Demand-responsive and sustainable ways of (public) transport to keep shrinking regions in Groningen accessible

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Colophon

Title:	Demand-responsive and sustainable ways of (public) transport to keep shrinking regions in the Dutch province of Groningen accessible.
Main question:	How can demand-responsive and sustainable ways of (public) transport be used in the future to keep shrinking regions in the Dutch province of Groningen accessible?
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Summary

Several regions in the province of Groningen have to deal with population decline which has large consequences for facilities, but also for maintaining the conventional ways of public transport. An often-suggested method in shrinking regions is a Demand-Responsive transport system (DRT) that responds to the needed demand on a certain moment in addition to conventional services that are driving on fixed schedules and routes.
There is only critique on the current DRT-system Hubtaxi in Groningen and DRT is not used already on a larger scale around the world. This research wants to find an answer on the next main question: "How can demand-responsive and sustainable ways of (public) transport be used in the future to keep shrinking regions in the Dutch province of Groningen accessible?". This main question is answered with the help of three subtopics: Public transport in shrinking regions (ST_1), Demand-responsive transport and the influence on accessibility (ST_2), and Car replacement by demand-responsive and sustainable public transport (ST_3).

The first subtopic about public transport in shrinking regions focusses on how current public transport functions in these shrinking regions and which challenges it faces. The main challenge for rural bus services that came out of the research, is the search for a good balance between financial viability and the social factor of accessibility. To prevent problems with the accessibility of inhabitants and higher costs for transport under the Social Spatial Act, lines with low occupancy rates have to be preserved in some cases. It is namely important for dependent groups to keep mobility and prevent transport poverty. Facilities can also be moved to easily accessible and central locations to reduce the amount of movements. This so called 'Transit-oriented development' can help with a good accessibility of facilities by public transport. A good accessibility of facilities can reduce population decline, but is according to the interviewees mainly a facilitating and not a determining role for where people are going to live. Smaller rural villages have for their attractivity more need by more workplaces and better facilities.

The second subtopic went further on these challenges by researching if demand-responsive transport can have a role in the accessibility of facilities in these regions. The implementation is rated in this research as mainly positive, but it is not seen as a total replacement of the conventional transport system. The challenges for a day covering exploitation and the threshold of booking makes it less exploitable and accessible for operators and users and should only be used when public transport cannot be offered anymore in an acceptable way. The largest opportunities are seen in villages who are in need of several small connections that does not fit in the current public transport system. The DRT system functions here as a way to bring people to the nearest hub location or bring them back to their homes from this hub. The groups of elderly, schoolchildren and commuters have different needs in the system with factors like reliability, comfort and efficiency. The current DRT system in Groningen, called the Hubtaxi, has however to deal with critique about findability, affordability and reliability. Improvement to solve these problems are on

the way but is not all already realised. Especially the integration of DRT in travel apps is mentioned as an important step to a better findability.

In the last subtopic is focussed on the group next to the dependent users, the independent users. DRT can attract these independent groups that are nowadays depending on the car. It will, however, be a hard challenge, especially to convince subjective car-dependent users. Attracting objective car-dependent has far more potential, because there is only a need for a good alternative where there is also needed for subjective car-dependent users that the system is promoted and is offered during a discontinuity of their lives. DRT has especially change to replace the second car

Next to the dependent groups, DRT can also attract independent groups that nowadays use the car. From literature and from the interviews it became, however, clear that this will be hard challenge, especially to convince subjective car-dependent users. Attracting objective car-dependent users has far more potential, because there is only a need for a good alternative public transport system. But still when this point is met, it is hard to surpass the privilege of the car because of its high privacy level, convenience and flexibility. According to this research, DRT has therefore especially chance to replace the second car. In order to convince people, targeted marketing on the moment of a discontinuity in their lives is most effective. Next to a DRT system, the interviewees are also enthusiastic about the integration of (individual) sharing systems. Especially sharing bikes are popular because of the healthy effect on users and the absolute zero emission. The creation of a zero-emission sharing system can be stimulated by legislation and subsidies and is therefore far easier to make sustainable than the total car fleet. This can in the end lead to a sustainable transport system.

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Table of contents

1. Introduction

In this first chapter the cause for researching this topic will be explained. Information from literature research will be provided and the problem statement will be introduced. The problem statement consists out of the goal of the research, the main question and three sub-questions, and their hypotheses. This chapter ends with a reading guide.

1.1. Population decline and demand-responsive transport

The Dutch province of Groningen has to deal with a proximity of population incline and decline (CBS, 2020). Where the city of Groningen is constantly growing, the surrounding land has to deal with population decline. This decline has large consequences for facilities like shops, schools and communal facilities, but has also results for the maintaining of the conventional way of (public) transport to keep these areas accessible (De Jong et al., 2011; Gogola et al., 2018). An often-suggested method in similar regions is the implementation of a wide expanded Demand-responsive transport (DRT) system (Mageean & Nelson, 2003). This system responds to the needed demand on a certain moment in addition to conventional services that are driving on fixed schedules and routes. Conventional systems are therefore especially difficult to maintain in these low-demand regions (Mulley & Nelson, 2009). The DRT systems can be seen all around the world and is researched a lot in the search for a vital connection for regions with population decline.

This research focusses on the shrinking regions in the Dutch province of Groningen. In this region a demand-responsive system is already active since 2018, called the Hubtaxi (Tillema, 2019). In literature, however, there are still a lot of critiques from organisations like travel organisation Rover and there are several questions asked in the Dutch States-provincial about the misfunctioning of the Hubtaxi (Vinkenvleugel, 2019). The challenges in Groningen are the same as the ones that can be seen at other places around the world (HEREmobility, 2020; Vinkenvleugel, 2019). Firstly, the excessive flexibility that attracts can also lead that the system is too variable for passengers that need a reliable solution. Secondly, it is hard to optimize routes and make the arrival of transport reliable and prevent long waiting times. Thirdly, DRT is not included in transportation maps and travel application which makes the systems hard to find and lastly the costs of usage are higher than conventional services, even up to three or even five times in Groningen (Vinkenvleugel, 2019). These challenges have to be overcome to make the system successful and ultimately play a potential role in forming an alternative to car use.

1.2. Social relevance

This research has social relevance for the inhabitants of shrinking areas in Groningen, but also around the world. The lessons that can be learned from Groningen can also be used for regions with similar challenges, in for example Lincolnshire in the United Kingdom (Better Transport, n.d.) and the United States (Litman, 2014) that also have to deal with population decline. It can also help other regions to implement DRT in the right way that people can find

it, use it and see it as a full alternative. Moreover, it can help governments to find alternatives for the car usage of their inhabitants. This can have positive effects on the reduction of greenhouse gas emissions and congestion.

1.3. Personal motivation

The personal motivation to research this topic comes from an interest that was additionally aroused during the bachelor of Civil Engineering at the Hanze University of Applied Sciences in Groningen, the pre-master of Spatial Planning and Design and the master of Environmental and Infrastructure Planning at the University of Groningen. Next to that, during internships at engineering firms like Roelofs Groep and Tauw, the affinity with mobility and especially public transport was addressed. Especially the future of mobility is an interesting topic, especially in areas that have to deal with a change in passenger demand. Especially during visits of family and friends that are living in municipalities that have to deal with large population decline, the question rises how these regions are accessible in the future when public transport lines disappear and cars that run on fossil fuels are no longer the standard. Next to that was an important part of the bachelor, pre-master and master focussed on sustainability and how to prevent further global warming by lowering greenhouse gas emissions.

1.4. Location description

To clarify the situation of the research area this section will focus on the demographic and geographic features of the area and the current state of the public transport network.

Geography

The province of Groningen is located in the north of the Netherlands and is bordered by the provinces Friesland in the west and Drenthe in the south. To the east the province borders Germany and to the north the Wadden Sea. The capital and most important city of the province, is the eponymous city of Groningen which is located at the southern border with Drenthe. The region outside the city can be described as rural, with no cities with more than 25,000 inhabitants (City population, 2020). The province is therefore, after Drenthe, Friesland and Zeeland, the least densely province of The Netherlands. The city of Groningen is well connected by rail and road to the rest of The Netherlands and therefore the main station of Groningen functions as the main connection hub for (public) transport in the province (OV Bureau, 2018).

Demography

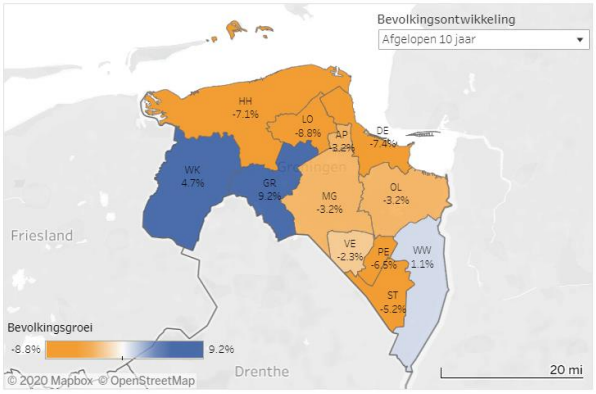

Figure 1: Population difference in the municipalities of Groningen (2010-2019)

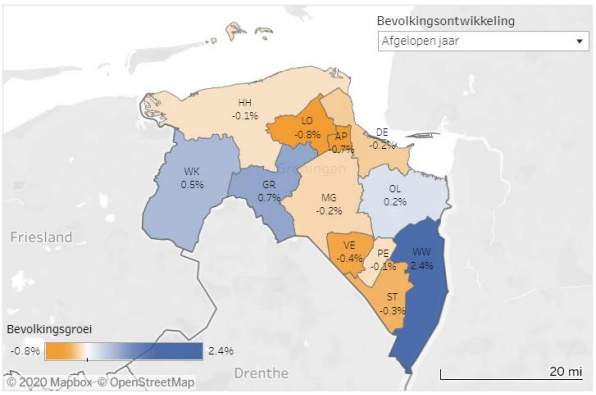

Figure 2: Population difference in the municipalities of Groningen (2019)

The province of Groningen has a population of 584,355 of which 39.6% or 231,299 live in the city of Groningen (CBS, 2020). The city has to deal with a large population increase of around +9.2% between 2010 and 2020 (Sociaal Planbureau, 2020), where large parts of the surrounding countryside has to deal with population declines of up to -7.4% in the former municipality of Delfzijl and -8.8% in the former municipality of Loppersum in the same period (Elshof & Simon, 2016) (figure 1). There is a lot of fluctuation in the annual decline, but the downward trend can be seen since 2010. The former municipality of Loppersum for example also has a decline of -0.8% of its population in 2019 (figure 2). The forecast for the upcoming years until 2035 expects that the city will grow even further with up to +10% and that municipalities like Loppersum will see a decline up to -18% (Te Riele et al., 2019).

(Public) Transport

The public transport network in the province of Groningen consists out of two types of fixed public transport systems: a train network and a bus network. The train network consists out of one main connection from Groningen to the south (black dotted line in figure 3) and several regional railway lines known as the “Noordelijke Nevenlijnen” (blue dotted lines in figure 3). These lines all start at the main station of Groningen and run from there to Leeuwarden in the West, the Eemshaven and Delfzijl in the north and Weener and Veendam in the east. The service is provided by Arriva Personenvervoer Nederland, a company part of the Deutsche Bahn.

Next to the rail network there is a well-extended network of bus lines that cover both the province of Groningen and the province of Drenthe (OV-bureau, 2018). The main lines are during the current concession facilitated by Qbuzz which keeps this responsibility until at least 2029. The network is however directed by the OV-bureau, and independent transport authority created out of a collaboration between the two provinces and the municipality of Groningen. The OV-bureau functions as the developer, organizer, and manager of the bus services and awards the concession to the transport companies.

