Accessibility of elderly in the region Alkmaar related to the 15-minute city concept

Master thesis in partial fulfillment of the requirements for obtaining an MSc degree in Transport & Supply Chain Management

VU Amsterdam
School of Business and Economics

Name: Abdenour El Baghdadi
Student number: 2792615
Date: July 29, 2024

First supervisor: Dr. E Koomen
Second supervisor: Dr. T. de Graaff, and Dr. J. Tanhua
Word count: 7,438

Declaration of own work

I declare that this thesis has been composed solely by myself and has been solely the result of my own work. It has not been submitted, in whole or in part, in any previous application for a degree. Except where stated otherwise by reference or acknowledgment, the work presented is entirely my own.

Place: Alkmaar Date: July 29, 2024

Name: Abdenour El Baghdadi

Signature: 

Summary

This research examines the accessibility of essential services for elderly residents in the region Alkmaar, utilizing the 15-minute concept. This urban planning model aims to create neighbourhoods where residents can reach essential services within a 15-minute walk or cycle ride.

The literature review provides an overview of the 15-minute concept. It teaches us about the environmental benefits of walkable and bike-friendly cities. Additionally, it covers different views on which services should be included in the 15-minute concept and methods for measuring accessibility with their applications.

A gravity-based measurement is used to assess the accessibility, focusing on residential areas with a significant elderly population. With QGIS is analysed which services are within 15 minutes travel time, this analysis includes walking and cycling. Travel behaviour and the importance of different services to elderly residents of the region Alkmaar are analysed. Buffers around residential areas are created to calculate accessibility scores.

Central areas, such as Alkmaar city centre score high accessibility scores, peripheral areas show lower scores. Looking at transportation by foot Dijk en Waard has the highest percentage of elderly that can access all five essential needs, it has an accessibility score that is 0.02 lower than Alkmaar. For transport by bicycle Alkmaar scores the highest on both measures. Heiloo has the worst accessibility. None of the municipalities can be labelled as 15-minute cities.

This research underscores the necessity of improving urban planning to better service elderly residents. The region Alkmaar demonstrates notable differences in accessibility scores between areas.

1.Introduction

Core literature
Nowadays many cities are still designed as car dependent cities. This leads to several urban issues such as increased traffic congestion, energy consumption and air pollution (Appleyard, 1980). However, in some major cities there are efforts made to encourage the use of public transportation and other alternatives than the use of car. The objective of these cities is to minimize emissions and with that the use of private car ownership (Newman, Beatley & Boyer, 2017).

Reaching this objective can be done by implementing the 15-minute city concept. This concept aims to create self-sufficient neighbourhoods with essential functions of living, working, commerce, healthcare, education, and entertainment by decentralizing urban functions and services. By realizing this, car usage should decrease. The main functions of living are the set of essential amenities that people need to access daily (Bocca, 2021).

In cities, many different demographic groups live together. One of these groups, and one of the most vulnerable, are elderly people. They negotiate coexistence with their physical and social environment (Wahl, Iwarsson & Oswald, 2012). This group tries to find a balance between their abilities and age-related limitations to obtain benefits in terms of physical capacity, social network, life expectancy, and active longevity. A crucial factor in obtaining these benefits is an environment that facilitates the needs and desires of elderly people (Lawton & Nahemow, 1973).

The health condition of elderly people is not a determinant of the quality of social networks, but rather the environment and urban mobility impact this (Nimkar, 2017). This is because they do not facilitate accessibility to daily activities or personal sustenance, nor do they enhance social interaction (Ward et al., 2018).

The 15-minute city concept is an alternative solution to the problem of the quality of life of elderly people. This is because the concept is based on strengthening neighbourhood life, both in spatial function and in the political organisation of communities. The concept aims to change the scales of metropolitan governance to neighbourhoods and give greater decision-making power to communities (Yen, Michael & Perdue, 2009).

Research area
Elderly people are a vulnerable group at risk of being excluded from society because of limited accessibility to essential services. The concern for the wellbeing of this group is the reason for starting this research. To further define the research area, the region Alkmaar in the Netherlands is selected. Specifically, the region Alkmaar exists of the municipalities Alkmaar, Dijk en Waard, and Heiloo. This is the region of interest and has a large share in active transport, specifically by bicycle and strives for the integration of public and active transport networks (Regio Alkmaar, n.d.). The exact population are people that are 65 or older and live in Alkmaar, Dijk en Waard, and Heiloo.

Research questions and research gap
The aim of this research is to gain insight into the accessibility of elderly people in the region Alkmaar based on transportation by foot and bicycle. This will clarify whether Alkmaar, Dijk en Waard, and Heiloo can be considered 15-minute cities.

To reach this goal, the following research questions are defined:

1. What is a 15-minute city, and which services can be characterized as the basic amenities the elderly people in the region Alkmaar need?
2. Can elderly people that live in the region Alkmaar access their basic amenities within 15 minutes by foot?
3. Can elderly people that live in the region Alkmaar access their basic amenities within 15 minutes by bicycle?

Researching these questions will address the identified research gap. It has been found that there is no research focussing on the accessibility of a specific group of elderly within the 15-minute concept, using actual travel behaviour to determine their desired services.

Research type
To address the research gap and answer the research questions, an analysis will be performed using a critical realism perspective. This means that observations are assumed to be filtered and influenced by human theories, concepts, and social contexts. This perspective believes that there is an independent reality which we seek to uncover (Easton, 2010).

This perspective is related to a mono quantitative research method, which focuses on researching several quantitative variables in relation to a dependent variable (Easton, 2010). In this research, the independent variables are the services for elderly people, and the dependent variable is access by bicycle or foot. A spatial analysis will be performed as the method of research.

Research relevance
This research aims to contribute to science and society. The scientific contribution is the clear definition of services for elderly people. By analysing travel behaviour of elderly people, it will be made clear which type of services they want to visit.

The societal relevance of this research lies in showing the municipalities in the region Alkmaar which desired services are accessible to elderly people and which are not. Based on this insight the municipalities can implement appropriate solutions to improve the accessibility of the specific services. By doing so, the municipalities will make progress towards becoming 15-minute cities.

Research structure
The rest of this paper is structured as follows: section 2 presents the literature review, which introduces the definition of the 15-minute city concept, the impact of social factors, and accessible facilities. Section 3 details the methodology, research area and used data. In section 4 will the findings be presented. Section 5 will cover the discussion. Section 6 will present the conclusions. Lastly, section 7 will offer the recommendations for further research and discuss the limitations of this research.

2.Literature review

The aim of this section is to provide a framework of current literature to serve as a reference for defining the way to perform this research. For the 15-minute concept that this research focusses on, the key concepts and theories will be defined using the views of different authors. These definitions are reviewed and used in defining the research gaps. This research gap is crucial in emphasizing the importance of this research.

The 15-minute city concept

Moreno et al (2021) have defined the 15-minute city concept as follows: The 15-minute city rides on the concept of “chrono-urbanism”, which outlines that the quality of life is inversely proportional to the amount of time invested in transportation, more so by automobiles. This perspective is in favour of a setup in which locals can access all the basic needs at a distance that would not take them more than 15 minutes by foot or bicycle. This concept represents a city structured as a so called “compact city”. The aim for those cities is to optimize land use from the perspective of pedestrians.

Correa et al (2020) understand the 15-minute city concept as a city designed with respect to pedestrians instead of cars. Because of this view, it has an improved public infrastructure resulting in a walkable space with good mobility by public transport. Besides minimizing travel time, the idea of 15-minute cities is also inspired by trying to create a healthier environment by also reducing emissions. It is since the last decade that initiatives have been identified in terms of urban mobility policies that address the issue of creating “compact cities”.

The biggest difference that can be found between the views of the authors is the perspective from which the concepts are defined. Moreno et al (2021) define it from the perspective of quality of life and show what the impact can be on civilians. On the other hand, Correa et al (2020) define it from the perspective of city design with the translation to travel time. The other big difference between the authors is that Moreno et al (2021) relate the concept to transportation by foot or bicycle, whereas Correa et al (2020) relate it to transportation by foot or public transportation. The goal of the concept description from Correa et al (2020) is to minimize emissions. This gets done by focussing on reducing private car usages. The best way of minimizing emissions is to focus on modes of transport that do not pollute. This means that travelling by foot or bicycle would be the best mode of transport in the description of the concept by both authors. As this research aims to be in line with current literature, there will bel further focus on transportation to basic needs by foot and bicycle within 15 minutes travel time.

Health and environmental impact

Allam et al (2022) have found that air quality, noise, lack of green areas, heat and lack of physical activity have an impact on cardiovascular, muscular, and psychological diseases. The virtue of applying the 15-minute concept is the optimization of space and time. This is due to the constant search to increase the supply of services in public spaces. This results in healthier spaces, in terms of walkability and the sustainable use of public and private transport. Better walkability of neighbourhoods improves the people’s physical activity, active

transport, and mental health. The 15-minute city is a strategy that facilitates the right to the city, which makes cities and neighbourhoods more age friendly urban spaces.

