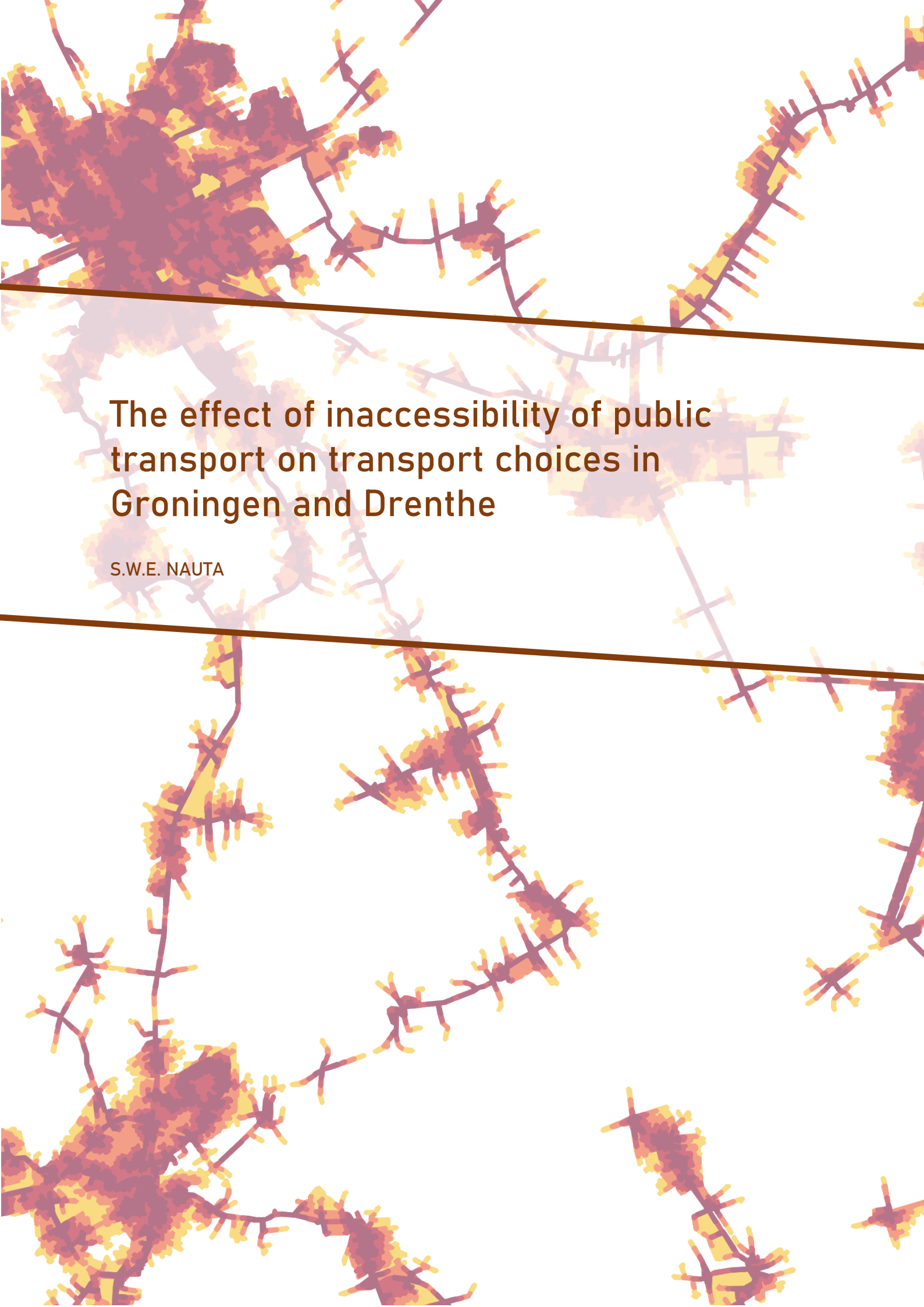

The effect of inaccessibility of public transport on transport choices in Groningen and Drenthe

S.W.E. NAUTA

Abstract

This research explores the perceived accessibility within the Dutch provinces of Groningen and Drenthe. A combination of qualitative and quantitative research looks into the effects of little to no excess to public transport in low-density areas. With the use of network analysis, it established accessibility deserts in the regions. In four of these areas, a questionnaire is spread to look further into their social-economic status, capabilities and attitudes towards transportation. In these regions, it is found that car and bicycle are the most used transportation modes and public transport is rarely used for transportation to main activities on the week of weekend days. The main finding of this research is the relationship between the transport mode choices on weekdays and weekends. The choice of transport mode in the week influences the choice of transport mode in the weekend, mostly showing that the respondents have the habit of choosing one mode of transport for all situations. It was also found that there is a relation between the reason why they pick their transport mode on weekdays and weekends. This means that here again people handle from a place of habit and something that is known. Within the sample of this study, there might have been an under presentation of the minorities living in the region based on the sampling method and due to COVID-19 restrictions on public transport.

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1.0 – Introduction

With the rising attention for sustainability in transport, the focus has shifted towards the use of public transport in mostly urban areas. This research investigates how the inaccessibility of public transport affects the choice of mode of transport. The focus is on the areas that are of low density. In these areas, it is traditionally harder and less cost-effective to offer public transport (Jong et al., 2011). In most metropolitan areas, it is found that the integration of public transport is mostly focused on areas with a high population density and activity (Nigro et al., 2019). However, due to increasing urbanisation, we also see an ageing population in the lower density areas of the Netherlands. Furthermore, this increase in urbanisation lead to public transport heading into a vicious circle described by Jong et al. (2011, p. 68);

> *"The decrease in demand led to a decrease in supply, leading to a decrease in demand, etc.".*

In the Netherlands, the number of cars in private ownerships has increased faster than the population above 18 (Kampert et al., 2017). The biggest growth in car ownership between 2006 and 2016 was in the group above 65 years old. Citizens over 65 in the Netherlands are becoming increasingly wealthier and therefore are able to own a car for a longer time. (Kampert et al., 2017)

This research is also focused on the supply of public transport from the mobility justice view. The ability to move or remain stationary is unequally distributed. Some people can travel over long distances with relative ease and comfort, while others must endure daily travels that cover relatively little ground but take an inordinate amount of time (Bierbaum et al., 2021). This can be the result of the inefficient availability of different mode choices, which then continues to increase the effect of the ageing population in lower-density areas. Sheller (2018) also added that often in planning groups are neglected because of the assumption that walking and bicycling are possibilities available for all. Sheller (2018) also noted with the increasingly expensive city centres lower-income groups get pushed out of the city into lower-density areas surrounding the city. However, the most changes and job opportunities are still found in the city as well as most facilities. Without sufficient public transport, these people can easily get excluded.

Lucas (2012) also found that there is not only a disadvantage that is experienced by the traveller but that this can also be linked to economic and social exclusion. Therefore, this topic is very relevant to creating a society that offers equal chances to everyone. Previous research has already proved multiple times that there is a big interplay between the availability of good transportation options and the social-economic inequality within the context of the UK and the US (Lucas, 2012).

Therefore, the goal of this research is to find out where in the region of Groningen and Drenthe and also to what the effects are for these people on their abilities and possibilities.

This research will answer the following question;

- *How does the inaccessibility of public transport influence life in relation to transport choices in Groningen and Drenthe?*

To answer this research question the following sub-questions have been set up to provide an answer to the main research question;

- *Which places in the region of Groningen and Drenthe have little to no accessibility by public transport?*
- *What is the effect of little to no accessibility of public transport on mode choice?*
- *What is the perceived effect of little to no accessibility of public transport by inhabitants of the region?*

2.0 – Theoretical framework

2.1 Mobility justice

As explained before, there is not an equal ability for all to move to and from places based on where they live (Bierbaum et al., 2021). Mobility justice is a movement in research that criticizes transportation equity for focusing solely on distributive justice, which prioritizes access to opportunities while ignoring the larger issues outlined above. (Bierbaum et al., 2021).

There are multiple negative effects known for populations that are not well connected to a public transport network. First of all, the inaccessibility of public transport can have a negative effect on one's quality of life. Because of a lack of public transportation available, the access to basic service can become mainly dependent on the use of a privately owned car (Errington, 1994) (Mugion et al., 2018). This dependence on a car can have an especially negative effect on those who are not able to afford a car or are not able to drive a car. Because this can exclude one from new possibilities to improve the quality of life and can exclude you from basic services that are better accessible in villages (Errington, 1994). Additionally, Errington (1994) also found that lower density areas are also characterized by high levels of car ownership partly because people moving in from higher density areas want to retain their previous lifestyles. This means that they need a car to frequently visit urban areas.

Within the creation of transport networks according to the movement of mobility justice, there should also be a deliberative focus on the determination of which governmental actions should be protected and which should be reduced. Examples of such actions are the funding for the expansion of physical access to public transport, which should increase according to the mobility justice movement. (Sheller, 2018). Sheller (2018) composed multiple principles of mobility justice of which two apply to public transport and relate to principles central in this research.

- *"Public transport systems must not arbitrarily deny access nor impose undue burdens, externalities, or limitations. (…)*
- *Cities should ensure equitable provision of public transportation through a social benefit analysis based on population-level measures of social exclusion and minimum thresholds of accessibility (as described by Martens); and should seek to reverse the historical subsidies and other preferential treatment given to private automobility."*

  Sheller (2018, p. 229-230)

2.2 Factors when choosing public transport

It is critical to recognize that whether using public transportation or driving, the primary purpose of transportation is to go somewhere. (Mugion et al., 2018). Therefore, multiple factors can influence choosing behaviour when picking a mode of transport for a trip. Convenience is often one of the most important factors. Convenience is particularly related to the frequency in which each type of public transport is available. At this moment this availability is mostly, depends on the demand visible for the public transport provider (Jong et al., 2011). Another aspect that is also important for travellers is safety, by increasing the feeling of safety demand can rise (Jong et al., 2011). The effect of price is a little more complex. It has been seen that a small decrease in price often

does not have the requested effect. However, a generous change in the cost of travelling with public transport can change the behaviour of travellers (Jong et al., 2011). This can be explained by the fact that this small price often does not outweigh the convenience of a car. It is important to state that urban density is by far not the only factor that can influence the attractiveness of public transport. The main influence is the quality of the public transport network. (Nigro et al., 2019)

2.3 Perceived accessibility

This research will look into the perceived accessibility of public transport for the inhabitants of the area. When investigating the accessibility of a place, often there is only an evaluation using spatial data however when taking into account the perceived accessibility the research can get a better understanding of the impact of little to no accessibility of public transport for the inhabitant of the area (Pot et al., 2021).

For this research the definition as given by Pot et al. (2021, p.2) will be used;

> *"perceived accessibility is defined as the perceived potential to participate in spatially dispersed opportunities. This definition builds on the view that accessibility is most generally about the potential to engage in activities distributed across space."*

Important for perceived accessibility is that it is highly influenced by one's perception of the environment. Therefore, two neighbours in the same area could perceive the effect of their accessibility to public transport very differently from each other. Pot et al. (2021) proposes a model of perceived accessibility that will be central for this research data collection. In this model, the different components explaining why people perceive accessibility different from others are made clear. (Pot et al., 2021)

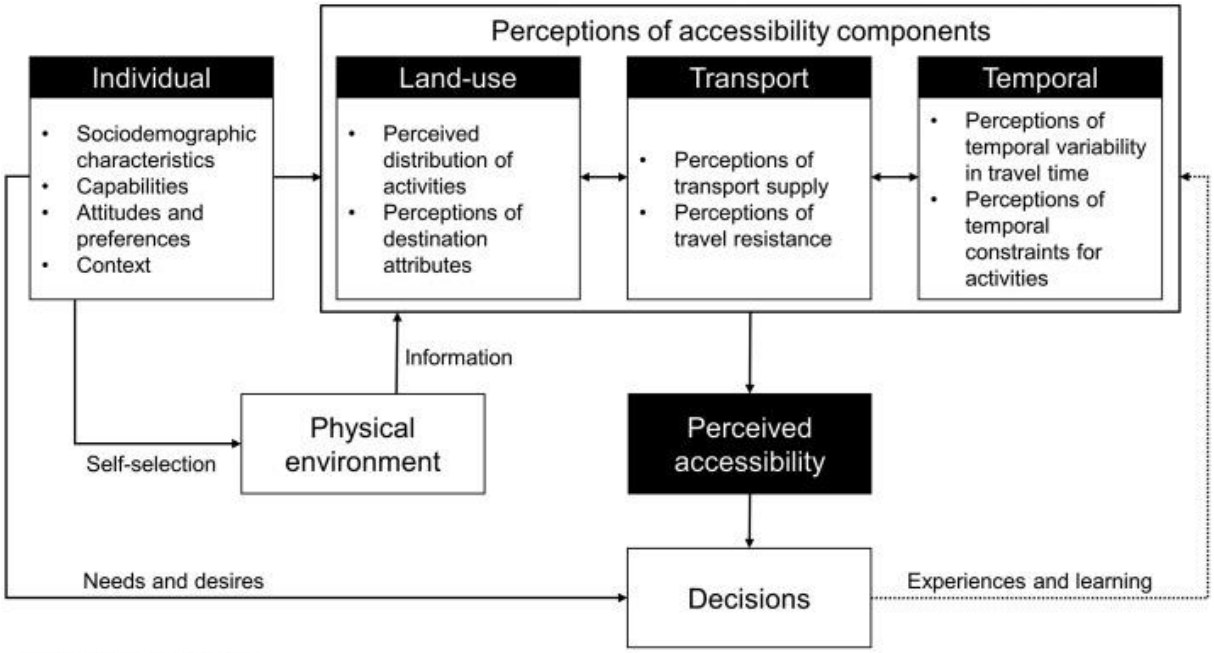

Figure 1 – Model of perceived accessibility made by Pot et al., (2021)

2.4 Social Exclusion

The definition of social exclusion used for this research is;

> *"Social exclusion is a complex and multi-dimensional process. It involves the lack or denial of resources, rights, goods and services, and the inability to participate in the normal relationships and activities, available to the majority of people in a society, whether in economic, social, cultural or political arenas. It affects both the quality of life of individuals and the equity and cohesion of society as a whole."* – Levitas et al. (2007, p. 9)

When discussing social exclusion related to transportation issues it is essential to see that the concept of social exclusion highlights the relationship between the individual circumstances and the local area in which the individual wants to move, combined with factors such as the local services and economy, culture and migration (Lucas, 2012). For this research, there will be a focus on the individual characteristics and the local areas offerings. An important example of this influence of transport modes on social exclusion is the ability to own a car. It is seen that those who can own a car often travel more than half the distance of the distance travelled by non-car owners, because of this if you are not able to own a car you are excluded from changes. (Lucas, 2012)

Lucas (2012) also composted a diagram to show all of the different components that can influence social exclusion. See Figure 2 for this diagram. This diagram shows multiple influences that are taken into consideration for the questionnaire created for this research. Furthermore, Lucas (2012) also states that to analyse exclusion based on transport mode possibilities, it is vital to get an insight into the users own preferences, needs and attitudes that influence their view on the public transport mode choice that is available.