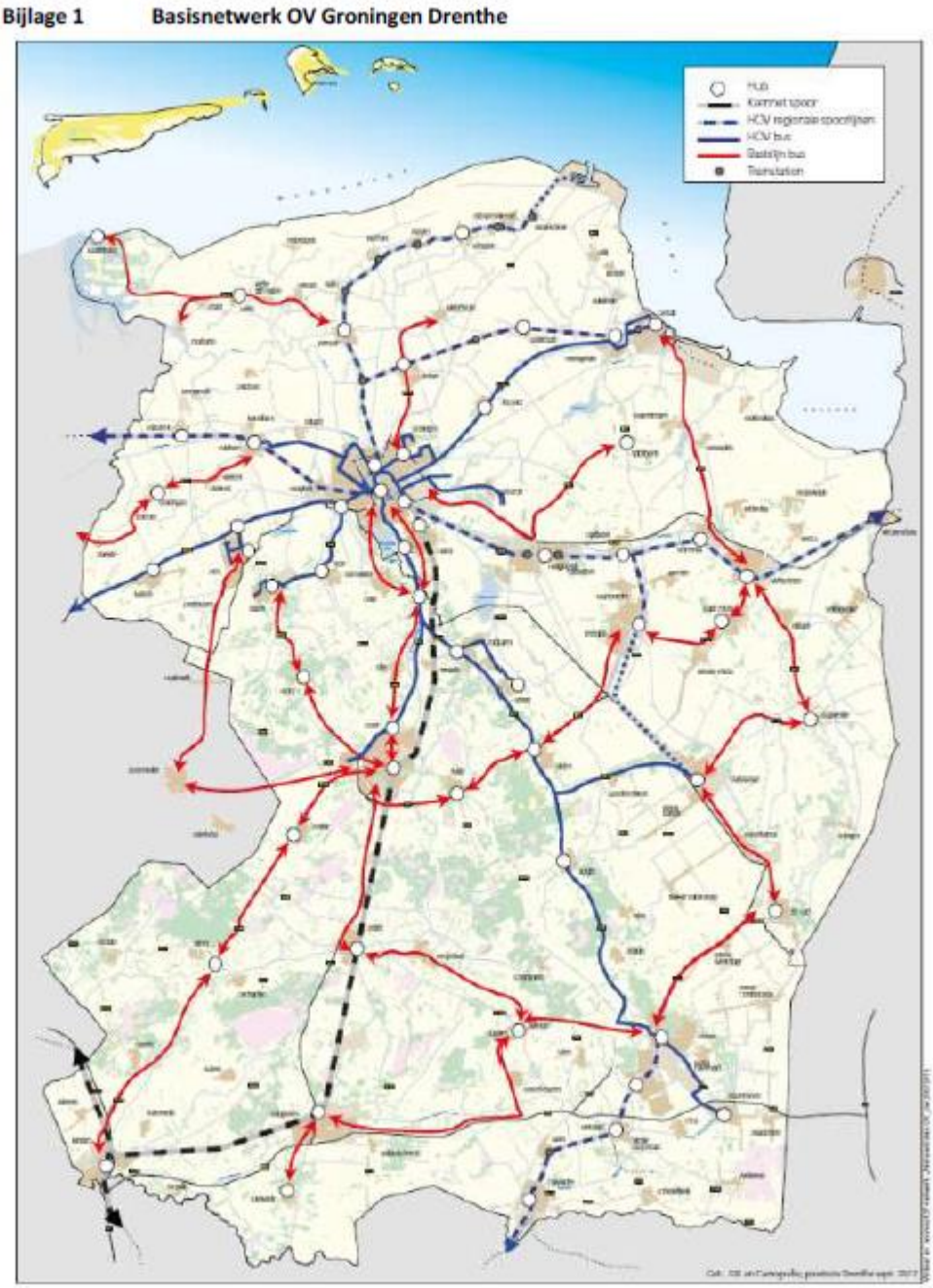

Figure 3: Map of the basic bus network in the province of Groningen

The bus network consists out of network of Bus rapid transit (BRT or in Dutch HOV) lines (solid blue lines in figure 3) that serve the main connections that are not offered by trains. This are connections from the city of Groningen to larger cities like Delfzijl, Emmen and Drachten (OV-bureau, 2019). The rest of the network is based on figure 3 that shows with red arrows the lines that have to be facilitated. These are important connections between cities and villages that are not offered by the BRT-lines or the trains. For the smaller villages that are not served by all of these three there is an additional network. This supplementary system, that strives for 100% coverage, is facilitated by Publiek Vervoer and consists out of

local bus services driven by volunteers, the demand-responsive Hubtaxi system, and transport to fulfil the Social Spatial Act (SSA). All the lines and services are the responsibility of Publiek Vervoer that grants each part of the province to a regional taxi company. Connexxion Taxi Services has the responsibility for the north of the province, UVO Vervoer for the north, De Grooth Vervoer for the east and Taxi Nuis for the southeast of the province.

This research is focussing on this lowest part of the public transport system and then especially on the Hubtaxi. The Hubtaxi is a DRT-system that replaced all call busses in the provinces of Groningen and Drenthe in April 2018 and consists out of flexible taxi services that brings passengers to the closes hub. From this hub the passengers can travel further with the conventional public transport service (Reisviahub, 2020). There are nowadays more than fifty hubs in the two provinces with large differences between the available facilities. There are smaller hubs at bus stops with only basic facilities like Wi-Fi and a bicycle shed, but there are also larger hubs where there are expanded facilities like a water tap, fitness equipment, a kiosk, bicycle lockers, a park and ride, and shops. Such a large hub can be found in for example Hoogkerk (figure 4) (Reisviahub, 2020).

Figure 4: Example of a larger hub location in Hoogkerk

Next to the Hubtaxi system that is accessible for everyone, there are busses for the 40.789 passengers (11-2018) under the SSA-act, in the Netherlands better known as Wmo-vervoer (Publiek Vervoer, 2020). On behalf of the municipalities, the purpose of this transport is to facilitate mobility for those who cannot travel independently like elderly, chronically ill people and people with a mental or physical disability (Pieper et al., 2014; Zorgwijzer, 2020)

1.5. Problem statement

Research objective

The research objective is to find out how to keep a good (public) transport availability in rural areas that have to deal with a large population decline even when conventional transport services are not financially viable anymore because of the declining demand. A future system has to facilitate firstly a good alternative for the people who are dependent on public transport, but there also could be an opportunity to provide a system that can attract current car users. The reduction of car usage can be an important step in the reduction of emission gasses and therefore a step to more sustainable transport. With a good functioning and sustainable transport system, rural areas can remain accessible and liveable for all age groups.

Main question and sub-questions

The main question of the research is:

"How can demand-responsive and sustainable ways of (public) transport be used in the future to keep shrinking regions in the Dutch province of Groningen accessible?"

To answer the main question, three sub-questions are formulated:

ST_1) How well does public transport in shrinking areas function and what are the challenges that these services have to deal with?

Before researching DRT, it is important to focus first on current public transport systems in shrinking areas and which challenges they are facing. One of these challenges is already mentioned and is the financial viability with a reduction in demand. Public transport in rural areas will be compared with the situation in Groningen to understand the situation in this research area. The answers on this question can be used to analyse which opportunities DRT can have and how it can influence and improve accessibility compared to current systems (see sub-question 2).

ST_2) How does demand-responsive (public) transport functions, and how does it influence and improves accessibility for groups in shrinking areas that are depending on public transport?

To answer this question, there will be analysed how demand-responsive (public) transportation functions around the world and how it can help to keep shrinking areas accessible. There will be a focus here on people that have no car and are dependent on public transport. This subtopic will be focussed on several areas around the world and of course on the current situation in the province of Groningen. On the people that are not depending on public transport but can be attracted to a new system, will be focussed in sub-question 3.

ST_3) How can demand-responsive (public) transport help to reduce car usage and thereby reduce exhaust gas emissions in shrinking areas?

The last sub-question is focussing on groups that can use a car nowadays. These groups are not depending on public transport for their mobility, but there is a potential to reduce the number of cars by effective public transport systems like DRT. A car reduction leads to less greenhouse gas emissions which can make transport more sustainable.

1.6. Hypotheses

The expected outcomes of this research are summarized in the next hypotheses:

- Public transport in shrinking areas cannot function in a financially viable and effective way with conventional transport methods.
- Demand-responsive (public) transport improves the accessibility of shrinking areas.
- Demand-responsive (public) transport has potential to reduce car usage and thereby reduce exhaust gas emissions in shrinking areas.

1.7. Reading guide

This master thesis has the following structure:

In chapter 2 the theoretical framework will be explained with the relevant concepts and theories. The three subtopic and the main topic are being displayed in a conceptual model. Each of the subtopics will also be further explained in this chapter.

In chapter 3 the methodology used during the research is explained with the methods for data collection and the methods for data analysis, organized per subtopic. The last paragraph of this chapter are the ethical considerations.

In chapter 4 the results of the empirical research are included. The answers which have the same intention are merged. At the start of the paragraph the used codes are shown in a figure.

Chapter 5 is the conclusion of the report where the findings from literature and the empirical research will be appointed.

The last chapter is the discussion with recommendations for further research.

In Appendix 1 is the interview guide included. This interview guide consists out of the subtopic name, the questions that are asked to the interviewees in Dutch, the question translated in English and the code in Atlas.ti which is connected to this question.

Appendix 2 contains the agreements of participation. First the agreement as filled in by the interviewees in Dutch and then an English translation.

2. Theoretical framework

This chapter will give an overview of the used theories in this research and what the different terms of shrinking regions (2.1), demand-responsive (public) transport (2.2) and transport sustainability (2.3) mean. After that the conceptual model is included where the different connections are schematized. In the sections after that the relevant theory per subtopic is discussed.

2.1. Shrinking regions

Shrinking regions are regions that have a long-term demographic trend of population decline or depopulation (Ubarevičienė et al., 2016). Regions where there is a fast population decline as a result of a war, pandemic, famine or catastrophe are not considered as shrinking regions. The population decline has large consequences for facilities in the region and asks for new and innovative solutions to keep regions liveable and accessible (Haartsen & Venhorst, 2010; Verwest & Van Dam, 2010). Shrinking regions come in different sizes: it can be whole countries or even multi-country regions like Eastern Europe but also regions within a country (Gogola et al., 2018). There are also shrinking regions in the Netherlands that are, according to the Dutch government, the result of three causes (Rijksoverheid, 2020). Firstly, there are fewer children born partially because of an aging population, secondly families move to larger towns and cities as a result of urbanisation, and lastly there is the trend that young and better-educated people move to the larger towns and cities for higher education and work (Rijksoverheid, 2020).

The population decline in these regions have been seen for quite some time and asks for the creativity of planners. An overview of all the current shrinking regions (krimpregio's) and the anticipation regions (anticipeerregio's) that expect a larger population decline in the future are displayed in figure 5. Three of the seven shrinking regions in The Netherlands are located in the province of Groningen (regions 2, 3 and 4 in figure 5). There are no anticipation regions in the province of Groningen, but these can be seen in the neighbouring provinces of Friesland and Drenthe (12, 13 and 14).

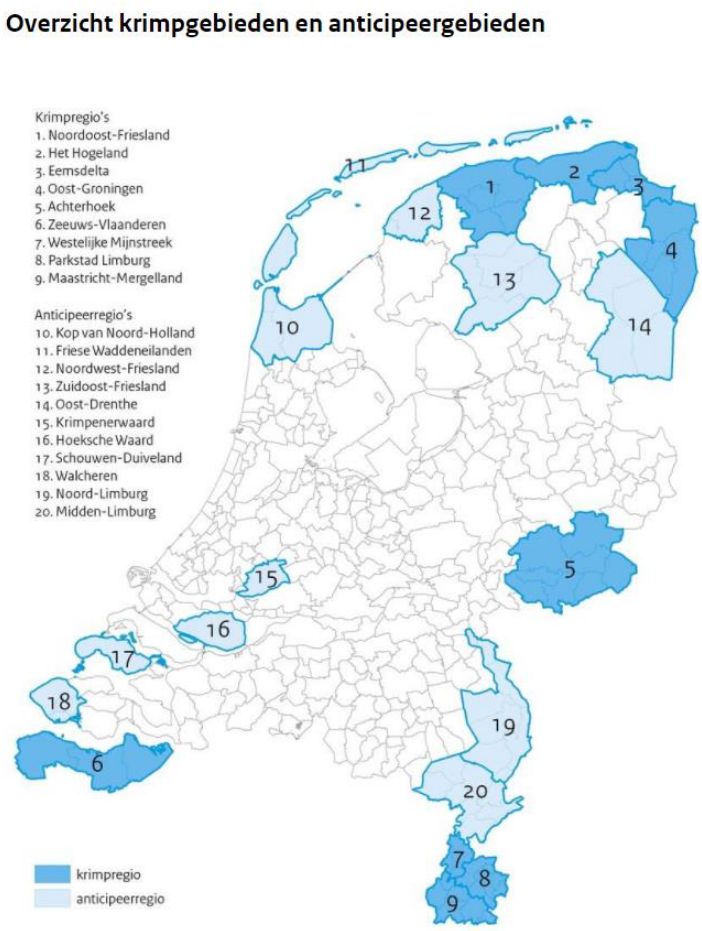

Figure 5: Shrinking & anticipation regions (Rijksoverheid, 2020).

For a long time, the effects of population decline in Groningen where not seen as an acute problem, but this changed when planners where warned by the report of "Structurele Bevolkingsdaling" of the Ministry of Transport and Water Management (Derks et al., 2016). It is however difficult to predict how the population decline will continue because it has proved to be a multifaceted phenomenon which is highly dependent on several different conditions (Ubarevičienė et al., 2016). The conditions in Groningen that influences the population can be political, economic and social but cannot be seen independently of the earthquake problems as a result of gas drilling in the region (Provincie Groningen, 2015).