Southwarth (2005) has found that urban mobility is fundamental to carry out daily activities, but also to facilitate social aspects, promoting relationships between people, especially for elderly people. Social connections are one of the major determinants of individual health and wellbeing. Pozoukidou & Chatziyiannaki (2021) add that social participation is part of inclusion. It plays a crucial role in the social integration of people especially those how are at risk of exclusion. Social inclusion consists of local social interaction, participation in local community services, sense of belonging, and feeling safe. Social accessibility strongly depends on urban mobility.

Allam et al. (2022), Southwarth (2005), and Pozoukidou & Chatziyiannaki (2021) emphasize the influence of the social aspect and the consequences in urban mobility. The key point in their theory is that walkability towards services improves mental and physical health. This results in more age friendly urban spaces and promotes inclusion, which means that the social aspect and the importance of social facilities are critical.

Implementation of the concept

The 15-minute city concept is a design and management concept according to Moreno (2020). This concept states that a city is polyrhythmic and polychronic. Polyrhythmic means that people have different daily life rhythms. Polychronic means that the use of places is variable because of the various schedules people have. Because of this, the view on 15-minute cities shifts from the traditional view of “urban planning” to “urban life planning”.

According to Pozoukidou & Chatziyiannaki (2021), several cities presented plans inspired by the 15-minute city concept. Political agendas have called for a “transition”, which encourages a participation process. It is a generation scenario in which the ecological perspective is combined with digital and energy innovative programs in the framework of a green and circular economy. The goal of this concept is improving the quality of urban life, in terms of wellness, liveability, and community relations, resulting in an increased time available for personal creative freedom.

Reimer (2020) claims that the adoption of the 15-minute city concept opens gateways for more novel digital innovations such as bike-sharing technologies that would increase the living experience of residents. Gehl (2013) adds that reconsidering the way cities are organised facilitates implementation of parks, squares, and public spaces within neighbourhoods.

Moreno (2020) teaches us that when implementing the 15-minute cities, it must be considered that the daily life rhythms of people influence the use of places. Knowing this, the accessibility of facilities can be influenced by crowdedness. Even though a facility is within 15-minute travel time, it does not add value to the people if it is not accessible. Pozoukidou & Chatziyiannaki (2021) emphasize that different cities are busy implementing the 15-minute city concept and that their goal is to improve the quality of life with the result of more time available for personal freedom.

Accessible services

Moreno et al. (2021) suggest that residents will be able to sustain a decent urban life and enjoy a higher quality of life where they will be able to effectively enjoy four dimensions: density, proximity, diversity, and digitalization. Density refers to the optimal number of residents a district can sustain in terms of service provision and resource consumption.

According to Moreno et al. (2021), proximity refers to six dimensions. These six dimensions are: living, working, commerce, healthcare, education, and entertainment.

Gaxiola-Beltran et al. (2021) have identified several services to measure urban accessibility by walking and cycling. The services included are schools (preschool, primary school, secondary school, technical secondary school, and high school), hospitals (general hospitals, addiction and psychiatric hospitals, and other hospitals), and other services (supermarkets and employment centres).

Weng et al. (2019) included the following services in their measurement of the walkability of neighbourhoods: education (school or training institution), medical care (hospital or pharmacy), municipal administration (public transport, park and square, sport venue, cultural venue), finance and telecommunication (finance and post office), commercial service (restaurant, shopping, entertainment venue), and elderly care (nursing home or elderly education).

Diversity refers, according to Zumelzu & Barrientos-Trinanes (2019), to the heterogeneity of urban functions at the local scale and the co-existence of different identities and practices. Diversity is conducive to increased active travel and social encounters, resulting in increased resilience, vitality, inclusion, satisfaction, and quality of life (Liu et al., 2017)

Lastly, digitalization refers to the utilization of ICT solutions to optimize the provision of services.

The dimensions of Moreno et al. (2021) are an extension of their proximity dimensions. However, it has been found that besides the defined dimensions/functions, there is no further specification of what services are included in these dimensions/functions. For instance, it is not defined what is included or excluded in the proximity function “culture”. This could range from museums to temporary festivals. The defined dimensions/functions can be interpreted and further defined in different ways.

This research is performed for a specific group of people, namely elderly. The dimensions of Moreno et al. (2021) are defined without specific services. These dimensions are considered applicable for elderly people. The reason for this is that the specific services in these dimensions can be further defined based on the importance of the services for the population.

The functions and service definitions of Cheng et al. (2021), Zumelzu & Barrientos-Trinanes (2019), Gaxiola-Beltran et al. (2021), Weng et al. (2019), and Liu et al. (2017) are also generally defined and not dedicated to a specific group of people. Even though these definitions are not defined for a specific population, they are defined based on the aim of

their research. Therefore, it makes sense to base this research further on the definition of Moreno et al. (2021).

Accessibility measures

Accessibility measures can be categorized in four groups. These groups are distance-based, gravity-based, infrastructure-based, and walk score (Vale et al.,2016).

Apparicio et al. (2008) state that in distance-based measures, only the travel time or the distance from the starting point to the possible destination is considered. The destinations within a certain threshold are counted, for example the closest destination only. For this measure are origin points, points of interest, and a network needed. Various methods can be used to calculate the distance such as the network, Euclidean distance, or Manhattan distance.

Gravity-based measures assign weights to opportunities based on their distance or travel time from the origin point, factors such as the number of employees or floor space can also be considered. This makes this measure realistic, since destinations that are close can be more attractive for example (Papa et al, 2012).

Infrastructure-based measurement does not take origins and possible destinations into account. It only considers the network itself, this includes for instance the distances of road networks, and where they are located. However, it does not measure travel time, which makes it not suitable for the 15-minute concept (Rode et al., 2017).

The Walk Score captures both network quality, just like the infrastructure-based measurements, and the travel time to possible destinations, such as the distance- and gravity-based measurement (Hall & Ram, 2018). The bike score is a variant of the walk score. For the bike score, the gravity-based measurement is used, and this is combined with topological characteristics like bike lane presence (Winters et al., 2016).

Research gap

Reviewing the literature shows that there is plenty of research performed on the topic of 15-minute cities. The overall goal is to minimize emissions by organizing facilities in 15-minute travel time by foot or bicycle.

What has not been found in the literature is research in which the concept of 15-minute cities is related to a region consisting of different municipalities. Besides that, this kind of research has not been performed for the specific group of elderly people. This also means that in this kind of research, there has not been any special attention paid to the importance elderly people give to different services. Exploration is needed in the spatial needs of elderly people; this will be done by recorded data, this will be used to operationalise their needs in the concept of 15-minute cities.

When these needs are clear, a gravity-based measure will be used to get insight into the accessibility of elderly people in the municipalities of Alkmaar, Heiloo, and Dijk en Waard. This measure has been chosen because it is applicable for measuring travel times. Since this research is based on the 15-minute concept, insights in travel times are needed to determine whether elderly people can access their daily needs within 15 minutes or not. This

measure allows the inclusion of weights in the measurement, the relative importance of the different services gets this way included.

This is the gap that has been found in the current literature, this research will further focus on this gap. The importance of performing this research and filling this described gap lies in the contribution of including elderly people in society.

3.Methodology

The research gap has been found researching different literature. Besides that, the literature helps to define in this section the accessibility measurement and structure the services. To fill the research gap there has to be an analysis performed, this section describes how this analysis will be performed.

QGIS 3.28.11 is used for the analysis as QGIS provides flexibility in terms of customizing the analysis and can handle multiple types of data. The aim of this research is to get insight in inequalities in accessibility, visualization is key in this. Other research shows us that spatial-analysis is the best way for this (Weng et al., 2019; Zumelzu & Barrientos-Trinanes, 2019).

Study area

This research focusses on the residential areas of elderly populations within the selected municipalities of Alkmaar, Dijk en Waard, and Heiloo. This region has been chosen because it aims to improve their accessibility (Regio Alkmaar, n.d.). Researching this area will provide insight in how accessible they are, and how close these municipalities are to becoming 15-minute cities, particularly to elderly people. Dijk en Waard and Heiloo are included to compare the accessibility of elderly residents with these areas that are organized differently. In Figure 1 is the region of interest visualized.

Alkmaar is known for its historic city centre, robust cultural scene, and the cheese market (Alkmaar Tourism, n.d.). Alkmaar has 112,393 inhabitants, of which 20.6% are 65 or older and can be defined as elderly people. Alkmaar has 53,417 residents, and a surface of 31.22 km² (Visit Alkmaar, n.d.) Alkmaar offers a wide range of transportation options that includes bus, train, bike, and car transport (OV in Nederland, n.d.). Additionally, Alkmaar has multiple healthcare facilities, one of them is the Noordwest Ziekenhuisgroep hospital (Noordwest Ziekenhuisgroep, n.d.). Alkmaar is striving to improve its cycling infrastructure and create more pedestrian-friendly areas (Gemeente Alkmaar, n.d.).

