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Modeling Physical Accessibility Index for assessing physical accessibility in the City of Helsinki
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Case studies from Lauttasaari, Itäkeskus and Keski-Pasila

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Tiivistelmä

Kaupunkisuunnittelussa on perinteisesti keskitytty autovirtojen hallintaan, mikä on tehnyt kaupunkialueista pirstaleisia ja jalankulkijoista "kakkosluokan kansalaisia". Tämä on johtanut kansalaisliikkeiden syntyyn sekä laajoihin protesteihin, joissa varsinkin liikkumis- ja toimimisesteiset henkilöt ovat vaatineet parannuksia rakennetun ympäristön laatuun. Viime vuosikymmenten aikana onkin monissa kaupungeissa ympäri maailmaa aloitettu kehittämään infrastruktuurin laatua. Yksi tällaisista esimerkeistä, jossa kaupunkiympäristön laatua on parannettu ottamaan liikkumis- ja toimimisesteisten henkilöiden tarpeet huomioon, on Helsingin kaupungin Helsinki kaikille –projekti.

Tämän tutkimuksen tarkoituksena on luoda paikkatietopohjainen malli kaupunkiympäristön esteettömyyden tason arvioimiseksi. Samalla arvioidaan myös olemassa olevan paikkatietoaineiston käyttökelpoisuus tämänkaltaisen tutkimuksen tekemiseen. Tarkoituksena on myös kriittisesti keskustella sosiaalisen oikeudenmukaisuuden toteutumisesta kaupunkiympäristössä erityisesti liikkumis- ja toimimisesteisten henkilöiden näkökulmasta. Luotu paikkatietopohjainen malli suoritetaan tästä johtuen kolmen eri jalankulkijaryhmän näkökulmasta katsottuna, jotta nähtäisiin, miten nykyinen esteettömyyden taso vaihtelee eri käyttäjäryhmien välillä. Tarkoituksena on myös tutkia sitä, mikä merkitys esteettömyysohjeistuksilla on ollut esteettömyysaspektin tekemisessä luonnolliseksi osaksi suunnitteluprosessia.

Helsingin kaupungin rakennetun ympäristön esteettömyyden tasoa tutkitaan tässä tutkimuksessa luomalla esteettömyysindeksi, joka perustuu niin kutsuttuihin kaupunkirakenteen 3D- ja 6D malleihin. Näitä malleja, sekä Helsinki kaikille –projektin määrittelemiä esteettömän rakentamisen kriteerejä, käytetään tutkimuksen teoreettisena viitekehyksenä esteettömyysindeksin luomisessa. Näitä 3D- ja 6D malleja on muokattu huomioimaan esteettömyysaspekti. Lopullinen esteettömyysindeksi muodostuu kahdeksasta ulottuvuudesta, jotka ovat: maankäytön tiiviys, maankäytön monipuolisuus, jalankulkualueen laatu, kohteen saavutettavuus, joukkoliikenteen saavutettavuus, kohdealueen vastaanottavuus, maanpinnan kaltevuus, sekä jalankulkijoiden havainnot. Näitä ulottuvuuksia analysoitaessa on käytetty useita erilaisia menetelmiä.

Analyysi on suoritettu kolmen alueen osalta Helsingin kaupungissa: Lauttasaaresta, Itäkeskuksesta sekä Keski-Pasilasta. Tutkimusalueet on valittu sen mukaan, missä alueiden kehityksen vaiheessa esteettömyysaspekti on otettu huomioon. Lauttasaari ja Itäkeskus ovat rakentuneet aikana, jolloin ei vielä ole ollut kattavaa määrää esteettömyysohjeistuksia. Sen sijaan Keski-Pasilassa esteettömyysaspekti on otettu huomioon jo asemakaavaa tehtäessä. Näistä tutkimusalueista Lauttasaaresta ja Itäkeskuksesta on saatavilla rakennettua ympäristöä kuvaavaa paikkatietoaineistoa, jota on hyödynnetty tutkimuksessa. Aineistot on hankittu avoimen datan rajapinnoista sekä suoraan Helsingin kaupungilta. Keski-Pasilan kohdalla aineisto on hankittu suunnitteludokumenteista digitoimalla, sillä alue on tällä hetkellä vasta rakenteilla.

Tulokset osoittavat, että Lauttasaaren ja Itäkeskuksen kohdalla tutkimusalueiden keskusta-alueet ovat kehittyneet esteettömyyden kannalta hyvälle tasolle. Tulokset osoittavat myös, että esteettömyyden taso tulee olemaan erittäin hyvä koko Keski-Pasilan tutkimusalueen alueelta, jos alue rakennetaan suunnitelmien mukaisesti. Eri jalankulkijaryhmien välillä on kuitenkin suuria eroja Lauttasaaressa ja Itäkeskuksessa. Keski-Pasilassa ei ollut suuria eroja esteettömyyden tasossa eri jalankulkijaryhmien välillä.

Tutkimuksen suorittamisen yhteydessä kävi ilmi, ettei käytetty aineisto ole tarpeeksi tarkkaa tällaisen analyysin tekemiseksi. Helsingin kaupungin ylläpitämään paikkatietoaineistoon suositellaankin siis tehtävän lukuisia päivityksiä ja korjauksia. Tutkimusta varten ei myöskään ollut löydettävissä viitetietoja esteettömyyden kriteerit täyttävistä raja-arvoista kullekin tässä tutkimuksessa analysoidulle ulottuvuudelle. Siksi ehdotetaan, että asiantuntijaraati määrittelisi kullekin ulottuvuudelle soveltuvat esteettömyyden kriteerit täyttävät raja-arvot. Käytetty menetelmä itsessään vaikuttaa kuitenkin tulosten perusteella olevan soveltuva rakennetun ympäristön esteettömyyden arvioimisessa.

Avainsanat
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Muita tietoja

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Abstract

Traditional city planning has concentrated on auto-mobile flows since the 1930's making urban areas sprawled and pedestrians as "second citizens". This has led to widespread popular protests especially from the crowds of persons with impairments residing in cities. However, in recent decades, many cities around the world have shifted their infrastructure development to create better conditions for pedestrians and city life. One of the examples, where the urban environment is enhanced to enable the persons with impairments to fully be integrated in city life, is the Helsinki for all –project in the City of Helsinki.

The aim in this research is to create a model for assessing the level of physical accessibility in urban environments. At the same time, the usability of the existing spatial data is evaluated. The aim is also to critically discuss social equality in urban context, and especially from the point of view of the rights of persons with mobility or functionality impairments. Therefore, the model is performed for three different pedestrian user groups to find out, if the level of physical accessibility differs between these groups. The aim is also to research the impact which various physical accessibility criteria have had in making the aspect of physical accessibility a more natural part of the planning process.

The created Physical Accessibility Index, by which the current level of physical accessibility is assessed, is derived from the so-called 3D- and 6D models of Urban Structure. These models, and the physical accessibility criteria created by the Helsinki for all – project, are used as a theoretical framework in formulating the model for assessing the level of physical accessibility in the City of Helsinki. The 3D- and 6D models have been modified to take the aspect of physical accessibility into consideration, and the 8D model of physically accessible urban structure has been developed. This model includes the dimensions *Density*, *Diversity*, *Design*, *Destination accessibility*, *Distance to transit*, *Demand*, *Declination* and *Discovery*. Various methods have been used when analyzing the 8 dimensions in this 8D model.

The analysis is performed for three areas in the City of Helsinki: Lauttasaari, Itäkeskus and Keski-Pasila. The research areas have been chosen to represent areas in which the aspect of physical accessibility has been considered in different phases in the development of these areas. Lauttasaari and Itäkeskus have been built during a time when there was not yet a comprehensive amount of physical accessibility criteria. In Keski-Pasila, on the contrary, the aspect of physical accessibility has been considered already in the local detailed land use plan. Out of these research areas, Lauttasaari and Itäkeskus provide existing spatial data, which has been acquired from open data sources and directly from the City of Helsinki. In the case of Keski-Pasila, which is currently under construction, the required data has been digitized from planning documents.

The results show that the centers of the research areas in Lauttasaari and Itäkeskus have been developed and are built well from a physical accessibility point of view. The results show also that Keski-Pasila will in the future have a very good level of physical accessibility in all the new planned areas, if the areas are constructed according to the plans. There are big differences between the different pedestrian user groups in Lauttasaari and in Itäkeskus, but no visible differences between the groups were found in Keski-Pasila.

It became clear when performing the analysis that the acquired data was not precise enough for making this kind of analysis. Big updates to the spatial data that the City of Helsinki administrates are therefore needed. Also, criteria for physical accessibility could not be found from literature or previous studies for every dimension, which influenced both the chosen methods and in results. Therefore, an expert group should define thresholds to special and basic level accessibility for each of the dimensions. However, the method itself seems to be suitable in analyzing the level of physical accessibility.

Keywords
Physical accessibility, the 3D –model of Urban Structure, Walkability index, Helsinki for all, spatial data, Helsinki.

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Part I. Disabling City

Impairment is a human condition

disability is a human creation.

- *Brendan Gleeson, 1999*

1 Introduction: disablism and cities

Over half of the world's population lives in urban areas today (Gehl 2010, p. 215). Inflow migration from the countryside to the cities has slowed down in developed countries, but the urban population is still increasing all over the world. It has been expected that 75 % of the world's population will live in cities by 2050 (Gehl 2010, p. 215) and hence the urban areas need to be expanded and developed constantly. Traditional city planning has concentrated on auto-mobile flows since 1930's (Southworth 2005), making pedestrians as "second citizens" in urban environments. Auto-centered design has resulted in an urban sprawl, making urban areas almost unfriendly towards pedestrians. In recent decades, many cities around the world have shifted their infrastructure development to create better conditions for pedestrians and city life by making car traffic a lower priority by either closing car traffic altogether or by making streets car free during weekends (Gehl 2006, p. 50–51, 2010, p. 4, 113, 224). In cities such as Copenhagen, Melbourne, New York, Sydney, Mexico City and cities in Holland, automobile-dominated city centers have been transformed into pedestrian street systems through prioritized improvements; by upgrading pedestrian networks with broader sidewalks, laying better surfaces, planting trees for shade, removing unnecessary sidewalk interruptions and by improving street crossings (Gehl 2006, p. 50–51, 111, 2010, p. 113). The shift towards more pedestrian-friendly city planning will probably solve many of the contemporary problems in urban areas, but it will also bring forward new issues and discussions (Gant 1997).

Urban architecture has for a long time had a modernistic orientation where the visual aspects of the architecture are dominating. Modern architecture is considered sterile and the kind that serves little stimulus for the senses (Jokiniemi 2007, p. 32). This causes problems for mobility and functionality in urban environments for persons with impaired vision in particular. According to Jukka Jokiniemi (2007), modern urban architecture is focused in emphasizing the sense of sight; the urban environment is homogenized, there is little variation in materials and the sense of touch has been diminished (Jokiniemi 2007, p. 32). Jan Gehl stresses also that something is missing in the contemporary urban environments, which is supported by widespread popular protests and debates against physical planning as it is practiced today (Gehl 2006, p. 49). There are demands for improvements to the physical environment that ensure better conditions for pedestrians and bicycle traffic, for children, the elderly and the impaired persons.

According to the UN report on Good Practices of Accessible Urban Development (2016), 15 % of the world's population is somehow disabled by their physical or psychological impairments. Moreover, the amount of impaired persons increases as the population ages. Mostly mentioned age-related illnesses leading to disability are arthritis, heart conditions, limb/mobility problems and diabetes (Gant 1997, p. 724). Lack of access to the built environment, from roads and housing to public buildings and spaces, causes disadvantages and marginalization of the impaired population, further potentially leading to poverty, deprivation and exclusion on an individual level. Furthermore, it is estimated that inaccessible infrastructure causes a cut in tourism revenue by a rate of 15–20 % of the global market share (UN 2016, p. 9). For low- and middle-income economies, inaccessible environments could cause the exclusion of vital labor force leading to losses of up to 7 % of the national GDP (UN 2016, p. 9). The quality of public space plays a crucial role in building favorable conditions for outdoor activities (Gehl 2006, p. 129). The activities such as walking, standing, sitting as well as socializing in general, which make it attractive and meaningful to be in public spaces, are also the activities which are the most sensitive to the quality of the physical environment (Gehl 2006). Building accessible urban infrastructure and environments which consider all types of urban population bring in more efficient allocation of resources, organization of production, exchange-, consumption- and distribution of benefits thus more widely benefitting the society.

Physical impairments are functional problems that hinder the normal activity of a person. Disability is caused when a person is interacting with the built environment surrounding her, and the rate of disability is influenced by the surrounding urban structure and the possibilities for movement inside the city (Gleeson 1999; Vehmas 2005). Therefore, the urban structure and transport system have a huge impact on the accessibility to services and on how different people are included and can participate in social life. It is socially sustainable to build cities in a way that all the citizens can move freely and have access to services despite of their possible impairments (Gleeson 1999; Vehmas 2005). Although the planning and implementation of "the smart city" – and other concepts that promote more sustainable, smart and accessible urban environments – are proceeding in many countries across the globe, most contemporary cities remain inaccessible, inhospitable and unjust places for many people with impairments (Goggin 2016). To advance and encourage the building of more accessible cities, the European Commission has since 2010 awarded European cities which make efforts in becoming more accessible for persons with both physical and intellectual impairments (European Commission 2017a; Hild 2017). The physical accessibility work in the City of Helsinki was awarded with the second place in 2015 (European Commission 2017b).

The issue of disability in an urban context has made notable progress in becoming a mainstream social, political, economic and cultural concern during the recent decades on the international stage (Goggin 2016). In 2006 The United Nations adopted the Convention on the Rights of Persons with Disabilities (CRPD), a human rights instrument that reaffirms that all persons with all types of impairments must enjoy all human rights and fundamental freedoms (UN 2017). In this Convention, persons with impairments are no longer seen as objects of charity, medical treatment and social protection, but as subjects with rights to enjoy all aspects of the society. In October 2016, the same year the CRPD celebrated its tenth anniversary, the international community gathered together for the Third Global Conference on Housing and Sustainable Urban Development (Habitat III) and discussed the design of the New Urban Agenda, with great hopes to transform the current forms of urbanization by incorporating accessibility and disability inclusion in urban development policy and practices (Goggin 2016; UN 2016). The New Agenda, together with the 2030 Agenda for Sustainable Development, emphasizes physical accessibility as a common good and a key component in urban policy, design, planning and development. Accessibility in urban environments is promoted not only as a common good, but also as a basic human rights issue and as a means to economic, social, cultural and political empowerment, participation and inclusion (UN 2016).

Physical accessibility has been enhanced in urban environments predominantly by creating new legislation, guidelines and standards to guide urban planning, construction and maintenance. The current level of physical accessibility is evaluated usually by conducting field research with a list of accessibility criteria for the built environment. Physical accessibility is therefore usually measured by qualitative methods. Literature of quantitative methods for assessing physical accessibility of the built environment has not been found at the time of conducting this research. However, walkability – which is somewhat related to accessibility and physical accessibility – can be quantitatively measured by using many different methods, commonly named as walkability indices. Usually when measuring walkability, the process is divided to different parameters or components that together work as a walkability index. The mostly used parameters are related to density, diversity, proximity, connectivity and environmental friendliness (E.g. Southworth 2005; Leslie et al. 2007; Gallimore et al. 2011; Agampatian 2014; Kuoppa 2016). The parameters of walkability indices does to some extent respond to the question of physical accessibility, but in my opinion the different walkability indices do not completely portray physical accessibility of the built environment. Therefore, I will in this thesis model a potentially more suitable method or index for assessing physical accessibility, and this is done by modifying known walkability indices.

2 My motivation and research questions

I became interested in the subject of physical accessibility while working at the City of Helsinki Public Works Department as a GIS intern in a project in which the objective was to redesign the registry on accessible routes and areas during the summer of 2016. The registry is based on the Helsinki for all –project, during which Regional Accessibility Plans were created for 15 regions of the city. These Regional Accessibility Plans were digitized into the Accessibility Registry which was also completed with additional accessibility information for the whole area of the City of Helsinki. My job was to define new accessible routes and areas so that people with reduced mobility or functionality could in the future have better access to the most crucial services such as healthcare and educational services, public transport terminals and commercial areas, to name a few. The registry shows the most important routes and areas in the City of Helsinki that should be planned, built and maintained as having basic or special level accessibility; the level being based on the current supply of services and public transport routes in the area in question.

During the internship I became very familiar with the different barriers that the built environment creates for the impaired persons, hindering their free movement and activity. After the internship I started to read about the disabling city structure and got carried away with the topic. Especially the book *Geographies of disability* by Brendan Gleeson (1999), the articles by Rob Imrie (Imrie & Kumar 1998; Imrie 2000a, 2000b) and the books *Life between buildings* (2006) and *Cities for People* (2010) by Jan Gehl were eye opening. Gleeson concentrates on the underlying political and economic structures that have made cities disabling, inaccessible and discriminating from the perspective of the impaired persons, whereas Rob Imrie approaches the subject more from a political perspective; discussing accessibility legislation and planning traditions and practices in the UK. Gehl, on the other hand, is discussing further on the actual city planning and how it should take the "human scale" into consideration. According to him, urban planning should be a bottom-up kind of development so that the needs of individuals could better be met. Thanks to these writings I became increasingly more interested in how urban planning could advance the realization of social and environmental justice for the impaired in the cities.

2.1 Previous studies of physical accessibility and disability in urban settings

Discussions about accessibility and disability were quite vivid already on the fields of social politics and sociology during the 1970's. Discussions on the concept of disability were in the center of conversation especially. The different schools in disability studies – the social model and the medical sociology – are debating mainly on how the impact of the environment should be understood in the definition of disability (e.g. Thomas 2004; Owens 2015). International literature dealing with accessible urban planning, disability, participatory planning and other aspects of physical accessibility in urban environments, are in the recent years much rife. Much of the research that has been done has been conducted mainly in the USA and in the UK, but lately also in Canada and the Nordic Countries (e.g. Imrie & Kumar 1998; Imrie 2000a; Anderson 2001; Bendixen & Benktzon 2015; Gamache et al. 2017). The topics have become more popular even in the field of geography since the 1990's. Geographers have adopted quite a deterministic view on the causes of disablism and many of the writers point out the influence of city structure and planning on the materialization of physical accessibility in urban environments (e.g. Imrie & Wells 1993; Gleeson 1999; Goggin 2016). For example, Brendan Gleeson writes (1999) that disability is a critical feature of the capitalist city, which with its inaccessible design, both in macro-level land use pattern and in the internal design of buildings, discriminates against impaired people by not taking their mobility requirements into account (Goggin 2016).

The topics of accessibility, physical accessibility and disability have become more popular in research in Finnish context during the 2000's and some research has been done on the topics in Helsinki. Accessibility studies have concentrated predominantly on transportation, travel time, network and shortest routes as well as environmental impediments when modeling cycling and walking (e.g. Söderström, Schulman & Ristimäki 2015; Tarnainen 2017). It is worth mentioning, that during the 2010's, disability and physical accessibility were discussed on a general level in a few master's thesis and doctoral dissertations. For example, the Master's thesis by Heini-Sofia Luotola (2011) discusses how physical accessibility has been taken into consideration in many different political and governmental levels, in both national and international legislation, and in planning. The master's thesis by Katariina Ahokas (2015) discusses physical accessibility as a part of a spatial planning concept through a case study conducted in Tampere. In her study, physical accessibility is discussed from a political perspective and using Foucault's "power" as a theoretical concept. Mari Laakso has studied the possibility of improving accessibility for pedestrians with impairments through geographic information in her doctoral dissertation (2015).

Although the number of research carried out on disability and physical accessibility in the context of Helsinki is not that vast, the topics of these researches are varied, and disability and physical accessibility have been studied from an acceptable number of viewpoints. For example, Käyhkö (2015) discusses the mobility of the elderly population in city areas, and Jukka Jokiniemi (2007) has studied the elements of illumination, pavement materials and coloring as well as sound guidance in street crossings and their effects on accessibility. Jokiniemi has also studied the feeling of safeness for persons with impaired vision in his doctoral dissertation. His empirical studies resulted in modifications in crossing sound guidance systems and in lighting environments for pedestrians in urban settings. A topic which relates to physical accessibility – walkability – is becoming a more popular research topic in Finland. Walkability is discussed in Jenni Kuoppa's doctoral dissertation (2016) "The promises of walking in the city", and additionally, walkability is the topic of a few Master's thesis written in the University of Helsinki at the time of writing.

The rights of disabled persons have become a widely discussed topic during the 2000's in the political arena. The topic is discussed on various levels from the UN to local arenas. The UN started to address the issue of physical accessibility in cities in beginning of 2000 and the goal to improve the living conditions for disabled persons has been implemented in to the 2030 Agenda on Sustainable Development and in the recent Habitat New Agenda (UN 2016). UN has released several white papers that deal with disablism and development and has also published a classification of functioning, disability and health (the ICF –classification) (UN WHO 2013; UN 2014, 2016). Disability and urban development is also discussed in the European Union. Finland ratified the UN Convention on the Rights of Persons with Disabilities (CRPD) in 2016 after which the government started a fundamental renewal of disability legislation which is still ongoing.

Physical accessibility has been a hot topic in planning studies for some time already. There are ongoing projects in many big cities with the aim to improve livability in city centers by prohibiting the use of passenger cars and increasing walking and cycling. This kind of experiments can be found in Copenhagen, Malmö, and in Amsterdam (Gehl 2006, 2010). Even in Helsinki there have been discussions of closing some roads from car traffic and opening more space for walking and cycling. For example, there have been discussions of transforming the Northern Esplanade into a walking street and of closing the city center from personal car traffic (Malmberg 2016).

2.2 The aim of research and research questions

As no comprehensive model or tool has been developed to evaluate physical accessibility by quantitative methods, my aim is to create a model for assessing the level of physical accessibility in urban environments based on accessibility or walkability related tools and models described in the literature. I want in this research also critically address social equality in urban context, and especially the rights of persons with mobility or functionality impairments, to discuss how they are taken into consideration when planning urban environments and in the planning processes. Ahokas (2015) wrote in her master's thesis that physical accessibility is not taken into consideration sufficiently in cities and physical accessibility is usually a theme that is disconnected from other themes in urban planning processes. This is indicated by the need of adding separate sections in legislation that demand for the recognition of physical accessibility, and by the creation of accessibility guidelines that steer urban planning (Ahokas 2015). I believe that by creating a quantitative method to evaluate the current level of physical accessibility of the built environment, it is also possible to have an impact in what way and when physical accessibility is discussed in the planning processes, especially as planners start to use place based data and GIS methods more extensively in planning.

In 2001 the City of Helsinki City Board approved an accessibility strategy program for Helsinki with the aim to make Helsinki fully accessible by the year 2011. The implementation measures were stated in the City of Helsinki Accessibility Plan and carried out by the Helsinki for all –project. The Helsinki for all –project organized a so-called SuRaKu-project, in which the City of Helsinki participated together with 5 other Finnish cities, with the aim to create comprehensive accessibility guidelines to enhance accessibility in urban environments. The objectives of the Helsinki for all –project and the City of Helsinki Accessibility Plan were fulfilled by creating Regional Accessibility Plans to promote more accessible environments during 2005–2009 after which they became part of Strategic Regional Plans. Now the city is transforming its planning procedures towards more digital strategic planning, whereby regional plans are created using geographic information more extensively (Tirri 2017).

The aim in my research is to investigate what the state of physical accessibility is in the City of Helsinki by creating a Physical Accessibility Index and to discuss how physical accessibility is taken into consideration in urban planning. Emphasis is also given to the critical discussion of disablism in cities in general and to the structural grounds on which the inaccessible city has been built upon. Interests is given especially to a) how geographic information can be used in examining the level of physical accessibility of the built environment in its current state, b) is the available spatial data precise enough to be used in this kind of analysis, c) what kind of applications can be created from the Physical Accessibility Index, and d) how the Regional Accessibility Plans and other physical accessibility regulations and guidelines have promoted the creation of a more accessible environment in the City of Helsinki. These objectives will be fulfilled by executing a GIS analysis, by studying planning documents and literature and by interviewing persons who are in charge of planning and construction in the research areas. The research areas have been chosen to represent areas in which the aspect of physical accessibility has been considered and implemented in different phases in the development of these areas. The chosen areas reflect on a kind of evolution in the pursue to implement physical accessibility aspect in planning as a natural part of the development process. Therefore, these are optimal areas to study with what kind of affect physical accessibility guidelines and regional accessibility plans have had in the planning and construction of the research areas and whether these guidelines have had the influence in making physical accessibility a more natural part of the planning process.

The first part of the thesis is based on wider discussions about accessible city structures, urban planning processes, disablism in cities, and methods for assessing accessibility. Therefore, the methods of the first part are based on research of academic literature and other publications which have been published of the topics. In the second part of the thesis I will concentrate in evaluating the level of physical accessibility in the research areas. The analysis will be made by quantitative methods using geographic information systems (GIS) and planning documents. My main interest in this part is to model a Physical Accessibility Index which usefulness is also evaluated. Therefore I have formulated my main research question as;

1) How can the actualized, current level of physical accessibility of the built environment be measured and evaluated by using existing spatial data?

To evaluate the usefulness of the created Physical Accessibility Index I will modify the created Index according to physical accessibility criteria for different pedestrian user groups, and the reliability of the Index is also assessed. Hence, two complementary research questions are added;

2) Is the created Physical Accessibility Index valid in assessing physical accessibility of the built environment?
3) How does physical accessibility of the built environment differ when assessing accessibility from the point of view of different user groups?

After the analysis, I am asking experts for their opinions on the gained results to see whether these match with the actual level of physical accessibility of the research areas and to have a wider discussion on the influences that the Regional Accessibility Plans, accessibility guidelines and standards have adhered to in making the topic of physical accessibility a more natural part of the planning process. We can also assess what kind of an influence this has on the level of physical accessibility of the built environment. Therefore, a fourth research question, which is also my second main research question, is added:

4) What significance does it have on the actualized quality of physical accessibility of the built environment, based on the results from the research areas, in which stages of the planning process the accessibility aspect is taken into account?

Based on the results from the GIS-analysis it is possible to evaluate, how physical accessibility can be taken into consideration via GIS-analysis in regional planning, which is based completely on spatial data. By analyzing the results from the GIS-analysis it is also possible to evaluate the state in which the spatial data of the City of Helsinki is currently and what possibilities there are to use them in spatial analysis. These topics are discussed in the third part of this thesis where I will also respond to the research questions and further reflect upon whether the City of Helsinki could be considered an Access City.

2.3 Ethical considerations

I am not an impaired nor a disabled person and I have not to my knowledge ever experienced disability. The only time I could slightly consider myself being impaired was when I had a knee infection during my teenage years. During that time, I did experience pain when walking, but I did not consider myself as being disabled in a sense in which disablism is often understood. I did not feel marginalized or disadvantaged, which might be the case for many impaired persons. Taking this into consideration I was doubtful as to whether I would be qualified to discuss an experience which I have never experienced myself. However, my target group does not solely consist of impaired persons and I am discussing a topic that could concern any of us.

Fisher (2003) writes that to accurately explain a social phenomenon, the investigator must first attempt to understand the meaning of the social phenomenon from the actor's perspective. The focus should be on the actor's meaning and not on the intuitive or emphatic mental processes of the observer. If the method permits the observer to select and interpret social facts based on his or her own value system, no socially valid or relevant theory can be produced (Fisher 2003). As I have not experienced disability myself, I risk to make interpretations based on intuitive, and in this case, also on emphatic grounds. I understand this connection between the researcher, the observer and the social phenomena, and as such I aim to minimize the risk of misinterpretation by focusing on quantitative research and literature analysis. I rely in my analysis on information about the requirements that the persons with mobility or functionality impairments have towards the built environment, which have been obtained via qualitative research.

When talking about people, it is highly important to use politically correct language. No-one would like to be called names, and further, it is socially unacceptable. Therefore, I have paid attention to my diction and have chosen to use the accessibility vocabulary created by the Helsinki for all –project (Helsinki for all 2016). I am talking about persons with mobility or functionality impairments as this is an expression that these persons often use for themselves. When I talk about disability or disablism, I am referring to the phenomenon that the inaccessible urban environment creates for persons with mobility or functionality impairments.

3 Main terminology and theoretical framework

3.1 Impairment and disability

Anyone could be impaired at some point of their life, be it just for a day, a week, a year or the rest of their lives. The degree of impairment can be mild, potentially a twisted ankle, or more severe, making the whole body defunct. The medical definition of impairment is a "*deterioration in the functioning of a body part, organ, or system that can be temporary or permanent and can result from injury or disease*" (Cambridge dictionary 2017). It can be understood as a physical condition affecting the normal functions of the body. A person can be physically impaired having a disorder of movement, or have a psycho-cognitional impairment having a disorder of thought and understanding (Farlex Partner Medical Dictionary 2017). According to the RT Building Information File 09-11022, Basic information about the movement and functionality impaired, a person with mobility or functionality impairment is a person, whose ability to move, function, orientate or communicate is either permanently or temporarily constrained due to an injury or impairment, aging, or disease (Perustietoja liikkumis ja… 2011). Impairments can significantly affect a person's everyday life.

The term disability can be understood in two different senses, the first being one's bio-medical status and the latter a social status or a cultural category (Freund 2001). Impairment is a biomedical status and a feature of the individual (Vehmas 2005, p. 110–111; Perustietoja liikkumis ja… 2011) as, for example, weakened eyesight or hearing. There have been discussions and disputes on how the relationship between impairment, disability and the environment should be understood. The subject has been widely discussed in the fields of sociology and social sciences beginning in the 1960's with the rise of civil right movements in the USA and more extensively with the rise of the disabled people's movement during the mid-1970's (Gleeson 1999, p. 16; Vehmas 2005, p. 109; Oliver & Barnes 2010). Next I will introduce the different schools in disability studies and philosophize about how impairments and disability are connected with the environment.

3.1.1 The emergence of disability studies

The first wave of understanding disability was developed by Vic Finkelstein and Paul Hunt in the UK during the 1970's and was called the social relational model of disability (Thomas 2004). The model was formulated around the discussions within the Disability Alliance and the Union of the Physically Impaired against Segregation (UPIAS) – the organization of disabled persons, which was founded by Finkelstein and Hunt themselves (Thomas 2004; Vehmas 2005, p. 110, 118; Owens 2015). Through their model they wanted to reflect theoretically upon the nature of the social treatment of impaired people. The view was that society disables people with impairments and thus creates disability. The aim with the social relational model was to direct the disabled people's political struggle towards changing society (Thomas 2004).

Finkelstein's criticism was especially towards the welfare state which institutionalized persons with impairments by offering residential care and minimal benefits and by excluding them from employment and the educational mainstream via social benefits (Thomas 2004). A similar statement has been given by Rob Imrie, who criticizes institutionalization for the production of segregated spaces for the persons with impairments. The spatialization of institutions can be seen in the arrangement of special needs schools and special day care centers, and dial-a-ride bus services (Imrie 2000a, p. 7; Vehmas 2005, p. 124–126). Criticism was also pointed out on barriers to access in the built environment.

> Disability is something imposed on top of our impairments by the way we are unnecessarily isolated and excluded from full participation in society. Disabled people are therefore an oppressed group in society. (UPIAS, 1976, cited in Thomas, 2004, p. 572)

Later this social relational model started to give more emphasis on environmental factors leading to the evolution of the social model of disability by sociologist Mike Oliver (Thomas 2004). This model became quickly popular in disability studies and overshadowed the original social relational model. However, the mainstream sociology kept the dominant hegemony in regards to understanding disability as a medical or psychological term. The different schools of disability studies, for example the social model, medical sociology and later the socio-medical model, and the disputes between the different schools, produced a considerable amount of disability studies literature especially in sociology, but also in geography since the early 1990s.

3.1.2 Social and medical models of disability

The social model of disability is based upon the idea that people are not disabled by the functional limitations of their impairments, but by the external barriers that limit their full participation in the society (Vehmas 2005, p. 120; Oliver & Barnes 2010). External barriers, in this case, may be cultural, social or environmental, showing as exclusion by the social environment or limitations of movement by the physical environment. Disability is therefore understood as, and linked with, social exclusion with socially imposed restrictions on activity (Vehmas 2005, p. 120–121; Freund 2001).

The basic understanding of disability in the social model separates impairment and illness as different entities and make them purely social in nature. For example, a person might have an illness long before she receives a diagnosis which then is thought of as an impairment or, a person might be impaired long before receiving a diagnosis of illness (Owens 2015). Impairments may also become disabilities through the experiences felt by the impaired person through cultural stereotypes, attitudes, bureaucratic hierarchies, market mechanisms (Vehmas 2005, p. 122–123; Owens 2015) or by other structures and organizations on which the society is built upon. The individuals personal experience and the affect which the built environment has upon the experience of disability becomes distinct from the so called “disability paradox”. The paradox notices that although a person might have an impairment, she or he might not necessarily experience disability (Owens 2015). The experience of disability is being formed only when the individual experiences hinders moving or functioning in the environment.

An even more recent approach to the social model of disability is the model which could be called the socio-material model or the political economy of disability. The formulation of this model was created by sociologist Mike Oliver and geographer Brendan Gleeson and it yet remains open to finalization (Thomas 2004). This model takes into account the material aspects of social relations which are characteristic to market economies in industrial and developing-world societies (Thomas 2004). Especially Gleeson considers the materialistic approach in understanding disability as vital. He argues that societies have historically been built to exclude certain groups of people, capitalistic structure being the most excluding form of society. According to Gleeson, the capitalist city creates disability through discursive, institutional and material dimensions, with inaccessible design being the most disabling feature (Gleeson 1999, p. 137). Gleeson also states that there is no necessary correspondence between impairment and disability but only a historical-geographical correspondence which exist when certain societies in the course of political-economic reproduction transform impairment into disability (Gleeson 1999).

The sociological school of medical sociology states that disability is simply a purely medical problem (Oliver & Barnes 2010). A more exact definition of disability is offered by the medical sociology's sub-genre 'sociology of chronic illness and disability' which defines disability being caused by illness and impairment and it entails suffering and some social disadvantage (Thomas 2004). Disability is seen as a "restriction or lack of ability to perform an activity in a normal manner" (Thomas 2004). As illness or impairment is the central cause of disability, the grade of disability changes as the illness or impairment proceeds or changes. Medical sociology argues that impairment has a direct causative effect on the restrictions of activity that constructs disability.

Medical sociology has intertwined in some extent with the social model of disability in that many scholars have adopted some elements from the social model and added them into the socio-medical model of disability. In the socio-medical model, everyone is seen as impaired in varying degrees, because disability should not be reduced neither to a purely medical condition, nor should it be reduced to an outcome of social barriers alone (Shakespeare & Watson 2001, p. 24). In other words, people are disabled both by social barriers and by their bodies and therefore disability should be understood as restrictions of functionality (Thomas 2004). This leaves it open to both impaired and non-impaired to feel themselves being disabled in a specific physical or social context. In later years and with the increasing criticism towards the disembodiment and the denial of the impact of impairments on disability within the social model of disability, the socio-medical model has gained more interest in the field of disability studies.

Another branch of social models of disability is the Nordic social relational model of disability, which takes impairments into account in the definition of disability. In the Nordic model, the individual is seen as interacting with their environment, and while the environment is seen as a major cause in the formulation of disability, the functional aspects of impairments are still recognized as important (Owens 2015). Disability is placed on a continuum which shifts between the individual and their environment depending on the capacities and abilities of the individual (Freund 2001; Shakespeare & Watson 2001, p. 24; Owens 2015). Impairments are not defining characteristics of the individual. Although impairment and disability interact with each other, the model still views disabled people as flawed and unable to perform in society in the same way as non-disabled persons (Owens 2015). This definition of disability has been adopted by the European Union (EU) and by the World Health Organization (WHO) which used it to expand and construct the International Classification of Functioning Disability and Health (ICF) (Owens 2015). The EU social model of disability acknowledges the environmental barriers in society which prevent the full participation of people with disabilities and that these barriers must be removed.

3.1.3 My understanding of disability

In this research I am interested in physical impairments that are either temporary or long lasting and are inborn or caused by an accident or illness. By framing the research to include only physical impairments I have made a conscious decision to exclude mental and psychical impairments. This is not because I think that mental impairments could not cause disability in urban environments; mental and psychical impairments are just as enabling and disabling as physical impairments; but because I have decided to study movement and mobility of the impaired persons in the urban context, as well as what kinds of barriers the physical environment creates for free movement. However, studies have shown that the urban structure creates barriers of free movement also for mentally impaired persons (e.g. Imrie 2000a, p. 9; Hansio 2011, p. 9–10). It has been noted that persons with mental or intellectual impairments as well as psychological and memory problems have the same kind of mobility, functionality and orientational problems as persons with mobility or functionality impairments (e.g. Perustietoja liikkumis ja… 2011, p. 9–10). Therefore, I am positive that by concentrating on barriers of movement from the perspective of persons with mobility or functionality impairments, I am also taking persons with mental impairments into consideration. However, persons with mental or intellectual impairments have slightly different requirements for the built environment concerning color coding and signage of buildings and services than the persons with mobility or functionality have. I will not be covering these color coding and signings for the mentally and intellectually impaired persons in this thesis.

It should be noted that physical accessibility is not a topic concerning only the impaired, but also everyone else. For example, a pregnant woman, a person with a tram or luggage, or a person moving with children can feel him- or herself disabled in certain contexts if the environment hinders functionality. Illnesses and physiological impairments can be corrected medically, after which, for example, a person who has an amputated leg could walk and run again. The easiness of movement and functionality is in this case influenced more by the structures of the environment than the physiological state of the person. However, the physical structures of the environment can make even a non-impaired person feel him- or herself disabled (Jokiniemi 2007, p. 14). In this it is highlighted what the effect of the built environment has upon the development of disability.

My perspective is that a person with a mobility or functionality impairment can experience this impairment as hindrance for mobility and functionality only if the attributes of the environment are such that it causes disability. By medical treatments and by modifying the environment it is possible to ease the movement and functionality of persons with impairments, whereby he or she might not consider him- or herself being disabled. Impairments, however, still exist, but they do not affect everyday life. It depends on the context whether a person experiences his or her impairments as disturbing. However, I do not quite agree with the social model of disability, because I think that impairments are still causing some disadvantage to people. For example, walking with leg prosthesis may feel uncomfortable regardless of the enabling environment. My perspective is therefore more in accordance with the Nordic model of disability, or a mix of the socio-medical and the Nordic model of disability, as I believe that the experiences, possibilities and skills of the individual have an effect on the development of disability depending on which the attributes of the surroundings are.

3.1.4 Disability as a public issue – the meaning of impairment and disability to the society

As we have seen so far there are different, and even contrasting, meanings of disability and no clear unitary definition of disability. By saying ‘disability studies’ we may grasp all of the different perspectives on the nature of disability. However, although there are several approaches to the issue, this has been one of the main causes that has changed the society towards a less discriminating and marginalizing – through open discussion of the civil rights of the impaired persons. The social model of disability has especially been a success story for persons with mobility or functionality impairments, challenging the hegemonic structures of the society, linking civil rights and political activism and enabling persons with impairments to claim their place in society (Owens 2015).

The effect of the social model of disability is distinct in how it converts disability to a public problem by stating that the issues which the persons with mobility or functionality impairments face are purely social in nature. If a problem is seen as a private issue, as in the medical sociology of disability, then public responsibilities are ignored and forgotten (Owens 2015). Making problems public ensures action. An example by Owens (2015) about making private problems public is the development of accessible spaces and work environments for persons with mobility or functionality impairments through the use of legislation.

Geographers, such as Peter Freund, Brendan Gleeson and Rob Imrie, to mention but a few, have grasped to this social model of disability and discussed it from the perspective of spatial and temporal macro- and micro-geographical contexts, which the sociologist have not taken into account (Freund 2001). Freund (2001), for example, criticizes the one-sided view on impairments that especially the medical sociologic model has. Differences and variations in bodies should be taken more into account when talking about disability as a social phenomenon. Being, for example, very tall, short, small or large, or moving around with a bicycle or a pram, can be disabling in a particular spatial-temporal context, so many, instead of just a few, share same problems with disabling design and spatial organizations (Freund 2001) and this is why disability should by nature be a public issue.

The organization of space should be the core issue in the discussions of disability (Gleeson 1999; Freund 2001). The organization of space constructs bodies and offers bodily possibilities and constraints, thus working as a social experience and possibly leading to disability (Gleeson 1999; Mahlamäki 2013). In this sense, impairments do not even matter in the construction of disability and everyone could in some phase in their life experience disability depending on the spatial structures around us, may they be physical or social barriers caused by inaccessible environments, market mechanisms, stereotypes, or different cultural environments. This makes disability purely a public issue.

3.2 Urban structure and walkability

Urban environment is a mix of physical urban structure and social phenomena. The physical environment affects in the level of social and economic activity in the space (Gehl 2006, 2010; Junttila 2012). Some activities are more dependent on the level of urban environment than other activities. Necessary activities, those everyday tasks and pastimes that are compulsory to execute in daily life, are less dependent of the exterior environment than the optional activities and social activities, such as taking a walk, sunbathing, meeting people or socializing (Gehl 2006, p. 9–11). Optional activities take place only if the exterior environment is pleasant and the time and place is right. Necessary activities take place throughout the year and under nearly every weather condition regardless of the condition of the urban environment, although the quality of the environment greatly affects how pleasant it may be to run these obligatory errands. When the quality of the physical urban environment is good, the city is lively and many optional and social activities take place (Gehl 2006).

Physical urban structure could be understood as the interplay between different features of the built environment. It consists of outdoor and indoor spaces that have been created and modified by humans (Jokiniemi 2007, p. 14). In this thesis I am interested in public urban spaces. The public built environment consists of physical features of the urban landscape that shapes and defines the public sphere (Cervero & Kockelman 1997), land use and its densities, infrastructure and also the different processes in the urban environment, such as traffic system (Jang et al. 2011). The different features could be measured on a small scale consisting of sidewalks or retail shops on a neighborhood scale, or on large scale by studying, for example, transportation on a town or city level. All of the features, regardless of the scale, incorporate some, or all, of the elements of the so-called 3D's of the city structure; density, diversity and design. The original 3D model of city structure is also closely related to how walkability is defined and the model is often mentioned in walkability related literature (e.g. Southworth 2005; Leslie et al. 2007; Gallimore et al. 2011; Kuoppa 2016).