2.2. Demand-responsive (public) transport (DRT)

Demand-responsive (public) transport (DRT) is a flexible way of (public) transport that consists out of demand-based connections between the starting point of a users' journey and a central transport hub (Mulley & Nelson, 2009) (figure 6). At this hub there will be made a connection between the flexible services, conventional bus- and train services and sharing systems, and has the facilities that are necessary for this goal. The DRT-service is publicly accessible for everyone who lives in a certain area and uses low-capacity road vehicles that respond to the demand by changing its route and/or its time table and collects fares per passenger (Wang et al., 2015). DRT is often applied in regions where normal services are no longer seen as viable because of the low demand and are therefore mainly

found in rural areas with lower population densities (Barrilero et al., 2017). Mobility is seen here as a service, often referred to as MaaS, that might even replace car usage when successfully implemented (Ryley et al., 2014).

Figure 6: Hub location in Hoogkerk (Own work)

A system can, according to Wang et al. (2015), be called demand-responsive when it meets the following criteria:

- The service is available to the general public
- The service is provided by low capacity vehicles like small busses, vans and taxis
- The service reacts on changes in demand by providing different routes or driving according to changing time tables
- The ticket fare is charged per person and not per vehicle which makes different routes per passenger possible

Passengers register via a mobile application or by calling a telephone number and request a route. Drivers are then directed to the pickup point and take the passenger to its destination (HEREmobility, 2020). DRT is not a new system, because the first tests where already executed in the 1910's in the United States (Ellis & McCollom, 2009). The amount of systems was however very limited until a grow in North-America in the 1970's and the first services in Europe. New communication methods like the mobile phone in the 1990's made DRT more practical, because users can call everywhere and at every moment a telephone number to get picked up. Despite the developments that DRT has undergone, it has not yet been well accepted as a substitute for conventional services in low-demand areas (Davison et al., 2014). One of the main reasons for this low acceptation is that the systems have to raise ridership to reduce subsidies which often raises the necessity of a conventional line. This limits the application of DRT (Coutinho et al., 2020). However, with more and more regions with population decline it becomes more and more interesting. This is also why several systems have been set up in recent years (figure 7).

	Starting year	Type	Platform	Modality	Scheduling	Routing	Geographic coverage	Place of origin
HSL HRT kutsuplus	2012	Public	Website-based	Stop-to-stop	Flexible	Flexible	Area-based	Helsinki, Finland
VIA VAN	2013	Private	App-based	Stop-to-stop	Flexible	Flexible	Area-based	New York, USA
BRIDJ	2014	Private	App-based	Stop-to-stop	Flexible	Flexible	Area-based	Boston, USA
CHARIOT	2014	Private	App-based	Stop-to-stop	Fixed	Fixed	Line-based	San Francisco, USA
brengflex	2016	Public	App-based	Stop-to-stop	Flexible	Flexible	Area-based	Arnhem-Nijmegen, Netherlands

Figure 7: Characteristics of DRT services around the world (Coutinho et al., 2020)

There are differences between the several DRT services that can be found around the world, as can be seen in the figure above (Coutinho et al., 2020; Enoch et al., 2004). Firstly there can be differences in the reservation platform. There are systems that are working only via a website like the Kutsuplus system in Helsinki and the current Hubtaxi in Groningen. There are, however, also systems that are working with an application. Examples are Brengflex in the region Arnhem-Nijmegen and the future additional method to reserve a trip of the Hubtaxi in Groningen (Reisviahub, 2020). Secondly there can be differences in modality. There are systems that only bring people from certain stops to certain stops like the systems above, where other systems bring people from door to door. It is debatable if the Chariot system in Boston, mentioned in the figure, can be seen as a demand-responsive system because DRT systems are according to Wang et al. (2015) always systems with flexible routes and flexible schedules which is not the situation with that system.

2.3. Transport sustainability

Next to the need of public transport for dependent groups like elderly and children, DRT has also the potential to reduce or even replace car usage and make transport more sustainable by reducing greenhouse gas emissions (Interreg, 2018). In Canada for example, transportation is the single largest source of greenhouse gasses with 25% of the total emission (Vaughan, 2020). Less vehicles can also reduce the amount of congestion. Congestion makes air pollution worse and more dangerous for drivers, commuters and individuals who live next to major highways (Zhang & Batterman, 2014). To solve these problems, a sustainable (public) transport network is essential. Transport sustainability is largely measured by the effectiveness of a transport system and the environmental and climate impacts of that system (Jeon & Amekudzi, 2005). Next to that, the implementation of DRT in combination with (electric) biking, electric scooters and electric or hydrogen busses can improve the sustainability of a transport system (Zijlstra et al., 2018). To make a successful sustainable transport network it is important to include private parties in a private-partner collaboration strategy (Smith et al., 2018). These private parties can research and come up with potential new ways of transport, like sustainable self-driving vehicles, vehicle rent and new facilities. These innovations can potentially increase the public value of

the hubs and make it more attractive for travellers (Reisviahub, 2020). The scooter and bicycle sharing systems that already exist can also be integrated.

2.4. Conceptual model

During the research, the sub questions in the problem statement are answered, to come to the answer on the main question schematized in the conceptual model (see figure 8). In the three subtopics ST_{1-3} is respectively researched how public transport functions in shrinking areas, how DRT functions and how it influences accessibility, and how demand-responsive (public) transport can help to reduce car usage and thereby reduce exhaust gas emissions. This model is schematised in the figure below.

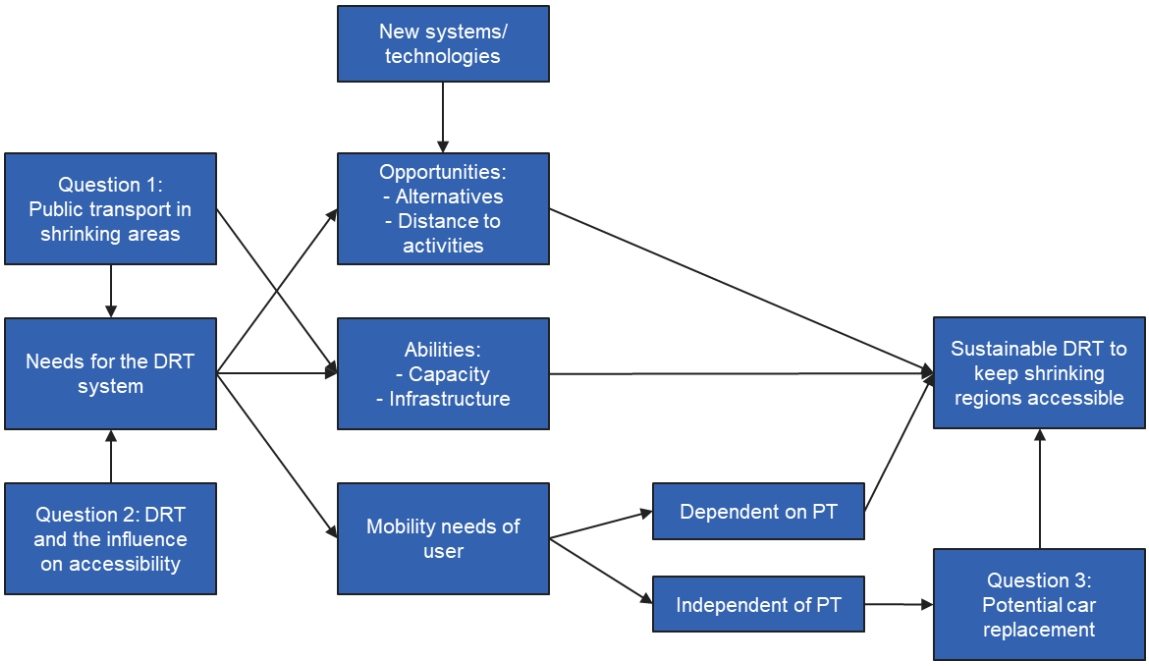

Figure 8: conceptual model

Central to the problem is the mobility of users, depending on the personal features of these users (Edens, 2006). These features have effects on the opportunity's users have in alternative ways of transport or other activities more nearby, the needs for mobility they have and what their abilities are when an eye on money, capacity and personal mobility. The abilities are split out in dependent users and independent users. This is to differentiate between people that have alternatives for other ways of transport and people that are totally dependent on the transport system for their mobility. The dependent group is analysed in subtopic ST_2 and the potential independent group that also has a car or other way of transport for longer distances is analysed in subtopic ST_3. The opportunities, needs and abilities in the end decide how demand-responsive and sustainable ways of (public) transport keeps shrinking regions accessible.

2.5. Public transport in shrinking regions (ST_1)

This research is divided in three subtopics (ST_{1-3}) related to the sub-questions. The first subtopic (ST_1) is focusing on two aspects: firstly, how well public transport functions in shrinking regions around the world and secondly what the current state of the bus network in the shrinking regions in the province of Groningen is.

Mobility is one of the basic needs for the liveability in regions, especially the connection between rural and urban areas is seen as a major factor to prevent people from moving out of rural areas and to keep it liveable (Šipuš & Abramović, 2017). Public transport has an important role in this mobility because of the capacity, effectiveness of costs and the ecological acceptability, but also because it is often the only available way of transport for groups that cannot afford a car (Bronsvoort, 2019). Governments, however, have major problems with keeping up the public transport systems in low-density areas because of the financial unviability as a result of low-demand (Barrilero et al., 2017). Where in the higher density areas a conventional scheduled public transport service is preferred because of the reduction of waiting times and the chance to provide an optimized system based on a timetable, this system will be too costly in low-density areas as can be seen in for example the United Kingdom (Better transport, n.d.). Cuts in the investments in these services can lead to stretching lines, a lower frequency and the disappearance of lines which has a negative impact on the travel experience of users because of longer waiting times and less direct services (De Jong et al., 2011). Population decline can make the effects for accessibility even worse, because facilities will disappear that lead to the situation that schools, shops and workplaces are too far away to reach by walking and cycling and increases car usage (Bronsvoort, 2019; Verwest & Van Dam, 2010; Wiersma et al., 2015). The disappearance of facilities can also cause people to move away, which again results in a lower demand for public transport (Duranton & Turner, 2008). When as last also public funding for the non-profitable lines becomes less, keeping these lines up will be (almost) impossible (Better transport, n.d.). Šipuš and Abramović (2017) state that a successful public transport service is a system which is accessible, has a short journey time, a high frequency, low ticket prices and is save to use.

Public transport in Dutch shrinking regions

Although the Netherlands has a high population density on average, regions as the beforementioned parts of the province of Groningen and parts of the provinces of Overijssel and Gelderland have a far lower population density (De Jong et al., 2011). Population decline has the same effects as in the United Kingdom, namely a reduction in public transport connections. Just like in other regions, public transport is also in Groningen essential to keep vitality in the shrinking regions and to keep these regions accessible for the dependent groups (BZK, 2018). The solutions, and for example the introduction of a well-integrated DRT system, have to be made by the provinces, the OV-bureau, transport companies and municipalities in shrinking regions. These groups are interviewed in this research.

2.6. Demand-responsive transport and the influence on accessibility (ST_2)

Demand-responsive transport is often suggested as the best solution to keep rural areas accessible where the conventional services can no longer financially fulfil this role (Ellis & McCollom, 2009; Mageean & Nelson, 2003; Wiersma et al., 2015). There are also examples of DRT systems in cities, like the former Kutsuplus system in Helsinki (Haglund et al., 2019), but most systems can be found in the more rural areas or for the connection between urban and rural areas (Barrilero et al., 2017). There are several examples of DRT systems all around the world, because in several cases it led to a significant decrease in passenger perceived travel time, an increase of mobility of the users and cost reduction in most simulations (Navidi et al., 2017). According to Hardy (2019) it is most important for the success of a DRT system that it is carefully planned and designed, that the right model is chosen, and that the visibility of the system and the functionality are monitored. To find out which different systems there are and how they functions or functioned, some examples from around the world are mentioned below.

Mokumflex Amsterdam-Noord

One of the locations in the Netherlands with a DRT system are the rural parts of the municipality of Amsterdam. The concept arose from a pilot program in the city that took place between December 2017 and December 2018 (Coutinho et al., 2020), consisting out of two separated rural areas. One of these areas is Landelijk Noord (Rural North) which consists out of rural farmland and four small villages. Before the pilot, the villages where served by the two local bus lines 30 and 31 of the GVB company (Jacobs, 2018). These busses only operated between Monday and Friday with three vans but where expensive to keep up because of the low passenger demand. To make the system more financial robust, the two lines where replaced by a DRT system that functions seven days a week with two vans of taxi company RMC (figure 9). The new system had a reduced mileage and a larger operating time-frame which contributed to a better overall efficiency, a lower number of total kilometres, lower operational costs and a reduction in greenhouse gas emissions. There was, however, also a downside because of a drop in ridership to less than 28% of the old situation. This makes that this system was successful in cost-reduction but did not appeal all the old passengers to use the system (Coutinho et al., 2020).

