Master thesis

Flexible or fixed?

A comparative case study on transport systems and equity

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Colophon

Title	Flexible or fixed? A comparative case study on transport systems and equity.
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Image front page	A vehicle operating on SyntusFlex in Molenvliet-West, Woerden (own work).

Preface

Writing this thesis to complete my Master's degree in Urban and Regional Planning on a topic so close to my heart and home has, albeit challenging at times, been a rewarding and educational experience. That is not to say that the fifteen months I spent on this project have always been easy, and I would like to extend my sincere gratitude to everyone who supported me in this effort over this time. First and foremost, I would like to thank my thesis supervisor, Dr. Corinne Vitale, who went out of her way to provide continued feedback throughout the project whenever possible, allowing me to get the most out of this process I possibly could. Second, my parents who as always were there to offer not just encouragement and help, but also who also thought critically alongside me, helping me to bring the project up to the standards I aimed to achieve. I would also like to thank my extended family and friends, who with their interest and support have been a great help in staying on track and not getting lost in the amount of work, as can so easily occur in longer-term projects such as these. Finally, I wish to thank Rob Plooy from Syntus Utrecht, Dennis Jongen from Arriva Limburg, and the over 800 inhabitants of Weert and Woerden who took the time to provide the data that allowed me to complete this research. My only regret is that I was not able to speak with more of you, as was the intention at the outset, but I have done my absolute best to represent all the information you provided truly and fairly in this thesis.

Jasper Jonkers
Vleuten, April 10th 2025

Abstract

Efficient and mobility-oriented thinking has resulted in Dutch peri-urban towns receiving little and decreasing amounts of local public transport, as the fact that peri-urban areas have a mobility pattern that is strongly focussed on mobility to and from the closest urban area results in low demand for services offering local connections. Although this is not a large problem for most inhabitants of such areas due to high levels of car ownership, it can lead to exclusion of those groups who do depend on public transport to get around. This is undesirable from an equity point of view, as an equitable public transport system should allow for everyone to be able to participate in society. Some scholars have argued that Demand Responsive Transport (DRT) might be a solution to this problem, while others argue that Fixed Route Transport (FRT) remains the best option. This research compares both types of transport systems, which are currently in place in the peri-urban towns of Woerden and Weert respectively, aiming to establish to what degree they are successful in providing equitable local public transport.

Keywords: peri-urban areas; transport equity; Demand Responsive Transport; Fixed Route Transport.

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1 Introduction

This thesis consists of a study into the fields of transport planning and equity in the peri-urban context. This first chapter will introduce each of these research fields, identify challenges that currently exist in bringing them together and formulate how this research can contribute to resolving these challenges. It also aims to illustrate how resolving these challenges is both relevant to the respective scientific fields as well as to society as a whole.

1.1 Introducing the fields of transport planning and equity

The field of mobility be studied from a variety of angles. A traditional approach is to look at its technical functionality: what is the most effective way of moving a certain amount of people or goods from one place to another? This form of transport research focuses solely on the system and how smoothly it functions (Handy, 2002; Levine et al., 2019; International Transport Forum, 2022). In recent years, other approaches have gained interest. Among these are first and foremost environmental concerns: the question of how to transport people not as efficiently as possible in terms of speed and economic cost, but in terms of environmental cost (Handy, 2002; Hickman & Banister, 2014; International Transport Forum, 2017; Moreno et al., 2021). Another perspective that has often been discussed is that of the desired improvements in safety (Pucher & Dijkstra, 2000; Sonkin et al., 2006; Raftery, 2023).

One of the latest fields to gain serious attention is that of transport equity, namely, how to make sure everyone's demand for transport is fulfilled to at least a minimum standard (Martens, 2017; Di Ciommo & Shiftan, 2017; Wee & Mouter, 2021). This issue is particularly relevant outside urban areas. Here, distances to amenities like hospitals and shopping malls, but also to facilities that offer employment tend to be larger. At the same time, demand for transit tends to be lower in these less populated areas, which usually results in a lower level of service being provided. So while people outside urban areas need to travel further to important destinations, they have at the same time got less means of doing so (Moseley, 1979; Martens, 2017; Brovarone & Cotella, 2020).

However, a lack of transport equity is not limited to rural areas, as pointed out by Martens (2017), who emphasizes that it also occurs in urban and suburban areas. Hardly mentioned in existing research is the position of peri-urban areas. These areas, also referred to as the 'urban fringe' and described as neither (sub)urban nor rural, are often overlooked in research (Hornis & Eck, 2009; Thao et al., 2023). The specific nature of peri-urban areas means that their inhabitants need mobility to have access to a lot of amenities, which tend to be located in the urban area they are in the vicinity of (Hornis & Eck, 2009; Ravetz et al., 2013; Gonçalves et al., 2017; Thao et al., 2023). This mobility pattern – focussed strongly on a dominant nearby urban area – is seen by some as the defining characteristic of peri-urban areas (Hornis & Eck, 2009; Gonçalves et a. 2017). Overemphasis on this pattern, however, can lead to a neglect of local mobility within the peri-urban area itself (Ravetz et al., 2013; Thao et al., 2023).