Dijk en Waard is organized as a municipality with both rural and urban areas, mixed with commercial, residential and agricultural zones. Dijk en Waard organizes initiatives that aim to improve the accessibility and quality of life for their elderly population This includes community health programs and accessible public spaces. Dijk en Waard is connected by a bus network, with ongoing projects to improve the accessibility of remote areas (Dijk en Waard, 2024). Dijk en Waard has 90,076 inhabitants, of which 20% are 65 years or older. Dijk en Waard has 37,459 residents. It has a surface of 67.02 km² (Gemeente Dijk en Waard in Cijfers, 2024). Dijk en Waard has a hospital and offers additional health services (MET Dijk en Waard, n.d.).

Heiloo is characterized by a suburban atmosphere, parks, and other green spaces (Gemeente Heiloo, 2024.). Heiloo has 24,312 inhabitants, of which 27% are 65 or older. Heiloo has 11,123 residents. It has a surface of 19.01 km² (Gemeente Heiloo in Cijfers, 2024). Heiloo is served by a train station and by buses that connect it with Alkmaar and other surrounding municipalities (Stations, 2023). Heiloo has community programs that focus specifically on the well-being of elderly people. These programs include support services

and social activities (Gemeente Heiloo, 2024.). There are several healthcare centres and clinics located in Heiloo (Huisartsenpraktijken Heiloo, n.d.).

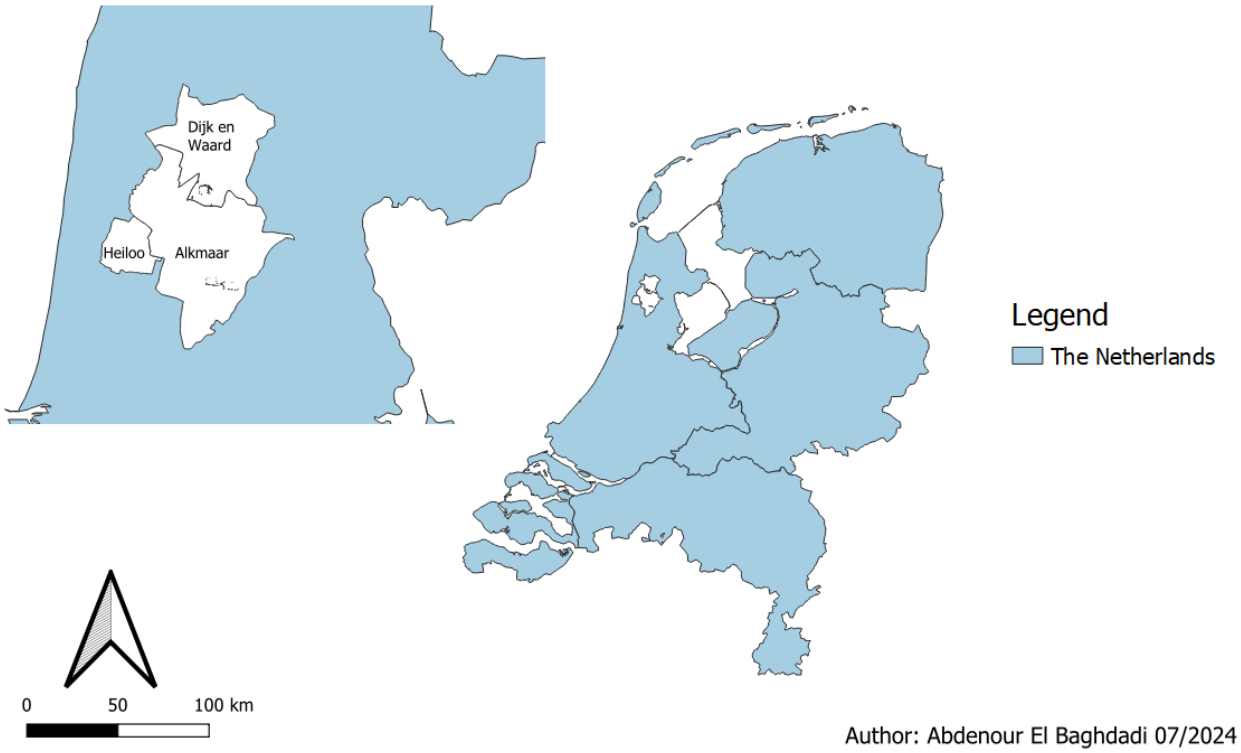

Figure 1: Region of interest, with the municipalities Alkmaar, Dijk en Waard, and Heiloo highlighted.

Analysing travel behaviour

This study explores the accessibility of elderly people using cycling and walking as transportation modes. These modes are selected as they align with the description of the 15-minute concept by Moreno et al. (2021), which includes the dimensions living, working, commerce, healthcare, education and entertainment. These dimensions are in this research renamed as personal care, education, sports, recreation and shopping. The living dimension is included as the residential areas of elderly people, and the working dimension is excluded since most elderly people do not work anymore. In Table 1 in the appendix are the dimensions restructured.

To measure the accessibility, the gravity-based measure of Papa et al. (2012) will be used. Unlike simplified distance-based measures that only count the number of destinations within a certain threshold, the gravity based-measure incorporates inherent attractiveness of destinations (Geurs & Wee, 2004). By considering both the importance and accessibility of destinations, the gravity-based measure aligns with the 15-minute concept's goal. Services should not only be within reach but also wanted to be accessed (Páez et al., 2012). The importance of destinations is incorporated as the importance elderly people that live in the region Alkmaar actually give to these different services, the weights for the different services can be found in Table 1 in the appendix. The accessibility gets measured with a threshold of 15 minutes travel time, the services that can be accessed in a travel time that is below the threshold are considered accessible.

For the first part of this study, the Onderweg in Nederland (ODIN) 2022 dataset is examined. It offers detailed insight into the daily mobility patterns of the Dutch population, covering various aspects such as travel times, origin and destination points, travel purposes, and transportation modes. The 2022 dataset provides an overview of the survey's methodology and execution (Centraal Bureau voor de Statistiek, 2023).

The objective of this research is to measure accessibility with a gravity-based measurement. To achieve this, insight into the services people visit and the importance in their daily lives is required. To assign weights to different services, the importance of each service is extracted from the dataset, focusing on elderly people living in Alkmaar, Dijk en Waard, and Heiloo. The data, provided in an Excel file, will be processed using pivot tables.

For calculating the weight for each service, the travel motives of elderly coming from the region of interest are extracted from the ODIN dataset. Motives from the ODIN data that are related to one of the services are selected, and classified under these services. These services are education, shopping, recreation, sports, and personal care. This gets done for Alkmaar, Dijk en Waard, and Heiloo separately, after which the average gets calculated. This is because all municipalities are considered equals, for that reason people from Alkmaar do not influence the importance more then people from Heiloo for example. The row total (average) will not sum up to 100%. This is because not all travel motives in the ODIN data are related to the named five services, so not everything is selected. To correct this and get a standardized accessibility score from 0-1, the weights get normalized. Lastly, the weights will be summed up for each service, which gives in the rightest row the weight per service. In Table 1 in the appendix is the weight calculation presented.

Assessing Accessibility

The second part of this research explores accessibility by the transportation modes the 15-minute concept aims to promote: walking and cycling. The aim is to asses accessibility scores in the research area, and to highlight inequalities in the research area.

This analysis is based on centred 100m x 100m grid cells on residential locations of elderly people in the research area. These locations are inferred from CBS data with spatially explicit demographic data (Centraal Bureau voor de Statistiek, n.d.-b), from which cells with more then five elderly were selected. This refined approach ensures that the accessibility assessments are directly applicable to the target population. The analysis gets separately performed for transportation by foot and by bicycle.

Centroids are used to create buffers; these buffers represent the travel reach. For walking a speed of 3 km/h is used (Stinchcombe et al., 2016), resulting in a 750-meter buffer for walking 15 minutes. Considering that walking in a straight line is unrealistic, a correction factor of 0.7 is applied, which corrects the buffer size to 525 meters. For cycling a speed of 10km/h is used (Xing et al., 2010), yielding a 2500-meters buffer for 15-minutes. This is on the conservative side as it does not account for electric bikes. The same correction factor is applied here, resulting in a buffer size of 1750 meters.

The function "count points in polygon" is used for each service layer separately, this shows how many service points are within the buffers. The "joins" function is used to merge the

data from different layers into one. The field calculator is used to present the amount of service points in each buffer as binary values (1 if equal to or greater than 1, 0 otherwise). The field calculator is used to multiply the binary variables with the weights obtained from the ODIN dataset, summing these values to produce an accessibility score from 0 to 1, with 1 presenting accessibility to all services. In Table 1 in the appendix the weights for the calculation can be found in the rightest column.