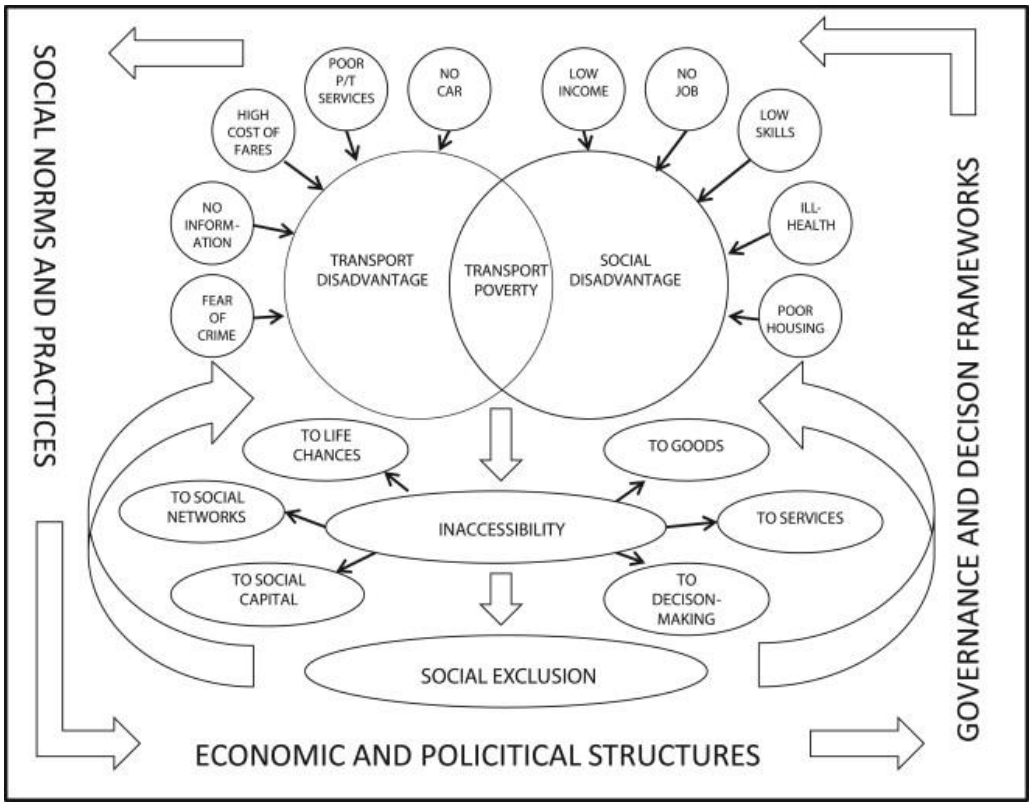

Figure 2 – Diagram to illustrate the relationship between transport disadvantage, social disadvantage and social exclusion by Lucas (2012)

2.5 Conceptual model

The conceptual model of this research can be seen in Figure 3. The first part of this research will be done via the ARE calculation method of the Swiss Confederation (Glezendanner, 2011). With this method, the quality level of public transport service in the region Groningen and Drenthe will be established. With this information, the lowest-scoring areas with little to no access to public transport will be selected. In these areas, this research will look into the effect of the low accessibility level. This will be done based on the choice-making process of the residents and the perceived availability.

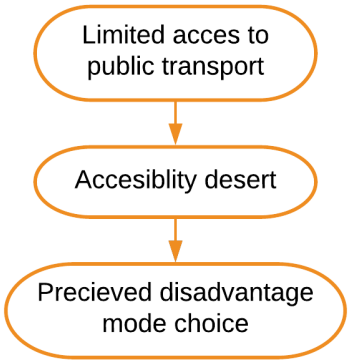

Figure 3 – Conceptual model

2.6 Hypothesis

Based on the literature review it is expected that within the mobility deserts car use will be more frequent than in areas with high accessibility to public transport. It is expected that the residents will be aware of their limited possibilities. Mostly the elderly and youth will experience the biggest mobility injustice.

3.0 – Methodology

3.1 Research area

In the Netherlands, public transport is grouped into various public transport authorities. The regions of Groningen and Drenthe are combined under one organization, the 'OV bureau Groningen Drenthe' (Jong et al, 2011). In the Netherlands, the service area of the OV bureau Groningen Drenthe is one of the biggest and cover many low-density regions. Figure 4 shows the population density in both the province of Groningen and Drenthe on the neighbourhood level according to the CBS (2020).

To answer the research question this research is divided into three steps. The first step is to identify which areas have the lowest level of accessibility. To identify these areas quantitative research will be conducted. This first step is further explained in the following part. The second step is the selection of The second step is to determine the effects for the inhabitants on living in the lowest level of accessibility areas. This will be done via qualitative research explained further on the next page.

To illustrate all the methodological steps a data analysis scheme has been made. This can be seen in Figure 5. The figure shows all the steps to be taken to come to the answer to the research question.

Figure 4 – Map of the population density in the research area (Geoproccesed by Nauta, S.W.E.: data retrieved from CBS, 2021)

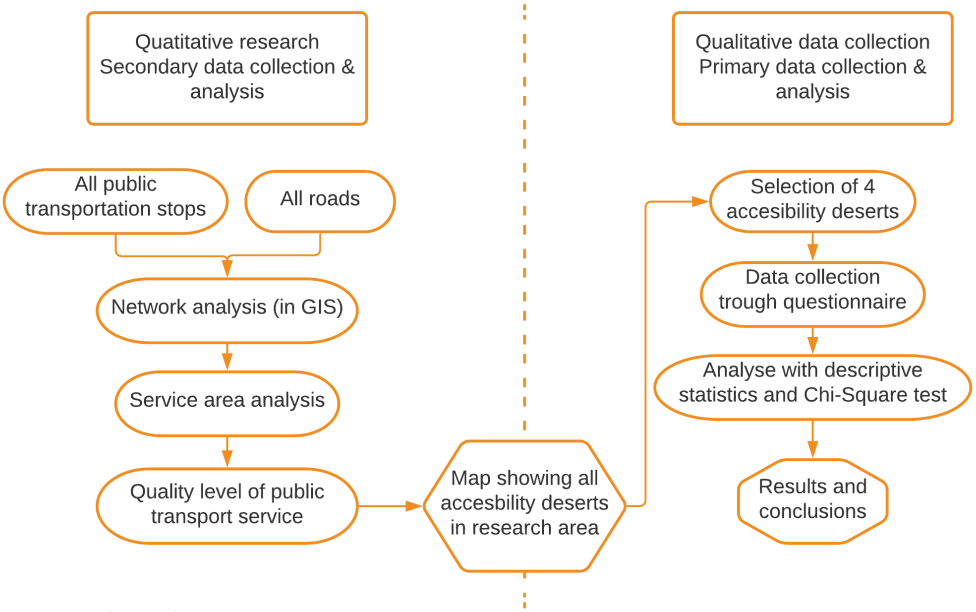

Figure 5 – Data analysis scheme

3.2 Step 1: Secondary data collection & analysis

The goal of the first step of the research is to establish the service area of the public transport network. For this, the network analysis tool of ArcGIS Pro will be used. To use this tool different types of data are needed. First of all, there is a need for all the stops in the area for different types of public transport available. In the research area Groningen & Drenthe there is a bus network and a train network. Therefore, the location of the bus stops and train stations have to be collected. In this research, this data for the bus stops was obtained from the OVapi B.V. and the data for the train stations was collected from the Nationaal Georegister (national georegister). The second type of data that is necessary is that off all roads. This data is needed for network analysis. This data was extracted from the Nationaal Wegenbestand (National roads file).

Other data that is also needed are the municipality borders and postal code borders (4 digits). Both these types of data are provided by Esri and are detracted from the Basisregistratie Kadaster (Basicregistration Kadaster). For the comparison to the population density, this data can be collected via the Centraal Bureau Statistiek (CBS).

3.2.1 Network analysis

The analysis is first based on the report written by the Federal Office for Territorial Development ARE, from Switzerland (Glezendanner, 2011). In their analysis, they look into the service network of the public transport available with the use of buffers. The buffers are around stops from various public transportation. Based on easy walking distances they used 4 categories for travelling;

- < 300 meters
- 300 - 500 meters
- 501 - 750 meters
- 751 - 1000 meters

These buffer distances were also used for the bus stops in the research area of this research. This gives the first look into the service area of the bus in the region Groningen & Drenthe. However, another important form of public transport in the Groningen and Drenthe region is the train. Therefore the same method has to be used to give the first insight into the service area of the train. For the train, people are often willing to travel towards the station by bike instead of just walking (SOURCE). Therefore greater distances were used to give insight into the train service network. The following buffer are formed;

- < 2000 meters
- 2001 - 3000 meters
- 3000 - 5000 meters

Using this method one can get a first look into the service network of public transport in the area. However, to create a more precise look into the service network of public transport this research does a network analysis with a GIS tool. To do a network analysis for the service area there is a need to have the existing road network available for the form of transport that you are interested in. The combination of the road network with the bus stops and trains

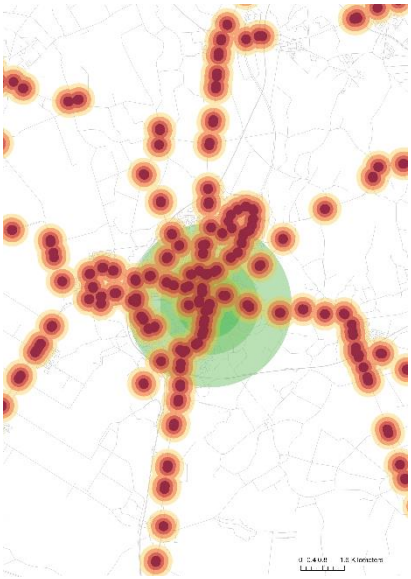

Figure 7 – Example Buffer

Figure 6 – Example Network Analysis

stations provides a way to see how far one can go or come from within a certain distance. For the network analysis, the same distance will be used to perform public transport as for the buffer service area analysis. This provides an interesting difference in the service network. To To establish the accessibility deserts in which step 2 of the research will be conducted is done via postal code barriers. With the use of four-digit postal code barriers, this research can see in which area people live but since there is no direct need for the address the use of postal codes is better for the privacy of the participants.

illustrate this better see Figures 6 & 7. In this figure, you see a part of the research area zoomed in with both types of analysis. Here one can seed the better difference between the buffer service area and the network analysis service area.

The choice of the research areas was done based on the absence of the service area of public transport. All areas need to have at least 5 different postal codes or a total amount of address of 500 to be suitable for this research. This has to do with the feasibility of this research within the set time frame.

3.3 Step 2: Primary data collection & analysis

For the primary data collection, a questionnaire is conducted in the identified areas of accessibility deserts. Within the 4 chosen accessibility deserts the questionnaire is spread. The area selection was based on the postal code areas and the network analysis. In each of the areas, there is very little to no accessibility to the public transport network. Within each of the research areas, the questionnaire is spread through convenience sampling.

3.3.1 The Questionnaire

The questions of the questionnaire are based on Figure 1, the model proposed by Pot et al. (2021) and Figure 2 by Lucas, (2012). The questions are based around the factors that influence perceived accessibility from Figure 1;

- Individual
  - Sociodemographic characteristics
  - Context
  - Capabilities
  - Attitudes and preferences
- Land-use
  - Perceived distribution of activities
- Transport
  - Perceptions of transport supply
  - Perception of travel resistance
- Temporal
  - Perception of temporal variability in travel time

Within each of these categories, some questions have been designed to fit one of the subcategories. The full questionnaire can be found in appendix 1. The questions around the socioeconomic status are based on the European Social Survey (Netherlands • Documents and Data Files, 2018)

3.3.2 The Chi-square test

To analyse the collected data the Chi-square test has been used. The Chi-square test is suitable for both nominal and ordinal variables. The test is used to figure out if the two variables are interdependent. With the Chi-square test, the null hypothesis is always there is no relationship between the two variables and this hypothesis can only be rejected when the test is significant. An important requirement of the Chi-Square test is that for a maximum of 20% of the cells the expected count is less than 5. If that is a higher percentage then the chi-square test can no longer be used. Then one can look at the likelihood ratio, also given in SPSS.

The Chi-Square test only says something about the existence of a relationship between the two variables. It does not say something about the strength of the relationship. The measure the strength of the relationship a measure of association is used. For this research measure of association that is used is Cramér's V (V). To establish the strength of the relationship the division shown in Table 1 will be used. V will only be used if the Chi-Square test or the likelihood ratio is significant. Because only when a relationship between both variables is established, there can be looked into the strength of the relationship. (Burt et al., 2009)

Table 1 – Interpretation strength of the relationship with Cramer's V

Value of Cramer's V	Interpretation strength of the relationship
< 0.3	(very) weak
0.3-0.5	Moderate
0.5-0.7	Strong
0.7-0.9	Very Strong
> 0.9	Extremely strong (Suspicious?)

4.0 – Results

4.1 Service area

Figures 8 and 9 show the three phases of the analysis of the service area that has been done for his research. The first map on both figures shows all the roads in the area in combination with Figure 8 the bus stops located in the research area and Figure 9 the train lines and train stations and all the roads in the research area. The second map shows the analysis by a buffer.

For the bus stops the lightest colour shows the service area (1000 meters) from the stops, whilst for the trains, the lightest green shows the furthest distances from the station (5000 meters). If this research would have stopped here for the analysis of the service area a great deal of precision would be lost. There the 3rd map shows the network analysis done for this service area. The analysis gives a clearer image of the service area of the public transport network.