The dimension of density describes the compactness or the intensity of land use and the built environment. It is measured by the ratio of the variable of interest and the unit area (Larrañaga & Cybis 2014) as for example the ratio between built and non-built area. For most scholars high-density neighborhoods are characterized by high concentration of activities in a given area. The most commonly used method is to calculate net residential density of a given area. Another way is to calculate retail floor area ratio, or commercial density, which indicates the density on points of interest. Population density could however better indicate more walkability as urbanization and high level of service centralization is expected to occur in areas with more population (e.g. Agampatian 2014, p. 10). Although population density alone does not reveal much of the distances to services or other destinations. Density should therefore be measured together with land use diversity. Density could be measured, for example, as the ratio between developed land to undeveloped land per area. Higher densities make distances between origin and destination shorter and give more opportunities to choose non-motorized modes of travel to perform daily activities.

Diversity is closely related to density in that diversity reflects the heterogeneity and distribution of land uses in a given area (Larrañaga & Cybis 2014). Higher diversity and land use mix relates also to the distance between the origin and the destination. Mixed land use offers a variety of services, such as housing, employment and commerce, and places of interest for residents in a given area and makes distances to destinations shorter and walking more attractive (Gehl 2006; Agampatian 2014, p. 11–12). There are several ways to study diversity, simple and more complex ones (e.g. Leslie et al. 2007, p. 116). Diversity can be measured by looking at land use mix, which is calculated as the ratio of non-residential zone-usage to residential zone usage or as the number of residential area in square meters in a given area divided by the total number of built area in square meters in the area (Agampatian 2014, p. 11–12). The simplest way, however, is to look at the number of different land use in a given area.

Design reflects the physical characteristics of the street network within a region and includes urban design elements that give added value to pedestrian environments. These added factors are safety, comfort, presence of sidewalks, trees and shade, aesthetics, continuity of sidewalks and illumination (Larrañaga & Cybis 2014). The dimension of design is often measured as path connectivity by looking at the ratio and the nature of intersections and the average block size in a given region (Larrañaga & Cybis 2014). Connectivity is defined as the measure that quantifies the degree to which pedestrian walkways, roads and other routes are connected to each other (Agampatian 2014, p. 12–13). High connectivity eases the transportation and travel between destinations as a well-connected network offers shorter and alternate routes to destinations. Good connectivity is often reflected as high amount of intersections and the lack of dead-ends and cul-de-sacs.

Later three more variables were included to the 3D’s model to add the dimension of accessibility to the original city structure model. The new variables in the so-called 6D model introduced by Larrañaga & Cybis (2014) are distance to transit, destination accessibility and demand. Distance to transit is usually measured as the average distance from the origin to the closest mode of public transport. It can either be measured by the distance or travel time or by the number of stops or stations per unit area or density of public transport routes (Larrañaga & Cybis 2014). The destination accessibility reflects the distance to the nearest shopping center, public services or other destinations of interest. It can be measured as distance, travel cost or access to destination or as time on regional or local level. The last variable for measuring accessibility is the dimension of demand, which could be measured by the possibilities of the target area in receiving and to welcome pedestrians and giving them the opportunity to stay in the area. An indicator for demand could be the amount of accessible parking lots or benches in an area of interest. The different variables for the six dimensions of the city structure are presented in figure 1 below.

Dimension	Candidate variables
Density	Housing density (no. dwelling units per km^2)
	Population density (no. inhabitants per km^2)
Diversity	Land use mix (1 = job concentrator area, 0 = mixed)
Design	% four-way intersections
	Block length (m)
Distance to transit	Transit availability(LITA)
Destination accessibility	No. shops and services
Demand management	Parking (1 = public paid, public free)

Figure 1. An example of candidate variables for the six built environment dimensions, measured at the neighborhood level (500 m). Source: Larrañaga & Cybis (2014), p. 575

3.2.1 The human scale of urban structure and Design for All (DfA)

When studying, planning and building public space on a micro level, we are operating on a level that Jan Gehl describes as the human scale (Gehl 2006, 2010). For the past 50 years cars have dominated in urban planning (Gehl 2006, p. 55, 91). Streets, plazas and sidewalks have been planned and built in a way that nothing gets in the way for the car traffic. This has had a big impact on how pedestrians and bicyclists feel about moving around in the city. Sidewalks are narrow and traffic signs, parking meters, bollards, street lamps and other obstacles are placed on the sidewalks creating hinderances for those who are using that space (Gehl 2006, p. 91). Instead of car traffic, the natural starting point of urban planning should be human mobility and the human senses as these provide the biological basis for activities, behavior and communication in city space (Gehl 2010, p. 33, 59).

Designing a city on the human scale means that the human needs are taken into consideration in planning and building the urban environment. To provide an environment for both necessary and optional activities, the urban environment should be inviting, interesting and easy to access. Design criteria should be on the level of the least well-off, so that it could be guaranteed that everyone's needs are met. For example, the acceptable walking distance in ordinary daily situations has been found to be approximately 400–500 meters for most people, but for children, old people and persons with impairments, the acceptable walking distance is often much less (Gehl 2006, p. 137, 2010, p. 121–125). This and other matters that have an effect on mobility and functionality of persons acting in urban space should be taken into consideration so that the urban environment could be inviting and easy to access for everyone.

The impact that good design has on experiences is evident in the example by Gehl (2006, p.137, 2010, p. 121–125): a straight and unprotected 500-meter path that offers little stimulus for human senses is often experienced as very long and tiring, however, a path of the same distance that is well designed and have good path quality and interesting surroundings can be experienced as much shorter.

The design requirements that are mentioned to be good design on the human scale are the same as the design requirements in the Design for All, or Universal Design –concept. Design for All refers to a design model for products, services, information, culture and environments – everything that are designed by people for people (Design for All Europe 2017) – that are designed in a way that all people can enjoy them. Universal Design and Design for All increases the potential for developing a better quality of life for a wider range of individuals by supporting people in being more self-reliant and socially engaged (Steinfield & Maisel 2012, p 28) by taking every persons' needs into consideration in designing environments, products and services (Jokiniemi 2007, p. 47).

3.2.2 Walkability

Over recent years, walking and the quality of walking environments have become a significant factor in city and transportation planning and design (Gant 1997; Ewing & Handy 2009; D'Alessandro, Apolloni & Capasso 2016). Walking and walkability can be valued for many reasons; it is proven that they have a positive impact in reducing congestion as well as decreasing the environmental burden (Cervero & Kockelman 1997; Southworth 2005; Kuoppa 2016). It is also known for its social and recreational value as well as for its effect in promoting health (Cervero & Kockelman 1997; Southworth 2005; Kuoppa 2016). Previously movement by foot or by bicycle was seen as purely recreational, but the shift in urban policy from car-centric planning towards a more pedestrian friendly policy has made walking and cycling highly considered modes of transportation.

Walking lays physically and psychologically determined demands on the physical environment (Gehl 2006 p. 133). Walking demands first and foremost space; it is necessary to be able to walk freely without being disturbed, without being pushed and without having to maneuver too much (Gehl 2006 p. 133). Secondly, walking demands a good walking environment, good quality of the path as well as interesting surroundings so that walking could be considered pleasant. The demands for a good walking environment vary from person to person and from situation to situation. Special demands for walking space are required especially from the “wheeled” pedestrians, such as wheelchair users, persons walking with baby carriages, luggage, shopping charts, etc. and from the impaired persons. Creating more pedestrian-friendly environments is considered as a question of social equality but it is also seen as a competitivity factor, making city centers and neighborhoods more attractive to tourists, new residents and investors (Kuoppa 2016).

Walkability has been defined in different ways in different disciplines. However, the essence of walkability is mostly defined as the extent to which the built environment is pedestrian-friendly and as to which extent the land use support and encourage walking; whether for leisure, exercise, recreation, access to service or travel to work. This is regarded by providing pedestrian safety and comfort, connecting people with destinations and offering visual interest throughout the network (e.g. Abley 2005; Southworth 2005; Leslie et al. 2007; Reyer et al. 2014). A definition for walkability is also the criteria or measures by which it is evaluated; the criteria will be presented below. The concept of walkability describes spaces, but it does not give any identity-relevant information (Reyer et al. 2014). Therefore, the concept does not grasp on a particular group of people, but instead it solely concentrates on the surrounding environment. An environment which fulfills the criteria for walkability is considered a good pedestrian environment and encouraging for mobility (Southworth 2005; Leslie et al. 2007; Reyer et al. 2014). In contrast, low walkability restrains movement.

Although walking is mentioned in the name of the concept, this does not mean that walkability concerns only walking. Walkability –related literature and research also use the terms ”pedestrianization” and ”pedestrians” (e.g. Gant 1997; Parent 2016). However, walkability literature has mostly focused on physical *walking*, leaving other pedestrian-minded forms of mobility, such as wheelchair mobility, beyond research. Walkability is by definition described as elements which create a good environment for *pedestrians*. In disability related studies, and also in legislation, wheelchair users are considered pedestrians (e.g. Gehl 2006, p. 134; Parent 2016, p. 524; Finlex 2017g, 1, 2 § mom.11), which means that the concept of walkability concerns also persons who use a wheelchair or other mobility aid; even motorized mobility aid (Finlex 2017g, 2, 45 §). Even wheelchair users themselves speak sometimes about “walking” while describing their mode of moving:

> ”It is important to recognize that wheelchair users in many cases use the term walking to describe how they move in the world. … Wheeling can be thought of as a mobile practice falling under the umbrella that covers a variety of walking

> practices (p. 524). … On the streets, I don't *really* walk. I wheel. That does not mean that I do not identify as a pedestrian (p. 521)." (Parent 2016, original ephasis).

Therefore, walkability as a concept does not mean that the environment is suitable only to physical *walking*, but it can be understood as the ease and comfort of moving and functioning in the surrounding environment. When the criteria of a good walking environment are met, it is also easy and comfortable to move and function in that environment. Pedestrianization and good walking environment is not important only for those with special mobility needs, but also for the society at large (Gant 1997). Therefore, walkability concerns all those who are considered as pedestrians.

3.2.3 Measuring walkability on different levels

Different studies of walkability present the measures for good walkability with varying context. However, all of them have the same basic idea of how walkability should be evaluated, which often is considered by the so-called 3D's; residential **d**ensity, pedestrian-friendly **d**esign and land use **d**iversity; which are also the same components as in the 3D model of urban structure presented earlier.

Leslie et al. (2007) talks about walkability via two dimensions by which land is organized; proximity (distance) and connectivity (directions of travel). Proximity is determined by land use variables of density; or compactness of land use, and land use mix; or heterogeneity of different land uses, that are co-located in space. The more compact and mixed the urban environment is, the shorter the distances are to different destinations (Leslie et al. 2007). Connectivity measures the directness of path network between location of origin, shops, places of interest and employment, and is based on the design of the street network (Leslie et al. 2007). Path directness is actualized where there is a lack of barriers, walls or other physical obstacles, and where there are several options for travel routes.

Other scholars have divided the 3D's into more exact criteria which constitute a good pedestrian design (e.g. Southworth 2005; Leslie et al. 2007; Gallimore et al. 2011; Kuoppa 2016). The six criteria, which are often repeated in walkability literature, are; connectivity, linkage with other modes, density or compactness of land use, safety, quality of path and path context; which are also related to the 6D model of the urban structure that was presented earlier. Connectivity is often stated as the factor that influences the most in whether an environment is considered as walking-friendly. A number of studies have shown, that people tend to walk more in areas that are interconnected, where there are more street intersections and the blocks are smaller (e.g. Doyle et al. 2006; Leslie et al. 2007). Sprawled areas tend to be less walkable mainly because of longer distances. Perceived safety of neighborhoods and a more pleasant environment are also factors that make walking more attractive (e.g. Doyle et al. 2006). These factors constitute walkability and it is measured on both macro- and micro-level.

Macro-level walkability consists of high residential density, of high diversity of land uses and destinations as well as of pedestrian-friendly design, where streets are well-connected and accessible (Gallimore et al. 2011). The factors are studied within a large area, often on neighborhood or city region scale. An area which is poorly designed when looking at walkability has lower residential densities, little land use variety and poorly connected streets. Poor walkability score on macro-level translates into long walking distances, little variety within the walking environment and indirect walking routes, which are seen as environmental barriers on macro-level (Gallimore et al. 2011).

Micro-level walkability factors are partly similar to macro-level factors, as even here residential density, pedestrian-friendly design and accessibility, and diversity of land use, are evaluated. However, the factors are studied on block- or street level. In addition, three other factors are added on micro-level walkability evaluation: traffic safety, pleasantness (path quality and path context), and low crime rate (Gallimore et al. 2011). Environmental barriers that indicate poor micro-level walkability are elements such as insufficient crosswalks and traffic lights on a block and experiences of unsafe walking environments (Gallimore et al. 2011).

The environments that are shown to stimulate higher pedestrian mobility are regions with higher density and diversity, areas with higher percentage of intersections in “X” or four-way intersections, and smaller block sizes (Cervero & Kockelman 1997; Larrañaga & Cybis 2014). Higher street connectivity which also relates to greater supply of alternative routes is associated with better accessibility and greater rates of walking. Density, land-use diversity and pedestrian-oriented design provide more accessible environments also for persons with mobility or functionality impairments.

The relation between the built environment and walkability can be measured either by using technological methods, such as the personal digital assistant (PDA), remote sensing, and GIS data, or by observations (D'Alessandro, Apolloni & Capasso 2016). Via observations it is possible to detect physical structures and obstacles that reduce the walkability of an area to a certain pedestrian group, such as persons with mobility or functionality impairments, the elderly or persons with a pram or luggage. Via GIS methods it is possible to observe structural elements and processes that reduce walkability on a larger area.

3.3 Accessibility and physical accessibility

Accessibility is a widely discussed topic in urban and traffic planning (e.g. Bhat et al. 2000; Geurs & van Wee 2004; Bertolini, le Clercq & Kapoen 2005; Salonen, Toivonen & Vaattovaara 2012; Moya-Gómez & García-Palomares 2015), but its definition seems to vary between different studies. One of the most frequent definitions for accessibility is "the ease with which activities can be reached, given a location, using a specific transport system, or the ease of interaction with a significant number of opportunities" (Moya-Gómez & García-Palomares 2015). This definition grasps the different components of accessibility:

- 1) the land-use component which measures the amount, quality and spatial distribution of opportunities at destinations;
- 2) the transport component, which measures the interaction between the origin and destination by looking at the transport system and the journey between the two;
- 3) the temporal component, which measures the opportunities to access destinations at different times of the day and the time budget of the individual; and
- 4) the individual component, which measures the needs, opportunities and abilities of the individual.

(Bhat et al. 2000; Geurs & van Wee 2004)

Briefly, accessibility measures the potential of movement. This could be studied from the perspective of the transport system (e.g. travel speed), of the qualities of the land-use system (densities and diversities), or accessibility could be studied from the perspective of economic goals (access to workers, customers or suppliers), social goals (access to employment, goods, services or social contacts) and environmental goals (resource efficiency of the associated activity) (Bertolini, le Clercq & Kapoen 2005). In addition to the factors stated above, accessibility is also measured through more fine attributes such as safety, convenience, comfort and aesthetics (Bhat et al. 2000). These attributes are studied in both the journey component; that is the transport component, and the destination; that is the land-use component.

When discussing accessibility, we are dealing with quite a vast topic. Accessibility of the environment, or physical accessibility, is one aspect of accessibility and it deals with the quality of the operational environment in such a way that both physical, psychological, communicational, social, cultural and economic environment is actualized, enabling every person to function equally among others regardless of his or her abilities (Siik 2006, p. 17; Jokiniemi 2007, p. 13; Ruskovaara 2009, p. 7; Invalidiliitto 2017c). Accessibility is composed of different perspectives; it can be tied to attitudes or senses, accessibility can be physical, economic, social, cultural or communicational, or it can be related to information and decision making (Siik 2006). Accessibility of attitudes is evident in the way by how the needs of different individuals are taken into consideration when planning, building and maintaining the environment and how different persons are involved in the society. Physical accessibility is related to the physical attributes of the environment and removal of obstacles (Jokiniemi 2007, p. 13). Communicational and information accessibility means the ease on how to get and to use information, logical construction of the environment, and all aids that help orientate in the surroundings. Social accessibility is evident in how different activities are planned to include all persons regardless of their abilities or possible impairments. Social accessibility means also that ones' culture does not hinder the participation in various activities. It is partly connected also to accessibility of attitudes. Accessibility of decision making means that decision making is transparent and every person has the possibility to influence decisions that concern him or her. This is also stated in legislation, which regulates participation in projects related to land use (Siik 2006).

Physical accessibility is also a vast concept, which enables every person to live independently at home, and to participate smoothly in all activities such as work, hobbies, culture and studies (Jokiniemi 2007, p. 14; Invalidiliitto 2017c). It is not just about accessibility of movement, although traditionally physical accessibility is thought of as a space where there are no obstacles for movement (Jokiniemi 2007, p. 47; Ruskovaara 2009, p. 7; Perustietoja liikkumis ja… 2011), but the idea of physical accessibility takes also into consideration aspects that are related to seeing, hearing, communication and digital communication which enables among other things accessibility of services, usability of different tools and the comprehensiveness of information. Accessible spaces and solutions make mobility and functionality easier for all individuals. It means ease, safety and quality of the operational environment (Ruskovaara 2009, p. 7; City of Helsinki 2016b; Invalidiliitto 2017c).

Physical accessibility is usually understood as a theme, by which especially persons with mobility or functionality impairments, and the society, strive to fulfill social equity in cities. For example, the UN Convention on the Rights of Persons with Disabilities defines accessibility as a cross-cutting issue that enables persons with mobility or functionality impairments to live independently and participate fully in all aspects of life (UN 2016). However, physical accessibility does not influence only those with impairments, instead, accessibility should be understood as an "element of a quality of life of universal interest and, therefore, a right of all citizens" (Gilart-Inglesias 2015) – a civil right – because inaccessible environments affect our ability to fully participate and interact in social and economic life. It should not be necessary to discuss any particular group while discussing physical accessibility, as it benefits us all. Furthermore, physical accessibility should not be derived from special legislation, nor should it be a concern solely to persons due a condition, for instance impairments, or demographic cohort, for instance the elderly (Rapley 2013), but it should be something taken for granted in the society. Physical accessibility is about taking the differences in individuals' needs into consideration in planning, building and maintaining the environment and it represents therefore equality and is part of sustainable development (Invalidiliitto 2017c). Physically accessible environments increase the wellbeing of all citizens and the functionality of the society (City of Helsinki 2017a). Nowadays it is understood that inaccessibility is primarily a problem that concerns the environment and the society (Vehmas 2005, p. 127; Jokiniemi 2007, p. 45; Mahlamäki 2013). The possibilities of the individual to move and function are improved by modifying the surroundings.

In most of the disability related researches, physical accessibility is discussed plainly as "accessibility". I would use the term *physical accessibility* to make a distinction between the environmental and physical factors and barriers that hinders movement from the universal meaning of accessibility, which is related to traffic systems, costs and travel time, as was discussed in the beginning of this section. I recognize the importance of these features also in the topic of physical accessibility, but in the context of this thesis I would prefer the term physical accessibility over accessibility to give more weight on physical environment and its barriers to mobility and functionality. By this definition, physical accessibility means the removal of all those barriers in the built environment that prevent the individual to fully participate in the society (Ahola 2017). Physical accessibility means also, that the differences in the needs, opportunities and abilities between different groups of people are taken into consideration when planning, building and maintaining the built environment (Invalidiliitto 2017c).

The term *physical accessibility* has been used in in a number of studies the same sense that I am now. In these studies, physical accessibility means accessibility of the physical environment (Siik 2006; Ribeiro, Martins & Monteiro 2012; Engelbrecht & de Beer 2014). Inaccessibility of the environment, due to structural and architectural constructions and design issues that reduce accessibility, is in the center of interest when measuring physical accessibility and it is usually measured by different accessibility criteria for the built environment (Sanchez et al. 2000; Losinsky et al. 2003; Mudrick et al. 2012; Engelbrecht & de Beer 2014). Physical accessibility is often enhanced via design requirements for, for example, doorways, stairs, pedestrian routes and similar. The term *environmental accessibility* has also been used when talking about accessibility of the environment, whereupon it is used in describing the built environment, traffic systems, services and communication (Rapley 2013). However, this term is not that widely recognized and the term physical accessibility is used more frequently. In some cases, physical accessibility has also been used when talking about spatial accessibility or geographical accessibility, in which case the spatial or geographical distances from the origin to destination is measured by actual or perceived distances (e.g. Black et al. 2004). Although there seem to be differences in the definition of physical accessibility, the most used definition is however related to the quality of the built environment which enables mobility and functionality. This is also the sense in which I will be using the term physical accessibility. I will also be using the term *accessibility* when talking about accessibility in general in the built environment, accessibility to services, information, discrimination, etc.

3.3.1 Requirements for the built environment from the perspective of different pedestrian user groups

Next I will present shortly the physiological features of different pedestrian groups and their basic requirements for the built environment. I will concentrate on describing only public outdoor spaces, more detailed instructions for indoor areas are found elsewhere (look e.g.

Verhe & Hirn 1996; Esteetön rakennus ja ympäristö… 2007). The requirements vary between different countries. I will be using Finnish definitions and requirements. The user groups are formulated according to their mobility and functionality specifications for the built environment. Typically the user groups are divided according to requirements of the motor variety, the sensory variety and the cognitive variety (Stude & Menger 2007, p. 8), but in this thesis I will be dividing the motor group into two and the sensory group will be consisting only of persons with impaired vision. The cognitive group will be covered only roughly and it will be implemented in other user groups in the empirical study. The user groups that I will be using are "wheelchair users", "persons using a walking aid", "persons with impaired vision" and "other", which consists of persons with a pram or luggage, and persons with, for example, a heart condition, hearing impairments, mental conditions or allergies. The group "other" will be implemented into the three other user groups in the empirical study and the user group "persons using a walking aid" will be named as the user group "other".

Wheelchair users

Wheelchair users have a decline or a loss of action activity or daily life activity, perhaps due to natural aging, accident, illness, impairment or pregnancy (Xiang et al. 2016, p. 12). Individuals may be wheelchair bound because of a decline in physical strength in the whole or part of the body, or by paralysis. Functions may be reduced or lost, the brain may lose the ability to control coordination and balance, and the waist or parts of the lower limb, like hip joint, knee joint or ankle joint, may be congenitally deformed, injured, or impaired (Xiang et al. 2016, p. 12). As a result, the individual may have difficulties in performing daily activities. Using a wheelchair compensates to the loss of mobility and functionality of the body and increases the accessibility of these persons.

Moving around in a wheelchair requires space. Movement area needs to be calculated in such a way that people are able to act freely and without restrictions (Stude & Menger 2007, p. 8). A person in a wheelchair requires a circular area with a diameter of 1500 millimeters (mm from now on) to be able to turn. Additionally, a space of 150 mm needs to be free on each side of the wheelchair (Perustietoja liikkumis- ja… 2011). A wheelchair may be manually moveable or motorized. Using a wheelchair places requirements on the path and the sidewalk quality. It is hard or almost impossible to wheel on a surface that is uneven, slippery, soft, or laterally sloping (Perustietoja liikkumis- ja… 2011). Because of this, the path surfaces need to be planar with minimum slope, of hard material and non-slippery. If there is a slope; railing and resting areas need to be provided along the path for those moving about in a manually moveable wheelchair. As the persons are sitting while moving around, their movement potential and action radius are limited. Therefore railings, benches, tables etc. need to be on such a level that they can access these while sitting.

Persons using walking aid

Those who have a decline of movement, but still can walk when aided, are using walking aids. Like for those who move in a wheelchair, individuals may have a decline in physical strength, mobility functions may be reduced, the brain may have lost the ability to control coordination and balance, or the waist or parts of the lower limb may be deformed, injured, or impaired in a way that makes walking and functioning difficult without a walking aid. The decline of movement may be due to natural aging, accident, illness or impairments. There is a variation of different walking aids to be used. The most common are a walking stick, crutches, or walking frames with wheels such as a rollator (Perustietoja liikkumis- ja… 2011). Walking may be hesitant and uncertain for a person moving about with a walking aid and therefore the path surface must be of good quality. Walking on an uneven surface, on a slippery surface, on steep slopes or stairs, in areas with lateral slope, as well as walking long distances may be hard for persons with reduced mobility or functionality. Therefore, the path surface must be even and non-slippery even when it is wet, changes in surface materials should not be drastic, and slope should be minimal. There should also be enough of space on the sidewalk as maneuvering is difficult for persons with reduced walking capacity. The rise of stairs should be such that persons with stiff limbs can easily walk them and railing should be provided to ease the rise. Long distances are tiring when the ability to walk is weakened and therefore there has to be places to rest along the path at even intervals. The benches should be such that a person with reduced mobility or flexibility is able to sit down and stand up easily.

Persons with impaired vision

A person with impaired vision is one who has difficulties in daily life activity due to the decline in vision (Jokiniemi 2007, p. 40). The group is divided into two; to those who have poor eyesight and to those who are totally blind. Only a small part of persons with impaired vision are totally blind and a large amount of the persons with impaired vision are able to sense light and see colors and contrasts (Verhe & Hirn 1996, p. 23). However, the ability to detect single objects and three-dimensionality is weakened. While walking, the risks to those with impaired vision is to collide with or stumble over objects and fall. To be able to orientate, the persons with impaired vision use their other senses and walking aids. The most crucial senses are the sense of touch, which is used to feel the differences in level, barriers and the edges of the walking line, and the sense of hearing, which is used to detect directions and distances (Verhe & Hirn 1996, p. 25; Jokiniemi 2007, p. 26). The kinesthetic sense in muscles and joints is used in feeling the shapes and the slope of the surface. The sense of smell can also be used in recognizing places (Verhe & Hirn 1996, p. 25). Persons with impaired vision usually use a white stick while walking to be able to detect landmarks, differences in level and possible barriers alongside the path (Verhe & Hirn 1996, p. 24).

To be able to orientate and walk with ease, persons with impaired vision need a clear, well designed, safe and logical environment. There should be signs that show upcoming changes in the path, like crossings, stairs and other danger zones, places of interest and resting areas. Contrasts, colors, sounds and surface pattering can be used to indicate danger zones, resting areas, and to give signs for movement. To feel safe, the sidewalk should be divided into separate pedestrian and bicyclist lines and the pedestrian line should have a noticeable edge which warns of the car traffic line. Good illumination along the pedestrian path and at landmarks, stairs and ramps helps in orientating (Jokiniemi 2007, p. 23). The path should preferably be straight with rectangular intersections and turns. Pedestrian areas should be accessible and free from obstacles which could be possible to collide with. In crossing areas the edge of the crosswalk should have a tactile or contrast warning area, sound signal and an edge that shows the direction of the crosswalk (Verhe & Hirn 1996, p. 30–32).

Physical accessibility is important when designing good environments for persons with impaired vision. However, the environment should not be totally stripped off elements, but it should have a lot of stimulus for all the senses (Jokiniemi 2007, p. 14–28). There is a risk that the urban environment becomes one-sided and dull when designing accessible surroundings. Jokiniemi talks about the curling-effect of physical accessibility (Jokiniemi 2007, p. 37). The term is originally from Sweden where it has referred to curling-parents who sleek all the obstacles away in front of their children. In the context of physical accessibility, this term refers to the design of an one-sided and sterile urban environment where all the obstacles have been removed, making it difficult to detect personal characteristics of the space and thus making orientating and creating imagery maps more difficult.

Other

Persons that have other kinds of mobility or functionality impairments, such as deaf-blind individuals, persons with cardiovascular disease or hemophilia, persons with dementia, and persons with intellectual impairments have the same requirements for the built environment as persons who walk using a walking aid. Children and persons walking with a pram, luggage or heavy carriage are usually considered needing the same requirements for the built environment as wheelchair users (Perustietoja liikkumis- ja… 2011). The elderly could be part of any of the groups. Usually they are walking using a walking aid, but they could also have impaired vision, be wheelchair users, or have mental problems (Perustietoja liikkumis- ja… 2011). A physically accessible environment makes it easier for all individuals to move and function in the built environment.

3.3.2 Physically accessible urban structure

It has been argued, that the urban environment has been designed by and for the able-bodied, leaving persons with impairments out of consideration (Gleeson 1999, p. 27; Imrie 2000b; Anderson 2001; Vehmas 2005, p. 127). Various studies have shown how the built environment has the capacity to impede and/or prevent mobility of persons with mobility or functionality impairments while restricting their access to specific places due to inaccessible design (e.g. Gant 1997; Imrie & Kumar 1998; Gleeson 1999; Imrie 2000a; Losinsky et al. 2003; Mudrick et al. 2012; Bendixen & Benktzon 2015; Kuoppa 2016). These kinds of environments can seem hostile and may have been designed only with able-bodied values, and these environments are not seen as welcoming for those with mobility or functionality impairments. There are little possibilities for persons with mobility or functionality impairments to participate in society if the built environment or the public transport system does not facilitate their mobility. Gaining access to particular places and services is an important part of the lives of persons with mobility or functionality impairments (Imrie 2000a) and fulfills social justice in cities. Therefore, the local authorities have the responsibility to regulate the building and refurbishing of public areas by enforcing accessibility standards (Imrie 2000a, p. 9). Equality in accessibility is not fulfilled if the requirements of the least well-off persons are not taken into consideration in planning, building and maintaining the built environment; the operational environment is as weak as the weakest person acting in it (Jokiniemi 2007, p. 139, 147). The level of accessibility that the built environment can provide in urban settings is dependent on the street design, environmental barriers and the existence of supportive elements for movement (Gilart-Inglesias 2015).

So far, I have discussed what the components are upon which the urban structure is built, on which elements it could be evaluated, what good walkability is, what a physically accessible environment means, and what the requirements are for the physical environment from the perspective of different pedestrian user groups. Physically accessible environments have been discussed in several studies and mentioned in sources, many of which are already presented in this thesis. In these studies it has been established, that the design of walkable areas, the choice of materials for paved surfaces and the positioning of street surfaces, can affect the levels of comfort within the built environment and help in creating more pedestrian-friendly environments for people with different needs and levels of mobility. These studies have presented the same themes and components, which are repeated also in the definition of walkability and in the models of urban structure. Consequently, it is possible to evaluate physical accessibility of the urban structure via the concept of walkability.

A physically accessible urban structure is comprised of different components. It is necessary to consider different peoples' abilities of mobility and functionality when designing and building the public urban environment. A person whose ability to move has been reduced demands more of the quality of the environment than a person with normal mobility. A wheelchair user or a person with another mobility aid needs a bit more space on the pavement and the path should be flat and not slippery. Long distances between destinations are tiring for persons who are not able to walk or move quickly and therefore different services should be placed near each other or there should at least be areas to rest along the sidewalk. There are also detailed instructions for the structure of accessible stairs and ramps. When considering persons with impaired vision, the criteria for accessible environments are more strict and these are related to guiding elements in the urban environment that are based on the senses of touch and hearing.

Physically accessible urban structure is formed through the before-mentioned 6D elements, with the exception that there are more strict criteria for physically accessible environments which are based on the persons', with mobility or functionality impairments, abilities to move and function. It has already been shown how the criteria for good walkability meet also the requirements of physically accessible environments for the impaired. The 6D model of urban structure includes also the elements of walkability, so I will take these as a starting point in formulating the model for physically accessible urban structure.

In the 6D model, density and diversity are related to how close different activities and services are in regards to one another. In a physically accessible urban structure, different activities are near one another, which make distances shorter. These components are often measured on macro level. Design component deals with elements on micro level. These are things as safety, comfort, presence of sidewalks, trees, aesthetics, continuity of sidewalks and illumination. In physically accessible environments the surroundings are planned, built and maintained in a way that persons with mobility or functionality impairments have ease to move and function. To facilitate this, different accessibility criteria have been created on how to plan and build sidewalks, stairs, illumination and crossings, to name a few, so that the needs of persons with mobility or functionality impairments are taken into consideration. These accessibility criteria will be introduced later in this thesis. The three final elements in the 6D model are distance to transit, destination accessibility and demand, which measure how accessible the destinations are from home and public transport stops, and how the destination is able to receive people; in the form of parking and places to stay and rest. In physically accessible environments the distances are short and there are plenty of benches and parking spots for persons with impairments.

When looking at walkability, the criteria are almost the same as in the 6D model of urban structure. The components of walkability are connectivity, linkage with other modes, density or compactness of land use, safety, quality of path and path context. Short distances, quality of the pedestrian environment, connectivity of path and to public transportation and safety, are elements that are highlighted in these components. If we look at the 6D model of the urban structure and add the components of walkability to it, we will get the components of *Density*, *Diversity* and *Design*; measured as quality of the path, in other words, network connectivity, signing, width of path, illumination and materials of the paved surfaces; *Distance to transit*, *Destination accessibility* and *Demand*; measured as accessibility to benches or parking spaces for persons with impairments. However, I would add a few more perspectives to the model: *Declination*, which measures the topography and slope of the environment, and *Discovery*, which describes the "fine" and subjective attributes which have been mentioned as elements in the dimension of design in walkability indices and in the 3D and 6D models of urban structure; aesthetic, safety and other comfort factors of the built environment. I would therefore talk about the 8D model of the physically accessible urban structure (see table 1 below). These are also the components which I will be using in the empirical study.

Table 1. The eight dimensions of physically accessible urban structure and their relation to the 3D and 6D models.

Model		**3D model**	**6D model**	**8D model**
Introduced by		Cervero & Kockelman (1997)	Larrañaga & Cybis (2014)	Hellén (2017)
		Description		
Dimensions	**Density**	Compactness of land use, e.g. housing density, population density	Compactness of land use, e.g. housing density, population density	Compactness of land use, building density
	Diversity	Distribution of land uses, land use mix	Distribution of land uses, land use mix	Distribution of land uses, land use mix
	Design	Safety, comfort, sidewalk design, trees, aesthetics, continuity of sidewalks and illumination. E.g. block lenght, intersection density.	Safety, comfort, sidewalk design, trees, aesthetics, continuity of sidewalks and illumination. E.g. block lenght, intersection density.	Sidewalk design, continuity of sidewalks measured as intersection density, and illumination.
	Destination accessibility		Distance to destination of interest	Distance to destination of interest
	Distance to transit		Average distance from the origin to the nearest collective traffic node location	Average distance from the origin to the nearest collective traffic node location
	Demand		Demand management. Possibilities in receiving pedestrians. E.g. number of parking.	Demand management. Possibilities in receiving pedestrians. E.g. number of parking.
	Declination			Slope of the area
	Discovery			Safety, comfort, trees, aesthetics, etc.

4 Physical accessibility considerations in Helsinki

The population in Helsinki municipality has increased steadily during the period of 1987–2016 (figure 2). The population was 635 181 in the end of year 2016 and is estimated to reach to over 700 000 persons by the year 2040. The popularity of living in the city center is high (figure 3). High population densities can also be found along the rail lines, metro lines and main highways that span from the peninsula point – where the CBD (central business district) is located – north-, east- and westward “as fingers” when speaking of Helsinki as in the shape of a hand. High densities are formed locally in district centers.

It has been estimated that almost 10 % of the population in Finland has a permanent mobility or functionality impairment (Jokiniemi 2007, p. 13, 41; Perustietoja liikkumis ja… 2011). Statistically there would be approximately 64 000 mobility or functionality impaired persons residing in Helsinki. This estimation includes persons with mobility impairment, impaired hearing or vision, and mentally impaired persons of different age. About 1,5 % or 80 000 persons of the population has impaired vision (Jokiniemi 2007, p. 14). Furthermore, it has been estimated that 5 % of the population is temporarily mobility or functionality impaired (Perustietoja liikkumis ja… 2011). Ageing increases diseases and impairments. As the population ages, the need for accessible environments also increases. The amount of the elderly population is increasing fast in Finland and it has been estimated, that by the year 2030, the percentage of the over 65-year old persons will be over 5 % (Ruskovaara 2009, p. 7). In the City of Helsinki the percentage of the elderly population has been a steady 16 % (Statistics Finland 2017), though it is estimated to rise slightly towards 2040 (figure 2). The saturation of elderly population is higher in areas further away from the CBD (figure 3).

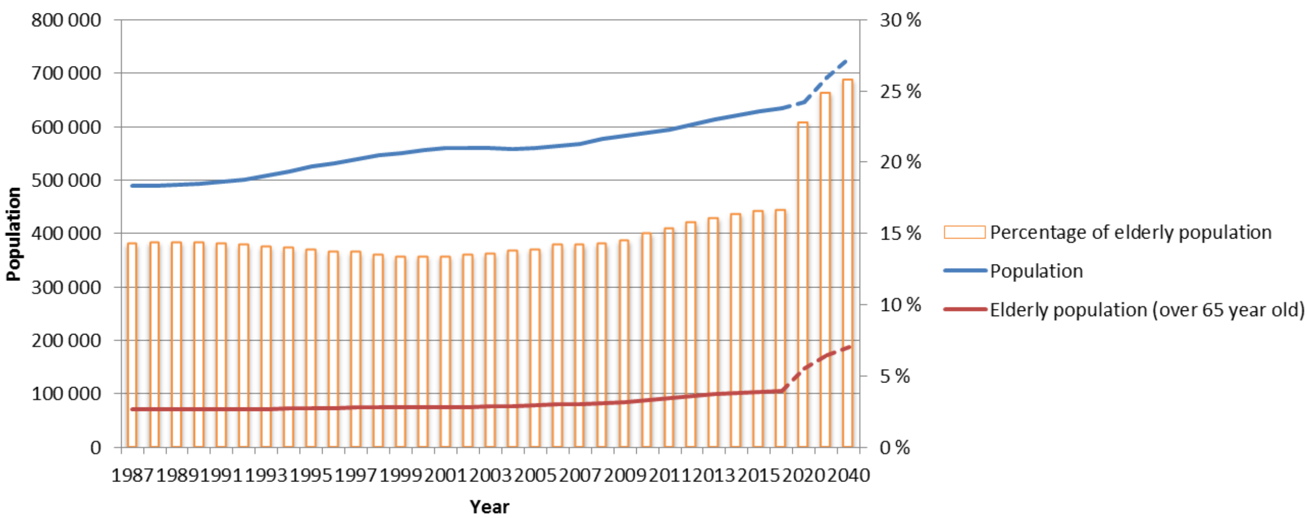

Figure 2. Population development in Helsinki municipality during 1987–2016 and prediction to 2040. Sources: Statistics Finland 2017; SVT 2013.

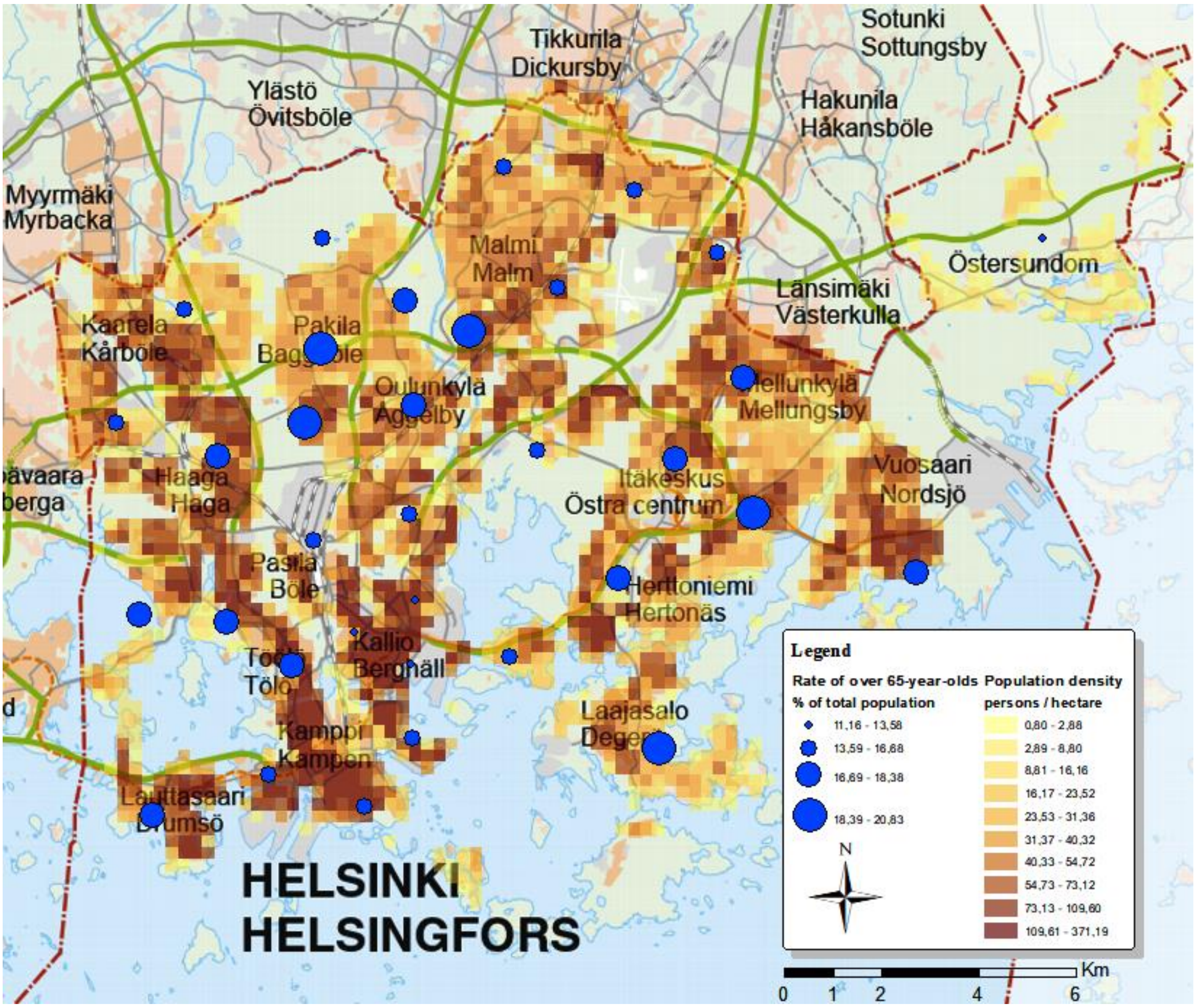

Figure 3. Population densities in the Municipality of Helsinki and the rate of elderly population (persons over 65 year old) in different districts. The darker the color the higher population density of the area. The densities have been calculated from population amount in 250 x 250-meter grid from Helsinki Region Environmental Services and from 1 x 1-kilometer population data grid from Statistics Finland. The size of the dots depict the rate of elderly population. The biggest dot represents the rate 18–20 % of total population. Sources: Statistics Finland (2015); HSY (2016); basemap: City of Helsinki 2016c.

Apart from the inhabitants, Helsinki not only attracts visitors from Finland, but also from abroad. In 2016 there were a total of 3,58 million overnight stays in Helsinki (Helsingin matkailutilastot 2016), which would translate into a few million more visitors during that year than usual. Among these visitors, we can expect that about 10 % are impaired in some way.