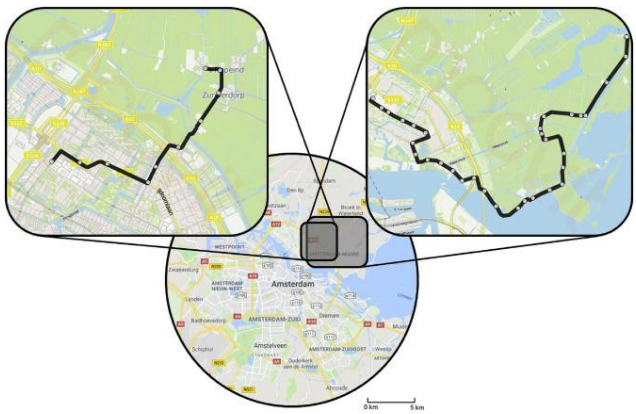

Figure 9: Replacement of bus lines 30 and 31 by Mokumflex (Coutinho et al., 2020)

DRT in Lincolnshire

Also, the rural region of Lincolnshire in the United Kingdom has to deal with a rising car ownership which has consequences for the financial viability of the bus services in this county (Wang et al., 2015). Also, an ageing population coupled with constraints on public spending make that a DRT system can be a possible solution to keep these regions accessible in the future (Baker, 2011). The system is implemented after successes in other counties like Northamptonshire and Herefordshire, a DRT system to a hospital in Essex, and flexible taxi services that have to be pre-booked in Leicestershire (Forster, 2011). DRT systems are popular in the United Kingdom and are already present since the 1970s but have never reached its full potential as a mainstream transport mode (Nutley, 1988). From the research of Wang et al. (2015) became clear that in this region the DRT system is especially successful for meeting the demand of elderly who are living in rural areas and who have a dependence on public transport to keep their mobility. In customer surveys became clear that users are highly satisfied by this service.

Kutsuplus Helsinki

Next to rural areas, there are also city regions where the DRT system is applied, like the former Kutsuplus system in Helsinki (Haglund et al., 2019). This flexible demand-driven micro-transit system was implemented in the Helsinki Capital Metropolitan Region (HCMR) between 2012 and 2015 and consisted out of a small amount of minibuses with a capacity of nine passengers. Unique of this system was that it was applied in a metropolitan region and not in a rural area. When the system was a success it was planned to expand further soon as what happened with earlier implemented systems (Dong et al., 2016). However, despite the capacity of nine seats, the occupancy rate was only 1,27 per ride, which was an important factor for the failure of this system (Haglund et al., 2019). One of the reasons for the low occupancy rates, was according to Coutinho et al. (2020) that the system did not made use of smartphone applications and the bookings had to be made via a website. Because the system had to less economic performance the operation ended in 2015 (Dong et al., 2016).

Overijssel

The Dutch province of Overijssel has also a DRT system, called the Regiotaxi. This system consists out of two systems: a core system of regional busses and trains that are driving all day, and an additional network that consists out of local busses driven by volunteers in low frequency and the demand-driven Regiotaxi. The costs of this system are paid by the province, via passenger contribution and by the municipalities. How much the passenger contributes depends on the type of passenger and the transport mode (De Jong et al., 2011). To force people to take a conventional parallel bus service, the passenger pays more for the Regiotaxi when this is the case. When there is no parallel service, in evenings or in weekends, the fares are lower. In this way the service makes as much yield as possible and serves also a large low-demand area in evenings and weekends.

Hubtaxi Groningen

As mentioned before, there is already such a system in the province of Groningen, but there is still a lot of critique on its implementation. The system is, according to the Dutch Public Transport Consumers Platform and the Dutch travel organization Rover, unfindable because it is not integrated in the most used 9292-OV application, unreliable and two to five times more expensive than conventional public transport (Vinkenvleugel, 2019). Because of the same reasons the former municipality of Vlagtwedde even tried to stop the implementation of the Hubtaxi within their borders, which could potentially lead to a severely reduced mobility, mainly for the elderly which travel outside the rush hour (RTV Noord, 2017).

2.7. Car replacement by demand-responsive and sustainable public transport (ST_3)

Next to the implementation of DRT for groups that are dependent on public transport, there is also a potential to reduce or even replace car usage in rural areas (Alonso-González et al., 2018). The replacement of several cars by a (DRT) bus service has advantages like fewer vehicles on the road, less congestion and less greenhouse gas emissions (Bischoff & Maciejewski, 2016; Navidi et al., 2017). This makes that public transport, also in the form of DRT, can also play a role in making transport sustainable. This can be offered in combination with sharing systems. These systems offer mostly individual transportation (car-sharing, bike-sharing and ride-sourcing) and have therefore not a significant contribution in the reduction of greenhouse gas emission and congestion (Alonso-González et al., 2018).

To attract car users to the new DRT system, it is important to know that there are two types of car dependent people: objective and subjective (Jeekel, 2013). Objective car-users are people who are dependent on the car to be mobile because there are no other acceptable (public) transport alternatives when looking to travel time and travel costs. In low-demand areas cars are usually more performing because public transport requires large mileages and serve displacements and should be used for comparison in the moment the decision for a mode is made (Coutinho et al., 2020). These people can therefore be attracted to a new system by offering better alternatives like a well-functioning DRT system (McCoy et al., 2018). There are only also subjective car-users that use their car because they are used to and do it every day because they always did. To attract these car-users to new DRT systems is far more difficult because it requires a change in behaviour (Wiersma et al., 2015).

3. Methodology

In this chapter the methodology of data collection, data analysis and the ethical considerations are included.

3.1. Data collection & analysis

The sub- and main questions are answered by primary data from the interviews that will be compared with secondary data from literature analysis. A qualitative analysis method is best in line with the research, because it gives space to think about innovation, new methods of flexible public transport and methods to make new services attractive. A quantitative data analysis cannot answer these questions in the same level of detail and is less suitable for the analysis of visions and opinions. The data collection will be elaborated according to figure 10.

Figure 10: Schematic representation of the data collection

Literature analysis

Before the primary part of the research by interviews, an analysis of the available literature was executed. This literature analysis gives inside in what is currently know about demand-responsive transport and gave direction to the questions that were asked during the interviews.

Preparing interviews

The qualitative research was carried out by semi-structured interviews with several experts from the field about their knowledge and opinions. Important is that these experts give a best possible representation by involving governments, external experts and operators. The interviewees were reached by making use of the personal network of former employers during internships of the bachelor of Civil Engineering, guest lecturers during the (pre-) master and sending e-mails to interesting parties like the OV-bureau with a request to interview an employee that focuses on this subject. The final interviewees, their institution, and company as well as their role are shown in figure 10. The codes in the first column are used in the rest of the report to refer to the interviewees.

Cd.	Name interviewee	Function	Company/party	Date
I_1	Jaap Mulder	Project manager	Province of Groningen	30-10-2020
I_2	Michiel Evers	Traffic engineer	Former municipality of Delfzijl (Now Eemsdelta)	03-11-2020
I_3	Jenno Kootstra	Senior consultant traffic safety		03-11-2020
I_4	Jorn van der Scheer	Planner & transportation developer	OV-bureau GD	13-11-2020
I_5	Petra Buitenhuis	Project- & contract manager	Publiek Vervoer	17-11-2020
I_6	Wouter Mantel	Transport engineer	Qbuzz	18-11-2020
I_7	Anne van der Veen	Program employee Smart Mobility	Over Morgen	24-11-2020
I_8	Almer Top	Consultant hubs	Reisviahub	09-12-2020
I_9*	Anita Medendorp	Human Resource Manager	UVO Vervoer	30-12-2020

*Figure 11: Interviewees in this research (*interviewed by filling in the question list)*

This combination of interviewees gives several different views on the research topic, from the client side of the governments of the province, municipality, OV-bureau and Publiek Vervoer but also from the side of public transport operators like Qbuzz and UVO Vervoer. Reisviahub and Over Morgen are organisations that are added to give also another view from the side of public transport hubs and sustainable transport development.

Interviews

The interviews were executed via the telephone and the online communication application of Skype as a result of the COVID-19 crisis. This crisis made it impossible to meet in person, because of the closed offices and risk of transmitting the virus. All interviews took around an hour with first an introduction of the research and where held in Dutch. This means that the opinions and quotes in the results are translated to English. The whole interview was sound recorded and notes were made. Before the start of the interview, the participant was asked whether this method was approved. Next to that, the participant was asked to sign an agreement of participation. All interviewees in the research agreed with recording for transcribing purposes. The last interview with UVO Vervoer was because of time issues within the company executed by receiving the question list with answers. These answers are used to expand on the answers given by the other interviewees in the transcripts.

Transcribing

The recordings are transcribed, with the software of Listen N Write. The recording is transcribed verbatim and not literally. This means that everything will be written down, but without hesitations, filler pauses and stutter, and with the addition of interpunction. This method makes it easier to analyse the text and to paraphrase it in the results. The interviews are transcribed in Dutch, the coding is executed in English.

Coding

After permission of the interviewees the transcripts are coded with the coding programme Atlas.ti. With the programme 27 codes where made of which most where based on the interview guide. The general codes are starting with a 1, the codes of the first subtopic with

a 2 and so on. Extra codes where added for extra topics that where mentioned in the interviews that where not in the interview guide.

3.2. Public transport in shrinking regions (ST_1)

The first subtopic functions as a research to the current state of public transport in rural areas and shrinking regions and which challenges there are. The interviewees was asked if these challenges also occur in the province of Groningen, which problems result out of these changes in bus lines and if it is the responsibility of governments to keep rural areas accessible even when the bus lines have no financial viability. The last question of the subtopic was if a good public transport network can in the end lead to a different pattern in where people live and if it slows down population decline.

3.3. Demand-responsive transport and the influence on accessibility (ST_2)

The second subtopic focusses on demand-responsive transport and what its potency is in dealing with the challenges that the current public transport in rural and shrinking regions is facing. For the creation and improvement of the current DRT network called the Hubtaxi it is important to ask which factors are important for the different user groups. The three largest user groups, the elderly, the schoolchildren and the commuters, are analysed first and after that there is asked if there are other important groups that can use the new and improved system. The current existing DRT system in Groningen-Drenthe also have to deal with critique (De Jong et al., 2011) and the interviewees is asked how to solve the current problems of unfindability, the high price and the unreliability and what the role of them or their company can be in this improvement.

3.4. Car replacement by demand-responsive and sustainable public transport (ST_3)

The last subtopic is about the replacement of the car by demand-responsive and sustainable public transport and how to attract new users that are not depending on public transport nowadays. Ryley et al. (2014) states that there is potential for car replacement but in this research is analysed if this is also the case in the province of Groningen and what the interviewees' vision is about this topic. First is asked how to attract former objective car users. However, there are also users that have a good alternative for their car but stick by the car out of habit and the interviewees is also asked how to attract these people to a good functioning DRT and sustainable system. Next to the Hubtaxi, also individual sharing systems like shared cars, shared scooters and shared bicycles are researched which also can have a potential in the reduction of car usage and potentially work together with DRT systems to make it more attractive. This will be, however, a large challenge according to literature (McCoy et al., 2018)

3.5. Ethical considerations

In the research to how demand-responsive and sustainable ways of public transport can keep shrinking regions in the Dutch province of Groningen accessible experts, and currents users of the Hubtaxi where interviewed. To prevent conflicts of interest or bias, there were no interviews held with employees or staff members where there are personal (financial) interests for the researcher, like team leaders or people from the immediate vicinity. Next to that, this research is not funded or pushed in a certain direction by an interviewee and will be executed as totally independent (KNAW, 2012).

Before every interview the interviewee is asked to sign an agreement of participation. In this agreement, the expert will be asked for a permission to record, if the participant wants to be anonymous in the report, and which pseudonym can be used in the transcripts. The transcripts were sent to the participant after completion and before inclusion in the research report. This guarantees that all the data is used without problems.

The recording is transcribed verbatim and not literally. This means that the answers are not quoted but paraphrased.

4. Results

Nine different interviewees of eight different companies where interviewed. The interviewed parties are: the province of Groningen, the former municipality of Delfzijl (now part of the municipality of Eemsdelta), the public transport agency OV-bureau Groningen, public transport agency Publiek Vervoer, bus operator Qbuzz, consulting firm Over Morgen, hub programme initiator Reisviahub and taxi operator UVO Vervoer.

4.1. General results

Role of company in providing public transport

During this research nine interviewees were asked about their vision and knowledge about public transport in rural areas, demand-responsive transport and the replacement of the car by DRT. In the general part of the interview, five codes where used. These are four basic codes ($C_{1.1\text{-}1.4}$) and one extra code to elaborate further on the MaaS-application ($C_{1.2.1}$). These codes are shown in figure 12 with the amount of answers behind it. Code $C_{1.3}$ was used to get advice of parties that also have to be interviewed for the research and code $C_{1.4}$ gave examples of DRT systems that were used in the introduction and theoretical framework and will not be covered in this result section.