For the accessibility score are the binary values that indicate whether there are service point(s) present inside the buffer reach (the set of service points, are points from the services; personal care, education, sports, recreation and shopping), and the weights that are given to the different services needed. When both of these are obtained, multiplied, and summed up over the different service points we get the accessibility scores. The mathematical model can be found below.

Sets and inputs	
S	Set of service points
B	Set of buffers
Lsb	0-1 Coefficient is equal to 1 if at least 1 service point $s \in S$ is within buffer reach $b \in B$ (0 otherwise)
Ws	Weights of service points $s \in S$

$$\sum_{s \in S} LsbWs$$

Lastly the “joins” functioned is used to get the accessibility scores in the grid cell layer of the residences. This shows the accessibility of the different residential areas around the research area, whether there are inequalities in accessibility around the research area and how big these inequalities are. Table 2 shows the data sources that are used. The relation between the data sources for the analysis are simplified presented in Figure 2.

Theme	Aggregation level	Source and type	Year
Travel behaviour	National	(Centraal Bureau voor de Statistiek, 2023) Excel data – Includes travel behaviour and motives	2022
Services	National	(Core Places, n.d.) Point data- Presenting points of interest	2024
Elderly residential density	National, 100m X 100m grid cells	(Centraal Bureau voor de Statistiek, n.d.-b) Multipolygon- Presenting 100m X100m grid cells that show the residential density of elderly	2022
Neighbourhoods	National	(Centraal Bureau voor de Statistiek, 2018) Multipolygon- Presenting neighbourhoods in the Netherlands	2018
Country borders	National	(Centraal Bureau voor de Statistiek, n.d.-a) Multipolygon- The country borders of the Netherlands divided in districts.	2011

Table 2: Data sources

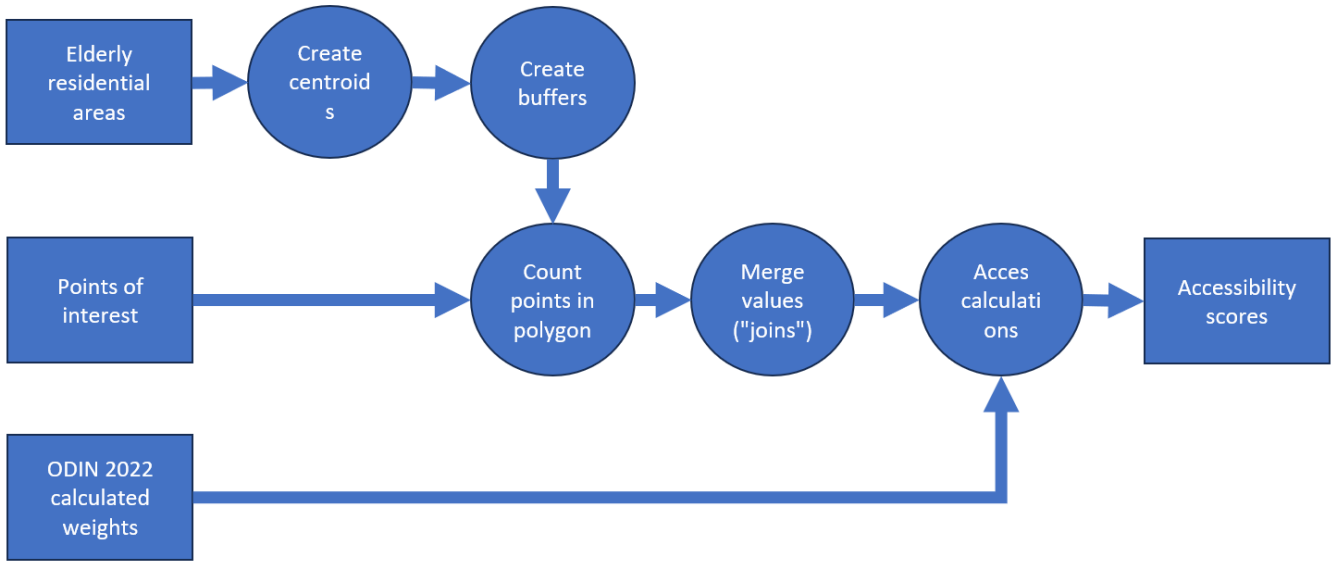

Figure 2: Analysis flowchart

4.Results

In this section the results are presented per research question.

What is a 15-minute city, and which services can be characterized as the basic amenities the elderly people in the region Alkmaar need?
The first part of this research question gets answered using the gathered literature from the literature review and the methodology. The dimensions that are used for this research or those that Moreno et al. (2021) have defined. These were: living, working, commerce, healthcare, education, and entertainment. To match these dimensions with the ODIN dataset these dimensions are redefined for this research. Resulting in the dimensions: personal care, education, sports, recreation and shopping.

The ODIN dataset provides 188,036 data records, of these records 419 are related to elderly people in the municipalities Alkmaar, Dijk en Waard, and Heiloo. The youngest age is 65, because of the age constraint. The oldest persons in this dataset are 91. They have an average age of 77 with a standard deviation of 7.4. Of this elderly population is 38% woman and 62% men. The distribution of the ages can be found below in Figure 3. All data and figures extracted from the ODIN dataset can be found in the provided “OD_processed” document.

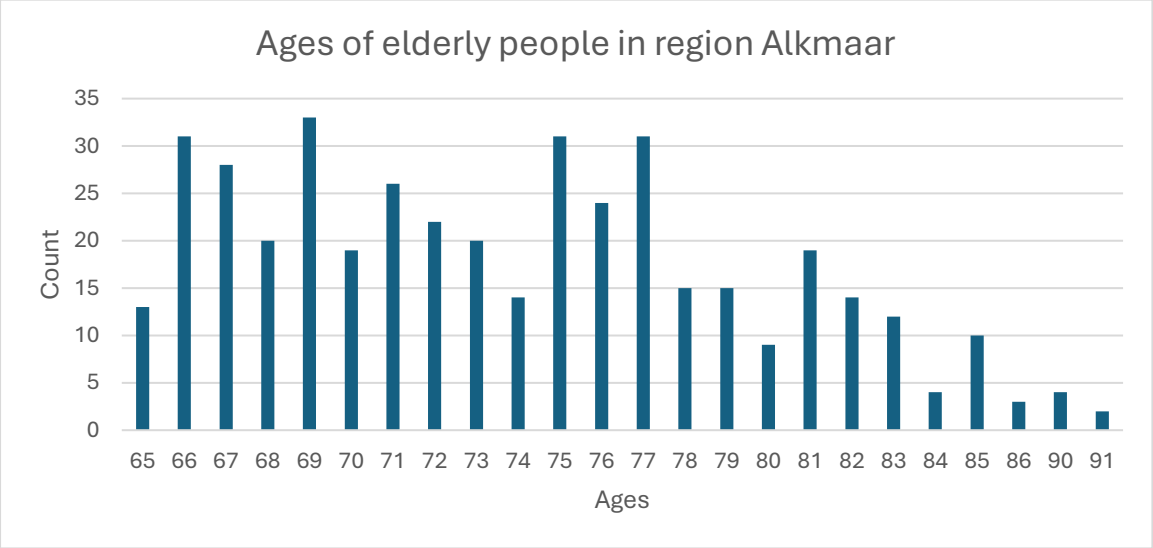

Figure 3: Age distribution of elderly in Alkmaar, Dijk en Waard, and Heiloo

In Figure 4 are the travel motives presented. The travel motives are used to determine a weight for the importance of services. The figure shows that (grocery) shopping is used by 38.42% of the elderly population as a travel motive, followed by touring/walking with 18.38%. The least used travel motive is business visit with 0.24%.