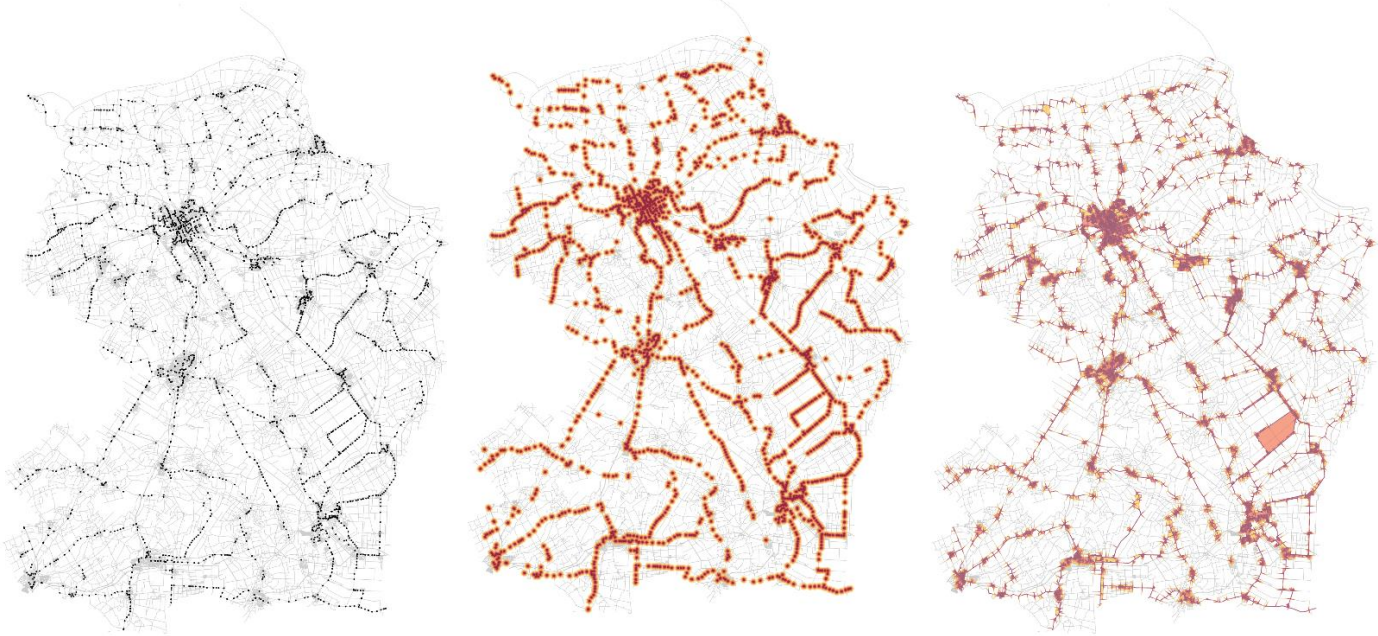

Figure 8 – The 3 steps of GIS analysis bus (Geoproccesed by Nauta, S.W.E.: data retrieved from OVapi B.V. (2021) & NWB (2021))

Figure 9 – The 3 steps of GIS analysis train (Geoproccesed by Nauta, S.W.E.: data retrieved from OVapi B.V. (2021) & NWB (2021))

4.2 The selection of the research areas

The selection of the research areas was based on the combination of the service area of the bus, the service area of the train and the postal code areas. Figure 10 shows the combination of the service area of both the train and bus available in the area. The figure also shows the four selected regions for further research with the questionnaire. The service areas of the bus and train network are covering very little to no area within the 4 selected research areas. The research areas can be seen well in Figure 12 on the next page of this thesis or in appendix 3. Figure 12 also shows the location of the research areas in the region. Figure 12 also show a smaller map of every area specifically with the corresponding postal codes.

For the selection of the 4 research areas, the population density was also taken into consideration. This show that there are still many residents in the area that are not well connected to the public transport network.

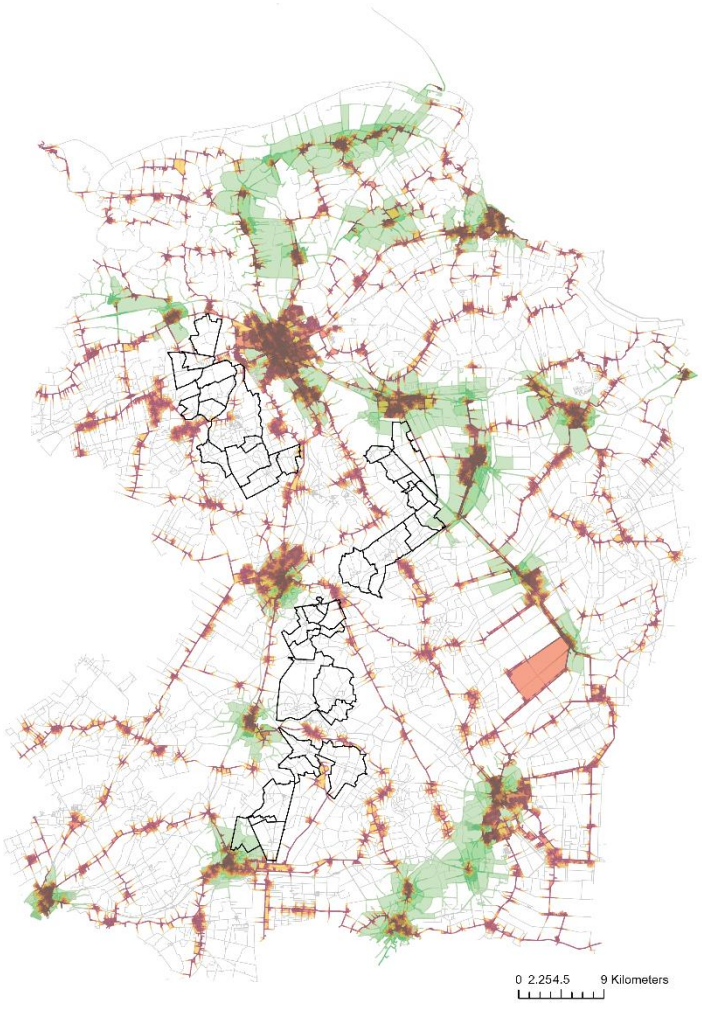

Figure 10 – Combination of the network analysis and research areas (Geoproccesed by Nauta, S.W.E.: data retrieved from OVapi B.V. (2021), NWB (2021) & Basisregistratie Adressen en Gebouwen (2021))

Figure 11 – Combination of the population density and the research areas (Geoproccesed by Nauta, S.W.E.: data retrieved from CBS (2021) & Basisregistratie Adressen en Gebouwen (2021))

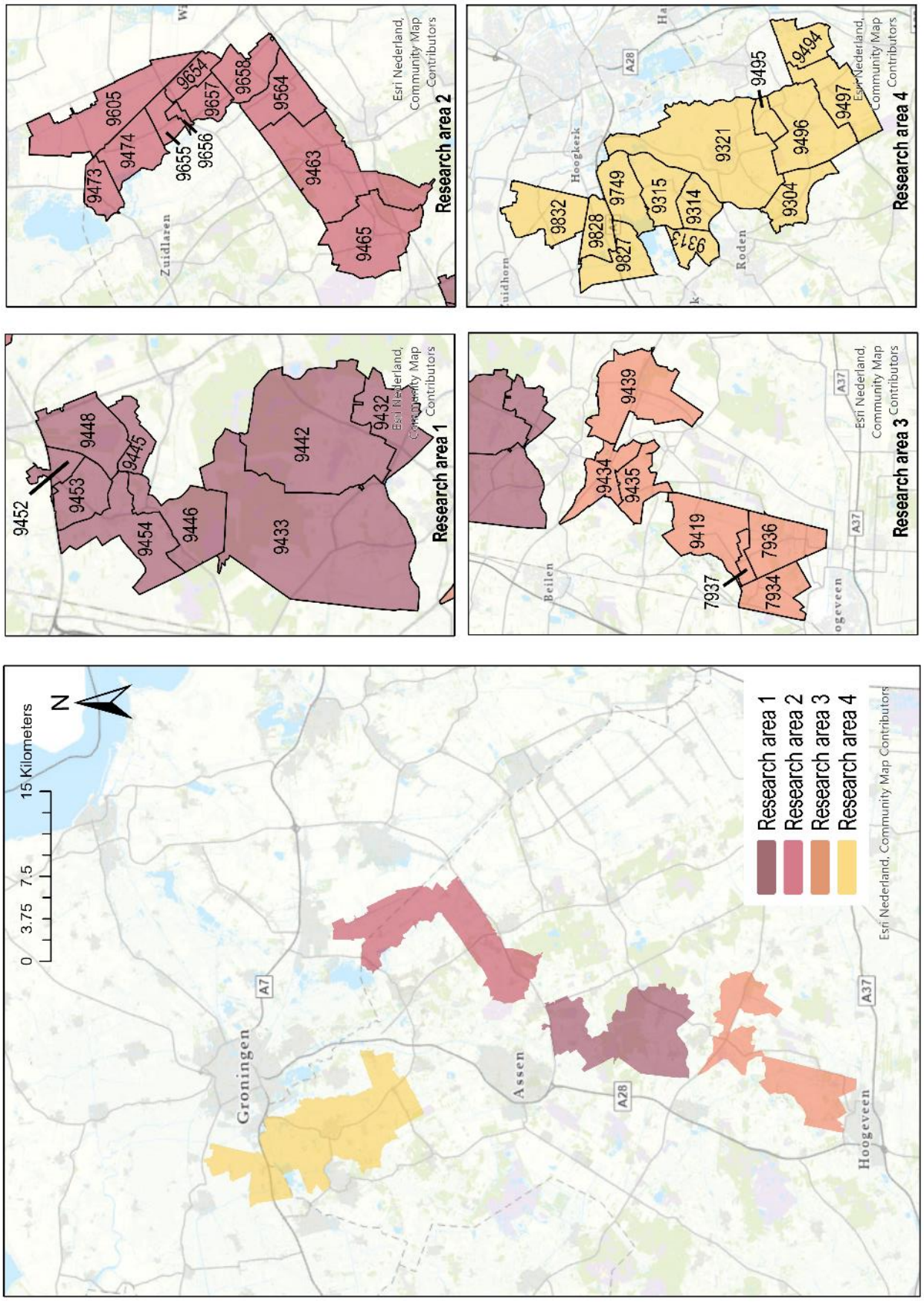

Figure 12 – Map of the location of the research areas combined with the research area postal codes in detail (Geoproccesed by Nauta, S.W.E.: data retrieved from Basisregistratie Adressen en Gebouwen (2021))

4.2.1 Research area 1

Research area 1 is located just south-east of Assen and northeast of Beilen. The region's biggest villages are located in the south of the area. The total amount of address locations for the area is 828. Within this research area, there are no bus stops and train stations. Very little of the area is within reach of a bus or train station as can be seen in figure 14.

Table 2 – Postal codes area 1

Postal code	Address locations	Villages
9432	32	Zuidveld
9433	357	Zwiggelte
9442	18	Elp
9445	12	Vredenheim
9446	41	Amen
9448	32	Marwijksoord
9452	32	Nijlande
9453	15	Eldersloo
9454	126	Ekerhaar
9 Postal codes	828 total	

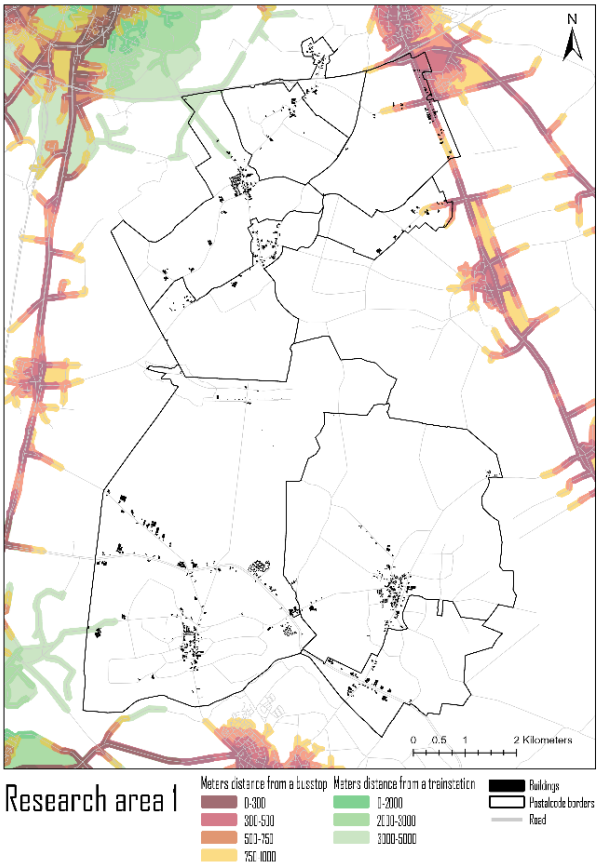

Figure 14 – Map of Research area 1 (Geoproccesed by Nauta, S.W.E.: data retrieved from OVapi B.V. (2021), NWB (2021) & Basisregistratie Adressen en Gebouwen (2021))

4.2.2 Research area 2

Research area 2 is located between the villages Hoogezand, Veendam, Zuidlaren and Gieten. The biggest village in the region is Eext, after that the biggest village is the village of Kiel-Windeweer which is located mostly alongside the Kieldiep (waterway). With 2178 address location in research area 2 it is a region that houses more inhabitants and businesses than research area 1. Within research area 2 there are no bus stops or stations, however close to the border of this research area a few bus stations can be found.

Table 3 – Postal codes area 2

Postal code	Address locations	Villages
9463	676	Eext
9464	64	Eexterzandvoort
9465	116	Anderen
9473	219	De Groeve
9474	143	Zuidlaarderveen
9605	401	Kiel-Windeweer
9654	198	Annerveensche Kanaal
9655	49	Oud Annerveen
9656	65	Spijkerboor
9657	46	Nieuw Annerveeen
9658	201	Eexterveen
11 Postal codes	2178 total	

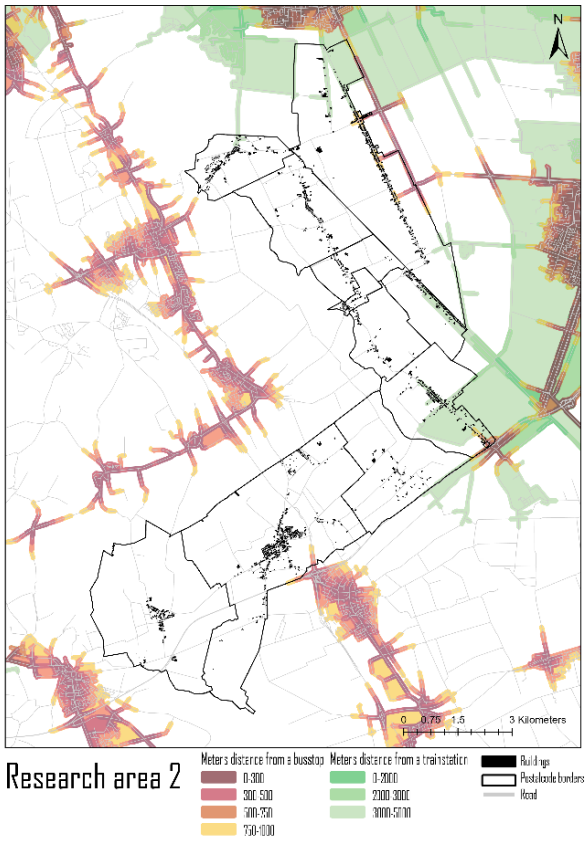

Figure 13 – Map of research area 2 (Geoproccesed by Nauta, S.W.E.: data retrieved from OVapi B.V. (2021), NWB (2021) & Basisregistratie Adressen en Gebouwen (2021))

4.2.3 Research area 3

Research area 3 is located north of Hoogeveen and southeast of Beilen. Research area 3 has several villages and a total of 1421 address locations. There are no bus stops or train stations located within the area. However, a part of the postal code region 7934 is in the service area of the train station in Hoogezand.