As has been shown in this section, it is important that every inhabitant of a peri-urban area has access to at least the minimum level of transport that is required to be able to participate in society. Martens (2017) calls this transport equity. However, it also transpires that this equitable access to transport is not always achieved in reality.

1.2 Problem statement

Traditionally, mobility issues are approached from a standpoint of efficiency. However, peri-urban areas are characterized by lower density than urban areas, and transport in lower-density areas tends to be less efficient. As such, efficiency-oriented thinking can result in peri-urban areas receiving less public transport service (Ravetz et al., 2013; Thao et al., 2023). Moreover, because the major flow of traffic in peri-urban areas is to and from the closest urban area, most of the already limited available public transport is aimed at that flow. As a result, the provision of public transport aimed at trips within a peri-urban area, typically referred to as local public transport, ends up being even lower, if present at all (Ravetz et al., 2013; Thao et al., 2023). For many inhabitants of peri-urban areas, this is not a problem, as car ownership levels are high. However, for those who do rely on local public transport, the lack of it can result in exclusion (Young & Kell, 2010; Fransen et al., 2015). This mean that Martens' (2017) threshold for transport equity is not met, as the fact that these people experience such exclusion means that they are not being provided with the minimum level of transport that they need to be able to participate in society.

It is proposed by some authors that using Demand Responsive Transport (DRT) systems might be a more efficient way to deliver a 'bare minimum' of public transport to as many people and places as possible when conventional public transport fails to do so. DRT systems are transport systems in which the deployment of vehicles is based on actual real-time demand, whereas traditional Fixed Route Transport (FRT) systems have pre-determined routes and timetables. However, others argue that an FRT system might still be the better option in peri-urban areas, primarily pointing to the failure of many DRT systems that have been launched in such areas in the past (Davison et al., 2012; Petersen, 2016; Currie & Fournier, 2020; Thao et al., 2023). To date, no scientific consensus has been reached as to what system is best equipped for providing equitable local public transport in peri-urban areas.

1.3 Research aim and research questions

This research will focus on advancing the understanding of how local public transport access can be provided in an equitable manner. To this end, a comparative case study will be conducted in the peri-urban cities of Weert and Woerden, in The Netherlands. Both cities are similar in size and can be qualified as peri-urban, but their local public transport systems differ significantly. Woerden relies mostly on a recently introduced DRT system, in contrast to the traditional FRT system of Weert. Based on this comparison of two different local public transport systems in otherwise comparable peri-urban cities, this research aims to establish which of the two systems best succeeds in equitably providing local public transport. Based on this research aim, the main research question is phrased as follows:

> *"To what extent and how do Demand Responsive Transport (DRT) systems and Fixed Route Transport (FRT) systems succeed in providing equitable access to local public transport in peri-urban cities?"*

In addition to this, I have formulated five sub-questions, each of which contributes to answering the main research question:

1. "*How are Transport Equity, Demand Responsive Transport (DRT) and Fixed Route Transport (FRT) defined and what are their characteristics?"*

In order to be able to compare between the two systems, it is required to develop a framework that dissects on which aspects they can be compared. This is the focus of the first sub-question. Rather than being studied through the collection of new data, this question will be answered based on a study of

existing literature on both systems. This ensures that that the study fits in with the broader body of research available on this topic.

2. *"How does each aspect of the respective transport systems in Weert and Woerden perform?"*

The second sub-question is aimed at analysing the performance of the respective transport systems, based on all relevant aspects of the four components of accessibility as defined by Geurs and Wee (2004), namely the transport, land-use, temporal and individual components. These four components together determine to which services and facilities individuals have access (Geurs & Wee, 2004). These components will be discussed further in Chapter 2, taking as a departure point the aspects of each component on which FRT systems and DRT systems differ.

3. *"To what extent does each aspect of the respective transport systems in Weert and Woerden meet the demands of inhabitants, particularly those reliant on local public transport?"*

The third sub-question is aimed at establishing what the inhabitants of Weert and Woerden expect from a local public transport system. This can be squared against the actual performance of the respective transport systems, which has been established in answering sub-question two. To allow for this comparison, this subquestion will also be organized around the different aspects of the transport, land-use, temporal and individual components.

4. *"Do inhabitants of Weert and Woerden prefer a Demand Responsive Transport (DRT) system or a Fixed Route Transport (FRT) system, and which aspects influence their preference?"*

Answering the first three sub-questions offers a perspective on how each aspect of the respective transport systems of Weert and Woerden does or does not contribute to equitable local public transport access. Sub-question four will complement this by offering insight into which inhabitants prefer which system when asked directly. This also allows for analysing which of the four previously discussed components influence this preference.