In Helsinki municipality, urban development has already for a long time focused on slow transport and more vivid physical environment. This means that bicycling and walking are preferred over passenger cars (Junttila et al. 2012, p. 9). The urban environment is built in a way that lively communities can be formed. Discussions on, and the planning of, the city center as a walking district started as late as in 1980's (Junttila et al. 2012, p 10). Due to the high net flow of migration into city centers, more thought and consideration has been given to the functionality and attractiveness of city centers (Junttila et al. 2012, p. 10–11). Physical accessibility and social equality have become important themes in urban planning in many cities in Finland, and also in Helsinki. Physical accessibility is not only considered in pedestrian street environments, but it has also become a theme that guides urban planning from national legislation to local land use plans in the scope of the entire city area.

Western planning has traditionally progressed from regional and local blueprints towards a more detailed planning of the environment. When the time for planning ends and the areas are to commence being built, the details of the new area are often ignored (Jokineimi 2007, p. 148). In order to take physical accessibility into account, more attention is to be paid to the details. Next, I will introduce how physical accessibility is taken into consideration on different administrative and planning levels. I will begin with the highest level of administration, that is, from the level of legislation as it controls lower levels in the Finnish planning tradition. Towards the end of this chapter I will present more detailed physical accessibility criteria for the different elements of the urban structure.

4.1 National legislation regarding physical accessibility

In this paragraph I will introduce sections from Finnish national legislation which regulate the treatment of persons with impairments and the building of accessible environments. I will primarily be concentrating in paragraphs of the Finnish legislation which deal with physical accessibility in public spaces. Many sections, especially in Land Use and Building Act and in Land Use and Building Decree deal with accessibility in buildings, indoor areas and private outdoor areas, but I will rule these out in this introduction. More information about accessibility in buildings and private or semi-public outdoor-areas can be found, for example, in Luotola's Master's thesis (Luotola 2011).

4.1.1 Ratified agreements

Finland, being among the first of 160 countries, signed the Convention on the Rights of Persons with Disabilities (CRPD) in March 2007 (Suomen YK-liitto 2015; UN 2017). The basic principle of the Convention is the prohibition of all kind of discrimination against persons with impairments, to guarantee full human rights to persons with impairments and to promote accessible environments (Ministry for Foreign Affairs of Finland 2016; Kynnys Ry 2017). The 9th article of the Convention on Accessibility lists measures which enable equity of people in the built environment (UN 2017). The Convention was ratified in Finland almost 10 years later after the integration with national legislation in 10.6.2016 (Ministry for Foreign Affairs of Finland 2016; Invalidiliitto 2017a; Kynnys Ry 2017). The CRPD obligates the contracting parties to "promote, protect and guarantee to all persons with disabilities full and equal access to their human rights and fundamental freedoms" (Ministry for Foreign Affairs of Finland 2016). By the ratification of the Convention, the rights of persons with disabilities are strengthened as legally binding human rights and it obligates the State to act in promoting these rights. The ratification resulted in the updating of several national legislations concerning persons with impairments (THL 2017). Further, a fundamental reform of disability legislation is ongoing at the time of writing.

4.1.2 The Constitution of Finland and the Non-Discrimination Act

The basis for other legislation regarding accessibility, equality and discrimination against persons with impairments is stated in the section 6 of The Constitution of Finland (Invalidiliitto 2017a). This section was added in 1995 (Koivu 2004). The section states that "*all persons are equal before the law*" and that "*No one shall, without an acceptable reason, be treated differently from other persons on the ground of sex, age, origin, language, religion, conviction, opinion, health, disability or other reason that concerns his or her person*" (Finlex 2017a, 2, 6 §). Accessibility is not stated in this section per se, but the demand of people being treated equally regardless of their impairments calls for accessible environments. A similar kind of demand for prohibition of discrimination is stated in the Non-Discrimination Act section 8 (Invalidiliitto 2017a). The section states that "*No one may be discriminated against on the basis of age, origin, nationality, language, religion, belief, opinion, political activity, trade union activity, family relationships, state of health, disability, sexual orientation or other personal characteristics*." (Finlex 2017b, 2, 8 §). These two laws legislate against discrimination towards persons with impairments in general.

Regulations concerning physically accessible environments are found largely in the Land Use and Building Act and Land Use and Building Decree. However, the Non-Discrimination act introduces a regulation in section 15 § for service providers and authorities, that legislate for physically accessible environments. Service providers are regulated to offer physically accessible environments and possibilities to participate in, among others, work and services.

The section states that the service provider should make the required adjustments so that a person with impairments could enjoy the same opportunities of participation as any other person: "*An authority, education provider, employer or provider of goods and services has to make due and appropriate adjustments necessary in each situation for a person with disabilities to be able, equally with others, to deal with the authorities and gain access to education, work and generally available goods and services, as well as to manage their work tasks and to advance their career*" (Filex 2017b, 3, 15 §). This section states that the social environment as well as the physical environment should be such that persons with impairments are enabled to participate in the society and have access to various services and goods. Although it emphasizes the non-discrimination against persons with impairments, it also lays a foundation for physically accessible environments.

4.1.3 Land Use and Building Act and Land Use and Building Decree

Regulations for physically accessible environments are introduced in more detail in the Land Use and Building Act. The sections which concern physically accessibility were added in the Land Use and Building Act in the beginning of year 2000 (Koivu 2004). The regulations concern both public spaces, such as parks, streets and plazas, as well as private or semi-public spaces, such as apartments. The Act demands that physical accessibility is taken into consideration already when planning land use and buildings, with the built environment and buildings being planned and built in such way that persons with impairments could enjoy them and have equal access to them. Specific regulations for planning, building and maintenance of public, semi-public and private spaces are stated in sections 5 §, 12 §, 117 § mom 3, 117e §, and 162 § mom 2.

The objective of land use planning is to promote "*a safe, healthy, pleasant, socially functional living and working environment which provides for the needs of various population groups, such as children, the elderly and the handicapped, functionality of communities and good building, and an appropriate traffic system and, especially, public transport and non-motorized traffic*" through interactive planning and sufficient assessment of impact (Finlex 2017c, 1, 5 §: mom 1, 7, 11). The objective of building guidance is to promote "*the creation of a good living environment that is socially functional and aesthetically harmonious, safe and pleasant and serves the needs of its users*" (Finlex 2017c, 1, 12 §: 1). A building must conform with its purpose and be capable of being repaired, maintained and altered, and, in so far as its use requires, also be suitable for persons whose capacity to move or function is limited (Finlex 2017c, 17, 117 § mom 3). Section 117e states that when commencing a building project, the constructor must ensure that the building and its courtyard are planned and built according to its planned use and the number of users in a way that physical accessibility and usability is especially taken into consideration from the perspective of children, the elderly and, persons with impairments (Finlex 2017d, 17, 117e §, authors translation). Section 167 mom. 2 deals with the maintenance of public spaces which regulates that "*an authority appointed for the purpose by the local authority shall ensure that traffic ways, streets, market places and squares, and parks and areas intended for the enjoyment of residents meet the standards of a satisfactory townscape and of pleasantness and comfort. Routes provided for non-motorized traffic must be kept safe and free of obstacles*" (Finlex 2017c, 167 § mom 2).

Accessibility to services is regulated in Land Use and building Act sections 71c §, 71d § and in Land Use and Building Decree 53 § mom 1 (Invalidiliitto 2017a; Luotola 2011). The section 71 § in Land Use and Building Act regulates the placement of retail centers in urban plans. The retail center should primarily be located in city center areas so that it is easily accessible to inhabitants (Finlex 2017d, 9, 71c §). The location is not strictly regulated and a retail center could also be placed elsewhere if the location is justified from accessibility point of view. Section 71d § regulates that a retail center area should not be placed outside of a commercial zone in regional land use plan or in local master plan (Finlex 2017d, 9, 71d §). The Land Use and Building Decree regulate the physical accessibility in and to buildings in section 53 §. The section states that "*administrative and service buildings, commercial and service premises in other buildings to which everyone must have access for reasons of equality, and their building sites shall also be suitable for use by persons with restricted ability to move around or function otherwise*" (Finlex 2017e, 10, 53 § mom 1). By these regulations it is ensured that the distances to services are kept short and services are easily accessible to individuals.

4.1.4 Other legislation

Detailed building and construction regulations are found in the Finnish Building Code. These regulations are as binding as Finnish legislation (Ministry of the Environment 2016). The Building Code consists of complementary regulations and instructions for the construction of primarily new buildings, but regulations can also be applied for repair- and modification projects (Ministry of the Environment 2016). The regulations in the Building Code are considered mainly in indoor areas, but some of the regulations can be applied also for public and semi-public spaces. However, most of the Building Code regulations do not affect public spaces (Kilpelä 2017). Sections which can be applied for public outdoor areas are found in Building Code part F1 about Accessible buildings section 3.3 Gathering places, and in part F2 about the Utilization Safety of Buildings sections 2.5 Handrail and 3.2 Glass constructions regulation 2.5.1. In section 3.3 Gathering places is stated that "auditoriums, festivals, meeting and dining rooms, study halls and classrooms and similar meeting rooms must be adapted to persons with impairments" (Invalidiliitto 2017a, authors translation). Although this section possibly deals with indoor areas, such meeting places might also be found in outdoor areas where the physical accessibility should be taken into consideration as is stated in the Building Code. In part F2 about the Utilization Safety of Buildings sections 2.5 Handrail and 3.2 Glass constructions regulation 2.5.1 states that handrails must be installed in stairs and ramps for the whole length of the stair or the ramp. The handrail must be designed so that edges are safe and it is possible to get a firm grip of the handrail. Regulation 2.5.2 states that the handrail, which is located either in public outdoor or indoor space, must be placed on both sides of the stairs or ramp and it must be continuous on landings. Regulation 3.2.3 states that all glass constructions, which are placed so that it might be possible to walk into them, must be marked so that they are easily recognizable (Invalidiliitto 2017a).

Accessibility is demanded also in Rescue Act sections 9 §, 10 § and 11 §. Section 9 § regulate that the building and its surrounding are kept in such condition that all persons are able to leave the building on their own or be rescued using other means in the event of fire or other dangerous situations (Finlex 2017f, 3, 9 § 2 mom). Sections 10 § and 11 § regulate the accessibility of emergency exits and passageways from buildings and emergency access roads, which are regulated to be kept serviceable and free of obstructions (Finlex 2017f, 3, 10 §, 1. mom, 11 §, 1 mom).

4.2 Accessibility in land use plans

The purpose of land use planning is to regulate the use and construction of land as well as to create functional environments where everyone has the same possibilities for a good life. Urban planning should take into account all residents, the availability of services and, for example, good public transport conditions (Invalidiliitto 2017b). There are three levels of planning in the Finnish planning system: regional land use plans, local master plans and local detailed plans. Planning is directed on a national level by national land use objectives

(NLUO). NLUO is a strategic plan which directs the placement of different activities and functions. Different planning levels can regulate land use on different scales and precision. Regional land use plans are broad-minded plans where it is possible to locate large functional entities such as highways and other important motorways as well as commercial and industrial areas. Local master plans and local detailed plans show land use on a smaller scale and are therefore more detailed. On these planning levels it is possible to draft very exact planning orders. Regional land use plans directs the planning of the local master plan, which in turn directs the planning of the local detailed plan. The most detailed approved plan steers the land use of its area. Traffic-, street- and park plans are the plans in which the features of the built environment can be influenced on the most detailed level.

Physical accessibility can be taken into account via land use plans first and foremost by influencing the distances between different functions and services and by paying attention to topography of the planning area (e.g. Siik 2006, p. 27; Luotola 2015, p. 42). Additionally, it is possible to address the placement of sidewalks, entrances to buildings and functional areas in consideration to the streets and the building plot, and the placement of accessible areas and routes in land use plans. It is also possible to influence in that the built environment is recognizable and distinct by regulating the colors of the built environment and by planning logical street environments. Accessibility is enhanced also by managing micro-climate conditions, sound environments, and by preventing segregation and insecurity (Siik 2006, p. 27; Luotola 2015, p. 42). It is possible to emphasize the need of considering physical accessibility aspects by adding a –dfa suffix to established plan symbols. The abbreviation comes from the term Design for All, which has been presented briefly earlier. In addition to this –dfa suffix, it is also possible to highlight the physical accessibility aspect in the plan report, in which it is also possible to refer to various accessibility guidelines and instruction cards. Siik (2006) has in her master’s thesis presented different examples for accessibility plan symbols in different land use plan levels.

Before land use plans, and even street and park plans, are approved, they need to be placed publicly visible by the authorities so that the citizens and other appropriate actors such as, for example, the Association for the Elderly and the Disabled, have the possibility to influence the planning and building of their living environment by giving statements and by participating in discussion about physical accessibility in the planning area. Physical accessibility can also be considered by participatory planning procedures. Hearings of land use and other plans are regulated actions in the land use and building act (e.g. Jääskeläinen &

Syrjänen 2010, p. 398, 412, 464, 784–785). Through interaction and participation in planning processes it is possible to ensure good quality of planning and good living environments. Physical accessibility should be a topic that is discussed during all plans per se, because it in essence affects the formation of a good living environment.

All stages of the planning, construction and maintenance processes are vital and will influence the accessibility outcome. As the planning system is hierarchically arranged, the decisions made in earlier planning stages will eventually affect the planning outcomes in later stages. After the positioning of streets in the terrain and access to plots from the streets have been determined in local plans, this cannot be changed in any later planning stage and street planning cannot solve the fundamental errors that have been created from a physical accessibility point of view. Planners and constructors have the right and the obligation to follow the decisions that have been stated in urban plans (Jääskeläinen & Syrjänen 2010). Plan notations are therefore binding and plans have an effect on the quality of the built environment for a long time after the plan is finished. The plan should be actualized as it is, but it can also be altered via lengthy processes or deviation decisions (Luotola 2011, p. 40). Also, when constructing the areas it is important that the plans are followed or else the street surfaces and structures may develop characteristics of inaccessibility (Helsinki for all 2011). It is also important that public areas are maintained in a way that they remain physically accessible even after the planning and construction is finished. Next I will present the different planning levels in the Finnish land use planning tradition and discus in more detail how physical accessibility can be considered in these planning levels.

4.2.1 Regional land use plan

Regional land use plan is a general plan that observes national land use objectives (NLUO) and is a strategic plan that covers a large region, usually on the county or province level, and that have an influence on land use during a long period of time. In this plan, the general land use principles and guidelines for the urban structure which are vital for the development of the region, are visualized (Siik 2006, p. 29). The aim with regional land use planing is to enhance the defragmentation of urban structure and to ensure that the need for passenger car traffic is lowered, and that traffic systems and infrastructure for public transportation, walking and cycling, is improved in urban areas (Jääskeläinen & Syrjänen 2010, p. 233). The regional land use plan also shows the shape of the service network and the location of large retail units, which affects the accessibility of services.

As the regional land use plan is very general in nature, it does not usually have land use markings and symbols relating to physical accessibility. It is, however, possible to influence accessibility factors related to distances between different functions, to the existence of different options for traffic mode, and how the stations are situated related to the surrounding urban structure. Regional land use plan also gives possibilities to re-evaluate from an accessibility point of view significant destinations and objects that are important because of their landscape, cultural, historical or functional value (Siik 2006, p. 30; Luotola 2011, p. 43). Variant areas and environments can be conserved and highlighted so that their value is ensured for coming generations and access to them is secured also in the future. However, it is possible to highlight and remind of the importance of physical accessibility and the need of alternative physically accessible routes in the plan report (Siik 2006, p. 29). If necessary, it is possible to use the –dfa suffix to point out the need or the locations of physically accessible functions such as routes, connections, recreational areas, or areas to be developed as physically accessible. Some plan symbols, such as focus area for urban development, focus area for rural development, focus area for recreational and tourism development, include already the requirement of physical accessibility (Siik 2006, p. 30).

4.2.2 Local master plan

Local master plan is a general plan for land use that is made to guide urban structure and harmonization of different operations in the urban environment over the area of a municipality or part of it (Jääskeläinen & Syrjänen 2010, p. 257). Essential areas for development are pointed out for the basis of more detailed plans or construction. Functional characteristics of different areas and different functions, such as residential areas, service areas, business areas, leisure, conservation, and traffic areas, are defined while taking the principles of sustainable development into consideration (Jääskeläinen & Syrjänen 2010, p. 258; Junttila 2011, p. 9). In the contexts of planning and construction, the principle of sustainable developments considers the realization of common good and joint responsibility. The finished local master plan should fulfill the needs and interests of all actors that are situated in the planning area. Regional land use plan, and regulations made in it, need to be considered while making the local master plan. Furthermore, the functionality of urban structure, utilization of the existing built environment, needs of housing and the possibility for healthy as well as safe and balanced living environments from the perspective of different demographic groups must be ensured in the local master plan (Jääskeläinen & Syrjänen 2010, p. 263).

The consideration of physical accessibility in the local master plan is based on the locations of various functions and to the distances between them, and how topography has been taken into account while planning the locations of different functions. The local master plan defines the locations of roads, buildings, services, stations and recreational areas, to name a few, in relation to each other and in relation to the existing built environment as well as to the terrain. At this planning level, it is already possible to mark physically accessible routes as well as residential or recreational areas by using, for example, the –dfa suffix in plan symbols or the accessible plan symbols proposed by Siik (2006), or by mentioning the need of taking physical accessibility aspect into consideration in the plan report. While designing residential blocks, it is possible to create diverse living quarters and to mix land use, so as to enable lifecycle accommodation and proximity to services (Luotola 2011, p. 43). Functional diversity makes the urban environment livelier and more environmentally safe (Siik 2006, p. 33). Physical accessibility can also be achieved by designing the urban structure and locations of services as logically as possible, whereby the needs of the visually impaired and non-linguistic persons are also taken into account at this planning scale.

The locations of traffic routes are already defined on this planning scale and therefore it is important that the placement of different functions is planned in such a way that there are no unnecessarily long distances between the services and the residential areas. The locations of public sector services, such as schools, kindergartens, libraries, health centers and churches as well as shops, should be designed so that they have good accessibility either by walking, cycling or by public transport. These services should preferably have physically accessible light traffic lanes from residential areas and public transport stops, and have enough parking facilities (Siik 2006, p. 34–35). Every residential area should have at least one accessible route to the nearest public transport stop because of the fact that not everyone has the opportunity to move by car. In addition, care should be taken to improve areas that are less accessible at present, allowing more people to enjoy cultural and recreational, among other, services.

4.2.3 Local detailed plan

Local detailed plan is created for detailed planning, structuring, constructing and the development of the municipality or part of it. It monitors construction and other land use processes and gives the right to proceedings in land use development and places bans for construction and proceedings over the planning area of a legally binding local detailed plan

(Jääskeläinen & Syrjänen 2010, p. 302). Different operational areas are defined in local detailed plans and land use and construction is directed according to local circumstances, urban- and landscape, in advancing the use of existing developed land use, and for enhancing good construction means (Jääskeläinen & Syrjänen 2010, p. 305, 308). As a planning document, local detailed plan gives the opportunity to have an effect on land use and construction on a very detailed level, which gives good chances to influence on physical accessibility of the environment. The local detailed plan needs to be done in such a way that it enables the creation of a safe, healthy and comfortable living environment, good accessibility to services and good traffic arrangements without degrading the quality of the living environment of any person. Other higher scale land use plans, which have been created for the planning area, guide and assess the creation of local detailed plan and in turn, the local detailed plan guide and assess the creation of other detailed plans of the planning area, such as traffic plan, and street- and park plan.

The possibility of the local detailed plan to create physically accessible environments is to locate different activities accessibly by taking local topography of the area into consideration and by creating a logical and safe living environment. The logicality and legibility of the environment is influenced, among other things, by the diversity of services and different land uses and by easy identification of different structures, by logically positioning different activities and buildings in relation to the street and the parcel, and by creating a distinct street hierarchy, by adding signs and lighting, and by highlighting the entrances (Siik 2006, p. 40; Helsinki for all 2011; Luotola 2011, p 15–16, 43–44). Good access to the services is formed by designing the locations of different functions so that the distances between them are not too long. Several sources (e.g. Gehl 2006, p. 137, 2010, p 121–125; Siik 2006, p 41; Jokiniemi 2007) have stated that a maximum of 500 meters is an acceptable distance for individuals to walk to access services from residential areas or from public transport stops. The routes to services should be designed to be physically accessible. The availability and accessibility of local services can be ensured through the local detailed plan (Siik 2006, p. 40). By mixing different activities and land uses, the distances between different activities are shortened and the built environment becomes interesting and socially versatile. This will also create opportunities for many different user groups. It is also important to ensure the preservation of residential areas close to services and jobs (Siik 2006, p. 46). As an example, it is possible to increase the number of square meters in buildings and increase the number of dwellings to an already existing building stock through local detailed plans.

In the local detailed plan, distances can be influenced not only by planning the locations of different activities, but also by good traffic planning. The plan should therefore allow the functionality of public transport and the development of a good walking and cycling environment. A pleasant walking environment is affected not only by the quality of the surroundings but also by safety. The aspect of security can be taken into consideration from the viewpoint of persons with mobility or functionality impairments by creating a perceptible environment, by reserving enough space for movement for both pedestrians and cyclists, by ensuring that pedestrians are not blocked by obstacles such as snowdrifts during winter time, by affecting traffic speeds by selecting appropriate road surface materials, and by choosing the applicable locations of pedestrian crossings (Siik 2006, p. 43–44). Further, it should be ensured that no hazardous spaces such as elevated areas without railing are designed. One major factor contributing to physical accessibility is looseness and space in the local detailed plan. By reserving enough space for pedestrians and cyclists on light traffic routes, such as in front of building entrances; by increasing the number of parking for mobility or functionality impaired persons; and, on the other hand, by compressing the distances between different activities; the environment can be much more enjoyable and future development can better be considered.

Paying attention to physical accessibility on local detailed plans, as well as on other planning levels, is a strategic task. If it is not possible to design the whole environment as fully accessible, it should be carefully planned so that there are at least correctly placed physically accessible routes and parking spots for persons with impairments. Priority should be given to good physical accessibility in areas of central activities. Special attention can be given to physical accessibility in local detailed plans with distinct plan symbols that indicate physically accessible routes or areas. In addition, it is possible to point out the need of taking the aspect of physical accessibility into consideration in the plan report and in regulations, or to refer to physical accessibility guidelines, such as the SuRaKu instructions and RT guide cards.

4.2.4 Other planning documents

Municipalities have the obligation to plan and execute building and maintenance of public streets, parks and other public areas (Jääskeläinen & Syrjänen 2010, p. 462–464). The public area is an umbrella concept, which is used for areas in the local detailed plan that have been marked as street areas, plazas, traffic areas, leisure areas, or other areas that are related to the above-mentioned. Characteristic of these areas is that public organizations are obligated to arrange these areas. This is done by drafting more detailed plans, such as traffic, street and park plans. The maintenance of public areas can be arranged by the municipality or by another public organization, or the municipality can give the task to another actor (Jääskeläinen & Syrjänen 2010, p. 463–464).

It is possible to influence the details of the public built environment, such as the height of the curbstone or illumination, only truly in street plans, traffic plans and park plans. Municipalities can also steer their more detailed planning through specific detailed guidelines for building. However, land use plans set the baselines for more detailed plans and therefore they influence on how physical accessibility can be taken into account in more detailed plans. According to the Land Use and Building Act, street areas should be designed and constructed in such a way that they adapt to the layout of the local detailed plan and meet the requirements of functionality, safety and comfort (Jääskeläinen & Syrjänen 2010, p. 464).

The street plan should show the principles of traffic management, drainage as well as rainwater management, street elevation and paving materials and, if necessary, the locations of plantations and permanent structures and equipment (Jääskeläinen & Syrjänen 2010, p. 783). Instead of technical details, the street plan focuses more on issues that are relevant to the users, neighboring real estates, and the cityscape. The street areas can be categorized according to their quality or maintenance classes, in which the physical accessibility criteria also can be addressed. When designing a park or other public area, a stricter planning procedure is to be followed if the area concerned is significant based on its location, its users or the cityscape. In this case, the regulated interactive or participatory procedure for the street plan should also be followed.

The more detailed plans which direct the construction of public areas can have an influence on the physical accessibility of the public areas even beyond the local master plans and local detailed plans. These planning levels have the potential of influencing such features as warning areas, sound and light signals at pedestrian crossings, magnitude of illumination, the location of different structures, and height of curbstones and pavement material. Street and park planning thus occupies a key position when considering the physical accessibility of the environment (Helsinki for all 2011). Guidelines where physical accessibility criteria are explained in detail, such as SuRaKu guidelines, type drawings of the street areas or RT cards, can be utilized in designing public areas.

In addition, separate accessibility plans can be created for streets and other public areas, where physical accessibility requirements are shown directly on the map. There are no separate guidelines or established status for such Physical Accessibility Plans in the Finnish planning system, so practices vary from one municipality to another (Junttila 2011, p. 29). In general, the Physical Accessibility Plans of the public areas should include an overview of the functionality of public areas and the mapping of the obstacles for mobility and the plan to eliminate or reduce their adverse effects. Particular attention should be given to the design of structures that create clear obstacles to mobility and to the ability to clearly detect the surrounding in pedestrian areas. Such structures include the height of curbstones, the condition and quality of paving materials, detectability and steerability of pedestrian crossings, and the detectability and placement of stairs, retaining walls and ramps (Junttila 2011, p. 29). Next I will present one such project where Physical Accessibility Plans have been created to enhance accessibility in urban settings.

4.3 The Helsinki for all –project

In 2001 in the City of Helsinki, the City Board approved an accessibility strategy program which aim was to make Helsinki fully accessible by year 2011. This was to be accomplished through construction and restoration of the city’s public spaces, buildings and public transport systems to make them safe and accessible for all, including to those with mobility or functionality impairments, the elderly, children and families (City of Helsinki 2005, p. 10; Junttila et al. 2012, p. 153). The aim was to also contribute to user-based planning, to create long lasting co-operation between branches of city administration and various partners, such as Associations for the Elderly and the Disabled, the trade and business sector, property owners and the government, and to ensure that physical accessibility aspect is to become a natural part of planning, construction and maintenance processes (City of Helsinki 2005, p. 10–11). The measures for the objectives in the strategy were stated in the City of Helsinki Accessibility Plan, which was approved by the City Board in 2005 (Tujula, 2015; City of Helsinki 2016b). The accessibility strategy was divided into two parts where the first part consists of the strategy objectives relating to accessibility and the second part is the implementation programme; or also the methods and measures for achieving the objectives in the first part. The implementation program was eventually called the Helsinki for all –project.

The Helsinki for all implementation program was divided into three sections: coordination, planning and implementation (figure 4) (City of Helsinki 2005). The task of coordination aims at the interplay of various actors, such as different branches of administration inside the City of Helsinki, Associations for the Elderly and the Disabled, the trade and business sector, property owners and the government, to work towards the common goal of achieving good accessibility. The task for the section of implementation was to ensure, that accessibility is implemented as a natural theme in everyday functions of the different branches of administration. The task for the planning section was to assess the current level of physical accessibility and to develop solutions for improving physical accessibility by creating regional accessibility plans and other physical accessibility guidelines. The purpose of physical accessibility guidelines is to "function as coherent general guidelines for the entire city and all branches of administration when undertaking accessibility work" (Helsinki for all 2011; Tujula 2015). The accessibility guidelines are divided into five focus areas; land use and traffic planning, buildings, public areas, residential environment, and services. They form a framework for the implementation program and act as a boost for cooperation of the various spheres of activity of the administrative branches, thus ensuring that accessibility is taken into consideration in all activity inside the city administration (City of Helsinki 2005).

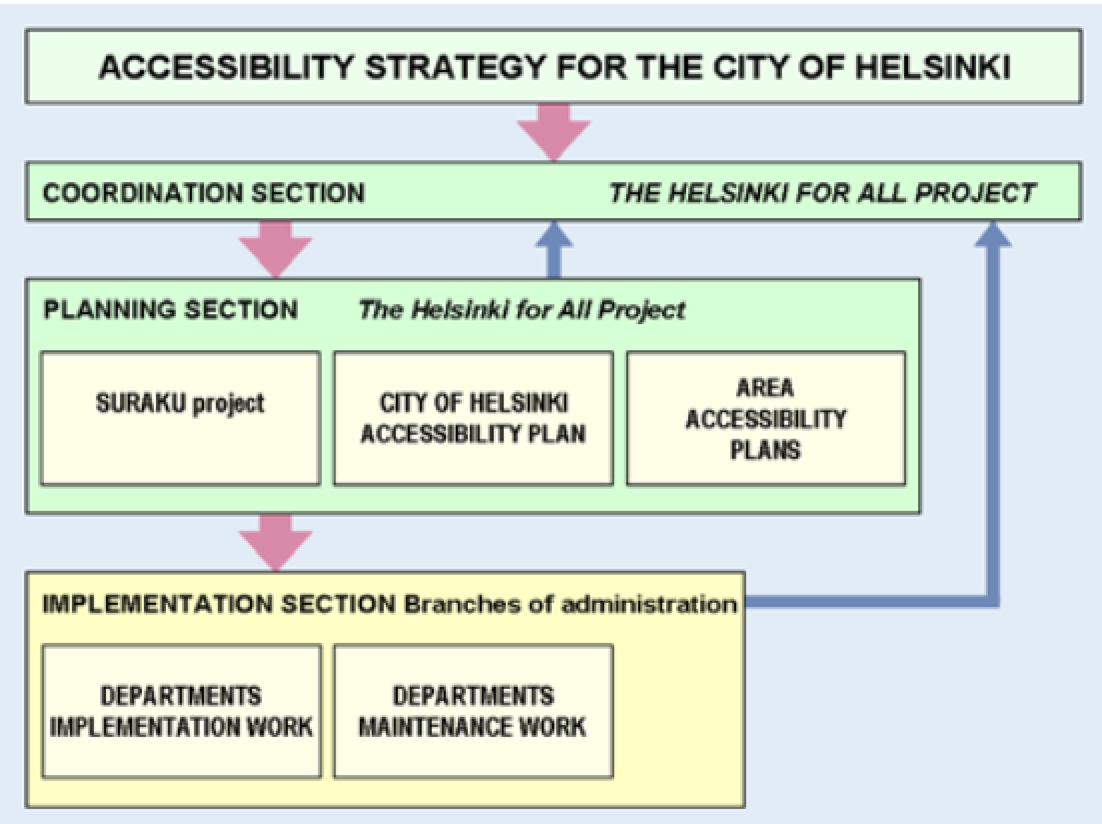

Figure 4. The organization of accessibility work in City of Helsinki. Source: City of Helsinki 2005.

The Helsinki for all –project covered program coordination, communication, reporting and quality assurance, and was assigned to the Public Works Department (Helsinki for all 2011).

The objective for the Helsinki for all –project was to create a city in which everyone has the facility to move, live and act and where streets, parks, buildings and public transportation work seamlessly together, creating an physically accessible urban environment with public services for all (City of Helsinki 2005, 2016b). The Helsinki for all –project included the drafting of the City of Helsinki's accessibility guidelines in 2010 in cooperation with authorities, public enterprises and through interaction with focus groups (Helsinki for all 2011). Guidelines were later introduced to councils for the elderly and disabled for comments.

Another tasks that the Helsinki for all –project was given was to "coordinate and maintain an information system based on geographic data for the purpose of monitoring accessibility projects" (City of Helsinki 2005). This was done by creating a registry of physically accessible routes and areas. The thesis that I am currently working on, is a continuation of this task.

The Helsinki for all –project ended in the end of 2011 and since then the work for gaining better physical accessibility in the city has been continued via a project manager who is responsible for physical accessibility. Furthermore, a council for accessibility work was also formed where representatives of different branches of administration, as well as representatives for Association of the Elderly and Disabled, can meet and discuss accessibility-work related topics (Tujula 2015).

4.4 Regional accessibility plans

Helsinki City Accessibility Plan was, at first, actualized via Regional Accessibility Plans, or Neighborhood Access Plans. The aim of these Regional Accessibility Plans was that different branches of administration would create yearly implementation plans to enhance accessibility in their field of responsibility and this was to be carried out using their own yearly budgets. The goal was that different areas should be viewed as a one uniform entity and that different branches of administration would work together to improve accessibility of the area so that walking routes would be continuous and services would be accessible for all. During the Helsinki for all –project a total of 15 Regional Accessibility Plans were created for different regions in Helsinki municipality (figure 5). These were based on the Helsinki City Accessibility Plan and were made by the Helsinki for all –project as well as in cooperation with citizens, different branches of administration, Associations of the Elderly and Disabled, and different services which are operating in the planning area. Since 2010, Regional Accessibility Plans have been an integrated part of Strategic Regional Plans, which are created by the Street- and park department at the Helsinki City Public Works Bureau (the Urban Environment Division since 2017) due to which accessibility work continues even though the Helsinki for all –project has ended. Regional Accessibility Plans are reports of the current state of public outdoor areas, such as streets, parks, plazas and market squares, of the requests from the citizens regarding physical accessibility in the area, and the needs of maintenance, which together guide the development of the area to become more physically accessible (City of Helsinki 2011, p. 104).

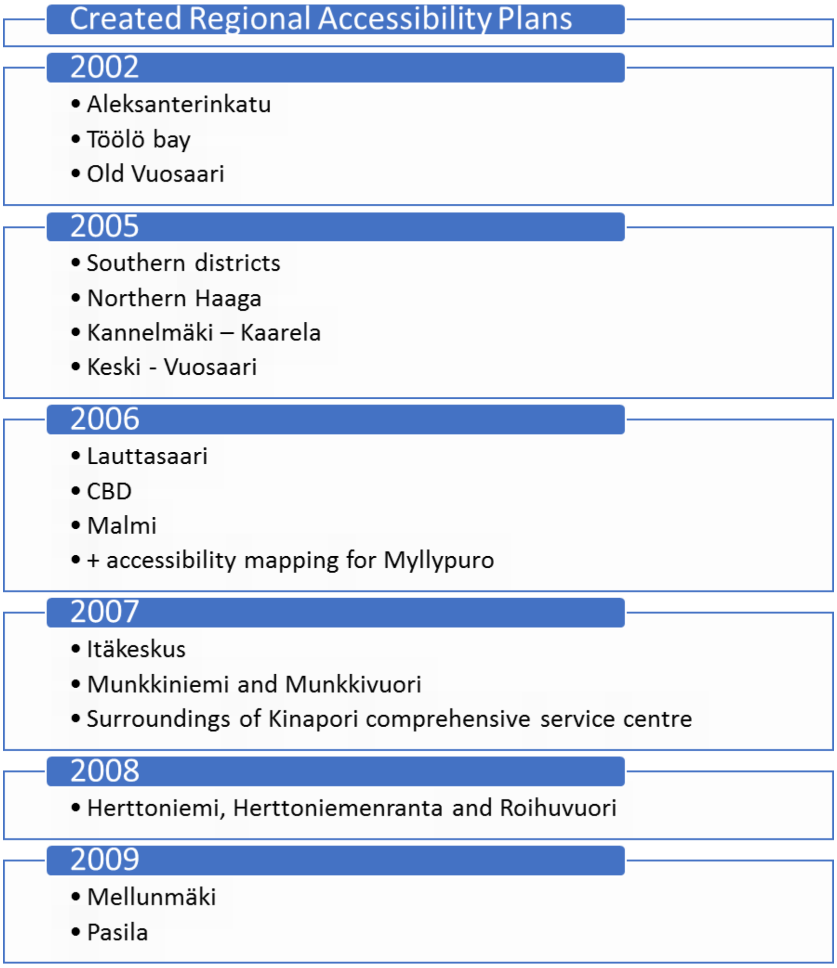

Figure 5. Created Regional Accessibility Plans. Sources: City of Helsinki 2011, p. 111; City of Helsinki 2016a.

Development areas were defined in Regional Accessibility Plans based on needs-based-prioritizing, and the areas were divided into three classes based on the urgency of development. During 2005, pilot areas were created with the help of information gathered during workshops which were developed to put the Helsinki City Accessibility Plan into practice. During the years 2006–2007 mapping commenced in areas which were classified as urgent, such as the Central Business District (CBD), and during the years 2008–2010 accessibility mapping was made in the second-most urgent areas (City of Helsinki 2011, p. 103). Needs-based-prioritizing commenced from the viewpoints and the needs of the user groups, such as the amount and quality of services and the age structure of the citizens in the planning area. The first Regional Accessibility Plans were made for areas that had a large population base of aged citizens and where the level of daily mobility is high. Also, if a planning project was to be commenced in the area, a Regional Accessibility Plan was made before the work of the other plan was started.

The Regional Accessibility Plans consisted of fieldwork, during which the physical accessibility of the regions was evaluated using participatory methods and the criteria listed in instruction cards made by the SuRaKu-project (City of Helsinki 2011, p. 104–105). The plans define the needs of improvement in physical accessibility for the region and the long period measures for the improvements (City of Helsinki 2011, p. 105; Junttila et al. 2012, p. 153). Special and basic level physical accessibility routes and regions were indicated in these Regional Accessibility Plans.

4.5 Physical accessibility specifications and instructions for the built environment

A project for improving the level of physical accessibility was carried out during 2003–2005 by six Finnish cities (Espoo, Helsinki, Joensuu, Tampere, Turku and Vantaa), by all central organizations for the elderly and the disabled persons, as well as the Ministry of Social Affairs and Health, Ministry of Transport and Communications and Ministry of the Environment (Ruskovaara 2009, p 13; Junttila et al. 2012, p. 154). The aim of the project, called the SuRaKu-project (suunnittelu, rakentaminen ja kunnostus = planning, construction and maintenance of physically accessible environments) which was organized and managed by the Helsinki for all –project, was to develop criteria as guidance for planning, constructing and maintaining of public outdoor areas. Additionally, eight instruction cards that present a planning model for typical outdoor areas, such as resting areas, were created. The instruction cards and criteria for physically accessible built areas present basic physical accessibility solutions for the design, dimensions and usage principles for the most important structures in the public environment; such as public street, park and garden areas (Ruskovaara 2009, p 13; Junttila et al. 2012, p. 154). The aim of the SuRaKu-project was also to collect all separate physical accessibility related instruction cards as a complete collection of guidelines for public outdoor areas.

The SuRaKu accessibility guidance collection consists of two parts. The first part includes the eight planning model instruction cards which represent specific functional entities, such as a resting area along a route. The second part includes the criteria for the 18 mostly used structures in the built environment that have an influence on the physical accessibility of the environment, like the structure of a pedestrian crossing. In 2007 the cities of Helsinki and Espoo started using new type drawings for planning and constructing physically accessible street areas that are based on the previous accessibility criteria (Ruskovaara 2009, p 14). Type drawings along with recommendations for materials, coloring and measurements have been created for the following basic structures: sidewalk, combined and separated pedestrian sidewalk and cycling route, askew pedestrian crossing, small roundabout, parking place for the impaired along the street, and tactile plates for orientation and attention. Many of the physical structures that are used in these physical accessibility criteria, type drawings and instruction cards, were developed in the ELSATUOTE-project, which started in 2004 with the purpose to design physical accessibility -products for the public environment. The kind of accessibility products that this project planned together with the Ministry of Transport and Communications, Ministry of the Environment, Ministry of Social Affairs and Health and product manufacturers includes edge supports for crosswalks, stair prefabs, and guidance tiles – or tactile plates – for persons with impaired vision. A guide for designing tactile maps and guidance for persons with impaired vision was created later in 2008 (Junttila et al. 2012, p. 154).

The SuRaKu instruction cards and criteria have been accepted as a national guideline for planning and construction of physically accessible environments and structures. In 2011, the SuRaKu-project won the national Accessibility price of the Year, awarded by the Association of Architecture, Construction and Design "ARMI" and The Finnish Association of People with Physical Disabilities (City of Helsinki 2011, p. 100). The instruction cards and the physical accessibility criteria have gained a significant status as national guidance for planning and construction of physically accessible urban environments, and they have been introduced in several Finnish municipalities (City of Helsinki 2011, p. 100). This in turn speaks for the quality of these guidelines and for the increasing interest in the planning and construction of physically accessible environments. The project and the physical accessibility criteria and instructions have also gained international interest.

The criteria are based on the environmental requirements that persons with mobility or functionality impairments need to be able to act independently. The criteria have been developed by taking into account different user groups, such as persons moving about with a walking aid; such as a walking stick, walking frame, wheelchair, crutches or a walker (Esteetön rakennus ja ympäristö… 2007); persons with impaired vision or children and families. Therefore, the physical accessibility criteria are divided into basic- and special-level physical accessibility depending on the requirements that the different user groups have on the built environment. By basic-level physical accessibility is meant high-class, accessible and safe planning, building and maintaining of the built environment which takes different user groups into consideration (Ruskovaara 2009, p 13; City of Helsinki 2011, p. 96; Junttila et al. 2012, p. 153). Basic level accessibility should be a standard in all public areas, but especially near schools and kindergartens, libraries and museums, churches and parish buildings, natatoriums and other sports facilities (City of Helsinki 2011, p. 107, 2016b). Special-level physical accessibility has more demanding criteria for the built environment and it takes into account the needs of persons with impaired vision. For example, the criteria for illumination, route and ramp slopes, frost protection systems, handrails, sound signals and other mobility guidance, such as tactile plates, are more strict in special level areas (Ruskovaara 2009, p 13). There should be special level accessibility environments around and to the following destinations: walking streets, center areas, health care, hospitals and service center areas, areas where there is a large elderly population, terminal areas for public transportation, and sports- and playground areas which are meant for everyone (City of Helsinki 2011, p. 96, 2016b).

The physical accessibility criteria for different elements of the built environment are introduced below divided into basic- and special level accessibility. The criteria have been collected from literature, accessibility instruction cards, RT-cards, type drawings and other physical accessibility guidelines. The criteria for different elements of the built environment presented in this section are also summarized in appendix 1. As there are a vast number of different physical accessibility criteria and guidelines for different kinds of elements and structures of the built environment, I in this section only cover those structures and elements that I am using in the empirical research. More details and guidelines can be found on Helsinki for all –webpage.

4.5.1 Pavements and sidewalks

Pedestrian traffic is quite sensitive to the condition of sidewalks, starting from pavement materials, sidewalk space, coloring and the height of sidewalk curbstones, and to the placement of various street furniture and static structures (Junttila 2011, p. 11). As we humans use our senses in orientating and while moving around in our surroundings, even the smallest details have an influence on how well we enjoy in our environment.