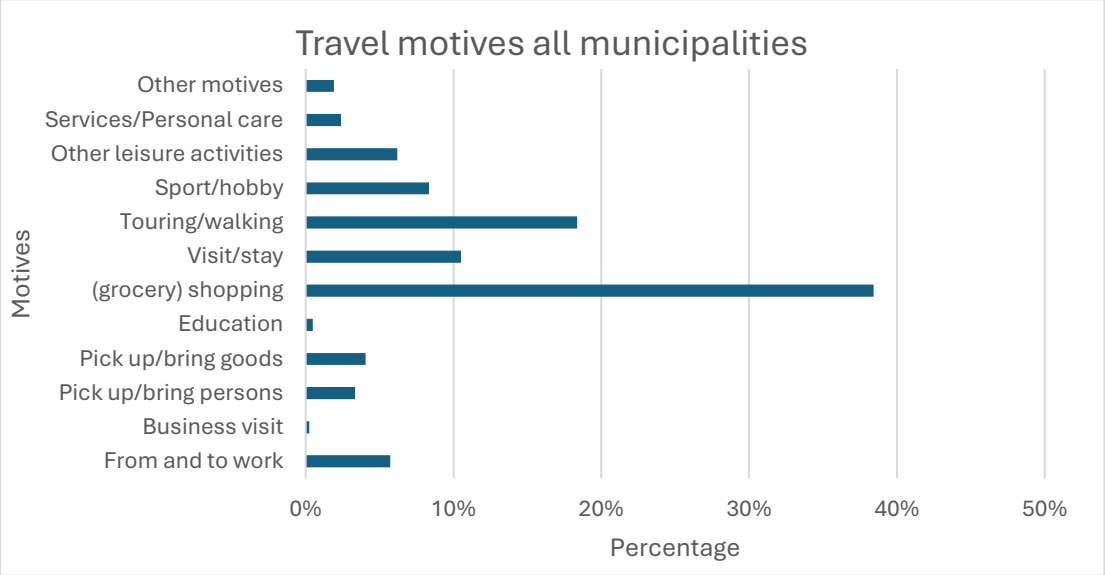

Figure 4: Travel motives of elderly in Alkmaar, Dijk en Waard, and Heiloo

For calculating the weight for each service, the data from Figure 4 is used. The motives pick up/bringing goods, pick up/bringing persons, other motives, business visits, and from and to work are excluded in this calculation since they are not related to the defined five services this research focusses on. The row total (average) is not summing up to 100% but to 86.63%. To correct this and get a standardized accessibility score from 0-1, the weights have been normalized. Lastly, the weights have been summed up for each service, which gives in the rightest row the weights per service. This shows that the most important service is shopping (44.35%), followed by recreation (42.79%), and the least important service is education (0.55%). The values from the calculations can be found in Table 1 in the appendix and in the “OD_processed” document can the complete calculations be found.

The transportation modes elderly people use in the area of interest are visualized below in Figure 5. It shows that car (35.5%), walking (28.4%), non-electronic bicycle (17.9%), and electronic bicycle (15%) are the most used transportation modes.

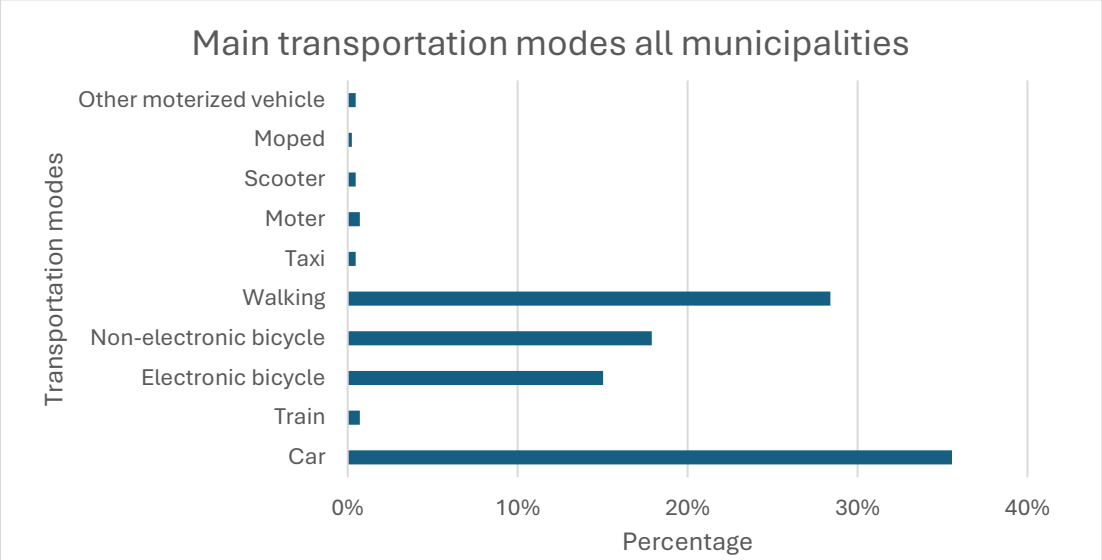

Figure 5: Main transportation modes used by elderly in Alkmaar, Dijk en Waard, and Heiloo

Can elderly people that live in the region Alkmaar access their basic amenities within 15 minutes by foot?

As mentioned earlier this second part will focus on presenting the accessibility of the region Alkmaar. After performing the analysis, the map in Figure 6 is presented. The map shows much variation in walking accessibility scores. The dark red colour presents a high accessibility score, the lighter the colour the lower the score.

Dijk en Waard shows a mix of accessibility levels, some areas have a moderate score and it has peripheral areas showing low scores. The city centre of Alkmaar shows a high accessibility, but the further we move to the outskirt the lower the accessibility scores get. Heiloo shows a moderate score throughout the municipality, but it shows that nowhere in the municipality the maximum score has been found.

Overall, the map shows that around the centres of the municipalities the accessibility improves. There will be looking at the accessibility from two perspective, one looks at the grid cells this is the average accessibility score. The other perspective takes the density of the grid cell into account, this is the share of elderly with access to all service types. By looking at it from two perspectives we know which municipality has the most elderly that have the benefits of a 15-minute city, and which municipality provides access to the most services around the residential areas of elderly.

Alkmaar scores an average accessibility score of 0.42, Dijk en Waard scores 0.40, and Heiloo scores a 0.31. Looking at the amount of elderly in the grid cells Alkmaar has 10 elderly that have access to all five services within 15 minutes walking, Dijk en Waard has 80 elderly, and in Heiloo this is 0. Relatively the most elderly from Dijk en Waard have the benefits of a 15-minute city, this is shown in Table 3. In Figure 8 in the appendix are the locations of the different service locations visualized.

	Alkmaar	Dijk en Waard	Heiloo
Number of elderly	21,160	15,075	6,075
Number of elderly with full access	10	80	0
Share of elderly with access to all facility types	0.05%	0.53%	0%
Average accessibility score	0.42	0.40	0.31

Table 3: Accessibility by foot scores for elderly per municipality

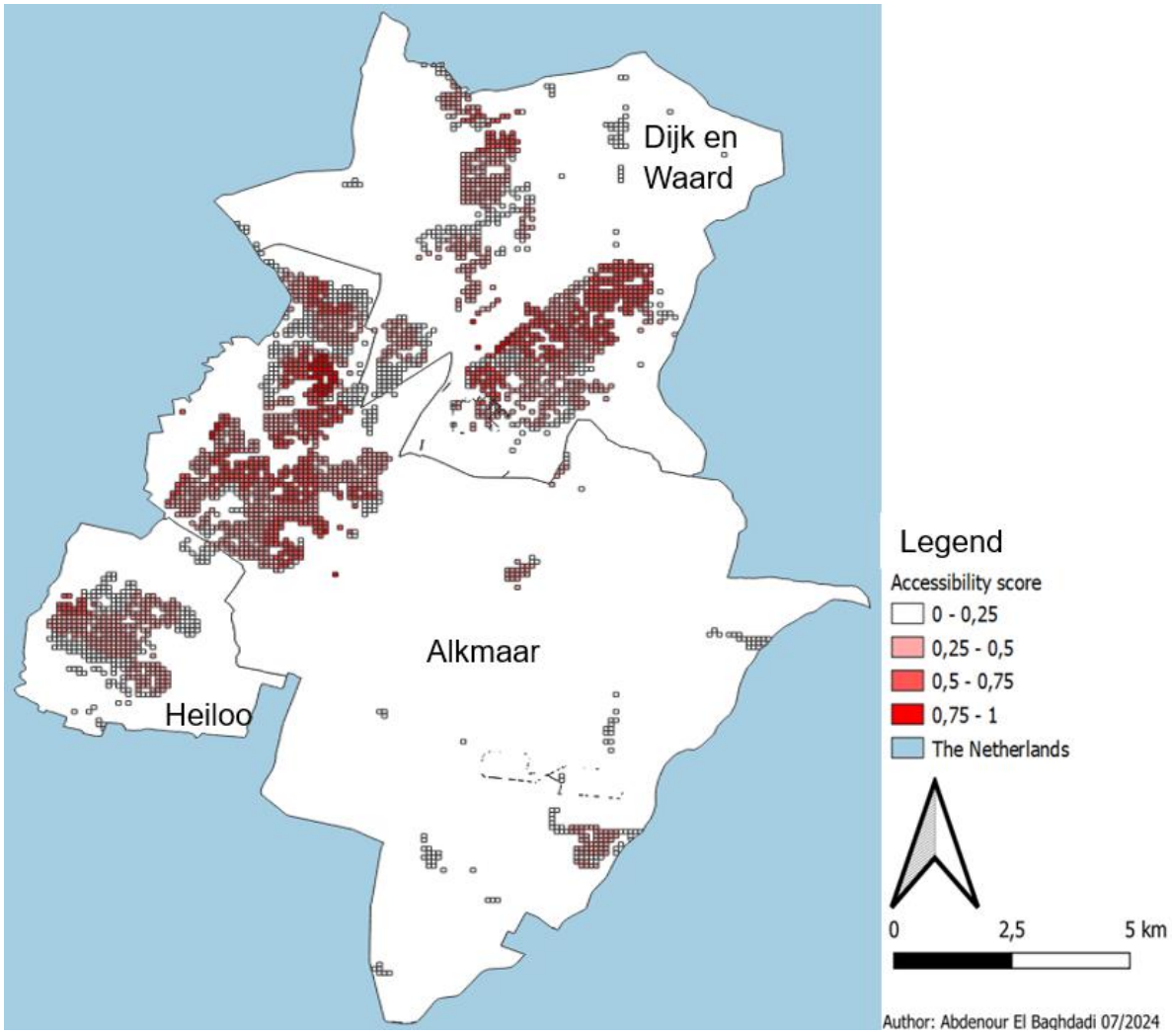

Figure 6: Spatial distribution of accessibility by foot scores for elderly.

