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THESIS

Ageing in place and the public space

Assessing the suitability of the built environment for elderly people in Kanaleneiland

Abstract

As the population of the Netherlands ages the Dutch government is pushing the concept of ageing in place more and more. Ageing in place means people can grow old in their own living environment healthily and happily. The Dutch government wants built environment spaces that are usable and suitable for the activities of elderly residents. This requires assessment on whether and how the built environment is suitable for ageing in place.

Using the neighborhood of Kanaleneiland in Utrecht as a case study this work presents a participation-based framework for assessment. Using the theoretical lens of familiarity, the suitability of the built environment is measured using the key factors of diversity and accessibility. To do so, this research gathers data from the residents of the neighborhood on their activity patterns, their frequently visited places, the routes residents take to these places and their opinion of the built environment. Next, these factors are quantified and measured to create a GIS-model that shows what the familiarity of the neighborhood is and consequently whether the built environment is a conduit for activities of the elderly.

The results show that participation-based assessment of built environment suitability for elderly people is possible and that the results can be used to improve the ageing in place experience of the current and future elderly population of the Netherlands.

Keywords

Livability
Ageing in place
Participation
Active ageing
Built environment

THESIS

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Assessing the suitability of the built environment for elderly people in Kanaleneiland

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Preface and reading guide

Before you lies the thesis “Ageing in place and the public space”. Without the help of other people writing this thesis would not have been possible. Therefore, I would like to thank Yanliu Lin and Martijn van der Hurk from Utrecht University for their supervision, Roland Goetgeluk and Hans van der Reijden for the chance to write the thesis while doing an internship at RIGO Research en Advies and their great help during the process, Kika Aalberts from the Gemeente Utrecht for letting me use the *omgevingsvisie* to gather data and Amina Berkane from Basmah Coaching en Training for her help in letting me tailor the survey to the needs and wants of the residents of Kanaleneiland and the Transwijk.

The thesis is structured using an ‘hourglass model’. Firstly, the paper paints a broader picture on the context and the research area of Kanaleneiland and the Transwijk. Second, the specific methods are discussed. Finally, the results are shown and discussed. The table below shows all the different chapters of the thesis.

Chapter 1: Why should this be researched? • An ageing population means that the built environment needs to be suitable for all age groups living in a neighborhood, especially elderly people • For “active ageing” a suitable public space means a built environment that makes sure that elderly people can do all their activities • Current GIS-models measuring the livability of neighborhoods do not take into account elderly people, do not focus on the built environment and do not provide the possibility for predicting the future suitability • This means that this part looks at the societal relevance and the context
Chapter 2: What is the theory behind the research? • Participation is required due to the *omgevingswet* (environment and planning act). This means that the GIS-model should be based on participatory data • The theory behind the suitability of the built environment for elderly is shown
Chapter 3: How should it be researched? • By using a case study (Kanaleneiland) the data can be location-specific • Using a customer journey perspective data must be gathered on the activities of elderly, how elderly people use the built environment and what their problems and solutions for the built environment are • This means that this part looks at the methods for the gathering and analysis of data
Chapter 4: Activity and the built environment
Chapter 5: How can the GIS-model be created?
Chapter 6: Discussion • Using the measurement of the current suitability of the built environment a prognosis of the familiarity can be made using demographic data for the future • The data gathered can be used to solve different issues, like the question on which people in Kanaleneiland use the central shopping center • Using the customer journey perspective in data gathering can prove to be useful for citizen participation • These perspectives mean that this part covers the conclusions of the research and the discussion. What could be markers for future research?
Chapter 7: What are policy recommendations?
Chapter 8: Conclusion

1 Introduction

"Ageing Europe faces demographic time bomb" (The Times, 20th of January 2020). This headline, ominous as it is, is just one of many showing how an ageing population is one of the problems facing the countries of the developed world. This includes the Netherlands, which has a population that is rapidly ageing (CBS Statline, 2020). This is impacting government policy in the country too. The government is pursuing a path of more people living in or near their original home. This is based on concept of ageing in place, which states that people want to grow old safely and happily in their own living environment. To make this happen, according to the Ministry of Health (hereafter, VWS), there need to be enough homes and the living environment in neighborhoods need to be adapted to the needs and wants of an ageing population. Having built environment spaces that are usable and livable for an older population requires an assessment of whether and how a neighborhood can "get into trouble" when the inhabitants living in the neighborhood get older and how to adapt to it. There is a lack of knowledge on this, some neighborhoods might also be less adaptable than others (Van der Wouden, 2011).

However, this assessment does not currently exist yet. Making it GIS-based can visualize what needs to be done to improve the suitability. RIGO Research & Advies shares the urgency of this assessment, therefore a GIS-based assessment model that identifies the present and future suitability of the built environment of neighborhoods for elderly people is necessary and useful. The assessment is based on a set of algorithms that estimates the present and future utility of physical elements in a neighborhood. The model does not currently exist yet, therefore the creation of this GIS-assessment model fills a gap in societal analysis capabilities. With this research project, a prototype for a GIS-model will be designed and tested. The model will be designed for people 55 years and older, as they are considered to be aged according to the Dutch government, so this is the general age marker for old age (Hooimeijer, 2007).

To help bring about change the government started an action program with three important goals: More homes need to be adaptable, there needs to be an availability of care and there is supposed to be more knowledge on living that is suited for people that are aged (Platform31, 2020). Within these main goals there is an objective to create more built environment spaces that are useable and livable for an older population (Ministerie van VWS, 2019).

Why is it so important?

The 2020 Global Risks Report by the World Economic Forum (WEF, 2019) has called population ageing one of the megatrends of the 21st century. Until the second half of the 21st century, when a new demographic equilibrium will be reached, the share of older people in the population of most developed countries is projected to rise. The brunt of consequences for this demographic shift will be in cities, which already house 43.2% of the older population in all OECD (Organization for Economic Development) countries (OECD, 2015). To make sure that the potential for continued potential for human development is fulfilled, cities must make sure that older people are included and have full access to urban spaces, structures and services. Cities need to complement the efforts of national governments to guide the way in adapting to this new normal of an older population (Van Hoof and Kazak, 2018).

The creation of age-inclusive cities is a path chosen by many. It's a concept originally thought of by the World Health Organization and stipulates that all age groups need to be taken into account when maintain and developing the city. The concept focuses on the needs and wants of the elderly, as, according to the WHO their presence is becoming much more important in the cities of tomorrow. (WHO, 2019). How to make this inclusivity more concrete has puzzled city planners for a long time already. Ever since Lawton (1974) identified how the built environment can make life harder for those less able there have been pushes to make design more inclusive. Poorly thought out homes, inaccessible meeting spaces and infrastructure made for more able people can prove to be a barrier to life for those less able. Cities for all shouldn't only take able bodied into account, in terms of design, but should also be made of accessible and welcoming spaces for physically impaired people. The focal point of inclusive cities, inclusive design, can be very

important in creating an urban design process that could lead to more sustainable communities. According to Egan (2004), these communities “meet the diverse needs of existing and future residents, their children and other users, contribute to a high quality of life and provide opportunity and choice.” According to Imrie and Hall (2001) there are multiple reasons for building cities for the largest consumer group, and not smaller, more marginalized groups. One of these that there is simply not enough demand for an accessible built environment. Population ageing is changing this argument.

This view is shared by Handler (2017). However, according to her, the current view on inclusive design is still focused too much on a “segregated” setting. This means that in her view, the subject of age-inclusive design is reduced to simple design considerations around the ageing body, like the availability of care. Arup (2010) also mention the importance of age-inclusive cities is becoming ever more prominent. Bates et al. (2019) state that how older people view a neighborhood needs to be emphasized. When people get older their perceived livability of an area changes, as different factors, like adaptability of homes and accessibility of infrastructure start to play a role in how people view an area. The importance of the built environment in this is mentioned by Cervero and Kockelmann (1997). In their research they coined the term of the three D’s: Density, Diversity and Design. According to Garin et al. (2014) how elderly people perceive the built environment also impacts health. Huber et al. (2011) define health as a broader concept covering physical, mental and social health. When this is in balance, a person is healthy. How one perceives the built environment and how livable it is for them, taking into account growing impairments, can impact the health of vulnerable people, like those that are aged (Kochtitzky, 2011).

Previous research on the subject has focused on how the built environment works for older people (Coleman, Kearns and Wiles 2016), what might impact their perception of it (Christiansen, 2016) and how they use the built environment (Davis et al, 2011). In the Netherlands the conversation around ageing is also becoming more and more important. Van Hoof et al. (2011) state that in-house and built environment adaptation is necessary to realize that the growing population of elderly people living in their original communities can continue to live there. However, Van der Wouden (2011) says that some neighborhoods in the Netherlands are less adaptable than others and that not a lot is known about which neighborhoods are age-inclusive, sustainable communities and which are not.

This shows that there is a problem related to assessing perceived built environment livability for elderly people in neighborhoods. The factors impacting it are known, the reasons why it is worthwhile to look at it are there too, but there is no real framework than can be used to see whether a neighborhood is livable for elderly people or not. The only Dutch framework for assessing livability in neighborhoods is the Leefbaarometer (RIGO, 2015), but this model focuses on many more aspects of livability than just the built environment and only takes into account the livability for working age people.

Therefore, a framework that can assess whether the built environment of a neighborhood can sustain, and be livable for, the older population living in an area now and in the future can impact spatial interventions. Knowing how and why an area’s-built environment is livable for older people or not can make sure that decisions based on evidence are made. Creating such an GIS-assessment framework would mean looking at the different factors impacting built environment livability for those that are aged. Two factors are assumptions, the remaining are empirical consequences.

First, it is necessary to argue that the built environment of a neighborhood should be able to facilitate the activity preferences of all age groups (Sarkar and Webster, 2017). Second, one should have elderly evaluate to what extent their present neighborhood facilitates these preferences. Third, one needs to take the type of neighborhood into account, especially noting the kind if design and population. Fourth, one should link this evaluation to physical elements and design elements in the neighborhood. Fifth, one needs to test what the results are controlled for demographic variables. The result is a probability, or score, that shows how any person or household evaluates a physical design element of a neighborhood. This leads to the utility of an element being the crux, conditional for the kind of household.

A framework should be able to predict whether this can still happen in the future. Currently, livability monitors only show the livability of a neighborhood now and do not use participation-based data.

The aims of the research are:

1. Generate insight into how the built environment suitability for people that are 55 years and older can be measured
2. To understand what factors impact built environment suitability
3. To understand the activity preferences of elderly people

The objective is:

- To create a GIS-model for assessing the built environment usability based on participation-based data

Using this objective, the following research questions can be elucidated:

Main question: How can built environment suitability in the Netherlands for those 55 years and older be assessed?

Sub-questions:

- What activity preferences for those 55 years and older use the built environment as a route or as a place of activity?
- How does the built environment impact these activity preferences?
- To what extent can activity preferences and impact factors be made into objective variables using GIS?

By using a test case the design of the framework and the GIS model can be improved. There are multiple reasons for this. First, to show the policy-value of the model one needs to apply in a practical use case scenario. Second, for the use-value it is important to discover how to approach elderly to deliver their evaluations. Third, a test-case can show whether the evaluation by those 55-years and older can be translated into GIS-data.

The research case is the Kanaleneiland and Transwijk area in Utrecht. This neighborhood is just one of many “scientifically planned” neighborhoods that were built in the 1960s. Considered to be an icon of Dutch spatial planning, made for car-based living by families it is now beset by problems (Ministerie van Infrastructuur en Milieu, 2012; Volkskrant, 2004). The population in the neighborhoods is also rapidly ageing (CBS, 2020), creating questions on how the built environment can cope. This combination of factors makes Kanaleneiland/Transwijk ideal as a research area.

Due to the fact that the multiple spatial planning acts are being replaced by the new *omgevingswet* (environment and planning act) from the first of January 2022 onwards there are certain new procedures that are required for planning processes. One of those procedures is that citizen participation needs to become a part of every local government planning and environment plan (Rijksoverheid, 2016). As the proposed GIS-model framework is supposed to support planning processes it is important that citizen data is incorporated in it. This means that citizen data plays an important role in the design of the GIS-model.

Also, because an *omgevingsvisie* (environmental vision) for the area is currently being put forward by the council of Utrecht (omgevingsvisie.utrecht.nl, 2019) to make sure inhabitants can give their opinion on the future of the neighborhood the research can be integrated with the planning process. By doing this, inhabitants can have their say on the future of the built environment of the area and what the factors inhabiting their use of the built environment are. By being part of an *omgevingsvisie* the research also touches upon the new *omgevingswet* (environment and planning law) in the Netherlands. This law is supposed to replace all current planning laws that are active in the country.

To summarize, due to the increasing importance of ‘ageing in place’ and the lack of knowledge on how suitable the built environment of areas in the Netherlands is; it was decided to create a GIS-model to assess and visualize this suitability of the built environment. By doing this, the gap in knowledge can be bridged and improved decision making on ‘ageing in place’ can happen.

2 Theoretical framework

In the following chapter the theoretical base of how one needs to approach the subject is touched upon.

When one looks at how the built environment works for people of age there are multiple concepts and theories that need to be taken into account. The context of the research can be elucidated by looking at the previous work done in the field of planning in ageing. In this chapter, the basic conceptual model supporting the research will be explained and the broader theories surrounding the subject will be covered.

Conceptual model

First, the conceptual model. Looking at whether an area facilitates or inhibits activities, one needs to cover three areas: The diversity of an area, the accessibility and as a result of this: The familiarity. This leads to the following conceptual mode, which is explained more below.

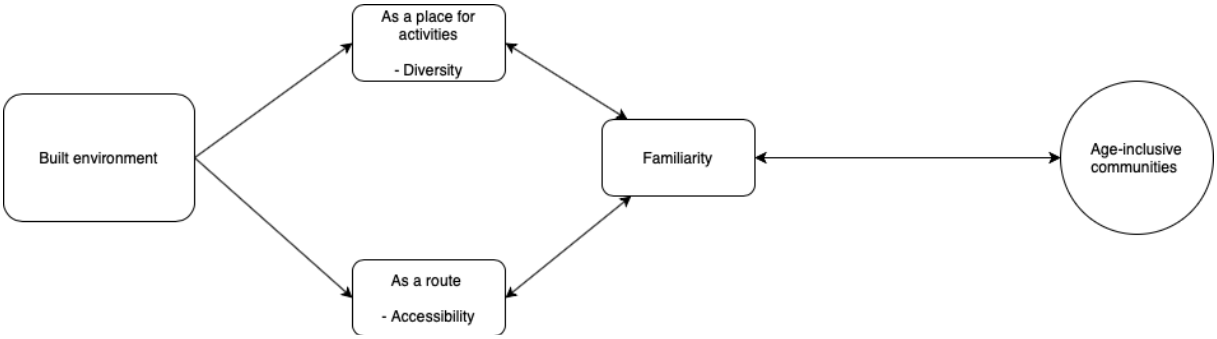

Figure 1: The conceptual model

According to the theory, the built environment is seen as a place that people use for their daily activities, their place-making and a route towards other spaces (Bowling, 2005; Paez et al., 2007). This means that the built environment needs to support the daily activities of the people in it, needs to have places for social connection and can provide accessible routings to local destinations for people. This is noted especially by Frankl (1986) in his books on the meaning behind activities in life. Summarizing these prerequisites, one can use the two concepts of accessibility and diversity. When the factors for these two concepts are positive, this leads to familiarity. Familiarity is when a neighborhood generates close acquaintance with it, which leads to place-making and improves the quality of life. This familiarity is a latent variable, as it cannot be measured by itself, but by measuring the factors one can construct an argument around familiarity and the amount of it (Hess et al., 2016).

