote people to use more active travel modes unconsciously, well-designed urban planning can lead to healthier food selection unwittingly (Kent & Thompson, 2019; Macias, 2008), and the urban realm is the right place to start by making the food system more sustainable, local, nutritious, and less carbon-intensive (Schuff & Risom, 2018).

Research shows that food choice is often driven by what people can access, whether if they have time or energy or if they can afford it (Ball et al, 2009). Additionally, **proximity to supermarkets** turns out to be the largest effect on healthy diet choices. Locating supermarket which provides healthy and fresh ingredients relatively close and preferably walkable can promote people to use them, and it is more likely lead to intake fresh and less processed ingredients (Dannenberg et al, 2011). In terms of urbanization, arable lands have constantly been reorganized from agricultural to urban areas. This scenario highlights the need to **preserve agricultural lands on the peri-urban lands** around large cities. This often causes extensive food transport and decline of locally produced food, conflicting with the dense urban development. Protecting farming lands and encouraging people to grow their food in their own neighborhood can preserve local food production (Kent & Thompson, 2019).

While city planning has given attention to solutions such as bicycles or public transportation, there have been few focuses on the relationship between the food system and urban planning. Food choice has a huge role in people's health and more research is needed to understand this complex relationship.

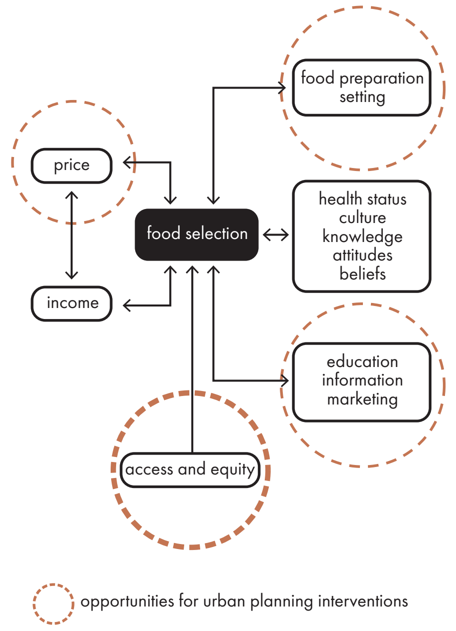


Figure 3.1.4 >
opportunities for urban planning (Kent & Thompson, 2019)

Active lifestyle
Healthy food

i. Active travel mode should be well designed for every unit to make utilitarian physical activities in daily routine.

j. High quality of outdoor spaces and recreation facilities nearby

k. Community garden

l. Proximity to supermarkets where people can get fresh and healthy ingredients and provide the place to grow fresh food.

2. social infrastructure

Yamaguchi et al (2020) is defining social isolation as "a lack of involvement with others, a lack of engagement in social organizations, and a sufficiency in fulfilling quality relationships." Many studies have indicated that social isolation is associated with mental health diseases, cardiovascular diseases, diabetes, all of which cause mortality (WHO, 2016). This indicates that social isolation is highly related to negative health impacts.

When people feel they are belonging to the place, that fosters perceptions of security, comfort, and confidence and thus encourages people to be active physically and socially (Thompson & Kent, 2014; Williams & Pocock, 2010). Therefore, it attributes to our daily lives to be more interconnected. Loneliness and isolation which are the critical problems in modern society should be handled in neighborhood scale planning (WHO, 2016; Zhang & Lawson, 2009).

"Linger-ability"

A healthy built environment has the potential to create and enhance the community. Neighborhood streets, open space, and space between buildings where the most interaction happens have a key to make a healthy built environment. Especially, it is important to recognize the street as space where people could have a casual, public meeting, while not just a path to one another (Mehta, 2007; Lorinne, 2007; Lund, 2002). 'Walkability' can encourage people to walk and promote daily activity. But to connect people, the design needs to be considered once more - how urban planning can make people linger and provide the reason for being there. When the city and neighborhood are composed of streets with 'linger-ability', people are likely to stay longer outside, which means there is more likelihood of casual and informal social interaction. 'Linger-ability' requires walkability as a prerequisite.

The importance of the ground floor is stated previously in order to make the street interesting and pleasant to walk. **The potential of the ground floor as a public realm** is also recognized in the neighborhood area, and it is important to keep the ground floor accessible to the public. Once designated as residential accommodation it is unlikely to become available for any other use (Macdonald, 2005; London, 2020). Ground-level residential accommodation is less straightforward, as it can be awkward to design in terms of providing enough daylight and sunlight, and ensuring adequate privacy and security for residents. These private spaces at the ground floor level can also have the negative effect of preventing the adjacent public realm from being genuinely public.

To make space function properly, space needs to be clear with its function and purpose. Thus, space can control the users or activities (CPTED, n.d.). Especially for the neighborhood environment, the built form should be identified whether it is a public space which everyone can visit, or it is private which only limited access is allowed. **This clear definition between public and private** makes public space more publicly used, and private space more secured. However, it is not about legally designating the space as public or private, but about people feeling about the space. It is specifically important in the neighborhood area. The public who uses the public spaces should feel secure in their right to visit these places, while the residents who live in the neighborhood should feel safe in their private places (FBW, 1996). Even without physical access control, residents can feel safe and assume spaces around their homes as their own. When residents have ownership of the space, they are more likely to look after those spaces and add a positive impact on them (Thompson & Kent, 2014; Williams & Pocock, 2010).

Figure 3.2.1 >
'Linger-ability'

Microclimate

The physical comfort from a good **microclimate** is particularly important for public life, encouraging walking, cycling, and spending time outdoors (Sim & Gehl, 2019). As the worldwide population becomes urbanized and cities enlarge and densify, the need for cities to consider microclimate is growing. Increased temperature and increased risk of urban flooding and potential damage caused by urban heat islands threaten outdoor experiences, negatively affecting the urban environment and success as a social setting (Chen & Ng, 2012; Tavares & Swaffield, 2017). It exposes the public to the discomfort that potentially reduces daily-based exercise and casual community meetings and increases health-related problems (Moonen et al, 2012). It will be covered in chapter 4 in detail.

However, we should admit that in some climates it is not achievable to provide outdoor spaces within human thermal comfort thresholds for most of the year. In this condition, the social quality of space becomes a key point in the design of liveable streets, public space, and courtyards. This shows that the character of urban spaces and the associated social function generate adaptive practices concerning microclimate conditions. The concept of urban comfort includes not only the urban microclimate but also social life (Tavares, 2015).

Figure 3.2.2 >
Urban comfort (Tavares, 2015)

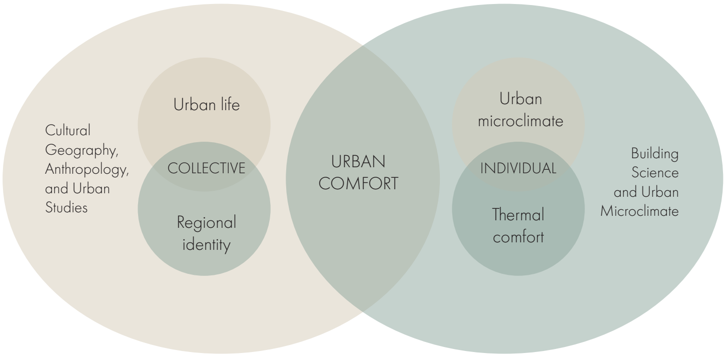
Diversity

Diversity is crucial to make city attractive. Uniformity of built forms and land use with monotonous urban landscapes makes the city boring, producing segregation and congestion (Jabareen, 2013). It is important to recognize diversity as one factor to vitalize cities and make walking more intriguing (Macdonald, 2005). Diversity is a multidimensional phenomenon that includes not only built forms, but also housing type, culture, and users at various stages of life (Jabareen, 2013). Community and social capital will only develop if the various groups are given access to make the social connection. The multiplicity of outdoor space, barrier-free design as well as various housing types can accommodate the diversity (Williams & Pocock, 2010).

Safety

Fear of crime makes people likely to decrease outdoor activities thus decrease social interaction (Palmer et al, 2005). **Crime Prevention Through Environmental Design (CPTED)** begins with the insight that a person who is likely to commit a crime in a certain environment would not consider doing so in another. Its emphasis is on making the place safe through the manipulation of the environment where crimes might occur, rather than targeting individual offenders.

To make the neighborhood safe and feeling safe, the creator of CPTED, Jacob, introduced nature surveillance. This concept of "eyes onto the street" is achieved by locating residents outside, and overlooking from spaces inside. As people are moving around an area and staying outside, they will be able to observe what is going on around them and serve as a security camera (CPTED, n.d.). As a result, every intervention for 'linger-ability' (e.g diversity of users and outdoor space, street designed as public realm) is associated to increase the safety of the neighborhood, as are active frontages and facades of spaces in buildings.



	Lesson learned
'Linger-ability'	a. Streets should be designed for the public realm b. The ground floor should be designed for the public realm (ground floor function should not negatively affect the public realm.) c. The clear definition between public and private spaces d. Address weather condition e. Propose outdoor activities that tailored to culture and context f. Diversity of architecture form g. Diversity of housing type h. Diversity of outdoor spaces i. Consider the diversity of users (e.g the disabled, the old)
CPTED	j. Locate people onto outdoor space for 'nature surveillance' k. Make space 'linger-able'

3. natural infrastructure

Biophilia refers to the hypothesis that human has an innate need to interact with nature (Grinde & Patil, 2009). Considerable research has been carried out proving the positive effect of being in nature (Abraham et al, 2010; Douglas et al, 2017) by diminishing health impacts related to NCDs. Firstly, natural infrastructure in urban areas can be contributed to **increasing physical activity** (Nielsen & Hansen, 2007) as well as counteract sedentary lifestyle (Tzoulas et al, 2007). This provides the opportunities to increase **social interaction** especially for the old and young (Maas et al, 2009; Susan, 2007; Sugiyama & Thompson, 2007).

Furthermore, numbers of research support the idea that nature provides a restorative experience that directly affects people's health and psychological well-being in a positive way (Tzoulas et al, 2007). For many urban dwellers, everyday life is filled with a stressful situations, and mental illness is one of the rapidly increasing NCD (Frumkin & Haines, 2019). This adverse environmental condition, which is chiefly driven by urbanization such as density and crowding, increases the need for **mental restoration** (Evans, 2003; Gidlöf-Gunnarsson & Öhrström, 2007).

Moreover, improving the local **microclimate and air quality** is one of the most encouraging roles that natural infrastructure can play in urban areas. This will be covered in each A.4 Microclimate and A.5 air quality and noise.

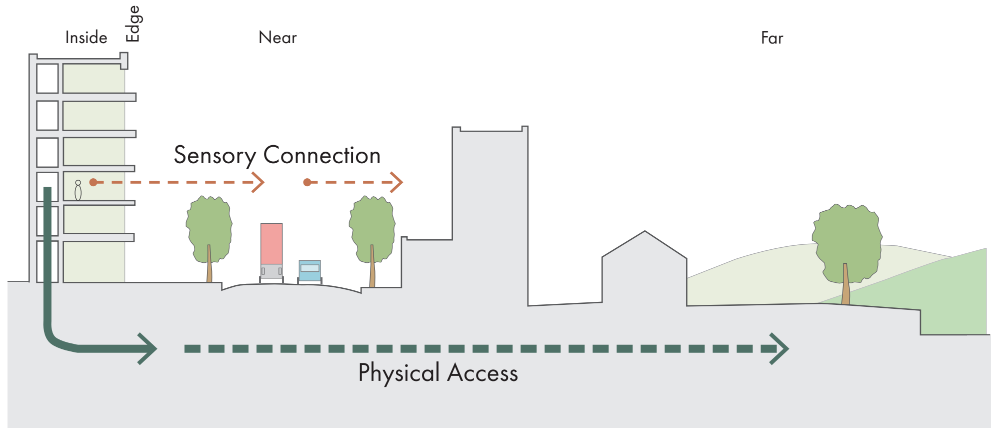
Physical access + Sensory connection

To maximize the benefits of natural infrastructure, neighborhood design can enable daily contact with nature. The contact includes not only the physical but also the sensory connection with nature, and both of which can bring health benefits (Maller et al, 2009; Grinde & Patil, 2009). Baker & Steemers (2019) divided the total environment into four zones, and explained their connection with 'sensory' and 'physically'. This suggests that the contact with environment can be accomplished not only with physical access but also with sensory connection - see Figure 3.3.1.

Community garden

Community gardens, known as established recreational activities, are associated with promoting public health through improved mental health, increased physical activity, increased social engagement, and improved nutrition. Gardens as a community-based environment transcend age, race, income, and education. Teig et al reported that "the community garden has the potential to strengthen and sustain neighborhoods and improve residential health across the lifespan." (Teig et al, 2009.) Many studies have demonstrated that community gardens can have a positive effect especially on promoting children's and seniors' health (Susan, 2007; Sugiyama & Thompson, 2007).

By arranging community gardens on a variety of scales, including parks, rooftops, courtyard, and balconies, it allows people to be exposed to a culture that celebrates fresh and healthy food and can maximize the benefits of a garden in their daily life (Kent & Thompson, 2019). An increase in urban agriculture projects in densely populated cities is not only a tribute to the sustainability of the local food movement, but also a realization of the potential of urban agriculture in the city (Teig et al, 2009; Macias, 2008; Thompson & Kent, 2014).



< Figure 3.3.1
access to nature (Baker & Steemers, 2019)

Green Infrastructure (G.I)

Those living in cities are especially vulnerable to flooding. Urbanization covers previously permeable ground and green infrastructures to absorb rainfall, preventing water from overflowing. Climate changes exacerbate the urban flood risk and damage potential by forcing the water utilities to adapt to a higher frequency of extreme rain events such a cloudburst (O'Donnell, 2015; Mukherjee, 2016) as well as rising sea levels along coasts lines. World Resources Institute (2020) reports that "flooding risk is expected to more than double globally by 2030, from 65 million to 132 million people, and to triple by 2050." This indicates that there is no safety zone from **flooding risk** and making cities more resilient and able to mitigate and adapt to flood risk is in urgent demand.

The relationship between urbanization and **biodiversity** is complex. As reported by Brown & Mijic (2019), "increased urbanization can be detrimental to habitat size, connectivity, and condition, which are key components of resilience to climate change." Previous study conducted by Lawton et al (2010) reports that when the green cover increase from 33 percent to 52 percent, it doubles the biodiversity potential of a site.

To tackle flooding risk and improve biodiversity efficiently, an interdisciplinary approach is required. A green infrastructure throughout the whole city is one strategy, and it should be continued at neighborhood-scale planning. A naturally oriented water flow with **green infrastructure (G.I)** can mitigate flood risk by slowing and reducing stormwater discharges. The traditional approach which aims to remove surface water as quickly as possible through the subsurface drainage system is not enough (O'Donnell, 2015; Andersson et al, 2019). Tahvonen (2018) highlights that "urban planners need to realize its potential in neighborhood scales as the outcome may improve biodiversity potential in the whole residential area and that returns to residents as ecosystem services."

As shown in Figure 3.3.2, different measures of green infrastructures can filter and detain stormwater before it runs-off to the nature. It is important to provide appropriate "fit-for-purpose" measures to clean, capture, and reuse stormwater as an additional water source for the neighborhood (Fraker, 2013).

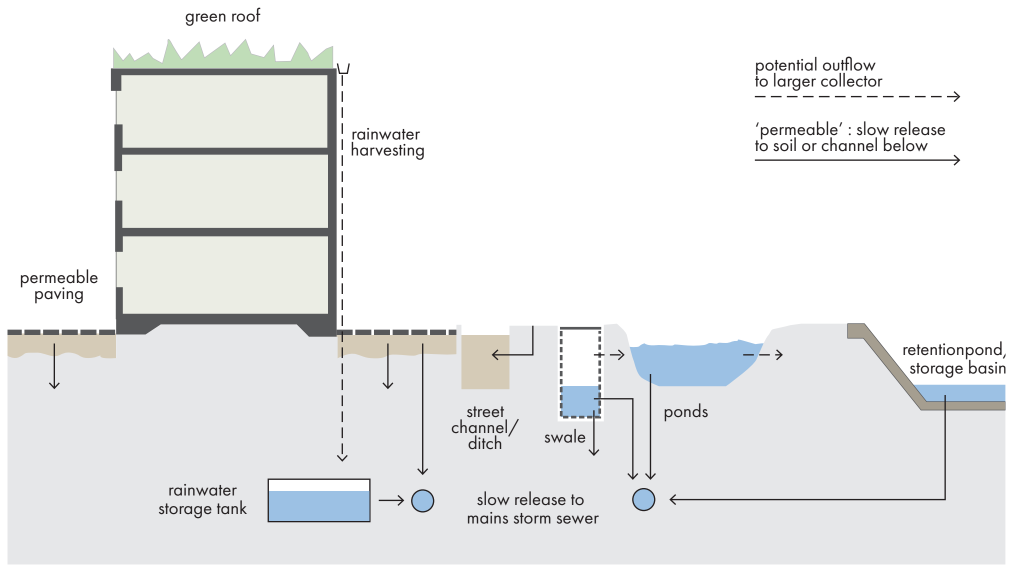


Figure 3.3.2 >
SuDs (Pelsmakers, 2015)
Different sustainable drain systems that can be applied in the neighborhood.

	Lesson learned
Biophilia	a. Make daily contact with nature possible (short distance to nature, located nature on the way/ sensory, physical connection) b. The natural infrastructure of neighborhood should be interconnected with other scale plannings
Community garden	c. Make community garden possible with different scale (e.g public park, rooftop, balconies) d. Easy access to for children and the old
Green-Blue infrastructure	e. Consider where the neighborhood is located regarding blue-green connection on bigger scales, and decide which part of the neighborhood should be kept green, blue or both f. Suggest appropriate G.I measure to clean, capture, and reuse rainwater g. Consider biodiversity, and suggest three-dimensional solutions

4. microclimate

Cities are undergoing major physical and climate changes which largely result from rapid urbanization and global warming (Moonen et al, 2012; Lenzholzer, 2015). While current energy and environmental policies give major attention to building energy efficiency, the minor focus has been given to the quality of the urban environment and interdependence with urban design (Strømann-Andersen & Sattrup, 2011). This absence of **context and climate consideration** leads to consider buildings as stand-alone entities that lean on mostly energy equipment, thus adversely affecting the health and well-being of their tenants and decreasing the quality of the urban environment (Delmas et al, 2018). A good urban microclimate can reduce building energy use by utilizing free solar gain, and reduced wind pressures.

Additionally, the Microclimate is one of the **pre-conditions for social infrastructure**. The enjoyable microclimate can encourage people to be active physically and socially and improve cities from social, economic, environmental points of view (Sim & Gehl, 2019). The addition of new buildings without enough consideration of context can affect the liveability of outdoor spaces, as well as the city scale set-up by reassigning the natural resources available at a place (Moonen et al, 2012; Martins et al, 2016).

However, microclimate design is often neglected (Brown, 2010). "Working with built form and microclimate is about softening the weather, not denying or changing it" (Gehl, 2011.) As people dress depending on the weather forecasts, cities need proper urban microclimate intervention which can filter out the extremes.

Dealing with outdoor microclimate is not simple because of its numerous parameters. Thus, using **the simulation software** which helps to identify balancing points of solar gain and wind pressure from urban geometry is crucial. Recent developments in computation include analyzing detailed thermal, shading, and wind comfort simulation, offering the perception of the relationship between climate conditions and urban geometry.

Thermal comfort

Compared to car drivers, pedestrians are exposed to their immediate environment including sunlight, shade, wind, and other variations. Thus, to encourage people to spend time in the streets and outdoor spaces, comfortable thermal experiences which are strongly formed by the local microclimate are important (Chen & Ng, 2012). This also extends to spaces in buildings and can help reduce energy use and create delightful places for residents.

According to the research, green infrastructure is particularly effective to reduce temperature among the many factors that influence thermal comfort (Gunawardena et al, 2017; Martins et al, 2016). This is for warm climates but also relevant to Finland during heatwaves. The research (Martins et al, 2016) is conducted with one-off measures to compare various urban design strategies (e.g vegetation, water, built form, and material) for the area of Toulouse, France. The research reports **"green scenario"** which locates trees along the street reduces approximately 6 °C than the base-case scenario, providing pleasant shadows over sidewalks. It could also enhance biodiversity as mentioned elsewhere.