5. *"How satisfied are inhabitants of Weert and Woerden with the current local public transport system in their respective cities?"*

Finally, in addition to having general preferences on the aspects that set the two types of system apart, the inhabitants of Weert and Woerden also live in a city where one of the two is currently operating. The experiences with the systems currently in place in their respective cities are covered by sub-question five.

1.4 Scientific relevance

This research contributes to the existing body of knowledge in three different ways, namely by expanding the understanding of mobility issues, by approaching an existing field of research from a relatively new theoretical perspective and by adopting different methodologies than have predominantly been used in previous research.

First of all, there is a demand for more extensive research into the area of mobility in peri-urban areas, particularly when it comes to local public transport. In so far as research has been conducted, the common focus point was the transport between the peri-urban area and adjacent urban areas, turning local public transport into a blind spot (Hornis & Eck, 2009; Ravetz et al., 2013; Thao et al., 2023). Moreover, it is argued that the importance of a good local public transport system in peri-urban areas is rising, due to an apparent shift in overall mobility behaviour. This shift has resulted in access to local

destinations within peri-urban areas becoming more important, thus increasing the significance of furthering the scientific understanding these systems (Hornis & Eck, 2009; Pucci, 2017). One study that has already been conducted found that while high car ownership in the area means that demand for local public transport is generally low, a lack of public transport provision can result in exclusion for people who do depend on it, which they see as unjust (Young & Kell, 2010). Thao et al. (2023) argue that DRT systems could help bridge this gap, although they emphasize the lack of research so far into DRT systems in peri-urban areas. Young & Kell (2010), however, argue that demand might not immediately be sufficient to support a successful operation of these systems, and that additional use might have to be stimulated.

Second, this research aims not only to increase the objective understanding of mobility in peri-urban areas, but will also be looking at the issue from the perspective of transport equity. The importance of providing equitable access to at least a minimum level of local public transport has already been illustrated by Young and Kell (2010), focussing specifically on peri-urban areas. It is particularly interesting to study equity in relation to DRT systems, as it is claimed that DRT can have a positive impact on equity (Gomes et al., 2015; Papanikolaou et al., 2017). Perhaps contrarily however, most research has been focussed on the technical aspects of DRT, rather than how it succeeds in providing equitable access to public transport (Davison et al., 2012; Thao et al., 2023).

Finally, this research applies a different methodological angle from previous research. Studies that have been conducted so far rely mostly on models, rather than on actual cases in practice (Diana, et al., 2009; Li & Quadrifoglio, 2010). Frigg (2024) point out that models, while having many applications within the scientific field, also have some inherent weaknesses. While generally good at approaching the truth, they can often distort the exact truth, making a diversification of research methods on this topic desirable. In addition to that, the comparative nature of this research increases its relevance, as there is also a lack of comparative studies between DRT systems and the FRT systems they frequently replace (Petersen, 2016).

1.5 Societal relevance

The share of the world population living in peri-urban areas is increasing significantly (Ravetz et al, 2013; Shaw et al., 2020). In The Netherlands, more people now live in peri-urban areas than in cities or elsewhere (Hornis & Eck, 2009). This increase in peri-urbanisation comes at a time when public transport access outside urban areas is declining, both in The Netherlands and worldwide (World Economic Forum, 2019; Planbureau voor de Leefomgeving, 2022; NOS Nieuws, 2023). This trend is not limited to the most rural areas of the country, but also impacts typical mid-sized cities that could be qualified as peri-urban, with local public transport being scrapped completely in cities like Meppel, Oss and Dronten (Brabants Dagblad, 2014; RTV Drenthe, 2021; Provincie Flevoland, 2022). Similar cutbacks are being discussed in other places like Harderwijk, where the last remaining local bus service has already been considered for removal several times (De Stentor, 2018; Harderwijker Courant, 2024). Research by the Kennisinstituut voor Mobiliteitsbeleid (Witte et al., 2022) shows a corresponding trend in public opinion, with two-thirds of those living in rural areas and half of those living in peri-urban areas indicating that they feel increasingly dependent on their car. This quantitative research found increased distances to amenities outside urban areas to be a major explaining factor in that process (Witte et al., 2022). Another, qualitative study also pointed towards the significance of decreasing public transport options as a reason for an increased feeling of car-dependency (Krabbenborg & Uitbeijerse, 2023).

This in itself does not yet constitute a problem. Like Young and Kell (2010), Pot (2023) shows that a very high percentage of the population outside urban areas has access to a car, while also pointing out that satisfaction with overall accessibility is roughly equal throughout the country, from urban to rural areas. The Planbureau voor de Leefomgeving (2022) does however warn that while most people are satisfied, there is also a small group that depends on public transport, and that they are increasingly struggling to access both employment and essential amenities. Government statistics support this claim: out of all households in The Netherlands that can be defined as living in peri-urban areas,[1] 18 % do not own a car, and in 12 % of these households no-one has a driver's license (Centraal Bureau voor de Statistiek, 2018). Moreover, there is reason to believe that this group could grow in the near future due to the aging population, as there is a rapid decline in car ownership after the age of 75 (Witte et al., 2022).