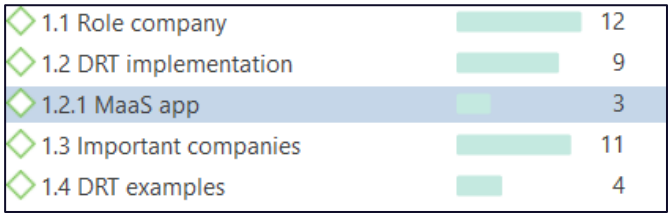

Figure 12: Codes used for the general questions

Role of the interviewed company in public transport ($C_{1.1}$)

All interviews where started with the question what the companies' or governments' role is in the current public transport. This is summarized in figure 13.

Company/government	Int.	Role company/government
Province of Groningen	I_1	• Grantor bus- and train transport in Groningen-Drenthe together with the province of Drenthe • Working on demand-responsive transport as part of the OV-bureau
Former municipality of Delfzijl (Eemsmond)	I_2, I_3	• Input of wishes for the new concession • Facilitation and realisation of bus stops • Target group transport (SSA and schools) • Railroads and stations
OV-bureau GD	I_4	• Responsibility for PT and awarding the concession of Groningen-Drenthe • Leading in the development and improvement for the purpose of the passengers • Making plans that are assessed by councillors of the two provinces and the municipality of Groningen • Responsible for development and management of the Hubtaxi
Publiek Vervoer	I_5	• Grantor school transport, SSA-transport and other local transport in the concession of Publiek Vervoer to local taxi companies like UVO vervoer • Creation of a good network at the bottom of the market
Qbuzz	I_6	• Public transport company with busses in Groningen • Development of a bus network together with the OV-bureau • Responsible for customer service, management and maintenance of the bus fleet • Meeting the requirements of the OV-bureau and provinces in the way to zero-emission and other services
Over Morgen	I_7	• Consultancy for sustainable area development and energy transition • Research for municipalities about sharing systems and demand-responsive transport • Involved in the programme of Smart Mobility in the transport region Amsterdam
Reisviahub	I_8	• Improving quality of transport hubs for all sorts of transport like public transport, sharing systems and own vehicles
UVO Vervoer	I_9	• Providing the Hubtaxi as part of the transport contracts with Publiek Vervoer • Providing transport under the SSA and school transport as part of the transport contracts with Publiek Vervoer • Further additional taxi transport

Figure 13: Overview of the roles of the companies in public transport and DRT systems

Implementation of demand-responsive transport ($C_{1.2}$)

At the start of the interview the interviewees were asked how their knowledge about demand-responsive transport is and how the interviewees see the implementation of demand-responsive transport. All interviewees are familiar with the term of demand-responsive transport and knowns how it is implemented in the province of Groningen and in other regions ($I_{1\text{-}9}$). The provinces of Groningen and Drenthe are together in Interreg Community Initiative G-PaTra (Green Passenger Transport in Rural Areas) which strives for added value in combination with cheaper and more sustainable transport (I_1). This programme is housed at Publiek Vervoer, an organisation that forms the bridge between the governments and the selected taxi companies that provide the services of local busses and the Hubtaxi (I_5). The interviewees see demand-responsive transport as a high potential part of the answer to mobility problems and the goal of 100% area coverage to prevent transport poverty, but not as the total answer (I_1, I_4). DRT can be used for the lower part of the market for supplementing the basic network at places where trips cannot be bundled properly (I_4, I_7). Important to make it a success is also to convince inhabitants because they often do not think about other modes that cars or bicycles and most are not willing to sacrifice their car for a bus that have to be reserved, even not when you can take this service at every moment (I_3).

Implementation of a MaaS-application ($C_{1.2.1}$)

To make a system also digitally integrated there are already pilots with Mobility as a Service-applications, which can be used to plan a route and reserve a trip (I_1). These applications can help to make the usage of a DRT system easier for users and appliers. It is for example far easier to book a ticket in this application then that you always have to call an hour in advance (I_4). Publiek Vervoer sees contracted transport, however, still separated from the MaaS-application as mentioned in the next quote:

I_5: "We see the SSA-transport as a separated world of contracted transport that does not belong to the Maas-app at this moment. Slowly we want to go there, but for now is it contracted target group transport. We talked about it and it will be nice if it can be in there as well in a couple of years."

4.2. Public transport in shrinking regions (ST_1)

In the first subtopic ST_1, seven codes where used. These are six basic codes ($C_{2.1\text{-}2.6}$) and one extra code to elaborate further on transit-oriented development ($C_{2.2.1}$). These codes are shown in figure 14 with the amount of answers behind it.

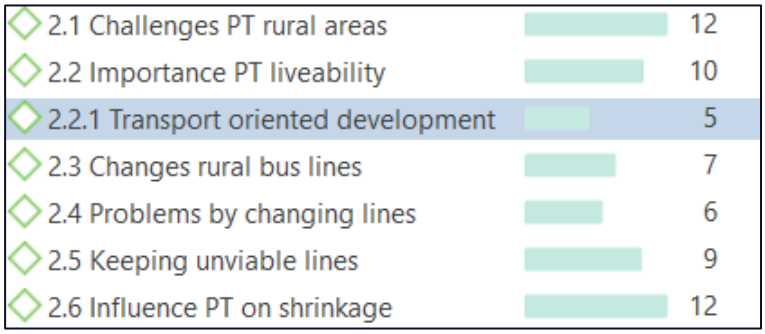

Figure 14: Codes used for subtopic ST_1

Challenges of public transport in shrinking regions ($C_{2.1}$)

Public transport in shrinking regions and rural areas have to deal with several challenges that have effects on the viability of public transport. Especially the financial viability is mentioned by the interviewees as a challenge ($I_{1\text{-}8}$) and is also mentioned the next quote by the OV-bureau:

> *I_4: "Busses are expensive, the cost coverage ratio in Groningen is approximately 50%. This means that for every euro that a passenger pays, the government had to add pre-corona a euro as well".*

The lower number of users of the line leads to a low occupancy rate which in its turn leads to less profit (I_5, I_6, I_9). Because facilities in the shrinking regions become more centralized, like the hospitals in Winschoten and Delfzijl that have been merged in Scheemda, public transport becomes even more important for the liveability and gets a larger social task (I_4). Next to a lower demand, the demand also becomes more shredded because the chance that people want to make the same route reduces (I_7, I_8). It is important for public transport in shrinking regions to find a balance between the exploitational factor of financial viability on one side and the social factor of accessibility on the other side (I_7, I_8).

Importance of public transport for liveability ($C_{2.2}$)

All interviewees agree that public transport is important for the liveability in rural and shrinking regions ($I_{1\text{-}9}$). An example is a situation where a hub is too far away from the village where you live:

> *I_4: "The usage of the Hubtaxi is not really large, but it is used. When you live for example in a small rural village and you have to cycle three kilometres to a hub, it is pretty sad if you cannot do that"*

Especially children that are part of families that live in these areas, there is a great need for public transport to keep their mobility and visit activities (I_1). Where their parents can buy a car to come around, children need other people to bring them to their activities. This challenge becomes even larger in regions with population decline, because facilities disappear or are centralized which makes that longer distances to these facilities have to be bridged (I_4, I_9). When public transport or a reasonable alternative is not available for this group, together with other groups that are not able to drive a car, you can speak of transport poverty. There is then a large social network needed to still keep their mobility (I_4). There is also a role for planners to be critical about where facilities can be centralized or moved to, also known as transit-oriented development (I_8).

Transit-oriented development ($C_{2.2.1}$)

This so called 'Transit-oriented development' can reduce the amount of movements that have to be made and can offer a situation where everyone in a certain area can reach that facility with public transport (I_4, I_6, I_8). Three examples where given by the interviewees: two different schools in the city of Coevorden and the village of Woldendorp (I_4) and the hospital in the village of Scheemda (I_8). All these three facilities have in common that they are located in a less optimal locations further from large transport axes which results in longer travel times for the visitors, extra school lines in rush hours and more transfers. Transit-oriented development can fix these problems in the future by the realisation of these facilities on a more accessible location near to a public transport hub (I_4, I_6, I_8).

Changes in rural bus lines ($C_{2.3}$)

It became clear in the literature that bus lines in shrinking regions are changed. Frequencies are reduced, lines are stretched and connections disappear mostly because of financial purposes (De Jong et al., 2011). The interviewees see similar changes in the rural bus lines in the province of Groningen, but make thereby the side note that the downscaling is limited in comparison to other rural areas (I_1). This is mostly the result of the fact that the governmental OV-bureau has the lead in addition to other regions where a commercial party, that more has to strive for financial viability instead of social issues, has this responsibility (I_1, I_3, I_5, I_6, I_9).

Problems by changing rural lines ($C_{2.4}$)

The downscaling of lines can lead to several problems. Stretching lines have positive and negative effects, which became clear in the next quote of Over Morgen:

I_7: "Stretching lines is good for three quarters of the bus travellers and bad for a quarter. That is for me the rule of thumb, because the most of the people have no problems with walking a little bit further and most of the schoolchildren are only happy that there is an extra bus".

Because bus stops at stretched lines are often located outside of the cities there will be also consequences for social safety, physical safety for people who cross busy roads at the wrong

place, and for the accessibility for groups of reduced mobility (I_1, I_7). Frequency reductions have high consequences for rural bus lines and are therefore more applied on lines with higher frequencies as can be seen during the current corona-epidemic (I_4). Consequences when frequencies are reduced on rural lines have high effects on the regions' accessibility and give more complaints about the product quality. This also gives higher pressure on the SSA-transport to keep needy groups mobile (I_6). Other groups have no transport anymore or will start complain about the bad quality of the offered transport, municipalities get higher costs because of SSA, and lines drive less efficient which results in a higher emission (I_6).

Keeping up unviable lines ($C_{2.5}$)

All interviewees have the vision that unviable lines must be preserved at least partly ($I_{1\text{-}9}$). This is also the current situation in the province of Groningen because tickets simply do not cover the whole cost of the service (I_1, I_4, I_6). The governmental organisation OV-bureau is responsible for keeping the basic connections (I_4). This organisation has the responsibility to prevent that only costs play a role in determining which line should be retained which leads to a socially unacceptable network (I_1, I_4, I_8). Publiek Vervoer wants to prevent this by the next statement:

I_5: "I sort of think that if there is no other alternative that everyone can use that is affordable and accessible, you should maintain public transport lines even if they are not profitable".

The trips that cannot be made anymore, will potentially be made by car in the future or cannot be made by people who are dependent on public transport (I_2, I_5, I_8). Important side note is here however that resources are also limited and not all connections can be kept upright against all costs (I_8). An example where this happened was in Belgium where a lot of unviable small lines where preserved to give everyone a bus stop within 500 meters from their home. This resulted in several almost useless lines which entailed unnecessarily high costs.

Influence of public transport on population decline in Groningen ($C_{2.6}$)

In the interviews it became clear that public transport has influence on population decline in the region but that this is more a facilitating role and not a determining role (I_1, I_2). The facilitating role consists out of the fact that people who do not have alternative ways of transport potentially move away to another place with better connections (I_6, I_8). Also, for people that want to move to a place it can be part of the consideration if they want to live there when the needed connections are absent or when there is a possibility that connections will disappear in the future (I_4). Other factors are however more important like work and other facilities, and factors that reduce the living pleasure such as the earthquakes in Groningen as a result of gas extraction (I_2, I_3, I_7). The interviewees see only more impact when larger connections are constructed, such as for example the future Lelylijn from Amsterdam to Groningen or the Hofplein metro connection between The Hague and

Rotterdam (I_5, I_7). This has however only effect on places that have already potential and will not save smaller rural villages (I_8).

4.3. Demand-responsive transport and the influence on accessibility (ST_2)

In the second subtopic ST_2, eleven codes where used. These are seven basic codes ($C_{3.1\text{-}3.7}$) and three extra codes to elaborate further on DRT to complement public transport ($C_{3.1.1}$), the replacement of school busses ($C_{3.3.1}$) and the promotion and marketing for demand-responsive transport ($C_{3.6.1}$). These codes are shown in figure 15 with the amount of answers behind it.