Furthermore, the comprehensive approach of the "green scenario" can lead to better results by including not only the shady trees, but also the green façade of the lower floors of the building, green roof, the lighter-colored and permeable paving. A simulation study for areas of Phoenic reports that a coordinated strategy of them has been shown to lower heat island temperature by 13-15° C (Bryan & Hoffman, 2008). On facades, it can reduce energy use and help protect from moisture (Edelman et al, 2019). Based on previous studies, Fraker (2013) claims that "the greening solution needs to be thought of as three-dimensional, indlucing not just the surface of the ground but also the walls and roofs of buildings."

On the other hand, while green is effective to lower the temperature alone, the **"blue scenario"** which is related to water bodies shows no remarkable impact on pedestrian temperature. However, when the water body is combined with the prevailing winds, it shows significant influence with its evaporative cooling effect. It is expected to have a stronger effect if the water spaces were associated with the shadow (Martins et al, 2016), indicating the need for comprehensive solutions for comfort outdoor experience.

While shade is beneficial in warm climates and during warm summer periods, overshadowing of spaces between buildings and buildings themselves can be detrimental in cold climates (e.g. lack of thermal comfort and reduced lingerability, and increased building energy use). To control the overshadowing to outdoor space and secure enough sunlight for all residential units, urban neighborhood planning should take these four things into account.

1. The ratio of building heights to street width

2. Orientation of window

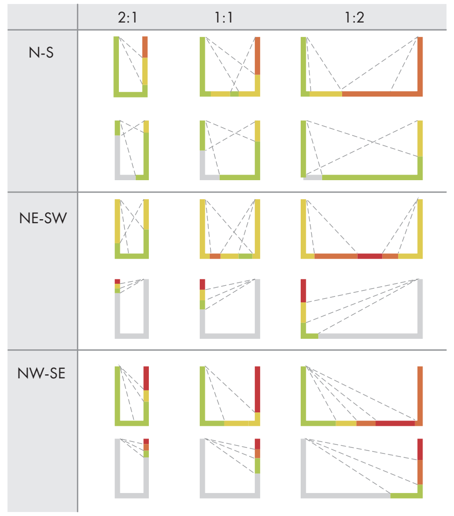
3. Width and depth of building itself

4. Density

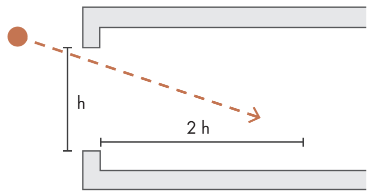
1,2 Distances between buildings and the basic geometry of building heights can limit access to light and solar heat. Appropriate urban planning can control the overshadowing that buildings may cause to other buildings and public space by regulating the height-to-distance ratio (Erell et al, 2011). This is particularly important in Finland with low sun angles. Additionally, building and street orientation are also related to the amount of sunlight, as illustrated in Figure 3.4.1 (Lenzholzer, 2015).

3 To secure natural light to housing units, the depth of buildings should be controlled. According to Figure 3.4.2, the daylight can reach only two times the height of opening within the dwelling (Pelsmakers, 2019) and building depth of course can be compromised by placing dark spaces (e.g storage). The choice of neighborhood masterplan affects the quality of the dwellers' living environment, and thus their health. It is important to understand the inter-relationship between the different scales of the urban plan, the building typology, and the apartment plan.

4 The density of the neighborhood which is mostly driven by **1**, **2**, and **3** affects inside as well as its energy consumption. There is one research (Strømann-Andersen & Sattrup, 2010) that compares total energy consumption of housing and office with different densities. The total energy use can be different up to 30% for offices and 19% for housing, referring that the geometry of urban form is a key factor in energy use in buildings. Other than that, the reflectivity of building facades is also highlighted as an important contribution to building energy consumption.



< Figure 3.4.1
(1), (2) (Lenzholzer, 2015)
Solar exposure of different type of street canyons (different ratio, different orientation)



< Figure 3.4.2
(3) (Pelsmakers, 2015)

Wind comfort

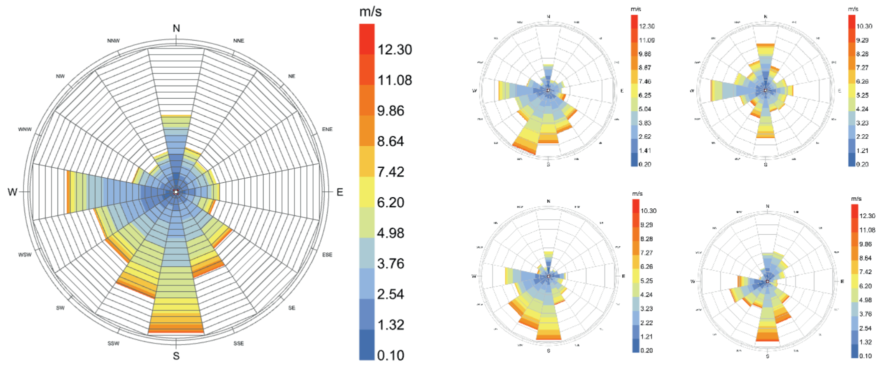
While the wind provides the main source of cooling for warm objects (Brown, 2010), it can also put pedestrians in a dangerous environment with high speed. The average wind speed in urban areas is about 30-50% lower than outside the city, but wind speeds can easily exceed the comfortable level, depending on the local wind system, including nearby coast (Lenzholzer, 2015).

To ensure the positive effect of microclimate, it is vital to create a pleasant climate throughout the whole urban form, not just to create pockets of the pleasant climate. Each outdoor activity requires different threshold values of the wind speed (Stathopoulos, 2006), which can guide the planner to place outdoor activity in a suitable place.

To work with urban form and wind, it is important to understand urban wind properly, and this is highly related to air circulation thus air pollution. The wind is produced by the interaction of variables at different scales like the regional scale, the city scale, and the microscale (Lenzholzer, 2015; Stathopoulos, 2006). Even within the city, the wind can be very different depending on architectural intervention.

The regional-scale wind results from the Earth's rotation, so that depends on the location within the Earth it can be predicted (e.g the northern hemisphere as south-westers, and the southern hemisphere as north-western) or easily analyzed with EPW weather file which contains sunlight, wind direction as well as speed data all year around. Most of the days, the effect of this large-scale wind system prevails, but when it is weak the smaller and local scale wind which are developed by the difference of warm and cool air can be observed (Lenzholzer, 2015).

v Figure 3.4.3
wind rose
wind analysis of Helsinki, Finland
(1) whole season, (2) January to March (3) April to June
(4) July to September (5) October to December



All winds change their direction and speed when they hit objects with causing **channelization, venturi, and bar effect.** Bigger obstacles cause stronger wind and increase the intensity of gusts (Spirn, 1986). Using the weather file of each city, it is possible to make a wind map that expresses wind speeds, as illustrated in Figure 3.4.4. Strategic placement of elements in the landscape can slow the winds, and this map can guide the designer to locate windbreakers as well as appropriate activities depending on wind speeds. For example, if there is a huge wind compression between tall buildings, locating trees can help to release the compression. Brown (2010) states that "vegetation with about 50 percent porosity generally is the most effective windbreak in the landscape. Windbreaks that are less porous than this will generate turbulent air, which adds to the cooling effect of the wind."

Evergreen vegetation is one of the effective ways to reduce wind speeds in winter. The closer the building is to the 'shelterbelt', the more the wind speed decreases. The wind speed can be reduced by as much as 20% at 1-2 times the shelterbelt height. However, this should not prevent natural ventilation, daylight, and solar gain (Pelsmakers, 2019).

Perhaps, the best way to analyze the weather is to visit the site in person and observe it throughout the year. However, it is pretty much impossible, especially for urban planning, it is trickier to observe every part of the site. In this context, using the simulation tool seems efficient and productive method to predict the sunlight access and wind effect. The flexibility of the simulation tool can support getting the best-suitable intervention. The decisions of planners and designers are long-lasting to the environment where people live thus every decision is associated with their health and well-being. It is, therefore, crucial to check the design with tools and provide the optimal environment solutions.

Figure 3.4.4 >
windcomfort map
Eco-Viikki wind comfort analysis (whole season)

	Lesson learned
Thermal comfort	a. Suggest three-dimensional measure to maximize the cooling effect of green b. For a cooling effect, consider nearby green and prevailing wind direction to maximize the benefit of blue c. Consider the ratio of building height and street width d. Consider orientation of building e. Consider depth of building f. Consider density g. Consider the reflectivity of building facades
Wind comfort	h. Consider the wind in planning and understand the local wind system. i. Different outdoor activities require different wind speed j. Analyze the prevailing wind direction k. Analyze the impact of new additions on wind comfort and propose solutions accordingly l. Use evergreen vegetable as a shelter belt

5. air quality & urban noise

With the growing population of urban areas and the development of private transportation, people suffer from air pollution and urban noise more than ever before. Air pollution is the second leading cause of death from NCDs and health impacts associated with air pollution include respiratory disease, heart disease, stroke, and lung cancer (Giles-Corti et al, 2016).

According to WHO, "traffic noise is the second biggest environmental problem in the EU. After air pollution, noise is affecting human health the most." Traditionally, noise pollution has been neglected as a health-hazard, but it is time to pay attention on that. To achieve improvement, a concerted solution of mitigation and adaptation should be suggested (Chalmers University of Technology, 2014).

To mitigate air pollution, the interconnection with other criteria should be highlighted. First, **a good microclimate** has a potential to reduce air pollution by maximizing free solar gain, and reducing wind pressures. This can decrease the dependence on energy equipment and thus decrease indirect reverse health impact through climate change. Not only that, the neighborhood with **a good accessibility** can reduce air pollution by encouraging walking, cycling and the use of public transportation. Motor vehicle is the main source of air pollution (Woodcock et al, 2009), so less use of personal cars can effectively decrease air pollution. Giles-Corti et al (2016) states that " physical activity outdoors, including walking and cycling, can increase exposure to air pollution. However, research supports that air pollution exposure is higher for those in cars than for cyclists through the same environment."

Studies show that worldwide pandemic Covid-19 restrictions have been improving air quality. According to Anttila, a researcher at the Finnish Meteorological Institute (FMI), as the traffic volumes have decreased significantly due to the restrictions, so have the emissions and this had a positive effect on air quality. These environmental benefits are only temporary and cease to exist as soon as the regular traffic patterns return (Yle, 2021).

Air quality

After the pollutant is exposed, it is dispersed and diffused by the wind. The wind slows down, speeds up, or changes direction depending on the urban form and landscape (Lenzholzer, 2015). According to the wind, air pollution level can vary from spot to spot. To effectively release pollutants and avoid trapping them within the city, a design should be considered in a large context including big water bodies, green areas, highways, parkways, and railroad corridors. These can create wide and continuous corridors to channel winds and prevent pollutants from staying in the city (Spirn, 1986).

Considering that people who live within 300 m of heavily trafficked roads are particularly dangered to high levels of pollutants (Giles-Corti et al, 2016), the most straightforward measure is **keeping distance from the source.** The relative location of housing, commercial as well as courtyard and gardens can be considered. To protect cyclists from increased air pollution exposure, the distance between motor vehicle traffic and cycle lanes also needs to be considered (Tumlin, 2012). It is not feasible to protect the whole neighborhood area from air pollution. However, special attention is required for pollution-sensitive users such as children and seniors by carefully locating places which are used by them (Nieuwenhuijsen et al. 2018).

While **prevailing wind** can keep the levels of pollutants low by blowing them away, the wind also can trap them in public spaces depending on architectural form. It is important to understand where highly polluted areas are, where the wind blows, and take this into account when arranging outdoor activities (Xie & Leung, 2007).

Furthermore, **building height: street width ratio** can affect air pollution. Depending on the H/W ratio, different flow is generated between buildings as described in Figure 3.5.2. Additionally, temperature differences from building orientation and building material can also trap the air pollution between buildings (Nelson, 2006; Xie & Leung, 2007).

One of the most promising and cost-effective ways to control air quality is **greening the cities**. The trees not only filter air pollutants and limit their dispersion, but also absorb CO2 emitted from vehicles, serving as a natural form of carbon sequestration (Fraker, 2013). Street trees are more effective than trees far from the road and have a positive impact on public health by reducing carbon dioxide in cars and lowering local temperatures (Speck, 2018; Tumlin, 2012).

However, not always do trees improve air quality - it depends on their spacing, grouping and distance to buildings (i.e. they can slow and trap air pollution). According to field research conducted by Viippola et al (2018), NO2 levels in urban areas with a forest were slightly higher compared to the sampling point without trees. Worsening air quality was explained by a "trapping effect" meaning that pollution from a busy road cannot escape to the atmosphere due to dense greenbelt working as a barrier. It is to be noted that this subject requires further research since the outcome of other similar studies do not correlate with this result (Yli-Pelkonen et al, 2020).

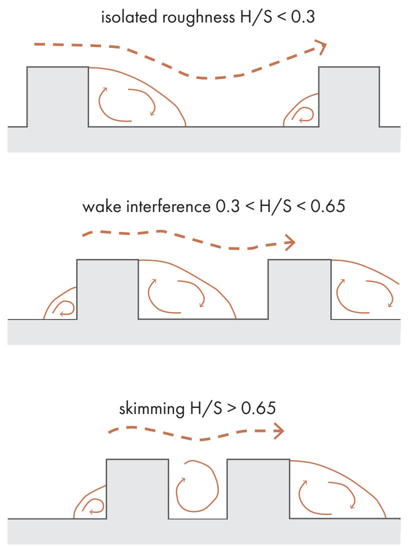


Figure 3.5.2 >
3 different wind flow (Nelson, 2006)

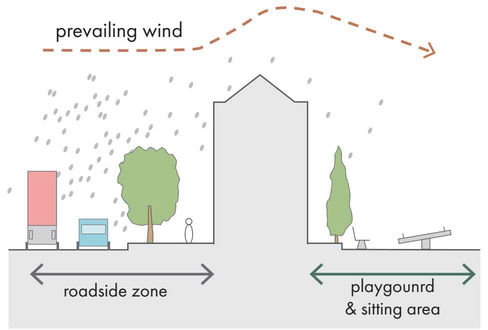


Figure 3.5.1 >
prevailing wind (Spirn, 1986)

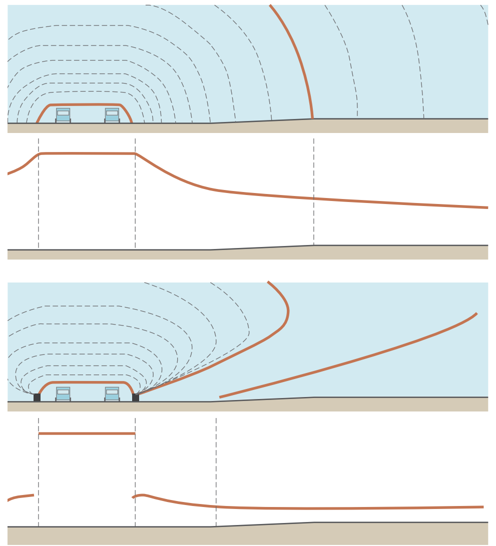
Urban noise

Noise from transport is a great growing environmental problem in urban areas (Gidlöf-Gunnarsson & Öhrström, 2007). It has been calculated that approximately 20%, around 80 million, of the EU population suffer from noise levels considered to be unacceptable. Chronic noise exposure has implications for physical and mental health including cardiovascular diseases (WHO, 2016).

Like air pollutants, the most straightforward way to ameliorate noise exposure is setting homes, schools, and other services **away from busy roads**. By reducing road speed and using noise abating road-surfacing materials, the noise level can be controlled. Furthermore, when there are heavily tracked routes near the neighborhood, attention should be paid to the housing layout, including locating bedrooms and balconies away from noise sources (Giles-Corti et al, 2016).

After noise is produced, it spreads to the surrounding area. To efficiently protect the neighborhood from noise pollutants, an **acoustic barrier should be close to the source**. Compared to barriers located close to the receiver, the former way can protect a wider area since this can control the focal point of noise, as described in Figure 2.5.3 (Baker & Steemers, 2019).

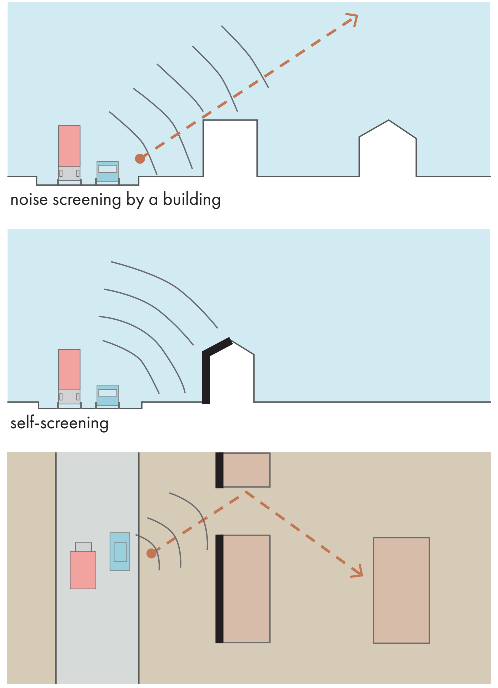
Figure 3.5.3 >
acoustic barrier close to source
(Baker & Steemers, 2019)



Building itself can be an acoustic barrier for other buildings. Residential buildings are probably the most noise-sensitive building types, so other types of buildings, such as commercial, can be used to screen residential areas. Another option is self-screening by using a principal fenestrated façade or placing the outdoor area away from the noise source. However, the noise-reduction performance can be undermined by reflections coming into the 'open' facades, as illustrated in Figure 2.5.4 (Baker & Steemers, 2019).

Figure 3.5.4 >
way to screen noise, problem of reflection
(Baker & Steemers, 2019)

The nearby green area can relieve the stress from noise pollutants. This leads to the benefit from natural infrastructure which is mentioned in chapter 3. **Green areas in proximity** to where people reside may provide urban residents a place to escape from stressful and challenging situations, such as chronic noise exposure. Relating to this, it is important to maintain and further develop accessible "noise-free" urban greenery within and close to the residential area. Urban neighborhood planning should take into account noise during the process, and green spaces should be dictated by a sophisticated approach (Gidlöf-Gunnarsson & Öhrström, 2007).



	Lesson learned
Air pollutant	a. Active travel mode should be well designed for every unit. b. Check if the site is in an important blue-green corridor, near a highway or railroad. c. Keep the distance from the air pollutant source. d. Locate the barrier near the pollutant source. e. Prioritize the space (special attention on the place where pollution-sensitive frequently use). f. Analyze prevailing wind direction. g. Utilize green.
Urban noise	h. Be aware where are the busy roads or other noise sources. i. Keep the distance from the noise source. j. Located acoustic barrier near the noise source k. Screen noise by layout and less noise-sensitive functions. l. Add green, 'noise-free zone', where people can escape from a stressful and challenging situation.

4.
case studies

This section presents 5 selected sustainable city districts in Europe. The focus is on the assessment of the 5 criteria which were introduced in the previous section. The evaluation was conducted with secondary research. The information on the reference districts is based on a literature review with publicly available data, and simulation software is used. All of them claim sustainability as their main aim, and they were selected based on weather and context similarity with Kalasatama, the chosen design site – see chapter 5.

1. Eco-Viikki

Helsinki, Finland

At the beginning of the 1990s, Finland started to increase interest in ecological sustainability, and Eco-Viikki exemplifies this. The Eco-Viikki project as a pilot area was designated to test the implementation of new sustainable solutions in practice. A universal planning competition was organized in 1994-1995, and the winning proposal was based on a structure of "green fingers" and put into practice in the city plan (Helsingin kaupunki Kaupunkisuunnitteluvirasto, 2004).

1. Accessibility

Construction area 23ha

Population 2,000

Dwellings 750

Distance from the city center 8km

Eco-Viikki is located far away from the existing city. This might intrigue the use of private cars. However, the mixed land-use development and well-connected pedestrian and cycle road encourage walking and cycling (City of Helsinki, 2009). In the beginning, there was a problem of lack of public transportation. Later new bus lines have been added and two nearby shopping centers with basic public services have been built, which has made the situation better (City of Helsinki, 2005).