Can elderly people that live in the region Alkmaar access their basic amenities within 15 minutes by bicycle?

For this last research question, we look at the accessibility of elderly people depending on transport by bicycle. After the analysis the map in Figure 7 is presented. The map shows variation in accessibility over the region. Again, the dark red colour shows a high accessibility and the light colour shows a low accessibility.

Dijk en Waard shows again a mix of accessibility levels, it shows some central areas that have moderate accessibility and peripheral areas with lower scores. Alkmaar its centre shows a high accessibility but when moving to the outskirt the accessibility decreases. Overall, Heiloo shows a good accessibility throughout the municipality. Alkmaar has an average accessibility score of 0.81, Dijk en Waard scores average 0.70, and Heiloo scores

average 0.55. In Alkmaar 12,010 elderly have access to all five service within 15 minutes cycling, for Dijk en Waard is this 5,490, and for Heiloo is this only 40. Relatively the most elderly from Alkmaar have the benefits of a 15-minute city, this is shown in Table 4.

	Alkmaar	Dijk en Waard	Heiloo
Number of elderly with full access	12,010	5,490	40
Share of elderly with access to all facility types	57%	36%	1%
Average accessibility score	0.81	0.70	0.55

Table 4: Accessibility by cycling scores for elderly per municipality

Bicycle accessibility scores are obviously higher compared to walking accessibility because of the higher speed of this transport mode. Besides that, Figure 7 shows us that on the south edges of Heiloo and Alkmaar the accessibility is higher now, because services in other nearby municipalities can be reached within 15 minutes. In Figure 8 in the appendix are the locations of the different service locations visualized.

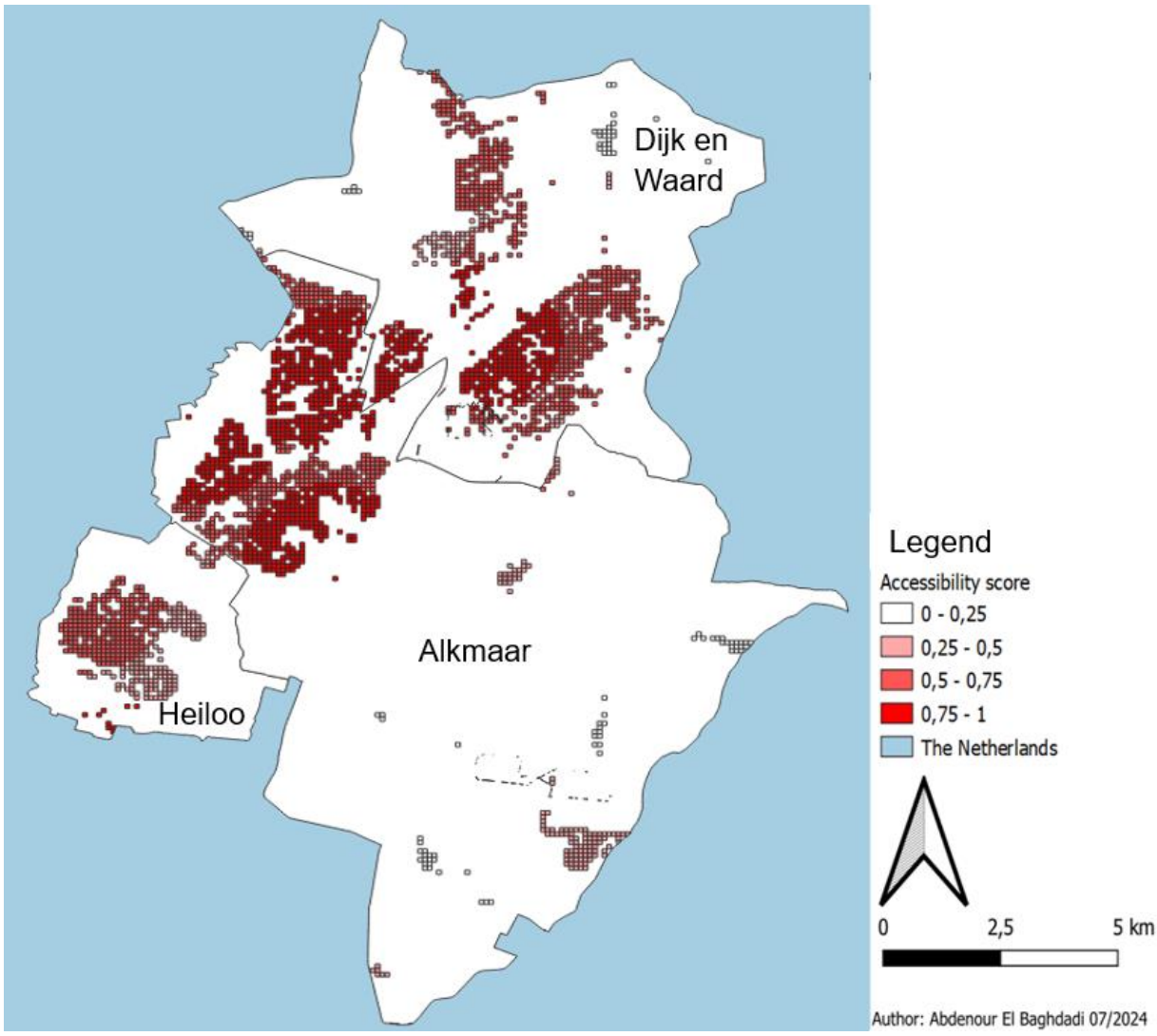

Figure 7: Spatial distribution of accessibility by cycling scores for elderly.

5.Discussion

The aim of this research is to evaluate the bicycle and the walking accessibility of the elderly people in the region Alkmaar, while applying the gravity-based measure to indicate how well the region Alkmaar meets the 15-minute city concept as defined by Moreno et al. (2021). The findings of this research provide insight in the current state of accessibility for elderly people. These insights highlight areas that are well accessible but it also shows which areas have room for improvement.

To obtain the goal of this research an accessibility measures was defined. This measure helped pointing out how accessible the different municipalities are. We have found two values that present this, namely the average accessibility scores, and the percentage of elderly with access to all five services. But it is not made clear which of those accessibility measure better define whether a city is close to being a 15-minute city.

In the literature was found that a 15-minute city provides access to all five essential services, this definition was without taking into account how important these services are. The method that has been used in this research is more personalized for the population. As the original aim of the 15-minute concept is to improve the accessibility for everyone, it can be considered to focus on more vulnerable populations their accessibility as done in this research. This can also be applicable for refugees, or children for example. Looking at what they need and how important these needs are can help in getting insight in their current accessibility and how this can be improved.

The results show that the accessibility for elderly people is better when they use a bicycle as their transportation mode. This finding aligns with the broader literature, which concluded that cycling infrastructure and usage of bicycle often extends the reach of the urban residents, that way accessibility gets improved (Páez et al., 2012; Geurs et al., 2012). The gravity-based measure effectively takes the attractiveness and the distance of destinations into account.

The higher bicycle accessibility scores compared to walking can be attributed to the extended range of bicycles. Cycling has a lower physical exertion, which is beneficial for elderly people. Looking back at the findings of previous literature it is shown that our results are robust and in line with previous research. However, walking and bicycle accessibility scores do not meet the ideal of the 15-minute city. This concept claims that every essential service should be accessible within 15 minutes, it has been found that none of the municipalities are 15-minute cities.

The findings of this research can have broader applications for urban planning and policy-making. This research emphasizes the need for enhanced urban planning, this includes repositioning commercial centres and specific services, for better accessibility of the services.

6.Conclusion

This study aimed to evaluate the accessibility of elderly people in the region Alkmaar by transportation by foot or bicycle. Research questions were defined to guide this research. For each research questions the conclusions get presented.

What is a 15-minute city, and which services can be characterized as the basic amenities the elderly people in the region Alkmaar need?
The 15-minute concept involves an urban environment where residents can access essential services within 15 minutes walking or cycling. The services that elderly people want to access and that are important to them in the region Alkmaar are classified as education, sports, recreation, personal care, and shopping.