All public streets, market squares and park areas have some sort of coating or paving. For all user groups to be able to walk or move about safely in the built environment, the pavement material should be non-slippery, hard and even, and its quality should stay the same in changing climate conditions and when the pavement material changes from one to another (Verhe & Hirn 1996, p. 63–65; Esteetön rakennus ja ympäristö… 2007, p. 16; Gehl 2010, p. 132; Junttila 2011, p. 46). The slope gradient has a big effect on how well a person with walking difficulties or a wheelchair user can move about on the sidewalk. The slope should not be more than 5 % on longitudinal inclination and not more than 2 % on lateral inclination on special level accessibility areas and less than 8 % and 3 % on basic level accessibility areas. Good pavement materials for all user groups are asphalt, crushed stone fines, concrete or stone slab (Verhe & Hirn 1996, p. 63–65; Esteetön rakennus ja ympäristö… 2007, p. 16; Junttila 2011, p. 46). Cobblestones, sand, loose gravel and an uneven ground surface are in most cases unsuitable, especially for wheelchair users and persons with walking difficulties (Gehl 2006, p. 135). Gaps and seams between two elements should not be more than 5 mm wide as a wheelchair might get stuck in a gap wider than this (Verhe & Hirn 1996, p. 63–65; Esteetön rakennus ja ympäristö… 2007, p. 16; Junttila 2011, p. 72–74). This also concerns gutters that are located along or across the sidewalk. Additionally, any bumps, sinkholes or street inlet covers should be less than 5 mm high above the surface level or otherwise a person with impaired vision could stumble on them. These also feel displeasing to wheelchair users.

As persons with walking difficulties may have problems in maneuvering and as wheelchair users need space for both moving forward and turning around, there has to be enough space on a pedestrian sidewalk so that there is enough space for everyone. The sidewalk should be divided into separate lanes for pedestrians and bicyclists so that pedestrians can feel safe when walking in their designated lane. The different lanes should be recognizable by different paving material or color and the border between the two areas should be noticeable even to persons with impaired vision (Esteettömän ympäristön suunnitteluohjekortti 1/8 2008). To be able to move a wheelchair, at least 150 mm of free space is required on both sides of the wheelchair and to be able to turn around, a wheelchair requires a circular space of 1500 mm in diameter (Perustietoja liikkumis- ja… 2011). A space of 1500 mm is required even for a person who walks with an assistant or a dog. Therefore, preferable space on a sidewalk, on each side, would be at least 900–1800 mm (Verhe & Hirn 1996, p. 61), and a total of at least 2300 mm of space is required so that street cleaning machines can operate on the sidewalk (Esteettömän ympäristön suunnitteluohjekortti 1/8 2008). Both special and basic level accessibility routes and areas require wintertime maintenance.

The above-mentioned criterion for pavement attributes concern both special and basic level accessibility. However, special level criteria have to take persons with impaired vision into consideration and therefore there are more strict criteria for pavement materials and attributes on this level. The pavement should be designed and constructed in a way so that persons with impaired vision can easily orientate in their surroundings. This means that the pavement surface needs to be bright and reflective and there has to be elements that help in navigation (Jokineimi 2007, p. 82). This is done by using tactile tiles which either warn for upcoming change, such as a pedestrian crossing, or help navigate a person to walk straight across, for example, a market square (Verhe & Hirn 1996, p. 63–65). Colors, contrasts and different materials are also used in giving signals (Verhe & Hirn 1996, p. 34; Esteetön rakennus ja ympäristö… 2007, p. 11, 18; Perustietoja liikkumis- ja… 2011). A warning tactile tile, where nodules are usually used to signal danger or change, should be placed before pedestrian crossings, stairs, and the beginning of a roadway (Verhe & Hirn 1996, p. 63–65; Esteetön rakennus ja ympäristö… 2007, p. 18; Jokiniemi 2007, p. 97). The warning tactile tile should also be of another color than the surrounding pavement so that it is recognizable from distance. Steering tactile tiles are usually designed with longitudinal relief and are placed to show the way to entrances, across large open areas and the location of resting areas along the path (Verhe & Hirn 1996, p. 63–65; Esteetön rakennus ja ympäristö… 2007, p. 18; Perustietoja liikkumis- ja… 2011). Curbstones should be high enough between the roadway and the pedestrian sidewalk, so that a person with a white stick can easily recognize the beginning of the roadway (Esteetön rakennus ja ympäristö… 2007, p. 18; Perustietoja liikkumis- ja… 2011). Preferable height of curbstones are 120 mm along the road and 60–80 mm along parking area intersections and the curbstone should be lowered along intersections to parking space for persons with impairments (Junttila 2011, p. 62).

4.5.2 Pedestrian crossings

All sidewalks should continue with a pedestrian crossing with clearly recognizable pedestrian crossing markings at intersections with driveways to give the feeling of safety. Measurements for crossing areas are the same for both special and basic level accessibility crossings. The difference between these levels is that special level accessibility crossings require sound signals and differences in pavement materials and colors which act as warning areas. The crossing area should be divided into pedestrian and bicycle lines to minimize the risk for accidents.

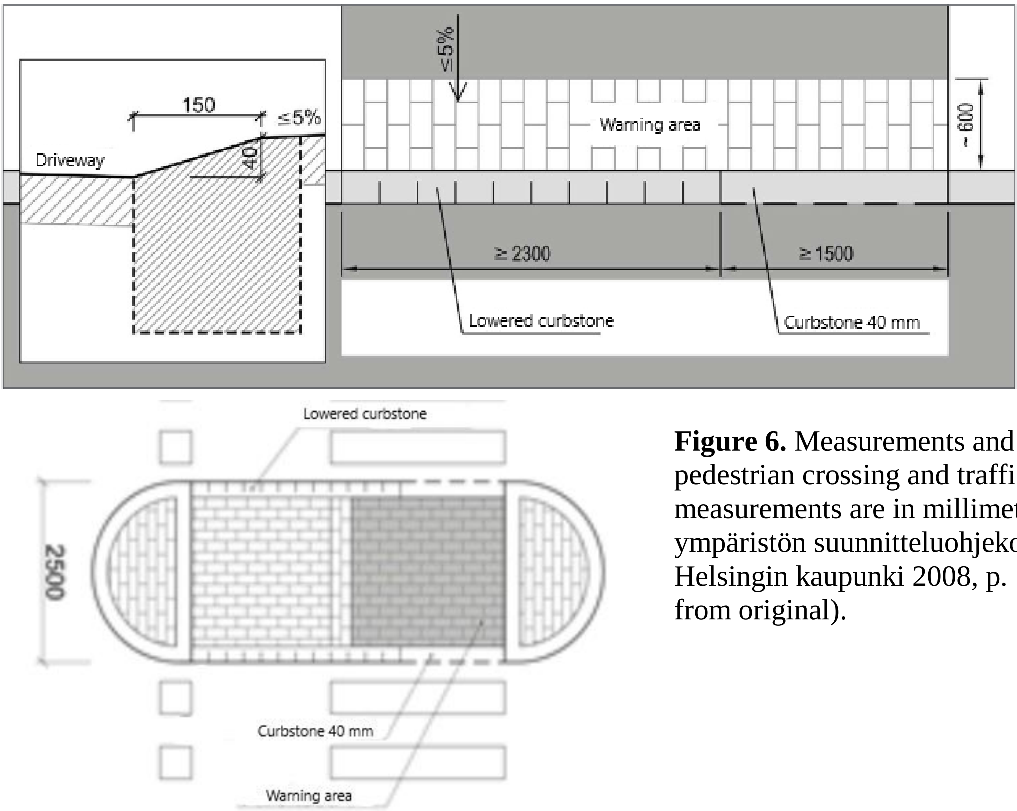

Figure 6. Measurements and design of pedestrian crossing and traffic island. The measurements are in millimeters (Esteettömän ympäristön suunnitteluohjekortti 1/8 2008; Helsingin kaupunki 2008, p. 16, translated from original).

A special level accessibility crossing area for pedestrians is divided into a section with a ramp-curbstone for wheelchair users and an edged curbstone for persons with impaired vision. Ramp-curbstone section should be of a minimum width of 2300 mm so that the crossing can be cleaned mechanically. The edged section should be a minimum width of 900–1500 mm and of minimum height of 10 mm and be in right angle towards the sidewalk so that persons with impaired vision can orientate straight across the roadway if using a white stick. The measurements of ramp-curbstones' minimum width is 1500 mm and the maximum height on sidewalk sides is 40 mm on a tread of 130–160 mm (figure 6) (Helsingin kaupunki 2008, p. 1; Perustietoja liikkumis- ja… 2011). On special level accessibility areas there has to also be a warning area the width of 600 mm before the crossing. The warning area could be of tactile tiles and it should at minimum be of different material and color than the surrounding area. The slope should be less than 5 % on longitudinal inclination and less than 2 % on lateral inclination (Helsingin kaupunki 2008, p. 1).

A pedestrian island in the middle of the crossing should be big enough to enable a wheelchair to stop if necessary. An example of the measurements for a pedestrian island is presented in figure 6. The measurements for curbstones are the same as stated above. On special level accessibility areas the pedestrian island should be covered with paving that gives the signal of warning.

4.5.3 Stairs and ramps

Differences in level cause a real problem for pedestrians. All movement upward or downward requires more effort, muscular activity and interruption in the walking rhythm than walking on an even path (Gehl 2006, p. 142–145). Stairs are a traditional way to solve the problem of level change in urban environments, but for a path to be accessible for all, there has to be an alternative route to the destination so that stairs can be avoided or circumvented. Ramps should be offered along with stairs. The design of stairs should be such that persons with walking difficulties can easily ascend or descend them. Gradual, short ascents and descents are less difficult to move about on than long sharp ones as a long, steep stairway is felt psychologically more tiring than a number of short set of steps that are interrupted by landings (Gehl 2006, p. 142–145).

The measurements for an accessible stairway differ in source literature. The measurement requirements are different for stairs in indoor space and outdoor space. The riser of the stair in outdoor space is recommended to be maximum 120–160 mm and the tread should be minimum of 330–400 mm (Helsingin kaupunki 2008, p.2; Junttila 2011, p. 66–67; Perustietoja liikkumis- ja… 2011). There should be a landing after every 10–15 steps which is at least 900–1200 mm long where it is possible to rest (Helsingin kaupunki 2008, p. 2; Junttila 2011, p. 66–67). The edge of the stair should be equipped with a color contrast stripe 30–40 mm wide so that the step would be more noticeable (Helsingin kaupunki 2008, p. 2). Handrails should be installed if there are more than 3 steps in the stairway in which case the handrail should be at the height of 900 mm and 700 mm on special level accessibility areas and at the height of 900 mm on basic level accessibility areas (Esteetön rakennus ja ympäristö… 2007, p. 23, 26; Helsingin kaupunki 2008, p. 2; Junttila 2011, p. 144). The handrails should preferably be on the both sides of the stairway and have to be continuous as well as start and end 300 mm before and after the stairway. In wide stairways the handrail can also be placed in the middle of the stairway (Esteetön rakennus ja ympäristö… 2007, p. 26; Helsingin kaupunki 2008, p. 2). That way it is easier to stop and let other persons walk by if necessary.

There should always be a ramp near the stairway, or alternatively a lift, for persons with walking difficulties, wheelchair users, and for persons with a pram or luggage. Even other user groups, than the ones mentioned, often tend to prefer ramps over stairs when possible (Gehl 2006, p. 142–145, 2010, p. 130–131). Therefore, the ramp should be designed physically accessible and easy to use from the perspective of several user groups. The longitudinal slope of the ramp should not be more than 8 % (1:12,5), preferably 5 % (1:20), and the length should be maximum of 6 meters after which there should be a landing with minimum of 1500–2000 mm length for resting (Helsingin kaupunki 2008, p. 3; Junttila 2011, p. 66–67; Perustietoja liikkumis- ja… 2011). If there is no landing, the longitudinal slope of the ramp should be a maximum of 5 %. The lateral slope should not be more than 2 % as otherwise the wheelchair user might have to make adjustments while wheeling. The width of the ramp is minimum 900 mm when the ramp is less than 6 meters long, 1800 mm width if there is a landing so that two wheelchairs can go past one another and also of 1800 mm width if the ramp is longer than 6 meters and there is no landing (Esteetön rakennus ja ympäristö… 2007, p. 23). The requirements for handrails are the same as for the stairways (Esteetön rakennus ja ympäristö… 2007, p. 23; Helsingin kaupunki 2008, p. 2; Junttila 2011, p. 66–67; Perustietoja liikkumis- ja… 2011). Ramps should be kept free of ice and snow during winter either by mechanical maintenance or by heating. The measurements of a stairway, ramp and handrailing are illustrated in figure 7 below.

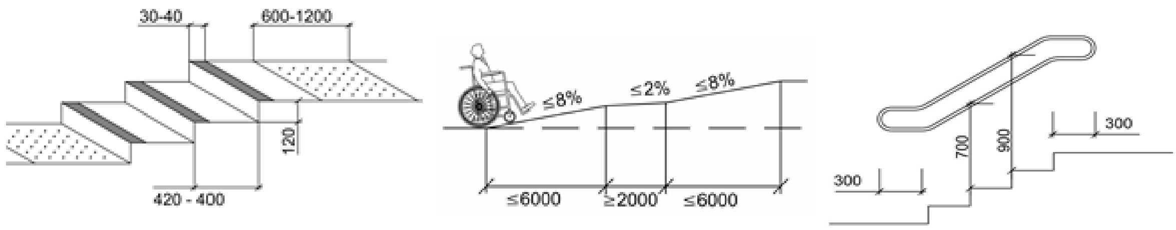

Figure 7. Measurements of stairways, ramps and handrailing. Measurements are in millimeters. Source: Helsingin kaupunki 2008, p. 2–3, 10.

4.5.4 Illumination

Good illumination is important for all user groups. It provides a feeling of safety during the dark period of the year and in areas with little natural light or light from other sources (Jokiniemi 2007, p. 82). All walking lanes both indoors and outdoors, entrances and structures that are relevant from a mobility point of view, such as doors, stairways and ramps, should be illuminated so that walking is safe and easy also when it is dark (Esteetön rakennus ja ympäristö… 2007, p. 11; Jokiniemi 2007, p. 43). Good illumination is especially important for persons with impaired vision, as good illumination helps in recognizing shapes of objects, markings in the pavement, possible barriers, hazards such as ice and water on the pavement, and the shape and direction of the street (Jokiniemi 2007, p. 43; Junttila 2011, p. 159).

The requirements for illumination are defined based on the lighting class of the surrounding street area and the functions of the area, like the services, main modes of traffic, and density of intersections and parking, to name a few (Junttila 2011, p. 12, 159). Light should be evenly distributed in the public urban space and there should not be formed dark spaces that make it difficult to recognize the locations of the motorized street and the pedestrian sidewalk. The function of illumination is to help in orientation, to show the interest points such as entrances and resting areas, and the direction of walking routes, locations of barriers, hazards, and destinations and to essentially help people see in dark spaces (Verhe & Hirn 1996, p. 34; Esteetön rakennus ja ympäristö… 2007, p. 12–18; Jokiniemi 2007, p. 43). Therefore, street lights should be placed continuously on the same side with the sidewalk, about 1-meter distance from the sidewalk edge, and by the first and last step of the stairway, as well as near ramps and entrances (Esteetön rakennus ja ympäristö… 2007, p. 18, 80; Jokiniemi 2007, p. 43). Lighting can also be placed in the hand railing in stairways and ramps, but preferably not on the ground so that the light points straight up as it may blind (Jokiniemi 2007, p. 82).

Good lighting should highlight contrasts of the surroundings, show colors brightly and take advantage of reflective attributes of objects. Good illumination classes have been defined in Jukka Jokiniemi's research and the result was that class K4, or 5 lux is not enough for the elderly or for persons with impaired vision. Class K4 is often used as sidewalk lighting amplitude (Jokiniemi 2007, p. 82). Good lighting amplitude, when using lighting classes for light traffic, is K1–K3, or 10–15 lux by the routes, 20–50 lux by interest points such as entrances, intersections, stairways and ramps, and 30–50 lux at underpasses (Verhe & Hirn 1996, p. 46; Esteetön rakennus ja ympäristö… 2007, p. 80; Jokiniemi 2007, p. 82).

4.5.5 Urban furniture and stationary objects

Urban furniture are all kinds of stationary or moveable objects, equipment, device and light structures that are relevant for street life and various urban functions, such as traffic, maintenance and leisure (Junttila 2011, p. 113). These kinds of objects are trash bins, benches, planter boxes, railings, fences, different canopies and kiosks, to name a few. The choice of urban furniture and their placement is dependent on the functionalities of the objects and the area (Junttila 2011, p. 113–117). It is possible to affect human behavior by the placement of urban furniture. For example, by placing benches it is possible to interest people to stop in the area and by placing fences it is possible to prevent walking to or through an area.

The lack of places to sit is the most frequently named complaint for the elderly in urban areas (Gehl 2006, p. 162). Placing out benches is the most traditional way of creating comfortable urban environments. The need to rest and sit down for a long or a short period of time can be required by anybody and for any reason. It is suitable that there are places to sit at regular intervals in city or residential areas, in areas where people tend to wait; such as by public transport stops and traffic nodes, and especially along pedestrian paths or in areas where there is a lot of mobility (Gehl 2006, p. 162; Junttila 2011, p. 140–142). A good interval for benches could be, according to Gehl, every 100 meters (Gehl 2006, p. 162). When choosing where to place the benches, it is important to take care that the placement does not become a barrier for free movement for pedestrians. The location of a resting spots can be highlighted by illumination, by using different pavement materials and steering elements in the paving so that persons with impaired vision have it easier to locate benches.

In accessible benches the seating height should be a bit higher than in benches commonly, approximately 500 mm high, while usually they measure 400–500 mm (figure 8) (Helsingin kaupunki 2008, p. 14; Junttila 2011, p. 140–142). Benches in the same area could also be designed to different heights. There should always be a back rest and handrailing by benches in order to aid persons in sitting down and standing up.

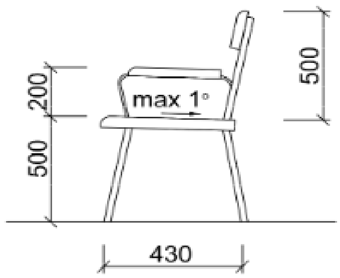

Figure 8. Excample of accessible benches in pedestrian areas. Measurements are in millimeters. Source: Helsingin kaupunki 2008, p. 14.

4.5.6 Public transport stops

Public transport (PT) stops are part of the public transport network and they enable people to access various places along the traffic network route. The placement of public transport routes and stops has an influence on how well different locations and points of interest are accessible from residential, or other, areas. As it has been noted earlier, the acceptable walking distance in ordinary daily situations is approximately 400–500 meters for most people, and preferably less for children, the elderly, and persons with impairments (Gehl 2006, p. 137, 2010, p. 121–125). This results in that the distance between two public transport stops should be 500 meters or less and that all significant services should be accessible within a 500 meters radius from the public transport stop.

Public transport (PT) stops and stations should be noticeable from the sidewalk and from its surroundings. It is possible to use contrast materials and colors in pavement to indicate the location of PT stops. Signing should be visually accessible and signs should be placed both high and low so that blind persons may feel the braille of the signing. PT stops which have a canopy are more easily noticeable for persons with a white stick than PT stops with just a signing pillar (Verhe & Hirn 1996, p. 97). Suitable depth of the canopy is 1500 mm so that a wheelchair fits underneath. A bench is to be placed at the height of 420–520 mm inside the canopy for resting while waiting for the vehicle (Helsingin kaupunki 2015). There should be a protective railing, especially if the PT stop is in the middle of the motorized roadway. A good height for the railing is 900 mm (Junttila 2011, p. 126). A steering railing could also be used near the stop to help in orientating. The loading island should be at the same level as the floor level of the vehicle and it should be situated in a way that enables bicycle traffic to pass behind the waiting space. Appropriate curbstone height for the loading island is 160–200 mm if the waiting area is raised, else 120–160 mm (Helsingin kaupunki 2015). The edge of the loading island is to be clearly marked with a 300 mm wide warning area with contrast stripe and different paving materials than the surrounding (Helsingin kaupunki 2015).

The size of the PT waiting area when measured from the edge of the loading island to the walls of the PT canopy should be at least 1500 mm but preferably 2250 mm wide so that mechanical maintenance is possible. Free space around the canopy should be a minimum of 900 mm but preferably 1500 mm so that a wheelchair can have access to the canopy. The slope of the waiting area should be less than 3 % of longitudinal inclination and less than 2 %

of lateral inclination. Lateral inclination should be faced away from the edge of the waiting area to prevent prams, wheelchairs and other objects with wheels from drifting towards the driveway. (Helsingin kaupunki 2015). The measurements for PT stop and the canopy are illustrated in the figure 9 below.

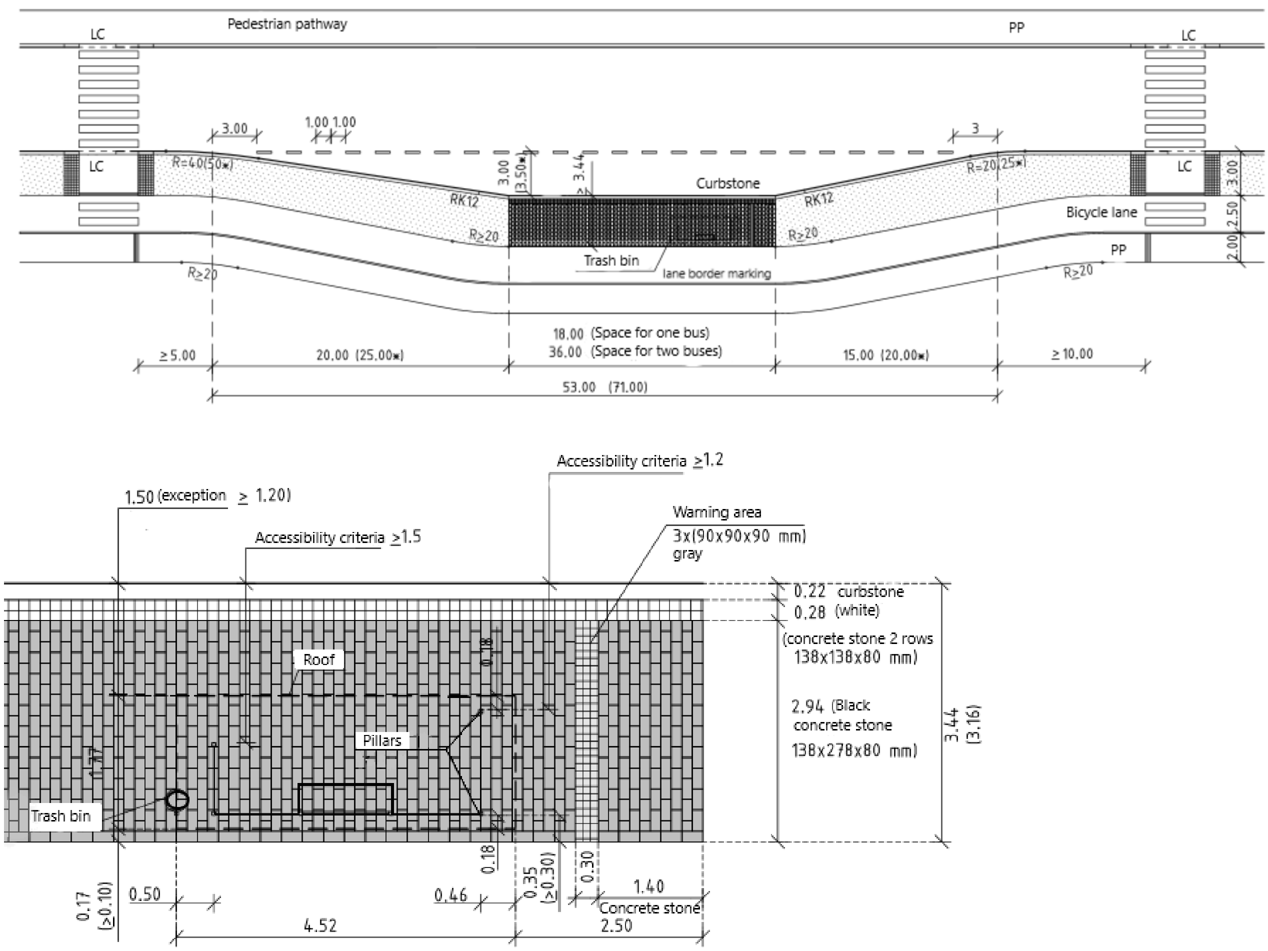

Figure 9. Measurements of a public transport stop and a loading island with a canopy. The measurements are in meters. Source: Helsingin kaupunki (2015).

Part II Modeling physical accessibility index

5 Introduction to empirical research

The aim with this empirical research is to study the current level of physical accessibility in the research areas through using GIS (geographical information systems) based methods. To achieve this, a method will be developed based on the 8D model of the urban structure that has been introduced previously. The physical accessibility criteria, which were introduced in chapter 4.5, will be taken into consideration in the analysis, when it is possible.

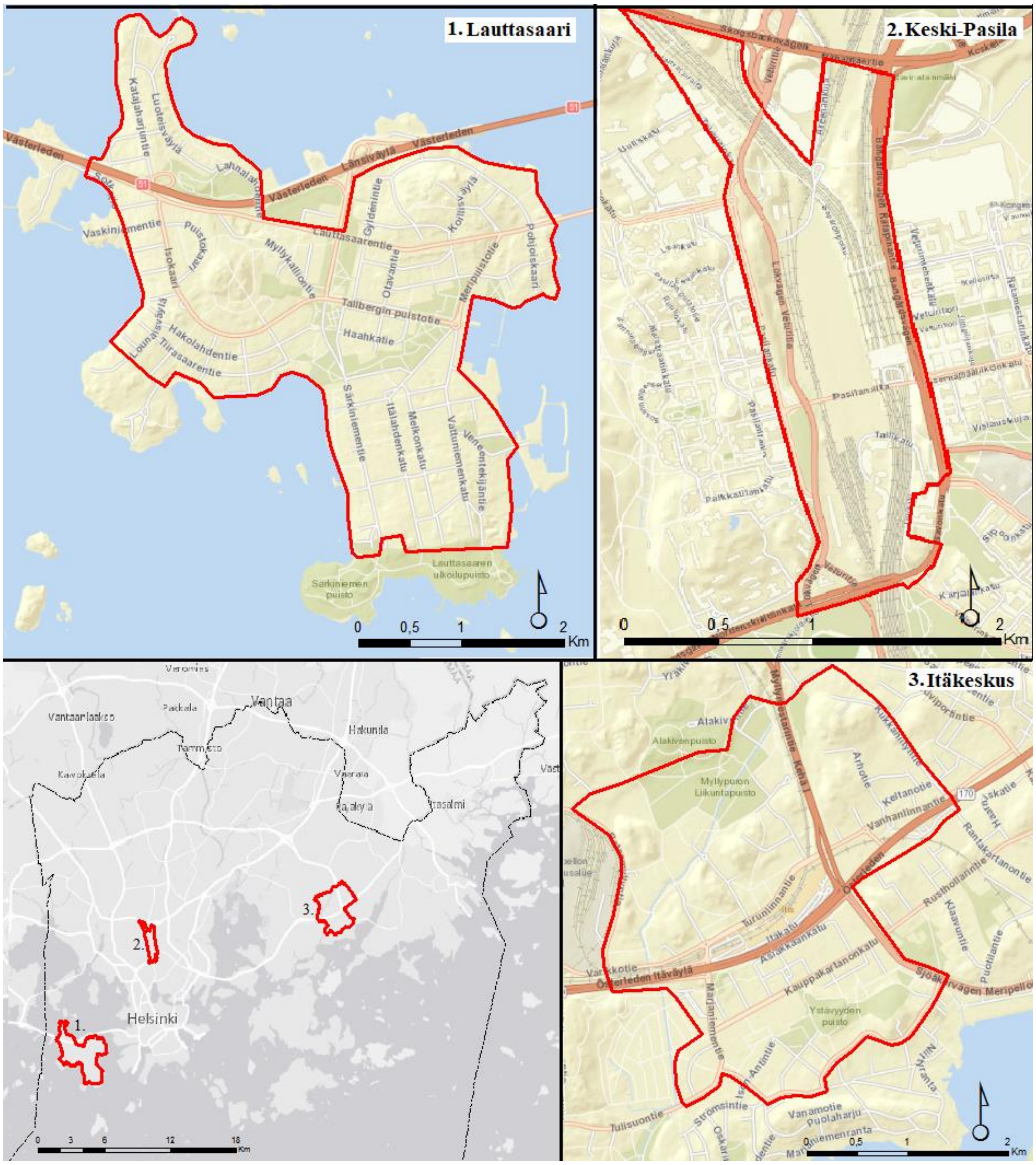

Figure 10. Locations of the research areas. Research area borders are marked with red contours. Source of basemap: City of Helsinki 2016c.

Empirical research is made for three different research areas: Lauttasaari, Itäkeskus and Keski-Pasila (figure 10). The research areas in this study have been chosen according to which stages of development physical accessibility has been implemented in the design and building of these areas. Lauttasaari and Itäkeskus were one of the first areas to have a Regional Accessibility Plan and these plans were created after the planning of the areas had already been done (Tujula 2017; results from the electronic questionnaire). At that time physical accessibility work had just begun in Helsinki. These areas were selected also because there is spatial data available to be used in a GIS analysis. In Keski-Pasila the aspect of physical accessibility has been implemented in all stages of the planning and building of the new neighborhood area (Tujula 2017). This is a completely new neighborhood area is currently under construction. Therefore, there is no spatial data available that could be used in a GIS analysis; as such, this is substituted by digitizing planning documents from the area. There are big differences in how physical accessibility has been taken into consideration in the study areas. The chosen areas reflect a kind of an evolution in the pursue to implement physical accessibility aspects in planning as a natural part of the process.

5.1 Itäkeskus

Itäkeskus research area is located in the eastern major district of Helsinki municipality (figure 10). The research area border is defined similarly as the research border in the Regional Accessibility Plan of Itäkeskus, which was created in 2007 (Helsingin kaupunki 2007). However, the border shape has been adjusted slightly in its southern part. The research area now borders the roads Marjaniementie, Kissankellontie and Kunnallisneuvoksentie (figure 11). This has been done so that the residential areas that are located north of these roads, as well as Puotila underground station, would be included in the analysis. In the Regional Accessibility Plan the research border stretches across the residential area and the green area located in the southern part of the research area (Helsingin kaupunki 2007).

The research area has about 26 700 inhabitants (Statistics Finland 2015), and work places for over 10 000 persons (City of Helsinki 2017b). The number of persons over 65 years old is somewhat higher in the research area than the average in Helsinki municipality. The number of elementary school kids (7–15 years old) is similar to the average in Helsinki, however, the number of children under elementary school age (0–6 years old) is lower than the average in the municipality (Mäki & Vuori 2016).

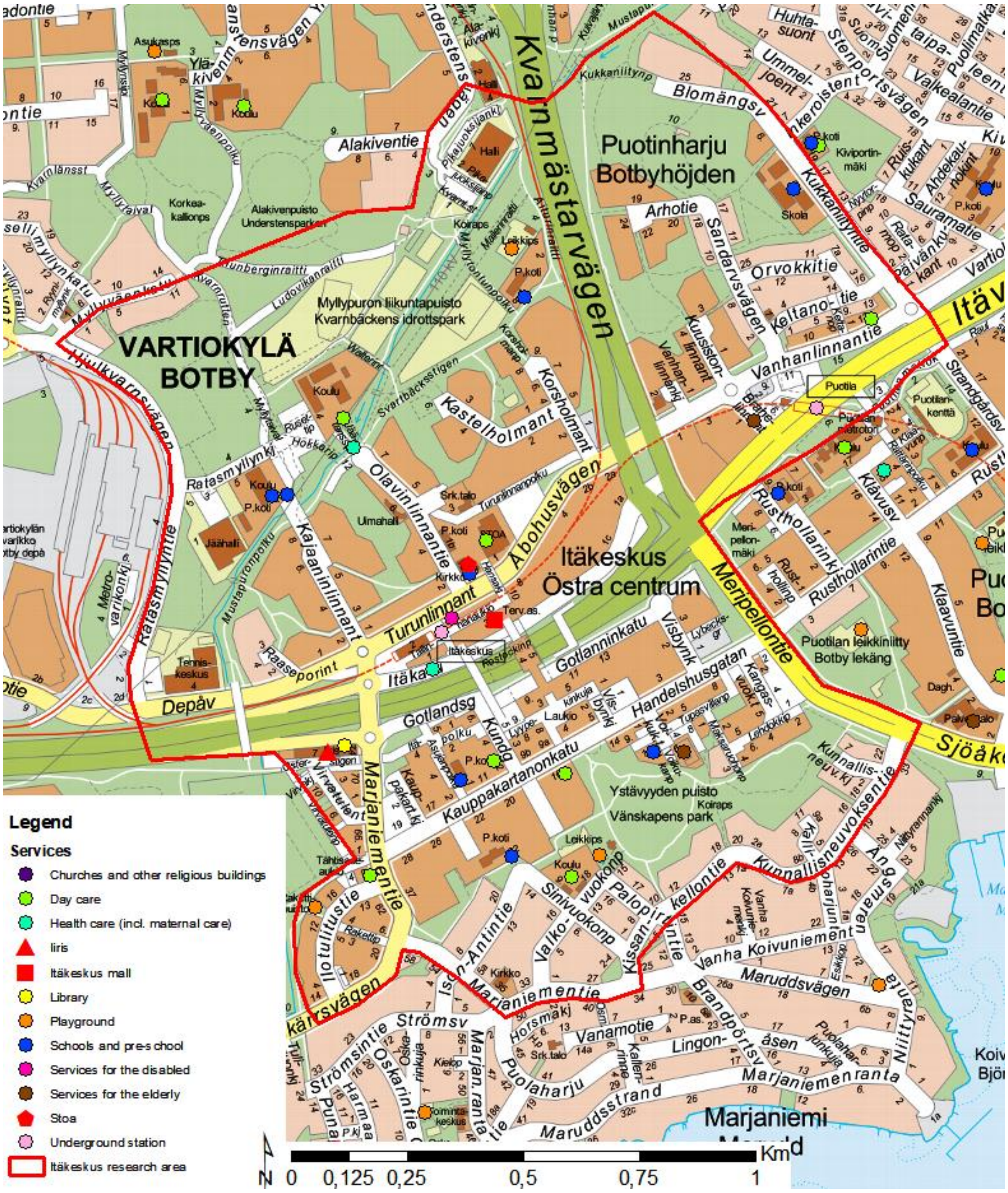

Figure 11. The locations of services which require good level of physical accessibility environments in Itäkeskus research area. Sources: data; City of Helsinki Service Registry 2017, base map; City of Helsinki 2016c.

Puotinharju, which is located in the northern part of the research area, consists of mixed residential dwellings in a forested area with detached houses, townhouses and high-rise apartment buildings. The area has been built according to suburban ideals during the 1960's (Helsingin kaupungin rakennusvirasto 2016a). Community center Stoa and Puotinharju mall were built during the 1980's in this area. The northern side of Puotinharju consists mainly of a vast green area with many recreational services. The center of the research area is dominated by Itäkeskus mall. The surroundings of Itäkeskus mall is to a large extent made up of high-rise apartment buildings and was built during the 1970's (Helsingin kaupungin rakennusvirasto 2008). The southern side of the mall was built during the 1980's. The southern part of the research area, Marjaniemi area, has been formed by developments during many different decades and is comprised of detached housing. The topography of the research area is mostly planar, however, elevated areas can be found in Marjaniemi area and in the north-western part of the research area.

There are many services in the research area that require special level accessibility (figure 11). These services include the office building of Finnish Federation of the Visually Impaired (FFVI) called Iiris, Itäkeskus mall, community center Stoa and many service housing centers for the elderly (Helsingin kaupungin rakennusvirasto 2008, 2016a). Additionally, there are many day care centers and schools, a library, church and congregational buildings, which also require special level accessibility. As the research area has been built before there were any physical accessibility criteria, type drawings for street areas or even requirements for physical accessibility in the national legislation, physical accessibility of the public areas have been considered only during refurbishments and renovations carried out in the area at a later stage.

The areas that require special level accessibility were defined in the accessibility mapping for the Regional Accessibility Plan. Special level accessibility areas are the Itäkeskus mall and the pedestrian routes surrounding the mall (Helsingin kaupunki 2007, Helsingin kaupungin rakennusvirasto 2008). It is noted in the accessibility mapping that many of the pedestrian routes in the area are largely said to be accessible and the pedestrian crossings are also in good condition. However, these do not fulfill the criteria stated in the type drawings for street areas as many of the streets have been built during a time when there were not any accessibility criteria. The research area was mapped again after the Regional Accessibility Plan was finished to gain base information of the condition of the pedestrian network for Regional Plans. There are two existing Regional Plans for the research area; the Regional Plan for Myllypuro, Puotinharju and Roihupelto for the years 2016–2025, and the Regional Plan for Itäkeskus-Marjaniemi for 2009–2018 (Helsingin kaupungin rakennusvirasto 2008, 2016a). In these mappings the pedestrian routes were also stated to be largely in good condition, except in Puotinharju, where there is a need for renovations (Helsingin kaupungin rakennusvirasto 2008, 2016a). In addition, especially the road leading to the school had major safety issues.

An electronic survey was carried out during this research where regional planners as well as traffic- and street planners were asked to answer questions concerning the accessibility of the research areas. Based on the answers, the Itäkeskus research area has a comprehensive basic level accessibility pedestrian route network. The level of accessibility has been improved through maintenance, updated planning, restorations and new construction. However, according to traffic and street planners, there is not enough space for major improvements as the area has already been built and space is now limited. Special level accessibility solutions require more space, and according to the planners, if this has not been taken into consideration in local masterplans or detailed land use plans, it is difficult to find the required space. This dilemma is however well known and as there are more physical accessibility guidelines for planners available, the situation is improving.

5.2 Lauttasaari

Lauttasaari research area is situated in the southern major district and is the most south-western neighborhood of the Helsinki municipality (figure 10). The area consists of the sub-areas Kotkavuori, Myllykallio, Koivusaari, as well as Vattuniemi and Katajaharju capes (City of Helsinki 2017c; Wikipedia 2017c). The research area border is defined to include all built areas, but the southern, western and northern green areas have been excluded from the research area (figures 10 and 12). The southern and western recreational areas are not therefore included in the research. By this it is ensured that the research is made for built areas only.

Lauttasaari is the home for about 23 000 inhabitants (Statistics Finland 2015) and there are workplaces for about 8 000 persons (City of Helsinki 2017c). The number of over 65 year old persons is slightly higher than the average in Helsinki municipality and the number of school-aged children (7–15 years old) is a bit lower than the average in Helsinki (Mäki & Vuori 2016). The residential areas consist mainly of high-rise apartment buildings, with detached housing being located south of the road Isokaari as well as by the coastline of the cape Katajanharjuniemi (Helsingin kaupungin rakennusvirasto 2010). There is a national bicycle route stretching across the area as well as a guided scenic route along the coastline. The area hosts services that require special level accessibility; there are two service housings centers for the elderly, a church, congregation buildings, a health-clinic and maternal services, several day care services, and three schools (figure 12). Furthermore, there are plenty of parks, recreational areas and playgrounds. The topography of the area is varying with the elevation shifting between 0 and 35 meters above sea level. However, most of the area is located below 5 meters above sea level (Helsingin kaupungin rakennusvirasto 2010). According to the results from the electronic questionnaire, elevation causes problems from an accessibility point of view, especially along the road Lauttasaarentie.

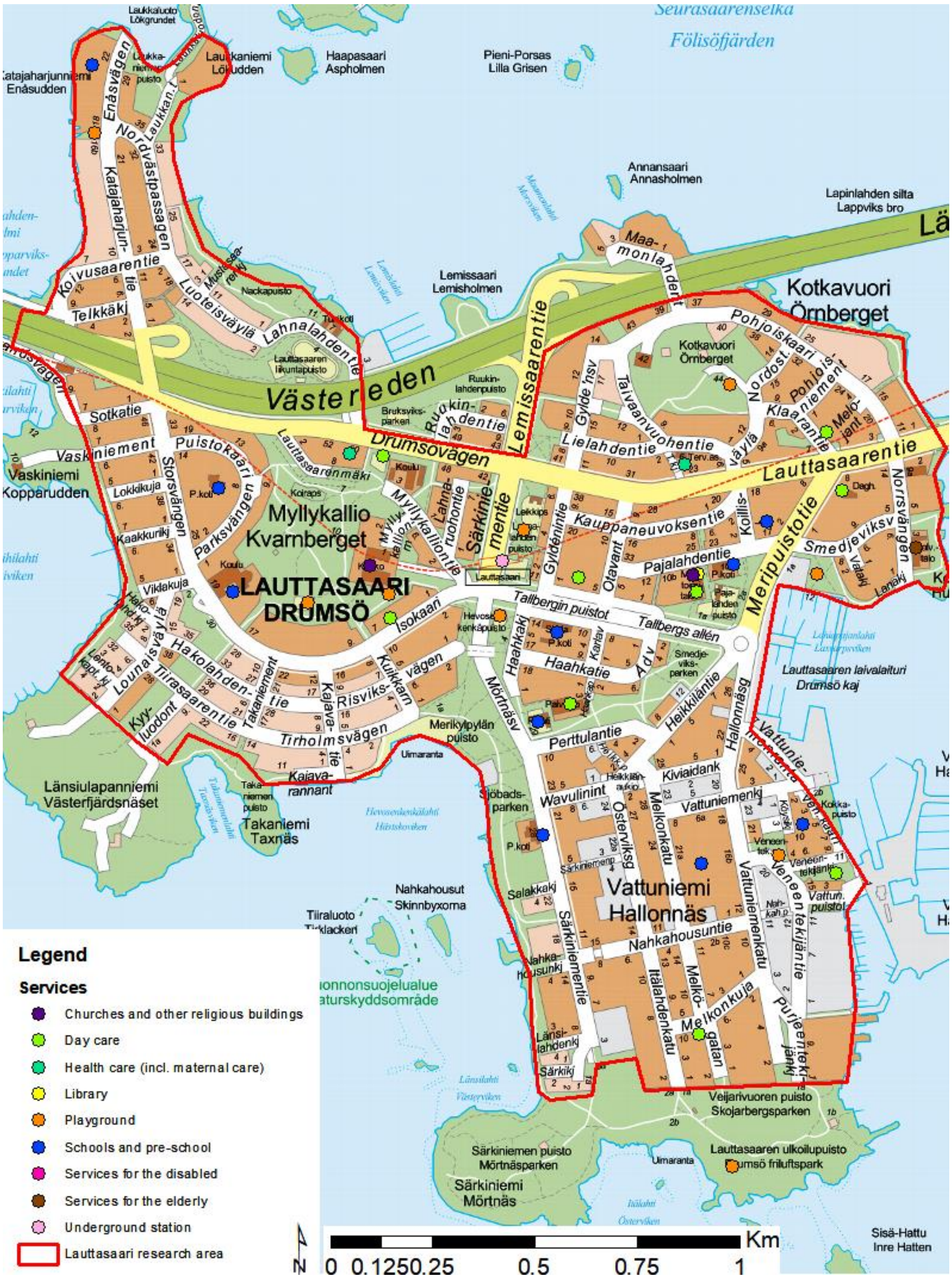

Figure 12. The locations of services which require good level of physical accessibility environments in Lauttasaari research area. Sources: data; City of Helsinki Service Registry 2017, base map; City of Helsinki 2016c.