Table 4 – Postal codes area 3

Postal code	Address locations	Villages
7934	257	Stuifzand
7936	353	Tiendeveen
7937	29	
9419	223	Drijber
9434	33	Eursinge
9435	27	Bruntinge
9439	499	Witteveen
7 Postal codes	1421 total	

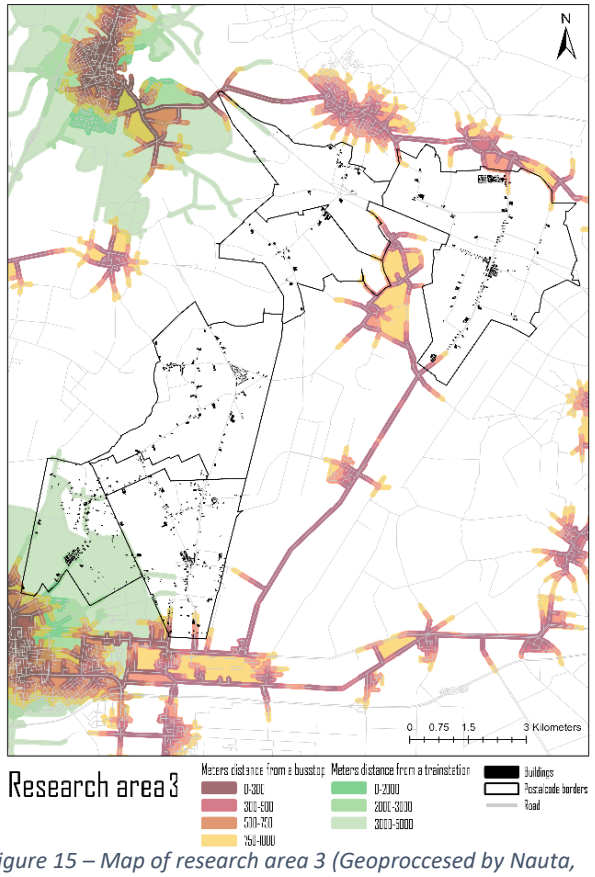

Figure 15 – Map of research area 3 (Geoproccesed by Nauta, S.W.E.: data retrieved from OVapi B.V. (2021), NWB (2021) & Basisregistratie Adressen en Gebouwen (2021))

4.2.4 Research area 4

Research area 4 is the biggest research area of the 4. The area is located west of Groningen and east of Roden and Leek. The area is very close to the biggest city in the region Groningen-Drenthe, but still very little of the area is within the service area of public transport. The village of Peize is the biggest in the research area. Within this village there are bus stops available, however, these do not provide a big enough service area to cover the whole village or postal code area. Therefore this area is especially interesting for this research.

Table 5 – Postal codes area 4

Postal code	Address locations	Villages
9304	116	Lieveren
9313	74	Leutingewolde
9314	104	Foxwolde
9315	165	Roderwolde
9321	2639	Peize, Altena
9494	381	Yde (de Punt)
9495	38	Winde
9496	95	Bunne
9497	203	Donderen
9749	186	Matsloot
9827	73	Lettelbert
9828	310	Oostwold
9832	176	Den Horn
13 Postal codes	4560 total	

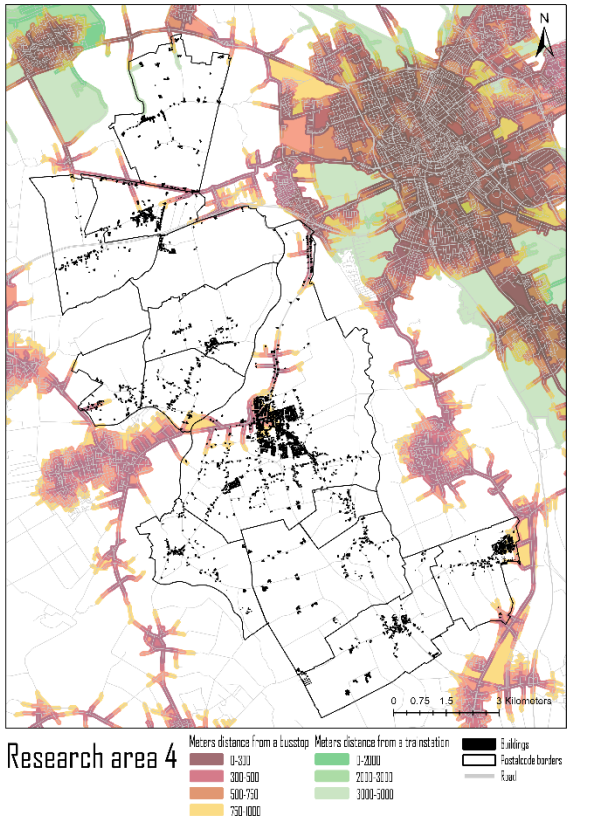

Figure 16 – Map of research area 4 (Geoproccesed by Nauta, S.W.E.: data retrieved from OVapi B.V. (2021), NWB (2021) & Basisregistratie Adressen en Gebouwen (2021))

4.3 Questionnaire results

Within this section, the outcomes of the questionnaire will be discussed according to the categories as well as the addition of the weekday vs. weekend comparison. The first category that will be briefly discussed is the sociodemographic characteristics of the sample. The second category which is discussed is the capabilities related to transport and mobility of the sample. Combined with the sociodemographic characteristics this gives an insight into the options of the respondents when needing to use transport. Category 3 and 4 are about the perceived distribution of activities, the attitudes and preferences when using transportation. From these two categories, an interesting relationship was found between the weekday and weekend. The last category discussed is transport and temporal, this category's possible relationship to other categories gives insight into the perceived accessibility by directly asking.

General

The questionnaire got a total of 131 replies that were selected based on the given postal code of the respondent. The respondents were located in all 4 of the research regions, however not from every specific postal code. The distribution of respondents is illustrated in Table 6.

Table 6 – Distribution of respondents over postal codes

Research area	Postal code	Number of respondents	Sum per research area
1	9446	6	
	9454	5	
	9456	1	
	9447	1	13
2	9473	25	
	9464	1	26
3	9419	24	
	9439	1	25
4	9321	38	
	9304	26	
	9331	1	
	9495	1	
	9827	1	67
		Total	131

4.3.1 Sociodemographic characteristics

The sociodemographic characteristics of the sample can indicate their possibilities, needs and preferences. Within this sample, most of the respondents were female, have a job and have a high income. In Figures 18, 19 & 20 the distribution of these questions has been shown. The mean age is 55 and the age distribution is shown in Figure 17. The distribution shows that a wide range of different ages has been reached which is important to ensure no group is excluded for this research. The ages have been categorized into age groups, this has been done to make the variable more suitable for statistical testing. The 5 age groups were based on age groups used by CBS (Leeftijdsverdeling, 2021).

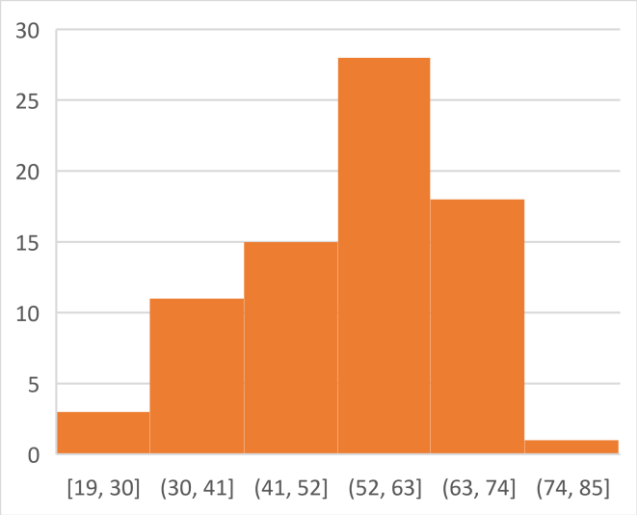

Figure 17 – Histogram of the age distribution of the sample

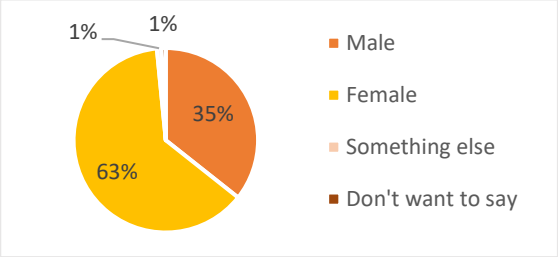

Figure 18 – Gender distribution of sample

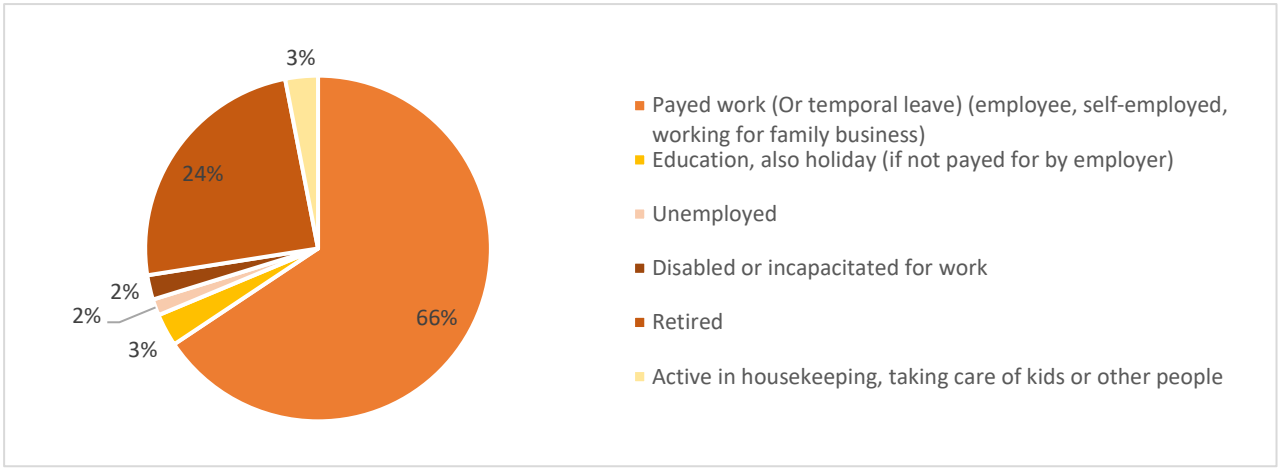

Figure 20 – Employment situation of the sample

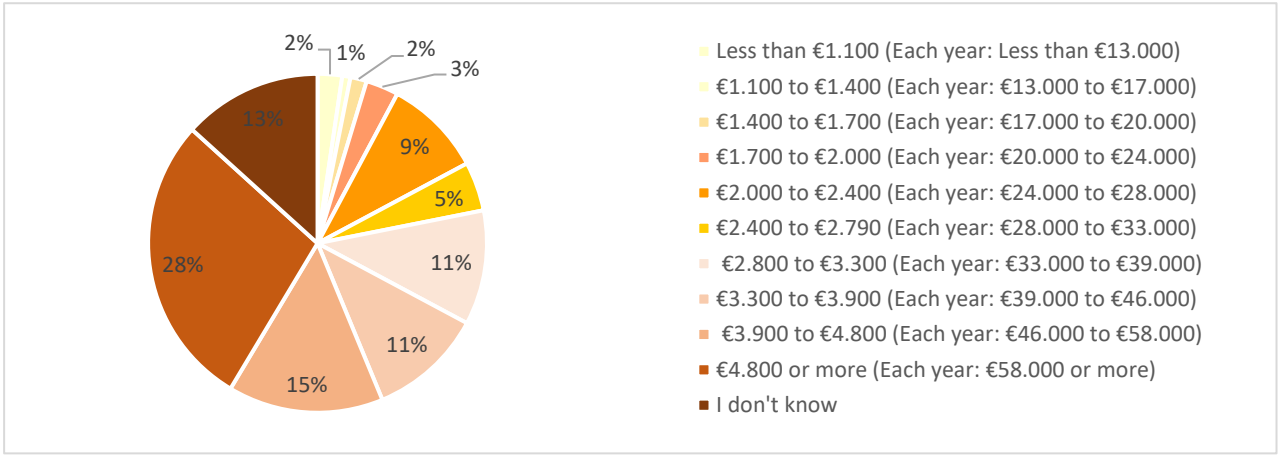

Figure 19 – Income distribution of the sample

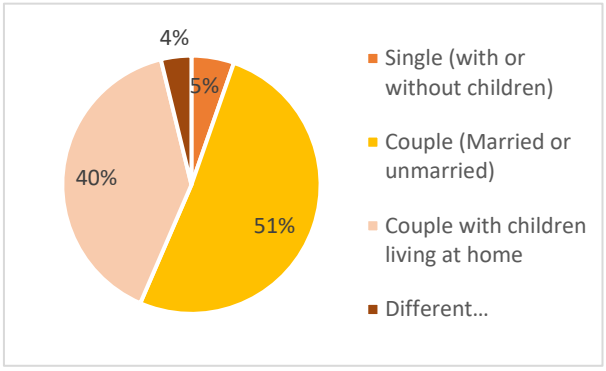

Figure 21 – Distribution of household types in the sample

From the respondents, most are in a couple either with children living at home or a couple without children. The combination of these sociodemographic characteristics of the sample shows the general profile of a working civilian in a household of at least two with a medium to high income.

4.3.2 Capabilities

To create insight into the capabilities of the sample several questions were asked. The results for these questions are shown in Table 7. The combination of these results shows that the majority of the sample has access to multiple forms of transportation and is classifiable as very mobile. This can influence the perceived accessibility of the sample.

Table 7 – Results questions about capabilities respondents

Amount of respondents that have or are capable…	
Valid driver's licence	96,2 %
Access to a car	94,4 %
Able to ride a bicycle	97,7 %
Access to a normal bicycle	53,4 %
Access to an electrical bicycle	44,3 %
Ability to walk long distances (over 500 m)	93,9 %
Easy access to the internet	100 %

Unfortunately, within the sample, every respondent answered yes to the questions about easy access to the internet. Because of this the question became unfit for the Chi-square test and could not be compared to other factors. This phenomenon can be explained by the distribution technique of the questionnaire, since this was mostly done via the internet, partly due to the COVID-19 pandemic. Within the sample, people from the youngest age group (<20) have less access to the car and often do not poses a driver's licence.