Basic factors per concept:

- Accessibility: Walkability, support of mobility
- Diversity: Services, places for social connections, unique feature, safety and attractiveness

The explanation for the decision of factors is that they cover both the built environment as a route and a place for activities. For a built environment that facilitates activities as a route towards them it needs to support mobility and be walkable. For the built environment as a place for activities it needs to have services, places for social connections and features that make the neighborhood attractive and unique for residents (Paez et al., 2007). This conceptual model can be used for multiple age groups in participation-based research, in this research paper the focus is on those 55 years and older.

Human existence and activities during the lifespan

For a clear picture on why age-inclusive communities are a goal one needs to start with the definition of geography, which can be summarized as geography being the field of research focused on how and why people do activities in a spatial environment (Walford, 1996). For a "full" life different kind of activities are considered to be necessary, the most basic being eating and sleeping and the more specific ones being things that can give meaning to life (Huber et al., 2011). This implies that the environment can influence the lives of people.

An important researcher on how human activities are structured is Maslow (1943). According to Maslow, people manage time in different ways, but there are cogent hierarchies at the base of it. He identified five tiers of needs: Physiological, safety, love and belonging, esteem and self-actualization needs. Needs lower in the hierarchy, like physiological needs, need to be satisfied before can attend to needs higher up the five-tiered "pyramid". According to Maslow, when physiological needs, like sleep, water, clothes and shelter were fulfilled a person could get the motivation for spending time on other needs, like social belonging. What this means that for a good quality of life, one must fill up gaps in more basic needs before moving on to the other tiers. However, according to research by Ludwigs et al. (2017), all factors of happiness are of importance when looking at broader quality of life, which means that there is no real hierarchy. These factors of happiness tend to change when people get older, especially when people become part of the 55+ age group (de Boer et al., 2017)

According to the Tijdbestedingsonderzoek (de Boer et al., 2017) elderly people tend to spend significantly more time on things like domestic work, including going to the supermarket, and consuming media. They also spend less time on caring for others, while spending more time on volunteering. More time is also spent alone. After 80, the situation changes more. In a study on the activities of people that are older than 80 shows that the amount of active time drops significantly, as physical and mental impairments take their toll (Lättman et al., 2019).

When people get older their activities also change. As people get older, health tends to deteriorate. This means that a lot of things that younger people may do or like might like might not be possible anymore. These impairments, or health constraints, can have impacts on the subjective well-being of old aged people. Health-related losses influence the physical dimensions of well-being, while not impacting the other dimensions [of well-being] (Kunzmann, 2000). This higher health care need can often be unmet, as people do not have the will, time or money to solve the constraints. This can create a vicious circle of health-related losses (Park, Kim and Kim, 2016). In poorer neighborhoods, there could be a higher proportion of unmet needs, as people that have a worse socioeconomic status have a higher chance of not having their medical needs met (Lee et al., 2015). The health status of elderly people can change significantly in the 21st century, as healthcare gains make sure than people can live healthily for longer (Erlich and Litwin, 2019). Physical activity at old age can also help slow the degradation of muscle fibers, making sure that people are less physically impaired (Rise, 2019).

An important information source for health during old age is SHARE (Survey of Health, Ageing and Retirement in Europe, 2019), which is a survey using face-to-face interviews for those 65 years and older. Questions are asked about factors impacting health, health and the future perceived health of the respondents. The results for the latest "wave" of surveys show that health-related issues include cardiovascular diseases, decreased mental capacities, cancer and related diseases, reduced eyesight, reduced physical capacities and/or incontinence. Increased heat stress amongst elderly people also means that during times of "extreme" weather there is a higher chance that plans for trips might get cancelled (Tuomaala et al.,2013) Loss of health can change the way of and the intensity of travel, this because getting out and about is more difficult (Paez et al., 2007).

The WHO formulated a definition for active ageing:

"The process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age. […] It allows people to realize their potential for physical, social and mental well-being throughout the life course and to participate in society according to their needs, desires and capabilities, while providing them with adequate protection, security and care when they require assistance." (WHO, 2002).

Activity in this definition is the continued participation in the affairs of life. Key parts of the concept of active ageing are: Autonomy, which is the ability to control, cope and make personal decisions. Independence, which is the ability to perform functions related to life. Quality of life and healthy life expectancy are also important (WHO, 2002).

Evidence-based active ageing indicators, like social participation and the possibility for healthy and secure living can show how age-inclusive societies are (Buys and Miller, 2011; Zaidi et al. 2018). Health, security and participation domains of active ageing are considered to be the pillars on which the indicators are supposed to fall (Active Ageing Australia, 2019). Regular active travel can improve the possibilities for active ageing, according to Cheng et al. (2019). The role of the built environment is based on the fact that this active travel needs be facilitated spatially (Alsnih and Hensher, 2003). Oerlemans, Bakker and Veenhoven (2011) mention happy ageing, which is based on a research paper that showed that older adults can improve their happiness when they combine effortful social, physical, cognitive, and household activities with restful activities. Participation in social activities can also contribute.

How older people, taking into account possible impairments and what might be good for them and good for society in terms of activities, spend their time has been the subject of debate. Time spent by those that are aged goes through a shift when people get older (Feddersen and Lüdtke, 2018). Older gender roles and family economics caused by the man working and the woman staying at home start to fade when people reach the age of retirement, this because the man doesn't work anymore (Leopold and Skopek, 2015). Frankl (1986) mentions that because of the fact elderly people are closer to their "end", they focus more on what they consider to be the important things in life. These things are "pride", "joy" and "richness", and can be encapsulated within the concepts of emotional goals and emotional poignancy.

According to Erikson (1980) older adults try to add coherence to their place in the world by maintaining familial social ties. Roles as parents and grandparents start to carry more personal importance as people age. Also, as Erikson (1980) states, older people do not attempt to achieve long-term goals anymore, but emotional satisfaction and meaning in the here-and-now. This view that the final stage in stage in life is one of self-acceptance has also been stated by Cross and Markus (1991). How one has more of a need of the familiar when one is aged has been called the control condition by Fung et al. (1999). When an end is considered to be "near", like in the research period of the weeks before the handoff of Hong Kong to China in 1997, familiarity becomes very important. The control part is based on the fact the familiar can become important for every age group, but an "ending" needs to be perceived to be within proximity.\

Activities within time-space

How people actually perform those activities in geographical space is the subject of time-geography, which is a theory devised by Hägerstrand. The basis of the theory was formed by looking at the time-space "choreography" of an individual's existence at different temporal scales of observation. This means that an existence can be depicted using a diagram, in which there are events and physically fixed buildings or territorial units of observation (Pred, 1977). These building or geographical units can be called "stations" or "domains" where groups congregate or dissolve into our out of an "activity bundle". This combines both the structure and process of existence (Hägerstrand, 1975). There also constraints which steer action.

The three main classes of constraint are:

1. Capability constraints, these are the physiological constraints that steer one's use of time. It also covers the limits on distance one can cover given transportation limitations.
2. Coupling constraints, which are the limitations caused by the joining of other individuals in "activity bundles". When one stays in these bundles for longer, further movement is constrained, as there is less time.
3. Authority constraints, which are derived from the fact that space-occupation is exclusive, and spaces have a limited packing capacity.

There are other constraints too, like the fact that people cannot be at two places simultaneously and that station-to-station movement also consumes time (Ellegard, Hägerstrand and Lenntorp, 1977). When looking at the temporal scale of a day there is also the concept of the *prism*. This is the part of the total time-space that is within reach in the time one can be away from home (Hägerstrand, 1985). Critique on the concept has been formulated by others, who mentioned that time-geography "tells us nothing about how 'stations' and 'domains' are produced and time and space are not passive frames (Holt-Jensen, 1999). Sullivan (2017) mentions that space, time and place are intrinsically connected, and all need to be taken into account when looking at time geographies. However, time-space geography is considered to be a good model to use for the assessment of public spaces, as one can use it to decipher whether and how people use public spaces (Varna, 2018).

The home plays a special role in the analysis of the activities people undertake in their area. This because of one important reason. People spend the time they have in two areas: Inside and outside their home. The home is considered to be a center of activities and a base for activities outside of the home (Hooimeijer, 2007). This idea of the home being a node for activity has been prominent since the publication of the book by Bourne (1981) on housing and the time-space activity patterns of residents. Using time-space mapping the way housing played a role in the daily activities, like recreation, shopping and work was elucidated

How the built environment influences activities

Good livability can contribute to age-inclusive cities and sustainable communities, as mentioned by Egan (2004). This is the final part of the conceptual model. Age-inclusive communities that are also sustainable are covered by the concept of age-friendly cities, which has been playing a role since the World Health Organization (WHO) and partners wrote a guide to how to create an age-inclusive city in 2007 (WHO, 2007). The process for the guide was started in 2005, bringing together qualitative data gathered by multiple researchers, in multiple cities, in a collaborative way. The basis for the guide was formed in the 2002 *Madrid International Action Plan for Ageing*, endorsing the designing of enabling and supportive environments for older people (WHO, 2002). The 2007 guide on age-friendly cities mentions multiple topic areas constituting all the parts an age-friendly city requires. One of which is an age-friendly outdoor space. The guide emphasizes the lack of seating areas, accessible infrastructure and poor urban design as being emblematic for cities that do not have a special care for their older population. Research on age-friendly cities is often formed using the Vancouver Protocol, which calls on a qualitative assessment of 8 domains of ageing within cities, including the perceived quality of outdoor spaces and transportation (WHO, 2007).

This WHO-definition of an age-inclusive city, as mentioned before in the introduction, constitutes two parts. First, according to the WHO "an age-friendly city encourages active ageing by optimizing opportunities for health, participation and security in order to enhance quality of life as people age." Second, "[…] an age-friendly city that adapts its structures and services to be accessible and inclusive of older people with varying needs and capacities."

The concept of age-friendliness in cities has been operationalized in different ways. An example of this is the AARP Network of Age-Friendly States and Communities. This is a joint group of cities, states and communities that help policy makers to make cities more

walkable and enable access to key services (AARP, 2020). The concept has been considered too vague by many though, including Plouffe, Kalache and Voelcker (2016). They argue that the concept could be considered a good goal, but the targets set in the guide are too vague to provide any real meaning. Buffel et al. (2012) also identified other issues that need attention in future developments of age-friendly communities. According to them, recognizing the diversity and the city its inhabitants have and more of a life-course perspective to the needs of the residents are important. Flores, Caballer and Alarcón (2019) also state that for evaluation of age-friendliness not only the qualitative Vancouver Protocol method should be used, but quantitative methods are also necessary.

Age-friendliness (or age-inclusiveness) has also been approached in other ways. Yuen (2018) mentions that in Singapore the age-inclusivity of the built environment is now part of the decision-making process by the nation's *Housing Development Board*, which owns most of the public housing in Singapore. As the country is ageing rapidly, how to deal with the older population has been quickly picked up by the nation's policymakers and urban planners.

For an age-friendly built environment designing physical objects with an inclusive approach is necessary, which is considered to be inclusive design. The concept originated with Sommer (1983), which termed it to be social design. Taking from the ideas of environmental psychology, he created a set of principles one needs to adhere to for designing physical spaces that can take the differences of people and behavioral patterns in mind. The concept has evolved over the years to become more of a holistic way of looking at design. Clarkson & Coleman (2015) define inclusive design as "which addresses the needs of the widest possible audience, irrespective of age. This definition is the reverse of previous approaches to inclusive design, which singled out those that are aged as one of the focus groups. Inclusive design for the built environment has been aiming to reduce the barriers that people that are aged have when "going out and about". This includes adapting the already existing built environment and creating new spaces that are inclusive to all (Imrie and Hall, 2001; Langdon et al. (2019).

Looking back at the previous two parts of this chapter, one can decipher the fact that for a fulfilling life people undertake different kinds of activities. Over the lifespan, these activities and how people spend their time also changes. Due to constraints, like capability constraints, people can do less or value other activities more. A lot of activities happen inside the house, but a lot happen outside too and that is where the built environment starts to play a role.

This influence of the built environment can be felt especially in the area of health, which is an important topic in "healthy ageing". How the built environment can impact health is a field of research that has been covered in different ways. Physical activity, the main thing the built environment can influence, has shown to be one of the main reasons that elderly mortality is lower in more walkable neighborhoods than in those that aren't (Diez Roux, 2004). Kochtiztky (2011) also mentions the effect that the built environment can have on vulnerable populations. He argues that vulnerable people, for example those that are aged, engage in more life-improving activities and have maintain social networks in neighborhoods that have a high quality in terms of the built environment. Using terms taken from economics, according to Sarkar and Webster (2017) the built environment can incentivize healthy or unhealthy behavior. Health externalities of urban living can improve when the built environment is adapted for a positive influence on health.

How suitable the built environment is for activities also shows the success of a space. According to Carmona (2010) successful spaces are spaces that support and facilitate people's activities. For those activities, the built environment can be more or less suitable. Focus on the suitability of the built environment for activities have focuses on more health-positive active travel activities, like walking. In their 2008 study on the suitability of the areas around schools for walking; Lee, Tudor-Locke and Burns identified the following factors that impact the suitability: Traffic count, number of through lanes, problem spots in sidewalks, streetlamps and intersections. Using all these factors, they gave each street surrounding schools a walking suitability score. A similar approach has been taken in

Nijmegen, in the “Nijmegen Toegankelijk” project they created a guidebook to score and improve streets and public spaces (Gemeente Nijmegen, 2016).

Another way to look at the suitability of the built environment for activities as mentioned by Yuen (2018) is through activity mapping. Using the results in her research on activity of older people in Singapore the conclusions were that creating more “sittable spaces”, introducing “landmarks”, the clustering of activity areas and the programming of built environment (designating specific function to public spaces) and adopting participatory design can help with creating a greater suitability to activities in the built environment. Increasing the suitability of public spaces to activities can also have social impacts, as when more people partake there is a higher chance of making social connections (Worpole and Knox, 2008).

Environmental gerontology covers how the built environment can influence the lives of older people. Research states that assistance devices, which are used to increase mobility for people that are less able, can prove to be difficult and a built environment usage inhibitor for people that are aged (Iwarsson, Ståhl and Löfqvist, 2012). Familiar spaces for older people are also important. This means that spaces need to be attractive, easily accessible and facilitate ease of mobility. Due to increased sensitivity to environmental cues and features, familiarity is more important for elderly people than people that are of a working age (Philips, 2012). Unfamiliarity can lead to things like disorientation, social exclusion and loss of independence. Such factors limit activity for older people and create anxiety. Increased anxiety can lead to falls and public embarrassment (Baragwanath, 1997). Increasing familiarity can be done by reducing clutter, increasing lighting and allowing views for orientation (Day et al., 2000). For creating familiarity, the quality and intensity of an experience is more important than its duration (Tuan, 1977).

3 Methodology

Following the theoretical base brought forward by chapter two, which showed that the activities done by elderly people can be considered different from other age groups and the factors impacting quality of life are also different. The built environment is a space for activities and a route towards activities (Hooimeijer, 2007) and constraints make the suitability of it different for elderly people.

Based on this theory and conceptual model, a methodology for assessment needs to be constructed. For a deeper understanding of the subject sequential mixed methods research will be used (Venkatesh, Brown and Sullivan, 2016). This means using surveys, qualitative data and secondary data. In this chapter the case study, the research design, assessment model design and data gathering procedure will be covered.

Case study

The place to apply the theory, the setting of the research, is, as mentioned earlier, the neighborhood of Kanaleneiland/Transwijk in Utrecht. There are multiple reasons to choose this neighborhood.