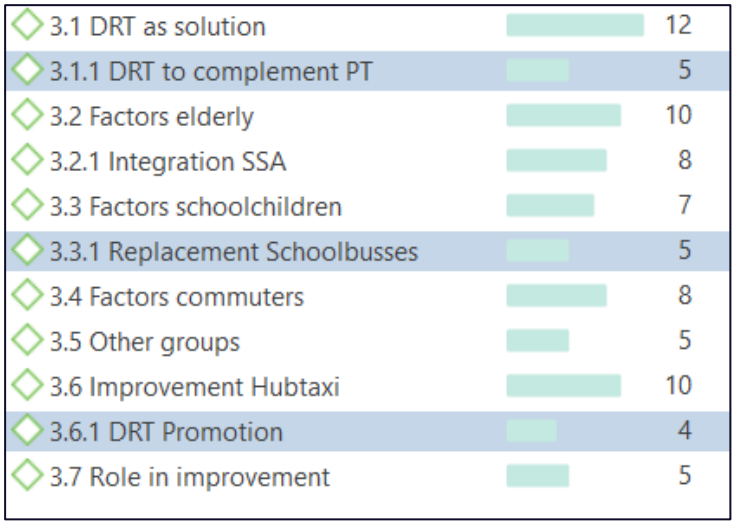

Figure 15: Codes used for subtopic ST_2

DRT as solution for keeping low-demand regions accessible ($C_{3.1}$)

The opinion of the interviewees if demand-responsive transport is the solution for accessibility problems, is mainly positive. The interviewees see this way of public transport only more as a way to complement the system instead of a total replacement of the current public transport network (I_1, I_7). The province of Groningen said the next about this:

I_1: "It is not the intention that we just going to replace bus lines. During the introduction of the Hubtaxi only former call busses where replaced. You had to call for these lines as well, but they were driving, in addition to the Hubtaxi, according to a set time schedule. A large part of those busses became later again conventional services and only a small part was replaced by the Hubtaxi".

The current Hubtaxi together with the conventional transport, the SSA transport, and the school transport offers already an expanded network. There is need for mobility profiles for each village to optimize the network and to find out for which connections demand-responsive transport can be used (I_2, I_3). Large opportunities are there for villages who need a lot of smaller connections in several directions and trips that does not fit in the current public transport routes (I_2, I_6).

DRT to complement public transport ($C_{3.1.1}$)
The reason why not the total network should be replaced by demand-responsive transport, but that DRT is used as part of the chain trip, are the difficulties for exploitation in comparison to conventional services (I_1, I_6). This difficulty is described by Qbuzz as:

I_4: "We plan busses in a way that they have to do something all day. This means that when you have demand-responsive transport that you always have to determine to what extent you can expect passenger requests. If that is on a high level we prefer, in the eye of exploitation, that a bus runs every hour. My expertise is only to limited to know what the exact tipping point is".

This preference for conventional services comes from the fact that a driver and a bus can be reserved for that line for the whole day, where a demand-responsive transport possibly standing still for a long time to wait until a request (I_6). It can also create a threshold for groups to reserve a ride, especially for elderly (I_7). Because of these reasons the Hubtaxi replaced by its establishment in 2018 only the already existing call busses and not the conventional lines (I_1). Passengers in this network use the conventional public transport to go and leave from their nearest hub. Demand-responsive transport will be used after that to transport passengers from the hub to their house or the other way around and in that way complement the normal network to reach 100% area coverage (I_1, I_3, I_4).

Factors that are important to keep low-demand areas accessible for elderly ($C_{3.2}$)
The elderly is a group that is using SSA related transports a lot, that are organised by their municipality where they live (I_1). All interviewees agree that these systems have to be integrated with public transport as good as possible, because of the large cost savings that can be achieved and the current small margins as a result of low occupancy rate and high number of needed vehicles ($I_{4\text{-}6}$). The first steps to integration are already made but these are not a success because there is a lack of clarity about the different responsibilities (I_4). When current SSA users, but also other elderly, has to make use of conventional public transport or a demand-responsive transport system it is according to the interviewees most important that it is easy to use and to find ($I_{2\text{-}5}$, I_7). Therefore, it should also remain possible to reserve a bus by calling instead of only via an MaaS-application where the usage of a smartphone can be a too large step (I_3). Other factors that are important for making travel easier is by offering coaching to help with making a ride reservation (I_7). To make public transport usable, attractive and trustworthy for people under the SSA legislation, it is important that enough busses are available (I_3), that all the busses are good accessible for people with a reduced mobility ($I_{4\text{-}5}$), that the ride is comfortable ($I_{7\text{-}8}$), and that the services are as reliable as the SSA transport services (I_3). The comfort and reliability are already on a high level with the current busses in the fleet of the concession of Groningen-Drenthe but is also important to implement in new services. It is therefore important to know if someone is coming with a wheelchair of attendant especially when they take a smaller bus (I_1). Next to that, consideration should also be given to the SSA indication, as mentioned by Reisviahub:

I_8: "It is nowadays the case that when someone ever got a pass to make use of SSA-transport, it is valid for ever. It can, however, be the case that someone has a sad circumstance for what you have to go with this SSA-transport and that the pass is not needed anymore when that person is recovered".

Factors that are important to keep low-demand areas accessible for schoolchildren ($C_{3.3}$)
According to the interviews, the most important factors of public transport services for schoolchildren are convenience (I_2, I_5), a high frequency (I_7), a low price (I_4), a short travel time (I_2, I_8) and luxury services like Wi-Fi and mobile charging points in the bus and bicycle parking and a kiosk at the hub location (I_{7-8}).

Replacement of school busses by DRT systems ($C_{3.3.1}$)
There is however discussion if the school lines to for example the Dollard College in Woldendorp have to be facilitated by the government or that the school has to offer it themselves (I_2). The replacement of these school services however by demand-responsive transport is according to the interviewees a bad idea and there is more potential for sharing systems (I_1, I_3, I_4). When the schoolchildren have to go with the taxi, they can get the feeling that they are not normal passengers and school lines are better in offering this function (I_1). Demand-responsive transport is only seen as a good way to supply schoolchildren from the small villages where they live to the larger school lines as mentioned by Publiek Vervoer:

I_5: "According to me the system works fine. What I hear is that the schoolchildren use the smaller busses to get to the school lines and change over there".

Factors that are important to keep low-demand areas accessible for commuters ($C_{3.4}$)
For commuters it is most important that the services are reliable, punctual and also available on early moments to be on time for early work shifts of for example healthcare workers (I_{7-8}). For groups that cannot afford a car this transport should be payable or their have to be a social safety net to still offer them the possibility to go to work and activities (I_{2-4}). For the higher earning groups this problem is smaller because the number of owned cars but also lease cars is far higher (I_7). Next to the usage of public transport, commuters have also high potential for using sharing systems when they are available (I_5). It is also important that there are enough facilities on hub locations to park their (sharing) bicycles and (sharing) cars (I_8).

Other important groups ($C_{3.5}$)
The interviewees were also asked which other groups, next to elderly, schoolchildren, and commuters, are important to keep an eye on when setting up or expanding a demand-responsive transport system. The province of Groningen and the OV-bureau see opportunities to bring tourists to attractions in the province, a bike rental, or to the start- or from the endpoint of a walk or bicycle tour (I_1, I_4). The former municipality of Delfzijl sees also an important group in port employees in the Eemshaven (I_2, I_3). These employees often

travel together and would therefore make efficient use of such a transport service. The last group which is mentioned are the users which cannot use SSA transport but think that normal taxis are too expensive (I_4). This can be the small amount of people who go out on a Saturday evening and go home after the last bus has driven.

Point of improvement for the Hubtaxi ($C_{3.6}$) & Promotion of DRT systems ($C_{3.6.1}$)
As mentioned before, the Dutch Public Transport Consumers Platform and the Dutch travel organization Rover where not so positive about the current Hubtaxi in the province of Groningen. The system is according to these organisations unfindable because it is not integrated in the most used 9292-OV application, unreliable, and two to five times more expensive than conventional public transport (Vinkenvleugel, 2019). The interviewees is asked if they see the same problems and how these problems can be improved. Several parties agree that the current Hubtaxi reservation system is difficult to find and that steps have to been made to make it easier findable (I_1, I_2, I_5). To make it more findable, the interviewees suggest to include the reservation of the Hubtaxi it in the public transport applications (I_1, I_2, I_5) and making promotion via advertisements in this same application but also on websites of Publiek Vervoer and 9292 (I_1, I_5). It is only important to have a good functioning system before promotion starts so that the points that are made in the promotion can be made true (I_8). For the reservation of a ride request steps have to be easy to find and to make, also for people who are less digitally educated (I_2, I_5). For groups that cannot use a smartphone, like elderly, it is also important to keep it possible to call for a bus (I_5). Also mentioned where the two to five times higher prices of the Hubtaxi in comparison to conventional public transport. To tackle this problem the first steps are already made by subsidizing the Hubtaxi and lower the price from two and a half times normal price to one and a half times (Provincie Drenthe, 2021) (I_1, I_4). Publiek Vervoer does not recognize the problem of unreliability of the Hubtaxi and does not see it back in the amount of complaints:

I_5: "When we speak about unreliability, we see of course the data which we receive right now and we see an absolute minimal amount of complaints about the Hubtaxi. The unreliability is a rumour that we hear more often, but it cannot be substantiated by the amount of complaints we receive".

To make and keep the system reliable the former municipality of Delfzijl suggests to increase the availability and have more busses available per municipality (I_3).

Role in improvement ($C_{3.7}$)
The interviewees was also asked what their companies' role can be in the improvement and realisation of a successful demand-responsive transport system. The province of Groningen takes here the lead together with the other parties that form the public transport agency of the OV-bureau (province of Drenthe and the municipality of Groningen) to initiate, finance and introducing chain mobility (I_1). Publiek Vervoer can help these parties by connecting the services to the taxi companies in their knowledge network and make an integrated system of

all carriers (I_5). The Reisviahub organisation can facilitate the hub locations to make transfers easily (I_8). Transport companies like Qbuzz and UVO Vervoer are willing to research and participate in pilots to see how to deal with low occupancy issues and to realise a financially covered system (I_5, I_9). Municipalities like Eemsdelta includes points for fossil fuel reduction and giving people the opportunity to make sustainable mobility choices in their Environmental and Planning act and are responsible for supervise compliance with these rules (I_3).

4.4. Car replacement by demand-responsive and sustainable public transport (ST_3)

In the third subtopic ST_3, four codes where used. These are all basic codes ($C_{4.1\text{-}4.4}$) and are shown in figure 16 with the amount of answers behind it.

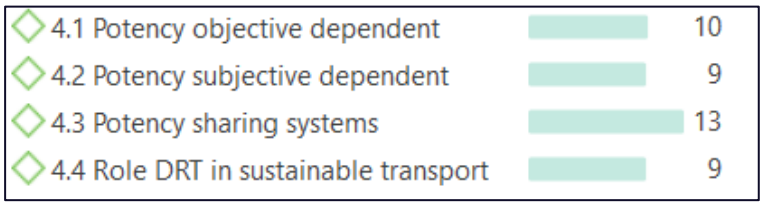

Figure 16: Codes used for subtopic ST_3

Potency objective car-dependent people into DRT system ($C_{4.1}$)

The interviewees are mainly positive but also critical about the potency of demand-responsive and sustainable public transport to attract objective car-dependent people into these systems and in that way reduce emission and congestion. Demand-responsive transport will only be attractive to this group when the offered alternative is of higher quality than the car, that people are familiar with the fact that the system works as it should be, and that it meets the mobility desires of the groups which are in need for it (I_1, I_2, I_4, I_6). Points that are mentioned are for example a convenient reservation system, a guarantee that the bus is on time and a guarantee that the bus is also available for the way back without a long waiting time (I_5). However, even when these points are met it can be hard to surpass the privilege that the car provides, like a high level of privacy, convenience, comfort and flexibility as also mentioned by the former municipality of Delfzijl:

I_2: "It will always be the question if people is offered an alternative, if this alternative is better for them than using a car. If the answer is yes, you have to make sure that those people are going to use it and that they can get acquainted with it to experience how well it works. If the answer is no, they will stay in their cars forever".

Even when these points are met it can be hard to surpass the privilege of the car that provides a high level of privacy, convenience, comfort and flexibility (I_2, I_5). The interviewees see the most potential in the replacement of the second car of a household by demand-responsive transport, which of course still results in a reduction of car movements (I_1, I_8).

A demand-responsive transport system will be especially attractive when facilities are located at public transport hubs (transit-oriented development) which results in a direct connection to their destination (I_8). The corona epidemic can change the amount of congestion because more people are working at home so this can make the need for replacement smaller while the problem of greenhouse gas emissions keeps existing (I_7). It is unfortunately still unknown how this will work out in the future.

Potency subjective car-dependent people into DRT system ($C_{4.2}$)

Where most of the interviewees where quite optimistic about attracting objective car-dependent people to the DRT system the image for the subjective car-dependent group is far more sceptical ($I_{1\text{-}3}$, I_7). Subjective car-dependent people keep using their car even when there will be better public transport options, just because they are used to it but also because the car is really practical for combining several activities in one route ($I_{1\text{-}3}$). The only moment that this travel behaviour can be changed is in a period of discontinuity in people's life, like for example moving to another place, find other work, or when their normal route is out of use for a longer period (I_2). Especially at these kind of moments people are sensitive to targeted marketing. This marketing has to be at the right mentalities to reach the right groups and can be a YouTube video when you want to reach younger people and an article in a newspaper when you want to reach elderly (I_4). Important in this marketing is to make clear how to use the system, how convenient reservation is and other factors to make it attractive to them and also make this true in reality ($I_{5\text{-}6}$). Promoting and making the product attractive is the only way to attract new people because of course nobody can be forced (I_1). Next to that are governments not always willing to get everyone out of the car because of the high incomes from excite duties and taxes (I_1).