2. Social infrastructure

The good community spirit is invariably ascribed as one of the most important aspects keeping them in the area (City of Helsinki, 2009). The community gardens, common laundries, and shared saunas attribute the development of a sense of community which is not usually found in other similar neighborhoods. Although these activities require participation and may bring inconvenience, collectivity works as a strong cohesion factor. Combining with nearby kindergarten, school, the closeness to nature, diversity of housing and park for children support the activity and involvement of the residents (City of Helsinki, 2005).

The relatively higher buildings which are located at the perimeter of the village purposely intensify the contrast between the outside and inside. This clear definition between inside and outside as well as community activities make residents feel secure and increase social interaction. The concept of the green fingers which partly restricts car access, space between buildings seems fully used as a public area for residents. Combining with park benches and community areas, the whole neighborhood seems highly 'linger-able'.

Figure 4.1.2 >
Picture of 'green fingers'
(City of Helsinki, 2005)

3. Natural infrastructure

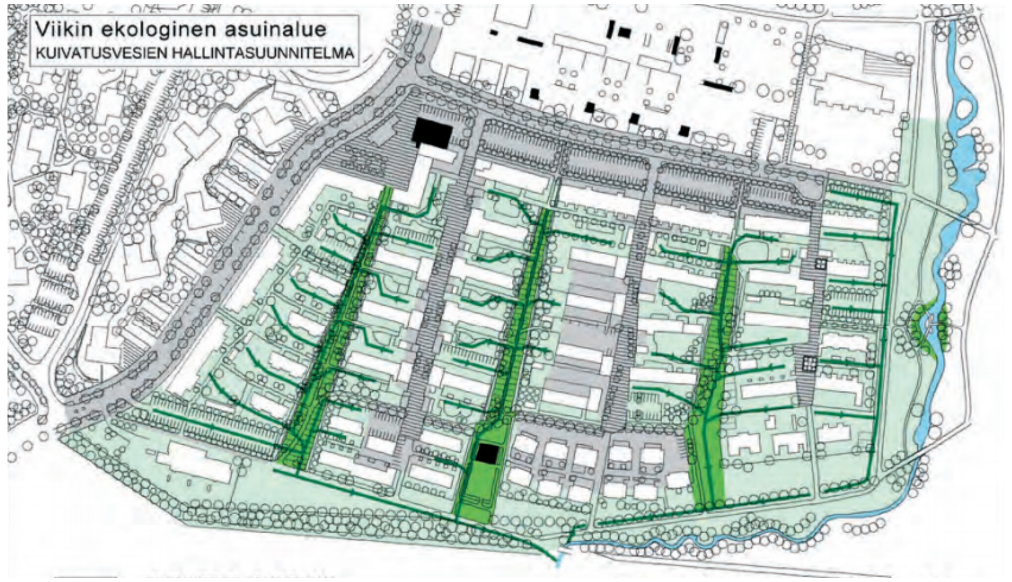
The whole area is based on the concept of **"Green fingers"** which is characterized by the alternation of green spaces and built areas (City of Turku, 2015). The surface water system is channeled from "green fingers" between the houses to the nearby stream, Viikinoja. By slowing down rain and melting snow, the system is effectively working to prevent flooding. Together with the community garden along with the green fingers, the water is reused and makes the place bustling (City of Helsinki, 2009).

By using **PIMWAG criteria**, sustainable and ecological planning of the district is accomplished – see Figure 4.1.3. Unlike the five criteria introduced in this thesis, the PIMWAG criteria laid out three different levels including minimum levels that every building should follow which helps to transfer knowledge on practices. Furthermore, the PIMWAG criteria cover not only the construction phase but after the completion of the project. Monitoring of the practices after completion has also helped to gain the desired result (City of Helsinki, 2005).

Pollution	Natural resources	Health	Biodiversity	Nutrition
carbon dioxide emission	primary energy	internal climate	plant selection and habitat types	cultivation of useful plants
clean water consumption	heating energy	moisture risks		
building material waste	electrical energy	noise	storm-water management	
household waste	adaptability and multi-use of space	wind and sun		
environmental labelling		alternative house plans		

^ Figure 4.1.3
PIMWAG criteria
(City of Helsinki, 2005)

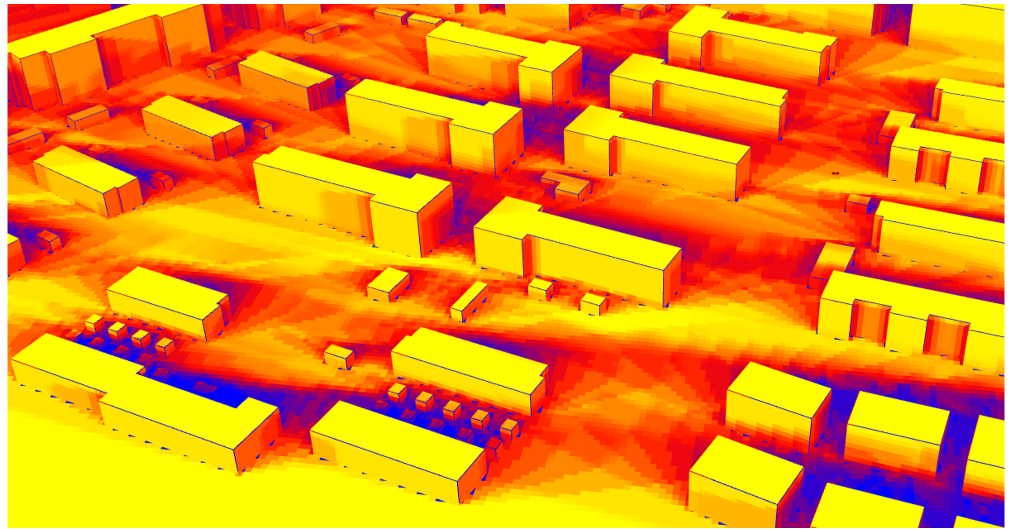
v Figure 4.1.4
'green fingers' plan
(City of Helsinki, 2005)



4. Microclimate

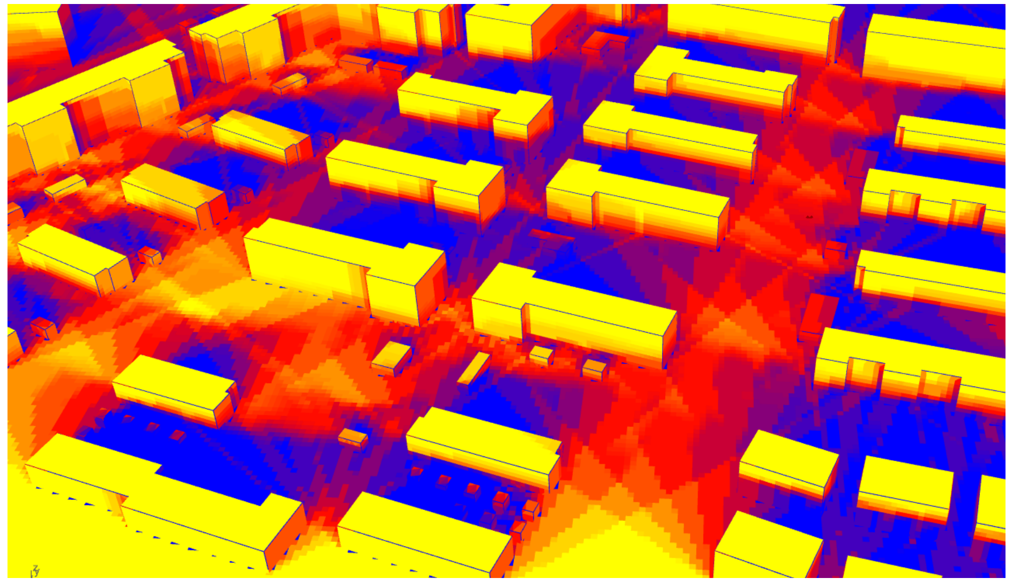
Housings in Eco-Viikki are mostly facing south and have a wide distance between buildings. This ensures sufficient sunlight hour for both housing units and outdoor spaces all year around – see Figure 4.1.5, 4.1.6. Additionally, most of the buildings has a depth within 10 m which has the potential to provide natural light to every room. While this low-density development (roughly 86 residents per hectare) might negatively work for accessibility to public transportation and public facilities, positively affects sunlight gain. In the context of Finland which has low sun inclination, the negotiation between dense urban development and access to sunlight is especially indisputable.

According to wind analysis of the Finland Helsinki area, the prevailing wind direction is from the South-West. As Figure 4.1.7 and 4.1.8 show, it can be uncomfortable because of the strong wind speed on the 'green fingers'. This requires adequate urban planning windbreak intervention, such as trees or bushes.



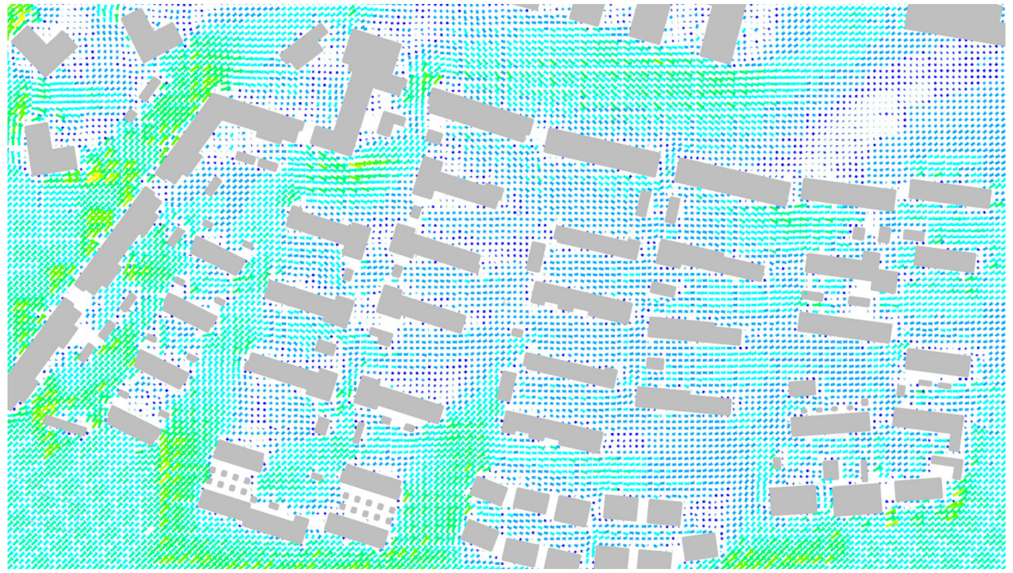
^ Figure 4.1.5
sunlight hour analysis
typical week

v Figure 4.1.6
sunlight hour analysis
coolest week



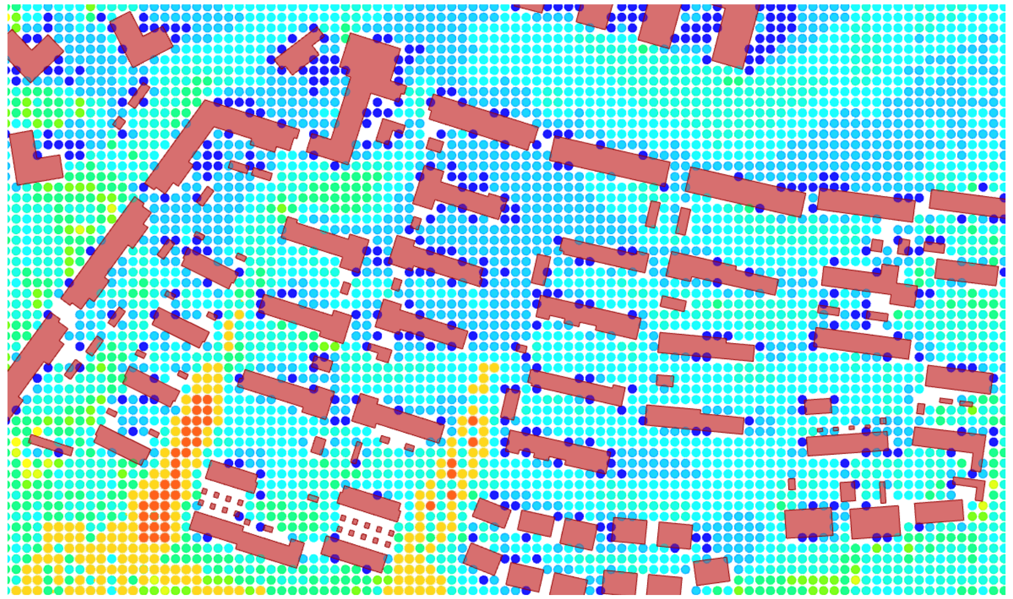
5. Air quality and noise

The closeness to nature keeps the place safe from air pollution, and renewable energy including solar panel contributes to CO_2 reductions broadly. Concerning the fact that most of the air pollution from cars is produced when they stop and go (Spirn, 1986), more protection near the parking lot is recommended. Other than that, natural ventilation with technology that controls the ventilation and humidity of greenhouse temperature is reported (City of Helsinki, 2005).

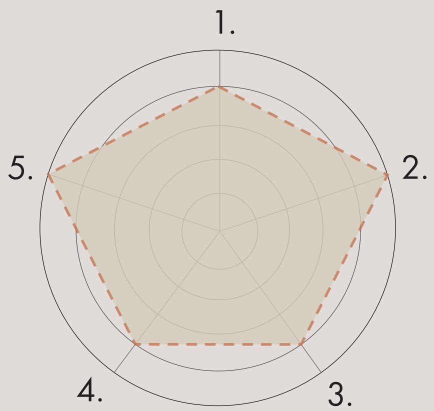


^ Figure 4.1.7
wind analysis (prevailing wind direction)

v Figure 4.1.8
wind comfort



Evaluation



1. Accessibility

The mixed land use plan and well-designed pedestrian and bicycle road encourage walking and cycling.

2. Social infrastructure

Clear definition between inside and outside as well as community activities make residents feel secure and increase 'linger-ability'.

3. Natural infrastructure

Clear concept of outdoor area, 'green fingers', and PIMWAG criteria which guide the whole design process to be sustainable and ecological are effective. However, the project is a greenfield development.

4. Microclimate

Wide distance between building and orientation ensure sunlight hours. Consideration for a windbreak is in need.

5. Air quality and noise

The closeness to nature keeps the place safe from air quality and urban noise.

2. BO 01

Malmö, Sweden

The European housing exhibition, Bo01, was hosted by the city of Malmö in 2001 (URBED/ TEN Group, 2010). Malmö aimed to gain international attention as a leading example of a sustainable neighborhood in an urban area. The main objectives of the projects are an ecological neighborhood that uses only locally produced renewable energy, supplies a well-designed public transport system and cycling road, stimulates sustainable society with high quality of life, and promotes the area's rich biodiversity (Persson, 2005).

1. Accessibility

Construction area 22ha

Population 2,300

Dwellings 1,450

Distance from the city center 2km

According to the main objectives, the project put public transport as a priority in transportation. There are limited parking spaces as 0.7 per household, arrange a carpool for the district's residents. Buses run frequently between the neighborhood and major destinations, and every unit is within 300 meters from the bus stops. The cycle roads are also well connected, and the use of them is common among the residents (City of Turku, 2015).

Nevertheless, a large parking garage had to be built after all. Even Bo01 was originally organized as an area with limited parking options and less use of private cars, it turned out to be keen on the use of them (City of Turku, 2015). This indicates that only a neighborhood-scale plan for transport cannot bring about the desired improvement. Active travel modes, among other things, should be promoted widely in order to truly contribute to the ecological goals of the district.

2. Social infrastructure

The architecture of Bo01 is very diverse, and this is achieved by subdividing the large block into small plots. Different architects designed plots with different sizes and different angles. Total of 18 different developers and 23 architects participated in the project and succeeded to make Bo01 versatile (Persson, 2005). At the same time, the outer perimeter with higher construction clearly defines the boundaries and clarify inside and outside of the neighborhood. Because of this clarity, the public can freely linger along the promenade and in parks, while the inside perimeter belongs to the residents and is sheltered (Fraker, 2013).

The diversity of architecture form and clarity between inside and outside succeeds to make the public space popular among the people in Malmö, while keeping the privacy for residents. Although there were many suggestions for diverse users such as creating homes for seniors, for large families, and students, and half-finished flats that residents could finish on their own, none of these have been realized. In the end, it has remained predominantly middle-high class in its social agenda, and it is largely driven by the higher infrastructure development costs (Fraker, 2013, Malmö stadsbyggnadskontor, 2011).

3. Natural infrastructure

In terms of making BO01 a "habitat-rich city district," developers follow two different approaches. Unlike the five criteria introduced in this thesis, those two different green criteria suggest a context-specified solution with the detailed guideline. For the first one, the developers satisfy at least ten points out of thirty-five from a list. In the second approach, every building project needs to satisfy a green space factor. The points are calculated as an average number of all factors, and this is required to be at least 0.5. Without specific solutions being suggested, teams are encouraged to make every property and courtyard as green as possible (Fraker, 2013). In the end, green space in the area reaches 53 percent, not including the green roofs (CMHC, 2005).

The different scales of green space in Malmö are connected and used as an alternative network to the streets. Some of them are serving various purposes including retention and habitat creation, active recreation, and storm-water collection. This green network makes it possible that every unit has access to a rich variety of green space within 300 m, and students can reach their school through the parks rather than through the streets (Fraker, 2013). To ensure the green space is used as a vibrant social interaction place, proper activities which are tailored to culture and context should be suggested (Dannenberg et al, 2011).

1. A nesting box for every dwelling unit.
2. One biotope for specified insects (plant biotopes excluded) per 100 square meters (m2) of courtyard area.
3. Bat boxes inside the plot boundary.
4. No hardstanding in courtyards—all surfaces permeable to water.
5. All nonhard surfaces in the courtyard have soil deep and good enough for vegetable growing.
6. Courtyard includes a traditional cottage garden, complete with all its constituent parts.
7. Walls covered with climbing plants wherever possible or suitable.
8. A 1 m2 pond for every 5 m2 of hardstanding in the courtyard.
9. Courtyard vegetation specially selected to yield nectar for butterflies.
10. No more than five plants of the same species among the courtyard trees and bushes.
11. All courtyard biotopes designed to be fresh and moist.
12. All garden biotopes designed to be dry and lean.
13. Entire courtyard made up of biotopes modeled on biotopes occurring naturally.
14. All storm water captured to run aboveground for at least 10 m before being led off.
15. Green courtyard but no lawns.