- First, it is as a neighborhood associated with the CIAM (Congrès International d'Architecture Moderne) movement, who stipulated that the modernist city should be a garden city with stacked building typologies (Lefaivre et al., 1999). They also stated that that there should be a division of living, working, recreation and traffic areas. This would create airy, green neighborhoods with a lot of space (Wagenaar, 2011). Using this rationality, Kanaleneiland was planned during the post-war housing shortage (ibid). As high-rise construction, like that used in Kanaleneiland, was quick and easy to build it became very popular in the 1955-1970 period (ibid). The neighborhood was constructed using an orthogonal grid, wide roads for traffic and one big, plus two smaller shopping centers. The strict grid and large amount of green space makes the neighborhood poorly adaptable to changing demographic pressures (ibid). The design of the neighborhood is also similar to some other neighborhoods in the Netherlands, which helps generalizability.
- Second, Kanaleneiland has a lot of social issues. According to the Leefbaarometer (2017) livability in Kanaleneiland, Kanaleneiland-Noord and the Transwijk is poor to very poor. This due to the fact that there is a high rate of crime and unemployment. In an area where general livability is already poor; looking at built environment livability for those 55 years and older can provide special insights.
- Third, as mentioned before, the population of Kanaleneiland is rapidly ageing (CBS Statline, 2020). This means that the neighborhood, which already has a large population of elderly, will become even more "aged".

Research strategy

Creswell (2018) in his book on data-driven research design notes the different kinds of mixed methods strategies that can be used to guide research. In this research paper a quantitative sequential explanatory design will be used. This involves gathering and analyzing quantitative data and then building on it by gathering qualitative data on the subject. This exploratory approach helps with researching phenomena that have not been completely set in stone yet (du Toit, 2016). Until now concept of livability of the built environment for those 55 years and older has not been properly researched yet.

Through gathering qualitative data validation of the results from the quantitative analysis can happen. By using qualitative a deeper understanding of the phenomenon can be created, while also creating extra data that can further deepen the effects of the results. Because of the fact that the open questions actually make sure that people can be asked about what they personally think of the built environment livability in their area the results of the open questions can be compared to the results of the model.

This meta-inference (Tashakkori and Teddlie, 2008) is mentioned as an essential part of mixed methods research. It can also create construct validity (Dellinger and Leech, 2007). Looking at whether the GIS-model measures livability in a way that is it supposed to measure, while also measuring the correct factors in a proper way creates this validity.

How this validity can be created within the framework of a case study research is researched by Creswell (2018), because, according to Creswell (2018) there are threats to internal and external validity in a case study. Within the design of the data gathering methods there is supposed to be attention to how to combat these threats. However, he also mentions that a case study such as this case study on Kanaleneiland, can be valid enough to create generalizable conclusions. Magolda (2006) state that a case study like Kanaleneiland is an exploratory case study, as findings and research can be generalized further later. This means that, when successful, a similar research design can be used to look at different (topologically similar) neighborhoods in the Netherlands.

Epistemology

Creswell (2018) states that mixed methods research is part of a pragmatic worldview. This worldview is based on the notion that the positivist and interpretivist schools of thought should not be opposed to each other, but complementary (Charmaz, 2006). Positivist factors like internal and external validity still play a role though, as the quantitative approach needs evaluation. Charmaz (2006) calls the topics of credibility, originality, resonance and usefulness the most important for researchers, so that research has a practical use.

Research design

In order to address the mentioned research questions the following operational model has been created:

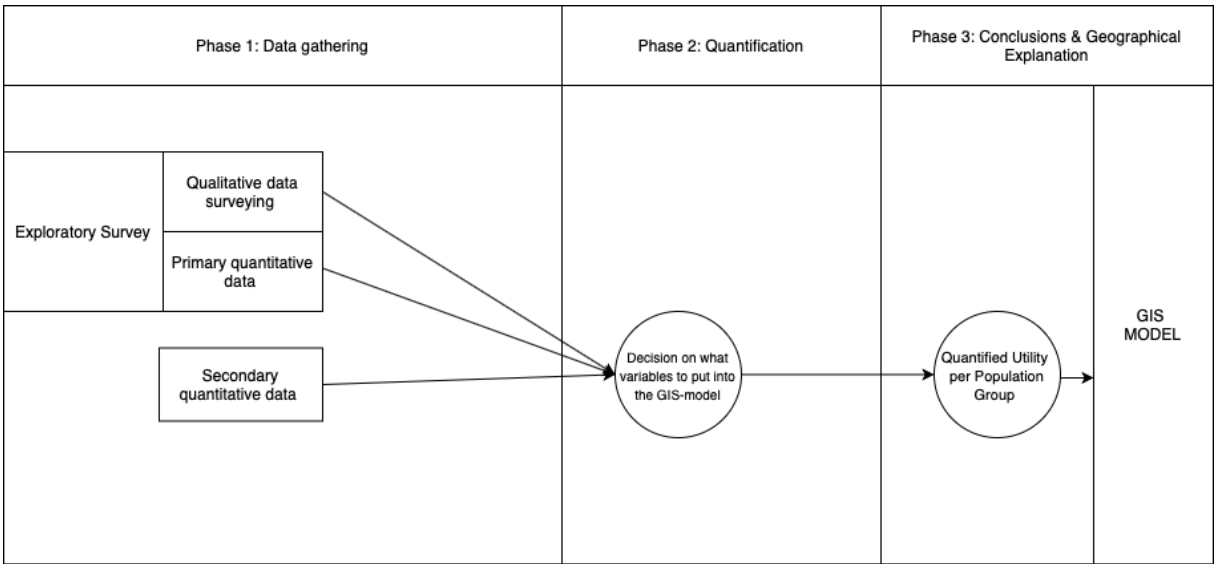

Figure 2: The operational model

The data gathering and analysis is split into three phases. The first phase consists of an extensive gathering of data, which is necessary to answer the questions of the built activity preferences for those 55 years and older and factors that may impact those preferences. Following this, using the theory as a basis, the qualitative data from the survey will be used for extra validation. The primary and secondary qualitative data consist of questions asking respondents about their perception of the built environment, experienced hindrances and their life. The final part of data gathering consists of questions on what respondents consider to be solutions to possible issues, giving an open view on how built environment livability flaws can be fixed. All will be combined with available secondary (geographical) data, which is phase two. At this time, the calculation on what factors should play a role in built environment livability will also be made. Constructing the GIS-model is the third phase. It involves combining the data, creating the geographical base layer and making sure that the data is presented correctly. Making calculations on how parts of Kanaleneiland support the necessary mobility for elderly people to thrive

or not happens in phase three too. The calculations are based on connecting the quantified utility of physical elements for those 55 years and older to the existing built environment elements in Kanaleneiland.

Data gathering procedure

To know what makes built environment livability for people it is necessary to gather data on the factors impacting the familiarity of the built environment, how the built environment facilitates people's daily and wanted activities, and how it facilitates routings to local places. By means of surveying, with open questions that can validate the results, while filling up gaps with secondary data it is possible to get a clear idea of whether the neighborhood facilitates or inhibits activities.

Surveying needs to happen within a customer journey framework (Kotler, 1965). This is a concept that comes from marketing but is also important when looking at citizen participation within an urban context. The customer journey approach makes sure that the data gathering approach is tailored to residents of the area. This is the only way to make sure that respondents have a good experience while filling out the survey and being part of the research. Kotler (1965) states that 4 "C's" are important for the customer journey.

- Convenience – This is how easy the survey is to finish
- Customer – The survey needs to be tailored to the foreseen respondent group
- Cost – As maximum response is necessary, the cost in terms of time used needs to be low for the respondent
- Communication – The respondent needs to be easily able to see the survey and what the survey is about

Combined, these C's show that a survey for Kanaleneiland and the Transwijk needs to be distributed using many different channels, needs to be easy to use, needs to use simple language and needs to be short.

The customer journey approach also means that there is strong focus on the opinions of the respondents themselves. This means that the survey can contain a lot of open questions asking the opinions of people and can give them the opportunity to value/rate things.

Survey

According to Bryman and bell (2019) exploratory primary research, like surveying, can help with generating a picture surrounding a phenomenon. Because it is important to know how residents want to spend their day and how they are currently spending it, while also making sure that possible impairments have are mentioned, one can gather a lot of background data on what people want to do later in life and what is holding them back. This is based on the idea that livability as a concept is different for the elderly. For happy ageing, like Oerlemans, Bakker and Veenhoven (2011) mentioned, one needs to be able to live his or her life to the fullest. Living life to the fullest means engageing in activities that mean a lot for well-being. According to Oerlemans, Bakker and Veenhoven these activities include social activities and physical activities, with household activities like shopping being considered to be actually detrimental to mental health. Thus, as household activities are essential, they also need to be facilitated.

Connecting the survey to the theory, there are multiple sets of questions:

1. People are asked to pinpoint where they live. This is to help the quality of the GIS-model.
2. Respondents are asked to mention four frequently visited places. After pinpointing these places, people are asked what kind of activities they do there and what they like the most and the least about the mentioned place. After this they are asked to give a rating from 1 to 10 in terms of how much they like the place.
3. After this, respondents are asked what the routes they take to these frequently visited places are. This will enable mapping how people use the neighborhood. Per route, their modal choice is also asked.

4. Another question is what possible problems are on the route, and respondents are also asked to explain the mentioned issues. This shows the constraints people have to deal with.
5. The final part of the survey consists of two questions asking people what they do on a normal day and on a “special” day. Using two hour intervals people can pick from a set of activities that have been picked from the Tijdbestedingsonderzoek (2017).

The questions asking the locations of their home and places people frequently visit connect to the theory by Hooimeijer (2007), which is ‘the house as a node’ principle. By asking what kind of activities they do at those visited place and what rating they would give the place connects to Huber et al. (2011) theory of positive health and Maslow’s (1943) hierarchy of needs. Asking people what the problems in terms of the built environment for them are connects to Hägerstrand (1975). By using the survey program called Maptionnaire it was possible to let respondents answer the questions in a better way. Respondents could see a map of the area and were, for example, able to draw their route towards their frequently visited places on the map. Using this application meant improved questioning was possible and enabled gathering of geographical data. The survey was available in Dutch and English.

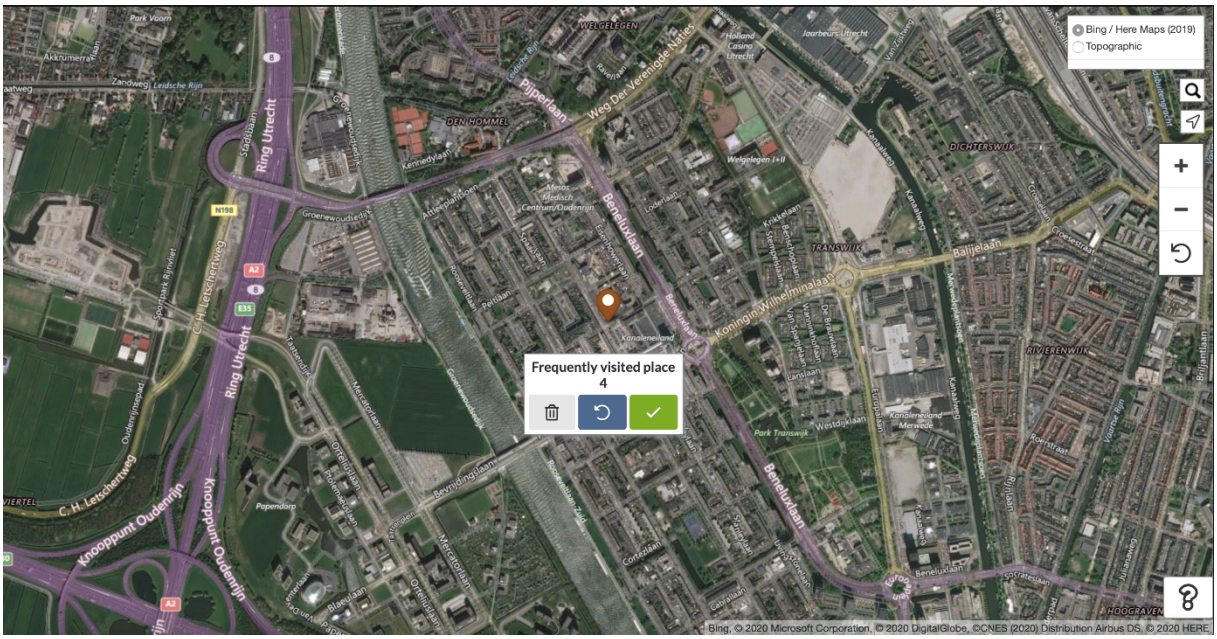

Figure 3: A screenshot showing the design of the first survey

Using the first meeting for the environmental vision of Kanaleneiland and the Transwijk the survey was tested by the people that were present at the meeting. With all the feedback generated during this session the survey was improved. By testing the survey first, it was possible to make sure that people properly understood and filled in the survey before rolling it out completely. The second and third meeting for the environmental vision were postponed due to Covid-19, so it was decided to move data gathering online. On the 23rd of March the survey was put forward to people in the area. This happened via an email to all the people that were interested in the environmental vision meetings.

Using this method, a lot of response was generated, but the response was skewed towards the younger, more highly educated population of Kanaleneiland. Therefore, it was decided to use Facebook ads targeted towards residents of Kanaleneiland and the Transwijk that are 55 years and older to have more people respond to the survey.

Using the data from the first survey a second, smaller survey was designed. This survey asked people to value the accessibility of certain features in the neighborhood on a scale from one to ten. Using pictures of the elements mentioned in the CROW Accessibility handbook (CROW, 2017) data could be gathered on the specific utility people assign to the different elements. The survey program that was used was Qualtrics. This because the questions asked were non-geographic, so a simpler survey program could be used.

This was done by asking questions on the five “most problematic” locations mentioned in the first survey. These locations were the ones having the highest density of mentioned problems *en route*. Respondents were asked what they thought of the design of the locations, how safe they thought they were and how accessible the locations were. This was done by asking respondents to give a specific mark to all of the factors. After this, respondents had to fill out an open question on whether they had any ideas on improving the specific location. Using this data, patterns could be deduced and a clearer picture on the utility of certain elements in the built environment could be generated. The survey was published on Facebook and respondents were sought in the Kanaleneiland/Transwijk area. The survey was also put forward to people in a Kanaleneiland neighborhood WhatsApp group.

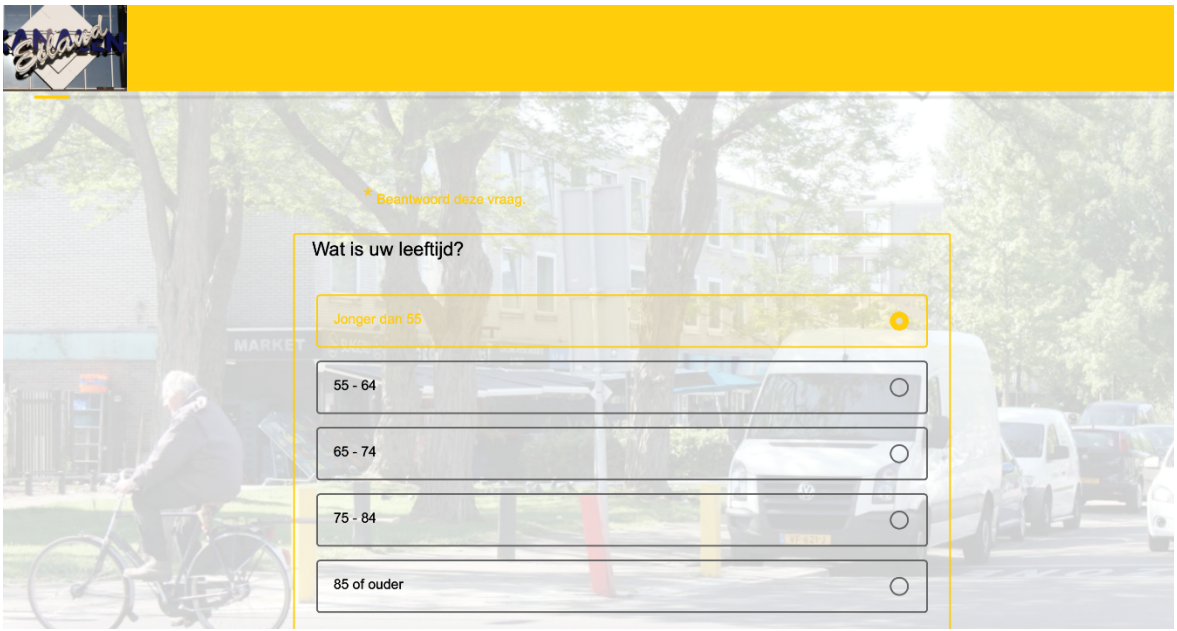

Figure 4: A screenshot showing the design of the second survey

As the surveys were geographical, the surveys needed to cover most of the neighborhood. Therefore, sampling could be nudged towards people from all areas in the neighborhood participating. Due to the fact that the survey is mainly descriptive the minimum sample size was 44, this is with a margin of error of 10% and a level of reliability of 90%. The population size of Kanaleneiland and the Transwijk together is 18695, 20% of the population is 55 years or older (CBS Statline, 2020).