Potency of sharing systems ($C_{4.3}$)

The interviewees are enthusiastic about the application of sharing systems because of the low or even zero greenhouse gas emission and the alternative that can be offered for situations where nowadays only the car is suitable for (I_1, I_3, I_4, I_8, I_9). Governments can steer which sharing systems will be offered by making regulations for emission to stimulate bicycles and zero emission vehicles and can also regulate that systems are offered by local companies to contribute to the local economy (I_1). Sharing bicycles are preferred because they are always zero emission and exercising is also good for the health of the user. However, it is also important to offer an alternative for less mobile groups and for moments when the weather is unsuitable to cycle (I_1). Which systems fit the best can be tested with a pilot, like the sharing e-bikes that are placed at the park and ride facility in Hoogkerk (I_3, I_8) (figure 16). By offering electric bicycles, longer distances can be bridged which makes these also usable for longer distances. Sharing systems have in this way more potential than only for the first and last mile (I_3, I_5).

Figure 17: The new launched e-bike sharing system in Hoogkerk (Deelfiets Nederland, 2020)

Important for a network which includes sharing systems is that it is digitally enclosed and that potential users know that it exists and how it works (I_1). For elderly there have to be a possibility to also reserve by calling to prevent the threshold of smartphones and digital systems as which was also the case with the DRT systems (I_5). However, the new elderly offers more opportunities for an expanded digital service that includes demand-responsive transport and several sharing systems. There can also be a difference in which sharing systems are offered at which hub location (I_8). Sharing bikes are for example better applicable for higher populated areas while sharing cars are more useful for rural areas (I_5). When applied in the right way these sharing systems can offer a ride which was impossible before (I_6).

Role DRT in sustainable transport ($C_{4.4}$)

Demand-responsive transport can contribute to a more sustainable system because governments can set a rule that used vehicles have to drive on electricity, hydrogen or green gas and are therefore emission free (I_1). The downside is that this can result in the situation described by Over Morgen during the interviews:

I_7: "One of the situations that I see, but where I am not totally sure how large the problem is, are the consequences of zero emission rules for the budget of operators. […] Bus operators have to realize charging infrastructure, a large power connection in a bus depot and things like that to let drive electric busses. This makes that they have less money for long-term investments and does not change their lines anymore".

Together with sustainable sharing systems, demand-responsive transport can offer a sustainable first and last mile (I_3). Especially when trips are combined and different passengers can be together in a vehicle instead of in eight different vehicles that are offered by different organisations, this will be even more sustainable (I_5, I_6, I_8). Also, the potential contribution to the reduction of car usage or at least stop the growth of car usage makes that emission will not further increase and can stimulate people to use more healthy options (I_1, I_3, I_4).

5. Conclusions

The interviewees in this research see demand-responsive transport as a high potential part on the answer to mobility problems and the goal of 100% areas coverage to prevent transport poverty. This is in line with the positive evaluations in existing literature (McCoy et al., 2018). It is only not seen as a total replacement of public transport but more as a supplementation at the bottom of the market where trips cannot be bundled properly. Pilots for the digital integration of MaaS-applications already started in Groningen and can help to make usage of a DRT system easier for users and appliers according to the interviewees and the literature (HEREmobility, 2020). It is only still seen as separated of contracted transport to fulfil the SSA-legislation by parties like Publiek Vervoer.

5.1. Public transport in shrinking regions (ST_1)

In the first subtopic there was a search for the answer on the question: "How well does public transport in shrinking areas function and what are the challenges that these services have to deal with?". From the interviews became clear that the challenges that are occurring in other rural and shrinking regions also occur in Groningen, like stretching lines, lowering frequencies and disappearing connections (Barrilero et al., 2017; De Jong et al., 2011; Haartsen & Venhorst, 2010). This downscaling can lead to problems of social and physical safety, higher pressure on transport under the SSA jurisdiction, higher costs for municipalities, reduced mobility for dependent groups, and higher greenhouse gas emissions. These changes are mainly the result of the low financial viability and the directly related factor of occupancy rate, which was also mentioned in literature (Barrilero et al., 2017). To prevent the problems mentioned it is important to find a good balance between the financial viability on one side and the social factors of accessibility and liveability on the other side. Therefore, unviable lines have to be preserved when it is important for the mobility of dependent groups like elderly and children. If this transport is not available and there is no reasonable alternative you can speak of transport poverty. This means a reduced liveability and people that move out of a region (Šipuš & Abramović, 2017). One of the factors in the region of Groningen-Drenthe that tries to prevent transport poverty is that the management is at the OV-bureau. This organisation has the responsibility to prevent that only costs play a role in determining which line should be retained. When a commercial party have the lead, it can result in a socially unacceptable but financially viable network which does not even provide the basic connections what also happened in the United Kingdom (Better transport, n.d.). Only when there are good alternatives available for the dependent groups there can be thought about replacing a bus line that is part of the basic network. Important side note is here, however, that resources are also limited and not all connections can be kept upright against all costs. Another view that came out of the research, is that facilities can also be moved to easily accessible central locations, known as 'Transit-oriented development' to reduce the amount of movements. These facilities can be combined with a public transport hub as they are now being created in the hub program. A good accessibility of facilities with public transport consisting out of busses and demand-

responsive transport systems have influence on population decline as also mentioned in the article of Wiersma et al. (2015). The interviewees pointed out that it is, according to them, mainly a facilitating role and not a determining role for where people are going to live. Only larger connections like the Lelylijn or the Hofplein Metro can have these impacts for larger villages. Smaller rural villages need more workplaces and facilities to make it more attractive.

5.2. Demand-responsive transport and the influence on accessibility (ST_2)

The second subtopic went further on the challenges in the shrinking regions by asking how demand-responsive transport can have a role in the accessibility in these regions. The question was therefore: "How does demand-responsive (public) transport functions, and how does it influence and improves accessibility for groups in shrinking areas that are depending on public transport?". The opinion of the interviewees in this research was mainly positive about the question if DRT is a good method. DRT is however seen as the last part to reach a 100% transport coverage and not as a total replacement of public transport. Day covering exploitation is therefore a too large challenge and booking can be a threshold, especially for elderly. The Hubtaxi, an example of DRT in Groningen and Drenthe, therefore only replaced the call busses by its establishment in 2018. DRT combined with conventional ways of transport, the SSA transport and the school transport offers a total network. Mobility profiles of villages can help find out where there is need for demand-responsive transport. The largest opportunities are seen in villages who are in need of several small connections that does not fit in the current public transport system. People can use the conventional public transport to go and leave from the nearest hub and demand-responsive transport from the hub to their house and the other way around. The integration of the SSA related transport is also important to reduce the large costs of this mostly individual transport. To make this happen, conventional and demand-responsive public transport have to be easy findable for especially elderly that want to keep their mobility (Wang et al., 2015). There is for them need for coaching, a high availability, comfortability and reliability. For schoolchildren convenience, a high frequency, a low price, a short travel time and luxury services like Wi-Fi and mobile charging points in the bus and a bicycle parking and kiosk at the hubs are seen as important. School lines should not be replaced by DRT because there is more future in sharing systems. Commuters are mostly in need for reliability, punctuality, affordability and services at early hours in the morning. Sharing systems have a high potential for this group. Tourists and people that do not want to use conventional taxis are also groups that potentially can make use of the Hubtaxi or another DRT system. From literature became clear that the current Hubtaxi is seen as unfindable, expensive and unreliable (Vinkenvleugel, 2019). The interviewees in this research agreed mostly with these points but mention that improvement is on its way or recently made. The integration in travel application still have to be made easier and there are already steps made by making the system cheaper by subsidizing since January 2021. Publiek Vervoer does not agree with the negative statements that are made about the reliability of the Hubtaxi. The negative rating cannot be seen back in the amount of complaints received. Data is not available

because of the corona crisis and will become available in the future. The parties indicated that they can play different roles in this improvement. The province of Groningen takes the lead together with the OV-bureau to initiate, finance and introduce chain mobility, Publiek Vervoer can help parties by appointing the right operators, Reisviahub can facilitate the hub locations to make transfers easily, transport companies like Qbuzz and UVO Vervoer are willing to research and participate in demand-responsive pilots, and municipalities can include points in their Environmental and Planning act.

5.3. Car replacement by demand-responsive and sustainable public transport (ST_3)

Where subtopic ST_2 analysed how DRT can help dependent groups, there is also potential to replace car usage by demand-responsive and sustainable public transport. The sub question is therefore: “How can demand-responsive (public) transport help to reduce car usage and thereby reduce exhaust gas emissions in shrinking areas?”. The interviewees are mainly positive but also critical about the potency of demand-responsive and sustainable public transport to attract objective and subjective car-dependent people as distinguished by Jeekel (2013). This in addition to the literature where several scholars are far more positive (Alonso-González et al., 2018; Bischoff & Maciejewski, 2016; Navidi et al., 2017). The interviewees point out that objective car-dependent people will only be attracted if the offered alternative is of higher quality than the car, that people are familiar with the fact that the system works as it should be, and that it meets the mobility desires of the groups who are in need for it like a convenient reservation system and a guarantee that the bus is on time. But still when these points are met it is hard to surpass the privilege of the car because of its high privacy level, convenience and flexibility. DRT has, however, more change to replace the second car. To convince subjective car-dependent people will be much harder because they will keep their car, even when there are better alternatives. The needed change in behaviour, where also Wiersma et al. (2015) warned for, can only happen in a period of discontinuity in peoples live. At that moment, people are most sensitive for targeted marketing and makes this strategy the best and only way to attract new people. The interviewees are enthusiastic about the application of sharing systems because of the lower or even zero greenhouse gas emission. Sharing bikes are preferred because they have also a healthy effect on their users but are not always suitable for less mobile groups and at all weather conditions. The whole network should be digitally enclosed but also via other systems than a smartphone for groups like elderly. When car usage is replaced by these sharing systems or a DRT system it is of course also important that the fleet are low-emission replacements and not only lower emission in the small amount it does nowadays (Alonso-González et al., 2018). They have therefore to drive on electricity, hydrogen or green gas and this can be pushed by subsidy of governments. An effective transport system in combination with low environmental and climate impacts can be described as a sustainable transport system (Jeon & Amekudzi, 2005).

5.4. Overall conclusions

Demand-responsive transport can have a high potential in the replacement in being at least part of the solution for the accessibility challenges in the province of Groningen. DRT can especially offer connections which are not financially viable for conventional services. The need for a DRT system are depending on the opportunities people have to have mobility, the abilities they have to afford mobility and which needs they have. The opportunities for mobility can be enlarged by offering sharing systems, expanded demand-responsive transport systems and conventional services. This combination can offer also a potential alternative for car users. Most users of a DRT system will be people that are dependent on public transport and where DRT forms the only ability for mobility. These are especially groups like elderly, schoolchildren and commuters that cannot drive or cannot afford a car. By improving factors like reliability, frequency, comfort and findability the systems can even be made attractive for car-dependent people. By reducing the car usage there can be a decrease in the amount of greenhouse gas emissions which can lead together with a good system for dependent people result in a sustainable DRT system that keeps the shrinking regions accessible.

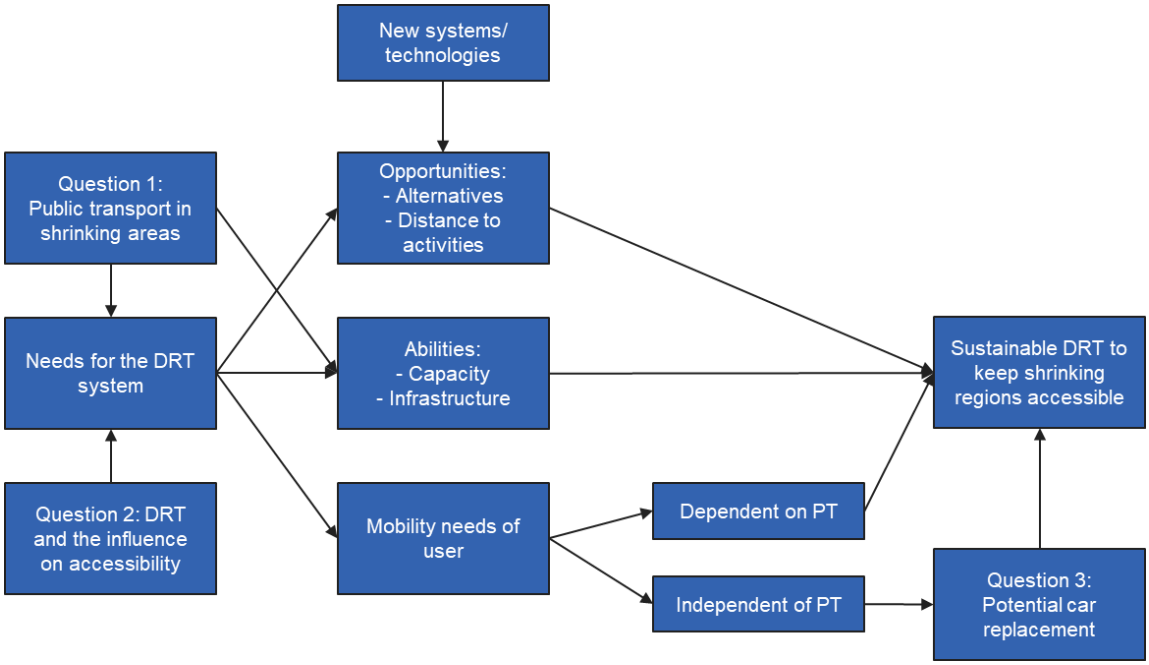

Figure 18: Conceptual model

6. Discussion

Because of the limited scale of this research it is difficult to estimate how representable these results are for comparable regions. This research only focusses on the shrinking regions in the province of Groningen. Differences in culture, society and for example landscape can make demand-responsive transport and certain sharing systems in some regions better applicable and in other regions less applicable. Where bicycles are for example an interesting solution in Groningen it will be less practical in regions with more height differences. Next to that is this research only focussing on experts in the facilitating and realisation of the network and not on potential users. It can be possible that users see other systems as more suitable than the experts whose opinion can be biased by the work they do. Next to that can new usage data give new views on how well the systems functions and how they can be improved. This trend was unfortunately broken by the corona-epidemic and was therefore not available for this research.