^ Figure 4.2.3
some of 'Green Points Criteria' (Fraker, 2013)

v Figure 4.2.4
Green Criteria (Fraker, 2013)

Partial Factors for Greenery

1.0 Greenery on the ground

1.0 Bodies of water in ponds, streams, ditches 0.8 Green roofs

0.8 Plant bed on joists, >800 mm deep

0.6 Plant bed on joists, <800 mm deep

0.4 Tree with trunk circumference >35 cm (calculated for an area of not more than 25 m2 of planting space per tree)

0.2 Solitary shrubs, multiple-trunk trees more than 3 m high (calculated for an area of not more than 5 m2 of planting space per shrub or tree)

0.2 Climbing plants more than 2 m high (calculated for a wall area with width of 2 m per plant times the height of the plant)

Partial Factors for Paved Surfaces

0.4 Open paved surfaces (grass-reinforced areas, gravel, shingle, sand, etc.)

0.2 Paved areas (stone or slabs) with pointing

0.0 Impervious areas (roofing, asphalt, concrete, etc.)

Partial Factors for Hard Surfaces

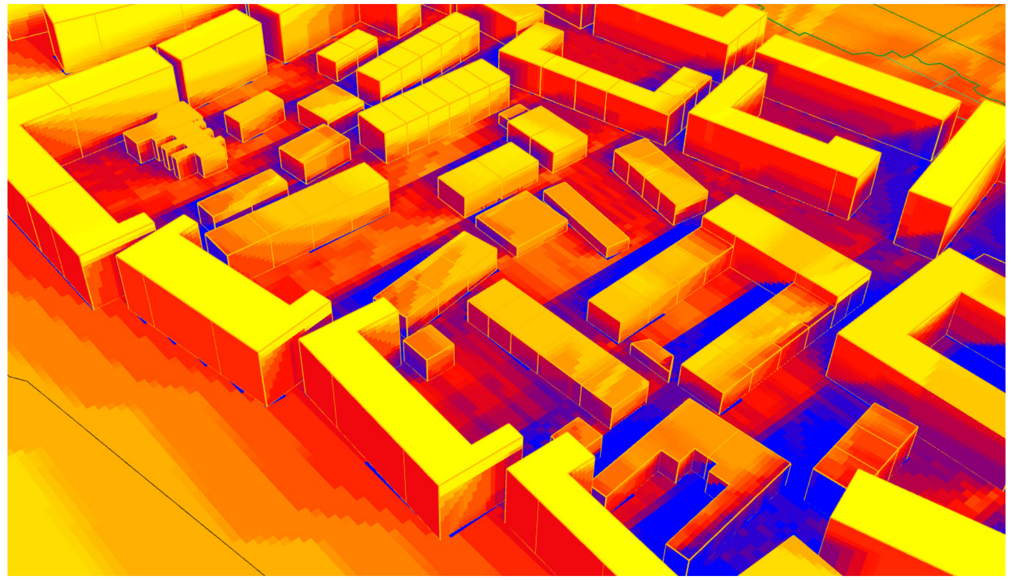
0.2 Collection and retention of storm water (additional factor of sealed or hard surfaces with joints draining into a pond or magazine holding >20 L/m2 of drained area)

0.1 Draining of sealed surfaces (to surrounding greenery on the ground)

4. Microclimate

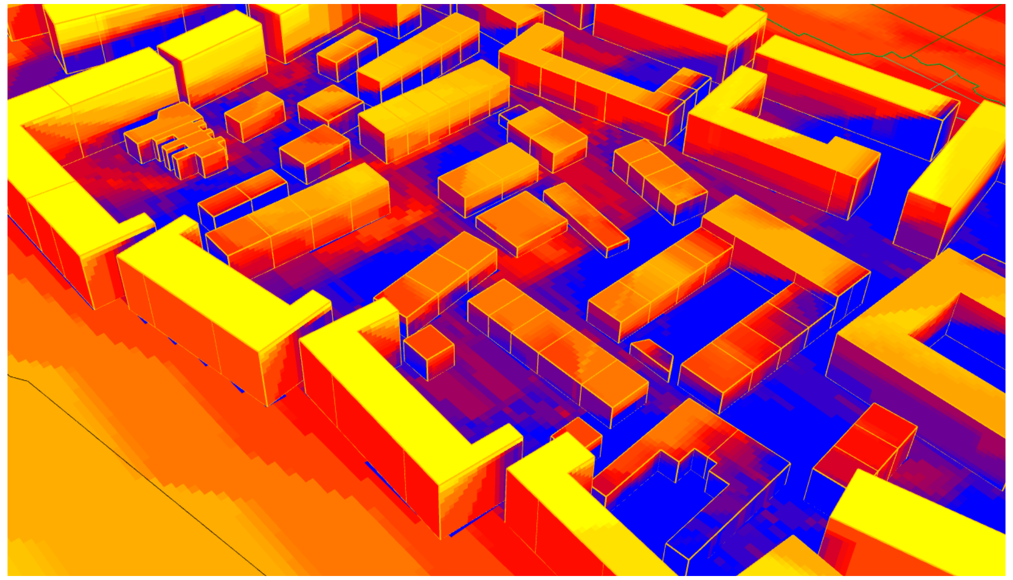
While most of the units gain sufficient sunlight hours, some of them have relatively lower sunlight hours. Especially their ground floor and narrow courtyard may experience a lack of sunlight – Figure 4.2.5, 4.2.6. Furthermore, some buildings have a thick depth of 15 m which can produce a lot of dark areas in the middle of the buildings.

From the simulation results, the boundary buildings work as a windbreaker. The wind comfort of the inside perimeter has a relatively better result than the outside, as illustrated in Figure 4.2.7. Regarding the weather condition in Sweden and the location of the site, which is near the seaside, it is important to protect both residents and visitors from strong wind. While the inside perimeter is protected by buildings, architectural action which can protect the outside is needed.



^ Figure 4.2.5
sunlight hour analysis
typical week (Sep 22 to 28)

v Figure 4.2.6
sunlight hour analysis
coolest week (Feb 10 to 16)



5. Air quality and noise

The busy road that connects to the city center is located other side of the sea. The prevailing wind that comes from the seaside can protect the neighborhood from air pollutants. The green area which is located between the neighborhood and the road can work as a buffer space for both air pollutants and noise from traffic. Furthermore, 100 percent locally produced renewable energy and buses using biogas from district food waste contribute to CO_2 reductions broadly.

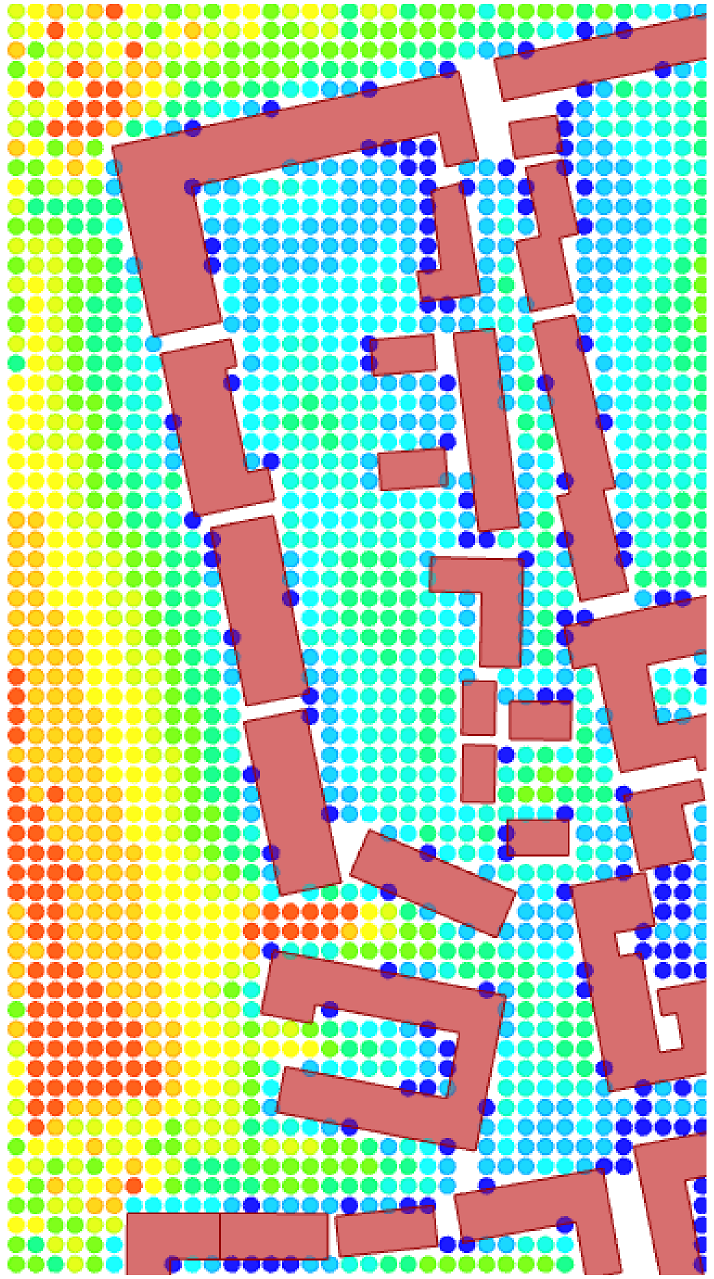
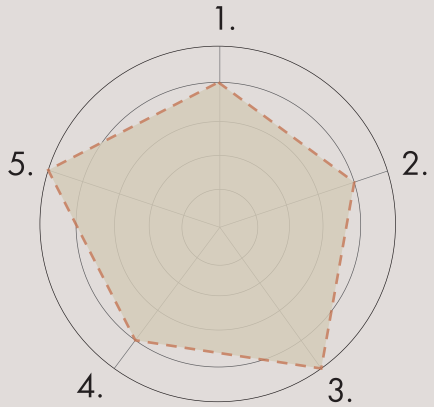


Figure 4.2.7 >
wind comfort

Evaluation



1. Accessibility

Neighborhood-scale plan for transport cannot bring the desired improvement. Active transport modes should be promoted widely in order to truly contribute to the ecological goals of the district.

2. Social infrastructure

The diversity of architecture form and clarity between inside and outside succeeds to make the public space. Many suggestions in terms of diverse users do not transfer in practice.

3. Natural infrastructure

"habitat-rich city district". Developers are required to follow two different but interconnected approaches. The different scales of green space in Malmö are connected and used as an alternative network to the streets.

4. Microclimate

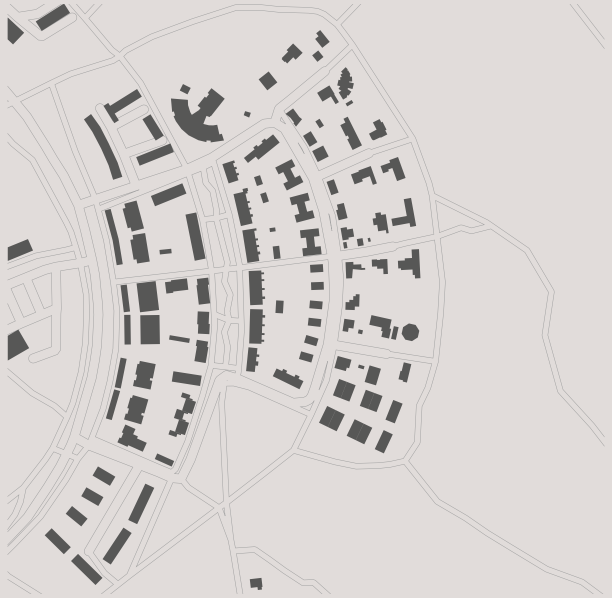
In terms of sunlight access, the thick depth of the building can produce a lot of dark areas. The boundary buildings work as a windbreaker for the inside, but the outside remains perplexing.

5. Air quality and noise

The green area which is located between the neighborhood and the road can work as a buffer space for both air pollutants and noise from traffic.

3. Vuores

Tampere, Finland



Vuores is one of the ECOCITY projects. The overall goals of ECOCITY can be seen in Figure 4.3.2. The Figure illustrates that those four elements such as urban structure, transport, energy and material flows, and socio-economic issues have the effect of raising health and wellbeing to the highest status. The project puts health and wellbeing as the highest priority as stated in the central field where all elements intersect (Ecocity, 2005).

- Minimize impairment of environment and human health; and

- Maximize mental wellbeing and community feeling.

Collective concepts of Vuores were extracted from the criteria of the ECOCITY project with six topics of urban planning, transport, energy, conservation of the natural environment, information, and technology and social issues (Ecocity, 2005).

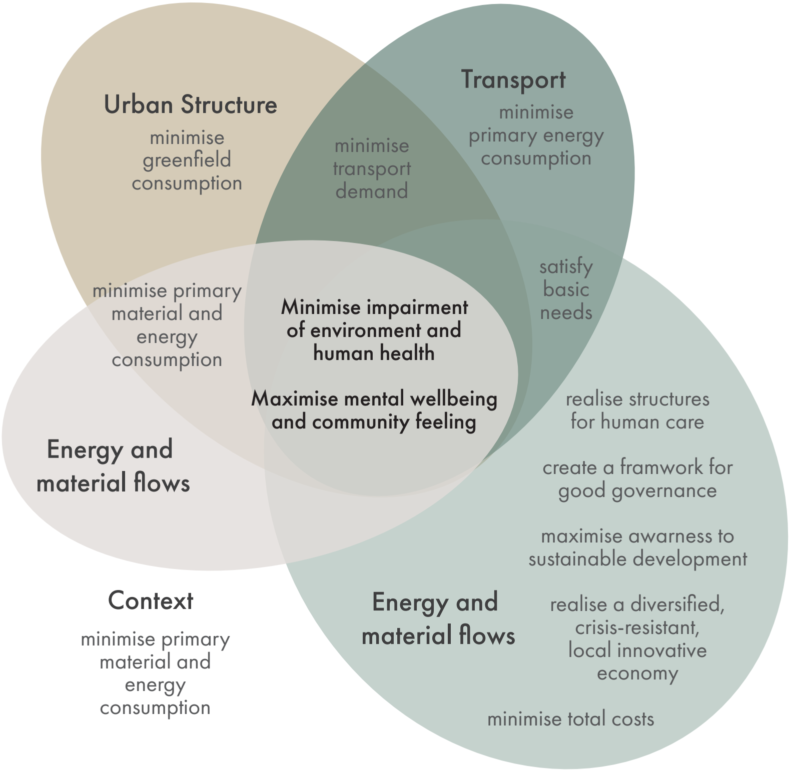
1. Accessibility

Public transport has a major role in the area's transport system plan. The public transport network is planning to have a light rail system that will run through the entire area (Ecocity, 2005). Concerning the distance to city center, comprehensive walking and cycling network must be supported to encourage the use of public transport. To avoid individual car use, it is important to check that every dwelling is well connected to public transport stops within walking and/or cycling distance.

2. Social infrastructure

Another important element of the Vuores project is the community structure. The five centers, which contain one main center and four sub-centers, are situated within short walking distances from the dwellings (Ecocity, 2005). The five centers with a high mix of uses should carry everyday basic services and workplaces as public squares.

Vuores is 7 kilometers away from the center of Tampere (City of Turku, 2015). To develop its independence, rather than becoming a dormitory suburb, the five centers have a strategic role. Just locating the centers may not create the expected outcome. Suggestions for appropriate activities which consider culture and context, interventions to address microclimate, clear definition between public and private, and diversity of architectural forms and users are required to support 'linger-ability' and social infrastructure.



< Figure 4.3.2
Concept of Ecocity project (Ecocity, 2005)

3. Natural infrastructure

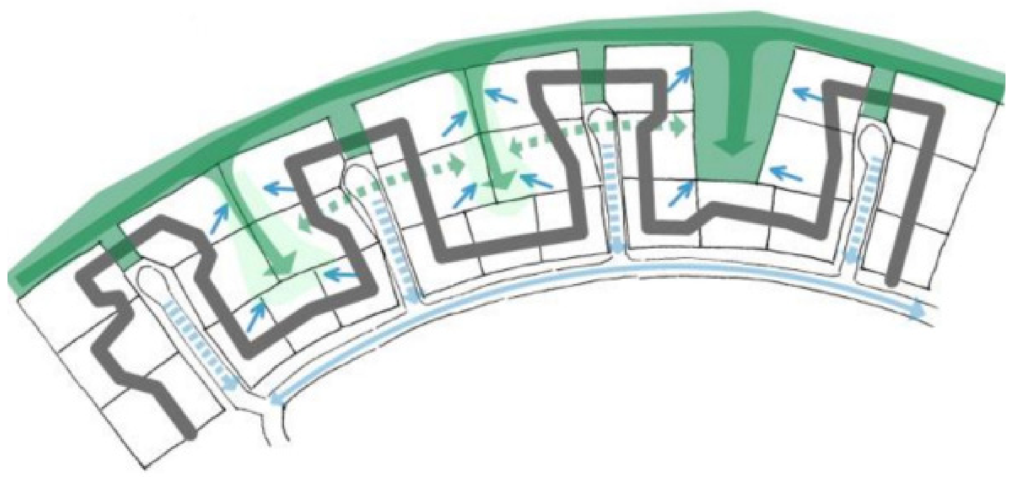
Vuores is a greenfield development, and one of the key elements for this project is including the natural environment into the planning. With the concept of 'garden city', the project tries to preserve biodiversity and adapt to the shape of the terrain (Ecocity, 2005). However, there are no specific criteria which help to transfer the concept into practice.

Special attention is on the stormwater system. In the Vuores area, there are several small lakes near the new residential area. The citizens of Tampere had some concerns that the lakes would be affected by the stormwaters from the residential area (Sito, 2013). Thus, the planning includes an extensive stormwater system to manage stormwater in an organic and controlled way by using the varied topography (Tamminen, 2012).

Furthermore, Tahvonen (2018) suggest rainwater solution throughout the ecological connection – see Figure 4.3.3. It is not clear if it will transfer in practice, but this shows how to apply different types of sustainable drainage systems on the neighborhood scale.

Figure 4.3.3 >
flooding routes and vegetation patterns (Tahvonen, 2018)

Ecological connection by corridors
Runoff / drainage route
Ecological connection by stepping stone
Runoff / drainage route, minor volumes
watershed
runoff route within plots



4. Microclimate

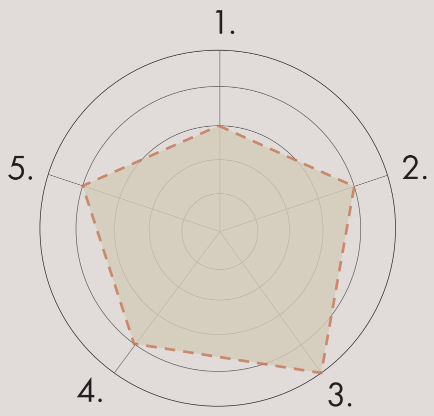
In terms of density of development, the masterplan should suggest an optimal solution. The Vuores has a low-density housing plan, and it assures high sunlight exposure while bringing inequality to public transportation. To maximize the use of public squares and public transport, it is important to offer a comfortable environment with greening. This strategy reconceives the public space and public transportation not as just for vehicles or daily needs but also as an opportunity for the landscape to deliver valuable eco-services.

5. Air quality and noise

The low density which can be a major cause for insufficient public transport accessibility and too much development on individual car infrastructure can maximize the dependence on the use of private cars. The low density makes sense concerning Finland's climate, but the solution should be positive for both mitigation and adaptation. The use of renewable energy sources such as wind and solar power and geothermal heat contribute to CO_2 reductions broadly. Vuores is also participating in the ECO2 program, which aims to reduce the city's emissions by more than 20% by 2020.

The problem of traffic noise is mostly solved by sufficient distances, the relative location of buildings, courtyards, and suitable traffic and parking arrangements. Nevertheless, some physical noise and air pollution abatement measures will have to be taken (Ecocity, 2005).

Evaluation



1. Accessibility
It might be difficult to arrange an effective and economic public transport system that serves the entire area equally.

2. Social infrastructure
To develop its independence, rather than becoming a dormitory suburb, the five centers have an important role. Just locating the centers may not create the expected outcome.

3. Natural infrastructure
The concept of 'garden city'. The project tries to preserve biodiversity and integrate nature with short distances to diverse green spaces. However, there is no clear criterion for this.

4. Microclimate
Public squares need a comfortable microclimate to foster vibrant community life. In the context of Finland, proper windbreak should be considered.

5. Air quality and noise
Low density which can be a major cause for insufficient public transport accessibility, and too much development on individual car infrastructure can maximize the dependent on the use of private cars.

4. Kalasatama

Helsinki, Finland

Kyläsaari is the northern part of the Kalasatama project in Helsinki. Earlier, this area housed a cargo port and small-scale industry, but today it is planned to offer homes and jobs to thousands of people as well as good commercial services (Kaupunkisuunnitteluvirasto, 2008). The project is developed with different scale planning competitions and idea competitions (The city of Helsinki, 2005). Kalasatama project is aiming to develop the area as a world-class district of smart, sustainable living.

1. Accessibility

Construction area 32 ha (exclude Hermanninranta park)

Population 10,000

Distance from the city center 2km

Kyläsaari has a dense development plan with 285 residents per hectare. This is nearly 3 times more than Eco-Viiki and Bo01 projects which have 86 and 104 residents per hectare each. Combining with the plan for additional tram and bus lines next to the neighborhood area (Kaupunkisuunnitteluvirasto, 2010), the Kalasatama plan has a good precondition to have an effective public transportation system. Furthermore, the area is planned to have bike and walking trails that connect to the city center and Kalasatama metro station. Combining with nearby commercial services, daycare centers, school, sports, and recreation services (The city of Helsinki, 2020), Kyläsaari has the potential to have active travel as a major mode.