Quantification of data

Creating and using data that can be “fed into” a GIS-model means that some answers to surveys have to be quantified. There are multiple ways to do this, but the latent factor method, which means inferring factors from data presented is the best way to quantify possible geographic data. Whether data is quantifiable is also a factor. Some factors are conceptually correct, but not quantifiable (Bryman and Bell, 2019).

The quantification of data means scaling up participation-based data to “system data”. This means finding patterns in the citizen data and enriching the data with data from secondary sources. By coding the answers to the open-ended questions patterns in the answers can be discovered. People were asked to describe what kind of problems they run into while taking the routes, why they think certain locations are highlights, what they like about locations and what they do not. Coding the answers to these questions means that it is possible to group the answers and find themes.

The process of quantification also means deciding what the values per variable are. This means that, for example, the accessibility of a street is assigned points on a scale from one to five, these points are also based on the different requirements a street might need to fulfil to be accessible according to the CROW Accessibility Handbook (CROW, 2017).

Combining this with other factors, like the diversity of shops, can create a combined familiarity score

The so called 'space syntax' is a way to look at movement in urban space. The theory exists to help understand the impact of spatial configuration of urban areas on people's movement. Originally coined by Hillier (1976) in a paper on the structure of cities and villages over time. As, according to Hiller, spatial organization can be considered a "morphic" language (a language that borrows from both numerical and normal languages, but is neither), the social and spatial are interrelated and socio-spatial analysis can help explain some social phenomena. This, according to Rattan et al. (2012) can be covered by different variables. An example of them is the availability of benches.

Using the data, a set of goal factors and explanatory factors can be deduced. Using the additive multicriteria model (Dolan, 2019) the different factors can be analyzed to filter out whether the built environment facilitates or inhibits the decisions necessary for maintaining the activities elderly people want to do. This because connecting the different values to the utility of built environment elements shows how much different population groups value a certain element. This rating of the utility of built environment features for different households shows the amount of familiarity in a neighborhood. Using the additive model is considered a good way to show certain nuances in research, as multiplication is considered to just give binary yes or no results (Dolan, 2019).

Ethical considerations

Bryman and Bell (2019) mentions four possible areas of ethical issues. The first is the risk of harm to participants. As the research does carry with it some questions that might actually impact respondents when traced back to them, for example the questions about impairments, place of habitation and the questions about routes taken to points in the neighborhood; proper data protection is very important. Data gathered should be kept on secure servers and should be untraceable in the research paper and the GIS-model; this will be communicated to participants. The General Data Protection Regulation (GDPR) is the guideline for protecting data and privacy (European Commission, 2018).

Second, when there is a lack of informed consent this is a risk. This means that, before undertaking the survey respondents are required to give consent to them being part of the research. Before this, they have to be informed on how the data will be used, the data protection level, and the possibility to rescind consent at any time. Third, invasion of privacy can be a risk. Respondents can refuse to answer questions they consider to be too personal. Involvement of participants is entirely voluntary, and it is important to do the upmost to uphold confidentiality and anonymity. Not mentioning information or views given by other research participants to new participants is essential too. Finally, if deception is involved there is also an ethical risk. To make sure this does not happen participants get exact and extensive information on what the research is about and why data is being gathered.

Position and Influence of the Researcher

Al-Natour (2011) describes the impact of the researcher on the subject of research to be dependent on whether one can be considered an "outsider" or an "insider". This positionality can influence the contents of research. As someone who is not part of the same generation, not living in the case study area and having no connection to the research group the researcher of this study can be considered an outsider. By contacting people that are insiders in the neighborhood the aforementioned gap can be reduced. Bryman and Bell (2019) also states that *closeness* to the research participants adds to the value of research, this can happen by attempting to look at the world from their eyes in the best way. For the surveys, this *closeness* is factored in.

How the GIS-model is set up

To create a GIS-model that shows and can predict the built environment livability for those 55 years and older in a neighborhood it is necessary to look at the three different parts of what ensures that an area facilitates or inhibits the activities of elderly people according to the theory, building on the concept of the house as a node. The parts are familiarity, accessibility and diversity, while the base consists of all other essential data.

Base

Data needed:

1. Data neighborhood topology (secondary data)
2. Demographic data (secondary data)
3. Data on possible locations of services and facilities (secondary data)
4. Data on the physical environment in a neighborhood, for example the amount of green space (secondary data)
5. Data on the age, sex, type of household and educational attainment of respondents (primary quantitative)

This base will show the different built environment elements the neighborhood has. Space elements like benches can be connected to accessibility and elements like places to meet can be connected to diversity. Using the data different utility values can be attached to a neighborhood grid for different population groups.

Accessibility

A good way to look at how accessible the built environment of a neighborhood for those 55 years and older is by analyzing whether a neighborhood can sustain and facilitate the daily activities of those 55 years and older. This means analyzing the basic accessibility of the neighborhood with secondary data, while adding primary data to show what people undertake in terms of activities, what impairments they may have and what the routes they take. Combined, this creates a picture of the accessibility of a neighborhood.

It also means analysis of mobility within a local perspective. This includes walkability, which can be measured by observing the problems people are having in the neighborhood and secondary data based on mobility support features being available.

Data needed:

1. Data on what the built environment activity preferences of people are (primary quantitative)
2. Data on what kind of routes people take to their daily activities (primary qualitative)
3. Data on what impairments people might have or experience (primary qualitative)
4. Data on what obstructing issues they find *en route* (primary qualitative)
5. Data on accessibility of a neighborhood (secondary qualitative)

Combined with the demographic data the accessibility can also be “predicted”.

Diversity

The factors related to the diversity of the built environment in a neighborhood are the access to services, social gathering spaces and shopping spaces. Data on what places people visit, why and what rating they would give to those places can be gathered. Combined, one can analyze the places most preferred by the elderly people in the neighborhood.

Additionally: How someone perceives a neighborhood, whether positive or negative, affects place-making will be researched. Place-making is essential for a built environment that is familiar and supports well-being for the residents (Williams, 2016). The contribution to happy ageing (Oerlemans, Bakker and Veenhoven, 2011) also makes it worthwhile to quantify.

Helping to foster familiarity can be done by creating spaces that people appreciate. Therefore, data is needed to know what places people actually appreciate in Kanaleneiland and why. From this data general guidelines for familiarity can be deduced.

Data needed:

1. Data on whether and how the built environment is used for social activities (Primary data)
2. Data about what environmental cues and features appreciate, for example, ratings given to places (primary quantitative and qualitative)
3. Data on environmental cues and features, for example “highlights” of the neighborhood (qualitative primary data)

4 Activity and the built environment

The base of researching whether the built environment of an area supports or inhibits the activities of the elderly people is formed by looking at the different activity preferences they have. This is because it is important to know how people use a neighborhood before assessing the utility of the built environment. Through surveying and secondary data gathering information was elucidated on how those 55 years and older in Kanaleneiland and the Transwijk spend their time.

To research what the influence of the built environment is data were also gathered in a variety of ways. In the first survey, the routes the respondents take to frequently visited places are, what they considered highlight of the neighborhood and what problems they were dealing with in terms of the built environment. The second survey highlighted the five most problematic places in the Kanaleneiland area. This to pinpoint what the direct troubles were that people experienced with those places, while also getting a deeper insight into the opinions of the respondents on physical elements in the built environment. The most important divide in the influence the built environment has is the difference between accessibility and diversity. Therefore, the text on the influence of the built environment will be split up according to that division.

The population of Kanaleneiland and the Transwijk

To know what the area of Kanaleneiland and the Transwijk in terms of the kind of people that are its inhabitants one study the WijkWijzer Zuidwest (Gemeente Utrecht, 2019). It shows that about 24000 people live in the area and that around 50% has a non-migration background. This means that buildings like mosques can play a role as places for social activities. Compared to the rest of Utrecht the average income, livability score and educational level is lower in Kanaleneiland and the Transwijk. The percentage of elderly people (55+) and of single-person households equals the rest of Utrecht. The data shows that the demographic makeup of the neighborhoods isn't that dissimilar from the rest of Utrecht, except for the percentage of residents with a migrant background, which is significantly higher. The socioeconomic situation in the neighborhood is also relatively poor. This is due to the low-income level and low employment rate.

Results surveying

In this part of the chapter all the basic results of the two surveys are covered. The tables below contain the survey metadata.

First survey – Response data	
Number of respondents	77
Number of people who viewed the survey	664
Response ratio	11.44%
Number of map responses (geographical data)	352
Number of people that filled out at least 95% of the questions	32
Dropout rate	59%
Average amount of time needed to finish survey	12 minutes

Table 1: Response data of the first survey

As we see in the first table the dropout rate of the survey was relatively high. This could be attributed to the length of the survey, which was very long due to the large amount of map response questions in the survey. Because of this high dropout rate the second survey was designed to be shorter and a "prize", which was a ten-euro gift card for a web shop, was offered to incentivize completely filling out the second survey.

Second survey – Response data	
Number of respondents	167
Amount of people who viewed the survey	1687
Response ratio	10.11%
Amount of people that filled out at least 95% of the questions	62
Dropout rate	63%
Average amount of time needed to finish survey	4 minutes

Table 2: Response data of the second survey

More respondents filled out the questions of the second survey. However, the dropout rate was higher. It is assumed that this is the case because the survey was shared using more general platforms, like Facebook. As people are not personally targeted to fill out the survey the incentive to finish the survey is lower. The “prize” did not help in reducing the dropout rate, but it is possible that it generated more interest for the survey.

In terms of geographical spread the surveys were highly representative. Only people from the area were asked to fill out the surveys and people from all over the area responded.

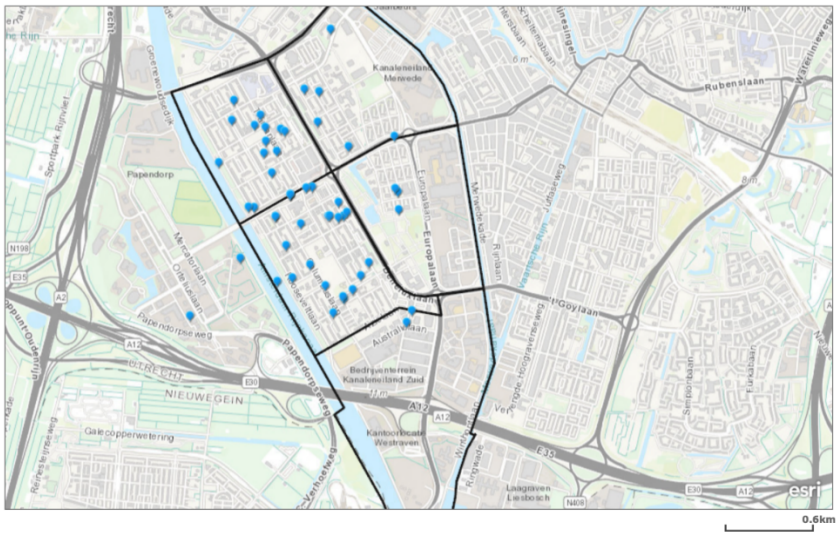

Figure 5: Map showing where respondents live (blue marker = home) (N=53)

The southern part of the Kanaleneiland neighborhood seems to be underrepresented. This is explained by the fact that the southern part of Kanaleneiland is an office park.
When it comes to the representativeness of the survey in terms demography the results show that there are caveats. People with a higher educational attainment seem to be overrepresented. Reaching lower educated residents of the neighborhood has proven to be difficult, although the targeted Facebook ads did help.

Age distribution	Actual (%)	First Survey (%)	Second Survey (%)
55 and younger	85.2%	41.9%	49.2%
55-64	7.1%	37.2%	25.8%
65-74	7.7%	16.2%	18.9%
75 and older		4.7%	6.1%

Table 3: Age representation (N=43 and N=132)

Distribution in educational attainment	Actual (%)	First survey (%)	Second survey (%)
No education	55%	0%	1.9%
Primary or secondary		41%	47.2%
Tertiary or higher	45%	59%	50.9%

Table 4: Representation in terms of educational attainment (N=25 and N=53)

Distribution in household size	Actual (%)	First survey (%)	Second survey (%)
One person no children	49.4%	36%	36.4%
One person with children	7.8%	0%	9.8%
Two people household no children	20%	44%	32.6%
Two people household with children	22.8%	20%	21.2%

Table 5: Representation in terms of household size (N=14 and N=132)

Older residents are also overrepresented, but that was because they were the main population that was necessary to reach. All data for the actual numbers is from www.wistudata.nl (Gemeente Utrecht, 2020a) and connects to the part of the thesis explaining the population of Kanaleneiland. The pour socioeconomic situation in the area explains the high percentage of people with no or little education.

The connection between the survey and the Tijdbestedingsonderzoek

To answer this sub question people were asked how they spend their time in the first survey. Respondents needed to fill out a basic schedule for a normal day and what was a special day for them. Respondents had to "self-identify" their special day. A weekend day or a normal weekday could be a special day. This to make sure the connection was made to the Tijdbestedingsonderzoek (de Boer et al., 2017) by the Sociaal en Cultureel Planbureau. As mentioned in the theoretical framework, this piece of research is undertaken every few years to get a deep understanding of how people of different age, educational and income groups fill in their days.

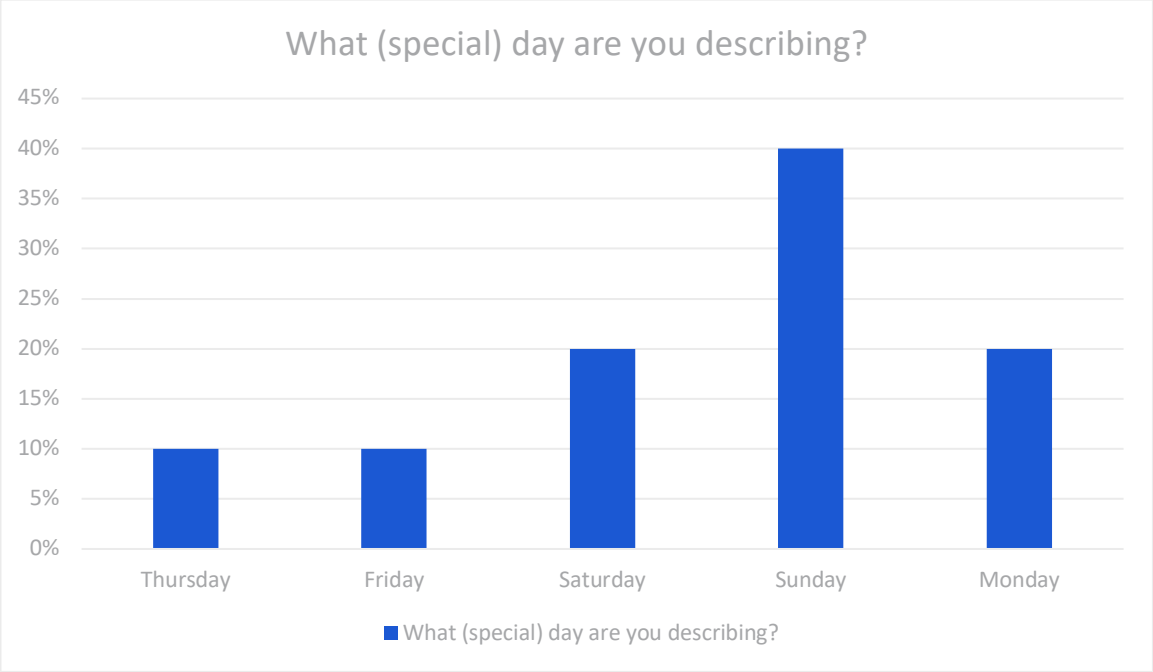

Figure 6: Answers to what the special day of the week is for respondents (N=23)

The basic schedule was structured using two-hour time blocks. Per two-hour time block people could choose from a set of activities that was transposed from the Tijdbesteding-sonderzoek (de Boer et al., 2017). The question was asked twice. Once for a normal day and once for a special day. A special day could be anything and the respondents were asked in an open question why this day was special to them. The general pattern in answers was that the normal day was a workday, and the special day was a weekend day according to the respondents. This also shows in how respondents filled out their schedules for those two days. Not many of the respondents answered the particular question. This because of the general length of the first survey and the fact that filling out the schedule actually takes quite some time. However, 23 respondents did answer the question. It means that the data can be used in a descriptive way only.