4.3.3 Perceived distribution of activities

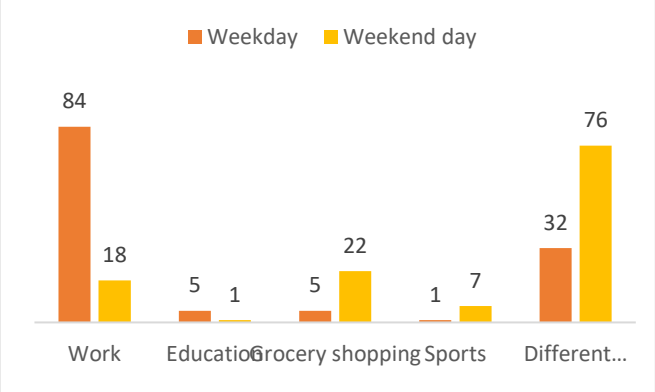

Figure 23 – Distribution of the main activities

With the perceived distribution of activities, respondents were first asked what their main activities are during the week and weekend. The distribution of these activities is shown in figure 23. The results show that most of the samples work during the week and have different types of activities during the weekend. This can influence the perceived accessibility since the type of activity is often related to whether there is a need to travel. To see if this relationship was also found in this research, the sample was split into two groups by the following question: *Do you need to travel for your main activity?*. The distribution of the answers is shown in Figure 22 and Figure 24. All of the respondents that did not answer 'No' got more in detail questions about the travel needs for their main activities.

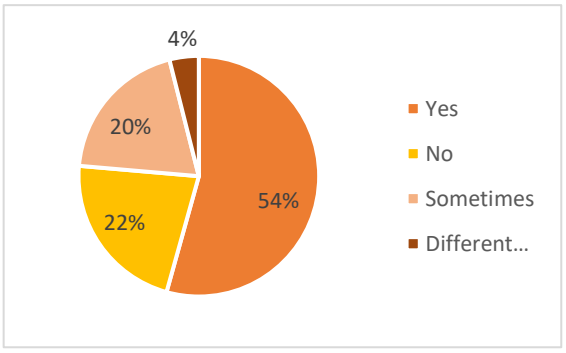

Figure 22 – Answers given; do you need to travel for your main activity? (weekday)

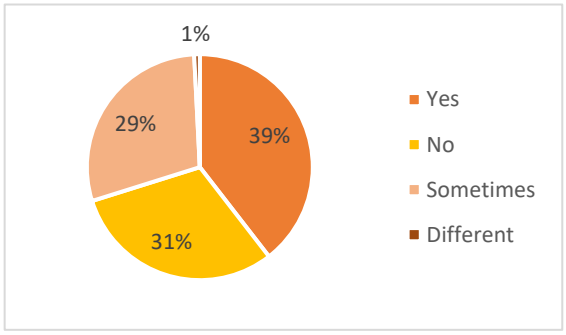

Figure 24 – Answers given; do you need to travel for your main activity? (weekend day)

With the use of the chi-square test, there was a weak relationship found between the type of weekday activity, and if there is a need for travelling. This same relationship was found for weekend day main activities and travelling only this relationship is a little bit stronger.

To show the distribution of the activities of the respondents connected to the type of transport most used Figure 25 has been created. The figure shows only the given distances for bicycles and cars since these were chosen the most and for public transport travel time is more important than travel distance. Each dot on the figure represents a respondents answer. This map, however, only gives a slight indication of the perceived distribution of activities as not everyone specified where their main activities take place and for main activities taking place in the same postal code area no estimated distance travelled can be given.

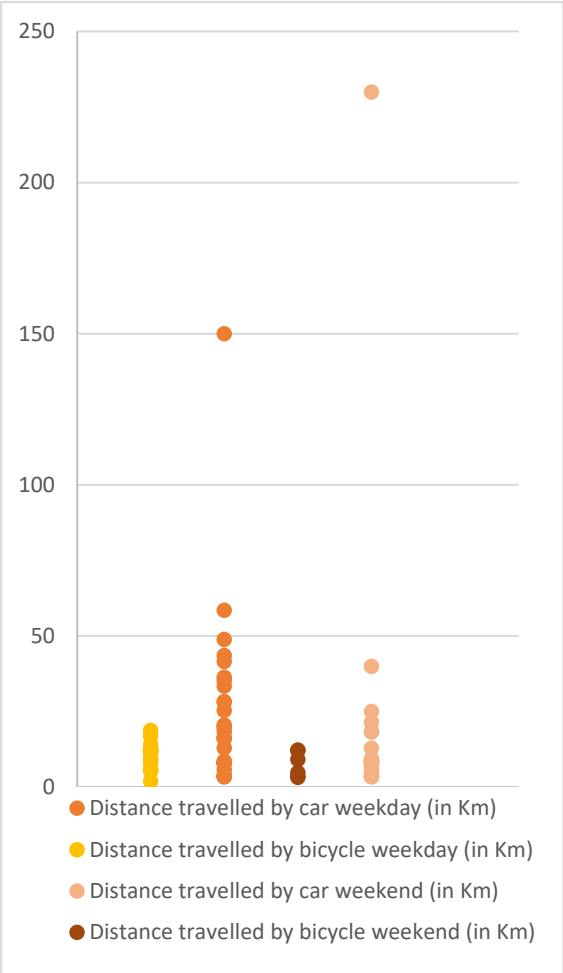

Figure 25 – Distribution of distance travelled per transport mode

4.3.4 Attitudes and preferences

Figures 26 & 27 illustrate the types of transport modes chosen by the sample to travel for their main activity and the reason why they chose this type of transport mode. These questions were asked as multiple answer questions. This means that the respondent was able to choose one or more answers. This also means that when using the chi-square test the comparison is between either did not click on the car or did click on the car. This also applies to the question of why the respondent has a preference for their chosen type of transport mode.

From these questions, it becomes clear that the sample chooses to take the car and/or bike the most often and that this is because of ease and/or availability. It is also very interesting to see that there were also a lot of different reasons given for choosing a type of transport mode. These can be summed up in a few different categories with the main being either health & physical movement and speed/time.

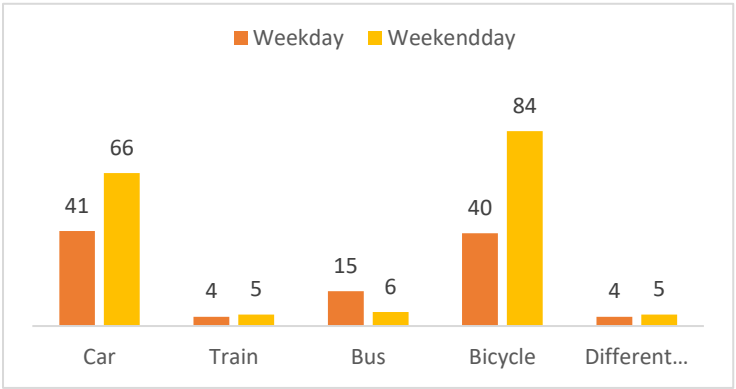

Figure 27 – Amount of times answer given, for preferred transport mode

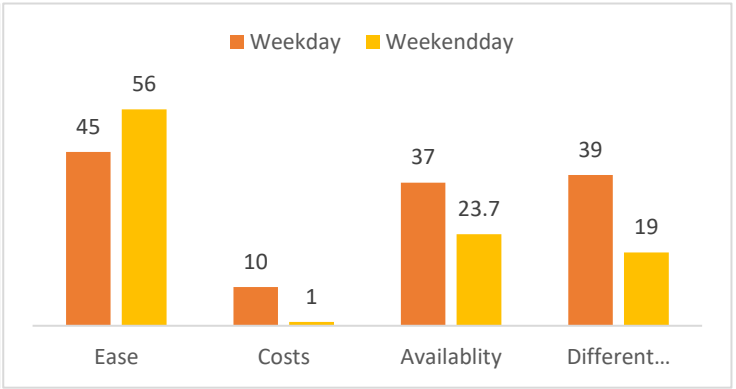

Figure 26 – Amount of times answer given, for reason behind choosing transport mode

When comparing mode choices made for the weekday activities it was also found that there is a relationship between the use of the car and the use of the bus or bicycle and a relationship between the use of train of the bus or bicycle. Especially the relationship between the preference of the car or the preference of the bicycle is interesting since this is the strongest relationship. It was found that when one chooses either the bicycle or the car as preferred transport mode they do not use the bicycle or car as a second transport mode. This means that they either choose to use the car or the bicycle both possibly in combination with the train or bus but rarely together. This relationship can also be found for mode choices made at the weekends. However, the strongest relationship here is found between the preference of the car or the preference of the bus. The results of these Chi-Square tests can be found in appendix 2.

Another interesting result from the questionnaire is the relationships found between the mode of transport and the reason why this is the preferred mode of transport. It was found that the availability only influences the mode of transport chosen when the respondents do or do not pick the bicycle. However, during the week there is a relationship found between the ease and the choosing for a car or not choosing for the car as a preferred transport mode. The costs also have an influence on this choice for the car. The cost and ease also have a relationship with the use of the choice for a bicycle. The results of these Chi-Square tests can be found in appendix 3.

4.3.5 Weekday vs. weekend

When comparing the attitudes and preferences of the sample between their given answers for the weekdays and the weekend day an interesting result was found. What is seen and illustrated in Tables 8 & 9. Here the significant results are bold. This research found that there is a relationship between the mode choice on weekdays and weekends as well as between the reason behind the mode choice. What is found here is that if the respondent uses a mode of transport on a weekday this will affect the respondents choice for this mode of transport at the weekend. The same connection is found between the reason why the respondents choose the mode of transport.

Table 8 - Comparison of mode choice between weekday and weekend day

Mode choice weekday vs Mode choice Weekend day		Car	Train	Bus	Bicycle
Car	Chi-Square α	**0.000**			0.084
	Likelihood Ratio α		0.065	**0.001**	
	Cramer's V	0.594		0.358	
Train	Chi-Square α				
	Likelihood Ratio α	0.202	**0.000**	0.201	0.004
	Cramer's V		0.763		**0.349**
Bus	Chi-Square α				
	Likelihood Ratio α	0.132	0.100	**0.000**	0.602
	Cramer's V			**0.646**	
Bicycle	Chi-Square α	0.090			
	Likelihood Ratio α		**0.002**	**0.683**	**0.000**
	Cramer's V		0.325		0.647

Table 9 - Comparison of the reason behind mode choice weekday and weekend day

Reason behind the mode choice weekday vs. weekend day		Ease	Costs	Availability
Ease	Chi-Square α	**0.000**		0.725
	Likelihood Ratio α		0.281	
	Cramer's V	0.442		
Costs	Chi-Square α			
	Likelihood Ratio α	0.165	**0.028**	0.559
	Cramer's V		0.362	
Availability	Chi-Square α	0.358		**0.000**
	Likelihood Ratio α		0.323	
	Cramer's V			0.710

4.3.6 Transport & temporal

Between socioeconomic characteristics and most of the questions from the categories transport and temporal no, relationships were found. This except an interdependence found between public transport safety and households. It was also found that the opinion of the respondent about the costs of public transport is influenced by the type of work situation they are in. However, both these relationships are weak relationships meaning that it does influence the opinion of the respondents but only weakly.

When comparing the different types of transport modes it was found that there was a relationship between choosing the bicycle as a mode of transport and taking sustainability into account when making transport choices.

Another interesting result was that for both choosing the car as a transport mode in the weekday as in the weekend there was found a relationship with ease as a reason for choosing a type of transport mode. This shows that many of the respondents see the car as an easy transportation mode. This was also found for choosing the car and availability. Both of these findings give an insight into why the car gets chosen as a mode of transport.

When comparing the respondents if they considered sustainability and what their opinion was on the cost of public transport, this research found that for those of the respondents that sometimes took sustainability into account, most of them found public transport too expensive. This indicates that people might make more sustainable choices if the cost would be lower.

The questionnaire also directly asked about the perceived accessibility of the respondents to public transport with the question; *How would you rate your accessibility to public transport from your house?* The answers of the respondents are shown in Figure 28. The figure shows that the respondents of this questionnaire have a negative image of their access to public transport.

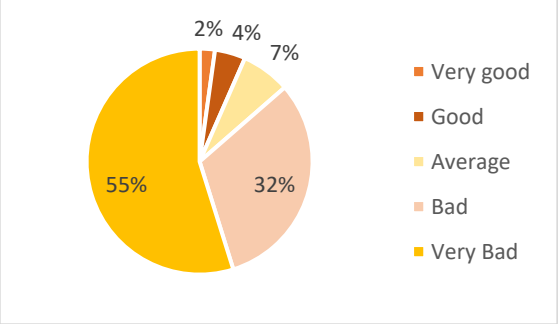

Figure 28 – Distribution of the rating of public transport access by the sample

5.0 – Conclusion & Discussion

In the existing literature, it was found that when people have no accessibility to good public transport this can lead to social exclusion. This research looked further into this phenomenon to establish whether this is also the case in the region of Groningen and Drenthe in low-density areas and how this might affect the transport mode choices of the inhabitants of these regions.
It was found that within the research areas with little to no access to public transport there is an overrepresentation of car usage The inhabitants that need to travel for their main activities almost always take either the bicycle or the car. And rarely take any form of public transport because of its limited availability.
The inhabitants of the area are aware of the fact that there is no public transport and express that they are not happy with this situation even though they mostly have access to other forms of transportation.
Within the sample of this region, the majority was highly capable and therefore their lack of access to public transport has less influence and does not lead directly to social exclusion.
If there is no public transport available it is found that people will take the car more often. It was also found that often for shorter trips people will use the bicycle.

Therefore the answer to the main research question is;

- *How does the inaccessibility of public transport influence life in relation to transport choices in Groningen and Drenthe?*

The inhabitants of the region travel often by car or by bicycle. Especially for longer trips where it is too long to go by bicycle, the car is the best and only alternative. They are very aware of their situation and not necessarily happy with this.
What is interesting to see is that often the use of a certain mode of transport on the weekday influences the use of this transport mode on the weekend day. This relationship was also found for the reason why people choose a transport mode. This suggests that most of the mode choices are made based on habits. That often people use a transport mode because they always use this mode and because this is known to them. Therefore it would be important to implement a strategy to increase access to public transport and to make sure that public transport also gets used. There would be a need to change the habits of the inhabitants.

Even though this research did not find the expected effects of the low accessibility to public transport on the socioeconomic demographics of the residents, it is still important that better public transport services get offered in the area. Within the light of sustainability and therefore offers more sustainable options to the inhabitants of the region. Since now the only option to travel long distances is by car.
What is important to learn from this research is that if a better public transportation network would be implemented this would only be successful in combination with a form of simulation to change the behaviour of the inhabitants of the region.

Discussion

One concern about the findings of this research is that due to the sampling method used the questionnaire might not have reached the more vulnerable groups in the population. This could have caused a type 2 error. Because the respondents were found mostly via online communication only people with easy and good access to the internet were reached. The results of the questionnaire showed that all people had good access to the internet. Another concern regarding the

outcome of the research is that the title and description of the survey caused uncertainties as the respondents assumed that they were not suitable to fill in the questionnaire because they lived in a region with no public transportation or never travelled with public transportation. It is also important to shortly note that the COVID-19 pandemic still had a lot of influence on travel behaviour in the Netherlands during this research. For this research, this might result in false conclusions because travelling with public transport has become less attractive due to the pandemic as well as more people are working from home and therefore do not need to regularly travel as much as before the pandemic.