Can elderly people that live in the region Alkmaar access their basic amenities within 15 minutes by foot?
The analysis showed that the accessibility scores for pedestrian vary across the region Alkmaar. Alkmaar has the highest average score, which means that the elderly overall have the best accessibility, in terms of accessibility scores. On the other side Dijk en Waard has the highest percentage of elderly that can enjoy the benefits of a 15-minute city. Heiloo scores on both the worst

Can elderly people that live in the region Alkmaar access their basic amenities within 15 minutes by bicycle?
Bicycle accessibility is higher than pedestrian accessibility. Again, centralized areas show the highest scores. Peripheral areas show an improved accessibility in comparison with walking. Alkmaar scores the highest average accessibility and the highest percentage of elderly that can access all five service categories. Heiloo scores again the worst on both.

This research did not directly take networks into account, but it already reveals places where the accessibility can be improved. Overall, should increasing or relocating the number of services the elderly cannot access from that grid cell improve the accessibility. Another solution is to locate elderly people around areas that have better access to the five services. These insights contribute to a broader application on urban planning and the 15-minute concept, this offers recommendations for creating more inclusive and accessible urban environments for elderly.

7.Limitations & Future research

Several limitations were identified in this research. One of them is the reliance on buffers to represent the accessible areas. Unfortunately, the QNEAT3 tool that suits itself for analyses like performed in this research, was not usable. This means that cycle- and walking networks are not taken into account in the analysis. Including the networks would make the analysis, the results, and the conclusions more realistic. A correction was made on the distance that can be travelled, this is based on an assumption and may be not realistic.

Another limitation is that this research depends on 100m X 100m grid cells that represent residential areas were elderly people live. As the buffer size for walking is 525 meters, the analysis could present services as unreachable because of the centroids that are used. In the worse scenario this could mean the buffer reach is limited by 50 meters, since the centroids are located in the middle of the grid cells. This also applies for the cycle buffer.

Besides that, is the accessibility presented as an average for each municipality. Since this is an average, it is hard to draw conclusions for all the elderly in that municipality. It could be that there is a large variation between the accessibilities of the grid cells, only the average doesn't show that.

The ODIN dataset is limited to a certain amount of available data, this is the fourth limitation of this research. The presented results are not representative for the entire population. The data of the respondents used in this research do not come near the minimum number of respondents that is needed to draw reliable conclusions for the elderly for each municipality individually. The municipality Alkmaar for example needs at least 378 respondents to draw conclusions with 95% confidence. Still, there are enough respondents to draw conclusions for the combined populations of the municipalities. Also, for that reason is for the weight calculation the data from all the respondents of the region Alkmaar aggregated.

The fifth limitation in this research is related to the use of grid cells. There are only grid cells used that present more than five elderly people that live in the grid cell. This can lead to exclusion of some elderly in this analysis. Since the values of the number of elderly that live in each grid cell are rounded off at five, everything below five does not show data. On the other side this also means the actual number of elderly that live in the grid cells could diver in reality.

Lastly, the statistic nature of the used data does not account for variations in accessibility such as changes in traffic conditions or weather impacts. Overall, this research cannot represent the realistic accessibility but it shows a good insight.

Future research can redefine the methodology and expand the scope of the analysis to address these limitations. This will provide deeper insights into urban accessibility and mobility for elderly people. Besides that, future research can also refine whether urban mobility changes directly influence the travel behaviour and decreases car usages, as in Figure 5 the current state is presented.

Reference

Alkmaar in cijfers - Gemeente Alkmaar. (n.d.). Kerncijfers. Retrieved July 29, 2024, from https://alkmaar.incijfers.nl/dashboard/kerncijfers

Allam, Z., Nieuwenhuijsen, M., Chabaud, D., & Moreno, C. (2022). The 15-minute city offers a new framework for sustainability, liveability, and health. The Lancet Planetary Health, 6(3), e181-e183.

Apparicio, P., Abdelmajid, M., Riva, M., & Shearmur, R. (2008). Comparing alternative approaches to measuring the geographical accessibility of urban health services: Distance types and aggregation-error issues. International Journal of Health Geographics, 7, 1-14.

Appleyard, D. (1980). Liveable streets: protected neighborhoods?. The ANNALS of the American Academy of Political and Social Science, 451(1), 106-117.

Bocca, A. (2021). Public space and 15-minute city. TeMA-Journal of Land Use, Mobility and Environment, 14(3), 395-410.

Brown, J. R., Morris, E. A., & Taylor, B. D. (2009). Planning for cars in cities: Planners, engineers, and freeways in the 20th century. Journal of the American Planning Association, 75(2), 161-177.

Centraal Bureau voor de Statistiek. (2018). Wijk- en buurtkaart 2018. Retrieved July 29, 2024, from https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische-data/wijk-en-buurtkaart-2018

Centraal Bureau voor de Statistiek. (2023, July 4). Onderweg in Nederland (ODIN) 2022 - onderzoeksbeschrijving. Centraal Bureau Voor De Statistiek. Retrieved July 29, 2024, from https://www.cbs.nl/nl-nl/longread/rapportages/2023/onderweg-in-nederland--odin---2022-onderzoeksbeschrijving?onepage=true

Centraal Bureau voor de Statistiek. (n.d.-a). CBS gebiedsindelingen. Retrieved July 29, 2024, from https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische-data/cbs-gebiedsindelingen

Centraal Bureau voor de Statistiek. (n.d.-b). Kaart van 100 meter bij 100 meter met statistieken. Retrieved July 29, 2024, from https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische-data/kaart-van-100-meter-bij-100-meter-met-statistieken

Correa-Parra, J., Vergara-Perucich, J. F., & Aguirre-Nuñez, C. (2020). Towards a walkable city: Principal component analysis for defining sub-centralities in the Santiago Metropolitan Area. Land, 9, 362.

Dijk en Waard. (2024, June 28). Gemeente Dijk En Waard. Retrieved July 29, 2024, from https://www.dijkenwaard.nl/

Easton, G. (2010). Critical realism in case study research. Industrial Marketing Management, 39(1), 118-128.

Gaxiola-Beltrán, A. L., Narezo-Balzaretti, J., Ramírez-Moreno, M. A., Pérez-Henríquez, B. L., Ramírez-Mendoza, R. A., Krajzewicz, D., & Lozoya-Santos, J. D. J. (2021). Assessing urban

accessibility in Monterrey, Mexico: A transferable approach to evaluate access to main destinations at the metropolitan and local levels. Applied Sciences, 11(16), 7519.

Gehl, J. (2013). Cities for people. Island Press.

Gemeente Dijk en Waard in cijfers en grafieken (bijgewerkt 2024!) | AlleCijfers.nl. (2024, June 17). AlleCijfers.nl. Retrieved July 29, 2024, from https://allecijfers.nl/gemeente/dijk-en-waard/#:~:text=Gemeente%20Dijk%20en%20Waard%20heeft,25%20wijken%20en%206920 buurten

Gemeente Heiloo in cijfers en grafieken (bijgewerkt 2024!) | AlleCijfers.nl. (2024, June 17). AlleCijfers.nl. Retrieved July 29, 2024, from https://allecijfers.nl/gemeente/heiloo/

Geofabrik download server. (n.d.). Retrieved July 29, 2024, from https://download.geofabrik.de/europe/netherlands/noord-holland.html

Geurs, K. T., & Van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: review and research directions. Journal of Transport Geography, 12(2), 127-140.

Gössling, S. (2020). Why cities need to take road space from cars-and how this could be done. Journal of Urban Design, 25(4), 443-448.

Hall, C. M., & Ram, Y. (2018). Walk score® and its potential contribution to the study of active transport and walkability: A critical and systematic review. Transportation Research Part D: Transport and Environment, 61, 310-324.

Heiloo. (2024, June 28). Gemeente Heiloo. Retrieved July 29, 2024, from https://www.heiloo.nl/

Huisartsenpraktijken in Heiloo. (n.d.). Retrieved July 29, 2024, from https://www.zorgkaartnederland.nl/huisartsenpraktijk/heiloo

Lawton, M. P., & Nahemow, L. (1973). Ecology and the aging process. In C. Eisdorfer & M. P. Lawton (Eds.), The psychology of adult development and aging (pp. 619-674). American Psychological Association.

Liu, Z., Ma, J., & Chai, Y. (2017). Neighborhood-scale urban form, travel behavior, and CO2 emissions in Beijing: implications for low-carbon urban planning. Urban Geography, 38(3), 381-400.

MET Dijk en Waard. (n.d.). Retrieved, July 29, 2024, from https://metdijkenwaard.nl/gezondheid-en-leefstijl

Moreno, C. (2020). Et après?# 30 Vie urbaine et proximité à l'heure du COVID-19.

Moreno, C., Allam, Z., Chabaud, D., Gall, C., & Pratlong, F. (2021). Introducing the "15-Minute City": Sustainability, resilience and place identity in future post-pandemic cities. Smart Cities, 4(1), 93-111.

Newman, P., Beatley, T., & Boyer, H. (2017). Resilient cities: Overcoming fossil fuel dependence. Island Press.