It transpires then that even in peri-urban areas there is a need for local public transport, as a small but significant segment of the population cannot participate in the dominant car-centred mobility system. That makes DRT a potentially interesting development, given its theorized ability to efficiently provide at least some transport access, particularly in areas with lower demand (Thao et al, 2023). In fact, several cut-back local bus systems in The Netherlands have already been replaced with DRT systems. This has occurred in places such as Spijkenisse, Bergen op Zoom, and Woerden, which has been selected as one of the two cases for this study (BN De Stem, 2018; Syntus Utrecht, 2020; Algemeen Dagblad, 2021). However, albeit often tried out, these DRT systems are not always successful. For example, after an unsuccessful pilot of three years, Helmond returned to an FRT system (De Volkskrant, 2018; Bravo, 2020), whilst in Doetinchem the system was scrapped without replacement (REGIO8, 2023), leaving many local areas without any public transport access and cutting those dependent on it out of society (Planbureau voor de Leefomgeving, 2022).

This introduction has shown both the need that still exists for local public transport in peri-urban areas and some of the challenges that it faces. Understanding how the two main alternatives, DRT and FRT, succeed in fulfilling that need is therefore critical in providing policymakers with the knowledge required to decide how best to use the limited resources available.

1.6 Thesis outline

Chapter 1 has introduced the topic, aim and relevance of this thesis. Chapter 2 provides a more in-depth theoretical understanding of its two main concepts – transport equity and transport systems – and the peri-urban environment, culminating in a conceptual framework of the expected pattern of interaction of these concepts. Next, Chapter 3 sets out the methodological approach, explaining how this pattern of interaction has been researched. The results of this research are presented in Chapter 4 and discussed in Chapter 5, leading to a conclusion on the main research questions in Chapter 6. Chapter 7 will reflect on the entire research, and finally Chapter 8 comes with recommendations.

[1] The CBS (Centraal Bureau voor de Statistiek) does not use peri-urban as a category. For this calculation the two middle categories, those in between 'very urban' and 'not urban', have been classified as peri-urban.

2 Theory

The aim of this research is to increase the understanding of how *local public transport* can be delivered in an equitable manner in *peri-urban areas*. This theoretical chapter starts out with an exploration of how the scientific discussion of these two fields has evolved and what theoretical positions are currently dominant. Next, it delves deeper into the current theoretical understanding of both proposed alternatives for the equitable provision of local public transport: *Demand Responsive Transport* (DRT) and *Fixed Route Transport* (FRT), before finally discussing theories on how these topics relate to the particular nature of peri-urban areas.

2.1 Transport planning: the shift from a mobility-centred to an equity-centred framework

The frameworks used to analyse transport planning have shifted significantly over time. Neerven (2018) identifies three successive frameworks. First, there is the traditional, *mobility-centred framework*, which long formed the basis of transport planning. Later, mobility-centred thinking gave way to an *accessibility-centred framework*, emphasizing a broader range of factors relevant to transport. More recently, focus has shifted towards fairness and justice, resulting in an *equity-centred framework*.

2.1.1 From a mobility-centred to an accessibility-centred framework

Historically, transport planning has been focussed solely on transport systems. The presence of a good transport system was deemed a prerequisite for economic growth, and as such seen as a priority. The degree to which a transport system was deemed successful was based on the amount of people it managed to transport and the efficiency, both in terms of time and cost, with which it was able to do so (Banister, 1993). When a system started to fall short in this respect, solutions were generally sought in the expansion of the system, described as mobility-enhancing measures by Handy (2002). This approach worked well initially, but issues started to arise as the continued growth in mobility proved that there were limits to the degree to which transport systems could accommodate this growth. Over time, making the expansion of transport systems keep up with the growth in usership proved unsustainable. This was not only due to physical spatial constraints, but also because the growth in mobility was so vast that expanding transport systems at a similar rate would be unaffordable (Handy, 2002).

As a result, a new framework for studying transport systems was devised. It was argued that a shift in focus was required, away from the ability of transport systems to generate or process maximal mobility, and towards the degree of accessibility the systems in question could provide (Handy, 2002). In this argument, Handy (2002) defines accessibility as a combination of all potential destinations, and how easily they can be reached:

> "In most cases, measures of accessibility include both an impedance factor, reflecting the time or cost of reaching a destination, and an attractiveness factor, reflecting the qualities of the potential destinations." (Handy, 2002, p. 4)