Suggestions for further research

This research looks into the perceived accessibility in regions with very little access to public transport and shows that inhabitants of this region are often aware of their situation. Therefore it would be interesting to look further into this awareness in regions where there is a little more public transport available but with a low quality of frequency. Since the lack of public transportation available is less obvious to inhabitants since the options are there it would be interesting if the same results would be found.

Another comparison that would be interesting is to see what is the difference between the perceived accessibility in urban areas and based on what transport mode choices are made here.

Besides this, it would also be interesting to look into these very rural areas with little access to public transport with only qualitative research based on interviews with the inhabitants to hear and understand more about their choice-making process.

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Appendix

1 – Questionnaire design

Categories	**Subcategories**		**Question (NL)**	**Question (EN)**	**Measurement level (nominal, ordinal, interval, ratio)**	**Answer options**
Individual	Sociodemographic characteristics	1	Wat is uw geslacht?	What is your sex?	Nominal	Man (Man); Vrouw (Women); Anders (Different)
Individual	Sociodemographic characteristics	2	Wat is uw leeftijd?	Wat is your age?	Interval	Open vraag alleen nummers mogelijk (Open question, only numbers possible)
Individual	Context	3	Wat zijn de cijfers van uw postcode? (De eerste 4 cijfers)	What are the numbers of your postal code? (The first 4 numbers)	Nominal	Open vraag, 4 nummers (Open question, 4 numbers)
Individual	Sociodemographic characteristics	4	Hoe ziet uw huishouden er uit?	What does your household look like?	Nominal	Alleenstaand (met of zonder kinderen) (Single); Stel (gehuwelijkt of ongehuwelijkt) (Couple, Married or not); Stel met in huiswonende kinderen (Couple with kids living in the house); Samenwonend zonder partner (Living together without partner); Anders… (Different…)
Individual	Sociodemographic characteristics	5	Welke van de onderstaande beschrijvingen past het beste bij uw situatie (in de afgelopen 7 dagen)?	Which of the statements fits best within your situation in the last 7 days?	Nominal	Betaald werk verricht (of tijdelijk afwezig) (werknemer, zelfstandig werkzaam, werkzaam voor

						familiebedrijf); Onderwijs gevolgd, ook indien op vakantie (niet door de werkgever betaald); Werkloos; Invalide of arbeidsongeschikt; Gepensioneerd; Actief in het huishouden, voor kinderen of andere personen zorgen
Individual	Sociodemographic characteristics	6	Wat is uw ongeveer netto huishoudinkomen per maand?	What is approximately your net income per month?	Ordinal	Minder dan €1.100 (Per jaar: Minder dan €13.000); €1.100 tot €1.400 (Per jaar: €13.000 tot €17.000); €1.400 tot €1.700 (Per jaar: €17.000 tot €20.000); €1.700 tot €2.000 (Per jaar: €20.000 tot €24.000); €2.000 tot €2.400 (Per jaar: €24.000 tot €28.000); €2.400 tot €2.790 (Per jaar: €28.000 tot €33.000); €2.800 tot €3.300 (Per jaar: €33.000 tot €39.000); €3.300 tot €3.900 (Per jaar: €39.000 tot €46.000); €3.900 tot €4.800 (Per jaar: €46.000 tot €58.000); €4.800 of meer (Per jaar: €58.000 of meer); Weet ik niet

Individual	Capabilities	7	Bent u in het bezit van een geldig rijbewijs?	Do you have a valid driver's licence?	Nominal	Ja (Yes); Nee (No)
Individual	Capabilities	8	Heeft u een auto tot uw beschikbaarheid?	Do you have a car available?	Nominal	Ja (Yes); Nee (No); Soms, bijvoorbeeld een gedeelde auto (Sometimes, for example a shared car)
Individual	Capabilities	9	Kunt u fietsen?	Are you able to cycle?	Nominal	Ja (Yes); Nee (No)
Individual	Capabilities	10	Heeft u een fiets to uw beschikbaarheid?	Do you have a bicycle available?	Nominal	Ja, een standaard fiets; Ja, een elektriche fiets; Nee; Soms, bijvoorbeeld een gedeelde fiets;
Individual	Capabilities	11	Kunt u goed langere afstanden lopen? (Meer dan 500 meter)	Are you able to walk longer distances? (More than 500 meters)	Nominal	Ja (Yes); Nee (No)
Individual	Capabilities	12	Heeft u makkelijk toegang tot het internet?	Do you have easy access to the internet?	Nominal	Ja (Yes); Nee (No)
Land use	Perceived distribution of activities	13	Wat is uw hoofdactiviteit op een doordeweekse dag?	What is your main activity on a weekday?	Nominal	Werk (Work); Onderwijs (Education); Boodschappen doen (Doing groceries); Sporten (Sports); Anders.. (Other..)
Land use	Perceived distribution of activities	14	Moet u reizen om deze hoofactiviteit uit te voeren?	Do you have to travel for this main activity?	Nominal	Ja (Yes); Nee (No); Soms (Sometimes); Anders (Other…)
Antwoord vraag 14 Ja, Soms of Anders door naar vraag 15. Bij antwoord Nee naar vraag 18						
Individual	Attitudes and preferences	15	Welke vorm van transport heeft uw voorkeur?	Which form of transport has your preference?	Nominal	Auto (Car); Trein (Train); Bus (Bus); Fiets (Bicycle)
Individual	Attitudes and preferences	16	Waarom heeft u een voorkeur	Why do you have a preference for	Nominal	Gemak (Ease); Kosten (Costs); Beschikbaarheid

			voor deze vorm van transport?	this form of transport?		(Availability); Anders…
Land use	Perceptions of destination attributes	17	Waar vindt deze activiteit plaatst? (Plek, straat of postcode)	Where does this activity take place? (Place, street or postal code)	Nominal	Open question
Land use	Perceived distribution of activities	18	Wat is uw hoofdactiviteit op een weekenddag?	What is your main activity on a weekend day?	Nominal	Werk (Work); Onderwijs (Education); Boodschappen doen (Doing groceries); Sporten (Sports); Anders.. (Other..)
Land use	Perceived distribution of activities	19	Moet u reizen om deze hoofdactiviteit uit te voeren?	Do you have to travel for this main activity?	Nominal	Ja (Yes); Nee (No); Soms (Sometimes); Anders (Other…)
Antwoord vraag 19 Ja, Soms of Anders door naar vraag 20. Bij antwoord Nee naar vraag 23						
Individual	Attitudes and preferences	20	Welke vorm van transport heeft uw voorkeur?	Which form of transport has your preference?	Nominal	Auto (Car); Trein (Train); Bus (Bus); Fiets (Bicycle)
Individual	Attitudes and preferences	21	Waarom heeft u een voorkeur voor deze vorm van transport?	Why do you have a preference for this form of transport?	Nominal	Gemak (Ease); Kosten (Costs); Beschikbaarheid (Availability); Anders…
Land use	Perceived distribution of activities	22	Waar vindt deze activiteit plaatst? (Plek, straat of postcode)	Where does this activity take place? (Place, street or postal code)	Nominal	Open question
Individual	Attitudes and preferences	23	Tijdens het maken van uw keuze voor een transport vorm, houd u dan rekening met duurzaamheid?	When choosing your transport mode, do you take sustainability into account?	Nominal	Ja, absoluut (Yes, definitly); Soms wel, soms niet (Sometimes yes, somtimes no); Nee, nooit (No, never); Anders …
Transport	Perceptions of transport supply	24	Hoe zou uw toegankelijkheid tot openbaar	How would you rate the accessibility of	Nominal	Erg goed (very well); Goed (well); Gemiddeld

			vervoer vanaf uw huis beoordelen?	public transport from your house?		(Average); Slecht (Bad); Erg slecht (very bad); Weet ik niet (I don't know)
Transport	Perception of travel resistance	25	Hoe comfortabel voelt u zich tijdens het reizen met het openbaar vervoer?	How comfortable do you feel whilst travelling by public transport?	Nominal	Comfortabel (Comfortable); Niet comfortabel of oncomfortabel (Not comfortable or uncomfortable); Oncomfortabel (Uncomfortabel); Anders.. (Different…)
Transport	Perception of travel resistance	26	Voelt uw zich veilig tijdens het reizen met het openbaar vervoer?	Do you feel safe whilst travelling by public transport?	Nominal	Ja (Yes); Nee (No); Soms (Sometimes); Alleen overdag (Only during the day)
Transport	Perception of travel resistance	27	Wat vind u van de kosten van het openbaar vervoer?	What do you think of the cost of public transport	Nominal	Ik vind het openbaar vervoer te duur (I find public transport too expensive); Ik vind het openbaar vervoer goed betaalbaar (I find public transport well affortable); Ik weet het niet (I don't know)
Transport	Perception of travel resistance	28	Vindt uw reizen met het openbaar vervoer gemakkelijk?	Do you find travelling by public transport easy/	Nominal	Ja (Yes); Nee (No); Soms (Sometimes); Alleen overdag (Only during the day)
Transport	Perception of travel resistance	29	Hoe comfortabel voelt u zich om met de auto te reizen?	How comfortable do you feel whilst travelling in a car?	Nominal	Comfortabel (Comfortable); Niet comfortabel of oncomfortabel (Not comfortable or uncomfortable); Oncomfortabel

						(Uncomfortabel); Anders.. (Different…)
Temporal	Perception of temporal variability in travel time	30	Voor uw meest gemaakte reizen, is uw reistijd hoger met het openbaar vervoer of met de auto?	For your most often made travels, is your travel time higher with public transport or with the car?	Nominal	Auto (Car); Openbaar vervoer (public transport); Anders (Other…)

2 – Results Chi-Square test Mode choice

Mode choice vs Mode choice Weekday		Car	Train	Bus	Bicycle
Car	Chi-Square α			**0.001**	**0.000**
	Likelihood Ratio α		0.377		
	Cramer's V			0.329	0.642
Train	Chi-Square α				
	Likelihood Ratio α	0.377		**0.006**	**0.006**
	Cramer's V			0.342	0.248
Bus	Chi-Square α	0.001			0.944
	Likelihood Ratio α		**0.006**		
	Cramer's V	0.329	0.342		
Bicycle	Chi-Square α	**0.000**		0.944	
	Likelihood Ratio α		**0.006**		
	Cramer's V	0.642	0.248		

Mode choice vs Mode choice Weekend day		Car	Train	Bus	Bicycle
Car	Chi-Square α				
	Likelihood Ratio α		0.331	**0.001**	**0.020**
	Cramer's V			0.418	0.265
Train	Chi-Square α				
	Likelihood Ratio α	0.331		**0.028**	0.011
	Cramer's V			0.321	
Bus	Chi-Square α				
	Likelihood Ratio α	**0.001**	**0.028**		0.739
	Cramer's V	0.418	0.321		
Bicycle	Chi-Square α				
	Likelihood Ratio α	**0.020**	0.011	0.739	
	Cramer's V	0.265			

3 – Results Chi-Square test Mode choice vs. Reason behind the choice

Weekday Mode choice vs. reason behind the choice		Ease	Costs	Availability
Car	Chi-Square α	**0.005**		0.58
	Likelihood Ratio α		**0.009**	
	Cramer's V	0.283	0.261	
Train	Chi-Square α			
	Likelihood Ratio α	0.867	0.385	0.611
	Cramer's V			
Bus	Chi-Square α	0.950		0.336
	Likelihood Ratio α		0.674	
	Cramer's V			
Bicycle	Chi-Square α	**0.027**		0.965
	Likelihood Ratio α		**0.049**	
	Cramer's V	0.224	0.200	

Weekend day Mode choice vs. reason behind the choice		Ease	Costs	Availability
Car	Chi-Square α	0.091		0.723
	Likelihood Ratio α		0.077	
	Cramer's V			
Train	Chi-Square α			
	Likelihood Ratio α	0.97	0.725	0.280
	Cramer's V			
Bus	Chi-Square α			
	Likelihood Ratio α	1.000	0.699	0.850
	Cramer's V			
Bicycle	Chi-Square α		0.105	
	Likelihood Ratio α	**0.027**		**0.024**
	Cramer's V	0.245		0.250

4 – All maps created for this research

Figure 4 – Map of the population density in the research area (Geoproccesed by Nauta, S.W.E.: data retrieved from CBS, 2021)

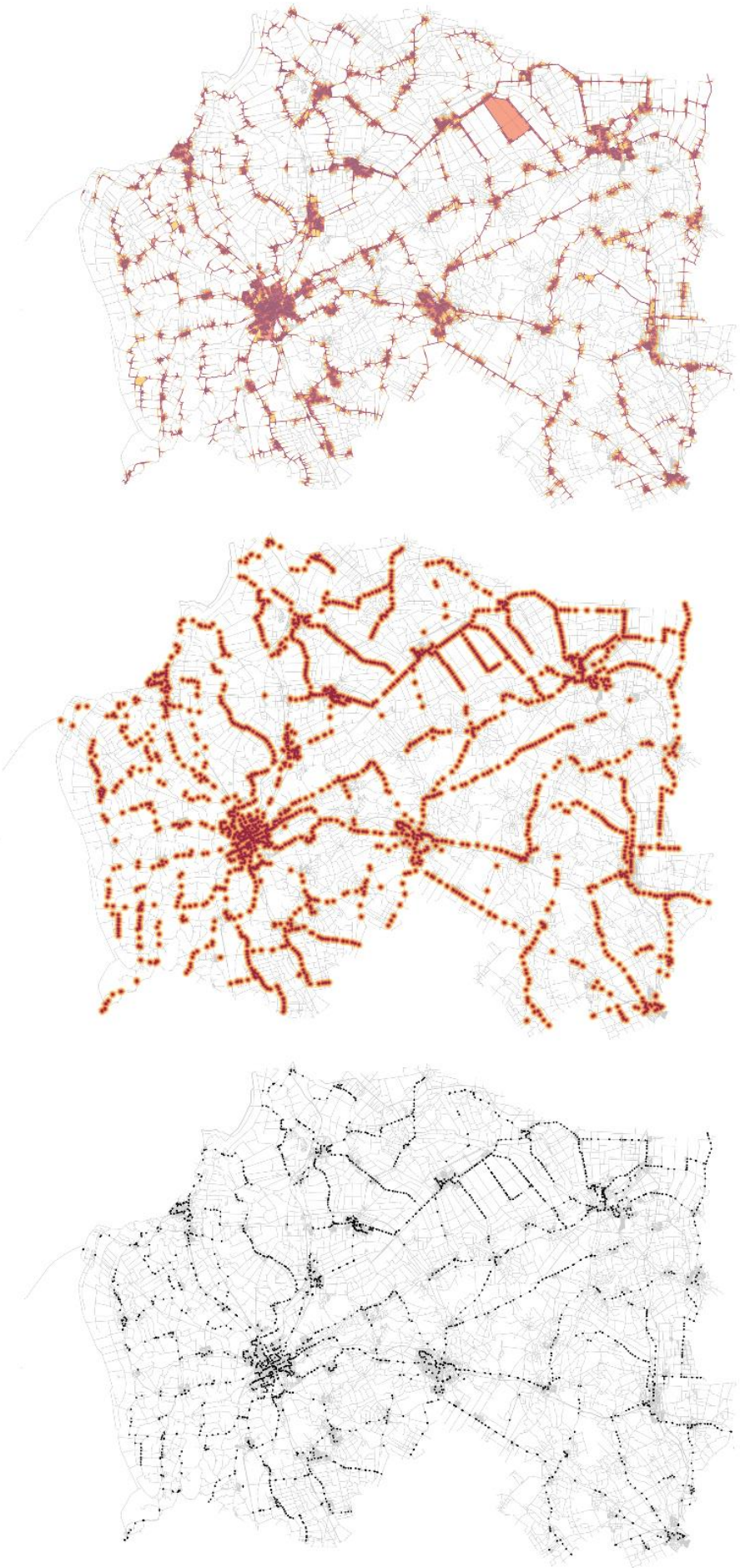


Figure 8 – The 3 steps of GIS analysis bus (Geoproccesed by Nauta, S.W.E.: data retrieved from OVapi B.V. (2021) & NWB (2021))