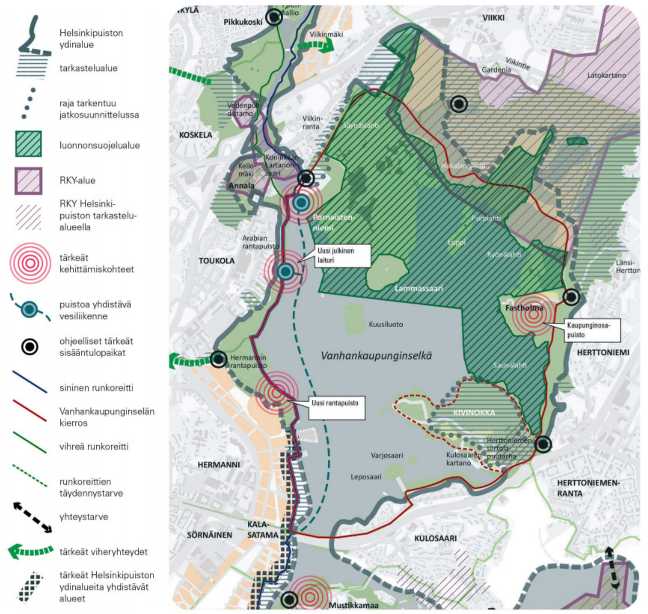
2. Social infrastructure

The area plans to accommodate diverse users with various housing types such as HOAS student housing, Kotisatama senior house, and health & wellbeing family center (The city of Helsinki, 2020). To transfer this plan on practice, and not to remain with certain classes in the social agenda, it is important to offer affordable costs and accessibility. Furthermore, the concept of 'Smart Kalasatama' includes using technology to use flexible spaces or shared-use vehicles (Smart Kalasatama, n.d.). There should not be an exception to access to the technology.

In the context of harbor development, the place should give the perception of welcome for both visitors and residents. Other than providing a seaside promenade, the place provides the reason to visit and linger around with the good urban design, diversity of architecture form, human scale, and quality of outdoor space, and addressing microclimate. The area where public and private conflict calls for special attention. While visitors feel secure in their right to visit the public space including Hermann park, the neighborhood should be kept calm and secured.

Figure 4.4.2 >

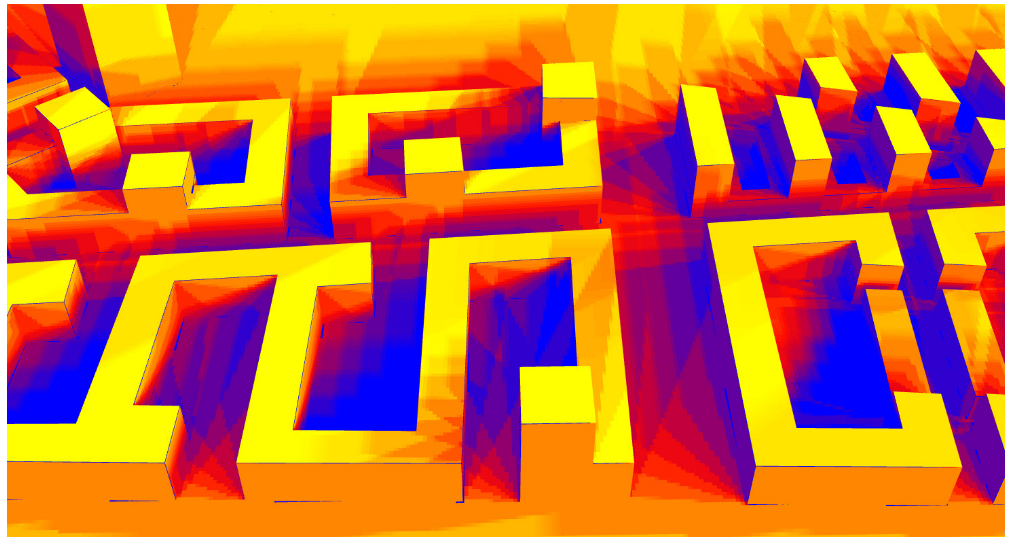
Vanhankaupunkiselkä route (Helsinki City, n.d.)



3. Natural infrastructure

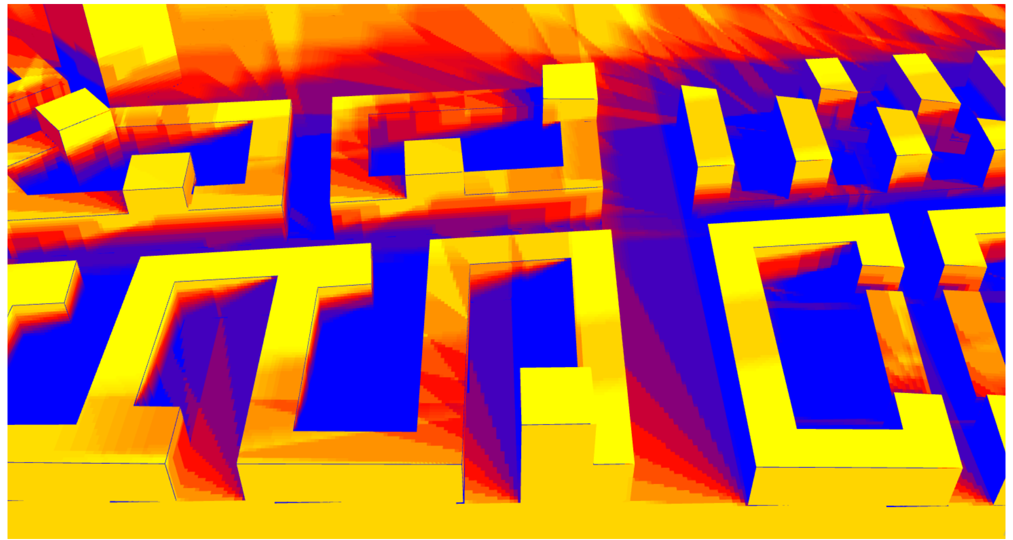
In terms of the green fingers of Helsinki (The city of Helsinki, 2016), Kyläsaari has an important role to preserve the green connection which is part of Vanhankaupunginlahti (The city of Helsinki, n.d.). The initial plan of Kyläsaari keeps a huge part of land clean from development and preserves bio-diversity zone including important bird and dragonfly zone.

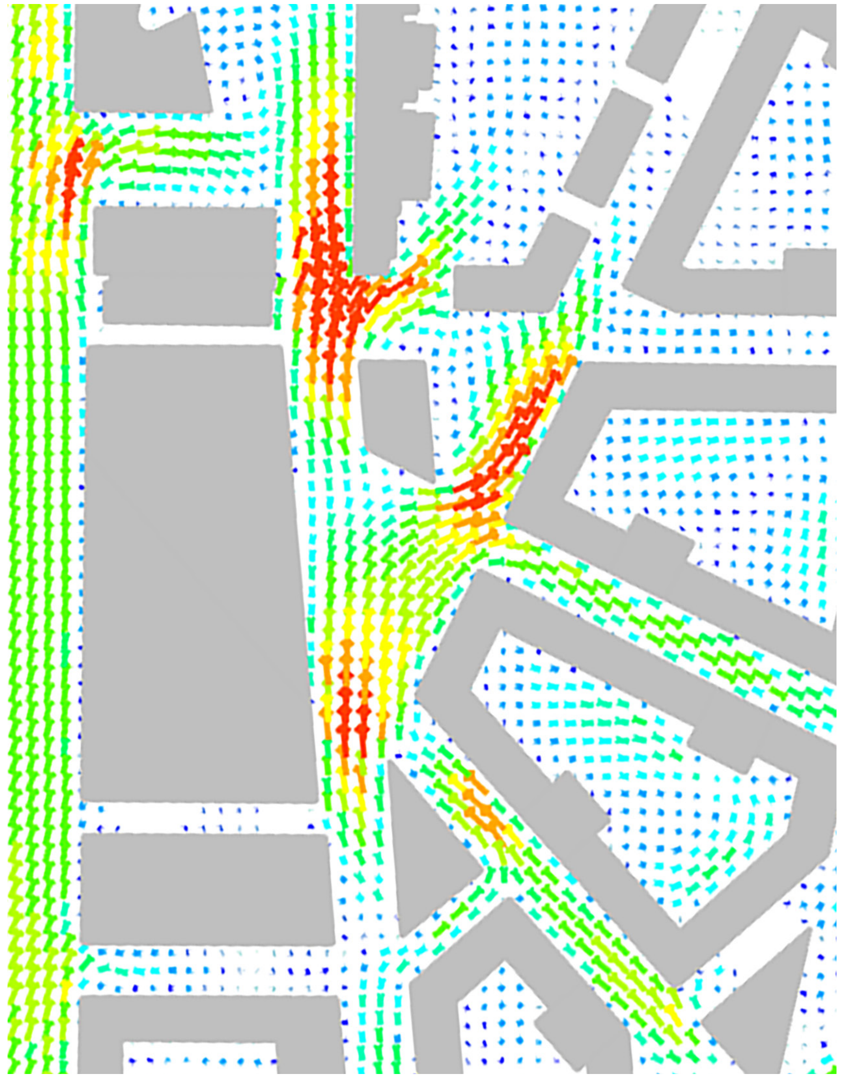
Kalasatama district is located by the sea, so the stormwater run-off into the sea. However, the stormwater system remains the traditional approach which aims to remove surface water via the subsurface drainage system, treating water as a nuisance rather than a resource. To fully conjugate the green connection, an interdisciplinary approach is required. The whole neighborhood can be connected with different scales and different functions of green space. By doing so, people can choose to walk to their destination through the parks and not on the street. This connection of green space can be used for storm-water collection as well. Rainwater which is collected from a private garden or green roof can channel to streets, to landscape filtering areas, and then to the sea. Rather than channeling all rainwater with pipes, stormwater can become an active spatial reference in the urban form.



^ Figure 4.4.3
sunlight hour analysis
typical week (Sep 29 to Oct 5)

v Figure 4.4.4
sunlight hour analysis
coolest week (Feb 3 to 9)





^ Figure 4.4.5
wind analysis (prevailing wind direction)

4. Microclimate

With regards to the climate condition of Helsinki, the Kyläsaari has an excessive dense development plan. The narrow gap between buildings decreases the quality of outdoor as well as indoor space -see Figure 4.4.3, 4.4.4. This can negatively affect social infrastructure. According to sunlight hour analysis, most courtyards and streets have limited access to sunlight all year around. One interesting factor is that even a small gap toward the south can bring about a huge increase in sunlight hours to the courtyard.

When the wind direction parallels the street, combining with a high building height: street width ratio, the urban form produces a strong channelization effect along the streets. According to Figure 4.4.5, some single buildings overly amplify the wind speed and thus threaten wind comfort. While dense development keeps the average wind speed lower than surrounding, narrow streets and tall buildings can easily make pedestrians uncomfortable – see Figure 4.4.6.

5. Air quality and noise

There is one busy road on the opposite side of the sea. The prevailing wind from the Northwest direction can bring traffic air pollutants to the neighborhood. In terms of high density, both traffic and anthropogenic noise should not be set aside. Some physical noise and air pollution abatement measures along the busy road will have to be taken. Kalasatama is the first model areas for smart grid solutions. Combining with indoor climate monitoring system using IT solutions, it can contribute to reducing CO2 emission.

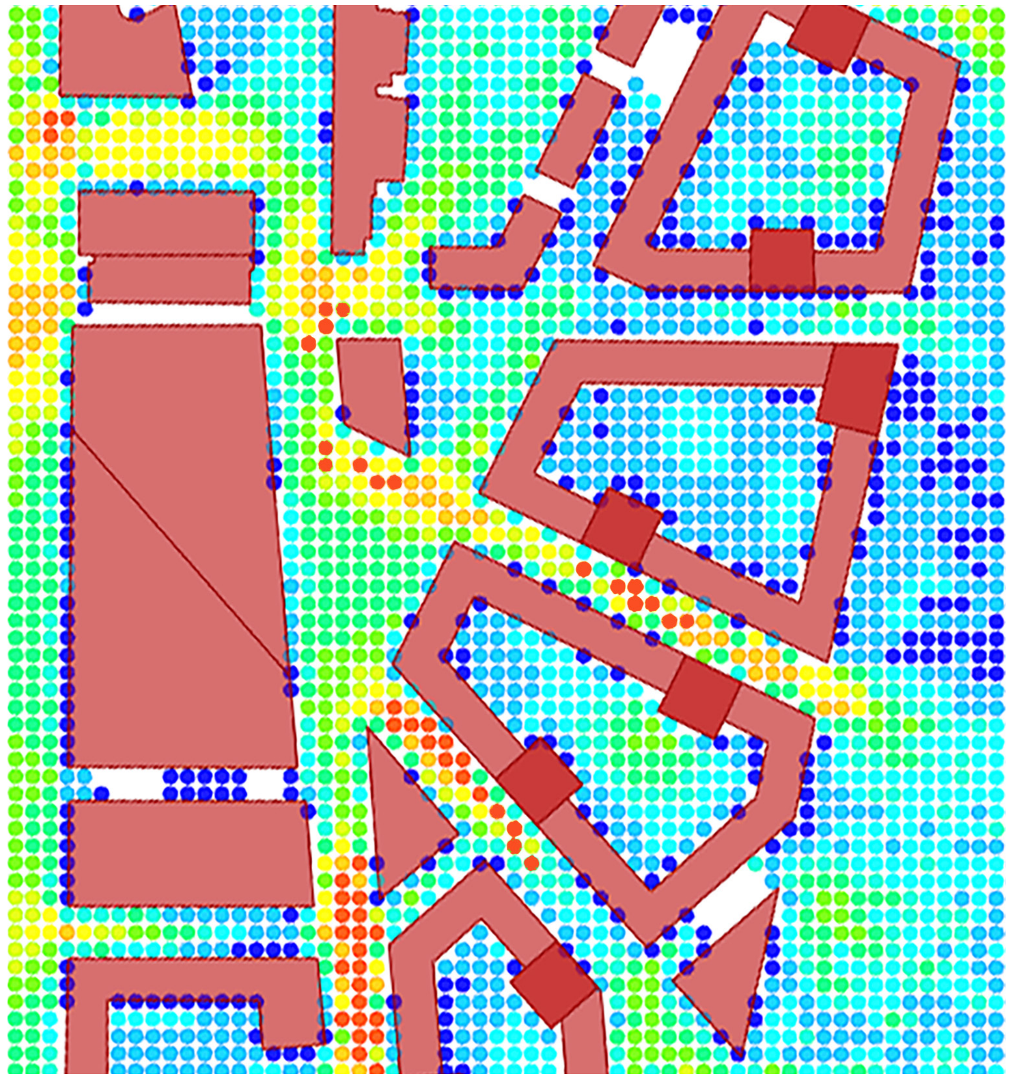
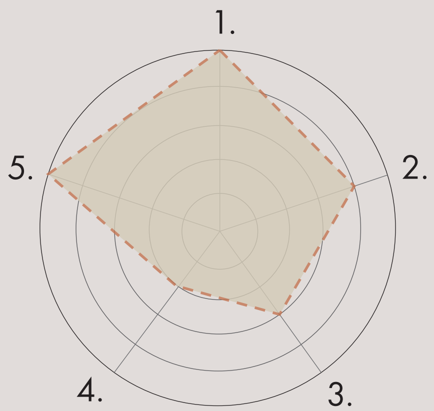


Figure 4.4.6 > wind comfort

Evaluation



1. Accessibility

Kyläsaari has a good precondition to have an effective public transportation system. (Plan for high density and additional transit)

2. Social infrastructure

Kyläsaari plans to have different unit types to accommodate different users. In the context of harbor development, a clear definition between public and private is required.

3. Natural infrastructure

Stormwater is highly recommended to be filtered before run-off into the sea.

4. Microclimate

Excessive dense development plan exceptionally decreases the quality of both outdoor and indoor space. In terms of natural light access and wind comfort, the distance between buildings as well as the usability of the courtyard should be more considered.

5. Air quality and noise

Busy road next to neighborhood area requires special attention on air quality and noise.

checklist

This is now a synthesis of all the key lessons learned from the five-criteria study.
This list can serve as a checklist for designers and developers,
and it is used in order to guide the design in chapter 5.

1. accessibility

Qualified density	a.	Qualified density	☐
	b.	Public transport stops should be located at an acceptable distance from every resident unit.	☐
	c.	Active travel modes should be well design on bigger scale planning.	☐
Mixed land use	d.	Every unit should be well connected to pedestrian and cycle road and have a short distance to daily destination.	☐
	e.	Safe and interesting streets to walk and cycle (special attention on ground floor regarding human scale)	☐
	f.	Address weather condition with proper interventions (e.g trees for windbreaker or shadow)	☐
	g.	Carefully design pedestrian-centered streets.	☐
	h.	Enough storage spaces for bike	☐
Active lifestyle Healthy food	i.	Active travel mode should be well designed for every unit to make utilitarian physical activities in daily routine.	☐
	j.	High quality of outdoor spaces and recreation facilities nearby	☐
	k.	Community garden	☐
	l.	Proximity to supermarkets where people can get fresh and healthy ingredients and provide the place to grow fresh food.	☐

2. social infrastructure

'Linger-ability'	a.	Streets should be designed for the public realm	☐
	b.	The ground floor should be designed for the public realm (ground floor function should not negatively affect the public realm.)	☐
	c.	The clear definition between public and private spaces	☐
	d.	Address weather condition	☐
	e.	Propose outdoor activities that tailored to culture and context	☐
	f.	Diversity of architecture form	☐
	g.	Diversity of housing type	☐
	h.	Diversity of outdoor spaces	☐
	i.	Consider the diversity of users (e.g the disabled, the old)	☐
CPTED	j.	Locate people onto outdoor space for 'nature surveillance'	☐
	k.	Make space 'linger-able'	☐

3. natural infrastructure

Biophilia	a.	Make daily contact with nature possible	☐
		(short distance to nature, located nature on the way/ sensory, physical connection)	☐
	b.	The natural infrastructure of neighborhood should be interconnected with other scale plannings	☐
Community garden	c.	Make community garden possible with different scale (e.g public park, rooftop, balconies)	☐
	d.	Easy access to for children and the old	☐
Green-Blue infrastructure	e.	Consider where the neighborhood is located regarding blue-green connection on bigger scales, and decide which part of the neighborhood should be kept green, blue or both	☐
	f.	Suggest appropriate G.I measure to clean, capture, and reuse rainwater	☐
	g.	Consider biodiversity, and suggest three-dimensional solutions	☐

4. microclimate

Thermal comfort	a.	Suggest three-dimensional measure to maximize the cooling effect of green	☐
	b.	For a cooling effect, consider nearby green and prevailing wind direction to maximize the benefit of blue	☐
	c.	Consider the ratio of building height and street width	☐
	d.	Consider orientation of building	☐
	e.	Consider depth of building	☐
	f.	Consider density	☐
	g.	Consider the reflectivity of building facades	☐
Wind comfort	h.	Consider the wind in planning and understand the local wind system.	☐
	i.	Different outdoor activities require different wind speed	☐
	j.	Analyze the prevailing wind direction	☐
	k.	Analyze the impact of new additions on wind comfort and propose solutions accordingly	☐
	l.	Use evergreen vegetable as a shelter belt	☐

5. air quality & urban noise

Air pollutant	a.	Active travel mode should be well designed for every unit.	☐
	b.	Check if the site is in an important blue-green corridor, near a highway or railroad.	☐
	c.	Keep the distance from the air pollutant source.	☐
	d.	Locate the barrier near the pollutant source.	☐
	e.	Prioritize the space (special attention on the place where pollution-sensitive frequently use).	☐
	f.	Analyze prevailing wind direction.	☐
	g.	Utilize green.	☐
Urban noise	h.	Be aware where are the busy roads or other noise sources.	☐
	i.	Keep the distance from the noise source.	☐
	j.	Located acoustic barrier near the noise source	☐
	k.	Screen noise by layout and less noise-sensitive functions.	☐
	l.	Add green, 'noise-free zone', where people can escape from a stressful and challenging situation.	☐

5.
design

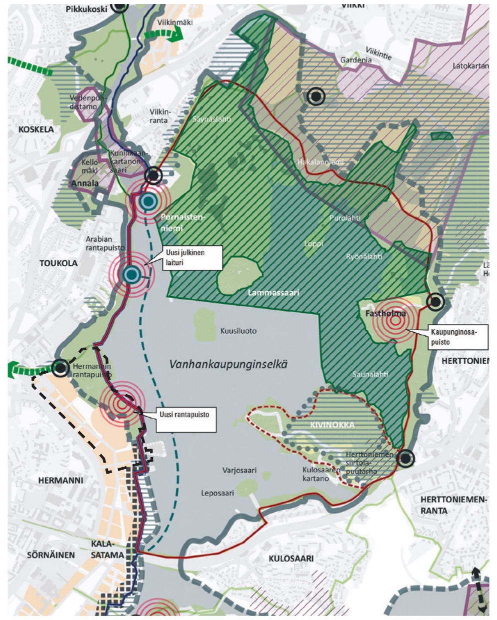
Kalasatama, Helsinki

The chosen design site, Kyläsaari and Hermannin-ranta, is part of the Kalasatama project. Kalasatama, literally translated as "fish port", is located by the sea in the eastern part of the city. The design site was a cargo port and small-scale industrial area and now planned to be home to about 10,000 inhabitants.