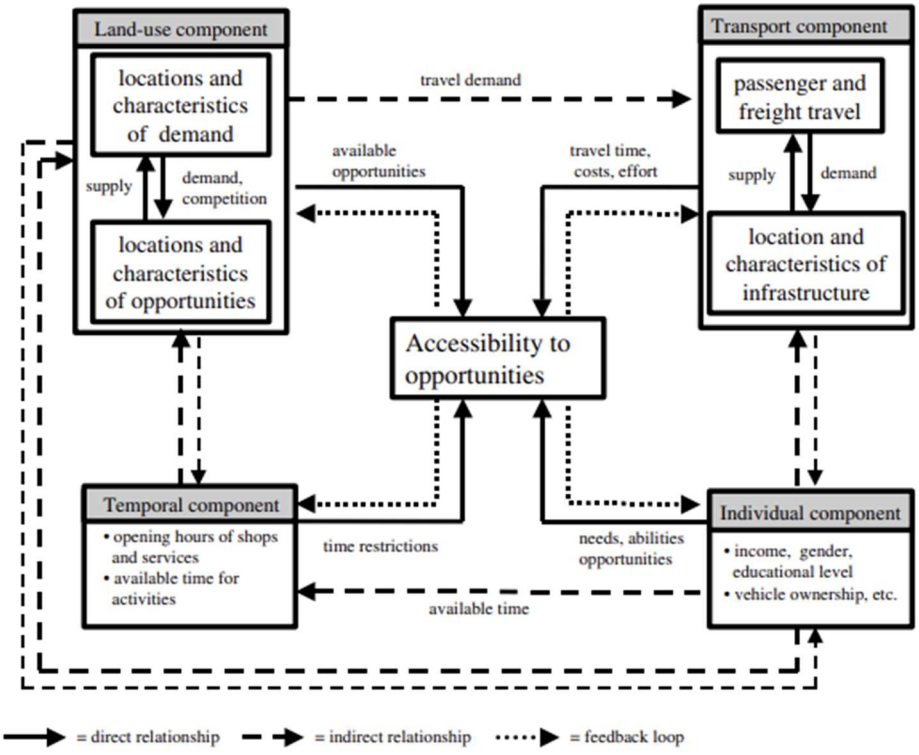
Geurs and Wee (2004) expanded the definition of accessibility in transport planning to four different components, which are shown in Figure 1. One of these components is the *land-use component*, which is similar to the *attractiveness factor* in Handy's (2002) equation. The other three components cover different aspects of what Handy (2002) jointly referred to as the *impedance factor*, with Geurs and Wee (2004) making a distinction between the *transport component*, the *temporal component*, and the

individual component. In this thesis, I will use the expanded definition by Geurs and Wee (2004), consisting of the aforementioned four components:

- the transport component, which covers the transport system itself, representing the pillar of the traditional, mobility-oriented framework;
- the land-use component, which covers the different locations that can be accessed through the transport system, and the importance of access to these different locations;
- the temporal component, which covers all time-related aspects, both the time it takes to travel somewhere, and the times at which access to these locations is important;
- the individual component, which covers individual variables which impact the degree to which people can or need to use the transport system.

Figure 1

Framework for accessibility (Geurs & Wee, 2004).



2.1.2 From an accessibility-centred framework to an equity-centred framework

The shift in focus from mobility to accessibility resulted in a different, accessibility-centred framework by which transport systems were analysed. More recently, however, another aspect of transport systems has become the subject of scientific and societal discussion: its *fairness* (Pereira et al., 2016) or *justness* (Martens, 2017). This is consistent with a wider academic trend of focussing on fairness and justness in planning practices (Fainstein, 2010; Lazarus, 2019). While advocacy for what is also known as equity in planning practices might be on the rise in recent years (Lazarus, 2019), it can be traced back to Paul Davidoff's (1965) call for advocacy planning and plural plans, impelling planners to actively advocate for all different interests. Defining the exact relationship between these two terms, *equity* and *just(ice)*, can be challenging, as their use is oftentimes not entirely consistent. Bruzzone et al.

(2023) analyse the definitions used so far by scholars and conclude that the relationship between 'equity' and 'just' is similar to that between 'equality' and 'equal'. Both equity and equality are moral standards for distribution, but whereas equality means focussing on an equal distribution, equity entails striving for a distribution that is just (Bruzzone et al., 2023). This results in a problem however, because while it may be easy to define what an *equal* distribution looks like, the same cannot be said of the question of what a *just* distribution looks like (Dworkin, 1981). Pereira et al. (2016) distinguish five key theories of justice, as shown in Figure 2.

Figure 2

Theories of justice (Pereira et al., 2016).

Theories of justice	Distribution of what?	Guiding principle of distribution	The fairest distribution pattern	Key authors
Utilitarianism	Welfare, well-being, utility	The greatest good for the greatest number	Whatever distribution that maximises aggregate welfare	Jeremy Bentham and John Stuart Mill
Libertarianism	Basic rights and liberties	Self-ownership	Absolute equality	Robert Nozick
Intuitionism	Different "whats", for example, resources (food, money, etc.), services (health, education, etc.)	Particular distributive problems demand different principles be applied to particular cases (rights, deserts, needs, expectations, procedural justice, etc.)	No clear distribution pattern	Brian Barry and David Miller
Rawls' Egalitarianism	Basic liberties	First principle (deontological justification)	Equal distribution	John Rawls
	Opportunities	Fair equality of opportunity as pure procedural justice	Equal distribution	
	Primary goods (rights and prerogatives of authority, income, and wealth)	Difference Principle	Maximin criterion: The distribution that maximises, subject to constraints, the prospects of the least advantaged groups	
Capabilities approach	Opportunities	Human dignity and equal respect	Equal distribution	Amartya Sen and Martha Nussbaum
	Central/basic capabilities		All should get above a minimum basic level	