One of the survey respondents stated the reasoning for Sunday being his special day:

"It is my weekend and it is really nice and quiet in the neighborhood" (Resident of Kanaleneiland, first survey)

With the answers to the time schedule questions one can compare the time that the respondents spend to the data from the Tijdbestedingsonderzoek.

Figure 7: Graph showing what activities respondents partake in from 8 to 10 AM (used as an example, N=23)

Figure 7 shows an example of what people spend their time on from 8 to 10 AM on their mentioned special day. The categories of activities mostly equal the data from the Tijdbestedingsonderzoek (hereafter, TBO). Comparing the two statistics show that they are highly similar. According to the TBO people spend about 10% of their weekly hours on social activities, like volunteer work (de Boer et al., 2017). In the survey this percentage of time spent on volunteer work is similar. This means it is possible to assume that the TBO can be used as a source on the time usage. Because of the low response rate to the time schedule questions this is especially useful.

The TBO (de Boer et al., 2017) mentions that there are no significant differences in time usage between elderly people that have a high educational attainment and those that don't. Higher educated people are overrepresented in the survey data, but this doesn't change time usage. In the TBO there is a strong split between activities that are "inwardly focused" (household activities, free time at home) and "outwardly focused" activities (volunteer work, meeting friends). These outwardly focused activities play a big role in the hierarchy of activities (Maslow, 1943).

Outwardly focused activities that start to play a bigger role when people approach their retirement age. Retired people spend significantly more time on volunteer work and social activities compared to other groups. For active ageing (Active Ageing Australia, 2019) social activities are especially important. To see what the locations are of the places people in Kanaleneiland and the Transwijk are, people were asked to pinpoint what their frequently visited places are on the map. A total of 138 frequently visited places were projected on the map. The central shopping center shows up as being the most visited place in the area.

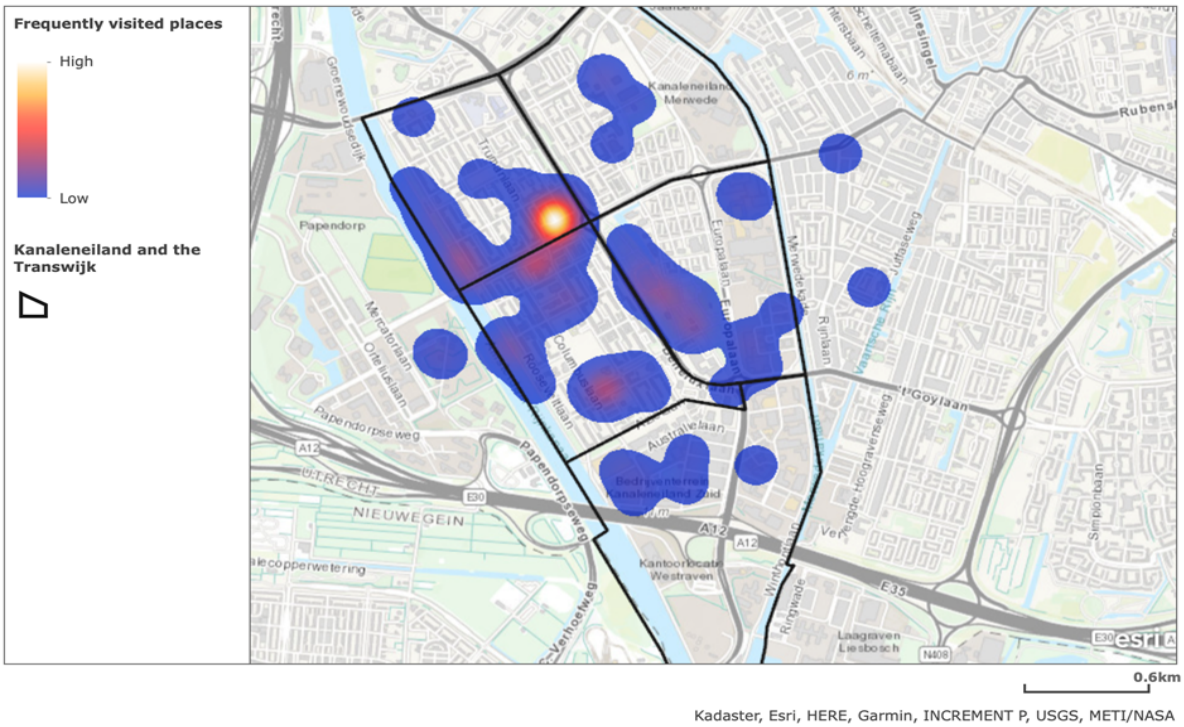

Figure 8: Heatmap showing the frequently visited locations (N=138)

After pinpointing the place on the map respondents were asked to give a score from 1 to 10 to the place and choose out of four categories what kind of place it was.

Report

This place gets the following mark from me:

This place is a:	Mean	N	Std. Deviation
Shop	7.56	50	1.215
Place for social contact inside (or work)	8.80	10	.919
Place for social contact outside	8.09	22	1.601
Place for physical activity	8.14	14	.770
Total	7.90	96	1.285

Table 7: Mean score per category of location (N=96)

As visible in figure 8 and table 7 people were mostly content with the frequently visited places in the neighborhood. Respondents attached higher scores to places for social contact inside and outside, combined with higher scores for places for physical activity. Shops were highly valued too but received lower marks. This means that people attach a higher value to the frequently visited places that are not absolute necessities to visit (shops are necessary for getting food).

The amount of services people mentioned shows a connection with the typology of the neighborhood. According to a 2006 governmental research paper called *Hoe Breed is de Buurt* (How Comprehensive is the Neighborhood) Kanaleneiland is supposed to be a modern inner-city neighborhood with many different kinds of services (Ministerie van VROM, 2006).

Analyzing how to categorize the different activities people partake in and which places people frequently go to it is possible to divide the activities in the ones that use the built environment as a route towards the activity and the ones that actually use the built environment for the activity.

Activities that use the built environment as a route	**Activities that use the built environment as a place of activity**
• Going to (volunteer/paid) work	• Getting physical activity outside
• Meeting social contacts inside	• Meeting social contacts outside
• Getting household items	
• Getting physical activity inside	

Table 8: Kinds of activities divided up according to usage of built environment

The first set of activities depends on the *accessibility* of the built environment. If someone can't get to an activity because of poor accessibility that person stays at home. The second set of activities depends on the *diversity* of the built environment. For someone to be able perform these activities in the built environment there need to be possibilities to do it and the built environment needs to be inviting enough to convince people to go outside.

The influence of the built environment

Now that the different kinds of activities are categorized it is important to study where the built environment plays a role. This is also the subject of the second sub-question, which is: *How does the built environment impact these activity preferences?*

To answer this question data was gathered in multiple ways. In the first survey, the routes the respondents take to frequently visited places are, what they thought was the highlight of the neighborhood and what problems they were dealing with in terms the built environment. The second survey highlighted the five most problematic places in the Kanaleneiland area. This to pinpoint what were the direct troubles that people had with those places, while also getting a deeper insight into the opinions of the respondents on physical elements in the built environment.

Diversity

For diversity to have an impact the built environment needs to be inviting and have enough social activities. In the survey, this was referenced by the question on the highlights in the neighborhood and the open questions concerning what people liked the most about their frequently visited places.

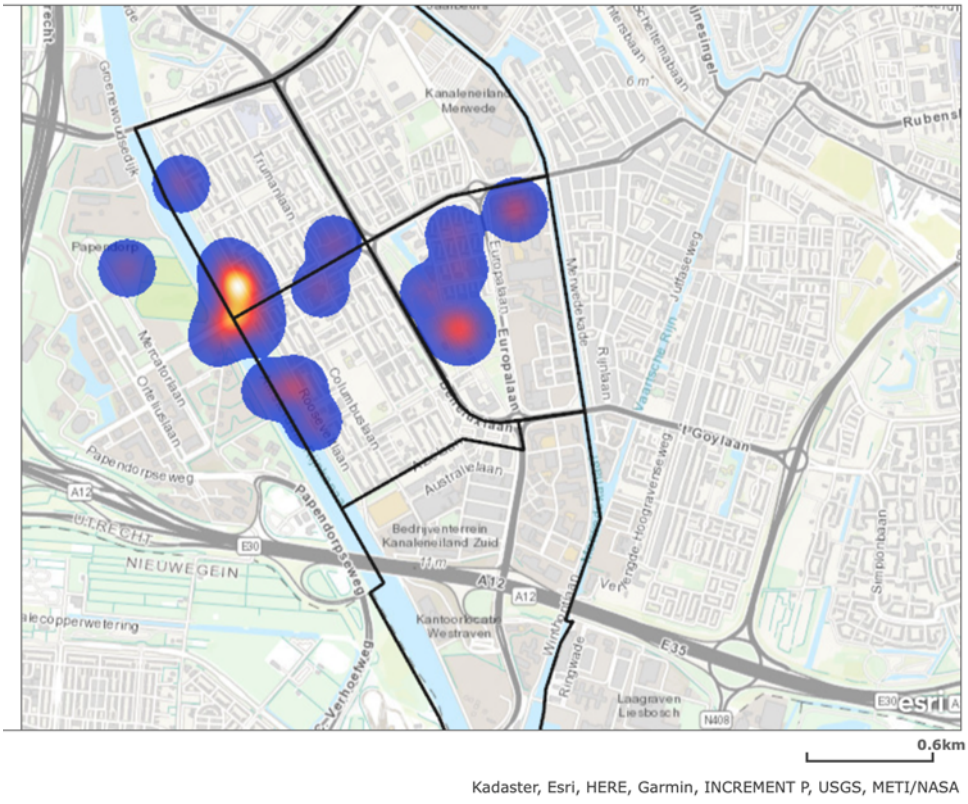

Figure 9: Heatmap of highlights in the area according to respondents.

The heatmap shows that most of the respondents decided that the park near Transwijk and the Prins Clausbrug were highlights to them. The respondents were asked why these locations were highlights. They stated that the design, green space and the fact that people come together at these places made them choose these locations. These highlights are very important for the distinctiveness of a neighborhood and can help facilitate activities. They are considered to be the places that make a neighborhood special and help the familiarity. People like it when there are highlights in a neighborhood and connect maximum utility to them (Philips, 2012).

The open questions on what respondents liked the most about their frequently visited places were coded using NVivo and show a similar pattern:

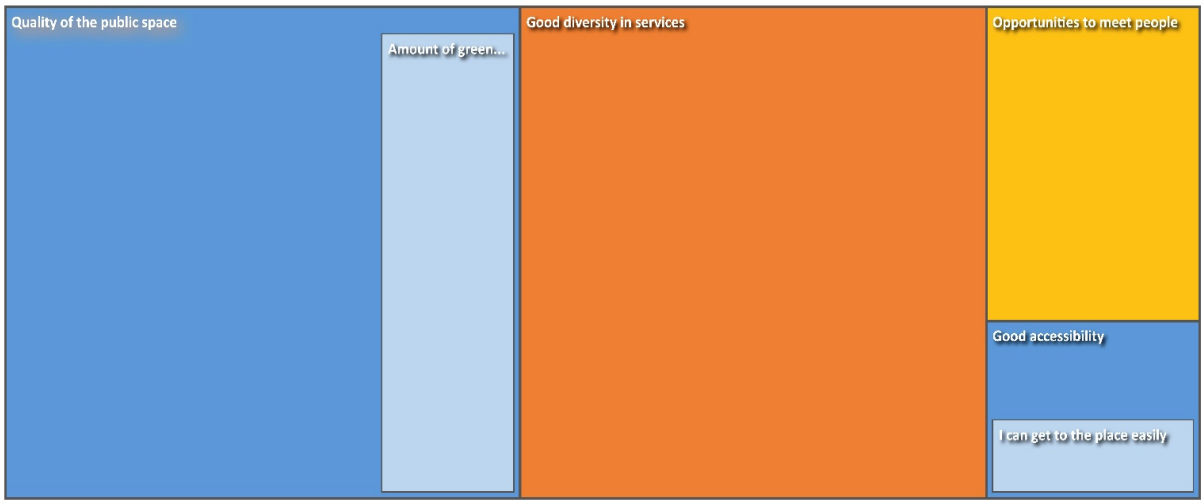

Figure 5: Amount of responses per "theme" (N=123)

People mention the quality of the public space and the good diversity in services as being the most important things when talking about why they like their frequently visited places. The amount of green space is important for the quality of the public space and people mentioned it often. The social aspects of diversity also play a role, as people like places because of the fact that there is an opportunity to meet people. This is even more important for elderly people, as the neighborhood as a space for social interactions becomes more important as one ages according to Worpole and Knox (2008).

It contrasts to what people filled in as being the thing they liked the least about the frequently visited places:

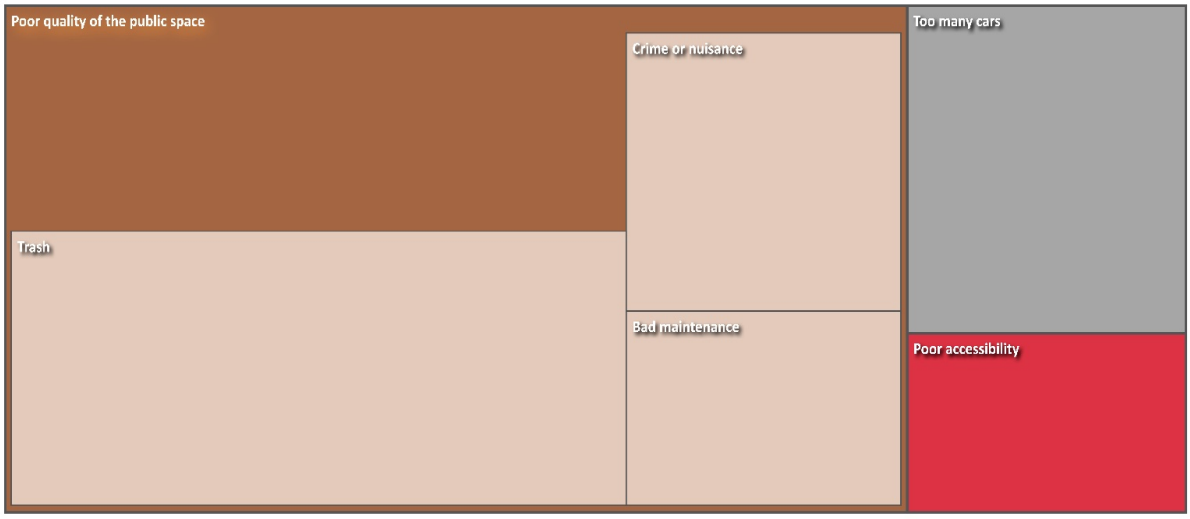

Figure 6: Amount of responses per "theme" (N=72)

It shows that to not negatively impact the activities by people the area needs to be distinctive (there need to be highlights, there needs to be green space), have opportunities for social contacts and needs to be of a high quality. Certain societal aspects like crime and nuisance also play a role. Trash in the built environment, for example near a street is a strong Important to note here is that both crime and nuisance can affect a feeling of security, so they are both placed in the same category.