Helsinki 'green fingers'

(Helsingin Kaupunkisuunnitteluvirasto, 2008)

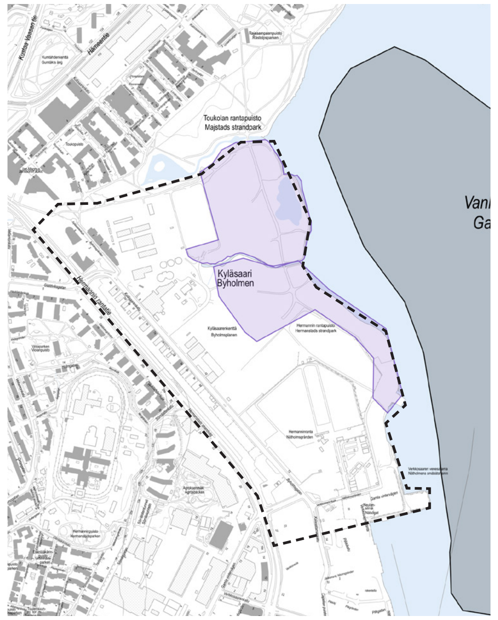
Vanhankaupunginselkä route



(Helsinki City, n.d.)

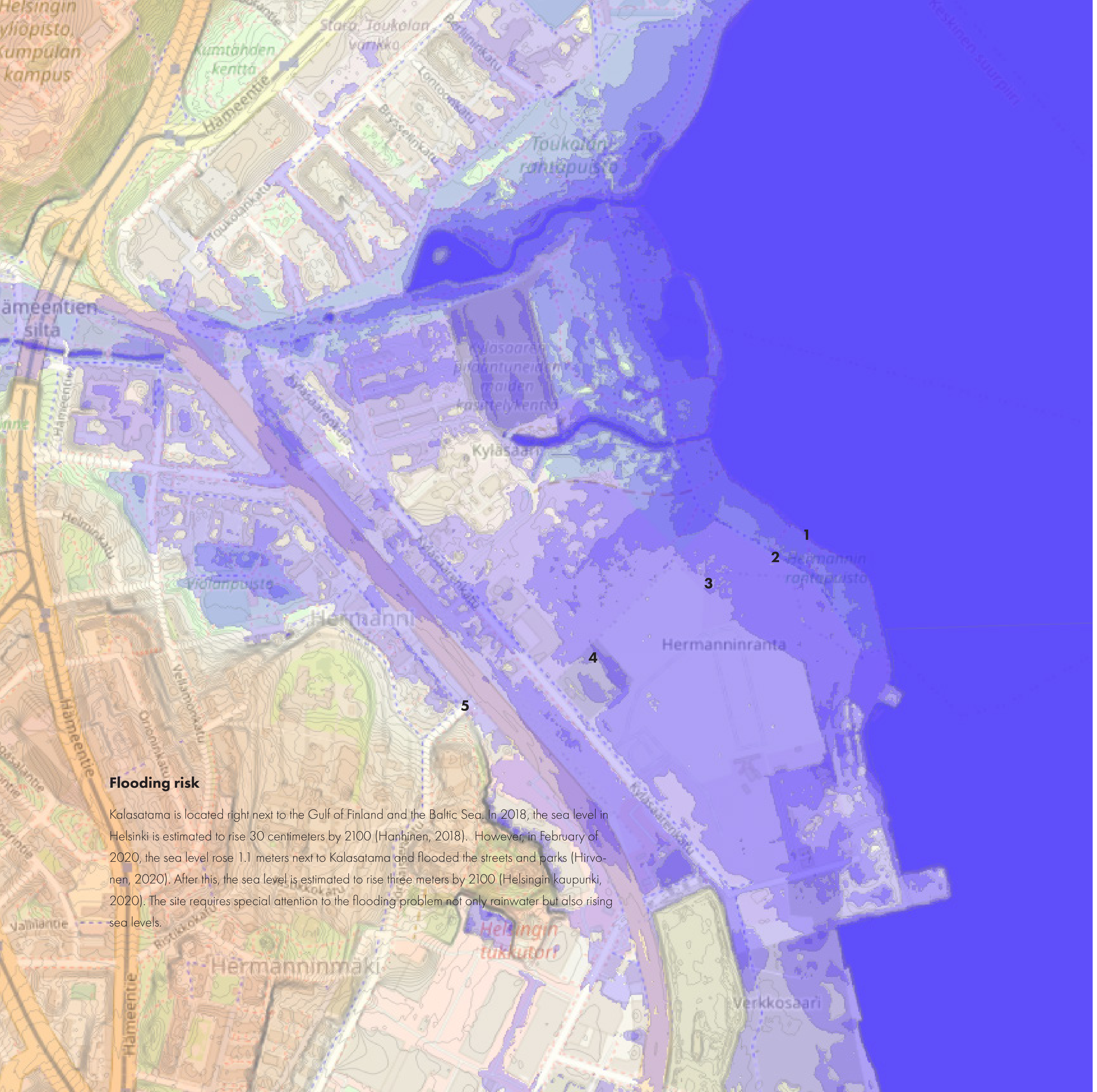
- Vanhankaupunkiselkä route
- core of helsinki park
- design site
- entry-points with guidance
- green connection

biodiversity



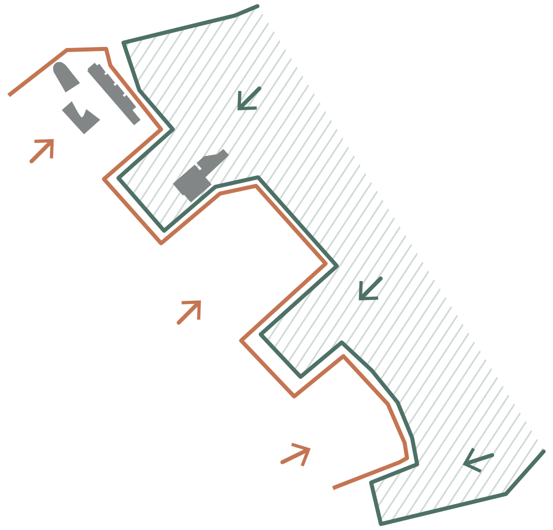
(Helsinki City, 2021)

- important bird area
- important bat area
- design site

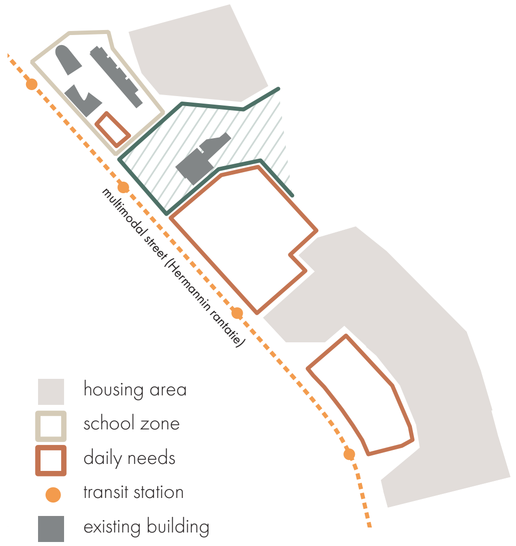


Flooding risk

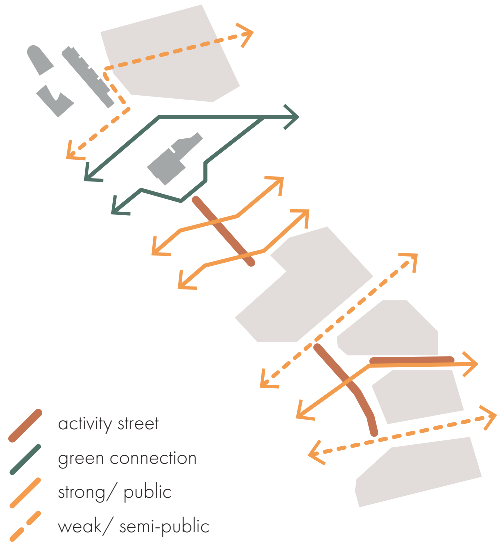
Kalasatama is located right next to the Gulf of Finland and the Baltic Sea. In 2018, the sea level in Helsinki is estimated to rise 30 centimeters by 2100 (Hanhinen, 2018). However, in February of 2020, the sea level rose 1.1 meters next to Kalasatama and flooded the streets and parks (Hirvonen, 2020). After this, the sea level is estimated to rise three meters by 2100 (Helsingin kaupunki, 2020). The site requires special attention to the flooding problem not only rainwater but also rising sea levels.



In the planning site, it is valuable to keep and develop the green area, and necessary to meet the growing needs of development and new housings.



The daily needs including stores are positioned between transit stations and housings, and transit stations are located within 200 meters from every unit. It can promote the use of public transportation and stores from where people can get fresh ingredients.



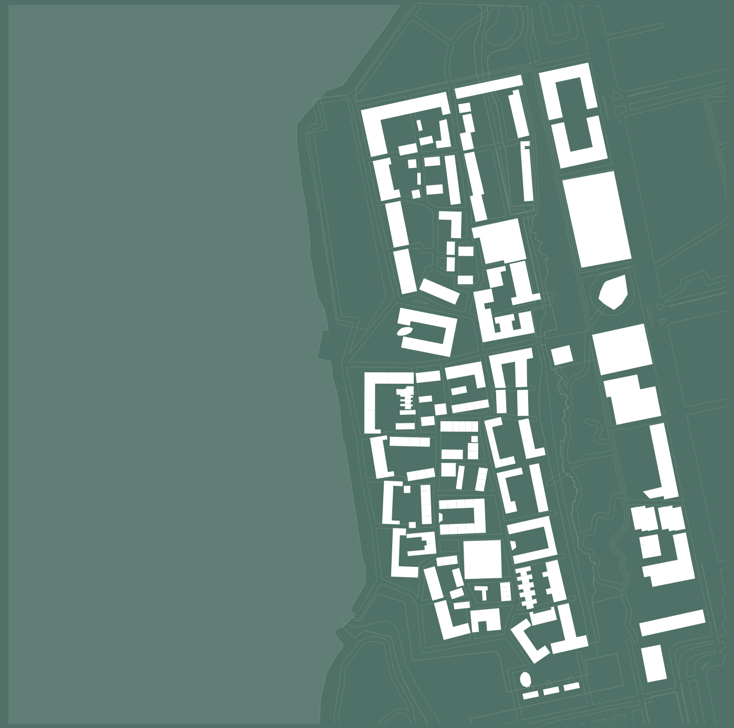
In the context of coastal development, it is important to keep the privacy of the neighborhood, and at the same time connect the city to the shoreline. There is no physical disconnection, but there is a clear differentiation between public and semi-public connections.

building typology

Here, the building typology of each case study is reviewed to be further used in the design phase.

Eco-Viikki

Eco-Viikki is a good example in terms of solar access. Most of buildings are south-oriented and have sufficient distance between them. This makes housing units and outdoor spaces to receive sunlight. The concept of outdoor space, 'green finger', is a good solution for both the social aspect and ecology.



BO 01

BO01 is a good example in terms of the windbreak. The relatively tall perimeter buildings keep inside comfort from the strong wind of the nearby sea and separate public and private areas. Buildings with different angles and different designs arouse diversity.

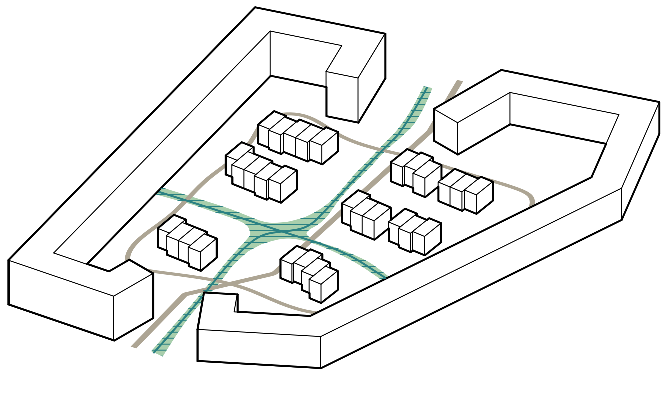
Vuores

Vuores is a good study concerning the stormwater system. Research highlights that habitat types and ecological connections for flooding routes should be planned in neighborhood-scale planning (Tahvonen, 2018).

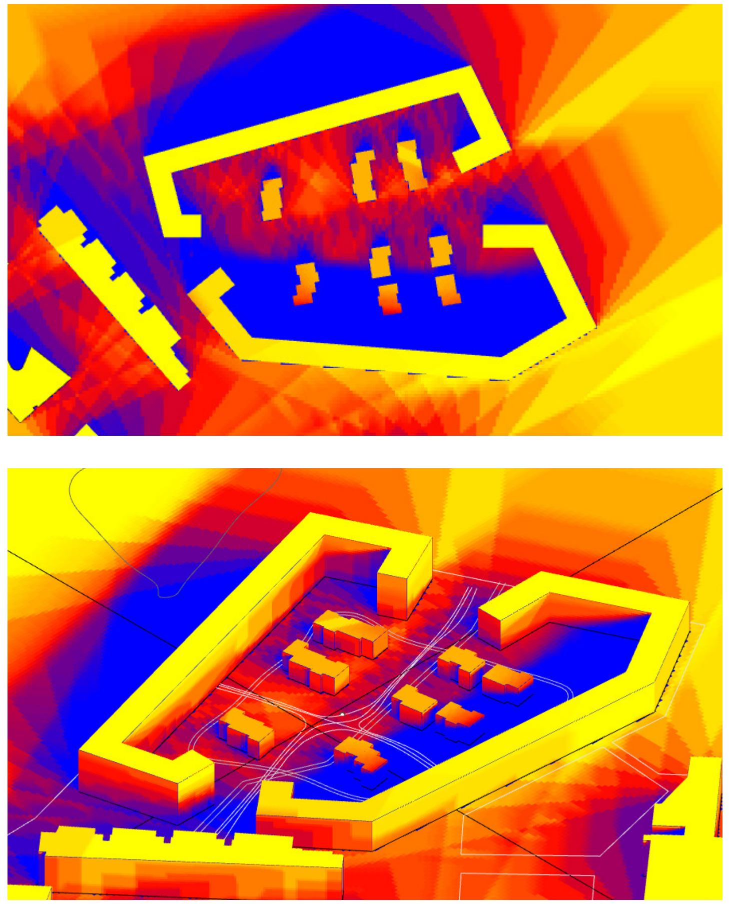
Kalasatama

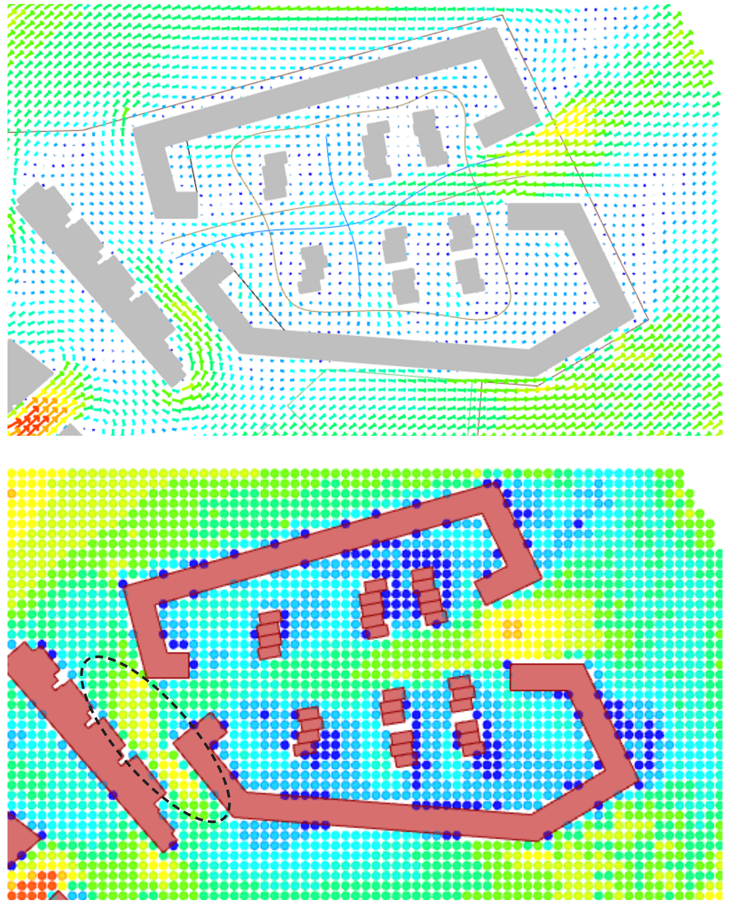
Concerning the low sun angle of Finland, the simulation result of Kalasatama shows the need for sufficient distance between buildings. Additionally, narrow streets can produce uncomfortable wind conditions.

design phase 1



The perimeter of the neighborhood is clearly shown by taller buildings (set as 7th floor for north 5th for south part), and those also work as windbreakers. The inside buildings have a relatively lower height (set as 3rd flood), which can ensure better sunlight hours. Ecological connection for flooding routes is traversing the neighborhood.



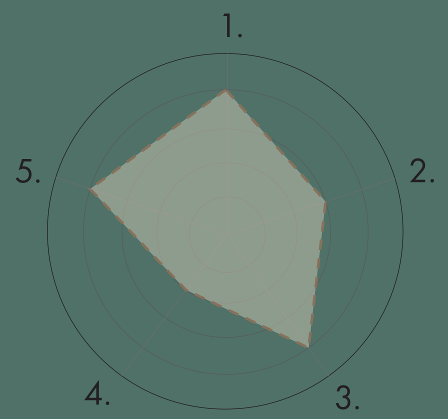


^ Figure 5.1.1.
sunlight hour analysis
coolest week (Feb 3 to 9)

^ Figure 5.1.2
wind flow analysis
(1. prevailing wind direction, 2. wind comfort)

The boundary buildings are effective to block the wind that keeps the inside comfortable from the wind. However, they produce a channel effect with the surrounding building - Figure 5.1.2 and cast huge shadow - Figure 5.1.1.

Evaluation



1. Accessibility

Mixed land use between housing and other daily destinations offers walking distance. The first proposal has a density of 102 residents per hectare.

(The density is roughly calculated with the condition of 20 % of indoor common area, and 45m2 of living area per person. The number is for comparison between each design phase. The settings can be different with other case studies.)

2. Social infrastructure

While the boundary building creates a clear definition between private and public areas, a unified form of them is detrimental to diversity and human scale. Elongated buildings can make streets boring.

3. Natural infrastructure

The stormwater channel is well reserved, but the green measures are disconnected by boundary buildings.

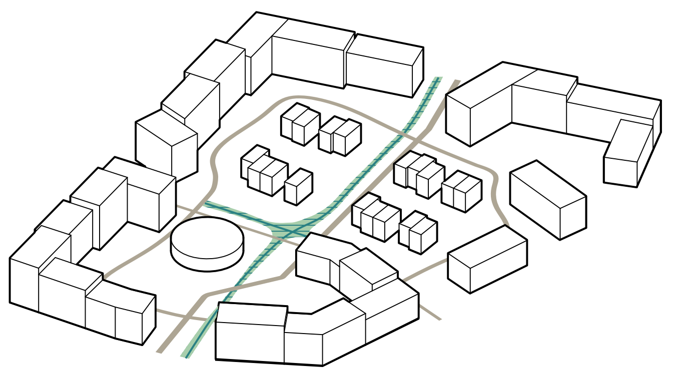
4. Microclimate

While the boundary buildings produce comfortable wind flow, they negatively work on solar access.