The first two of these theories are based on clear and simple foundations. *Utilitarianism* argues for a wide redistribution ranging from welfare to well-being and utility aimed at maximizing the total benefits for society (Kymlicka, 2002; Pereira et al., 2016), whereas *libertarianism* argues that these ought not to be redistributed at all, proclaiming that the free market will ensure justice so long as basic rights and liberties are equally distributed (Nozick, 2003; Hausman & McPherson, 2006; Pereira et al., 2016). Clear as they may be, both approaches are frequently criticized. Utilitarianism's sole focus on the highest aggregate ignores the well-being of individuals, often having the most negative impact on those already worse-off, whereas libertarianism discounts the fact that the achievement of well-being is not solely the result of actions by an individual (Kymlicka, 2002; Sen, 2006; Sandel, 2009; Pereira et al., 2016). At the other end of the spectrum, Brian Barry and David Millers' *intuitionism* calls for a

context-based approach to justice, guided only by a set of basic moral principles. This gives intuitionism little practical merit, as there is no framework to decide when to apply which principle (Rawls, 1999; Kymlicka, 2002; Pereira et al., 2016).

Rawls' egalitarianism tries to address the concerns with the aforementioned theories. His starting point is similar to that of a libertarian, stressing the importance of an equal distribution of rights and liberties. However, Rawls (1999) also argues for a redistribution of primary goods, aiming to creating equal opportunities for all. If achieved, outcomes should only vary based on the efforts made or not made by an individual. Rawls (2001) concedes that complete equality of opportunity is not possible, causing him to devise the *maximin criterion*. This entails that a policy should always be focussed at maximising the minimal level of primary goods that any person starts out with (Rawls, 1999; Rawls, 2001; Pereira et al., 2016). Amartya Sen (2006) takes this theory one step further. She criticized Rawls' focus on goods, pointing out that they are merely means to achieve other ends. The goods which an individual needs to reach these ends, varies based on their *capabilities*. Someone with an above-average starting point in life might need below-average primary goods to be capable of achieving an average outcome. From this perspective, the maximin criterion should not be applied to primary goods, but to capabilities instead (Sen, 2006; Nussbaum, 2011; Pereira et al., 2016).

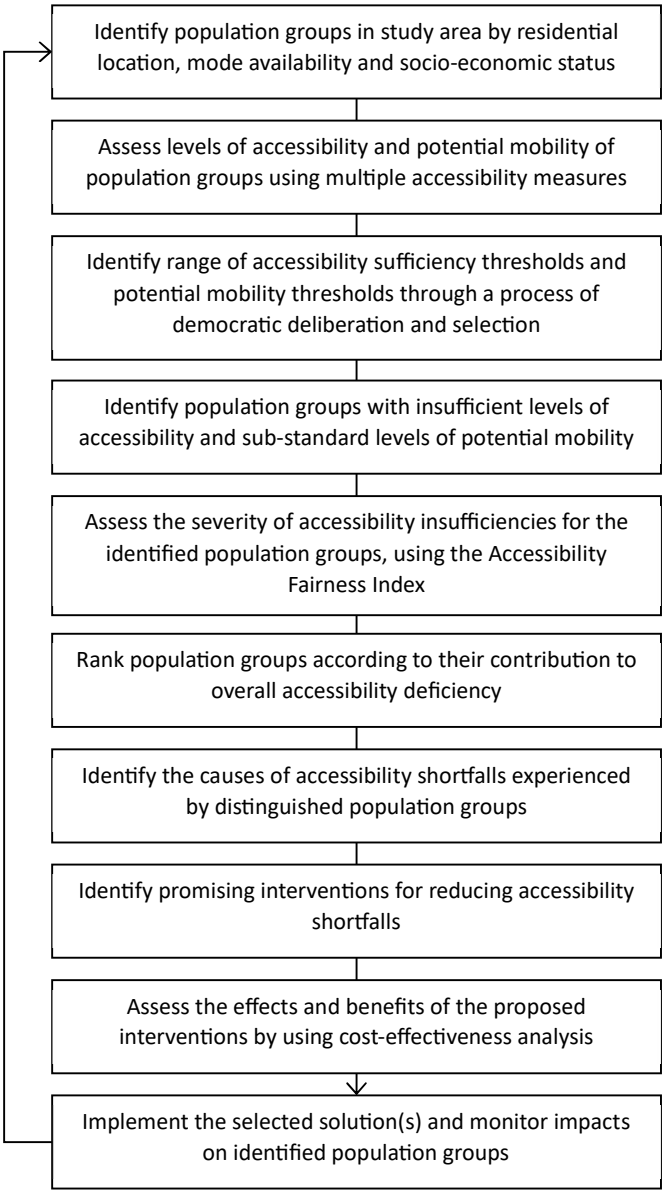
In this thesis, I will adapt the latter two theories of justice, namely the egalitarian approach and the capabilities approach, as definitions of equity. This choice has been made because the degree to which the utilitarian and libertarian approaches are actually fair has been widely questioned and because the intuitive approach is too vague for practical application. By contrast, the egalitarian approach and the capabilities approach combined can form the basis for a comprehensive analysis, with the former focussing on the service provided and the latter focussing on the individual. The following segment will discuss the application of this interpretation of equity to the field of transport planning.