There has been settlement in Lauttasaari already during the 16th century, but the area has been more densely built from the 1950's onward (Wikipedia 2017c). The southern part of the island, Vattuniemi cape, was built as an industrial area during the 1940's and 1950's. The central parts of the Lauttasaari island – Myllykallio and Kotkavuori – were also built mostly during the 1940's and 1950's. As the research area was built before there were physical accessibility criteria or even requirements for physical accessibility in the national legislation, physical accessibility of the public areas have been considered only during refurbishments and restorations that have been carried out in the area.

The Regional Accessibility Plan of Lauttasaari was made in 2006 (Helsingin kaupunki 2006). The accessibility plan includes defined locations for special and basic level routes and areas in addition to a list of actions of improvement for enhancing the physical accessibility of the area. According to the accessibility mapping, which was made along with the Regional Accessibility Plan, the pedestrian routes are mostly in good condition and the curbstones are in general accessible. However, it was stated that improvements are needed to curbstone accessibility at pedestrian crossings, and the painted crossing marks needed maintenance in several places (Helsingin kaupunki 2006). The accessibility at pedestrian crossings was considered quite poor from the point of view of persons with impaired vision. Pedestrian routes were considered narrow for a pedestrian and a bicyclist to meet safely in several places (Helsingin kaupunki 2006). The same observations were also made during the accessibility mapping for the Regional Plan from 2010 (Helsingin kaupungin rakennusvirasto 2010).

According to the insight gathered from the electronic questionnaire for planners, the level of physical accessibility is predominantly good in the Lauttasaari research area. However, the infrastructure in Lauttasaari has been built over several decades and in many places the structures are not built according to the type drawings for street areas as current physical accessibility guidelines were not yet available at the time of construction. For this reason, many of the pedestrian routes can be non-accessible, although they are continuously being updated to meet the requirements in the type drawings for street areas during new construction and restorations.

5.3 Keski-Pasila

Pasila is a neighborhood located in the central major district in the City of Helsinki (Figure 10). It is nowadays divided into four sub-areas: Eastern, Western, Northern and Central Pasila (Uutta Helsinkiä 2017); the last being the new Keski-Pasila area which is currently under construction. Pasila was built for the most parts during the 1970's and 1980's and it is much an office-building dominated area (Uutta Helsinkiä 2017). The structure of the neighborhood has for a long time been divided, as the areas of East-Pasila and West-Pasila are separated by a vast railyard area. This is the location where the new Keski-Pasila neighborhood is being built. The area has for a long time been a traffic area that has been owned by Senate Properties, ergo the State of Finland (Uusi Pasila 2017a). East and West Pasila have previously been connected only by the Pasila Bridge.

The planning of Keski-Pasila begun already during the 1970’s, but only after the Vuosaari harbor was opened in 2008 was it possible to transfer all cargo transports from Pasila to Vuosaari, which in turn opened new opportunities to reuse the railyard area (Uutta Helsinkiä 2017). The new local master plan of the area was approved 14th of June 2006 (City of Helsinki 2008). The vision is that Keski-Pasila would become a new center of commercial, residential and business activities. The new neighborhood will unite the formerly disconnected Pasila city area, providing accommodation and workplaces for thousands of people. According to the vision, by 2040 there will be 5 000 residents along with 13 000 work places for citizens (YIT 2017).

The new neighborhood consists of different sub-areas. The center of the neighborhood is dominated by Pasila railway station, which is the second busiest railway station in Finland right after Helsinki Central Railway Station (figure 13) (Uutta Helsinkiä 2017). All local and long-distance trains stop at Pasila railway station and nowadays there is also a rail connection to Helsinki-Vantaa Airport. There will also be new tram and bus lines after the area is built. According to calculations, as many as 40 000 tram and bus passengers will travel through Keski-Pasila daily (Uusi Pasila 2017d). The area will become a true traffic node in the future. Next to Pasila railway station an area called Tripla will be built, offering apartments for 400 persons, office space and workplaces for 7 000 persons, a parking hall, mall and hotels (figure 13) (Uusi Pasila 2017c; YIT 2017). A primarily residential area called Rail Yard Quarters will be built north of Tripla and will inhabit 3 200 persons. It is also expected to offer work places for about 1 000 persons along with a school and day care, to be located in the area (Uusi Pasila 2017a; YIT 2017). To the area south of Tripla a high-rise apartment building area called the Tower Area will arise. The area will consist of 8 to 10 hybrid high-rise buildings with commercial space, office space and residential apartments (Uusi Pasila 2017b; YIT 2017). The Tower Area will include the first Finnish skyscrapers with the highest buildings being as high as 40 floors (Uusi Pasila 2017b).

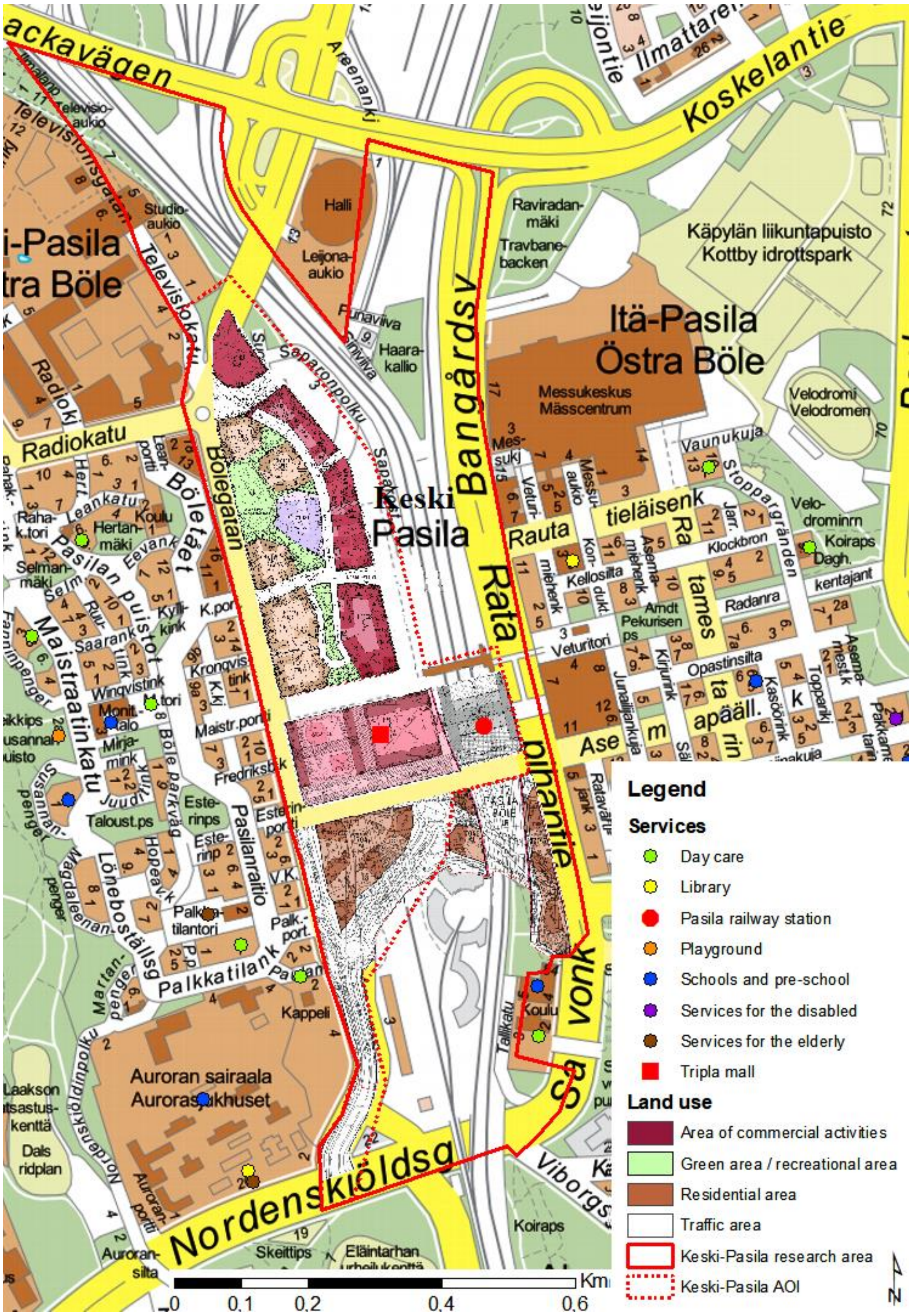

Figure 13. The locations of services which require good level of physical accessibility in Pasila as well as the defined land uses of the local detailed land use plans in Keski-Pasila research area. Sources: data; City of Helsinki Service Registry 2017; base map; City of Helsinki 2016c.

Keski-Pasila research area has been defined following the borders of Keski-Pasila local master plan (figure 10 and 13). The research area includes the new planned roads Veturitie, Tornikuja, Pasila Bridge, Firdonkatu, Kyllinkinportin jatke, Höyrykatu, Radioportti, Tenderinlenkki, Televisiokatu, Laskumäki, Tulistimenkatu, and the updated Pasilankatu, as well as the Pasila railway station and the new quarters Rail Yard Quarter, Tripla and Tower

Area. The research area also includes areas which do not yet have any detailed land use plans. This kind of area is located south of Tower Area and east of Veturitie. Even though the research area has been defined to follow the area of the local master plan, the area of interest (AOI) consist mainly of the areas from which it is possible to get detailed land use plans, traffic plans and street plans (figure 13). Some of the documents that have been used in the research are only drafts, but these have still been used as sources of information. All the planning documents that have been used in this research are listed in appendix 2.

Physical accessibility was already considered at the stage of the local master plan when planning Keski-Pasila neighborhood (Tujula 2017). In each planning stage it was ensured that physically accessible planning solutions have enough space. Furthermore, participatory planning procedures were used when planning the new neighborhood area. A total of 3 workshops were arranged where the citizens had the opportunity to have an influence on what the new area would look like (Tujula 2017). Different administrative units have also collaborated when making the different plans for the area. Besides the City of Helsinki, actors that have participated in the planning processes are, among other, Helsinki Region Traffic and Helsinki City Transport (Tujula 2017). Physical accessibility and different guidelines were closely considered when planning the area. According to the input by planners who responded to the electronic questionnaire for planners, type drawings for street areas and SuRaKu physical accessibility guidelines have been used as sources of information in making the plans. Special care has been given when planning the locations of public transport stops so that the distances from the PT stops to services would stay within an acceptable distance (Tujula 2017). All new street areas, and the street areas that are to be restored in the research area, are to be constructed to fulfill at least the basic level accessibility criteria. The street area near Pasila railway station and Pasilankatu between Pasila Bridge and Kyllikinportti will be constructed according to special level accessibility criteria (Helsingin kaupungin rakennusvirasto 2014, 2015a, 2015b, 2015c, 2016b). According to the respondents of the questionnaire, all existing street areas which have not yet been restored are considered old, meaning that these have not been constructed according to the criteria in the type drawings for street areas, and are therefore possibly not physically accessible.

6 Data and methods

6.1 Presentation of data

The data which was used in this research consists of planning documents, scientific publications, spatial data, and data about the built urban environment in other data formats. The research data is primarily acquired from secondary sources, although some primary sources have also been used. The primary source data is data from the electronic questionnaire and interview material.

Open source data has been used when possible in GIS analysis. However, this has not been possible in some cases. It has been necessary to acquire some data directly from the City of Helsinki. In addition to the City of Helsinki, the sources for data are the open data services kartta.hel.fi, Helsinki Region Infoshare and PaITuli. In the research areas of Lauttasaari and Itäkeskus it was possible to use existing GIS data, however, in the case of Keski-Pasila this was not possible as the area is still under construction. Therefore, the data for Keski-Pasila have been digitized from local master plans, detailed land use plans, traffic plans and street plans. The land use-, traffic- and street plans that were used in digitizing are summarized in appendix 2. The data which was used in the GIS analysis is introduced below and is grouped by the dimensions in which they are used. The used data for each dimension, the accessibility of the data and their sources are also represented in appendix 3.

For the result validation I used a dataset which was created during summer 2017 and was acquired directly from the City of Helsinki. The dataset is an physical accessibility registry where target physical accessibility levels have been inserted to route and area objects in the scope of all Helsinki. The target physical accessibility levels were defined by me during summer 2016, using the information from Regional Accessibility Plans. For the areas these Regional Accessibility Plans do not cover, the physical accessibility levels have been defined by the location of certain services which require good physical accessibility, by the location of PT stops, by demographic information and by slope information. In the updated registry from summer 2017, all routes and areas with target level of physical accessibility set as special level physical accessibility have been examined and their accessibility classification has been altered if the actual level of physical accessibility does not correspond to the target accessibility level. I will be using this information about the actual physical accessibility level when making the result validation.

6.1.1 Density

The data for the dimension density was acquired from Helsinki Region Infoshare. The data that was used is Buildings in Helsinki which shows buildings as areas in a shapefile (City of Helsinki 2016d). The information that was used is the area that the building is covering, not the total square feet meters of the building. In the case of Keski-Pasila, the building areas were digitized from local detailed land use plans.

6.1.2 Diversity

The data that was used for analyzing diversity in the research areas was Corine Land Cover from 2012 (SYKE 2012). The data is 20m x 20m raster data and it was acquired from open data service PaITuli. Corine Land Cover is provided by the Finnish Environment Institute. In Keski-Pasila, the land use classification was gained from local master plans.

6.1.3 Distance to transit

For distance to transit, the pedestrian network from the Registry of Public Areas (City of Helsinki 2017e) and the locations of public transport stops were used. The data for public transport (PT) stops was downloaded from Helsinki Region Infoshare (HRT 2016). The accessibility information for the PT stops was acquired from Helsinki Region Traffic service Digitransit (HSL 2016). The accessibility of PT stops has been measured only for a portion of all public transport stops as not all bus stops have yet been evaluated; this will have an effect on the results. In the Keski-Pasila research area, the locations of PT stops were digitized from traffic plans. According to the traffic plans, all PT stops in Keski-Pasila will be built physically accessible for wheelchair users.

6.1.4 Destination accessibility

For destination accessibility, the pedestrian network from the Registry of Public Areas (City of Helsinki 2017e) and the locations of grocery stores were used. Grocery stores were selected as points of interest as it is assumed that all citizens, or at least the majority of them, shop for groceries. The locations of grocery stores were downloaded as a KML file from Helsinki Region Infoshare (City of Helsinki 2017f). The data was modified as it also included restaurants, kiosks, and shops that sell groceries, however these are not classified as grocery stores. All pharmacies, restaurants, kiosks, cosmetic- and wellness shops, candy shops, sports shops and Tiger-shops – which also were included in the data – were excluded. Bakeries, R-kiosks, halal- and oriental shops were included in the data. Grocery stores and pedestrian networks which fall outside of the research areas were included in this analysis due to the nearest store potentially being located outside of the research area limit at the border areas.

In Keski-Pasila the street network was digitized from street plans. Locations of grocery stores were estimated by the locations of commercial areas in local detailed land use plans.

6.1.5 Design and Demand

Registry of Public Areas (City of Helsinki 2017e) was used in analyzing the dimensions of Design and Demand. The registry is maintained by the City of Helsinki Public Works Department, and it includes information on streets and green space areas (Helsinki Region Infoshare 2017). The registry was downloaded from kartta.hel.fi. The registry includes information about street segment locations and their paving material, winter maintenance, maintenance classification, and measurements, among other information. The dataset is built and updated based on land use plans, street plans, base maps and fieldwork (Helsinki Region Infoshare 2017). The registry was used in gaining information about benches, pedestrian network, location of pedestrian crossings and path quality. Locations of stairs were acquired directly from City of Helsinki. The information on stairs is maintained in a separate stair registry. In Keski-Pasila the information of street areas, their materials, stairs and benches were digitized from street- and traffic plans.

For illumination the data was acquired directly form the City of Helsinki as shapefile (City of Helsinki 2017e; Helsingin kaupunki 2017). The shapefile of lamps contains information about the lamp type, height of pillars, and power in watts. The lux values for street lights were acquired form a report made by the City of Helsinki Public Work department (Helsingin kaupungin rakennusvirasto 2015) and it shows the target lux values for street lights. In Keski-Pasila the information and the location of street lamps were gained from street plans.

6.1.6 Declination

Elevation model as 1m x 1m areas for the research areas was downloaded from kartta.hel.fi (City of Helsinki 2017g). The elevation model is a document file, in which the data for elevation is given as xyz-file where the elevation is given as z value and the location as x and y coordinates. The elevation model is maintained by the City Environment Sector.

6.2 Methods

6.2.1 Literature analysis

Literature analysis was the prime method in gathering information on the different ways to perform an analysis to measure physical accessibility of the built environment and of the characteristics of the research areas. Previous research, planning documents, legislation, political white papers, physical accessibility guidelines and standards along with other documents related to the topic were read for further information. The results of literature analysis are summed up in chapters 3 through 5.

6.2.2 GIS-analysis

The empirical research is executed as a GIS analysis, where the 8D model of the physically accessible urban structure presented in section *4.3.2 Physically accessible urban structure* is used as a theoretical framework. I will be using physical accessibility criteria when possible in performing the analysis for the dimensions in the 8D model. However, the dimension of *discovery* was decided to be excluded from the analysis as it deals mostly with subjective elements. The physical accessibility criteria, which have been used in the analysis, are introduced in sections *3.3.1 Requirements for the built environment from the perspective of different pedestrian user groups* and *4.5 Physical accessibility specifications and instructions*

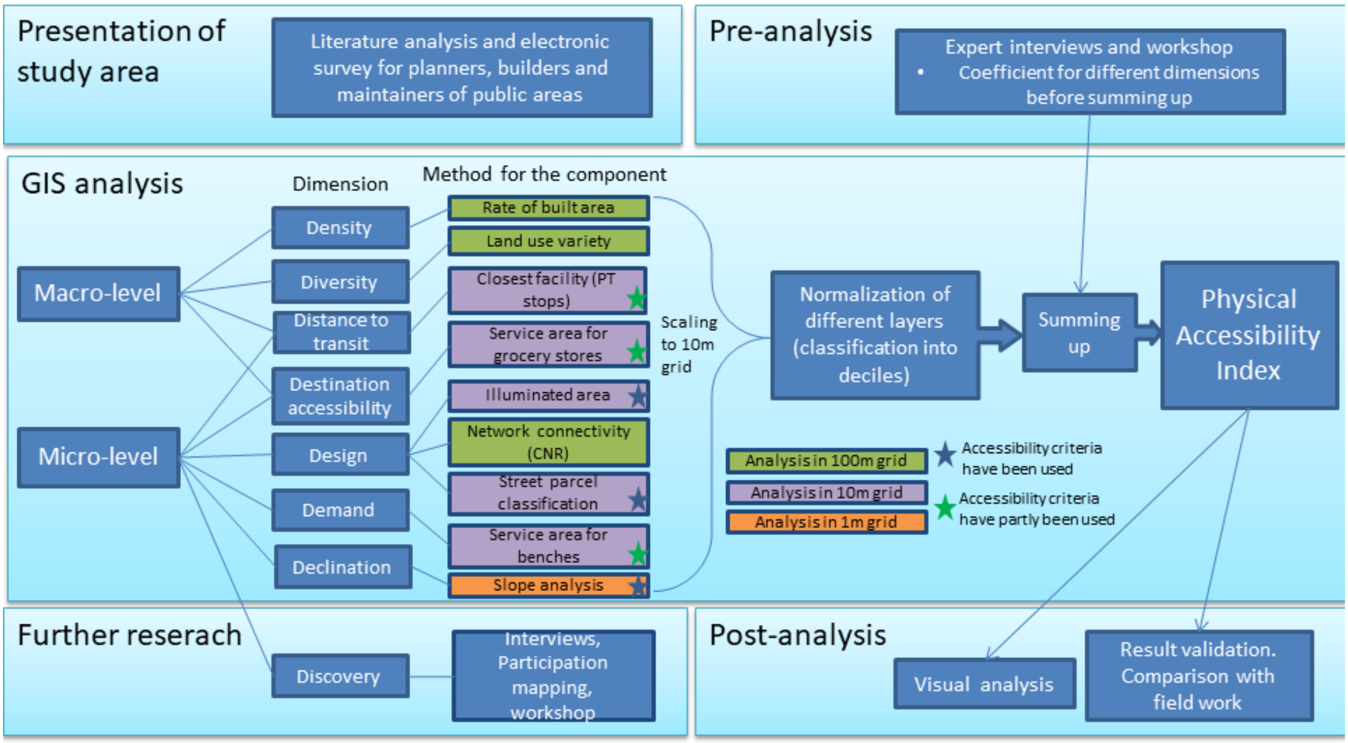

Figure 14. A brief illustration of the methods for the case studies.

for the built environment. A summary of the performed calculations is presented in the next section. The structure of the analysis is illustrated in figure 14. The scale which has been used in the analysis is marked in the figure, as is whether it has been possible to use physical accessibility criteria in the case of different dimensions and components.

6.2.3 Interviews

Informal interviews were conducted among land use planners of the research areas, physical accessibility experts and other experts from the City of Helsinki to gain information about the research areas and of the possibilities to apply the results of this analysis to real life applications. The interviews included a small workshop in which the accessibility experts were to arrange different elements of the built urban structure along with their attributes, such as pavement width, sound signals at pedestrian crossings, slope, winter maintenance and illumination, among other, in groups and give them graded priorities from the perspective of importance for the three user groups.

An electronic questionnaire was also sent out to planners and to persons in charge of constructing and maintaining public areas in the three research areas. The aim of the questionnaire was to collect information on how they can take physical accessibility into consideration in their work and to collect information about the research areas. Eight respondents participated in the questionnaire. A discussion session was organized after the analysis was finished, where urban planners and other experts had the opportunity to comment on the gained results from the GIS analysis. A themed interview was also arranged during this session with beforehand selected questions that were addressed to all participants. The questions and a list of interviewees are listed in appendix 4 and in the references respectively. The results from the interviews and from the questionnaire are discussed together with the presentation of the research areas and in the chapter of discussions.

6.3 Summary of performed methods for the Physical Accessibility Index

Each of the dimensions of the urban structure, the 8D's, were handled separately in GIS-programs. The dimension of discovery was not applied. ArcGIS, QGIS, Microsoft Excel and Access were used in modifying and analyzing data and the results were also analyzed using Microsoft Excel.

When selecting the smallest possible spatial units for data analysis, the human scale was considered. As the acceptable walking distance for a person is stated to be 500 meters (Gehl

2006, p. 137, 2010, p. 121–125), the macro-level analysis for the dimensions of *Density*, *Diversity*, as well as the *Design* element of connectivity were made in a 100 x 100-meter – or a hectare – grid. Micro-level accessibility is considered on large-scale level and is much closer to the actual individual. Therefore, the spatial unit for micro-level dimensions of *Design-path quality, Design-illumination*, and *Demand* was selected as a 10 x 10-meter grid. The macro-level dimensions of *Destination accessibility* and *Distance to transit* were analyzed directly in 10 x 10-meter grid. The micro-level dimension of *Declination* was analyzed in 1 x 1-meter grid as the data that was used for this dimension was in this scale and because too big generalizations would have been made had this analysis been made in a 10 x 10-meter grid.

All the dimensions were first analyzed on a scale that is best suited for the data in question, but before the layer aggregation all dimensions were scaled to 10 x 10-meter grids. Although the final analysis would be more exact when analyzing in a 1 x 1-meter grid, the 10 x 10-meter grid was selected so that the aggregation of the different dimensions in varying scales would give more exact results and so that it would not be necessary to make extreme generalizations when scaling the dimensions before layer aggregation.

The results of the different dimension analyses were reclassified and given an accessibility score according to accessibility criteria when possible. The dimensions were also normalized into deciles before layer aggregation, except for the dimensions of *Density* and *Design-connectivity* which were already at range 0–10. Normalization was made using reclassify-tool Slice in ArcGIS. The tool stretches the values in a raster dataset according to chosen classification method and reclassifies the pixel values to new classes. The classification method equal interval was used and the data was classified to 11 classes with values ranging from 0 to 10, except in the case of *Diversity*, where the lowest value is 1. All data in all three research areas were processed simultaneously when normalizing the data so that it would be possible to compare the results between the different research areas.

6.3.1 Density

Density was measured by calculating the Building Coverage Ratio (BCR) between developed land to undeveloped land. BCR is the ratio of the total area covered by buildings to the total area of interest (Pan et al. 2008). The formula is

$$BCR = \Sigma F/A$$

where F is the building's standing area and A is the total area of interest. The source data Building area (as shapefile) from City of Helsinki was used and the built area was analyzed in a 100 x 100-meter grid. The ratio of built area to total area of interest was calculated for each grid by using field calculator in attribute table and the results were given as square meters. The result is a decimal number between 0–1 and reveals the rate of built area in the area of interest. As no references were found for the appropriate rate of built area that is considered to be accessible, the gained percentage values were used as such in layer aggregation after multiplying by 10 to normalize the results in the range of 1–10. The results were analyzed further and the minimum-, maximum-, mean- and standard deviation values of densities as well as the rate of unbuilt area were calculated for each of the research areas.

6.3.2 Diversity

Land use variety was analyzed by looking at how many different land use classes there are in a hectare grid in the research areas. Corine Land Cover (2012) 20 x 20-meter raster map was used for identifying land use for Lauttasaari, Itäkeskus and already-built parts of Keski-Pasila. Land use classes in Keski-Pasila which are still under construction were digitized from local detailed urban plans. These areas were converted from polygon to raster and added to Corine Land Cover. Zonal statistics-tool in ArcGIS was used to calculate the sum of land use classes in a 100 x 100-meter grid. The result gave an integer value that equates to the variety of land uses in a specific grid area. The results were then scaled to a 10 x 10-meter grid.

Variety values were reclassified into deciles without giving them an accessibility score. This was done as there were no references for the value limits of what is considered to be the limit of accessible amount of different land use in an area. The more heterogeneous the area is, the more physically accessible it is considered to be as distances to different destinations are shortened (e.g. Leslie et al. 2007, p. 116). The level of physical accessibility is better the more variety there is in land use. The results were analyzed further and the minimum-, maximum-, average- and standard deviation values of variation, as well as the rate of areas with only one land use class, were calculated for each of the research areas.

6.3.3 Distance to transit

Distance to transit was analyzed by calculating closest facility as true distances from one point of interest (POI) to another by using route network and Network Analyst extension in

ArcGIS. The interest points are locations of public transport stops and their distances from each point in a 10 x 10-meter grid in the research areas.

To be able to calculate true distances between two POIs, it was necessary to make some corrections to the pedestrian route shapefile that was used as route network. The corrections that were made were corrections in connectivity as there were cases where two route vertexes did not connect even though the route seemed to be continuous in that place. Data management tool Feature vertices to points was used in ArcGIS in identifying dangled nodes in the network data. These nodes were manually corrected if they were in fact intersections. In the base data the route network had endpoints at intersections with no crossings. In these cases, the network was continued across the intersection as if there was a crossing, as people may cross the road even though there is no painted pedestrian crossing. In this way the network was completed and it became possible to calculate distances across the whole research area. For the user group "wheelchair users", all stairs were excluded from the routing if the stairs did not have a ramp. As the base data for pedestrian routes does not include information about the curbstone heights, this detail was not possible to take into account when considering wheelchair accessibility in intersection areas. Therefore, it is assumed that a wheelchair may cross every intersection.

The distances were calculated using the 10 x 10-meter grid. Points were first created in the center of the polygon grids and these points were used in network analysis as locations for incidents. Only points inside of the research areas were used. As destinations, or facilities in the Network Analyst, locations of public transport stops were used.

To calculate distances for wheelchair users, the accessibility of public transport stops was first analyzed. This was done by using the HSL API (application programming interface) Digitransit (HSL 2016), from which it was possible to search for all public transport stops in the Helsinki region and acquire their accessibility classification by using a query in GraphiQL. In Digitransit, the accessibility is stated as a possibility for wheelchair boarding. The values that a PT stop can get are "possible", "not possible" and "no information". The PT stops that had accessibility information set as "not possible" where excluded from this accessibility analysis, as a wheelchair user may not independently use the service from these PT stops. The PT stops with accessibility information set as "no information" were kept in the analysis, as there is an uncertainty of the accessibility of the PT stop. I will in this analysis make the assumption that these PT stops are in fact accessible to wheelchair users.

Distance to transit was calculated by calculating the true distance from each point in the 10 x 10-meter grid covering research areas to the public transport stops. When calculating distances for wheelchair users, only those public transport stops which are accessible for wheelchair users were used. Also, the network that was modified according to wheelchair accessibility was used.

After the analysis, the created route information was joined by table with the analysis points to get information on the distance to PT stop from each analysis points. Points were converted into a raster and the areas where the distance was between 0–500 meters were normalized into a 1–10 range thus creating distance zones with 50 meter interval. Shorter distances were given a higher value, for example, the distance zone stretching 0–50 meters from the PT stop was given the value 10, distance zone 50–100 was given the value 9, etc. The areas further away than 500 meters were given the value 0. The data was opened in Microsoft Excel for further analysis and the minimum-, maximum-, and average distances were calculated.

6.3.4 Destination accessibility

Destination accessibility was analyzed by calculating service areas around chosen services by using route networks for different user groups in the Network Analyst-extension in ArcGIS. The chosen interest points were grocery store locations and public transport stops. Locations of grocery stores were used as destinations, or facilities, in Network Analyst. Shops were selected also from outside of the research areas as it might be a shorter distance to these from the border areas in the research areas. The entrance accessibility of shops was evaluated by using visual interpretation from Google Street View and pictures from Social Media. All shops with steps to entrance and a narrow door were classified as inaccessible for wheelchair users and were removed as facilities for that user group. The same route networks that were used in *Distance to transit* analysis were used also here.

Service areas were calculated as rings around the service locations by 50-meter intervals and to a maximum distance of 500 meters, thus, 10 distance zones were created. The amount of public transport stops in each distance zone and for each user group was calculated by using intersect-tool in ArcGIS. The accessibility information of the PT stops was considered when calculating the amount of PT stops for each user group. The distance zones were reclassified and rasterized so that the distance zone closest to the service got the value 10 and the last zone got the value 1. All other areas were given the value 0. The statistics about the amount of PT stops in each distance zone was further analyzed in Excel.

6.3.5 Design

The design component is divided into three elements of design: path quality, route connectivity and illumination.

Path quality

Path quality was evaluated by classifying pedestrian path segments such as pedestrian street segments, pedestrian crossings, stairs and ramps according to accessibility criteria. An accessibility score was given to the pedestrian path segments (table 2). The elements that were taken into consideration are; pavement material, path width, winter maintenance and whether the path is divided into separate sections for pedestrians and bicyclists in the case of pedestrian pathways; sound and light signals, traffic island design, curbstone design and whether the path is divided into separate fields for pedestrians and bicyclists in the case of pedestrian crossings; the size of the raiser and the tread, and the existence of handrailing in the case of stairs; the measurements, the rate of slope and the existence of a landing and handrailing in the case of ramps.

The arguments for the physical accessibility scores are based on physical accessibility criteria described in chapter 4.5, but the scores are arbitrarily chosen. The objects of the built environment which fulfill the accessibility criteria are given the highest value of 10 and the objects that do not fulfill them are given the value 0. The arguments are excluding, meaning that if in the case of a pedestrian pathway the criteria for width and material are met for special level accessibility, but there is no winter maintenance on the pathway segment, then the accessibility score is 0. A pathway with no bicycle line was classified with lower values than a pathway with separated bicycle and pedestrian lanes because of the hazard factor; although it is not allowed to cycle on a pedestrian pathway, some bicyclist may still do this, which causes a safety issue for pedestrians. Non-accessible pedestrian crossings are given the value 1 because having a pedestrian crossing is much safer than not having a pedestrian crossing at all. The same reasoning applies for ramps. Having a ramp, even if the accessibility criteria are not completely met, is better than not having a ramp near a stairway. In the case of curbstones, the data acquired from the City of Helsinki did not include information about the curbstone design. In the research area Keski-Pasila the street plans included information about curbstones in pedestrian crossing areas and all curbstones in pedestrian crossings were accessible. In Lauttasaari and Itäkeskus the information from the fieldwork from summer

2017 was used in assessing the accessibility of curbstone design in pedestrian crossing areas. All other curbstones were handled as non-accessible.

Table 2. Defined accessibility scores for path segments based on their attributes.

Element	Accessibility score				Arguments (excluding)	Additional information
	Special level	Basic level		Not accessible		
Separated pedestrian and bicyclist pathway	10	8		0	Width, pavement material, winter maintenace	The arguments that separate special level from basic level is the pathway width. Value 0 is given to the pedestrian path if even one of the arguments are not met
Pedestrian pathway	6	4		0	Width, pavement material, winter maintenace	
Combined pedestrian and bicyclist pathway	3	1		0	Width, pavement material, winter maintenace	
Persons with impaired vision / other and wheelchair users	Sound signal	Light signal	No light signal	Not accessible		Not accessible pedestrian crossings are given the value 1 because an existing painted pedestrian crossing is better than not having a pedestrian crossing at all. Intersections with no crossings are handeled in path continuity analysis. The score on basic level depends on if there is a light signal. The user group "other" get the same score on basic level if there is a light signal as the user group "seeing impaired", because the group "other" doesn't need a sound signal.
Separated pedestrian crossing, short	10	8 / 10	7	1	Sound signal, light signal, path width	
Separated pedestrian crossing, long	10	8 / 10	7	1	Sound signal, light signal, path witdh, traffic island design	
Combined pedestrian crossing, short	6	4 / 6	3	1	Sound signal, light signal, path witdh	
Combined pedestrian crossing, long	6	4 / 6	3	1	Sound signal, light signal, path width, traffic island design	
Stairs with a ramp	10	6		1	Size of the raiser and the tread, handrailing. Measurements of the ramp: slope, landing, handrailing	Not accessible ramps are given the value 1 because a ramp is still better than not having a ramp.
Stairs without a ramp	5	3		0	Size of the raiser and the tread, handrailing	Not accessible stairs are given the value 0 because they can be hazardious if not even one of the arguments are met.

The scores for pedestrian crossings differ between the user groups. On special level the pedestrian crossing is given the value 10 (6 for combined pedestrian crossing) if there is a sound signal for the user group “persons with impaired vision”, and value 8 if there is no sound signal but there is a light signal. A crossing with no sound signal but a light signal is given the value 10 for the user group “other” and “wheelchair users”, as for these user groups the sound signal is not necessary.

After the classification, the path quality accessibility score was joined with the route network vector layer, which had been cut into 1-meter segments. This classified network was used as such in layer aggregation. No normalization was made to this layer as the values were already in the range 0–10.

Route connectivity

There are many ways to calculate network connectivity (e.g. Agampatian 2014), but I ended up using the Connected Node Ratio (CNR) in calculating route connectivity as this method takes dead ends and cul-de-sacs into account as the amount of real intersection nodes are compared to the amount of these dangled nodes. By using the CNR it is possible to analyze the effect of not having painted pedestrian crossings at intersections.

Connected Node Ratio (CNR) is calculated for the AOI as

$$\#Real\ nodes\ /\#Total\ nodes(real\ and\ dangled)$$

where real node is the endpoint of a link that connects to other links, such as an intersection, and a dangle node is an endpoint of a link that has no other connections, such as cul-de-sacs and dead-ends (Dill 2004). A well-connected area gets the score of 1 as there are no dangled nodes.

The connectivity analysis was initiated by preparing the route network data for different user groups. For persons using a walking aid, persons with impaired vision and other, except wheelchair users, the route network consist of pedestrian pathways, pedestrian crossings, stairs, ramps, over- and underpasses. In the case of wheelchair users, the stairs were excluded from the network if there was not a ramp connected to the stairway.

The network acquired from City of Helsinki was manually checked for errors by comparing the network, which has been drawn as the centerline for pedestrian pathways and crossings from the Base map of the City of Helsinki, to the Base map of City of Helsinki to recognize if the errors in the network were in fact errors. Some corrections were made. For example, in some cases there was a gap between two pathway segments even though the pathway was continuous in the base map, in which case the gap was removed and the route connectivity was corrected. Polyline corrections were also made to the network data. In the original data, the pathways were segmented into multiple segments. The correction was made in QGIS by using the Grass GIS tool v.build.polyline, which corrects the polylines and merges segments of a line into one segment and converts segment endpoints into vertexes. After the corrections were made the tool created endpoints in true intersections only.

After the route network was corrected it was possible to create components for the network. This was done using the ArcGIS Data management tool Feature vertices to points. Two kinds of points were created: true nodes to route segment endpoints and dangle nodes into dead-ends and cul-de-sacs. After the process was finished, all the nodes were manually checked and the nodes that locate in the endpoints of segments to routes that continue beyond the research area borders were deleted. Some nodes were added in the intersections which the analysis tool could not identify. This may have happened due to topological errors in the original data. A total of 9 nodes were added in Lauttasaari and Itäkeskus areas. All routes that end to an intersection with a street with no pedestrian crossing were classified as dead ends. In this way it was possible to consider the connectivity of pedestrian pathways with painted pedestrian crossings. There is better connectivity, when the route continues with a painted pedestrian crossing.

The points were opened in QGIS for further analysis. Saga GIS tool Point statistics for polygons was used in QGIS for calculating the count of total (all) nodes and dangled nodes in 100 x 100-meter grid for each research area. The number of real nodes was calculated in attribute table by subtracting the count of dangled nodes from the count of all nodes. After this it was possible to calculate the rate of real nodes to all nodes in one grid area. The value of 1 indicates perfect connectivity in the area, where all path segments are connected. The result is a decimal number which was normalized by multiplying by 10. This result was then scaled into a 10 x 10-meter grid.

Illumination

The area for illumination was calculated by using the information of lamp power, illuminance efficacy and the lux-value of the lamp. The values for illuminance efficacy were acquired from several sources and are they based on estimates of illuminance efficacy for different lamp types as I could not acquire more exact information. See table 3 below for the values that I used for luminous efficiency for each lamp type of the source data.

Table 3. Values of luminous efficacy of different lamp types.

Lamp type	Luminous efficacy of radiation lm/W
Mercury-vapor lamp	50
Induction Lighting lamp	65
Xenon arc lamp (Led)	60
Metal-halide lamp	87
High pressure sodium-vapor lamp	117
Low pressure sodium-vapor lamp	150

Sources: Wikipedia 2017a; Wikipedia 2017b; Taloon.com 2017; RapidTables.com 2017

The power of Led lamps was missing so I used an average power value of 30 for Led lamps. Information for many lamps in Itäkeskus was missing from the shapefile that I received from the City of Helsinki, so instead I downloaded spatial information for lamps as open source data from kartta.hel.fi (City of Helsinki 2017e). The locations of these lamps are not exact and the data did not contain information about the lamp power and lamp type, so I used average values; suggesting an average luminous efficacy of 85 lm/w and an average wattage of 50W.

There was no updated information of the actual lamp lux-values and therefore I used estimates of lux-values. The estimates that I used are target lux-values which have been defined for all street areas in Helsinki. The estimates were acquired from a report on illumination from the City of Helsinki (City of Helsinki 2015, p. 30–34). As target lux-values were used in calculating the area for illumination, the results from this analysis do not represent actual values.

The formula for calculating the area of illumination is derived from the formula for calculating lux-values:

$$Ev(lx) = P(W) \times \eta(lm/W) \,/\, A(m2)$$

where E_v is the illuminance in lux (lx), P is the power in watts (W), efficacy η is the luminous efficacy in lumens per watt (lm/W), and A is the surface area in square meters (m^2) (RapidTables.com 2017). From this we may derive the formula for the surface area:

$$A(m2) = P(W) \times \eta(lm/W) \,/\, Ev(lx)$$

From the value for area I calculated the radius of the area of illuminance:

$$r = \sqrt{(\frac{A(m2)}{\pi})}$$

The value for the radius was used for creating buffer-zones around each lamp, which represent the area of illuminance. The column information of lux was used for dissolving the buffer zones. Buffer zones were given accessibility scores as follows: zones with 10–15 lux or higher were given value 2 and all other zones were given value 1. All areas with no illumination were given the value 0. The buffer areas were rasterized in 1 x 1-meter grid, the pixel values being the accessibility scores. Thereafter zonal statistics was calculated in 10 x 10-meter grid, calculating the mean accessibility score for one 10 x 10-meter area. The values were then normalized in range 1–10. The rate of the area that is illuminated in each of the research areas was further analyzed in Excel.

6.3.6 Demand

There was no measurement information on the benches in the attribute table in the Registry of Public Areas making it impossible to classify benches according to the physical accessibility criteria related to measurements. According to City of Helsinki, the benches that fulfill the physical accessibility criteria are classified as HKR-D1 and HKR-D3 in material column in the attribute table (City of Helsinki 2017d; Tirri 2017). There were only 3 such benches. It may be that some of the physically accessible benches have been classified as "default material" in the attribute table (Ulvila 2017) as the fieldworker examining the benches may not have been aware of the true code for the bench type. For this reason, all benches that were used in this research were considered as being physically accessible.

Accessibility to benches was analyzed by creating service areas around the benches using the created route networks for different user groups in Network Analyst tool in ArcGIS. All benches were used for all user groups as the physical accessibility information of the benches was not reliable. Different networks were used for different user groups in the analysis. Accessibility was analyzed by creating distance zones at equal interval every 50 meters and to a maximum distance of 500 meters. The zones were selected to be dissolved according to the distance class. The result was then reclassified to a range of 1–10 so that the distance zones closest to the benches were given the highest value of 10 and the distance zone 450–500 was given the value 1. Areas further away than 500 meters were given the value 0. The result was then rasterized.

As the literature sources mention 100-meter distance between benches to be a convenient distance for persons to walk between two benches (Gehl 2006, p. 162), the distance zones 0–50 and 50–100 were analyzed more closely. The percentage of area that these distance zones cover for the whole research area, was analyzed in Excel.

6.3.7 Declination

Slope was calculated from point cloud xyz-format document. Point cloud was opened in QGIS-program and points were rasterized in a 1 x 1-meter grid to create a DEM (Digital Elevation Model) and saved as GeoTIFF. Slope was calculated from DEM with z-factor 1 using Slope mode in the Terrain models-tool in QGIS. The result was given as percentages. The result slope-raster was opened in ArcGIS for reclassification. The result was classified according to the accepted physical accessibility criteria for slope on basic and special levels; less or equal as 5 % on special level accessibility and between 5 % and 8 % on basic level accessibility. Classification was done using reclassify-tool in ArcGIS, where the areas with the slope of 5 % or less were given the value 2, slope of 5 % to 8 % were given the value 1, and the areas with over 8 % slope were given the value 0. These are the physical accessibility scores for declination data.