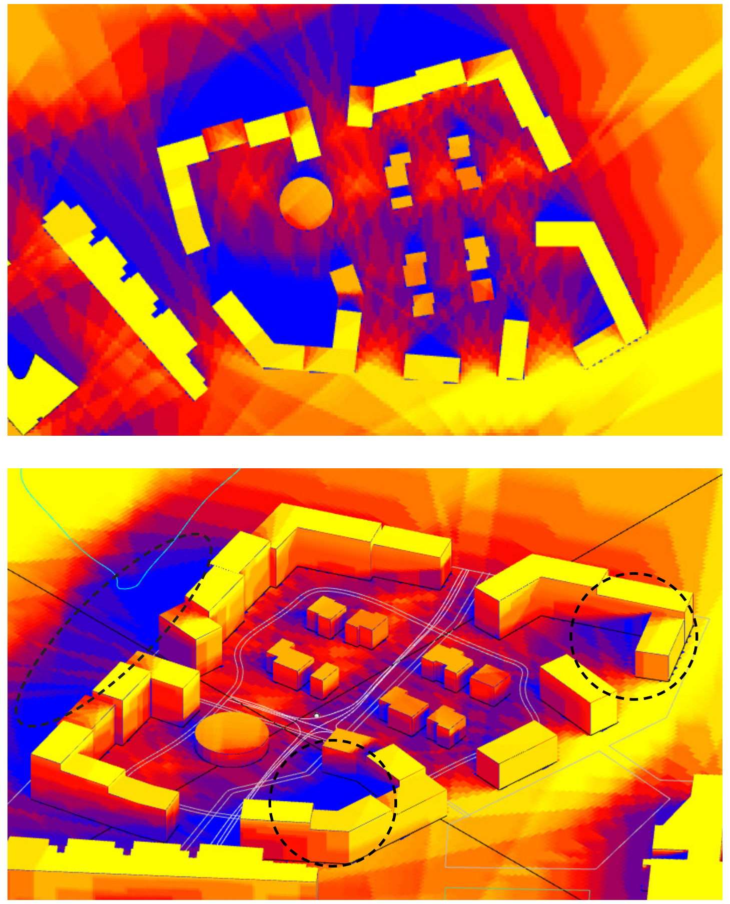
5. Air quality and noise

The building form that along the prevailing wind direction can prevent air pollutants from being trapped. Trees along Hermannin rantatie street can filter air pollutants and limit their dispersion. However, the bad solar access might increase dependence on energy equipment and decrease air quality.

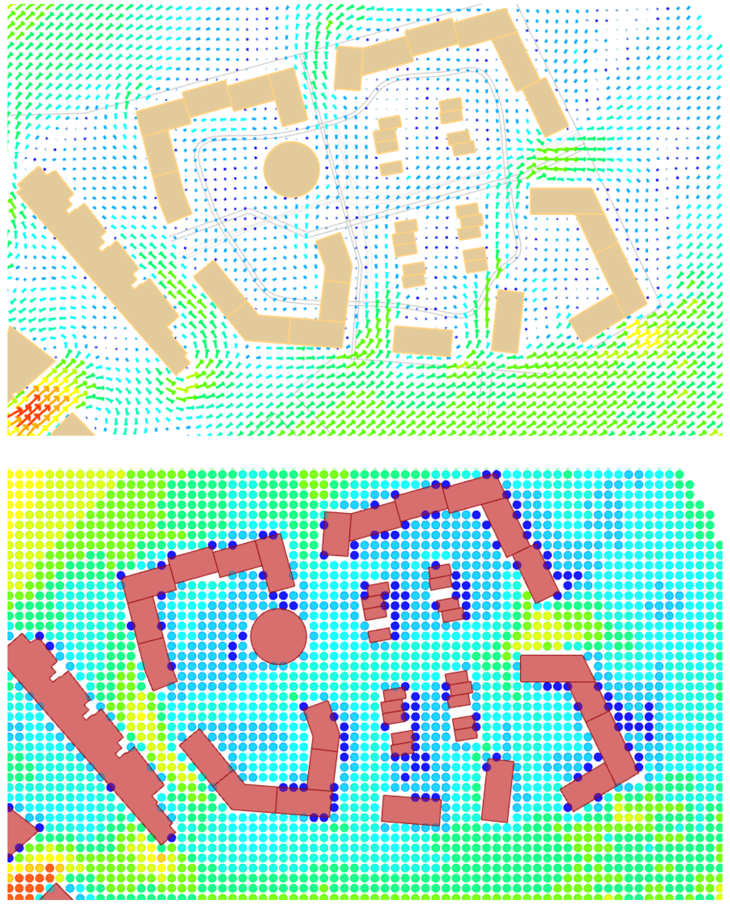
design phase 2



The perimeter buildings are divided on a human scale, and they have different heights (from 4 to 7th floor) to enhance solar access. The ecological connection for stormwater routes is kept. Community facility with round building form is added in every cluster and outdoor activities will be suggested along the street. The division of the perimeter buildings allows additional access to the neighborhood.



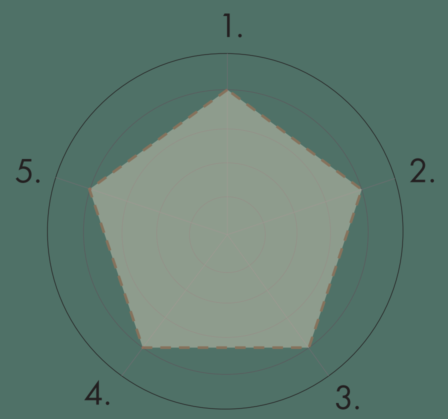
^ Figure 5.2.1.
sunlight hour analysis
coolest week (Feb 3 to 9)



^ Figure 5.2.2
wind flow analysis
(1. prevailing wind direction, 2. wind comfort)

There are some additional wind flows that come from the building gaps, but wind speed is kept comfortable – see Figure 5.2.2. The division of buildings allows more sunlight hours to outdoor spaces and buildings themselves. However, some parts still have problems. Special attention is required when horizontally placed buildings cast shadow to buildings behind them - Figure 5.2.1.

Evaluation



1. Accessibility

Nearby community facilities and outdoor activities can increase physical activity. Additional buildings increase the number of residents per hectare number by 120.

(The density is roughly calculated with the condition of 20 % of indoor common area, and 45m2 of living area per person. The number is for comparison between each design phase. The settings can be different with other case studies.)

2. Social infrastructure

Community facilities and outdoor activities also can increase social interaction between residents. The divided buildings can have various designs. Combining with different widths of streets, pleasant streets make people linger around.

3. Natural infrastructure

The gaps between buildings allow green infrastructure to connect in and out of the perimeter.

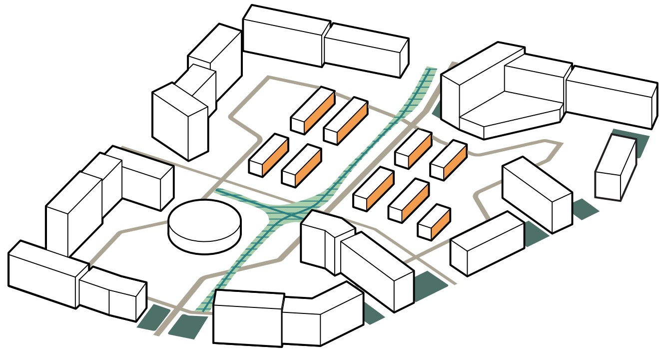
4. Microclimate

The division of buildings allows better solar access and keeps wind comfortable. However, there are still spots that require an additional break-up.

5. Air quality and noise

A better microclimate can reduce energy use by utilizing free solar gain and reducing wind pressures.

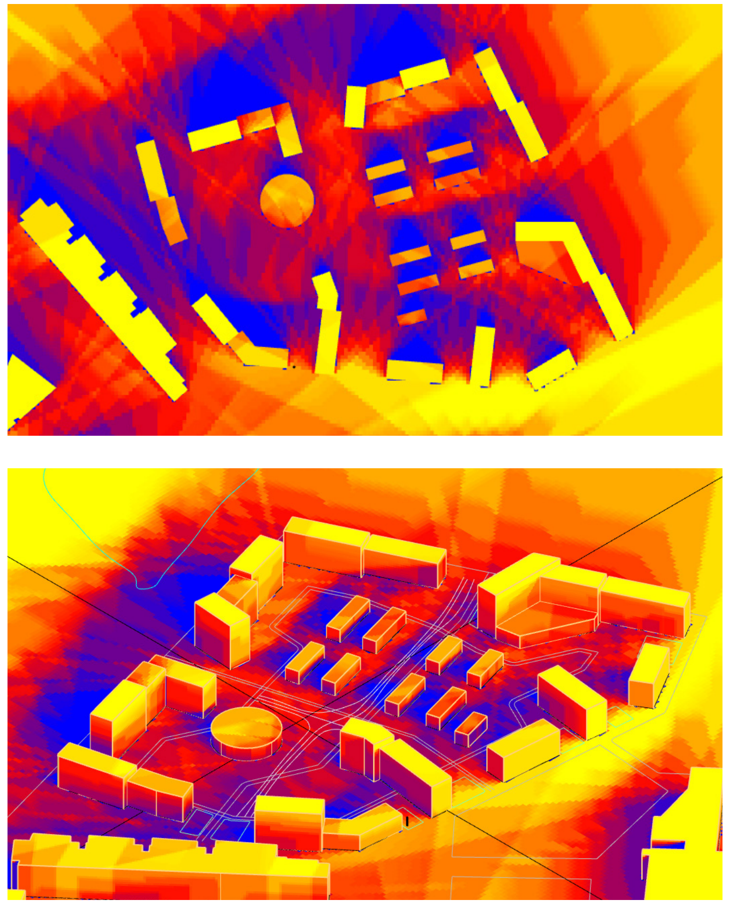
design phase 3



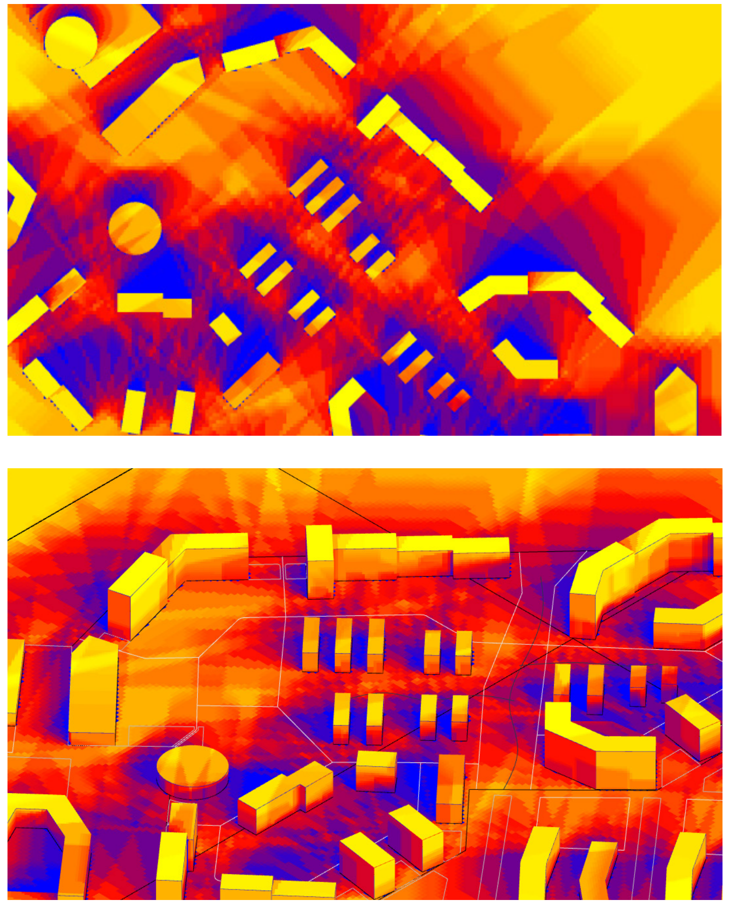
Concerning better solar access for both outdoor and indoor spaces, the perimeter buildings are further divided. The inner building typology also changed. Light color façade can increase the reflection of light.

The overall building proportions are adjusted to get a better building plan. To provide better daylighting, and increase the thermal envelope, the depth of buildings is adjusted (10 meters for the perimeter buildings, 6 meters for inside buildings). This could allow units to have a two-oriented layout.

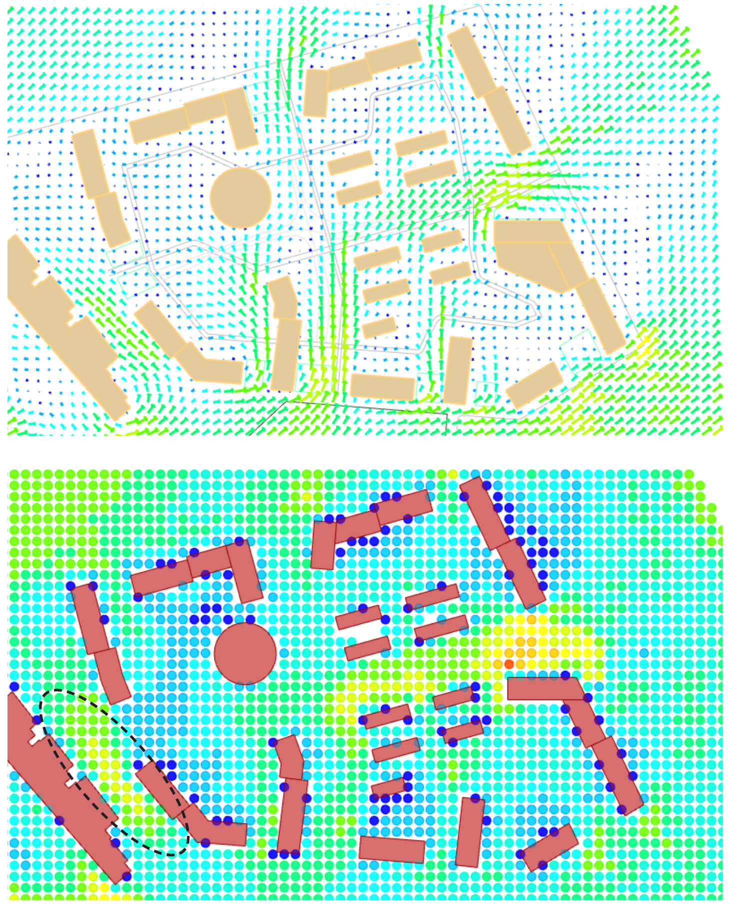
By locating trees along the boundary, the inside perimeter area can be kept secure and safe from the wind.



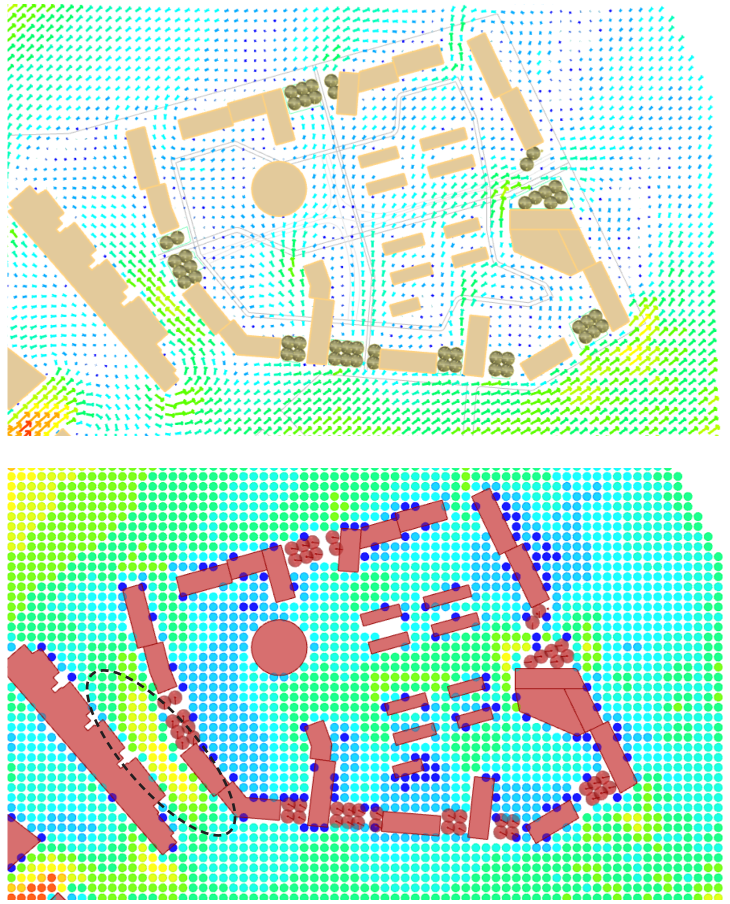
^ Figure 5.3.1.
sunlight hour analysis
coolest week (Feb 3 to 9)



^ Figure 5.3.2
sunlight hour analysis
coolest week (Feb 3 to 9)



^ Figure 5.3.3
wind flow analysis
(1. prevailing wind direction, 2. wind comfort)



^ Figure 5.3.4
wind flow analysis with trees
(1. prevailing wind direction, 2. wind comfort)

Most units are expected to have increased sunlight access. The reflection of material is not considered in simulation results. – see Figure 5.3.1, 5.3.2.

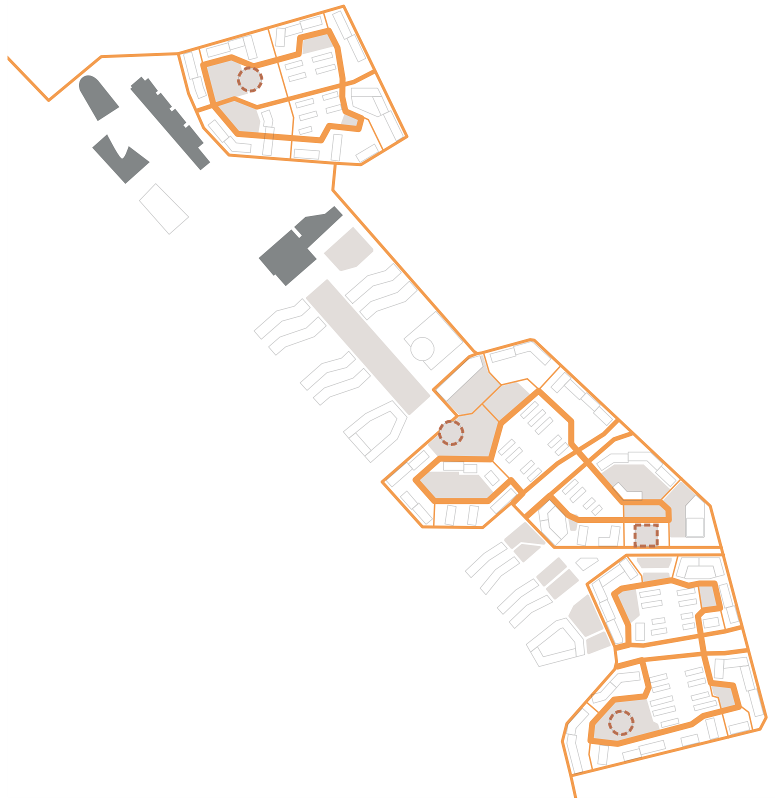
Addition of trees along the boundary increase comfort zone. However, those additions can increase the channel effect between the surrounding building. It highlights that both sunlight access and the wind flow should be considered with context – Figure 5.3.2. The measure that benefits one side can detriment the other side.