2.1.3 Applying an equity-centred framework to the field of transport planning

Having introduced the different theories concerning equity, and having established the egalitarian and capabilities approaches as the starting point for this thesis, the next step is to establish why transport planning in particular is a field where equity is an important goal to pursue. A range of scholars use Rawls' egalitarianist theory and argue that transport can be defined as a primary good. Their arguments are centred around the premise that access to certain places is needed to be able to fully participate in society (Lucas, 2012). Martens (2017) specifically links the argument that transport is a primary good to one of the five key primary goods as defined by Rawls (1999) himself: freedom of movement. Based on this premise, Martens (2017) created a framework for transport planning based on the principles of justice, as shown in Figure 3. The stated goal of this framework is what Martens' calls sufficient accessibility for all, which could be seen as an adaptation of Rawls' maximin criterion. However, Martens (2017) sees Rawls' egalitarianism as insufficient for determining what sufficient accessibility is, arguing that individual characteristics and circumstances are particularly relevant when it comes to accessibility. Determining one maximin or sufficient level of accessibility still creates significantly different outcomes on an individual level. This is why much of Martens' framework is focussed on identifying different groups with distinguishing transport needs. As a result, the final framework is more aligned with Sen's capabilities approach (Sen, 2006).

Figure 3

Framework for transport planning based on the principles of justice (Martens, 2017).



Martens' (2017) framework reflects the two ways of describing equity mentioned in the previous section. The egalitarian approach would mean that transport equity is pursued by raising the minimal level of transport that is provided to everyone, whereas the capabilities approach would entail focussing on raising the level of transport for those who need it most. Linking this back to the accessibility framework by Geurs and Wee (2004), both definitions of equity would call for the consideration of the transport, land-use, and temporal components. The main difference lies in the consideration of the individual component, which fits only with the capabilities approach. Jain et al. (2017) further specify the role of the individual component in equitable public transport access. They identify six demographic groups that have an increased likelihood to be dependent on public transport, as their capabilities place them at a disadvantage in accessing other forms of transport:

- young people;
- elderly people;
- people without access to a motor vehicle;
- disabled people;
- people on lower incomes;
- minority groups and new migrants.

In addition to these groups, Buehler & Pucher (2012) found that female people also have an increased likelihood of depending on public transport, stretching the list to seven potential target groups when adhering to the capabilities approach in striving to provide more equitable public transport access.

2.2 Transport systems: does an equity-centred framework warrant a different approach?

The previous segment discussed a shift in thinking on how the success of transport systems ought to be analysed, from efficiency to equity. Scholars have argued that this shifted goal also requires different transport systems, in particular systems that are less focussed on supply and more on demand. Their argument for demand-focussed transport is twofold. On the one hand, it could be seen as an incentive to lure transport users away from transport modes putting strains on space and the environment, primarily the car. On the other hand, it can function as a way to provide transport that better fits the need of people (Meyer, 2000; Handy, 2002). This second argument relates to the goal of achieving transport equity, which is the focus of this research.

2.2.1 Introducing Demand Responsive Transport

When discussing ways to make supply-based transport systems more demand-based, the solution tends to be sought in some form of Demand Responsive Transport (DRT). DRT is defined as an umbrella term for services using vehicles to transport people directly to and from places where they need to be, and only when they wish to travel (Mageean & Nelson, 2003). In theory, this setup fits in well with the aforementioned shift from a mobility-centred to an accessibility-centred framework. The fact that DRT runs on demand means that the amount of transport provided ends up being lower, but its flexibility in terms of destinations maximizes the accessibility it offers. Laws et al. (2009) found that improving accessibility is indeed often an important consideration for local policy makers when establishing DRT systems, particularly to prevent exclusion of particular groups of people. This is in line with the goal of transport equity according to Martens' (2017) and Sen's (2006) interpretation of justice.

That does not mean that offering improved transport is this only consideration surrounding the implementation of DRT. The two other major motivating factors that were frequently brought up were funding and cost effectiveness (Laws et al., 2009). The claim that DRT increases cost-effectiveness is highly contested, however. Ever since their inception in the 1970s, a majority of DRT systems has failed to achieve its targets. Consequently, many of these systems are short-lived, sometimes shutting within a few years. High costs and low cost-efficiency are often cited as the main reasons (Currie & Fournier, 2020). According to Davison et al. (2014), DRT systems can be cost-effective in dense urban areas where demand is high, but they rarely are in areas with lower demand, while this is where they are typically being introduced in western countries. A final motivation for the implementation of DRT systems are environmental concerns, in line with one of Handy's (2002) main arguments for focussing on accessibility rather than mobility. This reason was only scarcely mentioned by the UK policy makers however (Currie & Fournier, 2020).