The classified slope data was scaled from 1 x 1-meter grid to 10 x 10-meter grid by using zonal statistics -tool in ArcGIS. Accessibility scores were summed in zonal statistics and the result is a raster layer with 10 x 10-meter pixel where the values range from 0 to 200. After this the data was normalized by using the slice-tool, where the data was classified into 11 classes ranging from 0 to 10 by using classification method equal interval. The areas with lower slope values have the value 10. The rate of area of each declination class in each of the research areas was analyzed more closely in Excel.

6.3.8 Component aggregation

All layers were converted into raster datasets before value normalization, except for the classified route network vector data that was used in visualization. The values in the rasters were normalized in the range of 0–10 except in the case of the dimension of *Diversity*, where the lowest value was 1. Of the results 2 out of 9 of the components have decimal number values, all other are integer values (table 4).

Table 4. The minimum and maximum values and the data and value type of each of the dimensions.

Dimension	Data format	Min. value	Max. value	Value type
Density	**Raster**	0	9,04	Decimal
Diversity	**Raster**	1	10	Integer
Destination accessibility	**Raster**	0	10	Integer
Distance to transit	**Raster**	0	10	Integer
Design - path quality	**Vector**	0	10	Integer
Design - illumination	**Raster**	0	10	Integer
Design - connectivity	**Raster**	0	10	Decimal
Demand	**Raster**	0	10	Integer
Declination	**Raster**	0	10	Integer

The results of all the dimensions were spatially joined with the vector format pedestrian route, which already included the classification of the dimension *Design-path quality*. The pedestrian network had been segmented into 1-meter long segments. The layer aggregation was done using Field calculator in ArcGIS attribute table. Some of the dimensions were given a coefficient to highlight the elements which are important to the specific user group. The values of the coefficients are a combination from the results of the workshop that was arranged for accessibility experts (see table 5 below), and from the requirements for the built environment from the perspective of different user groups. The requirements for the built environment are acquired from literature and are presented in section 3.3.1 in this thesis as well as in appendix 1.

Table 5. The elements of the public built environments grouped by their importance to the user groups "wheelchair users" and "persons with impaired vision". The elements are grouped by importance based on literature and the results from the workshop.

	User group "wheelchair users"		User group "persons with impaired vision"	
	Based on the workshop	Based on literature	Based on the workshop	Based on literature
1st important elements	Slope, curbstones at pedestrian crossings	Path quality, slope	Illumination, measurements of stairs, pedestrian crossing sound signal	Illumination, path quality
2nd important elements	Width of pedestrian route, pavement material	Illumination	Curbstones at pedestrian crossings, curbstones at pedestrian path, Warning areas and tactile plates, width of pedestrian path, pavement material, separated pedestrian and bicycle lines	
3rd important element	Illumination, pedestrian crossing light signal		Slope	
4th important elements	Density of benches		Pedestrian crossing light signal	
5th important elements	Pedestrian crossing sound signal, warning areas and tactile tiles, curbstones at pedestrian path, separated pedestrian and bicycle lines		Density of benches	
6th important elements	Measurements of stairs			

Sources: Näkövammaisten keskusliitto ry 1996; Jokiniemi 2007; Rakennustietosäätiö RTS 2011; Heikkinen 2017; Kilpelä 2017; Tuominen 2017; Niemi 2017

For the user group "other", all of the components were weighted equally so as to have a result to which it would be possible to compare the results of the two other user groups. For the user group "wheelchair users" the components of declination, path quality and illumination were weighted by coefficient 2, 2 and 1,5 respectively. This was done as path quality and slope were stated to be the most important elements in the literature. Furthermore, slope and components, that are evaluated in the dimension of *Design-path* quality, were considered as 1st, 2nd and 3rd important elements during the workshop (table 5). Illumination was also stated to be an important element in literature and as the 3rd important element during the workshop. As such this component was also considered in the layer aggregation, but it was given a lower coefficient value. For the user group "persons with impaired vision" the components of illumination and path quality were weighted by coefficient 2 and 2 as these were stated to be important elements in both the literature the workshop (table 5). Even though the component of slope was stated as the 3rd important element during the workshop, there was not a mention about this in the literature, so this component was not weighted in layer aggregation.

The formulas of aggregation are illustrated below for each user group.

$$PAI_o = D_1 + D_2 + D_{3a} + D_{3b} + D_{3c} + D_4 + D_5 + D_6 + D_7$$

$$PAI_w = D_1 + D_2 + 2D_{3a} + D_{3b} + 1{,}5D_{3c} + D_4 + D_5 + 2D_6 + D_7$$

$$PAI_s = D_1 + D_2 + 2D_{3a} + D_{3b} + 2D_{3c} + D_4 + D_5 + D_6 + D_7$$

where
PAI_o = Physical Accessibility Index for the user group “other”,
PAI_w = Physical Accessibility Index for the user group “wheelchair user”,
PAI_s = Physical Accessibility Index for the user group “persons with impaired vision”,
D_1 = Accessibility value for diversity,
D_2 = Accessibility value for density,
D_{3a} = Accessibility value for design, path quality,
D_{3b} = Accessibility value for design, connectivity,
D_{3c} = Accessibility value for design, illumination,
D_4 = Accessibility value for destination accessibility,
D_5 = Accessibility value for distance to transit,
D_6 = Accessibility value for declination,
D_7 = Accessibility value for demand

After the layer aggregation the results were classified into deciles and visualized with a base map.

6.3.9 Result validation analysis

Result validation analysis was done for results from Lauttasaari and Itäkeskus only, as these areas have been built and therefore it is possible to use results from fieldwork that was done during summer 2017. Result validation analysis was conducted by joining the attribute information of the accessibility registry with the Physical Accessibility Index (PAI) result by using spatial join in ArcGIS. The result is a line shapefile, where one object has both the PAI-value and the information about the target and actual level of accessibility. The attribute table of this join was opened in Excel, where all those objects with target level of physical accessibility set as “special level” were analyzed, as these are the targets considered during the fieldwork in summer 2017. Some objects with target level set as basic level were also analyzed since changes to the actual level had been done during the fieldwork to these objects. Statistics of the PAI-values of the chosen objects were calculated in Excel.

7 Results

7.1 Dimensions

7.1.1 Density

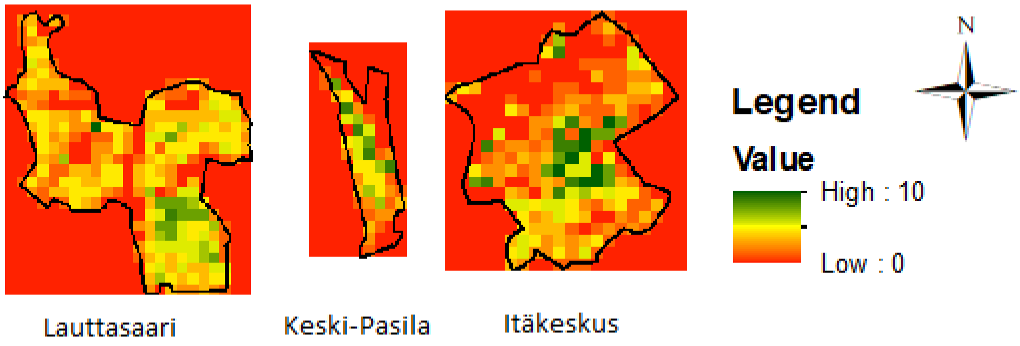

Figure 15. Results of the dimension *Density*.

Itäkeskus has the highest rate of maximum density (figure 15, table 6). Land use density is good especially in the center-areas and in the south-western parts of the study area. Some small areas with high density can also be found in the western and northern parts of the research area. In other areas the densities are moderate or low (figure 15). The area with the highest density is located in the district center where the rate of built area is over 90 % (table 6). The center areas in the other two research areas are much less densely built, in Lauttasaari the rate is nearly 58 % and in Keski-Pasila it is nearly 50 %. In Keski-Pasila the land use density is good in the center of the research area following the shape of the research area. In Lauttasaari the densities are moderate or low everywhere except for in the northern part of Vattuniemi and in the north-eastern part of the research area. The rate of unbuilt area is the lowest in Lauttasaari, where less than 10 % of the research area is unbuilt (table 6). In Itäkeskus the rate is 20 % and in Keski-Pasila it is nearly 27 %. Average density is the highest in Lauttasaari where the average density in a hectare grid is 14,2 %. Itäkeskus has an average density of 12,75 % and Keski-Pasila has 11,95 %. The lower values for Keski-Pasila are explained by the fact that not all of the research area has a valid detailed land use plan yet, from where the building areas were digitized for this research.

Table 6. Statistics of built area density in research areas.

	Itäkeskus	Keski-Pasila	Lauttasaari
Minimum density %	0	0	0
Rate of unbuilt area (no buildings)	20,93	26,80	9,27
Maximum density %	90,47	49,47	57,94
Average density %	12,75	11,95	14,2
Std. Dev.	0,1644	0,1376	0,0989

The standard deviation for density values are below 0,1 in Lauttasaari, meaning that the densities in each of the hectare grid are close to the average density value. The standard deviation in Itäkeskus is 0,16, which means that there is a larger variation in densities in this research area. Based on these results it seems that Lauttasaari has better accessibility from the point of view of building density. The built area is more evenly distributed across the research area.

7.1.2 Diversity

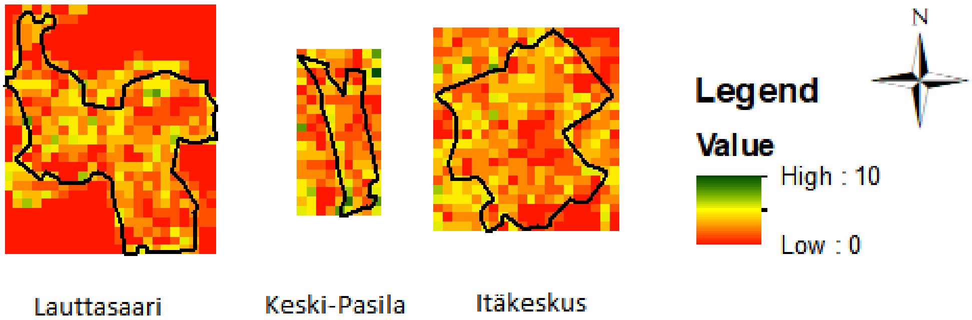

Figure 16. Results of the dimension *Diversity*.

The three research areas have the average land use variety of 4 (table 7). This is also visible in figure 16. There is not any visible pattern in the locations of high land use variety. Center areas seem to have more one-sided land use variety. Maximum variety in Itäkeskus and Lauttasaari is 9 and 10 in Keski-Pasila. The rate of area with only one land use class is the highest in Itäkeskus, where the rate of area with only one land use class is over 6 %. In Keski-Pasila and Lauttasaari this rate is less than 2 %. The standard deviation of land use variety is quite similar between the research areas. There are bigger differences in variation inside the research area of Keski-Pasila compared with the other two areas. According to these results, the best accessibility from the land use variety point of view would be in Lauttasaari, where the average variety is over 4, the rate of area with only one land use class is less than 2 and where the variation between the hectare grids within the research area is 1,5.

Table 7. Statistics of land use variety in research areas.

	Itäkeskus	Keski-Pasila	Lauttasaari
Minimum variety	1	1	1
Rate of area with only 1 land use class (%)	6,14	1,76	1,86
Maximum variety	9	10	9
Average variety	3,95	4,28	4,12
Std. Dev.	1,4845	1,7784	1,5723

7.1.3 Distance to Transit

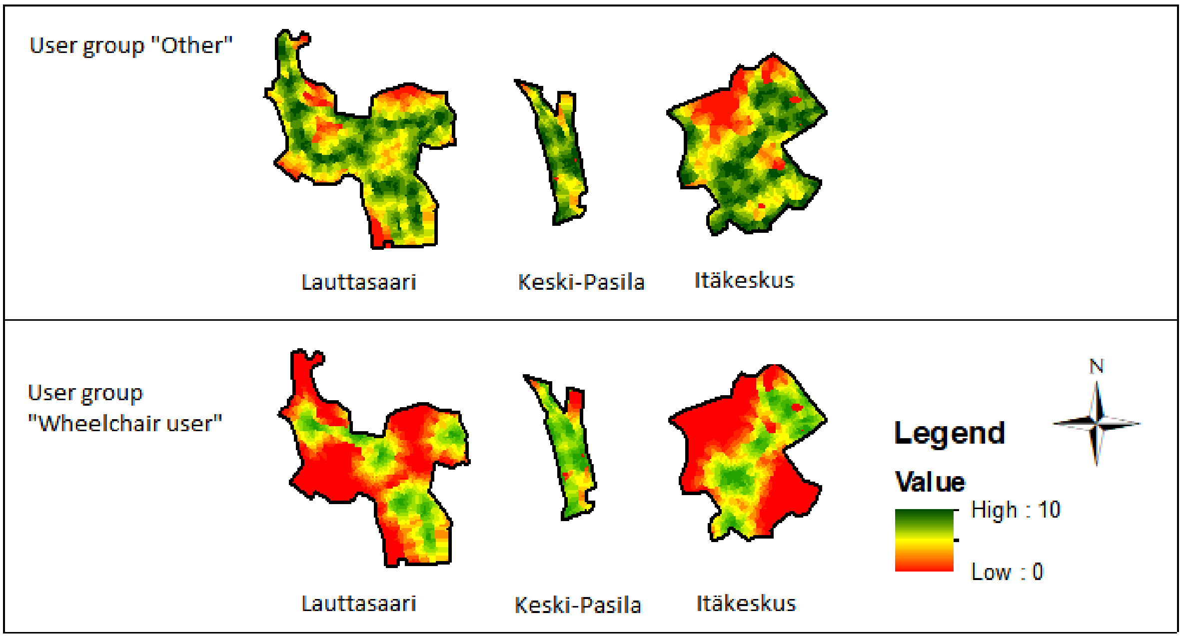

Figure 17. Results of the dimension *Distance to transit*.

Distance to transit is good in all three research areas when looking at the user groups “other” and “persons with impaired vision” (figure 17, table 8). The accessibility to transit is good in Itäkeskus in all other areas except for the eastern side of the Itäkeskus mall and in the northern part of the research area, which is dominated by a vast green area (figure 17). In Keski-Pasila the accessibility to transit is good in terms of the whole research area, except for the area south of Veturitie road, which is yet to be planned. In Lauttasaari the accessibility to transit is good for the whole research area.

Table 8. Statistics of distance to transit in research areas.

	Itäkeskus		Keski-Pasila		Lauttasaari	
	User group "Wheelchair user"	User groups "other" and "persons with imapired vision"	User group "Wheelchair user"	User groups "other" and "persons with imapired vision"	User group "Wheelchair user"	User groups "other" and "persons with imapired vision"
% of areas with less than 500 meter distance to transit	61,94	90,48	95,12	100	66,58	95,11
Minimum distance (m)	0,03	0,03	0,02	0,004	0,16	0,08
Maximum distance (m)	1215,07	846,74	665,83	437,4	1272,75	982,8
Average distance (m)	448,61	230,89	197,91	167,46	430,82	233,52

The rate of the area where distance to transit is less than 500 meters is over 90 % in all three research areas and 100 % in Keski-Pasila. The average distance is 230 meters in both Itäkeskus and in Lauttasaari and 167 meters in Keski-Pasila. The maximum distance to transit is less than 500 meters in Keski-Pasila research area, but it is twice as long in both Lauttasaari and Itäkeskus.

Accessibility to transit is worse for wheelchair users in all three research areas (figure 17, table 8), however, in Keski-Pasila the accessibility is considerably better than in the two other research areas. The percentage of areas that have less than 500 meters to the closest public transport stop with wheelchair access is 62 % in Itäkeskus and 67 % in Lauttasaari; the rate in Keski-Pasila is 95 %. The average distance to the nearest PT stop is over 400 meters in both Itäkeskus and in Lauttasaari, but less than 200 meters in Keski-Pasila. The maximum distances in Itäkeskus and Lauttasaari are over 1200 meters, while in Keski-Pasila the maximum distance is 665 meters.

Accessibility to public transport stops is worse for the user group classified as “wheelchair users” than for the other two user groups. Keski-Pasila has the best accessibility for all user groups and the accessibility for user group “wheelchair users” is even better than accessibility for all three user groups in Lauttasaari and Itäkeskus. The results might look like this due to the fact that the accessibility of all public transport stops has not yet been examined. Only in Keski-Pasila has the accessibility of public transport stops been confirmed. In Lauttasaari and in Itäkeskus it was assumed that PT stops with accessibility information “No information” are accessible, however this is not certain. Also, the size difference of the research areas might have an influence on the results.

7.1.4 Destination Accessibility

The accessibility to grocery stores is good in the center of the research area in Itäkeskus (figure 18). In Keski-Pasila the accessibility to grocery stores is good in the center of the research area but not in the northern and southern parts of the research area. In Lauttasaari the calculated accessibility areas are clearly clustered around the grocery stores.

Table 9 shows the number of public transport stops within the distance zones of grocery stores. We can see that in Itäkeskus there are more than twice as many public transport stops for persons in user groups “other” and “persons with impaired vision” than for the user group “wheelchair users”. 50 % of all public transport stops which are accessible for these user groups are within 250–300 meters from a grocery store. Nearly 65 % of all PT stops are within a walking distance of 500 meters for these user groups. Although there are less accessible PT stops available in Itäkeskus research area for “wheelchair users”, 50 % of these accessible PT stops are within 200–250-meter walking distance and over 90 % are within a 500-meter walking distance.

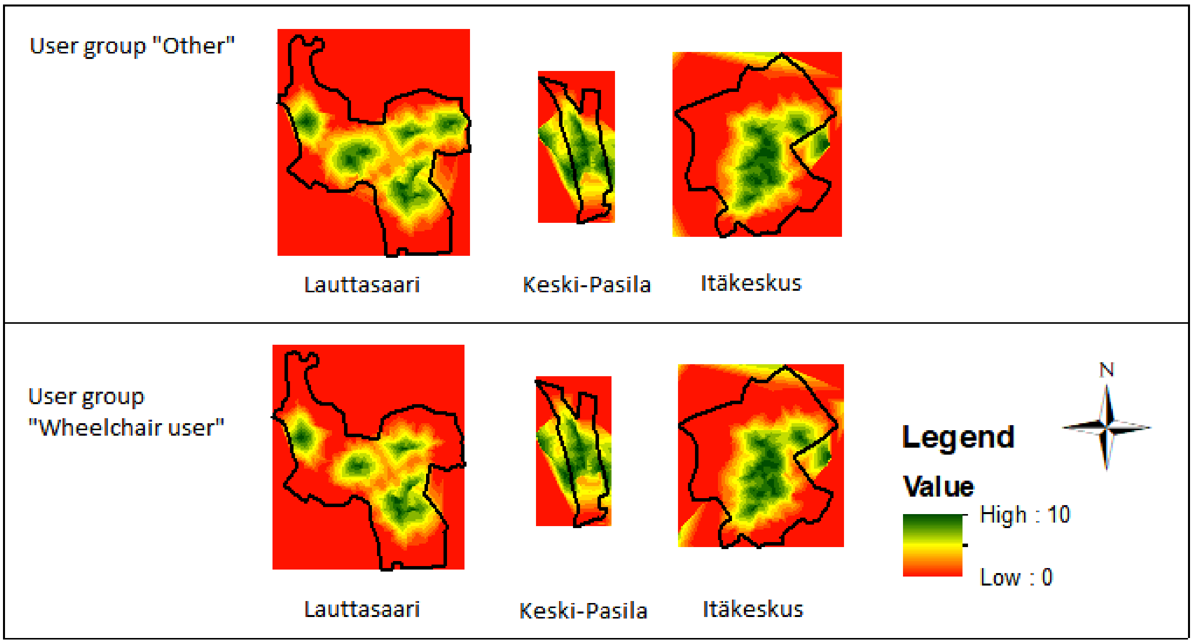

Figure 18. Results of the dimension *Destination accessibility*.

In Keski-Pasila research area the number of accessible PT stops is almost the same for the three user groups. The user group “wheelchair users” has 3 PT stops less than the user groups “other” and “persons with impaired vision”. For the user groups “other” and “persons with impaired vision” 50 % of all PT stops in the research area are within a 150–200-meter walk to the nearest grocery store and for the user group “wheelchair users” the walking distance for 50 % of the PT stops is 100–150 meters. In Keski-Pasila 77 % of all accessible PT stops are within a 500-meter walk in the case of the user group “wheelchair users” and 79 % of PT stops in the case of the two other user groups.

The most drastic difference in the number of accessible PT stops between the user groups is found in Lauttasaari where the user groups “other” and “persons with impaired vision” have 41 accessible PT stops, while the user group “wheelchair users” only has 8 accessible PT stops. For the user groups “other” and “persons with impaired vision” 50 % of all PT stops in the research area are within a 200–250-meter walking distance from the nearest grocery store. In the case of the user group “wheelchair users” the walking distance for 50 of all accessible PT stops in the research area is 250–300 meters. Over 90 % of all PT stops are within a 500-meter walking distance to a grocery store in the case of the user groups “other” and “persons

Table 9. Number of PT stops within a distance to a grocery store in research areas.

Number of PT stops within a distance to a grocery store in Itäkeskus				
Distance from grocery store (meters)	Number of PT stops		Cumulative % of all PT stops in distance zone	
	User groups "other" and "persons with imapired vision"	User group "Wheelchair user"	User groups "other" and "persons with imapired vision"	User group "Wheelchair user"
0 - 50	2	0	2,94	0,00
50 - 100	3	2	7,35	7,69
100 - 150	7	4	17,65	23,08
150 - 200	5	2	25,00	30,77
200 - 250	11	7	41,18	57,69
250 - 300	6	5	50,00	76,92
300 - 350	4	2	55,88	84,62
350 - 400	0	0	55,88	84,62
400 - 450	3	2	60,29	92,31
450 - 500	3	0	64,71	92,31
> 500	24	2	100,00	100,00
Total	68	26		

Number of PT stops within a distance to a grocery store in Keski-Pasila				
Distance from grocery store (meters)	Number of PT stops		Cumulative % of all PT stops in distance zone	
	User groups "other" and "persons with imapired vision"	User group "Wheelchair user"	User groups "other" and "persons with imapired vision"	User group "Wheelchair user"
0 - 50	1	1	2,63	2,86
50 - 100	8	8	23,68	25,71
100 - 150	9	9	47,37	51,43
150 - 200	2	1	52,63	54,29
200 - 250	2	2	57,89	60,00
250 - 300	1	1	60,53	62,86
300 - 350	4	4	71,05	74,29
350 - 400	1	0	73,68	74,29
400 - 450	2	1	78,95	77,14
450 - 500	0	0	78,95	77,14
> 500	8	8	100,00	100,00
Total	38	35		

Number of PT stops within a distance to a grocery store in Lauttasaari				
Distance from grocery store (meters)	Number of PT stops		Cumulative % of all PT stops in distance zone	
	User groups "other" and "persons with imapired vision"	User group "Wheelchair user"	User groups "other" and "persons with imapired vision"	User group "Wheelchair user"
0 - 50	1	0	2,44	0,00
50 - 100	5	1	14,63	12,50
100 - 150	6	0	29,27	12,50
150 - 200	6	1	43,90	25,00
200 - 250	4	1	53,66	37,50
250 - 300	8	1	73,17	50,00
300 - 350	0	0	73,17	50,00
350 - 400	2	0	78,05	50,00
400 - 450	4	0	87,80	50,00
450 - 500	2	1	92,68	62,50
> 500	3	3	100,00	100,00
Total	41	8		

with impaired vision", but only 63 % of accessible PT stops are within this distance for the user group "wheelchair users". It is obvious that accessibility from a PT stop to the nearest grocery store for wheelchair users is much worse in Lauttasaari than in the two other research areas.

These results might have been affected by the fact that not all PT stops have yet been examined and as such the accessibility information might not be fully correct. This was also the case for the dimension *Distance to transit*.

7.1.5 Design

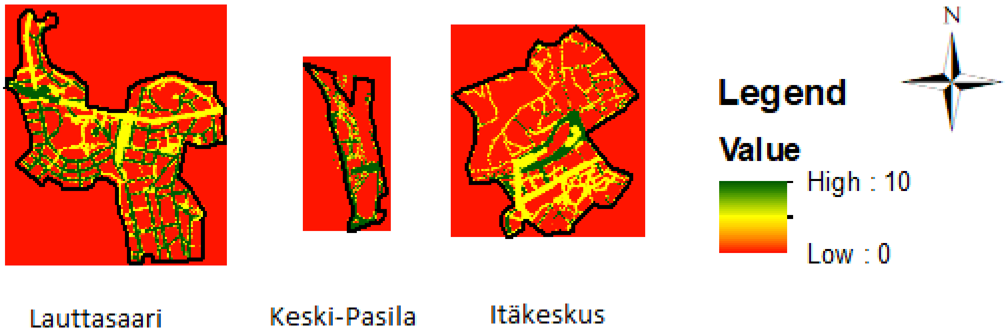

Figure 19. Results of the dimension *Design-illumination*.

In Itäkeskus the design element of illumination is good or moderate in the scope of the whole research area along the pedestrian routes (figure 19). In Keski-Pasila illumination is mostly good in the whole research area. Illumination is good in Lauttasaari in other places except along the roads Lauttasaaritie, Särkiniementie and Katajaharjuntie, where the level of illumination is moderate.

Lauttasaari has the highest rate of illuminated area when comparing the three research areas (table 10) where nearly 50 % of the research area is illuminated. In Itäkeskus the rate is 30 % and in Keski-Pasila the rate is 27 %. Lauttasaari has a bigger area illuminated with special level accessibility illumination (10 lux and 15 lux), while Itäkeskus has a bigger area illuminated with basic level accessibility illumination (less than 10 lux). In Keski-Pasila all illuminated areas are of special level accessibility. The average accessibility value in the whole research area is the best in Keski-Pasila, where the average is 1,38 (on the scale from 0 to 2). The worst average level of accessibility of illumination is in Itäkeskus.

Table 10. Statistics of illuminated area in research areas.

	Itäkeskus	Keski-Pasila	Lauttasaari
Illuminated area ha (accessibility 2)	26,92	16,77	81,15
Illuminated area ha (accessibility 1)	48,63		54,59
Rate of illuminated area (%)	30,60	26,90	48,41
Mean accessibility value in illuminated areas	0,96	1,38	1,23

Path quality is mostly good in center areas in Itäkeskus research area, moderate values are found in the western and eastern parts of the research area (figure 20). In Keski-Pasila, all routes, except for in courtyard areas, have very high values of path quality. The results may be such due to the fact that land use plans or park plans for courtyard areas were not found for this research. In Lauttasaari the level of path quality is mostly moderate in the whole research area, except along the roads Lauttasaarentie, Isokaari, Heikkiläntie and Meripuistontie, where path quality is good (figure 20). The gained path quality values seem to be higher for the user group “other” than for the user groups “wheelchair users” and “persons with impaired vision” in Itäkeskus and Lauttasaari research areas.

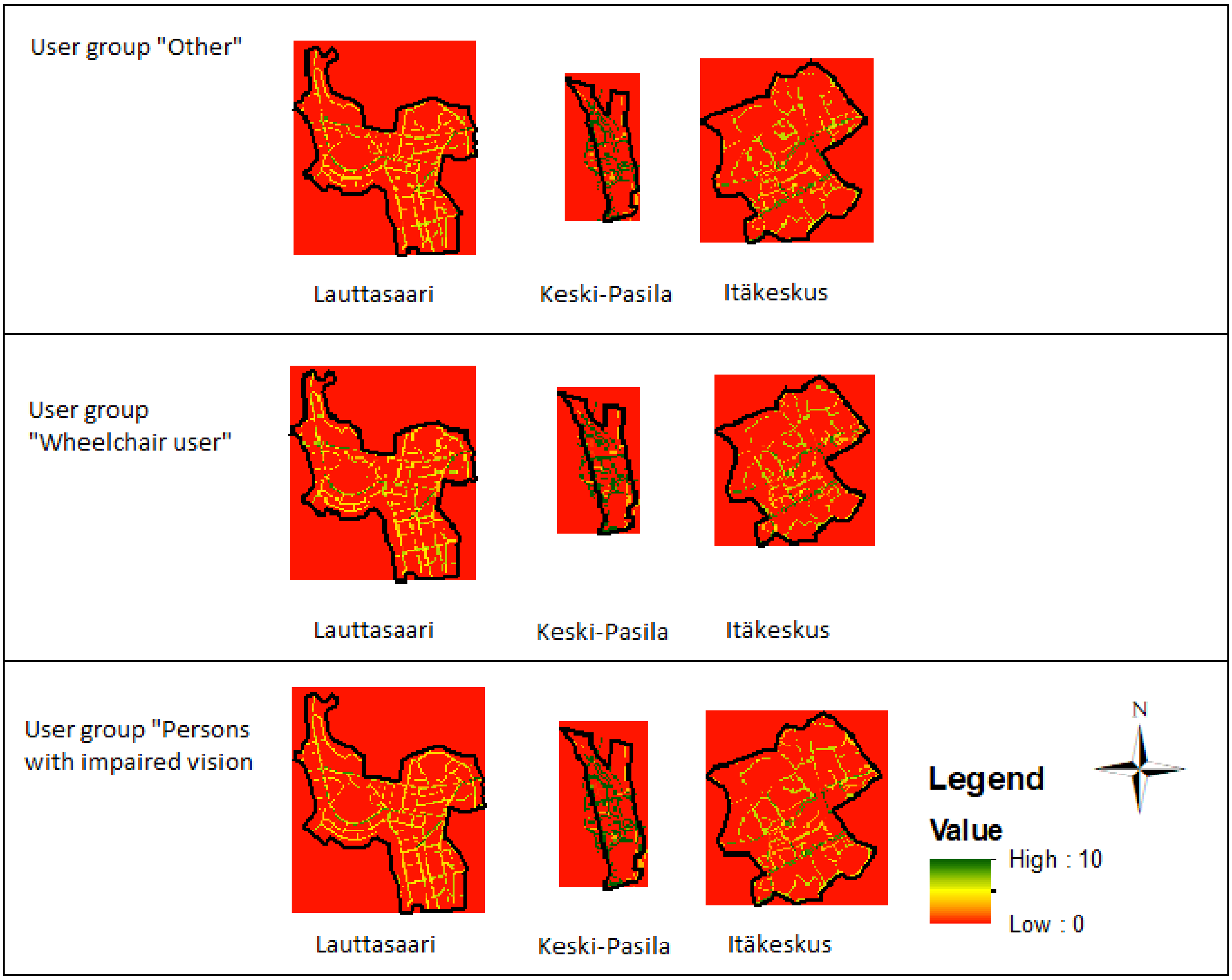

Figure 20. Results of the dimension *Design-path quality*.

Route connectivity is mainly good in all research areas (figure 21). In Itäkeskus we can see more areas with poor connectivity in the northern parts of the research area. In Keski-Pasila the poor connectivity areas are located in areas where no land use plans have yet been made (in the southern part of the research area), or where the area is dominated by main roads (in the northern part of the research area). In Lauttasaari the poor connectivity areas are located in such places where there are no painted pedestrian crossings.

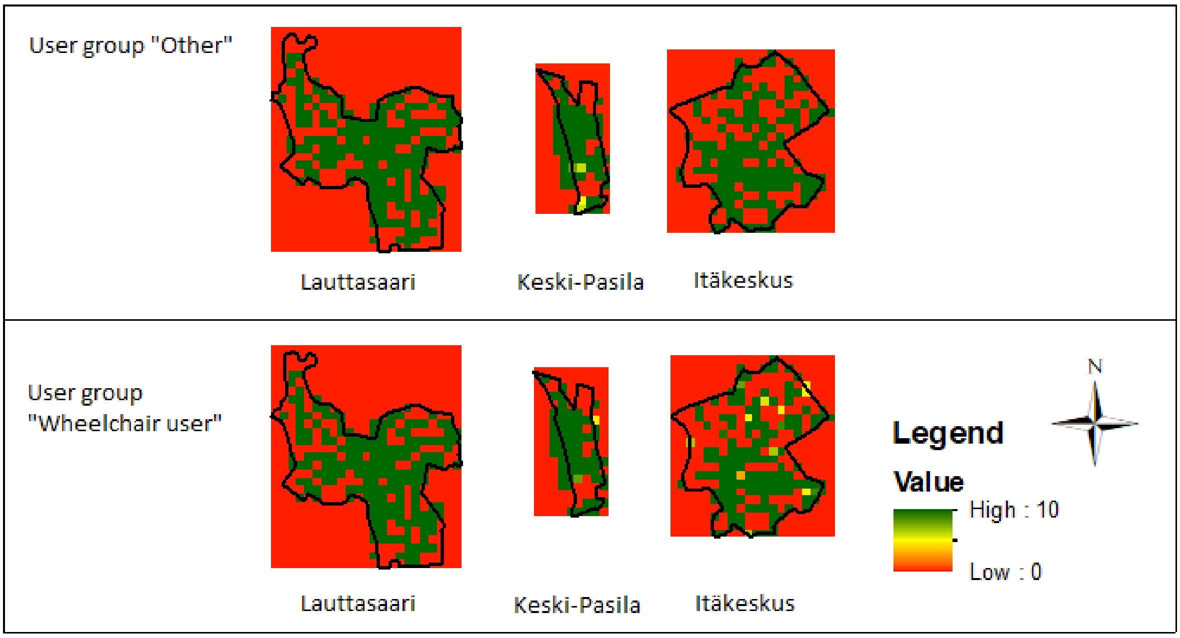

Figure 21. Results of the dimension *Design-route connectivity*

7.1.6 Demand

The accessibility to benches is good in the whole research area of Itäkeskus, however, an anomaly can be found in the eastern side of the Itäkeskus mall (figure 22). In Keski-Pasila there is a good accessibility to benches in the center part of the research area, but not in the southern and northern parts. In Lauttasaari the accessibility to benches is good in the whole research area.

The accessibility to benches is better in Lauttasaari when looking at the percentage of the area which is covered by accessible benches (table 11). The number tells the percentage of the research area that is within a distance of 100 meters from the nearest bench. In Lauttasaari the amount is over 40 % while in Itäkeskus it is 30 %. There is not much difference between the user groups. The research area Keski-Pasila has been left out from the table as the locations and number of benches is uncertain in this research area.

There are more areas with only one bench within a 100-meter radius in Lauttasaari than in Itäkeskus. In Lauttasaari there are 12 clusters with only one bench for the two user groups of “other” and “persons with impaired vision”, while there are 10 clusters in Itäkeskus respectively. For the user group “wheelchair users” there are less clusters with only one bench compared to the other two user groups in Itäkeskus, and one more cluster with only one bench in Lauttasaari. The information on the clusters reveal that these are stand-alone benches and that the distance from these benches to the next is longer than acceptable within the physical accessibility criteria. This result is odd as it could be expected that the amount of clusters would either be less or more in both research areas. This result might reveal a possible error in the calculations. If the result is correct, it tells us that the user group “wheelchair users” has better accessibility to benches compared to the other two user groups in Itäkeskus research area, and worse accessibility to benches compared to the two other user groups in Lauttasaari.

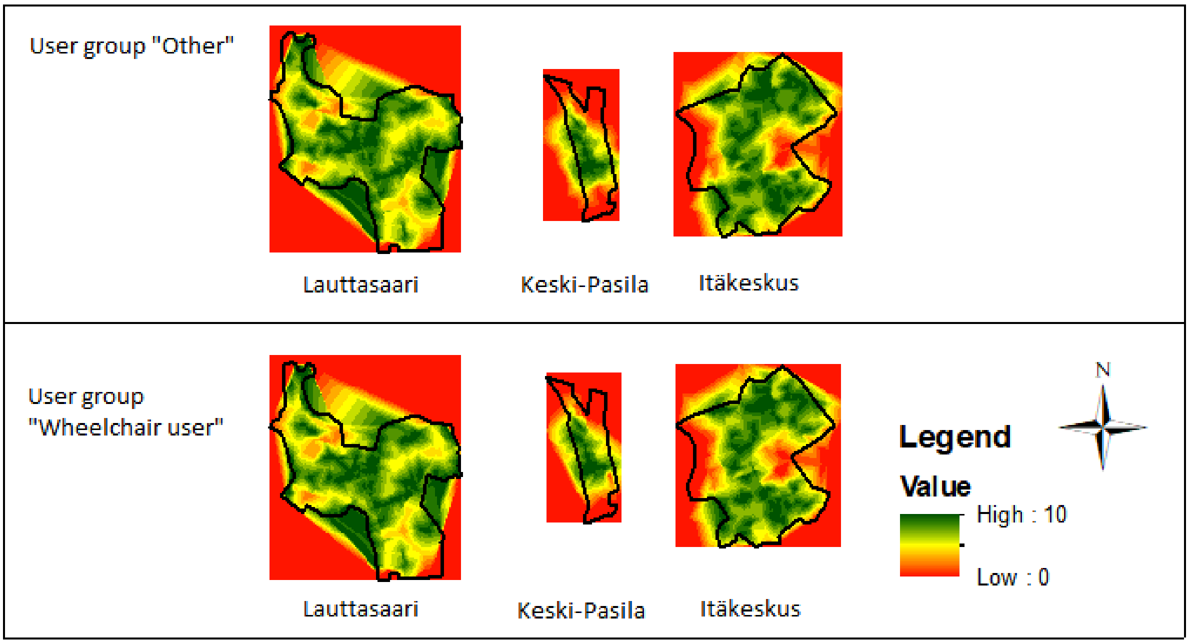

Figure 22. Results of the dimension *Demand*

Table 11. Statistics of accessibility of benches in research areas.

	Itäkeskus		Lauttasaari	
	User group "Wheelchair user"	User groups "other" and "persons with imapired vision"	User group "Wheelchair user"	User groups "other" and "persons with imapired vision"
Number of clusters	24	24	32	31
Minimum amount of benches	1	1	1	1
Maximum amount of benches	36	39	43	43
Number of clusters with 1 bench	8	10	13	12
Percent of total area covered by accessible benches (0–100 meter distance)	30,07	30,39	41,39	41,08

7.1.7 Declination

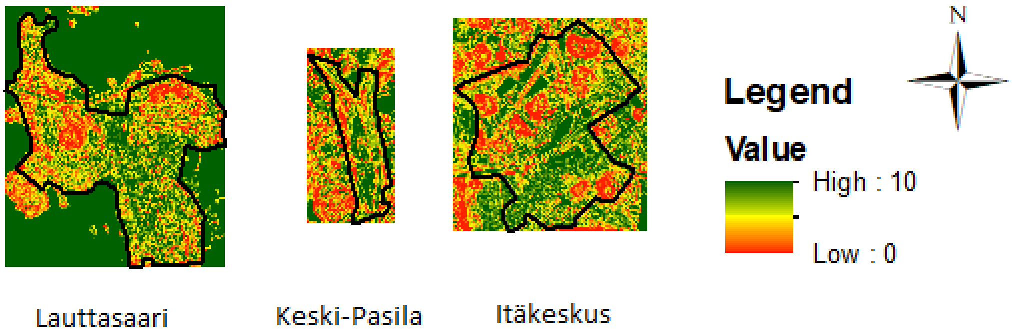

Figure 23. Results of the dimension *Declination*.

In Itäkeskus and in Keski-Pasila over 50 % of the research area has a good declination from a physical accessibility point of view (table 12). The slope is less than 5 % which corresponds to special level physical accessibility criteria. In Itäkeskus non-accessible slope areas are located in the northern, south-eastern and north-western areas (figure 23). In Keski-Pasila the research area is principally low-lying except for in the western parts of the research area where the slope is worse from a physical accessibility point of view. In Lauttasaari the rate of area that has a slope value within the special level physical accessibility criteria is a bit lower as in the other research areas, as 47 % of the research area has a slope between 0–5 %. The areas with non-accessible slope values are located in north-eastern, western and north-western parts of the research area. However, the topography is physically accessible by 65 % of the total research area in all three research areas.

Table 12. Statistics of declination in research areas.

	Itäkeskus		Keski-Pasila		Lauttasaari	
Slope	Area (ha)	Percentage	Area (ha)	Percentage	Area (ha)	Percentage
0–5 %	124,6238	50,48	32,6748	52,40	131,8815	47,04
5–8 %	35,7927	14,50	7,9907	12,82	49,5508	17,67
More than 8 %	86,4742	35,03	21,6884	34,78	98,9389	35,29

7.2 Physical Accessibility Index

7.2.1 Itäkeskus research area

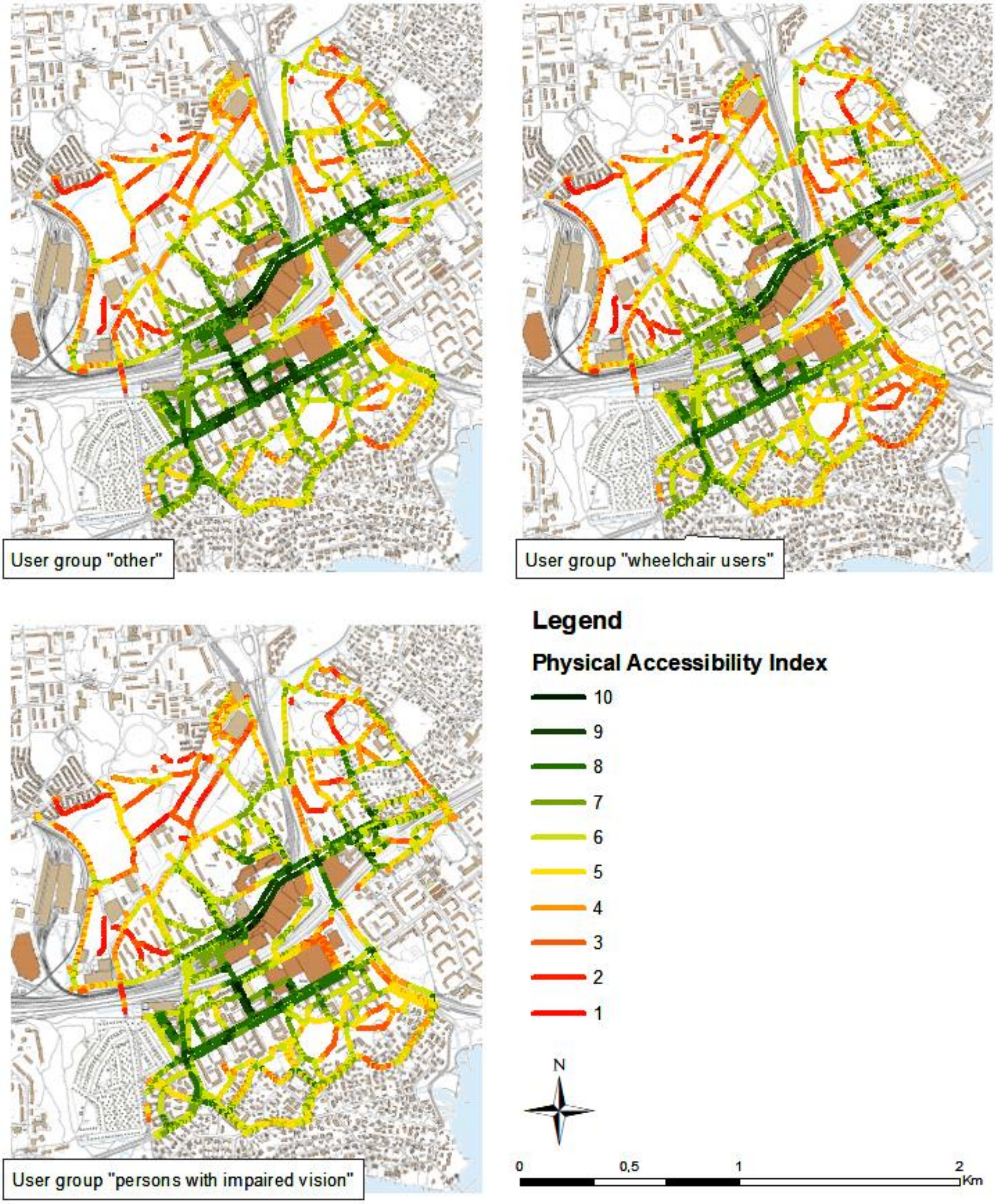

Figure 24. Physical Accessibility Index for the research area Itäkeskus and the three user groups. Green areas and higher values represent better physical accessibility level. Source of base map: City of Helsinki 2017h.