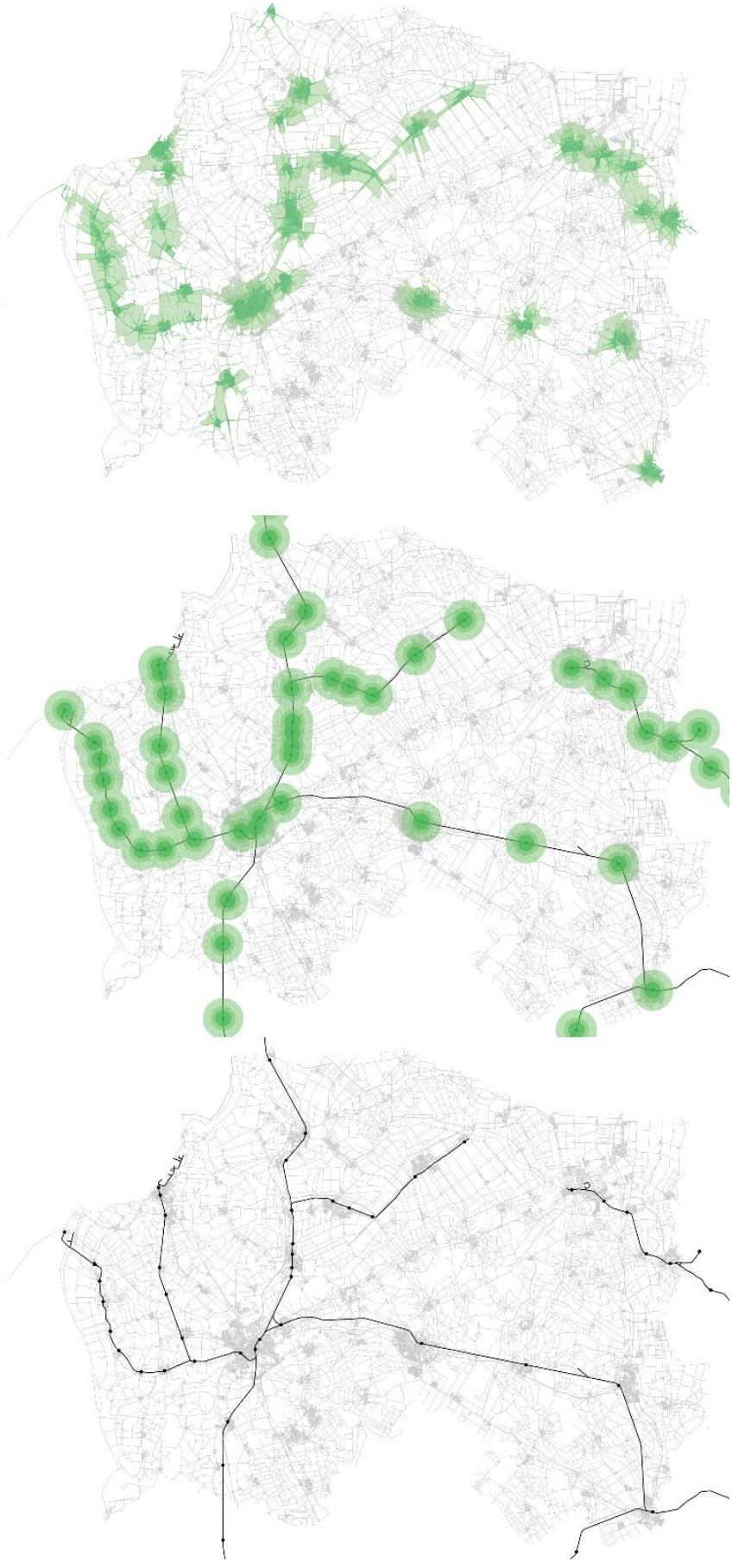


Figure 9 – The 3 steps of GIS analysis Train (Geoproccesed by Nauta, S.W.E.: data retrieved from OVapi B.V. (2021) & NWB (2021))

Figure 10 – Combination of the network analysis and research areas (Geoproccesed by Nauta, S.W.E.: data retrieved from OVapi B.V. (2021), NWB (2021) & Basisregistratie Adressen en Gebouwen (2021))

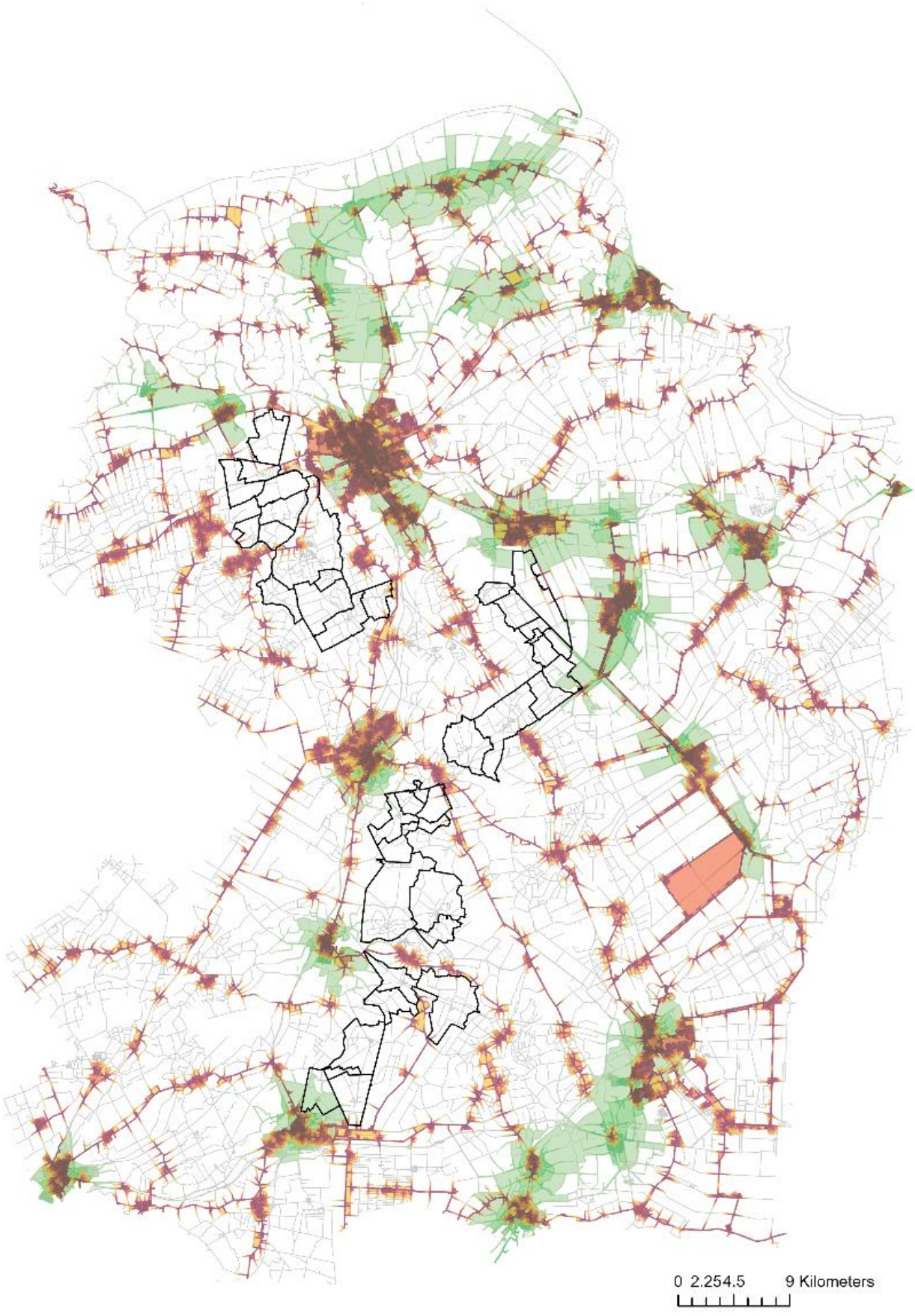
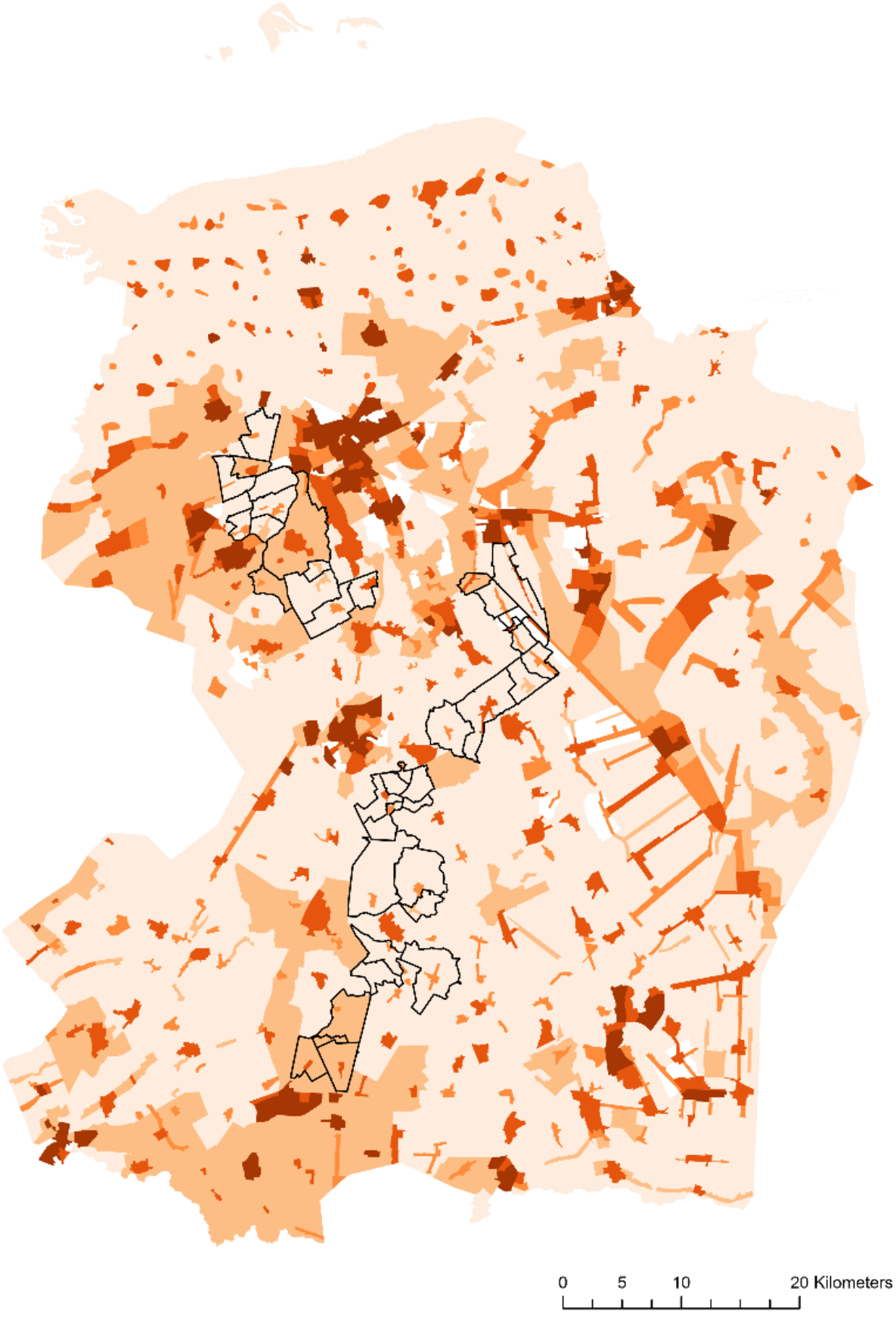


Figure 11 – Combination of the population density and the research areas (Geoproccesed by Nauta, S.W.E.: data retrieved from CBS (2021) & Basisregistratie Adressen en Gebouwen (2021))