Accessibility

A very important factor in the facilitating of activities by residents that are 55 years older is the accessibility of a neighborhood. For proper understanding of this, multiple questions were asked. First, people were asked to draw the routes to their frequently visited places on the map and they were asked what kind of public space problems they deal with *en route*. Together, this can form a picture on what the influence of the built environment is when it comes to activities that use the built environment as a route.

In the map show the locations of where respondents live below the brown thumbtacks. The heatmap shows the frequently visited places and the blue and red lines show the routes people take to these places. Blue is for a route taken by bike and red for a route taken by foot.

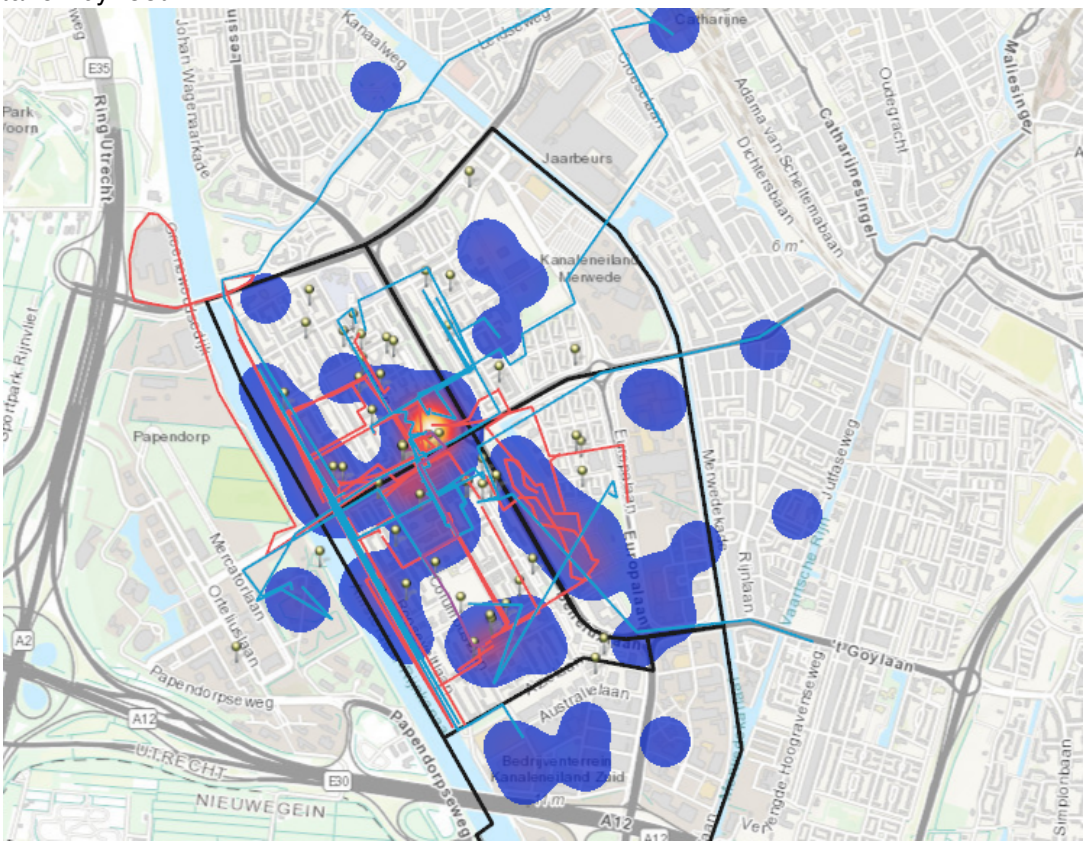

Figure 6: Routes taken, and places visited

The map shows that the places people visit, and the routes people take are mostly within the neighborhood and taken by foot or by bike. There is no difference in modal choice between age groups. This focus on the neighborhood means that for most residents the quality of the built environment of Kanaleneiland and the Transwijk is an important factor. This means that there needs to be a focus on the factors impacting these healthier modal choices.

Mode of transport	*N=65*
By foot	60%
By car	3.1%
By bike	33.8%
Using mobility assistance	3.1%

Table 9: Modal choices

The next part concerns problems people have while on the way to their frequently visited places. 39 problems *en route* were mentioned. There were hotspots of problems. These are the places that most people mentioned as inhibiting their route towards their frequently visited places.

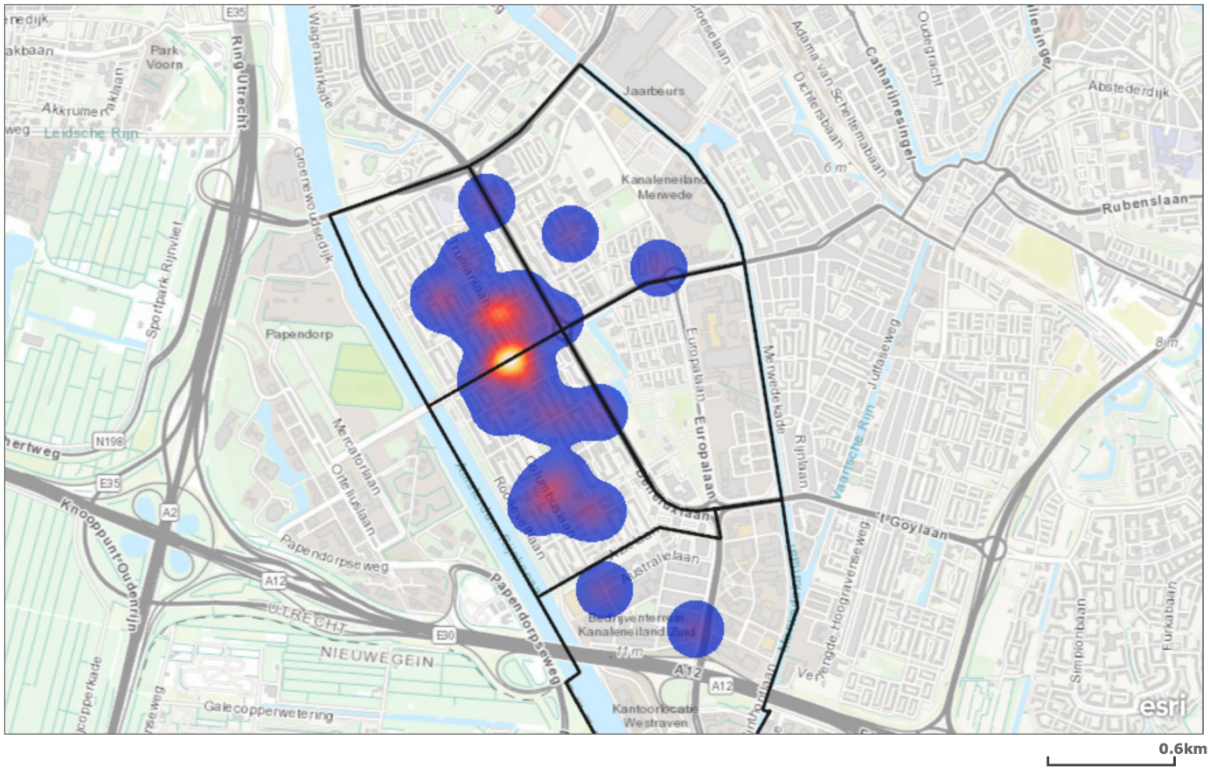

Figure 7: A heatmap of the problems en route mentioned (N=39)

Five locations were mentioned as being the most problematic. This was due to reasons relating to accessibility. To get a deeper understanding of what the problems concerning accessibility were the second survey was designed. The second survey asked questions on whether respondents thought the locations were accessible. The questions were based on the complaints from the first survey results.

- Two locations were intersections, so respondents were asked whether they thought they felt safe when crossing the road and whether they thought the intersections were clearly designed
- One location was a busy street, so respondents were asked whether they felt safe crossing the road and whether they liked walking there
- One location was a location near the main shopping center in the center of the neighborhood, so respondents were asked whether they felt safe crossing the road
- One location was near the southern shopping center, where the complaints were based around the number of cars and resting places, so respondents were asked whether they thought there was enough space for them and whether there were enough benches

The results for the first two locations show that people generally think that the two intersections are not that unsafe to cross, although there is a significant difference in feelings of safety between the first and second location ($p=<0.001$). This can be attributed to the fact that respondents feel that the second intersection is more clearly designed.

"When I cross the road, I feel safe."	
 *The intersection at the Churchilllaan*	 *The intersection at the 5 Mei Plein*
Location 1 - $\bar{x}$ = 5.85/10, s = 2.39, N = 82	Location 2 - $\bar{x}$ = 7.03/10, s = 2.17, N = 69
"I think the intersection is clearly designed"	
Location 2 - $\bar{x}$ = 5.59/10, s = 2.74, N = 82	Location 2 – $\bar{x}$ = 7.19/10 s = 2.205, N = 69

Table 10: Results first two locations

When comparing the two locations there seems to be no clear difference in feeling of safety between age groups (for the first location p=0.261 and for the second location p=0.542), people with different educational attainments (p=0.445 and p=0.128) and different kinds of household. One clear exception is that there is a significant difference between groups in feelings of safety between the kinds of household (p=0.038), which is based on the result that two person households with children seem to feel less safe when intersection the road at the first location. Testing this it was possible to see that there is a significant difference in feelings of safety between two person households with children and two person households without children (p=0.029). The presence of children in a household therefore seems to impact the feeling of safety when intersection these two locations. Whether respondents thought the intersections were clearly designed does not show difference when comparing age groups (p=0.510 and p=0.520), educational attainment groups (p=0.069 and p=0.128) and the different kinds of household (p=0.434 and p=0.714).

One respondent mentioned the following about the second location:

"There needs to be more time for walking traffic to cross. With a wheelchair I can hardly make it to the other side" (Resident Kanaleneiland, second survey)

Following the questions about the first two locations the third location analyzed. Complaints about this location concerned the number of benches and how clear the public space was designed. Therefore, the questions for the third location focused on these physical factors. The results (table 11) show that respondents thought that the location was troublesome in terms of public space. The average mark for the location, based on the two questions hovers around 5 out of 10.

See other side

The intersection at the Bernadette/Trumanlaan

“There are enough resting (benches) places at this location”
$\bar{x}$ = 4.97/10, s = 2.257, N = 65
“I think this location is clearly designed”
$\bar{x}$ = 5.25/10, s = 2.285, N = 65

Table 11: Results for the third location

There was no significant difference in marks given per age group (p=0.200), educational attainment groups (p=0.173) and different households (p=0.353) for the question concerning the number of benches. It would be likely that older residents would give lower marks to the number of benches, as they need more mobility support, but there is no significant difference found. Concerning the clarity of the design: There is a significant difference in opinions between different educational attainment groups (p=0.015). This is due to higher educated people giving lower marks on average.

The fourth most mentioned location in the first survey showed respondents experienced a lot of problems with there being too much traffic and the traffic speed being too high. This is why the questioning for the fourth location focused on how the location facilitates walking and whether respondents felt safe crossing the road. The average marks show that the respondents think the facilitation of walking and the safety is quite poor.

The Columbuslaan near the Herman Brood Academie

“I like walking here”
$\bar{x}$ = 5.73/10, s = 2.230, N = 63
“When I cross the road I feel safe”
$\bar{x}$ = 5.57/10, s = 2.146, N = 63

Table 12: Results for the fourth location

The results seem to show no significant difference between age groups in their valuations in terms of how they like walking at the location (p=0.770) and whether they felt safe crossing the road (p=0.918). There was also no significant difference in perception between the different kinds of household (p=0.546 and p=0.311). The clearest split between different demographic groups is in education attainment level and the answers to the two questions. More highly educated people liked walking at the location less (p=0.003) compared to those that had no (or little) education. The perception of safety when crossing was also significantly different (p=0.005). Why this is the case has not been researched, but the worse marks could point to social factors playing a role or higher educated people being more opinionated. Feelings of safety when crossing and liking walking at the fourth

location are strongly positively correlated (r=0.774 and p= <0.001). This shows that safety is an important factor in how much a location is appreciated.

The final location was one that was quite different from the other locations mentioned by respondents in the first survey. Issues focused on parking and how cluttered the area was. Therefore, the questions focused on these two issues. The marks given here were the worst of all. The average mark hovers around a 4.2/10, which indicates that people think that the location is troublesome and needs to be improved.


Vasco de Gamalaan near de Lidl
"I think this location is uncluttered"
$\bar{x}$ = 4.37/10, s = 2.278, N = 62
"I think there is enough space for cyclists or walking traffic"
$\bar{x}$ = 4.11/10, s = 2.262, N = 62

Table 13: Results for the fifth location

Analyzing the results based on background variables shows some interesting patterns. Both educational attainment and age shows a poor negative correlation to the mark given. There also seems to be no significant difference in terms of perception between the different age groups (p=0.755) and household groups (p=0.382). However, educational attainment plays a significant role (p=0.001). The correlation between educational attainment level and the marks given is negative (r=-0.479) due to people with a higher educational attainment give lower marks.

The statistical analysis of the second survey showed no strong patterns in terms of marks given and age groups, which may mean that built environment familiarity is important for all age groups. Adding to this, respondents with a higher educational attainment tend to assign lower marks. Why this is the case has not become clear yet. However, to get more data respondents were also asked qualitative questions. These qualitative data shed a better light on what the reasoning for some respondents was and what the factors for built environment familiarity are.

In the second survey respondents were also asked how they would personally improve the most problematic places. Using NVivo (a tool for qualitative data analysis), these answers have been coded to show patterns in which physical elements respondents care about. This kind of language analysis is especially helpful when dealing with a large dataset of open answers.

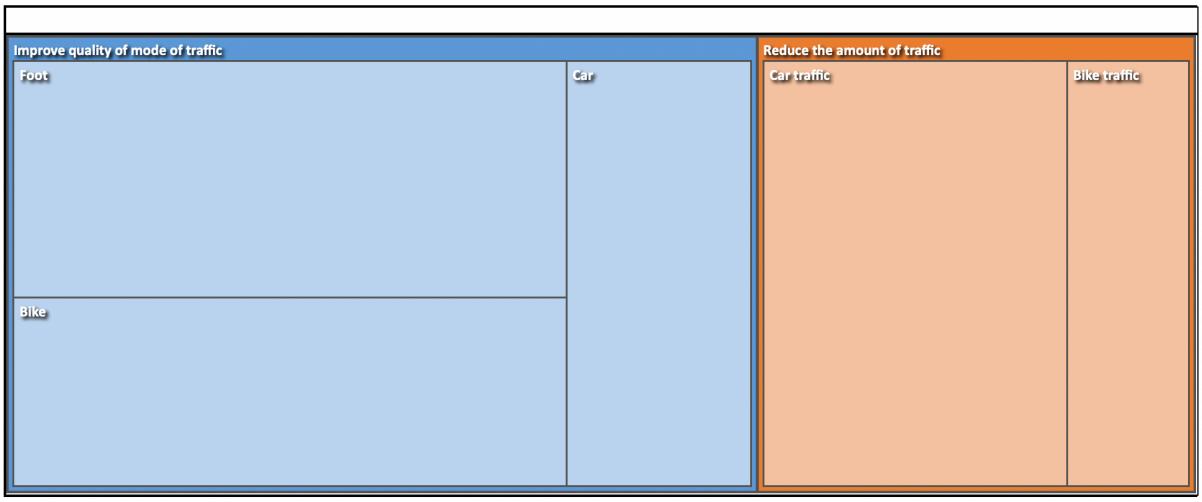

Figure 8: Mentioned changes needed (N=87)

The figure is split in two parts. The orange part shows the answers that respondents gave in terms of reducing a traffic mode and the blue part shows the answers that were focused on improving the mode of traffic. The coded answers show that the answers focus on the reduction of car traffic and improving the possibilities for foot and bike traffic. This connects to the results of the first survey, as the modal choices were focused around biking and walking. Some respondents mentioned improving the quality of car traffic, because there was considered to be a lack of parking bays.