When comparing the results from the different research areas, we notice that the user group ”other” has a larger area with good physical accessibility (high values) than the other two user groups (figure 24). The area of good physical accessibility is concentrated in center areas in the case of all user groups. For the user group “wheelchair users” the level of physical accessibility is lower especially in the southern and south-eastern parts of the research area and on the northern side of the Itäkeskus mall. The higher slope rates in these areas (figure 23) may have affected these results. The dimension of *Distance to transit* also got lower values in these areas as for the user group ”wheelchair users”. In addition, physical accessibility seems to be worse for this user group on the left of the southern side of the Itäväylä motorway, which is located in east-west direction in the center of the map. The level of physical accessibility is also lower for the user group “persons with impaired vision” at the northern side of the Itäkeskus mall and on the left of the southern side of the Itäväylä motorway compared to the user group “other”.

The lower scoring of the northern part of the research area might be explained by the fact that this area is less densely built. Many of the routes that cross the recreational area have not got any winter maintenance and have therefore also got low values for path quality, as is also the case of many routes in the southern part of the research area. The slope in the northern part is also worse from a physical accessibility point of view compared to the rest of the research area. Furthermore, the distances to the services in the center and to public transport are longer.

7.2.2 Lauttasaari research area

The level of physical accessibility is for the most part good in Lauttasaari research area (figure 25). However, the values are considerably lower at the periphery than in the center of the research area. The results for the user group “other” are evidently better than the results for the two other user groups. The results between the user groups “other” and “wheelchair users” differ mainly because of the big differences between the results of the dimensions *Distance to transit* and *Destination accessibility* (figures 17 and 18). The results for these dimensions are much worse for the user group ”wheelchair user” than for the two other user groups. From the results for the user group “wheelchair users” it is even possible to see the influence of slopes in the research area. In the areas where the slope is steep from the physical accessibility point of view (figure 23), even the value of the Physical Accessibility Index is lower than in other areas and when compared with the two other user groups. This kind of a difference is evident especially at the eastern part of the road Lauttasaarentie.

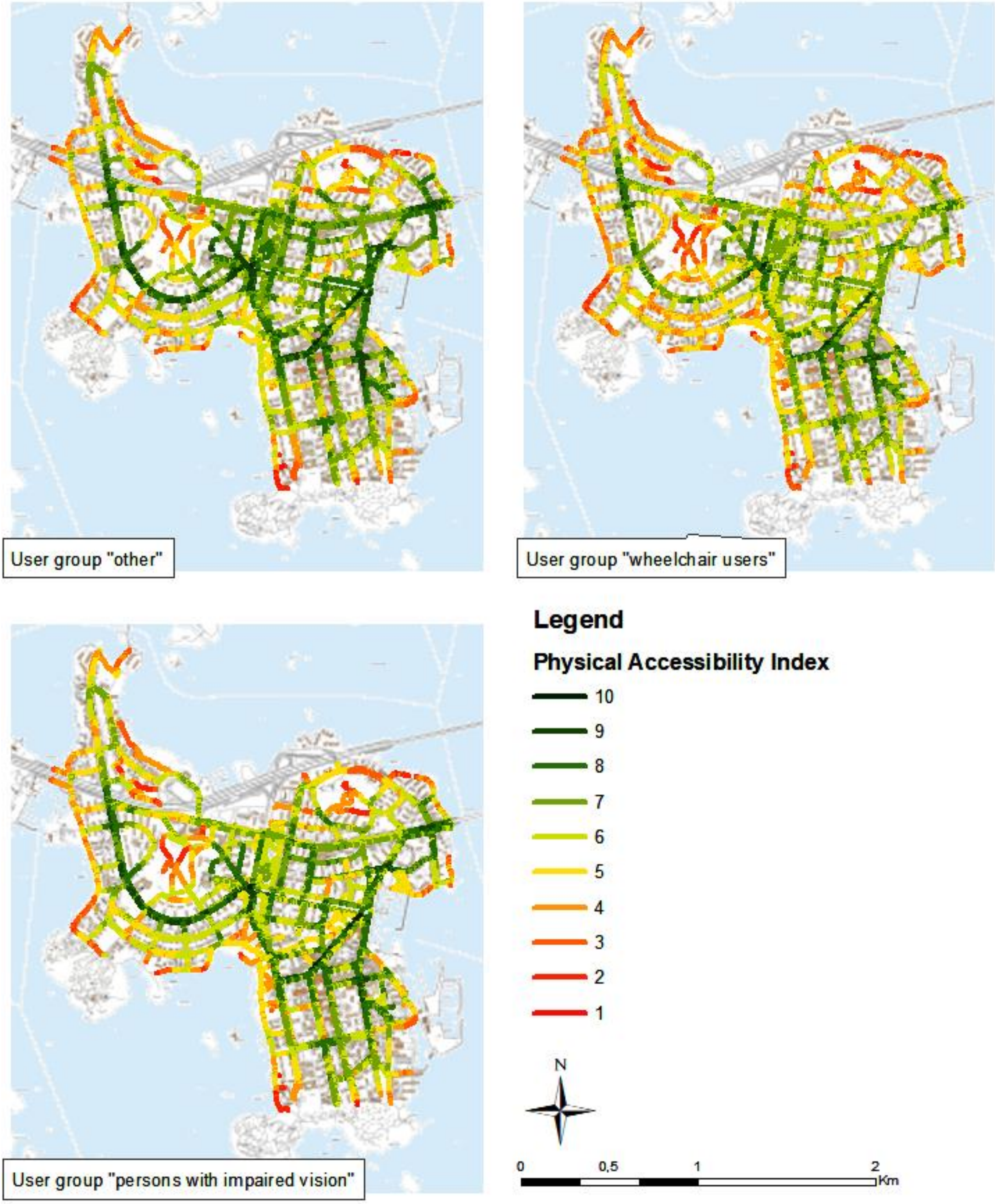

Figure 25. Physical Accessibility Index for the research area Lauttasaari and the three user groups. Green areas and higher values represent better physical accessibility level. Source of base map: City of Helsinki 2017h.

7.2.3 Keski-Pasila research area

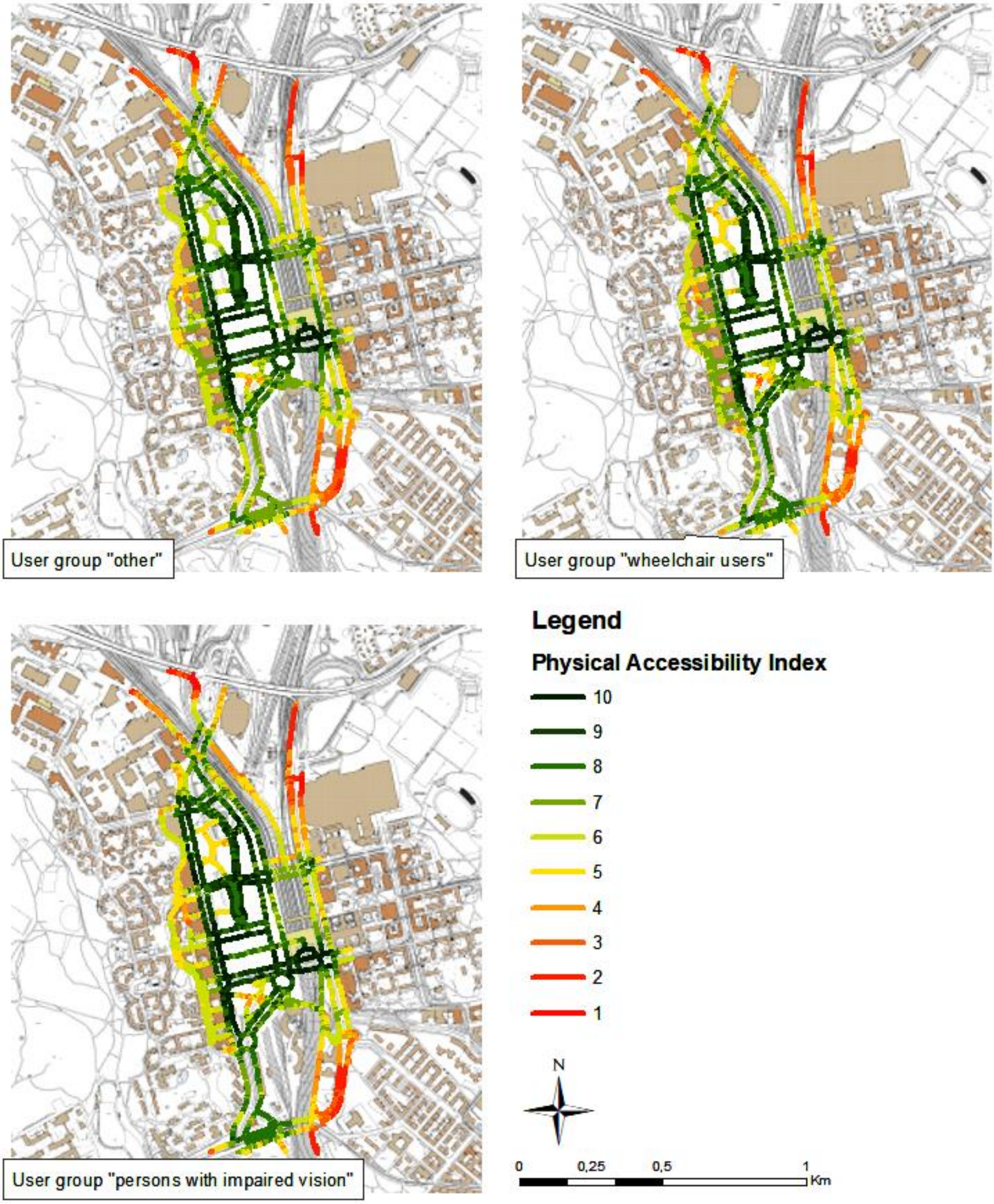

Figure 26. Physical Accessibility Index for the research area Keski-Pasila and the three user groups. Green areas and higher values represent better physical accessibility level. Source of base map: City of Helsinki 2017h.

In Keski-Pasila all new planned pedestrian route areas got very good Physical Accessibility Index values compared to the two other research areas (figure 26). The level of physical accessibility seems to be lower at the periphery of the research area, which may be explained by the lack of data from these areas, as I concentrated first and foremost on the planned new areas in the analysis. So, instead of looking at the whole research area, we should be looking at the results from the planned new areas, which are located in the center of the research area (area of interest, figure 13). The results for these areas show only high values. Also, when looking at the results from the different dimensions we can notice that Keski-Pasila has got considerably higher results than the two other research areas.

When comparing the results between the three different user groups, we can notice, that there are not many differences; or, when differences are found, they are minimal. The most visible differences can be found at the courtyards of the residential areas, for which I do not have exact planning documents, so these results cannot be considered as closely. Based on these results it could be said that Keski-Pasila was planned as physically accessible for all user groups.

7.3 Reliability analysis

Based on values in table 12, the objects that have been classified as special level accessibility objects during the fieldwork have gained values higher than 7 as 50 % of the object of PAI have got these values. It is noteworthy that PAI values 9 and 10 are not that common among the objects which have been classified as special level objects during the fieldwork. This is maybe because different elements have been evaluated during the fieldwork than during this research. The fieldwork does not include evaluations of macro-level elements. In the case of objects which were classified as basic level accessibility objects during the fieldwork, the objects have also got values higher than 7. These objects with accessibility level “basic” are only a total of 34 pieces, so no precise conclusions can be made from this result.

Table 13. Results from the validation analysis.

Actual level of accessibility	PAI value	Amount	%	Cumulative %
Special level accessibility	**2**	4	0,08	0,08
	3	97	1,83	1,90
	4	244	4,59	6,49
	5	265	4,99	11,48
	6	568	10,69	22,18
	7	1637	30,82	52,99
	8	1894	35,66	88,65
	9	599	11,28	99,92
	10	4	0,08	100,00
	Total	5312	100,00	100,00
Basic level accessibility	**7**	13	38,24	38,24
	8	4	11,76	50,00
	9	17	50,00	100,00
	10	0	0,00	100,00
	Total	34	100,00	100,00

Part III. Helsinki as the Access City

8 Discussion

Physical Accessibility Index results show that the centers of the research areas in Lauttasaari and Itäkeskus have been developed and are built well from a physical accessibility point of view. The results show also that Keski-Pasila will in the future have a very good level of physical accessibility in all the new planned areas. However, big differences can be found between the research areas. In Itäkeskus and Lauttasaari, where physical accessibility has been improved primarily through restorations, the level of physical accessibility is good on a much narrower area than in Keski-Pasila, where physical accessibility has been taken into consideration from the beginning of the planning process. The results are, however, only directional and they do not indicate the actual level of physical accessibility in a certain research area; only what the level of physical accessibility is in relation to the other research areas and between different user groups. I will discuss of the data, methods and results in more detail in the sections below.

8.1 Thoughts concerning data and methods

The method which I have modeled for assessing the physical accessibility in this research is highly data-dependent. This means that the success of the method and the results are dependent on the quality of the data. Results should not be scrutinized too closely as many assumptions were made in the analysis, making results imprecise. It became clear when performing the analysis that the data for dimensions and elements on micro scale especially were not precise enough. Big updates to the spatial data that the City of Helsinki administrates are therefore needed so that this kind of method could be used when assessing physical accessibility of the build urban environment.

Both micro and macro scales were used in the analysis which in itself presented some problems to the analysis. It was difficult to define the best scale to use in the analysis so that the results from both micro- and macro scale elements would reflect the reality as accurately as possible. It could be possible to simultaneously study dimensions at different scales even if the results would be scaled to 1 x 1-meter grids; this would give a more precise result from a pedestrian point of view. In this research the scaling was done to 10 x 10-meter grids and presented as a vector network that had been cut into 1-meter segments. The chosen scale might not be precise enough to study physical accessibility from a pedestrian point of view and as such developments could be made to the method to make it more precise. However, the gained results can still be used to study the level of physical accessibility on a general level in the research areas.

The data that I used in the analysis placed limitations on how precise the results could be by using the chosen methods. The data did not support the accurate study of the micro scale as the data was lacking information about the curbstone measurements, only to name one, which have a big impact on physical accessibility for many pedestrians. The quality of curbstones have an effect on the mobility especially of the user groups ”wheelchair users” and ”persons with impaired vision” as well as to persons with a pram, luggage or walking with a rollator. The data also lacked information about possible cracks or bumps in the pavement material, the locations of street inlets and their measurements and the measurements of ramps. These all have an impact on how precise the results are from the analysis on micro scale. Additionally, data for studying illumination lacked the information on the actual lux values or about the illuminance efficacy, and as such I had to use assumptions about the illuminance efficacy and I used target values instead of actual lux values. Furthermore, the accessibility mapping of the public transport stops has not been finished, yet, and I had access to accessibility information for only a portion of all public transport stops which also had an influence on the accuracy of the results. In addition, the accessibility information is not sufficient enough in the data on benches which resulted in that the physical accessibility criteria for the measurements of benches could not be considered in the analysis. Because of these circumstances the gained results are not precise, but merely directional.

It was suggested during the discussion event for regional-, traffic-, and street planners where I presented the results of this research, that elements of safety should be added to the method. The elements which should be considered when assessing physical accessibility are, based on suggestions by the planners, motorized vehicle speed limits in street areas, statistics over areas that are known to be slippery during winter time, locations of speed bumps and locations of dangerous intersections. This kind of information is to my knowledge not yet administrated in any registries in the City of Helsinki and could be added to spatial data servers. Furthermore, these elements could be added in the PAI model in the dimension of *Design -path quality* or in the dimension of *Discovery*.

Criteria for physical accessibility could not be found from literature or previous studies for every dimension, which influenced both the chosen methods and in results. As there were not any values for making comparisons, by which I mean thresholds for special and basic level accessibility in the case of each of the dimension, I had to submit to normalizing each dimension into deciles by using the equal interval reclassification method, which only classifies the data into similarly sized groups. Because of this, the results can only be used to compare the results inside and between different research areas and different user groups. The results cannot be used in confirming as to whether the gained physical accessibility values fulfill the criteria for special or basic level accessibility. In order to be able to do this and for the modeled Physical Accessibility Index to work as a valid index, each dimension should have defined thresholds representing special and basic level accessibility. This could be done by an expert group, although there were not enough resources available in line with this research. An expert group could be used in defining physical accessibility classification for each dimension so that this method could be further developed.

The created model for Physical Accessibility Index supports adding more elements or user groups into the model. In this research there were three different user groups and it was assumed that the user groups are internally homogeneous. This however is not the case in reality as variations can be found inside the user groups. If the model was to be further developed and if further elements of the built environment were added into the model, it could support the study of multiple user groups. The model seems to be very flexible and by changing the coefficients for each dimension, it would be possible to take more user groups into consideration in layer aggregation. The coefficients have been kept simple in this research and they have been arbitrarily chosen, but coefficients were still given to those elements that are relevant to the user groups. Expert groups could be used in defining suitable coefficients for different dimensions or elements to make the method more precise.

It was difficult to answer the fourth research question as only 8 full responses returned from the electronic questionnaire. However, answers were gained from each of the three research areas, but no answers were received from local master planners or detailed land use planners. Therefore, it was difficult to make any reliable conclusions about this particular question. I did, however, get some background information about the research areas, which has been introduced when presenting the research areas.

Suggestions for further action concerning data

- Information about the ramp and ramp measurements should be added in a registry or into the stair registry.
- Information about the actual lux values of the street lamps should be added in street lamp registry.

- The polygons that represent pedestrian paths and street areas are segmented in the Registry of Public Areas, which makes the evaluation of route segment width almost impossible. Information about the actual width of a pedestrian path should be added in the registry.
- Information about curbstone measurements should be administrated in a registry. This information could be added for example, in pedestrian path polygons in the Registry of Public Areas.
- Information about warning areas or tactile tiles should be administrated in a registry. Warning areas that are related to stairs could be added, for example, in the stair registry, and warning areas and tactile tiles in pedestrian path and crossing areas could be added, for example, in pedestrian path polygons in the Registry of Public Areas.
- Information about the sound and light signals, curbstone measurements, measurements of the traffic island, should be added, for example, in polygons or lines that represent pedestrian crossings in the Registry of Public Areas.
- The accessibility mapping of public transport stops should be completed as soon as possible.
- Safety –related spatial data could be added, for example, in the Registry of Public Areas. These kinds of data could be; speed limits in street areas, locations of speed bumps, locations of dangerous intersections and locations of areas that are known to be slippery during winter time.

Suggestions for further action concerning methods

- An expert group should define thresholds to special and basic level accessibility for each of the dimensions so that assessing physical accessibility with this method could be possible.
- The dimension of *Discovery* could be added into the method. Participatory mapping methods could be used to gather information about the elements in the dimension of *Discovery*.
- An expert group should define suitable coefficients for each dimension so that multiple user groups could be taken into consideration in the method.

8.2 Thoughts from results and validation

According to the results, the level of physical accessibility is good in the central parts of the research areas. The situation is a less satisfactory in the periphery of the research areas. These results are understandable when we consider that center areas tend to be more densely built than the areas outside the center of a neighborhood as there is usually more variation in land use and land use patterns are of smaller scale. In addition, there are more street lights, more pedestrian route options and pedestrian paths are usually designed for a bigger pedestrian crowd in center areas.

When these results were presented to regional-, traffic- and street planners, who know the research areas well, they were for the most part of the same opinion with the gained results. According to the planners, the Physical Accessibility Index did succeed in showing the good and weak areas of physical accessibility. On the other hand, the planners did also notice areas where the PAI-value is low even though the real level of physical accessibility is high. These kinds of areas were located especially outside of center areas where the dimensions of *Density*, *Diversity*, *Destination accessibility* and *Distance to transit* had got low values in my analysis. The collision between the PAI-values and the real level of accessibility can be explained by the fact that usually, when assessing physical accessibility, we are only looking at elements on micro level and at details of path quality especially. However, in my analysis I have considered also elements that are associated with walkability and measured on macro level.

When looking at the results it should be noted that many assumptions were made in the analysis, as the data used did not provide all the information that this kind of an analysis requires. The results are therefore only directional and they should not be considered as truths. However, based on the gained results, it is possible to respond to and analyze the research questions.

> *How can the actualized, current physical accessibility of the built environment be measured and evaluated by using existing spatial data?*

Based on the results it seems possible to measure and evaluate the current state of physical accessibility of the built environment by using these methods, but only if the data that is used supports the needs of this kind of analysis. In this research it was made clear that the acquired data only in part supports this kind of analysis. The analysis made for the dimensions on macro scale were successful apart from the analysis made using the information about the accessibility of public transport stops. The lack of necessary information on micro scale resulted in that it was not possible to make any reliable conclusions about the level of physical accessibility. Consequently, the spatial data from the City of Helsinki and from Helsinki Region Transport does not support the analysis of the level of physical accessibility on micro scale in its current state.

Furthermore, each dimension should have defined thresholds for, as an example, special and basic level accessibility, so that it would be possible to study if physical accessibility criteria are met for each of the dimensions in the research areas. In this research it was possible to use defined physical accessibility criteria only in the case of the dimensions *Declination*, *Design-illumination* and *Design-path quality*, and partly also in the case of *Demand*, *Distance to transit* and *Destination accessibility*. With the results from this research it is possible to study only how the current level of physical accessibility looks like inside the research areas and in relation to the other research areas. It is possible to compare the results from one research area to another, but even if the results show a good level of physical accessibility, the results do not tell the viewer what the actual level is. The model should therefore be developed further by defining thresholds for each dimension, so that it would be possible to study what the level of physical accessibility is in the research areas.

> *Is the created Physical Accessibility Index valid in assessing physical accessibility of the built environment?*

In reliability analysis, the results from the Physical Accessibility Index were compared with the results from the fieldwork from summer 2017, in which the physical accessibility of pedestrian routes were assessed by looking at the declination of the pedestrian route, the quality of the pavement, the detectability of the pavement, the measurements of the pedestrian crossings, and the light and sound signal of pedestrian crossings. A variety of elements were evaluated during the fieldwork compared to the PAI, and even though the dimension of *Design-path quality* does include some of the same elements evaluated during the fieldwork, not all of the elements had a corresponding spatial data in the source data that was used in the PAI analysis. In this reliability analysis, a result combining both micro and macro level elements was compared to a result, which deals only with micro level elements. Therefore, the result from the reliability analysis itself is not that reliable, but it does give some idea as to whether the locations of areas that have good PAI values correspond and correlate with the locations of areas which have been classified as having a good level of physical accessibility in reality. The reliability analysis gives results only for a portion of all objects that have a PAI value as only special level physical accessibility routes were evaluated during the fieldwork. According to the reliability analysis, the objects which had been classified as special level physical accessibility routes during the fieldwork got the value 7 or higher in the Physical Accessibility Index. The number of objects with low PAI-values was low in the areas that had good level of physical accessibility in reality. The fact that there was not that much of the highest PAI-values in the areas of actual special level of physical accessibility tells us the fact that different things were analyzed in the PAI and during the fieldwork. However, the PAI-values are clearly clustered towards higher values. This is a good result and it indicates that it could be possible to assess the level of physical accessibility by using these methods.

It is possible to tell based on the PAI results and from the reliability analysis, that the model has been developed from the ideas of the walkability index. Even though physical accessibility and walkability deal with somewhat similar things, big differences and collisions can be found between the indices on micro level. The model in its current form might consider too much of the elements from the walkability index. However, I do believe that with a few alterations the created model is valid in assessing the level of physical accessibility. Even the regional-, traffic-, and street planners to whom I presented these results were convinced that it would be possible to evaluate the level of physical accessibility, if the method should be further developed. In that process it should be thoroughly considered whether all of the used dimensions are necessary in assessing physical accessibility when further developing this model. Physical accessibility is traditionally assessed on micro level only, however, in this research macro level was also added in the analysis. In my opinion, at least the dimensions of *Distance to transit* and *Destination accessibility* should be kept in the model, but perchance one or both of the dimensions of *Density* and *Diversity* could be excluded, or alternatively, these dimensions could be combined as they measure principally the same thing but only from a different point of view. It could be possible to consider, for example, lowering the coefficients of the dimensions that mostly deal with the elements of walkability. These kinds of dimensions are *Density*, *Diversity*, possibly also *Discovery*, *Distance to transit* and *Demand*.

How does physical accessibility of the built environment differ when assessing accessibility from the point of view of different user groups?

It was possible to get clear, distinct results between the three user groups with these methods. Even though the analysis for the user group “persons with impaired vision” does not differ from the user group “other” in other ways except for the different accessibility scores for path segments on the dimension of *Design-path quality*, the different, and from the user group point of view significant, coefficients that were used in layer aggregation ensured that differences between the two groups could be found. The elements of the built urban environment which are relevant to each user group became more distinct when using coefficients in layer aggregation. However, the used coefficients were arbitrarily chosen, so it may be possible that some elements have been emphasized to an extreme compared to other elements.

The success of the method is visible especially in Lauttasaari research area, where the eastern side of the road Lauttasaarentie has got lower Physical Accessibility Index values for the user group ”wheelchair users” compared to the user group “other”. The regional planning experts whose expertise lie in this research area commented on these results by stating that the concerned area is in fact very steep from pedestrian point of view, which also places difficulties to fulfill the criteria of physical accessibility in the area. In the method that I have developed, this slope factor became clearly visible, resulting in lower Physical Accessibility Index values. Even though I used arbitrarily chosen coefficients in layer aggregation, using coefficients can bring forward elements of the built urban structure that are relevant to a specific user group.

> *What significance does it have on the actualized quality of physical accessibility of the built environment, based on the results from the research areas, in which stages of the planning process is the accessibility aspect taken into account?*

It was difficult to answer this question as I did not get a significant enough number of responses to the electronic questionnaire. As a result, I was not able to get enough background information about the research area nor about the planning processes that have been implemented in the research area. Some conclusions can still be made about the results based on the background information I do have.

The results from Keski-Pasila show that it does influence as to in which stage of the planning process the aspect of physical accessibility is taken into consideration. In Keski-Pasila this aspect has been considered starting from the local master plan, which ensures that physically accessible construction solutions have had enough space even in following planning stages. Keski-Pasila is a completely new neighborhood area where construction work has just begun, which is a great advantage when considering physical accessibility. The construction area has been given enough space to take physical accessibility in to account. The situation has been quite different in, for example, Lauttasaari and Itäkeskus, where the center areas are already built and space has become scarce. It will be interesting to follow how physical accessibility will be realized in Keski-Pasila in reality. As it looks, based on the results from this research, the plans that have been made for Keski-Pasila suggest a very high level of physical accessibility. The reality will be equally as good, if the plans are followed during the construction phase.

Suggestions for further action based on the results

- The analysis could be executed on a smaller scale, which would make the utilization of the results in different applications possible.
- The results from Keski-Pasila are superior compared to the other two research areas. If we wanted the level of physical accessibility to be as good in the rest of the City of Helsinki, or in any other city, the planning processes and methods that have been implemented in Keski-Pasila should be used also in other planning projects.

8.3 Helsinki, the Access City?

The City of Helsinki has worked hard and long to enhance the physical accessibility of the city so that the city structure would enable the unobstructed mobility of the citizens or its visitors. This is evident from the amount of physical accessibility criteria and guidelines for the public built environment that is used when planning, constructing and maintaining the city. There are criteria and guidelines for even the smallest of details for the public built environment. In Helsinki, disability has truly been made a public issue and the city has responded to it. First, via the City of Helsinki Accessibility Strategy and Plan, secondly by creating an independent actor – the Helsinki for All –project – to grasp the issue of inaccessibility, then through the Regional Accessibility Plans and finally by creating physical accessibility criteria and guidelines together with partner municipalities. The differences in the needs and abilities of different user groups have been taken into consideration in all stages in the physical accessibility guidelines which guide planning, construction and maintenance of the built urban environment. For these reasons I too would gladly call Helsinki the Access City.

Even though there is much work to be done to improve the level of physical accessibility in many areas of the city, as was evident in the empirical research, the development of taking physical accessibility into consideration in planning, construction and maintenance of the public built urban environment is going in the right direction. Neighborhood centers can already be considered physically accessible according to the results from the empirical research. Legislation and guidelines about physical accessibility are quite comprehensive and, according to the results from the electronic questionnaire, planners are well aware about the different physical accessibility criteria. Based on the results from the empirical research, it seems that the aspect of physical accessibility is becoming a more natural part of the planning process. This is evident in the way that Keski-Pasila has been planned. Compared to the two other research areas, which have been built long before there was this comprehensive amount of physical accessibility regulations and guidelines, the guidelines have really been used well when planning the new Keski-Pasila neighborhood area, and this is also shown in the results. The next step is to make the whole city physically accessible through new construction and restoration.

According to the results from this empirical research, it is possible to take the needs for physical accessibility of different pedestrian user groups into consideration and to create a physically accessible city, as long as the physical accessibility criteria are considered in the early stages of the planning process. The criteria for a physically accessible city can be found in legislation, there are planning methods for considering physical accessibility in all planning stages, and there are more means and possibilities for considering physical accessibility when we move to a more detailed level. However, the physically accessible solutions need to be created already in the very early stages in the planning process so that these solutions can be implemented in practice, as was found from the questionnaire.

To conclude this, I state that the effect of impairments to mobility and functionality in the urban environment can be diminished if physical accessibility is taken into consideration when planning the urban environment. Similar processes which were used when planning Keski-Pasila should therefore be implemented when planning future city areas so that the level of physical accessibility would become as good in other areas of Helsinki as well as elsewhere. Through careful planning, construction and maintenance of the public urban environment it is possible to make sure that impairments stay only as a human condition and do not evolve to disability through human creation.

8.4 Further research

Physical accessibility is a vast topic and even though vast research has already been done, there are still many topics in need of more investigation. For example, it would be interesting to study the development of Keski-Pasila to see whether the level of physical accessibility becomes as good as the plans made for the area would indicate. It would also be suitable to study the planning processes and methods which have been used in Keski-Pasila for gaining these excellent results more closely. What effect has the planning process had in the level of physical accessibility compared with other planning processes in other areas in Helsinki or elsewhere and their level of physical accessibility? In this context it would be possible to study how the different physical accessibility criteria affected the planning processes and whether the aspect of physical accessibility has become a more natural part of the planning processes. I tried to grasp at this topic in this research, but the lack of resources, time and the low number of answers to the questionnaire hindered me from studying the topic in more detail. This topic alone is rather vast and would be a good topic for research in a master's thesis.

Another good topic for further research could also be to study how the persons with mobility or functionality impairments are participated in to urban planning processes. Are their interests taken into consideration, do they participate in some kind of workshops, has some kind of soft-GIS applications been made where the persons with mobility of functionality impairments have participated? Another interesting topic would be to find out what travel choices persons with mobility or functionality impairments make in the urban environment and which the preferred travel routes are. This kind of research could be made using mobile phone applications such as SportsTracker or similar. A related topic would be to investigate the "fine" subjective attributes in the 8D model – the dimension of *Discovery* – and to add it to the now created 8D model. Methods such as SportsTracker could be used also in this topic.

The method that I have modeled in this research should be further developed so that it could be used in map applications, for example. It would be possible to create a physical accessibility layer from the Physical Accessibility Index to be used in quantitative accessibility research. An example of a map application to which this Physical Accessibility Index could be implemented is MetropAccess-tool, which has been created for the region of Helsinki for calculating travel time. By adding the physical accessibility layer, the travel time of walking could be measured more exactly in the future. In this way The Physical Accessibility Index could then be used in urban planning more efficiently.

The Physical Accessibility Index could also be implemented in the Helsinki Region Service map. The Helsinki Region Service map shows the locations of various public services and their accessibility information for, for example, entrances to public service buildings. It is possible to define routes in the Service map, to which Helsinki Region Transport Digitransit and Open Street Map are used (Tuominen 2017). The user may define criteria for the urban environment based on his or her abilities and the routing is done according to the most suitable routes when taking the abilities of the user in consideration. Physical Accessibility Index could well be used as background information for the network from which the routing is calculated, if the method is further developed and the index is calculated on a more detailed level (Tuominen 2017). Also, the values in the Physical Accessibility Index should be inverted so that it could be used in routing, as the routing is made by using Least Cost Path analysis.

It was suggested during the discussion event for regional-, traffic- and street planners that this Physical Accessibility Index could be further developed as an interactive index that would be constantly updated as the spatial data that is used in the model is updated. To make this possible, an API (application programming interface) should be developed for the Physical Accessibility Index. If this was done, then it would even be possible to use participatory methods for gaining information from the citizens and their opinions about the level of physical accessibility in a certain place and of possible physical accessibility issues in the surrounding urban environment. By further developing the model and the methods, it would be possible to use physical accessibility information in various interesting applications.

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10 References

Litterature

Agampatian, R. (2014). *Using GIS to measure walkability: A case study in New York City.* Masters' of Science Thesis in Geoinformatics, Royal Institute of Technology (KTH), Stockholm, Sweden, 4/2014

Anderson, C. A. (2001). Claiming disability in the field of geography: Access, recognition and integration. *Social and Cultural Geography* 2:1, pp. 87–93.

Bendixen, K. & M. Benktzon (2015). Design for All in Scandinavia – A strong concept. *Applied ergonomics* 46, pp. 248-257.

Bertolini, L., F. le Clercq & L. Kapoen (2005). Sustainable accessibility: a conceptual framework to integrate transport and land use plan-making. Two test applications in the Netherlands and a reflection on the way forward. *Transport Policy* 12 (2005), pp. 207–220.

Cervero, R. & K. Kockelman (1997). Travel demand and the 3D's: density, diversity and design. *Transportation Research D* 2:3, pp. 199–219.

City of Helsinki (2011*). Helsinki kaikille –projekti – 10 vuotta esteetöntä kaupunkia.* Helsingin kaupungin rakennusviraston julkaisut 2011:13 / Katu- ja puisto-osasto. Kopio Niini, Helsinki 2011. pp 182.

D'Alessandro, D., L. Apolloni & L. Capasso (2016). How walkable is the city? Application of the Walking Suitability Index on the Territory (T-WSI) to the city of Rieti (Lazio region, Central Italy). *Epidemiol Prev* 40(3–4), pp. 237–242.

Doyle, S., A. Kelly-Schwartz, M. Schlossberg & J. Stockard (2006). Active community environments and health: the relationship of walkable and safe communities to individual health. *Journal of the American Planning Accosiation*, 72:1, pp. 19–31.

Esteetön rakennus ja ympäristö; turvallinen toimia ja liikkua: Suunnitteluopas. Rakennustietosäätiö RTS 2007. Rakennustietosäätiö OY, pp. 88.

Ewing, R. & S. Handy (2009). Measuring the Unmeasurable: Urban Design Qualities Related to Walkability. *Journal of Urban Design* 14:1, pp.65–84.

Fisher, F. (2003). Public Policy as Discursive Construct. Social meaning and multiple realities. *In* Fainstein, S & S. Campbell (edits.): *Readings in Planning Theory*, 3rd. edition, pp. 445–460.

Freund, P. (2001). Bodies, Disability and Spaces: the social model and disabling spatial organizations. *Disability and Society* 16:5, pp. 689–706.

Gallimore, J. M., B. B. Brown & C. M. Werner (2011). Walking routes to school in new urban and suburban neighborhoods: an environmental walkability analysis of blocks and routes. *Journal of Environmental Psychology* 31, pp. 184–191.

Gamache, S., F. Routhier, E. Morales, M.-H. Vandersmissen, J. Leblond, N. Boucher, B. J. MCFadyen & L. Noreau (2017). Municipal practices and needs regarding accessibility of pedestrian infrastructures for individuals with physical disabilities in Québec, Canada. *Journal of Accessibility and Design for All* 7:1, pp. 21–55.

Gant, R. (1997). Pedestrianization and Disabled People: a study of personal mobility in Kingston town centre. *Disability & Society* 12:5, pp. 723–740.

Gehl, J. (2006). *Life between buildings. Using public space*. Arkitektens Forlag. The Danish Architectual Press, pp. 200.

Gehl, J. (2010). *Cities for people*. Island press, Washington, pp. 269.

Geurs, K. T. & B. van Wee (2004). Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport Geography* 12, pp. 127–140.

Gilart-Inglesias, V., H. Mora, R. Pérez-delHoyo & C. Carcía-Mayor (2015). A computational method based on radio frequency technologies for the analysis of accessibility of disabled people in sustainable cities. *Sustainability* 7, pp. 14935–14963

Gleeson, B. (1999). *Geographies of disability*. Routledge London and New York, pp. 253.

Goggin, G. (2016). Disability and mobilities: evening up social futures. *Mobilities*, 11:4, pp. 533–541.

Imrie, R. & M. Kumar (1998). Focusing on Disability and Access in the Built Environment. *Disability & Society* 13:3, pp.357–374.

Imrie, R. (2000a). Disabling Environments and the Geography of Access Policies and Practices. *Disability & Society* 15:1, pp. 5–24.

Imrie, R. (2000b). Disability and discourses of mobility and movement. *Environment and Planning A* (2000) 32, pp. 1641–1656.

Imrie, R.F. & P. E. Wells (1993). Disablism, Planning and the Built Environment. *Environment and Planning C*, 11:2, pp. 213–231

Jääskeläinen, L. & O. Syrjänen (2010). *Maankäyttö- ja rakennuslaki selityksineen: käytännön käsikirja*. 3rd edit., Rakennustieto 2010, Helsinki, pp. 927.

Jang, Y. J., J. Y. Go & S. Lee (2011). Evaluating integrated land use and transport strategies in the urban regeneration projects toward sustainable urban structure: case studies of Hafen City in Germany and Shinagawa Station in Tokyo. *International Journal of Urban Sciences* 15: 3, pp. 187–199.

Jokiniemi, J. (2007). *Kaupunki kaikille aisteille – Moniaistisuus ja saavutettavuus rakennetussa ympäristössä.* Doctoral dissertation, pp. 164, Teollisen korkeakoulun arkkitehtiosaston tutkimuksia 2007/29, 16.11.2007

Junttila, U.-K. (2011; edit.). *Katuympäristön suunnitteluopas*. Suomen kuntatekniikan yhdistys, julkaisu 24. Tammerprint Oy, Tampere 2011. pp. 176.

Junttila, U.-K., K. Lignell, L. Ilveskorpi, S. Laitinen, E. Härö, T. Tuominen, E. Kataja, A. Saaristo-Wahlberg (2012). *Hyvä kaupunkiympäristö – parempi elämä*. Suomen Rakennusmedia Oy. Tammerprint Oy, Tampere 2012, pp. 160.

Käyhkö, H. (2014). *Palveluiden saavutettavuus pääkaupunkiseudulla vanhusten kannalta.* Masters' thesis in Geography, University of Helsinki, Department of Geosciences and Geography, 16.6.2014.

Kuoppa, J. (2016). Kävelyn lupaukset kaupungissa. Kolme tapausta kävelijöiden arjesta ja kokemuksista sekä kaupunkisuunnittelusta. Väitöskirja, pp. 274, Tampereen yliopisto,18.3.2016. Suomen yliopistopaino Oy, Tampere 2016.

Larrañaga, A. M. & H. B. B. Cybis (2014). The relationship between built environment and walking for different trip purposes in Porto Alegre, Brazil. *International Journal of Sustainable Development and Planning* 9:4, pp. 568–580.

Leslie, E., N. Coffee, L. Frank, N. Owen, A. Bauman & G. Hugo (2007). Walkability of local communities: Using geographic information systems to objectively assess relevant environmental attributes. *Health & Place* 13, pp. 111–122.

Losinsky, L.-O., T. Levi, K. Saffey & J. Jelsma (2003). An investigation into the physical accessibility to wheelchair bound students of an Institution of Higher Education in South Africa. *Disability & Rehabilitation* 25:7, pp. 305–308

Moya-Gómez, B. & J. C. García-Palomares (2015). Working with the daily variation in infrastructure performance on territorial accessibility. The case of Madrid and Barcelona. *European Transport Research Review*, 7:20, pp. 1–13.

Mudrick, N. R., M.L. Breslin, M. Liang & S. Yee (2012). Physical accessibility in primary health care settings: Results from California on-site reviews. *Disability and Health Journal* 5, pp. 159–167.

Oliver, M. & C. Barnes (2010). Disability studies, disabled people and the struggle for inclusion. *British Journal of Sociology of Education*. 31:5, pp. 547–560.

Owens, J. (2015). Exploring the critiques of the social model of disability: the transformative possibility of Arendt's notion of power. *Sociology of Health & Illness*, 37:3, pp. 385–403

Pan, X.-Z., Q.-G. Zhao, J. Chen, Y. Liang & B. Sun (2008). Analyzing the variation of building density using high spatial resolution satellite images: the example of Shanghai City. *Sensors (Basel)* 8:4, pp. 2541–2550.

Parent, L. (2016). The wheeling interview: mobile methods and disability. *Mobilities* 11:4, pp. 521–532.