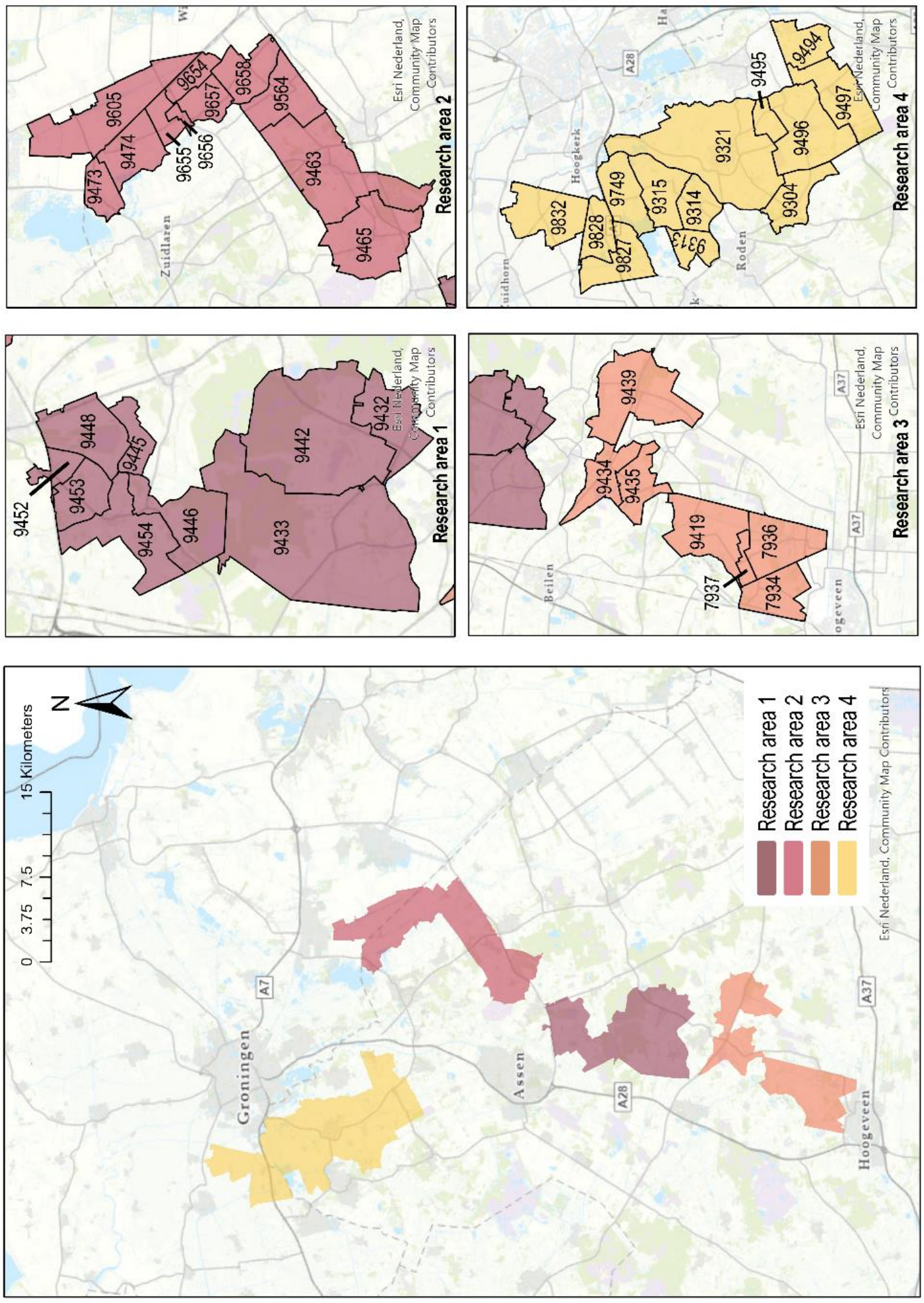


Figure 12 – Map of the location of the research areas combined with the research area postal codes in detail (Geoproccesed by Nauta, S.W.E.: data retrieved from Basisregistratie Adressen en Gebouwen (2021))

Figure 14 – Map of Research area 1 (Geoproccesed by Nauta, S.W.E.: data retrieved from OVapi B.V. (2021), NWB (2021) & Basisregistratie Adressen en Gebouwen (2021))

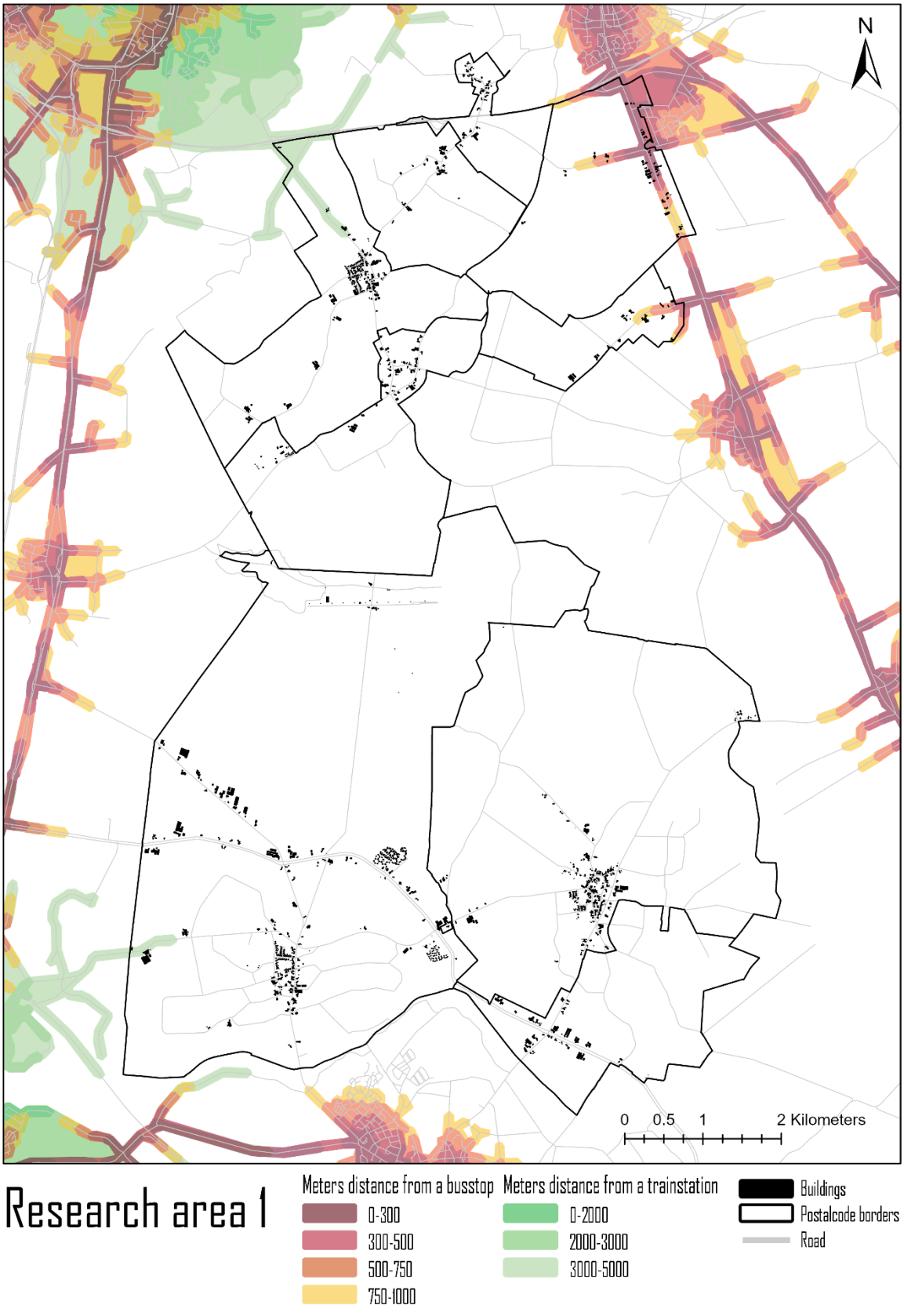


Figure 13 – Map of research area 2 (Geoproccesed by Nauta, S.W.E.: data retrieved from OVapi B.V. (2021), NWB (2021) & Basisregistratie Adressen en Gebouwen (2021))

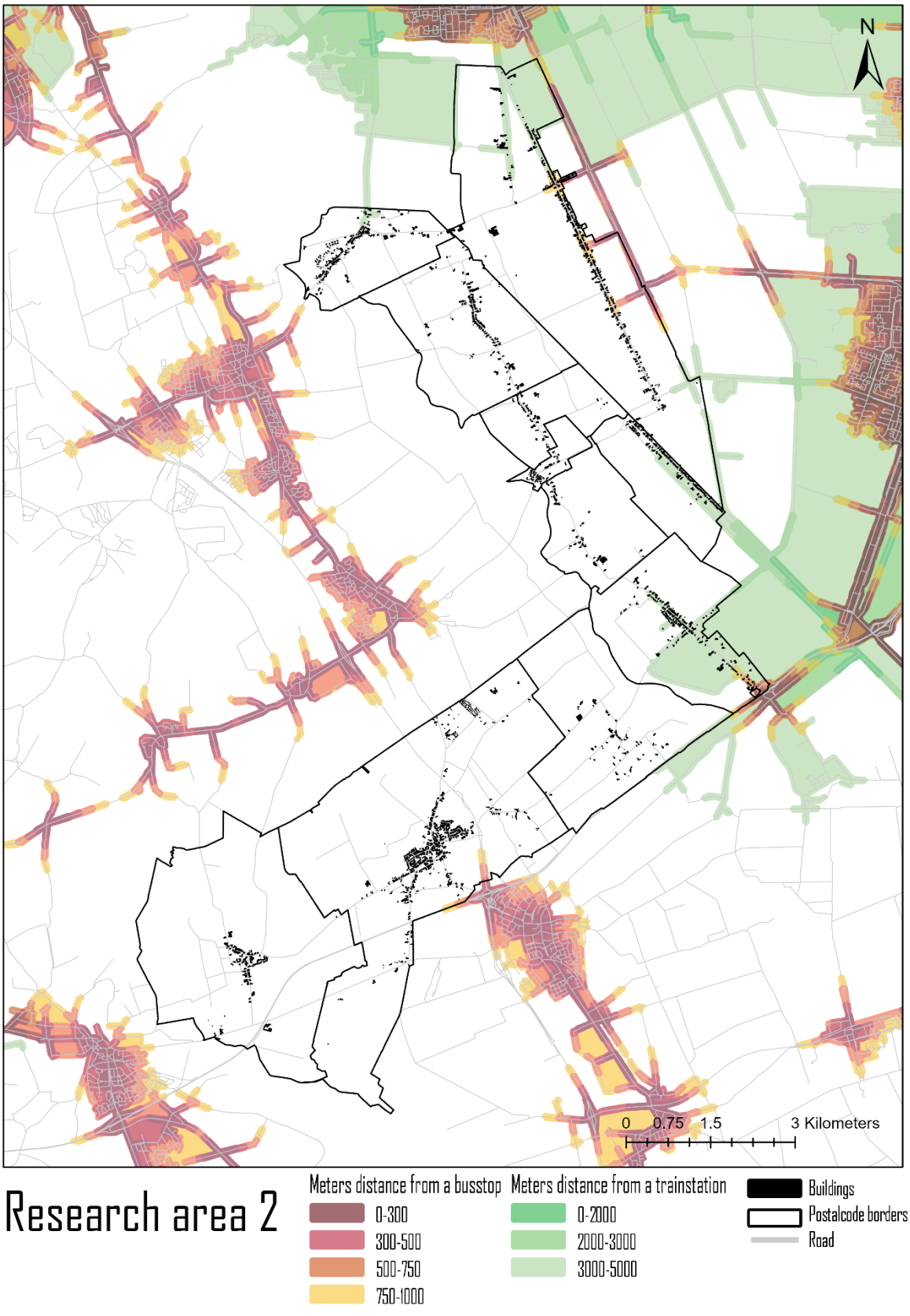


Figure 15 – Map of research area 3 (Geoproccesed by Nauta, S.W.E.: data retrieved from OVapi B.V. (2021), NWB (2021) & Basisregistratie Adressen en Gebouwen (2021))

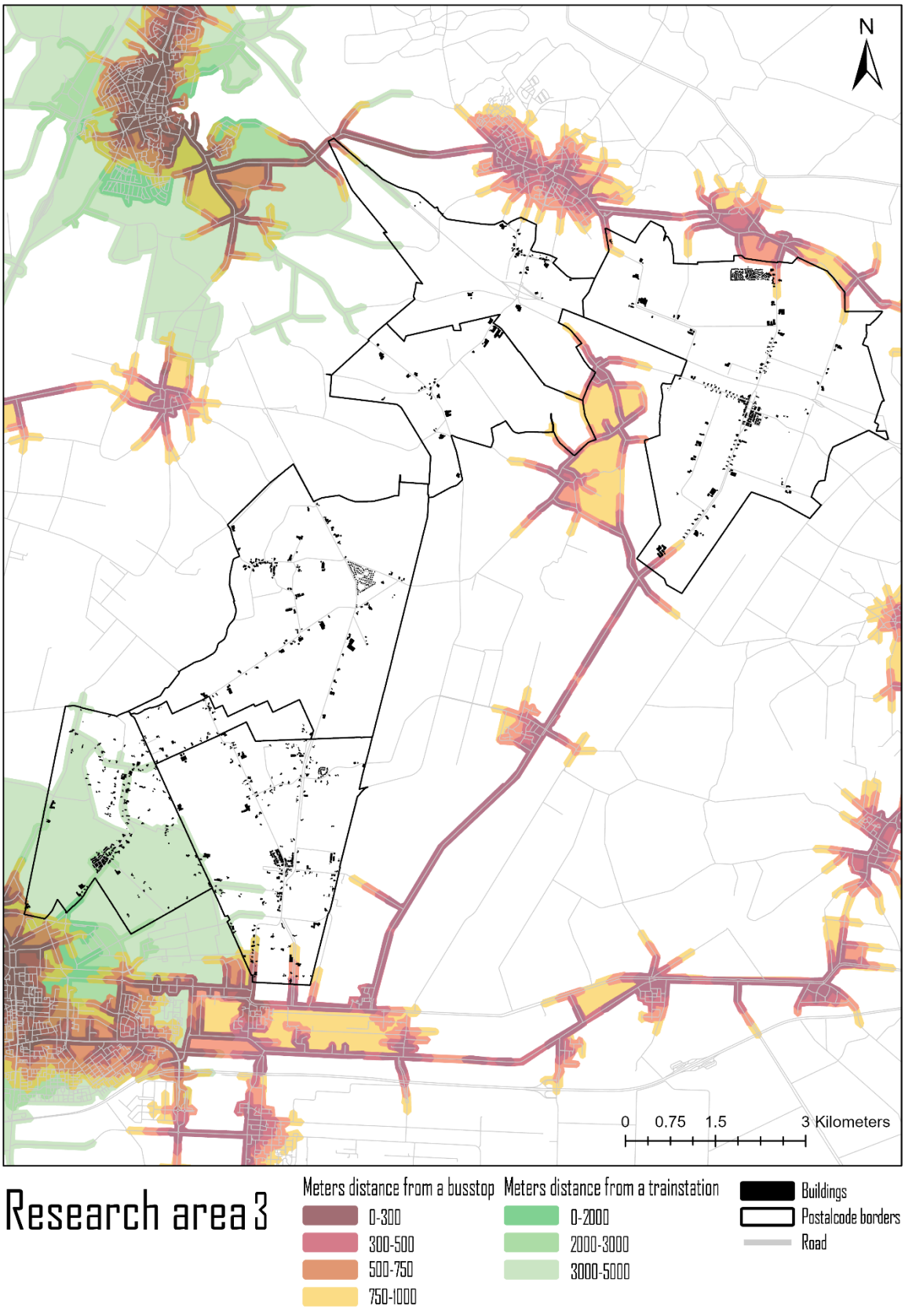


Figure 16 – Map of research area 4 (Geoproccesed by Nauta, S.W.E.: data retrieved from OVapi B.V. (2021), NWB (2021) & Basisregistratie Adressen en Gebouwen (2021))