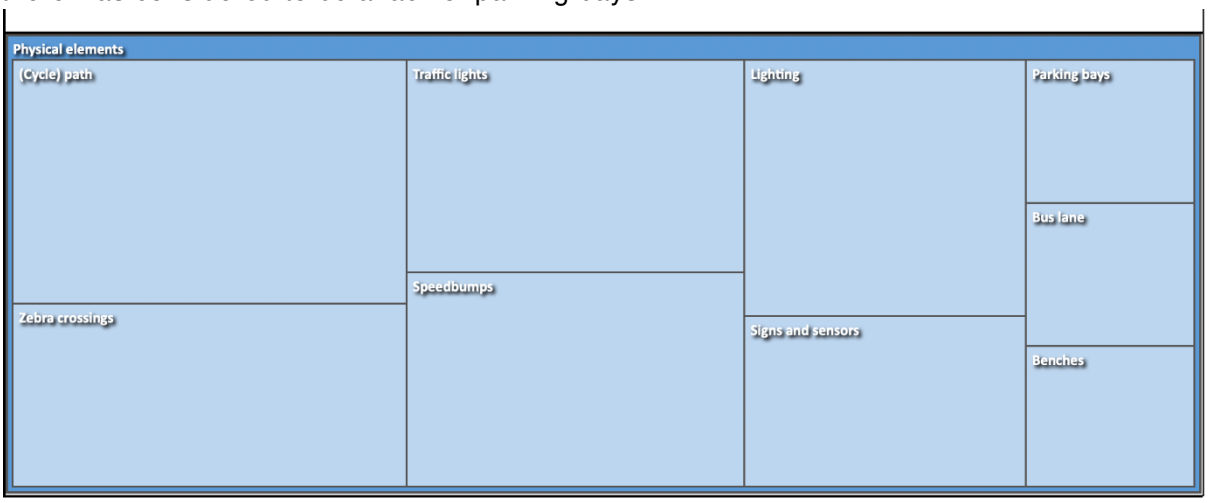

Figure 9: Mentioned needed physical elements (N=102)

Respondents called on adding or improving a lot of different kinds of physical elements in the built environment, as is visible in figure 9. Adding zebra crossings, traffic lights and improved (cycle) paths were considered to be very important.

The CROW Accessibility handbook also mentions these factors, saying that especially for older people the built environment needs to be very accessible. However, the CROW Accessibility handbook (CROW, 2017) does not mention factors like improving physical elements that other users of the built environment need or the influence of other traffic flows on the perceived accessibility of the neighborhood. All factors and physical elements are just focused on improving the experience of the less accessible, without accounting for the fact that other traffic flows can seriously hamper it. This means that things like traffic lights, speedbumps and parking bays should play a role in measuring the accessibility of the neighborhood for elderly people. An example could be that an accessible crossing is not safe at all without enough measures to slow other traffic down.

5 Measuring familiarity

The last few chapters covered the measurement of the built environment familiarity of a neighborhood, the study of activities undertaken by the residents and what role the built environment plays in it. With the data on and by residents a decision on what should be covered by a built environment familiarity GIS-model can be designed and constructed. This is the purpose of this chapter. The first part will cover which variables are important and can properly be integrated in a GIS-model and the second part covers the creation of the GIS-model and how it measures the built environment familiarity.

Which variables are important?

During the two surveys respondents mentioned what they thought was important in terms of the diversity and accessibility of the built environment of Kanaleneiland and the Transwijk. Using open questions and by letting respondents valuate the places that they visit often we get oversight on what is important for the residents. By doing this, all the different factors concerning diversity and accessibility mentioned by the residents were aggregated into the tables below. The source for the factors in this tables is the answers to the open questions in both the first and second survey. An important thing to note is that the tables also show whether the factor could be quantified and whether primary or secondary data on it is available. Quantification means whether a rule or a formula could be designed on whether the design/amount/quality of the factor is sufficient. The factors that are both quantifiable and have external data available are in bold and italics.

Factor	**Quantifiable / Data available**
Shopping opportunities	***Yes / Yes***
Green space	***Yes / Yes***
Areas and points considered "pretty"	***Yes / Yes***
Places for social activities	***Yes / Yes***
Crime	***Yes / Yes***
Trash	Yes / No
Bad maintenance	Yes / No

Table 14: Mentioned factors impacting diversity

Multiple factors are covered by the fact that primary data has been gathered on these factors. The reasoning behind this data gathering is that the theory showed that these things played a role in terms of the diversity of the area. The factors are ranked according to how often they were mentioned. Pretty or unique areas were considered to be a factor, for example, by Baragwanath (1997). Two factors are not considered to be workable when it comes to integrating them into the GIS-model, because there is no trustworthy open data on the amount of bad maintenance and trash in the Kanaleneiland and Transwijk area. The data is online, because the council of Utrecht has a website for complaints (Gemeente Utrecht, 2020b), but it is not open for the public.

See other side

Factor	Quantifiable / Data available
(Bike / Car / Foot) traffic	Yes / No
Traffic lights	Yes / No
Speedbumps	***Yes / Yes***
Parking bays	No / Yes
Signage	No / Yes
Street lighting	***Yes / Yes***
Cycle paths	No / Yes
Zebra crossings	Yes / No
Resting places	***Yes / Yes***
Street intersections	***Yes / Yes***
Public transport stops	***Yes / Yes***

Table 15: Mentioned factors impacting accessibility

The second survey covered matters concerning the accessibility of the built environment of Kanaleneiland and the Transwijk. By letting respondents think of solutions to built environment problems factors that they considered to be important could be deduced. The factors are ordered according to how often they were mentioned. The factor of public transport stops was not mentioned specifically but is called important by the CROW accessibility handbook (2017), so it was added. Around half of them were not quantifiable or had no available data. Data on the factors of signage, parking bays and cycle paths is available due to the fact that the Gemeente Utrecht supplied a large dataset of built environment physical elements after querying for this, but how and to what extent these factors play a role is not quantifiable without factor-specific research.

The GIS-Model

The base of the GIS-model is formed by the CBS *vierkantstatistieken* (CBS, 2019). This is a grid of 100 by 100 blocks that contain data on the demographic makeup of the grid block, how close it is to certain features and other data on the composition of the area. Because it contains demographic data it is an ideal layer to add data to. Annex I contains a map showing the composition of the CBS *vierkantstatistieken* layer. The flowchart below shows the two steps to constructing the map.

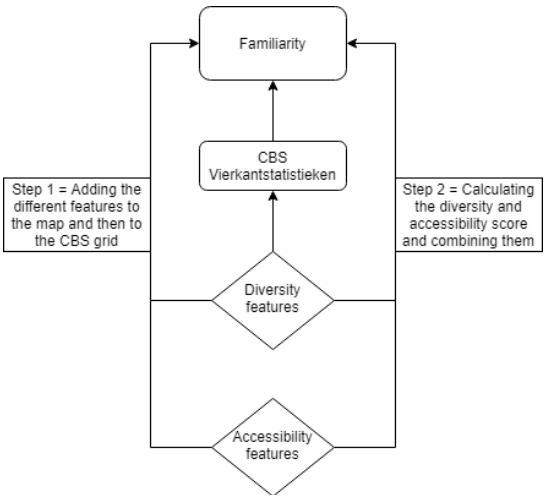

Figure 10: Flowchart on the GIS-model

The first step consists of adding all the actual features to the map as two different group layers (one for diversity, one for accessibility). The measure of diversity concerns all the factors on the built environment as a place for activities and accessibility and all the factors that concern the built environment as a route towards activities. Measurements summarizing the variables are then added to the different grid blocks

Using the factors that were mentioned by people a basic measurement model could be created. The table below shows how the different factors, or elements, were quantified and measured. All the different elements are aggregated into an ArcGIS-map.

Diversity		
Element	*How it is measured*	*Data source used*
Distance to social activities	• Distance to mentioned places for social activities from the first survey	• Data first survey
The distance to and the amount of green space	• Measured with secondary data • Density of green space and distance to a park (at least 0.5 hectares of green space)	• Basisregistratie Grootschalige Topografie (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2019)
Distance to a "highlight"	• Distance to a mentioned "highlight" of the neighborhood	• Data first survey
The amount of crime	• No direct data on crime • Building vacancy rate used as a placeholder, as it has a direct connection with the amount of crime in an area (Cui and Walsh, 2015)	• CBS *Vierkantstatistieken* (CBS, 2019)
Distance to shops	• Distance to nearest shop	• Data first survey
Coverage service area of a shopping center	• Whether a part of the neighborhood is covered by the service area of the biggest "shopping centers"	• Data first survey

Table 16: How the diversity factors are measured

These elements are then bundled into an ArcGIS-map and joined by all the different accessibility elements. The problems *en route* for respondents were added as a factor.

Accessibility		
Element	*How it is measured*	*Data source used*
Benches	• Amount of benches	• Straatmeubilair gemeente Utrecht
Lighting	• Number of streetlamps in area	• Straatmeubilair gemeente Utrecht
Intersections and crossinf	• Amount and size of crossings/intersections	• Basisregistratie Grootschalige Topografie (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2019)
Public transport stops	• Distance to stops	• Haltestops Gemeente Utrecht
Problems *en route*	• Amount of problems *en route*	• Data first survey

Table 17: How the accessibility factors are measured

Next, all elements are added to the map. Three group layers were used. One for the CBS *vierkantstatistieken*, one for the accessibility factor related data and one for diversity factor related data. The data consists of points showing the locations of different features, polygons showing the locations and size of features and points derived from the original data.

Secondary data was adapted to make sure it is fit for purpose in the GIS-model. The data showing the lampposts and resting places (benches) was derived from the dataset from the Gemeente Utrecht that contained all physical elements points related to the built environment. For the intersections and crossings feature data was taken from the *Basisregistratie Grootschalige Topografie* (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2019) and adapted. To decide what could be considered parks in the area the green space areas larger than 0.5 hectares were adapted to be points on the map showing the locations of the larger green space features, meaning parks.

In the first survey the Nova shopping area (in the center of Kanaleneiland) and the shopping center near the Vasco de Gamalaan were mentioned most frequent as areas people use to shop and have the biggest diversity of shops. To design the service area of the Nova and Vasco de Gamalaan the a convex was drawn around the different routes people drew in the first survey.

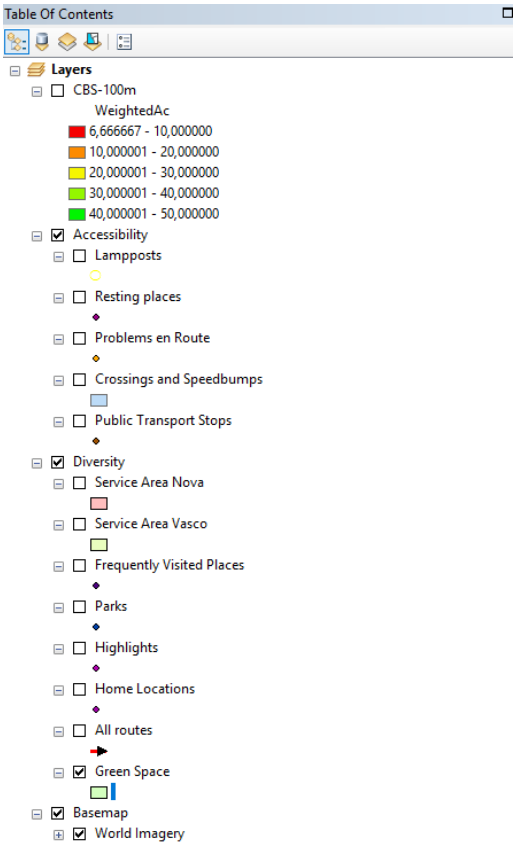

Figure 11: Table of contents GIS-model

Figure 12: Service areas most frequently used shopping areas

The service areas overlap in the center of Kanaleneiland, but the map shows that there is a clear split between the two shopping areas. The Nova area mostly covers the northern part of Kanaleneiland, and the Vasco de Gama area mostly covers the southern part of Kanaleneiland.

After adding all the different elements to the map, they were joined to the CBS 100-meter grid using the measurement method as listed in table 16. Using the added variables and the variables already in the attribute table connected to the grid a built environment utility scoring model could be created. Full built environment utility per grid block could be 100 points in total, 50 points for the diversity factors and 50 points for the accessibility factors. If the total utility was more than 50 points the utility is positive, and activities are facilitated. As, due to lower response rates caused by the Covid-19 crisis, a spatial variance analysis calculating how much the different factors play a role in terms of utility was not possible. Therefore, it is assumed at first that every factor has the same effect on built environment utility.

For the scoring model the accessibility handbook by (CROW, 2017) was used, because it mentions the maximum walking distance for most services being 500 meters for elderly people and 800 meters for those that are younger than 55. Table 18 shows the scoring model for the accessibility factors.

Diversity	**55+ (50 points)**	**55- (50 points)**
Places social activities (500m - 800m)	Yes=8 No=0	Yes=8 No=0
Parks (0.5ha) (500m - 800m)	Yes=8 No=0	Yes=8 No=0
Green space density Average density per grid block= 15.44%	Above average=4 Below average=0	Above average=4 Below average=0
Highlights (500m - 800m)	Yes=10 No=0	Yes=10 No=0
Shops (500m - 800m)	Yes=4 No=0	Yes=4 No=0
In service area Nova and Vasco	Yes=6 No=0	Yes=6 No=0
Crime (Vacancy rate) Average vacancy rate per grid block = 0	Below average=10 Above average=0	Below average=10 Above average=0

Table 18: Scoring model diversity factors

A few changes were made from the baseline scenario that every factor could receive ten points and all the factors combined could add up to fifty points in total. The score for places for social activities and parks is a maximum of 8, as table 7 shows the residents of the area giving those categories of locations that score. The density of green space can score only 4 points, because this was not mentioned very often as being a factor of

big importance. The service area and shops factors combine to a maximum of ten points, with the service area factor being the most important, as the diversity of shopping facilities was mentioned as being important.

Accessibility	**55+ (50 points)**	**55- (50 points)**
Number of Benches in grid block area Average number of benches per grid block area= 18.078	Below average=0 Above average=10	Below average=0 Above average=10
Number of streetlamps in grid block area Average number of streetlamps per grid block area= 13.39	Below average=0 Above average=10	Below average=0 Above average=10
Intersections and crossings area in square meters in grid block area Average area per grid block= 371.34 m2	Below average=10 Above average=0	Below average=10 Above average=0
Problems en route within 200 meters Average problems en route within 200 meters= 3.67	Below average=10 Above aveage=0	Below average=10 Above average=0
Public transport stops (500m - 800m)	Yes= 10 No=0	Yes=10 No=0

Table 19: Scoring model accessibility factors

For the accessibility factors it was decided to keep the baseline model of every factor being of equal importance. For every factor that required an average to be calculated this was done by seeing what the average amount per grid block was after joining the factors to the grid block area.

Figure 13: How the scoring model works

Using formulas in Microsoft Excel, the different scores were calculated using a multicriteria additive model. This means adding up the score per factor to reach a total per group. After this the scores were weighed using the demographic variables in the *vierkantstatistieken*. This meant that if there were more elderly people in a grid block the score for those that are 55 years and older would become of more importance and if there were more people younger than 55 in a grid block the score for those that are younger than 55 would be more important.