Perustietoja liikkumis- ja toimimisesteisistä. RT 09-11022. Rakennustietosäätiö RTS 2011

Reyer, M., S. Fina, S. Siedentorp & W. Schlicht (2014). Walkability is only part of the story: Walking for Transportation in Stuttgart, Germany. *International Journal of Environmental Research and Public Health* 11, pp. 5849–5865.

Ribeiro, G. S., L. B. Martins & C. M. G. Monteiro (2012). Methodological proceedings to evaluate the physical accessibility in urban historic sites. *Work* 41, pp. 4149–4156.

Salonen, M., T. Toivonen & M. Vaattovaara (2012). Arkiliikkumisen vaihtoehdoista monikeskuksistuvassa metropolissa – Kaksi näkökulmaa palveluiden saavutettavuuteen pääkaupunkiseudulla. *Yhdyskuntasuunnittelu* (2012) 50:3, pp.8–27.

Sanchez, J., G. Byfield, T.T. Brown, K. LaFavor, D. Murphy & P. Laud (2000). Perceived accessibility versus actual physical accessibility of healthcare facilities. *Rehabilitation nursing : the official journal of the Association of Rehabilitation Nurses* 21:1, pp. 6–9.

Shakespeare, T. & N. Watson (2001). The social model of disability: an outdated ideology? *Research in social science and disability*, 2 (2002), pp. 9–28.

Siik, S. K. (2006). *Esteettömyys kaavoituksessa. Lohjan keskusta mahdollisuuksien ympäristönä.* Master's thesis in Architecture, pp. 135, Arkkitehtuurin osasto, Tampereen Teknillinen Yliopisto, 3.5.2006.

Southworth, M. (2005). Designing the walkable city. *Journal of Urban Planning and Development* 131:4, pp. 246–257.

Steinfield, E. & J. Maisel (2012). Universal Design: Creating Inclusive Environments. John Wiley & Sons, Incorporated, 2012. ProQuest Ebook Central. pp. 390.

Tarnainen, A. (2017). Pyöräilyn nopeuksien ja matka-aikojen paikkatietopohjainen mallinnus pääkaupunkiseudulla. Masters' thesis in Geography. University of Helsinki, Department of Geosciences and Geography, 13.9.2017.

Thomas, C. (2004). How is disability understood? An examination of sociological approaches. *Disability & Society* 19:6, pp. 569–583.

UN = United Nations (2014). Accessibility and development. Mainstreaming disability in the post-2015 development agenda. *UN ST/ESA/350*. Department of economic and social affairs. Division for social policy and development.

UN WHO = United Nations World Health Organization (2013). How to use the ICF. A practical manual for using the International Classification of Functioning, Disability and Health (ICF). *World Health Organization*.

Vehmas, S. (2005). *Vammaisuus – Johdatus historiaan, teoriaan ja etiikkaan*. Gaudeamus kirja, Tammer-Paino, Tampere 2005. pp. 250.

Verhe, I. & H. Hirn (1996; edits.). *Selkeä ympäristö: näkövammaisille soveltuvan toimintaympäristön suunnittelu*. Näkövammaisten keskusliitto (1996), pp.128

Electronic sources

Abley, S. (2005). Walkability scoping paper. Available from *http://www.levelofservice.com/walkability-research.pdf* [8.2.2017]

Ahokas, K (2015). Esteettömyys osana tilallista suunnittelukokonaisuutta. Tapaustutkimuksena Tampereen matkakeskustunneli-hanke. Masters' thesis in Geography, University of Helsinki, Department of Geosciences and Geography, 10.2015. Available from *https://helda.helsinki.fi/bitstream/handle/10138/158593/Valmis_Gradu_Katriina_Ahokas.pdf?sequence=2* [11.11.2017]

Ahola, S. (2017). Esteettömyys ja saavutettavuus ihmisoikeutena. VIA-projekti. Available from *http://www.vike.fi/via/index.php?option=com_content&view=article&id=54&Itemid=55* [26.1.2017]

Bhat, C., S. Handy, K. Kockelman, H. Muhmassani, Q. Chen& L. Weston (2000). Accessibility measures: Formulation, consideration and current applications. Research report 4938-2. Center for transportation reseach, bureau of engineering research. The University of Texas at Austin. pp. 19 Available from *https://ctr.utexas.edu/wp-content/uploads/pubs/4938_2.pdf* [11.11.2017]

Black, M., S. Ebener, P. N. Aguilar, M. Vidaurre & Z. El Morjani (2004). Using GIS to Measure Physical Accessibility to Health Care. World Health Organization. Available from *https://www.researchgate.net/profile/Patricia_Najera/publication/228728167_Using_GIS_to_measure_physical_accessibility_to_health_care/links/5411d3930cf2fa878ad38fe3.pdf* [3.7.2017]

City of Helsinki (2005). City of Helsinki Accessibility Plan for 2005–2010. Available from *https://www.hel.fi/static/hkr/helsinkikaikille/suunnitelma/City%20of%20Helsinki%20Accessibility%20Plan.pdf* [21.8.2017]

City of Helsinki (2008). Keski-Pasila. Central Pasila. City of Helsinki City Planning Department.

Available from *https://www.hel.fi/hel2/ksv/julkaisut/esitteet/pasila_keski-pasila_en.pdf* [9.11.2017]

City of Helsinki (2015). Accessibility.
Available from
https://www.hel.fi/helsinki/en/housing/housing/functional/accessibility/
[21.6.2017]

City of Helsinki (2016a). Regional Accessibility plans.
Available from *https://www.hel.fi/helsinkikaikille/fi/alueelliset-suunnitelmat/*
[17.7.2017]

City of Helsinki (2016b). Helsinki for all. The City of Helsinki Accessibility Plan.
Available from *https://www.hel.fi/helsinkikaikille/en/accessibility-guidelines/accessibility-plan/* [21.8.2017]

City of Helsinki (2017a). Helsinki kaikille.
Available from *https://www.hel.fi/helsinkikaikille/fi* [29.6.2017]

City of Helsinki (2017b). Palvelut kaupunginosissa, Vartiokylä ja Myllypuro.
Available from *https://www.hel.fi/helsinki/fi/kaupunki-ja-hallinto/hallinto/kaupunginosat/vartiokyla-myllypuro* [23.10.2017]

City of Helsinki (2017c). Palvelut kaupunginosissa, Lauttasaari.
Available from *https://www.hel.fi/helsinki/fi/kaupunki-ja-hallinto/hallinto/kaupunginosat/lauttasaari* [23.10.2017]

City of Helsinki (2017d). HKR Penkit, teräsjalka (D1).
Available from *http://kaupunkitilaohje.hel.fi/kortti/hkr-penkit-terasjalka-d1/*
[5.9.2017]

Design for All Europe (2017). What is DfA?
Available from *http://dfaeurope.eu/what-is-dfa/* [26.7.2017]

Dill, J. (2004). Measuring Network Connectivity for Bicycling and Walking. TRB 2004 Annual Meeting CD-ROM. Portland State University, School of Urban Studies and Planning.
Available from *http://reconnectingamerica.org/assets/Uploads/TRB2004-001550.pdf* [18.9.2017]

Engelbrecht, L. & J.J. de Beer (2014). Access constraints experienced by physically disabled students at a South African higher education institution. University of Pretoria
Available from
http://repository.up.ac.za/bitstream/handle/2263/49602/Engelbrecht_Access_2014.pdf?sequence=1&isAllowed=y [3.7.2017]

Esteettömän ympäristön suunnitteluohjekortti 1/8 (2008). Esteetön ympäristö – suojatiet ja jalkakäytävät. SuRaKu-projekti 2004/2008.

European Commission (2017a). Access City Award.
Available from *http://ec.europa.eu/social/main.jsp?catId=1141&langId=en* [26.7.2017]

European Commission (2017b). Previous winners of the Access City Award.
Available from *http://ec.europa.eu/social/main.jsp?catId=1325&langId=en* [12.11.2017]

Finlex (2017a). The Constitution of Finland 11.6.1999/731.
Available from *http://www.finlex.fi/en/laki/kaannokset/1999/en19990731?search%5Btype%5D=pika&search%5Bpika%5D=constitution* [22.6.2017]

Finlex (2017b) Non-Discrimination Act 30.12.2014/1325.
Available from *http://www.finlex.fi/en/laki/kaannokset/2014/en20141325?search%5Btype%5D=pika&search%5Bpika%5D=Non-Discrimination%20Act* [22.6.2017]

Finlex (2017c). Land Use and Building Act 5.2.1999/132.
Available from *http://www.finlex.fi/en/laki/kaannokset/1999/en19990132.pdf* [22.6.2017]

Finlex (2017d). Maankäyttö- ja rakennuslaki 5.2.1999/132.
Available from *http://www.finlex.fi/fi/laki/ajantasa/1999/19990132#L17P117* [22.6.2017]

Finlex (2017e). Land Use and Building Decree 10.9.1999/895.
Available from *http://www.finlex.fi/en/laki/kaannokset/1999/en19990895.pdf* [22.6.2017]

Finlex (2017f). Rescue Act 379/2011.
Available from *http://www.finlex.fi/en/laki/kaannokset/2011/en20110379.pdf* [26.6.2017]

Finlex (2017g). Tieliikennelaki 3.4.1981/267
Available from *http://www.finlex.fi/fi/laki/ajantasa/1981/19810267* [13.11.2017]

Helsingin kaupungin rakennusvirasto (2008). Itäkeskuksen ja Marjaniemen aluesuunnitelma 2009-2018. *Helsingin kaupungin rakennusviraston julkaisut 2008*: 10 / Katu- ja puisto-osasto.
Available from *https://www.hel.fi/hel2/HKR/julkaisut/2009/It%c3%a4keskus-Marjaniemi_web.pdf* [23.10.2017]

Helsingin kaupungin rakennusvirasto (2010). Lauttasaaren aluesuunnitelma 2011-2020. *Helsingin kaupungin rakennusviraston julkaisuja 2010*:7 / Katu- ja puisto-osasto.
Available from

https://www.hel.fi/static/hkr/aluesuunnitelmat/lauttasaaren_alsu/Lauttasaaren_aluesuunnitelma_2011_2020.pdf [23.10.2017]

Helsingin kaupungin rakennusvirasto (2014). Katusuunnitelman selostus. Pasilankatu. HKR katu- ja puisto-osasto.
Available from
https://dev.hel.fi/paatokset/media/att/54/541f354d77554983d3d0c67941bd4446aec72a70.pdf [3.11.2017]

Helsingin kaupungin rakennusvirasto (2015). Ulkovalaistuksen tarveselvitys. Valaistuksen tavoitteet ja periaatteet. *Helsingin kaupungin rakennusviraston julkaisut* xx/xx, pp. 62.
Available from
https://dev.hel.fi/paatokset/media/att/8d/8d07414dcbd00aeabc37f4d058dad82879f25636.pdf [13.11.2017]

Helsingin kaupungin rakennusvirasto (2015a). Katusuunnitelman selostus. Veturitie välillä Nordenskjöldinkatu-Hakamäentie. HKR katu- ja puisto-osasto.
Available from
https://dev.hel.fi/paatokset/media/att/2c/2cd4dbeb4529ddaf474dafa4c1d79fd7c6317460.pdf [3.11.2017]

Helsingin kaupungin rakennusvirasto (2015b). Katusuunnitelman selostus. Tornikuja. HKR katu- ja puisto-osasto.
Available from
https://dev.hel.fi/paatokset/media/att/2d/2de5c9608f80391315ee5a48d1c70a471cf7194b.pdf [3.11.2017]

Helsingin kaupungin rakennusvirasto (2015c). Katusuunnitelman selostus. Firdonkatu. HKR katu- ja puisto-osasto.
Available from
https://dev.hel.fi/paatokset/media/att/c6/c6f42552dff5d279f24944e31ab0b6246fb09045.pdf [3.11.2017]

Helsingin kaupungin rakennusvirasto (2016a). Myllypuron, Puotinharjun ja Roihupellon aluesuunnitelma 2016-2025. *Helsingin kaupungin rakennusviraston julkaisut 2016:* 2 / Katu- ja puisto-osasto.
Available from
https://www.hel.fi/static/hkr/aluesuunnitelmat/myllypuropuotinharju_alsu/MyPuRo_alsu_raportti.pdf [23.10.2017]

Helsingin kaupungin rakennusvirasto (2016b). Katusuunnitelman selostus. Pasilansilta. HKR katu- ja puisto-osasto.
Available from
https://dev.hel.fi/paatokset/media/att/11/1131378f54af25ea74e408665d9c48c6f06ec088.pdf [3.11.2017]

Helsingin kaupunki (2006). Lauttasaaren esteettömyyssuunnitelma. Helsingin kaupungin rakennusvirasto.
Available from *https://www.hel.fi/static/hki4all/alueelliset/Lauttasaari_low.pdf* [23.10.2017]

Helsingin kaupunki (2007). Itäkeskuksen esteettömyyssuunnitelma. Helsingin kaupungin rakennusvirasto.
Available from *https://www.hel.fi/static/hki4all/alueelliset/Itakeskus.pdf* [24.10.2017]

Helsingin kaupunki (2008). SuRaKu. Esteettömän julkisten alueiden suunnittelun, rakentamisen ja kunnossapidon ohjeistaminen katu-, viher- ja piha-alueilla. Helsingin kaupungin rakennusvirasto.
Available from *http://www.hel.fi/static/hki4all/ohjeet/Kriteerit_01-18_060208.doc* [11.11.2017]

Helsingin kaupunki (2015) Katuja koskevat tyyppipiirrustukset. Pysäkki, linja-autopysäkit (30187/703). Helsingin kaupungin rakennusvirasto, Katu- ja puisto-osasto.
Available from *https://www.hel.fi/static/hkr/julkaisut/ohjeet/pysakki_30187_703.pdf* [14.9.2017]

Helsingin matkailutilastot (2016). Joulukuu 2016.
Available from *http://www.visithelsinki.fi/sites/default/files/legacy_files/files/Tilastot/FI/helsinki1216.pdf* [21.6.2017]

Helsinki for all (2011). City of Helsinki Accessibility Guidelines.
Available from *https://www.hel.fi/static/hki4all/esteettomyyslinjaukset/accessibility_guidelines.pdf* [27.6.2017]

Helsinki Region Infoshare (2017). The Register of Public Areas in the City of Helsinki.
Available from *http://www.hri.fi/fi/dataset/helsingin-kaupungin-yleisten-alueiden-rekisteri* [23.10.2017]

Hild, A. (2017). ”Access City Award” – the European award for accessible cities. Inclusion Europe. European Commission.
Available from *http://inclusion-europe.eu/?p=3126* [25.7.2017]

Invalidiliitto (2017a). Lainsäädäntö.
Available from *http://www.esteeton.fi/portal/fi/esteettomyys/lainsaadanto/* [22.6.2017]

Invalidiliitto (2017b). Kaavoitus.
Available from *http://www.esteeton.fi/portal/fi/rakennettu_ymparisto/kaavoitus/* [27.6.2017]

Invalidiliitto (2017c). Liikkumisen tuen palvelut. Esteettömyys.
Available from *https://www.invalidiliitto.fi/tietoa/liikkuminen-ja-esteettomyys/esteettomyys* [29.6.2017]

Koivu, H. (2004). Rakentamisen esteettömyys lainsäädännössä – teoria ja toteutuminen. Luento Invalidiliiton esteettömyysosaajakoulutuksessa 2004.
Available from *http://www.esteeton.fi/files/attachments/esteeton/luento_invalidiliiton_esteettomyysosaajakoulutus__rakentamis.rtf* [22.6.2017]

Kynnys Ry (2017). Suomi ratifioi YK:n vammaissopimuksen.
Available from *http://kynnys.fi/news/suomi-ratifioi-ykn-vammaissopimuksen/* [22.6.2017]

Laakso, M (2015). Improving accessibility for pedestrians with geographic information. *Publications of the Finnish Geodetic Institution* 156.
Available from *https://aaltodoc.aalto.fi/bitstream/handle/123456789/14992/isbn9789517113144.pdf?sequence=1* [11.11.2017]

Luotola, H.-S. (2011). *Esteettömyyden liittäminen nykyistä kiinteämmäksi osaksi kaavoitusprosessia*. Masters' thesis in Geography, pp. 122, University of Helsinki, Department of Geosciences and Geography.
Available from *http://www.hel.fi/static/hkr/helsinkikaikille/kirjasto/Opinn%C3%A4ytety%C3%B6_Luotola_Heini-Sofia.pdf* [11.11.2017]

Mahlamäki, P. (2013). Vammaisten ihmisoikeudet eivät toteudu. *Tilastokeskuksen hyvinvointikatsaus 3/2013*.
Available from *http://www.stat.fi/artikkelit/2013/art_2013-09-23_005.html?s=0* [11.11.2017]

Mäki, N. & P. Vuori (2016). Helsingin väestö vuodenvaihteessa 2016/2017 ja väestönmuutokset. *Tilastoja 2017*, Helsingin kaupunki, kaupunginkanslia, kaupunkitutkimus ja –tilastot.
Available from *https://www.hel.fi/hel2/tietokeskus/julkaisut/pdf/17_06_28_Tilastoja_1_Maki_Vuori.pdf* [23.10.2017]

Malmberg, L. (2016). Helsinki selvittää kävelykeskustan rajua laajentamista – autot saatetaan häätää Pohjoisesplanadilta. *Helsingin Sanomat* 22.12.2016.
Available from *http://www.hs.fi/kaupunki/art-2000005017813.html* [8.2.2017]

Ministry for Foreign Affairs of Finland (2016). Suomi sitoutui vammaisten henkilöiden oikeuksista tehtyyn yleissopimukseen ja sen valitusmenettelyyn.
Available from *http://formin.finland.fi/public/default.aspx?contentid=346189&nodeid=15146&contentlan=1&culture=fi-FI* [22.6.2017]

Ministry of the Environment (2016). Suomen rakentamismääräyskokoelma. Available from *http://www.ym.fi/rakentamismaaraykset* [22.6.2017]

RapidTables.com (2017). Watts to lux calclulator. Available from *http://www.rapidtables.com/calc/light/watt-to-lux-calculator.htm* [28.9.2017]

Rapley, C. E. (2013; edit.). Accessibility and Development: Environmental accessibility and its implications for inclusive, sustainable and equitable development for all. UN, The Department of Economic and Social Affairs (DESA) Available from *http://www.un.org/disabilities/documents/accessibility_and_development_june2013.pdf* [29.6.2017]

Ruskovaara, A. (2009; edit.). Rakennetun ympäristön esteettömyyskartoitus. Opas kartoituksen tilaajalle ja toteuttajalle. *Invalidiliiton julkaisuja 0.38* (2009). Available from *https://www.hel.fi/static/hkr/helsinkikaikille/eskeh/Esteettomyysopas_low.pdf* [29.6.2017]

Söderström, P., H. Schulman & M. Ristimäki (2015). Urban forms in the Helsinki and Stockholm city regions. Development of Pedestrian, public transport and car zones. *Reports of the Finnish Environmental Institute* 16. Available from https://helda.helsinki.fi/bitstream/handle/10138/155224/SYKEre_16_2015.pdf?sequence=4 [11.11.2017]

Stude, I. & S. Menger (2007; edits.). Barrier-free planning and construction in Berlin – Principles and Examples. Berlin Senate Department for Urban Development. DruckVogt GmbH, Berlin. pp.68. Available from *http://www.stadtentwicklung.berlin.de/bauen/barrierefreies_bauen/download/handbuch/00_BarrierefreiesBauen_gesamt_engl.pdf* [13.11.2017]

Suomen YK-liitto (2015). YK:n yleissopimus vammaisten henkilöiden oikeuksista ja sopimuksen valinnainen pöytäkirja. Available from *http://www.ykliitto.fi/sites/ykliitto.fi/files/vammaisten_oikeudet_2016_net.pdf* [22.6.2017]

SVT = *Suomen virallinen tilasto* (2013). Väestöennuste kunnittain 2012–2040. Available from *http://www.stat.fi/tup/julkaisut/tiedostot/julkaisuluettelo/yvrm_vaenn_2012-2040_2013_9843_net_p2.pdf* [4.7.2017]

Taloon.com (2017). Valaisininfo. Available from *http://www.taloon.com/valaisininfo/10210/dg* [31.8.2017]

THL = Terveyden ja hyvinvoinnin laitos (2017). Vammaislainsäädännön uudistus. Available from *https://www.thl.fi/fi/web/vammaispalvelujen-kasikirja/laki-ja-oikeuskaytanto/vammaislainsaadannon-uudistus* [22.6.2017]

Tujula, P. (2015). Esteettömyystyö Helsingissä – projektista pysyväksi työksi. *Aspa 2/15*. Available from *https://www.aspa.fi/en/node/716* [21.8.2017]

UN = United Nations (2016). Good practices of accessible urban development. Making urban environments inclusive and fully accessible to ALL. United Nations Department of Economics and Social Affairs.
Availabel from http://www.un.org/disabilities/documents/desa/good_practices_in_accessible_urban_development_october2016.pdf [11.11.2017]

UN = United Nations (2017). Convention on the Rights of Persons with Disabilities. Available from *https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html* [22.6.2017]

Uusi Pasila (2017a). Keski-Pasilan ratapihakortteleiden suunnitelmat valtuuston päätettäväksi. Published.
Available from *http://www.uusipasila.fi/uutiset/2017-05/keski-pasilan-ratapihakortteleiden-suunnitelmat-valtuuston-paatettavaksi* [2.11.2017]

Uusi Pasila (2017b). Tornialue.
Available from *http://www.uusipasila.fi/tornialue* [2.11.2017]

Uusi Pasila (2017c) Tripla.
Available from *http://www.uusipasila.fi/tripla* [2.11.2017]

Uusi Pasila (2017d). Liikenne
Acquired *http://www.uusipasila.fi/liikenne* [2.11.2017]

Uutta Helsinkiä (2017). Pasila, historia.
Available from *http://www.uuttahelsinkia.fi/fi/pasila/asuminen/historia* [2.11.2017]

Wikipedia (2017a). Luminous efficacy.
Available from *https://en.wikipedia.org/wiki/Luminous_efficacy* [31.8.2017]

Wikipedia (2017b). Xenon arc lam.
Available from *https://en.wikipedia.org/wiki/Xenon_arc_lamp* [31.8.2017]

Wikipedia (2017c). Lauttasaari.
Available from *https://fi.wikipedia.org/wiki/Lauttasaari#cite_note-10* [9.11.2017]

Xiang, Z., J. Zhi, S. Dong & B. Xu (2016). Study on Characteristics of the Wheelchair-User Combination. *Journal of Biosciences and Medicines* (2016) 4, pp. 9–17. Available from *http://file.scirp.org/pdf/JBM_2016052409341371.pdf* [13.11.2017]

YIT (2017). Tripla by YIT. Näin Tripla rakentuu. YIT Oyj.
Available from *https://tripla.yit.fi/nain-tripla-rakentuu* [2.11.2017]

Dictionaries

Cambridge dictionary (2017). Impairment.
Available from *http://dictionary.cambridge.org/dictionary/english/impairment* [3.6.2017]

COMMIN.org. COMING Finnish glossary. Central Finnish spatial development and planning terms
Available from *http://commin.org/upload/Glossaries/National_Glossaries/COMMIN_Finnish_Glossary.pdf* [11.11.2017]

Farlex Partner Medical Dictionary (2017). Impairment. Farlex 2012.
Available from *http://medical-dictionary.thefreedictionary.com/impairment* [3.6.2017]

Helsinki for all (2016). Accessibility dictionary.
Available from *https://www.hel.fi/helsinkikaikille/fi/julkaisut-ja-materiaalit/sanakirja* [4.9.2017]

Data sources

City of Helsinki (2016c). General Guide Map of the City of Helsinki. City of Helsinki, Department of Urban structure. Helsinki Region Infoshare, Creative Commons licence (CC BY 4.0).
Available from *http://www.hri.fi/fi/dataset/helsingin-yleiskartta* [21.6.2017]

City of Helsinki (2016d). Buildings in Helsinki. City of Helsinki, Department of Urban structure. Helsinki Region Infoshare, Creative Commons licence (CC BY 4.0).
Available from *http://www.hri.fi/fi/dataset/helsingin-rakennukset* [13.11.2017]

City of Helsinki (2017e). Register of Public Areas in the City of Helsinki. City of Helsinki, Department of Urban structure. Helsinki Region Infoshare, Creative Commons licence (CC BY 4.0).
Available from *http://www.hri.fi/fi/dataset/helsingin-kaupungin-yleisten-alueiden-rekisteri* [13.11.2017]

City of Helsinki (2017f). Food establishments in Helsinki under food control supervision by the Food Safety Department. City of Helsinki, Department of Urban Structure, Environmental Services. Helsinki Region Infoshare, Creative Commons licence (CC BY 4.0).
Available from *http://www.hri.fi/fi/dataset/elintarvikevalvonnan-piiriin-kuuluvat-elintarvikehuoneistot-helsingissa* [21.9.2017]

City of Helsinki (2017g). Elevation Models of City of Helsinki. City of Helsinki, Department of Urban Structure.
Available from *http://kartta.hel.fi/link/3Hk95e* [25.8.2017].

City of Helsinki (2017h). Base Map of the City of Helsinki. City of Helsinki, Department of Urban Structure. Helsinki Region Infoshare, Creative Commons licence (CC BY 4.0).
Available from *http://www.hri.fi/fi/dataset/helsingin-kantakartta* [13.11.2017]

City of Helsinki Service Registry (2017). Service map, REST open source interface. City of Helsinki Executive Office.
Available from *https://servicemap.hel.fi/?_rdr=* [13.11.2017]

Helsingin kaupunki (2017). Ulkovalaistuksen verkkotiedot. Helsingin kaupunki, Kaupunkiympäristön toimiala, kaupunkitekniikka-yksikkö.

HRT = Helsinki Region Transport (2016). Public transport stations. Helsinki Region Infoshare, Creative Commons licence (CC BY 4.0).
Available from *http://www.hri.fi/fi/dataset/hsl-n-joukkoliikenteen-pysakit* [19.07.2017]

HSL = Helsingin Seudun Liikenne (2016). Digitransit. Public transport stops.
Available from *https://digitransit.fi/en/developers/services-and-apis/1-routing-api/stops/* [26.9.2017]

HSY = Helsingin seudun ympäristöpalvelut (2016). Population grid. Helsinki Region Infoshare, Creative Commons licence (CC BY 4.0).
Available from *http://www.hri.fi/fi/dataset/vaestotietoruudukko* [21.06.2017]

Statistics Finland (2015). Population grid (31.12.2015), 1km x 1km shapefile.
Available from PaITuli service *https://avaa.tdata.fi/web/paituli/latauspalvelu*.

Statistics Finland (2017). Kuntien avainluvut 1987–2016. Helsinki.
Available from *https://pxnet2.stat.fi/PXWeb/pxweb/fi/Kuntien_avainluvut/Kuntien_avainluvut__2017/kuntien_avainluvut_2017_aikasarja.px/?rxid=444223df-f91c-4479-891f-5dcd50b983d2* [21.6.2017]

SYKE = Finnish Environment Institute (2012). Corine Land Cover, 20m x 20m raster data.
Available from PaITuli service *https://avaa.tdata.fi/web/paituli/latauspalvelu*.

List of interviewees

Heikkinen, M. (2017). City of Helsinki, Economic and Planning Centre, IT Division. Project manager. Interview 25.9.2017 in Helsinki.

Kilpelä, N. (2017). Ministry of the Environment (YM), Senior Architect. Interview 25.9.2017 in Helsinki.

Tirri, A. (2017). City of Helsinki, Land Use and City Structure Division, regional planner. Interview 6.10.2017 in Helsinki.

Tujula, P. (2017). City of Helsinki, Economic and Planning Centre. Project manager, physical accessibility specialist. Interview 6.10.2017 in Helsinki.

Tuominen, T. (2017). City of Helsinki, Economic and Planning Centre, IT Division. Software developer. Interview 25.9.2017 in Helsinki.

Ulvila, J. (2017). City of Helsinki, Land Use and City Structure Division, GIS expert. E-mail interview 23.9.2017

11 Appendix

Appendix 1. Requirements and the physical accessibility criteria of the public built urban elements grouped by the 8 dimensions of the urban structure.

Dimensions of urban structure (the 8D's)	Elements of the built environment	Attribute	Physical accessibility criteria	
			Special level accessibility	**Basic level accessibility**
Diversity	Land use diversity	Number of different land uses	No references	No references
Density	Rate of built area	Built area index	No references	No references
Design	Sidewalks	Widgth	>= 1500 mm	>= 900 mm
		Material	Asphalt, crushed stone fines, concrete or stone slab.	Asphalt, crushed stone fines, concrete or stone slab.
		Curbstone	> 40 mm	Lowered at crossings, else > 40 mm
		Grooves	<= 5mm above the ground	<= 5mm above the ground
		Seam	<= 5 mm wide	<= 5 mm wide
		Kurbstone	120 mm high	120 mm high
		Tactile tiles	Yes	Not neccessary
		Winter maintenance	Yes	Yes
		Separated fields	Yes	Yes
		Connectivity	Continouos	Continouos
	Crossings	Curbstone	Edged 10 –40 mm height and 1500 mm width	Lowered minimum 900 mm width
		Sound signal	Yes	Not neccessary
		Traffic light	Yes	Yes
		Tactile tiles	Yes	Not neccessary
		Route width	4000 mm	4000 mm
		Separated fields	Recommended	Recommended
		Intersection density	Pedestrian crossing at all sides	Pedestrian crossing at all sides
	Stairs	Riser	<= 120 mm	<= 160 mm
		Tread	>= 400 mm	>=330
		Color contrast stripe	On every step	The first and the last step
		Landing	900–1200 mm long	900–1200 mm long
		Handrailing	700 mm and 900 mm height	900 mm height
		Warning area	1200 mm	600 mm
		Heating	Recommended	Recommended

Dimensions of urban structure (the 8D's)	Elements of the built environment	Attribute	Physical accessibility criteria	
			Special level accessibility	**Basic level accessibility**
Design	Ramp	Width	> 1800 mm	> 900 mm
		Longitudinal inclination	<= 5 %	<= 8 %
		Lateral inclination	<= 2 %	<= 2%
		Handrailing	700 mm and 900 mm height	700 mm and 900 mm height
		Landing	> 1500–2000 mm	> 1500–2000 mm
		Winter maintenance	Yes	Yes
	Illumination	Distance from sidewalk	1000 mm	1000 mm
		Density	No dark spaces	No dark spaces
		Sidewalk lux	15 lux	10 lux
		Interestpoint lux	50 lux	20 lux
		Underpass lux	50 lux	30 lux
Distance to transit	Public transport stop	Distance between stops	< 500 m	< 500 m
		Distance to PT stop	< 500 m	< 500 m
	PT stop canopy	Depth	>= 1500 mm	Canopy not neccessary
		Bench height	420–520 mm	420–520 mm
		Free space around the canopy	>= 1500 mm	>= 900 mm
	Waiting area	Width	>= 2250 mm	>= 1500 mm
		Waiting area lateral slope	<= 2 %	<= 2 %
		Waiting area longitudinal slope	<= 3 %	<= 3 %
	Loading island	Curbstone height	160–200 mm	120–160 mm
		Warning area	>= 300 mm	>= 300 mm
Destination accessibility	Proximity	Distance to and from PT stop to services	< 500 m	< 500 m
Demand	Benches	Density	Every 50–100 m	Every 100 m
		Height	>= 500 mm	400–500 mm
		Hand railing	Both sides , 200 mm height	Minimum at one side
		Back rest	500 mm	500 mm
		Seating depth	430 mm	430 mm
Declination	Slope	Longitudinal inclination	<= 5 %	<= 8%
		Lateral inclination	<= 2 %	<= 3 %
Discovery	Safetiness	E.g. rate of accidents	No references	No references
		E.g. location of scary places	No references	No references
	Aestethics	E.g. location of trees and shades	No references	No references
		E.g. location of street art	No references	No references

Appendix 2. Planning documents for Keski-Pasila research area.

Planning level	Document / area	Scale	Drawing number	Date of acceptance	Source
Local master plan	Keski-Pasila local master plan	1:4000	11356	14.6.2006	City of Helsinki, Division of Land Use and City Structure, Office of Detailed Planning
Detailed land use plans	Keski-Pasila Rail Yard Quarters	1:1000	12360, part 1/2	17.5.2017	City of Helsinki, Division of Land Use and City Structure, Office of Detailed Planning
	Pasila Central Quarter	1:1000	12261 part 1/4	19.8.2014	City of Helsinki, Division of Land Use and City Structure, Office of Detailed Planning
	Keski-Pasila Tower Area	1:1000	Kslk 2009-1486	Draft 5.6.2012	City of Helsinki, Division of Land Use and City Structure, Office of Detailed Planning
Traffic plans	Traffic plan for Rail Yard Quarters	1:1000	6551-1	17.1.2017	City of Helsinki, Division of Land Use and City Structure, Traffic planning
	Pasilankadu traffic plan	1:1000	6311-34	13.5.2014	City of Helsinki, Division of Land Use and City Structure, Traffic planning
	Pasila Bridge traffic plan	1:1000	6277-34	11.2.2014	City of Helsinki, Division of Land Use and City Structure, Traffic planning
	Veturitie traffic plan, part 1	1:1000	6179-1	9.4.2013	City of Helsinki, Division of Land Use and City Structure, Traffic planning
	Pasila Central Quarter traffic plan	1:1000	6350-7	Draft 19.8.2014	City of Helsinki, Division of Land Use and City Structure, Traffic planning
	Veturitie traffic plan, part 2	1:1000	6180-1	9.4.2013	City of Helsinki, Division of Land Use and City Structure, Traffic planning
Street plans	Veturitie between Nordenskjöldinkatu - Pasilankatu	1:500	30306/1	1.6.2015	City of Helsinki, Public Works Bureau (Division of Land Use and City Structure), Street and Park Department
	Veturitie between Pasilankatu - Teollisuuskatu	1:500	30306/2	1.6.2015	City of Helsinki, Public Works Bureau (Division of Land Use and City Structure), Street and Park Department
	Veturitie between teollisuuskatu - Firdonkatu	1:500	30306/003	1.6.2015	City of Helsinki, Public Works Bureau (Division of Land Use and City Structure), Street and Park Department
	Veturitie between Teollisuuskatu - Kyllikinportin jatke	1:500	30306/4	1.6.2015	City of Helsinki, Public Works Bureau (Division of Land Use and City Structure), Street and Park Department

Planning level	Document / area	Scale	Drawing number	Date of acceptance	Source
Street plans	Veturitie between Kyllikinportin jatke - Radiokatu	1:500	30306/5	1.6.2015	City of Helsinki, Public Works Bureau (Division of Land Use and City Structure), Street and Park Department
	Veturitie between Radiokatu - Hakamäentie	1:500	30306/6	1.6.2015	City of Helsinki, Public Works Bureau (Division of Land Use and City Structure), Street and Park Department
	Tornikuja	1:500	30357/1	1.6.2015	City of Helsinki, Public Works Bureau (Division of Land Use and City Structure), Street and Park Department
	Firdonkatu between Pasilankatu - Veturitie	1:500	30237/11	Draft 7.7.2017	City of Helsinki, Division of Land Use and City Structure
	Pasilankatu between Pasila Bridge - Kyllikinportti	1:500	30170/00 1	x.x.2014	City of Helsinki, Public Works Bureau (Division of Land Use and City Structure), Street and Park Department
	Rail Yard Quarters, General plan for street and park areas	1:1000	30644/1	Draft 29.9.2017	City of Helsinki, Division of Land Use and City Structure
	Televisiokatu between Radiokatu - Studioaukio and Pasilankatu roundabout	1:500	29097/1	Draft 29.6.2006	City of Helsinki, Public Works Bureau (Division of Land Use and City Structure), Street and Park Department
	Televisiokatu between Studioaukio - Ilmalankuja	1:500	29097/2	Draft 29.6.2006	City of Helsinki, Public Works Bureau (Division of Land Use and City Structure), Street and Park Department

Appendix 3. Data sources of the used data, their accessibility and type for the three research areas, grouped by the dimension in which they are used.

Dimension	Itäkeskus and Lauttasaari					Keski-Pasila	
	Data	**Type**	**Accessi-bility**	**Source / hyperlink**	**Updated**	**Data**	**Accessibility**
Density	Buildings in Helsinki	Shapefile	Open source	City of Helsinki, Department of Urban structure, Helsinki Region Infoshare	19.5.2016	Building locations	Digitized from detailed land use plans
Diversity	Land use data, Corine Land Cover	20m x 20m raster	Open source	Finnish Environment Institute 2012, PaITuli	2012	Land use	digitized from local master plans and local detailed plans.
Design, connec-tivity	Route network, pedestrian route and pedestrian crossings	shapefile, line data	Open source	Register of Public Aareas in the City of Helsinki, kartta.hel.fi	Every day	Route network	digitized from local detailed plans, traffic plans and street plans
Design, illumina-tion	Street light locations and information	Excel table	Acquired from City of Helsinki	Helsingin kaupunki (2017).	na	Street lights as points	digitized from street plans
	Street light lux information	PDF document	Open source	Helsingin kaupungin rakennusvirasto (2015).	na	Street light lux information	information from traffic and street plans
Design, path quality	Street area data	Shapefile, polygon data	Open source	Register of Public Aareas in the City of Helsinki, kartta.hel.fi	Every day	Street areas and information	digitized from street plans
	Pedestrian crossings sound and light signal information	PDF-files, street crossing plans	Acquired from City of Helsinki	City of Helsinki, City Environment sector	na	Pedestrian crossings	digitized from street plans
	Stair registry	Excel table	Acquired from City of Helsinki	City of Helsinki, City Environment sector	na	Locations of stairs	digitized from land use plans and street plans
Destination accessibility	Route network, pedestrian route and pedestrian crossings	shapefile, line data	Open source	Register of Public Aareas in the City of Helsinki, kartta.hel.fi	Every day	Route network	digitized from local detailed plans, traffic plans and street plans
	Locations of grocery stores	CSV-data	Open source	City of Helsinki (2017y)	2.1.2017	Locations of grocery stores	Digitized from land local master plan

Dimension	Itäkeskus and Lauttasaari					Keski-Pasila	
	Data	**Type**	**Accessi-bility**	**Source / hyperlink**	**Updated**	**Data**	**Accessibility**
Distance to transit	Route network, pedestrian route and pedestrian crossings	shapefile, line data	Open source	Register of Public Aareas in the City of Helsinki, kartta.hel.fi	Every day	Route network	digitized from local detailed plans, traffic plans and street plans
	Helsinki Region Transport public transport stations	Shapefile, point data	Open source	HRT 2016	1.7.2017	Public transport stop locations	digitized from traffic plans
	Public transport stop accessibility information		Open source	HSL 2016	na		
Declination	Elevation Model, TRN -grid	xyz-data, text document	Open source	City of Helsinki 2017c	1.3.2017	Elevation Model, TRN -grid	Open source
Demand	Location of bences	Shapefile, point data	Open source	Register of Public Aareas in the City of Helsinki, kartta.hel.fi	Every day	Location of bences	Digitized from land use plans

Appendix 4. Interview questions of the electronic questionnaire for planners, constructors and maintainers of public urban areas.

Questionnaire about how physical accessibility is taken into consideration in planning, constructing and maintaining the public urban areas.

Basic information

1. Which neighborhood are you responsible for?
    a. Itäkeskus
    b. Keski-Pasila
    c. Lauttasaari
2. What tasks are included in your responsibilities?
    a. Local master planning
    b. Detailed land use planning
    c. Traffic planning
    d. Street planning
    e. Park planning
    f. Construction
    g. Maintenance
    h. Other, what?
3. According to your understanding, what does the physical accessibility of the public urban areas mean
4. In which ways can you consider physical accessibility in your work?

The consideration of physical accessibility in planning, construction and maintenance

The following questions should be answered from the point of view of the neighborhood of which the respondent is responsible for in his or her work. You may mention any of the stages; planning, construction and/or maintenance.

5. How do you feel that the current level of physical accessibility is in the neighborhood for which you are responsible?
6. In which stages out of planning, construction and/or maintenance, has physical accessibility been taken into consideration in your area?
7. What influence has this had in the results and efficiency of working (making the plans, building the area, etc.)?
8. Based on the two previous answers, what effect has these elements had on the quality of physical accessibility in the neighborhood?
9. Do you feel that the aspect of physical accessibility is a natural process of planning, construction and maintenance?
10. How has the physical accessibility classification of routes and areas (special and basic level accessibility) affected the planning, construction and maintenance in the neighborhood? Have these been considered during the processes of planning, construction and/or maintenance?
11. Do you want to mention something else concerning how physical accessibility has been considered during planning, construction and/or maintenance?

Questions about physical accessibility guidelines

The next questions should be answered from the point of view of the neighborhood of which the respondent is responsible for in his or her work. You may mention any of the stages; planning, construction and/or maintenance.

Physical accessibility guidelines are, for example, legislation, City of Helsinki Accessibility Strategy, -Plan and -Policy, Regional Accessibility Plans, Type Drawings for Street Areas, SuRaKu guidelines, and physical accessibility experts.

12. Which of the following references have been used in planning, construction and maintenance? In which ways have these been taken into consideration?
    a. Organizations (e.g. Associations of Persons with disabilities)
    b. Experts (e.g. City of Helsinki physical accessibility expert)
    c. Citizens
    d. Legislation
    e. City of Helsinki Accessibility Strategy, - Plan and Policy
    f. Regional Accessibility Plans
    g. Type Drawings for Street Areas
    h. SuRaKu guidelines,
    i. Other, what?
13. In your opinion, is information and/or guidelines about physical accessibility easily available and accessible? How could this be developed?
14. How has physical accessibility guidelines (e.g. the ones listed above) affected in how physical accessibility is considered when planning, constructing and/or maintaining public urban areas (compared to earlier times when guidelines for physical accessibility were not readily available)?
15. In your opinion, has the consideration for physical accessibility become better since the increase of physical accessibility guidelines?
16. In your opinion, what impact has different physical accessibility guidelines had in implementing the aspect of physical accessibility in planning, construction and/or maintenance?
17. Do you want to mention something else about physical accessibility guidelines?

<u>Information systems and spatial data</u>

18. Do you use spatial data?
    a. Yes
    b. No
19. Have you used physical accessibility information in spatial data format (physical accessibility target levels of pedestrian routes and public urban areas)?
20. In your opinion, is physical accessibility information about existing public urban areas or objects easily available and accessible? How could this be developed?
21. What kind of physical accessibility information would you like to get in spatial data format?
22. In your opinion, in what format, in what place and by whom should physical accessibility information in spatial data format be administrated?
23. Do you want to tell something else related to spatial data about physical accessibility?

<u>Other questions</u>

24. Do you feel that you would need more guidance or education about how to take physical accessibility in consideration in planning, constructing and/or maintaining the urban built environment?
25. Would you like to mention something else about the physical accessibility of the public urban built environment?