Future work can focus on interviewing people in other regions with similar challenges and were demand-responsive system are developed. A larger research group which also involves users but also more parties that have to operate the system, scholars and experts in the field of transport engineering can give a more total view on the topic. Next to that, can a lot of knowledge be gained by testing with pilots were also operators are involved and new innovative systems can be tested.

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Figure 5 – Rijksoverheid (2020). Krimpgebieden en anticipeergebieden.
Figure 7 – Coutinho, F. M., van Oort, N., Christoforou, Z., Alonso-González, M. J., Cats, O., & Hoogendoorn, S. (2020). Impacts of replacing a fixed public transport line by a demand responsive transport system: Case study of a rural area in Amsterdam. Research in Transportation Economics, 83, 100910.
Figure 9 – Coutinho, F. M., van Oort, N., Christoforou, Z., Alonso-González, M. J., Cats, O., & Hoogendoorn, S. (2020). Impacts of replacing a fixed public transport line by a demand responsive transport system: Case study of a rural area in Amsterdam. Research in Transportation Economics, 83, 100910.
Figure 17 – Deelfiets Nederland (2020). NIEUWS: Groningen, here we come! www.deelfietsnederland.nl

All the other figures (1-4, 6, 8, 10-16 and 18) and the front page are made by the writer of this thesis.

Appendix 1: Interview guide

Subtopic	*Question (as asked during the interview)*	*Question (English translation)*	*Codes*
General questions	1. Wat is de rol van u en uw bedrijf in het faciliteren van openbaar vervoer? 2. Bent u bekend met DRT en hoe het geïmplementeerd kan worden?	1. What is the role of you company in providing public transport services? 2. Are you familiar with what DRT means and how it can be implemented?	$C_{1.1}$ $C_{1.2}$ $C_{1.2.1}$ $C_{1.4}$
Public transport in shrinking regions (ST_1)	3. Welke uitdagingen denkt u dat er zijn voor het openbaar vervoer in plattelandsgebieden? 4. Hoe belangrijk is openbaar vervoer volgens u voor het leefbaar houden van plattelandsgebieden? En waarom denkt u dat dit belangrijk is? 5. Ziet u in Groningen dezelfde veranderingen als in andere krimpgebieden, waar bussen lagere frequenties gaan rijden, lijnen worden gestrekt en waar er verbindingen verdwijnen? 6. Welke problemen denkt u dat er ontstaan in Groningen als deze gevolgen van bevolkingskrimp optreden? 7. Denkt u dat overheden openbaar vervoerlijnen in stand moeten houden in plattelandsgebieden, ook als ze niet meer winstgevend zijn? 8. Kan een goed functionerend openbaar vervoersnetwerk bevolkingskrimp afremmen of misschien zelfs stoppen in het noorden en oosten van Groningen?	3. Which challenges do you think public transport faces in rural areas? 4. How important is public transport according to u for the liveability in rural areas? And why do you think that this is it important? 5. Do you see the same trends in Groningen as in other shrinkage areas, where there is a reduction in frequency, lines are straightened and where connection disappear? 6. Which problems do you think will appear in Groningen when these effects of population shrinkage appear? 7. Do you think governments have to keep up public transport lines in rural areas, even when they are not profitable anymore? 8. Can a good functionating public transport system slow down or even stop population decline in the north and east of Groningen?	$C_{2.1}$ $C_{2.2}$ $C_{2.2.1}$ $C_{2.3}$ $C_{2.4}$ $C_{2.5}$ $C_{2.6}$
Demand-responsive transport and	9. Denkt u dat DRT een oplossing is om gebieden met een lage vervoersvraag bereikbaar te houden?	9. Do you think DRT is a solution to keep low-demand areas accessible?	$C_{3.1}$ $C_{3.1.1}$

the influence on accessibility (ST_2)	10. Welke factoren zijn belangrijk om gebieden met een lage vervoersvraag bereikbaar te houden voor ouderen die geen auto kunnen rijden? 11. Welke factoren zijn belangrijk om gebieden met een lage vervoersvraag bereikbaar te houden voor scholieren die geen auto kunnen rijden? 12. Welke factoren zijn belangrijk om gebieden met een lage vervoersvraag bereikbaar te houden voor forenzen die zich geen auto kunnen veroorloven of geen auto kunnen rijden? 13. Welke andere groepen zijn afhankelijk van openbaar vervoer en welke factoren zijn belangrijk voor hen? 14. Er is kritiek op de huidige Hubtaxi in Groningen (onvindbaar, duur en onbetrouwbaar), hoe zou dit systeem verbeterd kunnen worden? 15. Wat zou uw bedrijf/overheid kunnen bijdragen aan een mogelijk toekomstig DRT system?	10. Which factors are important to keep low-demand areas accessible for elderly who cannot drive a car? 11. Which factors are important to keep low-demand areas accessible for schoolchildren who cannot drive a car? 12. Which factors are important to keep low-demand areas accessible for commuters who cannot afford or cannot drive a car? 13. Which other groups are dependent on public transport and which factors are important for them? 14. There is still critique on the current Hubtaxi in Groningen (unfindable, expensive and unreliable), how can this system be improved? 15. What can your company/government offer to a possible future DRT system?	$C_{3.2}$ $C_{3.2.1}$ $C_{3.3}$ $C_{3.4}$ $C_{3.5}$ $C_{3.6}$ $C_{3.6.1}$ $C_{3.7}$
Car replacement by demand-responsive and sustainable public transport (ST_3)	16. Wat is de potentie van een DRT systeem om objectief autoafhankelijke reizigers (geen goed alternatief) de auto te laten staan? 17. Wat is de potentie van een DRT systeem om subjectief autoafhankelijke reizigers (uit gewoonte) de auto te laten staan? 18. Er zijn tegenwoordig enkele individuele deelsystemen (deelscooters, deelauto's en deelfietsen), welke van deze hebben de potentie om autogebruik te reduceren en bij te dragen aan een meer duurzaam systeem?	16. What is the potential of a DRT system to let objective car-dependent people (no good alternative) stop driving a car? 17. What is the potential of a DRT system to let subjective car-dependent people (out of habit) stop driving a car? 18. There are nowadays some individual sharing systems (shared scooters, shared cars and shared bicycles), which one do you think have potential to reduce car usage and contribute to more sustainable system?	$C_{4.1}$ $C_{4.2}$ $C_{4.3}$

	19. Hoe groot en welke rol kan DRT spelen in het duurzaam maken van (openbaar) vervoer?	19. How large and which role can DRT play in making (public) transport sustainable?	$C_{4.4}$
General questions	20. Welke bedrijven/overheden zijn van belang voor het creëren van een DRT netwerk in de provincie Groningen?	20. Which companies/governments are important for the creation of a DRT network in the province of Groningen?	$C_{1.3}$

Appendix 2: Agreement of participation

Overeenkomst van deelname - Research Ethics Committee (REC)
in onderzoeksproject:
Titel: "Demand responsive and sustainable ways of (public) transport to keep shrinking regions in the Dutch province of Groningen accessible"
(NL: Vraagafhankelijke en duurzame methoden van (openbaar) vervoer om krimpregio's in de Nederlandse provincie Groningen bereikbaar te houden)

Subtitel: Empirical research by interviewing experts in shrinking regions in Groningen
(*Empirisch onderzoek door het interviewen van experts in krimpregio's in Groningen*)

Het doel van het onderzoek is het beantwoorden van de hoofdvraag: "How can demand responsive and sustainable ways of (public) transport be used in the future to keep shrinking regions in the Dutch province of Groningen accessible?"
(NL: Hoe kan vraagafhankelijk en duurzaam (openbaar) vervoer in de toekomst worden gebruikt om krimpregio's in de Nederlandse provincie Groningen bereikbaar te houden?)

- Het is mij duidelijk waar dit onderzoek over gaat
- Ik heb de mogelijkheid tot discussie over dit onderzoek en ben tevreden over de antwoorden die ik gegeven heb.
- Ik begrijp dat deelname aan dit onderzoek vrijwillig is en heb het recht om me terug te trekken uit het onderzoek tot drie weken na het interview en heb het recht om individuele vragen niet te beantwoorden.
- Ik snap dat mijn deelname in het onderzoek vertrouwelijk is. Zonder voorgaande toestemming zal geen materiaal in de rapportage worden gebruikt die mij zou kunnen identificeren.
- Ik snap dat de data die voortkomt uit het interview gebruikt kan worden in artikelen, hoofdstukken van boeken, gepubliceerd en ongepubliceerd werk en in presentaties.
- Ik snap dat alle informatie die wordt verkregen vertrouwelijk zal worden bewaard, zij het op een afgesloten faciliteit of op een met een wachtwoord beveiligde computer of bestand.

Gelieve JA of NEE te omcirkelen bij elk van de volgende stellingen:

Ik stem ermee in dat dit interview zal worden opgenomen worden voor verwerkings- en coderingsdoeleinden — JA / NEE

Ik wens anoniem te blijven in het interview — JA / NEE

Wanneer JA:
Mijn voornaam kan worden gebruikt in dit onderzoek — JA / NEE

OF:
Een pseudoniem naar mijn keuze kan worden gebruikt — JA / NEE

"Ik ga akkoord met deelname in dit individuele interview en bevestig de ontvangst van een kopie van dit toestemmingsformulier"

Handtekening deelnemer:_____Datum:_____

"Ik ga akkoord met de voorwaarden zoals hierboven uiteengezet en verzeker dat er geen schade wordt toegebracht aan de deelnemer gedurende dit onderzoek (invullen door onderzoeker)"

handtekening onderzoeker:_____Datum: _____

Gelieve de volgende informatie in te vullen. Dit e-mailadres zal worden gebruikt om een kopie van de interview notities naar toe te sturen, zodat de deelnemer de mogelijkheid wordt geboden om correcties te maken.

E-mail: _____

Agreement to participate - Research Ethics Committee (REC)

in (doctoral) research project:
Titel: "Demand responsive and sustainable ways of (public) transport to keep shrinking regions in the Dutch province of Groningen accessible"

Subtitel: Empirical research by interviewing experts in shrinking regions in Groningen

The goal of the research is to answer the main question: "How can demand responsive and sustainable ways of (public) transport be used in the future to keep shrinking regions in the Dutch province of Groningen accessible?"

- I have read and I understand the information sheet of this present research project.
- I have had the opportunity to discuss this study. I am satisfied with the answers I have been given.
- I understand that taking part in this study is voluntary and that I have the right to withdraw from the study up to three weeks after interview, and to decline to answer any individual questions in the study.
- I understand that my participation in this study is confidential. Without my prior consent, no material, which could identify me will be used in any reports generated from this study.
- I understand that this data may also be used in articles, book chapters, published and unpublished work and presentations.
- I understand that all information I provide will be kept confidentially either in a locked facility or as a password protected encrypted file on a password protected computer.

Please circle YES or NO to each of the following:

I consent to my interview being audio-recorded YES / NO

I wish to remain anonymous for this research YES / NO

If YES
My first name can be used for this research YES / NO

OR:
A pseudonym of my own choosing can be used in this research YES / NO

"I agree to participate in this individual interview and acknowledge receipt of a copy of this consent form and the research project information sheet."

Signature of participant:_____Date: _____

"I agree to abide by the conditions set out in the information sheet and I ensure no harm will be done to any participant during this research (fill in by the researcher)."

Signature of researcher: _____Date: _____

Please fill in the following information. It will only be used in case you want to be sent a copy of interview notes so that you have the opportunity to make corrections.

E-mail: _____