An example would be that 20% of residents in a grid block are younger than 55 and 80% older than 55 and the accessibility score in the grid block for people 55 years and younger is 38, while the score for people 55 years and older is 24. The weighed score would be:

38 multiplied by 0.2 + 24 multiplied by 0.8 = 26.8

What the GIS-model shows

After calculation the data was added back to ArcMap and then visualized to show what the scores are on a map. Figure 13 shows the unweighed familiarity score for elderly people per grid block.

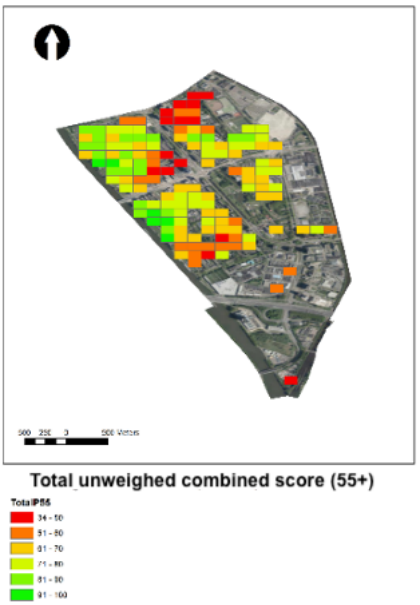

Figure 14: Total familiarity score for elderly people

The map shows that in general the built environment familiarity for the elderly can be considered good in large parts of Kanaleneiland and the Transwijk. However, the area around the Nova shopping center and the northeastern part of the Transwijk scores especially poor. For the area around the Nova shopping center (center area of Kanaleneiland) the accessibility score of the area is low. The fact that the area is popular and highly accessible by car impacts the healthy modal choices of walking and cycling. The low score is because of the large amount of problems in the area and the low number of resting places. The northeastern part of the Transwijk has a poor suitability because the diversity score is low because of the fact that is far away from the central shopping areas and the parks in the neighborhood.

Figures 15 and 16: Weighed accessibility and diversity scores

After adding weighing for demographic variables per grid block the scores change slightly, as shown in figures 15 and 16. For the total population the diversity score is very good in the entirety of Kanaleneiland and the Transwijk, except the southern tip and the north-eastern part of the Transwijk. This because large parts of Kanaleneiland and the Transwijk are within a walkable distance of shops, there are parks available and the area is close to many neighborhood 'highlights'. As mentioned before, the northeastern and the southern parts scores worse. These areas are farther away from services and could be actually using services in different neighborhoods. When looking at the weighed accessibility scores the center area of Kanaleneiland scores poorly. The locations mentioned as being most problematic were almost all in the center of Kanaleneiland and this is reflected in the accessibility score. This poor score is due to the number of problems in the center of Kanaleneiland. Car traffic is impacting on the other modes of traffic and the number of resting places is too low.

Figure 17: Weighed total combined familiarity score

When all the scores are combined and weighed according to the demographic makeup of the area the built environment utility is like shown in figure 16. In most of Kanaleneiland the combined public space suitability score is positive, but there are some areas that stand out as scoring quite poorly. Bad accessibility hampers the area around the Nova shopping center. This is connected to the accessibility problems that have been mentioned by residents in the first and second survey. The northeastern part of the Transwijk also scores poorly and as the grid block in the most northeastern tip is actually inhabited by 60 people that are elderly this seems like something that has to be researched further.

The created GIS-model that has been created shows that it is possible to objectively measure the built environment livability and built environment utility of a neighborhood Kanaleneiland for the residents aged 55 years or older. Quantifying factors that have been mentioned by the residents themselves as impacting their experience of the built environment makes sure that there is a certain amount of validation of the measurement model. The fact that the built environment livability has been connected to different grid blocks that contain demographic variables also means that it can be calculated for future situations.

6 Discussion

This research aimed to shine a light on the importance and assessment of built environment familiarity for people aged 55 years and older. The results indicated that it was possible to assess what the built environment familiarity of Kanaleneiland and the Transwijk is for elderly residents. Using data gathered from the actual residents of the neighborhood, diversity and accessibility impact factors could be deduced. Although the relation of these factors is not clear yet, it was possible to create an assessment model. This model generated insight into how the area scores in terms of built environment livability. The assessment can have an impact on the decision-making process for area revitalization, as it is now possible to see what areas have to be improved to create a universal good built environment familiarity to encourage positive health (Huber et al., 2011) of elderly neighborhood residents. The results are limited to the influence of the built environment and do not show what and where social groups for elderly people are, like a study by Hsu (2007) has done. The research demonstrated a number of other aspects, which mentioned in order of the relevant sub question:

First, the activity preferences of elderly people are different from people of working age. The case study area of Kanaleneiland and the Transwijk has higher poverty rates and the residents have a lower educational attainment level than usual in Utrecht. This could have an impact on their activity patterns and preferences. However, the difference in activity patterns and preferences between the different household groups in Kanaleneiland and the Transwijk is, compared to the rest of the country, actually very similar. Even though certain groups were overrepresented in the survey data it still showed that elderly people start partaking in more outwardly focused activities when they get older, like going outside for shopping, doing volunteer work and visiting friends. The *Tijdbestedingsonderzoek* (de Boer et al., 2017) mentions these changes too and the activity patterns of the respondents and the patterns mentioned in the SCP paper (2016) are highly similar. This means that this information is useful as a data source for future research, improving the generalizability of the topic. Most activities undertaken by people when they leave their house “node” (Hooimeijer, 2007) use the built environment as a route. However, the activities of “getting physical activity outside” and “meeting social contacts outside” use the built environment as a place of activity.

Second, the built environment plays an important role in facilitating residents’ activities. This adds to the current discourse on ageing in place, as mentioned by Sixsmith and Sixsmith (2008). It shows that not just the home is important for creating an age-proof living environment. According to the different researchers the built environment needed enough places for activities, which can be summarized under the term of “diversity”. Second, it was stated that the route towards activities needs to be suitable, which can be summarized under the term of “accessibility”. If both “accessibility and “diversity” are positive the role of the built environment is positive, and “familiarity” is created. Through gathering data in two surveys it was discovered that most frequently visited places of respondents living in Kanaleneiland and the Transwijk are in the neighborhood itself. When one reaches older age, the local neighborhood is very important, according to Worpole and Knox (2008) The modal choices of the respondents are also skewed towards biking and walking. The fact that the locations of frequently visited places connects to the modal choices. If the frequently visited locations would have not been in the neighborhood the car would become more prominent as a modal choice. The built environment needs to facilitate these modal choices so, like Sarkar and Webster (2017) said, it can incentivize healthy behavior by elderly people. Regular active travel can help (Cheng et al., 2019) the health and social participation pillars of active ageing (Active Ageing Australia, 2019). The research undertaken shows that the role of the built environment in active ageing is important.

This regular active travel means that places need to be within a walkable distance and need to be of a high quality. In Kanaleneiland and the Transwijk this seemed to be the case. A lot of the frequently visited places received high marks from the respondents. What respondent liked the most about their frequently visited places was the diversity in services, the opportunity to meet people and the amount of green space. Negative points were for example nuisance, trash and poor maintenance. This connects to the theory by

Baragwanath (2007) that a cluttered area can negatively impact the perception of a neighborhood.

Besides diversity, an important impact point for how the built environment influences activities is “accessibility”. The built environment should not only have good places for activities, but the route towards them should also be of a high enough quality. Philips (2012) also mentioned this and named it ‘the facilitation of mobility’. To get to know the opinion of people on the quality of the routes they took to their frequently visited places they were asked to name the problems they discovered while *en route*. Many respondents mentioned different problems in Kanaleneiland and the Transwijk, but five locations stood out as being the most problematic. To elucidate what the issues with these places exactly were respondents were asked their valuations of these locations and what they would see as solutions to improve the accessibility of the valuated place. The results demonstrated that things like a lack of resting places, lack of lighting and confusing signage made these locations less accessible. To improve this accessibility a variety of physical elements were mentioned, like resting places. This was also the case in the research by Yuen (2018), which placed focus on creating sittable spaces. Combined all diversity and accessibility factors mentioned by the respondents played a role on whether the built environment of Kanaleneiland facilitates activities for elderly people. When the sum of the diversity and accessibility factors is positive this creates familiarity, which means the built environment can be seen as a facilitator of activities.

Third, using citizen data on activity preferences and impact factors, the data were quantified and transformed to create a GIS-model assessing the built environment familiarity. A lack of secondary data or problems in quantifiability made some impact factors impossible to integrate in the GIS-assessment model. Using the factors that were possible to integrate a measurement model was created. The model indicated that some areas of Kanaleneiland and the Transwijk lacked built environment familiarity. The quantification was good enough to create a proper assessment, although it could be improved.

Future research could be focused on expanding the assessment. Using more substantial valuation of built environment elements by residents would enhance determination of what the specific impact of each factor is, to attain a more reliable assessment model. This means that it will be easier to pinpoint what exactly the issues are impacting the diversity or accessibility of a certain place. Using the demographic data that is within the CBS *vierkantstatistieken* grid (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2019) one can also extract predictions about the future built environment familiarity. An ageing neighborhood population could mean that the current state could change a lot. As demographic prognoses are not available on a small scale it would be necessary to use larger scale demographic data and create a simulation that makes sure the future demographic makeup can be reduced down to a grid level. A 2001 paper by Schotten et al. on what the future Dutch built environment looks like on a grid level shows that this is possible. The simulation could be designed using data on the typology of a grid block and assumptions on how likely one is to move to or stay in a certain house type.

The participation-based data gathering model also fills in a gap on how one should approach the assessment of service areas of neighborhood services. Using the routes drawn by respondents to neighborhood services one can visualize what the service area of a neighborhood service like a park is and how it is shaped without the need to make assumptions about the travel behavior of neighborhood residents. The same approach can be used for assessing how many people are affected by things like a problematic neighborhood intersection, as the routes drawn by residents correspond to the intersection “service area”.

7 Policy recommendations

The fact that it has been shown that it is possible to assess what the familiarity of the built environment for 55+ people has impact on the Dutch government policy of "ageing in place", which means that elderly people should age safe and happily in their own living environment. To enable this, changes are being made so that more homes specifically adapted for the elderly are being built (PBL, 2019). However, as the research has shown, the built environment also plays a big role. There should be a bigger focus on analyzing whether the built environment of neighborhoods is not an inhibitor for the activities of elderly people. The neighborhood should be accessible and diverse.

Assessment of future built environment familiarity for elderly people also can help councils help make decisions on what to improve to make sure the built environment is suitable and can carry the shock of the demographic shift of a rapidly ageing population. Proactive policy changes meant to improve the quality of the built environment need to focus on making sure shops, places for social activities and parks are within a walkable distance. Improving the accessibility is also important, as a higher number of resting places and a less car traffic means that elderly people can move around the neighborhood more easily. These solutions to the shock caused by population ageing need to be participation-based. That way it is possible to tailor the built environment to the needs and wants of the residents of the specific neighborhood. There is no one size fits all approach.

8 Conclusion

Merging concepts of diversity and accessibility which, when combined, lead to familiarity, the research of this paper attempted to determine how suitable the built environment is for elderly people with an effective conceptual framework. Other theoretical routes could have been used. An example of this is focusing more on the "walkability" aspect of built environment suitability, like Moura, Cambra and Gonçalves have done in their 2017 participatory assessment of walkability for distinct pedestrian groups. However, this would have meant that the other aspects like the quality of the built environment would have been researched in a less distinct way. The same research paper (Moura, Cambra and Gonçalves, 2017) shows the strength of participatory assessment as a methodological approach. Using this, validation of the chosen factors can happen, so the assessment of a neighborhood is done according to *what residents' think is important*. Other approaches, like preselecting factors and subsequently use mostly secondary sources could have also been used. This would make the research easier to replicate but analysis of just physical elements does not necessarily correlate with the *perceived quality* of a neighborhood (Jun and Hur, 2015).

Data collection proofed lacking during the research process due to the Covid-19 crisis. It meant that *in situ* data collection was impossible, so the original planned in person data collection had to be revised. All data collection was moved online, but this did impact the number of respondents. The first survey also originally was not constructed for online purposes, so it had to be changed. The second survey had an improved design. The lower number of respondents can impact the representability of the research. It was difficult to reach the lower educated population of Kanaleneiland and the Transwijk online, which meant the sample was skewed towards being more highly educated. Improving on this can make the research more reliable.

During analysis the results of the survey revealed little difference in perceptions of the built environment between elderly and non-elderly people. This could have been due to the sample, the analysis method chosen or lacking distinctiveness of the survey questions. Future research should make sure this distinction is improved, so more reliable analysis of the differences in opinion between population groups can be made. The re-

sulting GIS-model could also be improved by asking respondents their valuations of certain aspects of the built environment and the complete built environment more comprehensive. This would mean that there is a way to analyze which factors of built environment accessibility and diversity play a bigger role. Knowing which factors are more important or less important will surely improve the reliability of the assessment.

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Annex I: CBS vierkantstatistieken

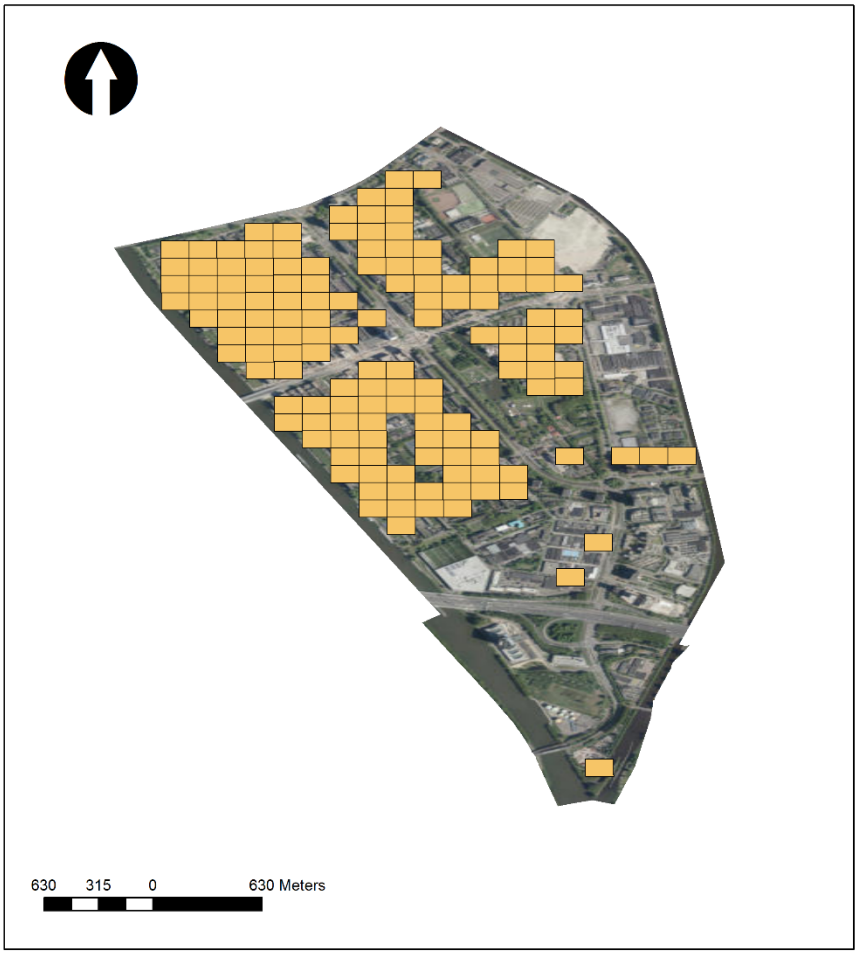

Figure 18: The CBS-vierkantstatistieken

This thesis was written using American English