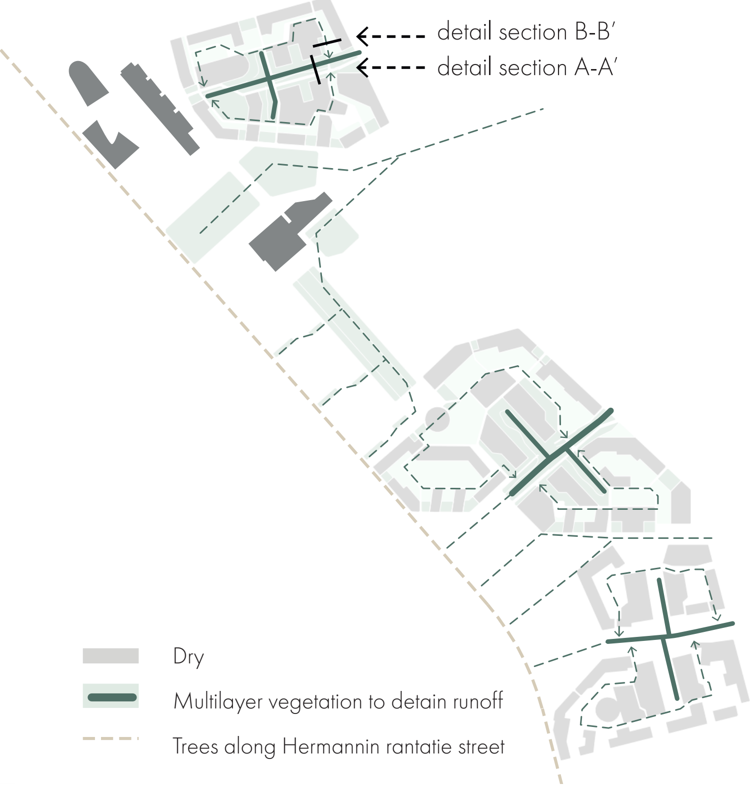
car traffic

Car access is restricted to give ownership to pedestrians, not cars. There is main car traffic leading to multistory parking lots.

parking lot

Multistory parking lots are located within 200 m for every housing unit, and emergency outdoor parking lots are also arranged.





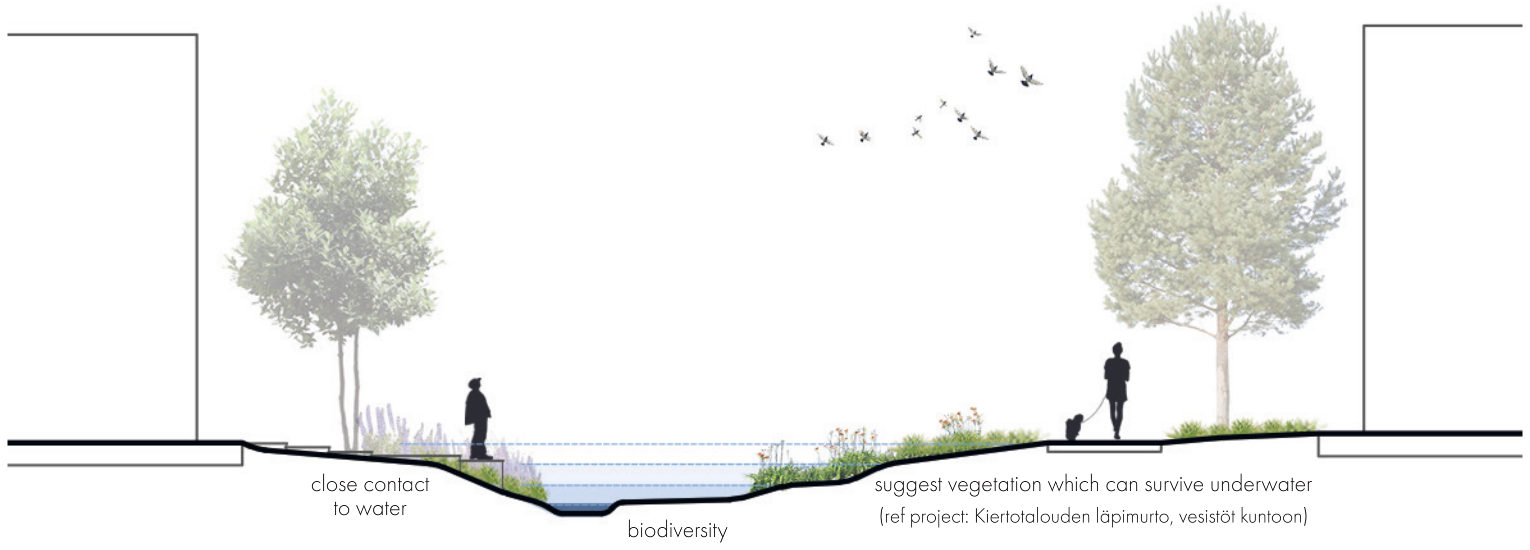
people flow

Different widths of streets, combining with outdoor activities make the street more interesting and pleasant. This can increase outdoor activities and increase drivers' attention to limit car speed.

stormwater system

There is a clear definition of habitat types to channel the rainwater and snow-melting water. The direction of the rainwater channel and building forms can enhance air circulation. Trees are located along Hermannin rantatie street.

detail section A-A′



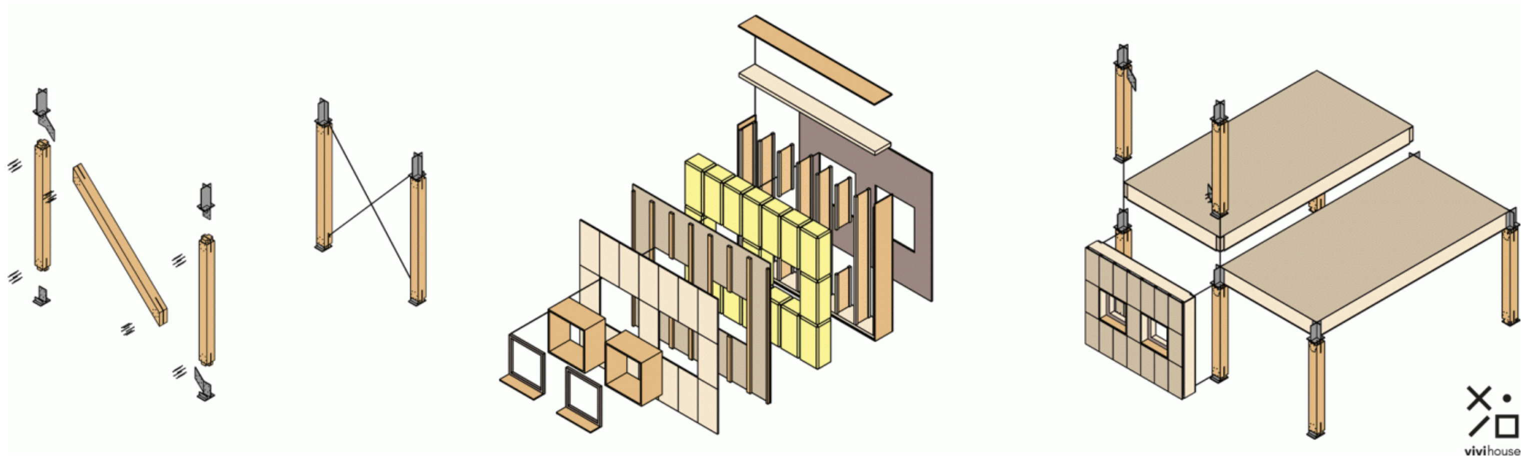
detail section B-B′

Design for Disassembly (DfD)

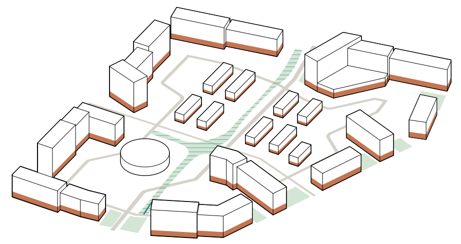
The planning site is by the sea. The flooding can be aroused from both rainwater and sea-level rise. In the context of coastal development, a careful solution concerning future climate changes is critical for genuine sustainable development. Design for Disassembly (DfD) is the concept in which buildings are designed intentionally for material recovery, meaningful next use and value retention. In other words, the design considers the building and all its parts and pieces to be reused at the end of its life in one site.

The major principle for DfD is to use 'dry' assembly, such as bolted, screwed, and nailed connections. One major difference for most buildings is the predominance of 'wet' assemblies, which are built for specific geographic sites. However, the use of 'dry' assembly can make the recycling of material possible at the end of its life for meaningful next use (Guy & Ciarimboli, 2008).

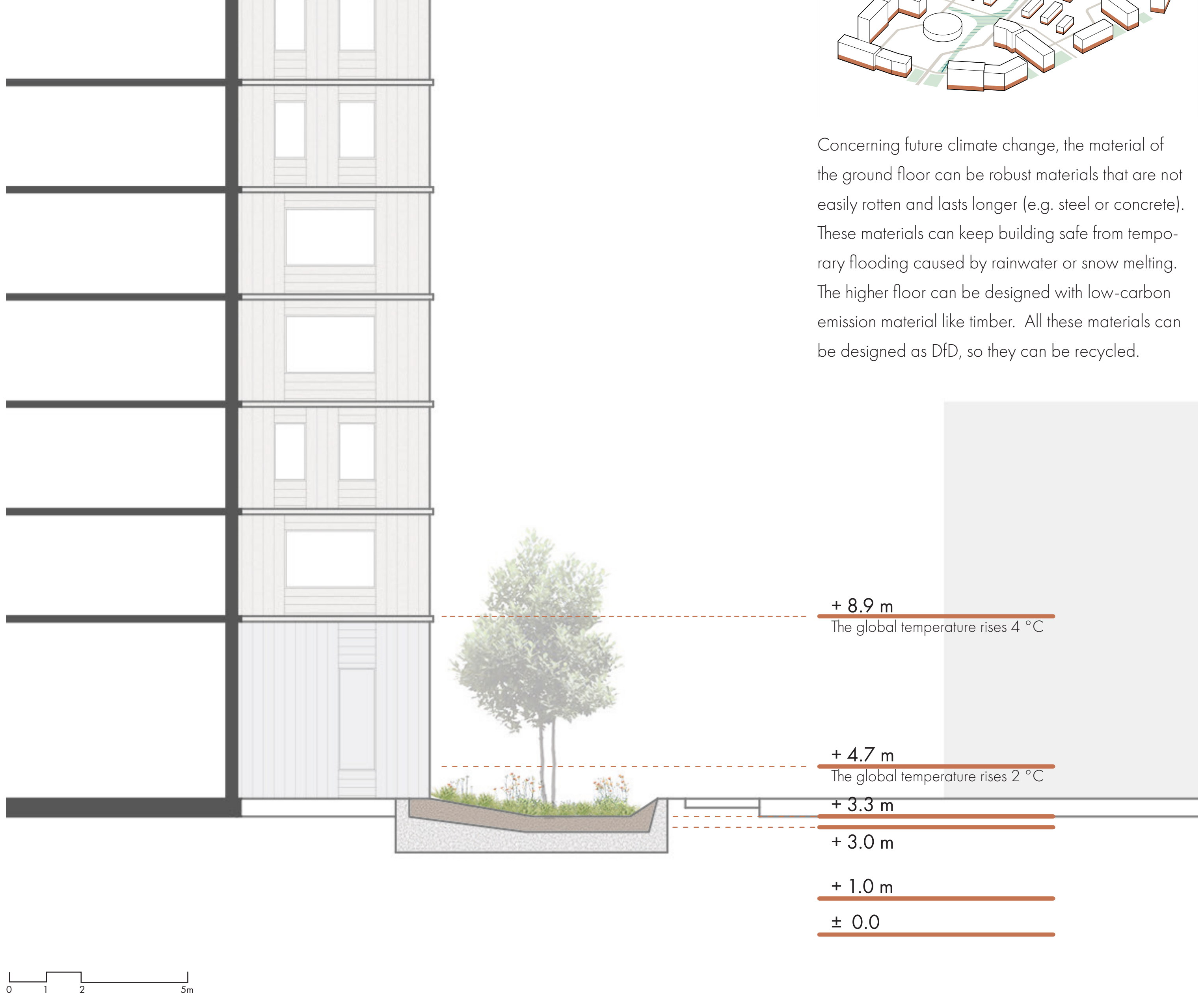
v Figure 5.3.6
DfD (Wikifactory, 2020)



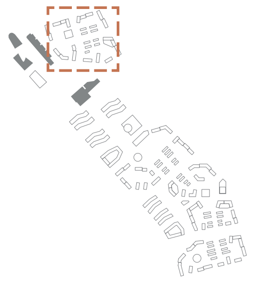
detail section C-C′



Concerning future climate change, the material of the ground floor can be robust materials that are not easily rotten and lasts longer (e.g. steel or concrete). These materials can keep building safe from temporary flooding caused by rainwater or snow melting. The higher floor can be designed with low-carbon emission material like timber. All these materials can be designed as DfD, so they can be recycled.



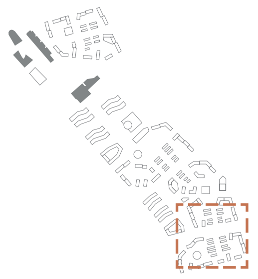
1 open gym
2 community garden
3 community facility
4 basketball courtyard
5 mini forest
6 playground



The various outdoor activities with various widths of streets are designed to be 'linger-able'. The emergency outdoor parking lots are located, and trees are located along the boundary for wind comfort.

Ecological stormwater channel crosses the neighborhood, and it can increase people's outdoor activities as well as biodiversity. This also makes daily contact with nature possible. Buildings are designed with a diversity of architectural forms.

1 cafe
2 community table
3 mini golf
4 community garden
5 community facility
6 playground
7 basketball playground
8 open gym
9 small forest



A round-shaped community facility and community garden are in every cluster to increase social interaction. The trees along the stormwater channel will keep the neighborhood safe from the public.

Outdoor activities that are tailored to Finnish climate are suggested, and they can increase social interaction and daily activity. The street channel is along the street and connected to main ponds. Every building includes storage space for bikes. Gardening is also possible from balconies.

Checklist

1. accessibility

qualified desity			
a.	☒	☐	☐
b.	☐	☐	☒
c.	☐	☐	☒

mixed land use			
d.	☐	☐	☒
e.	☐	☐	☒
f.	☐	☐	☒
g.	☐	☐	☒
h.	☐	☐	☒

active lifestyle & healthy food			
i.	☐	☐	☒
j.	☐	☐	☒
k.	☐	☐	☒
l.	☐	☐	☒

2. social infrastructure

'linger-ability'			
a.	☐	☐	☒
b.	☐	☐	☒
c.	☐	☐	☒
d.	☐	☐	☒
e.	☐	☐	☒
f.	☐	☐	☒
g.	☐	☒	☐
h.	☐	☐	☒
i.	☐	☐	☒

CPTED			
j.	☐	☐	☒
k.	☐	☐	☒

3. natural infrastructure

biophilia			
a.	☐	☐	☒
b.	☐	☐	☒

community garden			
c.	☐	☐	☒
d.	☐	☐	☒

green - blue infrastructure			
e.	☐	☐	☒
f.	☐	☐	☒
g.	☐	☐	☒

4. microclimate

thermal comfort			
a.	☐	☒	☐
b.	☐	☒	☐
c.	☐	☐	☒
d.	☐	☐	☒
e.	☐	☐	☒
f.	☐	☐	☒
g.	☐	☐	☒

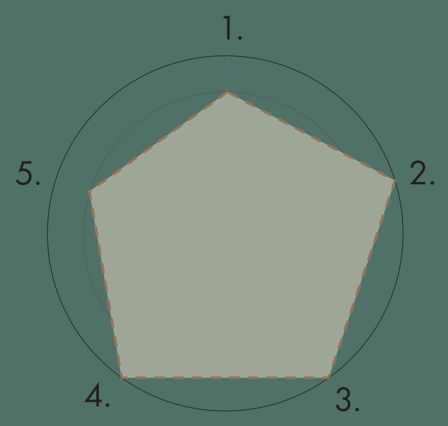
wind comfort			
h.	☐	☐	☒
i.	☐	☒	☐
j.	☐	☐	☒
k.	☐	☐	☒
l.	☐	☐	☒

5. air quality & urban noise

air pollutant			
a.	☐	☐	☒
b.	☐	☐	☒
c.	☐	☒	☐
d.	☐	☐	☒
e.	☐	☒	☐
f.	☐	☐	☒
g.	☐	☐	☒

urban noise			
h.	☐	☐	☒
i.	☐	☒	☐
j.	☐	☐	☒
k.	☐	☐	☒
l.	☐	☐	☒

Evaluation



1. Accessibility

Concerning the low sun path of Finland, it is hard to keep dense development. The narrow depth of buildings and additional division of buildings decrease the number of residents per hectare number by 92.

(The density is roughly calculated with the condition of 20 % of indoor common area, and 45m2 of living area per person. The number is for comparison between each design phase. The settings can be different with other case studies.)

2. Social infrastructure

Sitting furniture and sitting area can increase 'linger-ability'. The addition of trees along the boundaries can reinforce the perception of safety. Concerning the Finnish climate, winter sports (e.g. outdoor ice skating) are reserved. To accommodate diverse users, diverse housing units must be further considered.

3. Natural infrastructure

In and out of green measures are well connected, and they make daily contact with nature possible. Gardening is possible in a different way (e.g. outdoor, glass box, or balcony), and stormwater system is well designed.

4. Microclimate

Additional division of mass together with shallow plan design allows good daylighting conditions. There is possibility to adjust the location of outdoor activities depending on wind speed.

5. Air quality and noise

The ground floor near the Hermannin rantatie street is arranged with less-sensitive function (e.g. commercial). Including trees along busy street, noise and air pollution abatement measures should be further considered.

5.
conclusion
reference

conclusion

The design phase was developed based on the five design criteria that support and enhance sustainability and citizen's health and well-being. Each design phase was evaluated and further developed to get a perfect pentagon. Generally, the design process highlighted **the inevitability of compromise for some sustainability criteria.** A qualified density plan is one strategy for sustainable development that focuses on energy savings through shared infrastructure, efficient transport system. However, excessive density can detriment to other criteria by limiting the space for natural infrastructure, restricting solar access, and negatively affecting urban comfort. Elongated buildings can protect one place from strong wind, but it also can cause huge shadows and arose uncomfortable wind condition to another side – see Figure 5.1.1.

The design phase also highlighted **the iterative use of the computer simulation tool**. By including simulation in the process, the simulation results affected decision-making and design alterations to improve the comfort and sustainability outcome. There is no 'silver-bullet' that can make a place sustainable or healthy, and every building should be considered in context, not as stand-alone entities. The simulation results that considered site-specific climate and surrounding buildings helped to suggest an optimal solution.

In the context of Finland's climate, the low sun path means that the urban geometry affects solar access much more than other urban centers. Overshadowing is an obvious problem. To increase the usability of outdoor spaces including a courtyard and increase 'linger-ability', gaps toward the south can bring a huge increase in sunlight hours – see Figure 4.4.3.

Lastly, the thesis showed that the neighborhood scale plan which influences building form and plan depth can enhance solar access. The decisions of neighborhood-scale plans influence not only the outdoor but also the indoor space. Those decisions should be made in a way to decrease dependence on energy equipment by utilizing free solar gain and reducing wind pressures. This highlights **the inter-relationship between the different scales of the planning**.

The complexity of sustainability and the complexity of health and well-being can be pursued with **clear criteria**. Overall, the five criteria and following checklist guided the design phase. To transfer this knowledge of sustainable architecture into practice, this checklist can be developed with the detailed guideline. For example, the PIMWAG criteria of Eco-Viikki project and green points criteria of Bo 01 project are good examples which transfer ecological concept into practice.

Urban planning is key to determine the built environment, natural surroundings, and social relationships which shape people's lifestyle. Urban planning can increase daily exercise, social interaction, daily contact with nature, and decrease the use of private cars. Planners and designers therefore should be responsible to make healthy places and healthy people.

key findings

Five criteria need to compromise each other, and those compromises need multiple processes of reflection to get the optimal result.

Five criteria and the following checklist are a useful tool to guide design.

Finnish climate which has a low sun angle requires wider distances between buildings for lively streets and courtyards.

Computer simulation tool should be used iteratively in the design process.

further development

More sun shading and sunlight hour study focused on Finland climate, and its influence on energy use

Develop the five criteria with detailed guidelines

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introduction & background

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