Nimkar, U. (2017). Sustainable chemistry: A solution to the textile industry in a developing world. Current Opinion in Green and Sustainable Chemistry, 9, 13-17.

Noordwest ziekenhuisgroep. (n.d.). Retrieved, July 29, 2024, from https://www.nwz.nl/Contact#Locaties

OV in Nederland. (2024, June 29). Retrieved, July 29, 2024, from https://ovinnederland.nl/

Páez, A., Scott, D. M., & Morency, C. (2012). Measuring accessibility: positive and normative implementations of various accessibility indicators. Journal of Transport Geography, 25, 141-153.

Papa, E., & Coppola, P. (2012). Gravity-based accessibility measures for integrated transport-land use planning (GraBAM). In Accessibility instruments for planning practice (pp. 117-124).

Pozoukidou, G., & Chatziyiannaki, Z. (2021). 15-Minute City: Decomposing the new urban planning eutopia. Sustainability, 13(2), 928.

Regio Alkmaar. (n.d.). Bereikbaarheid. Retrieved July 23, 2024, from https://www.regioalkmaar.nl/bereikbaarheid

Reimer, J. (2020). The 15-Minute Infrastructure Trend That Could Change Public Transit as We Know It. CityLab.

Rode, P., Floater, G., Thomopoulos, N., Docherty, J., Schwinger, P., Mahendra, A., & Fang, W. (2017). Accessibility in cities: transport and urban form. In Disrupting mobility: Impacts of sharing economy and innovative transportation on cities (pp. 239-273). Springer.

SafeGraph. (n.d.). Core places. Retrieved, July 29, 2024, from https://docs.safegraph.com/docs/core-places

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

Stations.nl. (2023, March 23). Heiloo - Stations.nl. Retrieved July 29, 2024, from https://stations.nl/stations/heiloo/

Stinchcombe, A., Kuran, N., & Powell, S. (2016). Individual and contextual factors associated with the mental health and wellbeing of older adults in Canada. BMC Geriatrics, 16, Article 175. https://doi.org/10.1186/s12877-016-0201-x

Ulloa-Leon, F., Correa-Parra, J., Vergara-Perucich, F., Cancino-Contreras, F., & Aguirre-Nuñez, C. (2023). “15-Minute City” and elderly people: Thinking about healthy cities. Smart Cities, 6(2), 1043-1058.

Visit Alkmaar. (n.d.). Visit Alkmaar. Alkmaar Marketing. Retrieved July 29, 2024, from https://www.visitalkmaar.com/

Wahl, H. W., Iwarsson, S., & Oswald, F. (2012). Aging well and the environment: Toward an integrative model and research agenda for the future. The Gerontologist, 52(3), 306-316.

Ward, R., Clark, A., Campbell, S., Graham, B., Kullberg, A., Manji, K., ... & Keady, J. (2018). The lived neighborhood: understanding how people with dementia engage with their local environment. International Psychogeriatrics, 30(6), 867-880.

Weng, M., Ding, N., Li, J., Jin, X., Xiao, H., He, Z., & Su, S. (2019). The 15-minute walkable neighborhoods: Measurement, social inequalities and implications for building healthy communities in urban China. Journal of Transport & Health, 13, 259-273.

Winters, M., Teschke, K., Brauer, M., & Fuller, D. (2016). Bike Score®: Associations between urban bikeability and cycling behavior in 24 cities. International Journal of Behavioral Nutrition and Physical Activity, 13, 1-10.

Xing, Y., Handy, S. L., & Mokhtarian, P. L. (2010). Factors associated with proportions and miles of bicycling for transportation and recreation in six small US cities. Transportation Research Part D: Transport and Environment, 15(2), 73-81. https://doi.org/10.1016/j.trd.2009.09.004

Yen, I. H., Michael, Y. L., & Perdue, L. (2009). Neighborhood environment in studies of health of older adults: a systematic review. American Journal of Preventive Medicine, 37(5), 455-463.

Zumelzu, A., & Barrientos-Trinanes, M. (2019). Analysis of the effects of urban form on neighborhood vitality: five cases in Valdivia, Southern Chile. Journal of Housing and the Built Environment, 34(3), 897-925.

Appendix

Table 1

Points of interest	Motive	Alkmaar	Heiloo	Dijk en Waard	Row total	Normalized	Weights per POI
Education	Education	1.28%	0.00%	0.00%	0.48%	0.55%	0.55%
Shopping	(grocery) shopping	44.87%	36.78%	33.52%	38.42%	44.35%	44.35%
Recreation	Touring/walking	19.87%	6.90%	22.73%	18.38%	21.21%	42.70%
	Other leisure activities	4.49%	14.94%	3.41%	6.21%	7.16%	
	Other motive	1.92%	2.30%	1.70%	1.91%	2.20%	
	Visit/staying	7.69%	13.79%	11.36%	10.50%	12.12%	
Sports	Sport/hobby	5.13%	8.05%	11.36%	8.35%	9.64%	9.64%
Personal care	Service/personal care	3.21%	5.75%	0.00%	2.39%	2.75%	2.75%
					86.63%	100.00%	

Table 1: Weight calculations

Figure 8

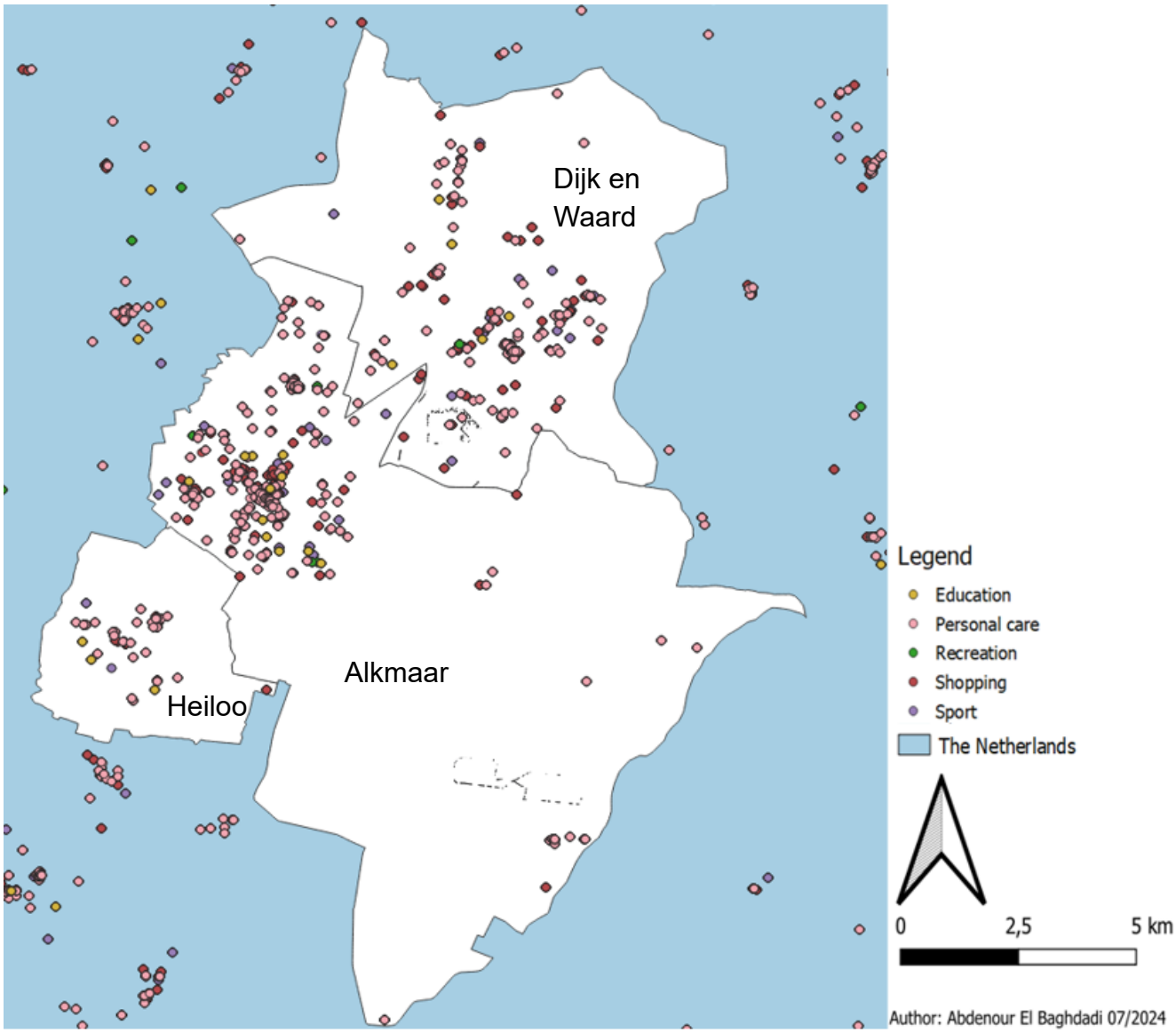

Figure 8: Service points in and around the region Alkmaar