2.2.2 Defining Demand Responsive Transport as opposed to Fixed Route Transport

DRT, which as previously stated is an umbrella term, appears in a wide variety of forms (Wang et al., 2014; Currie & Fournier, 2020). Two frequently used definitions are those by D'Este et al. (1994) and Enoch et al. (2004). The former distinguish systems based on their degree of flexibility; the latter distinguish systems based on their main purpose. This thesis will focus on what D'Este et al. (1994) describe as *many-to-many* DRT systems, seen as the 'fullest' form of DRT. Many-to-many systems allow travel to and from a wide range of destinations; the other forms described by D'Este et al. (1994) are hybrid forms which share more characteristics with traditional FRT systems. According to the categorization by Enoch et al. (2004), this thesis will focus on *Network* DRT systems, which are defined as replacing existing transport systems in certain places or times, as part of a more extensive network. Network DRT systems are relatively well-suited to peri-urban environments, where there is often a strong public transport link with the adjacent urban area, which is unlikely to be replaced by DRT. Instead, it is mainly the provision of local public transport that is proving challenging and where DRT systems could prove beneficiary (Ravetz et al., 2013; Thao et al., 2023).

As mentioned in the introduction, DRT systems are not always successful, and some end up being replaced again by more traditional FRT systems. There are several downsides to DRT systems which can cause their failure. Currie and Fournier (2020) found that off all types of DRT identified by D'Este et al., 'many-to-many' systems have the lowest survival rate, with hybrid systems faring better. This caused Petersen (2016) to question whether a DRT system is really preferable over a well-designed FRT system, and a case study he conducted in Switzerland led him to conclude it is not. In order to be able to compare these two system types based on more variables than merely their life span, it is important to understand exactly how they differ. Papanikolaou et al. (2017) identify four differentiating aspects:

- *network topology*, which comes down to whether the routes vehicles take are fixed (FRT) or responsive to demand (DRT);
- *boarding and alighting locations*, which tend to be available more in DRT systems than in FRT systems as not all stops have to be served all the time;
- *schedule*, which is fixed in FRT systems and more flexible in DRT systems, with buses running whenever a trip is booked rather than running according to a fixed schedule;
- *advance notice requirement*, the need to book a trip, which only exists for DRT systems.

These differences define the respective transport systems, and as such they are directly linked to the mobility component of accessibility as defined by Geurs and Wee (2004). However, they also relate to two of the other components. Most straight-forward is the link with the land-use component, as the potential of adding more boarding and alighting locations in a DRT system also leads to a potential increasing in the variety of land-uses that can be accessed. Furthermore, there is a link with the temporal component, specifically when it comes to the aspects of *operating hours* and *waiting time*. The flexible network topology and schedule make a DRT system more efficient when demand is lower, as only several stops have to be served at each time. An FRT system can only serve all stops, or none at all. As a result, the operating hours of a DRT system can more easily be extended into the quieter hours, as is also reflected by real-world cases (Enoch et al., 2004; Laws et al., 2009; Papanikolaou et al., 2017). At the same time, DRT systems are sometimes not operated when demand is highest, both because they run into capacity constraints and because FRT systems deal with high demand more efficiently (Enoch et al., 2004; Papanikolaou et al., 2017; Gorev et al., 2020). Although waiting time is also determined differently in each system, neither holds advantage in this respect. On the one hand, the flexible schedule of a DRT system can reduce waiting times when a trip was booked in advance, while on the other hand the advance notice requirement can increase waiting times when a trip is booked shortly before departure (Brake & Nelson, 2007; Gorev et al., 2020; Calabrò et al., 2023).

Several recent studies have provided more insight in how these differences can affect real-world outcomes. One of these outcomes is that, in spite of serving more boarding and alighting locations, usership can decrease significantly when an FRT system is directly replaced by a DRT system, as was found in case studies in rural Amsterdam (Coutinho, et al., 2020) and Helmond (Provincie Noord-Brabant et al., 2018). However, Thao et al. (2023) argue that this does not necessarily constitute a problem. Their case study of a DRT system in the Swiss town of Herzogenbuchsee also focussed on non-users of the system, most of whom indicated they preferred other means of transport, particularly walking and cycling. Therefore, in this case, the introduction of a DRT system did not necessarily result in people being excluded from society. Furthermore, Gorev et al. (2020) argue that the flexible network topology of a DRT system does not only allow for more boarding and alighting locations, but that it also enables unique journeys that would not have been possible with an FRT system. This claim is supported by a study conducted in Helmond (Provincie Noord-Brabant et al., 2018), where for 12 % of journeys the user indicated they would not have made the journey at all without the DRT system.

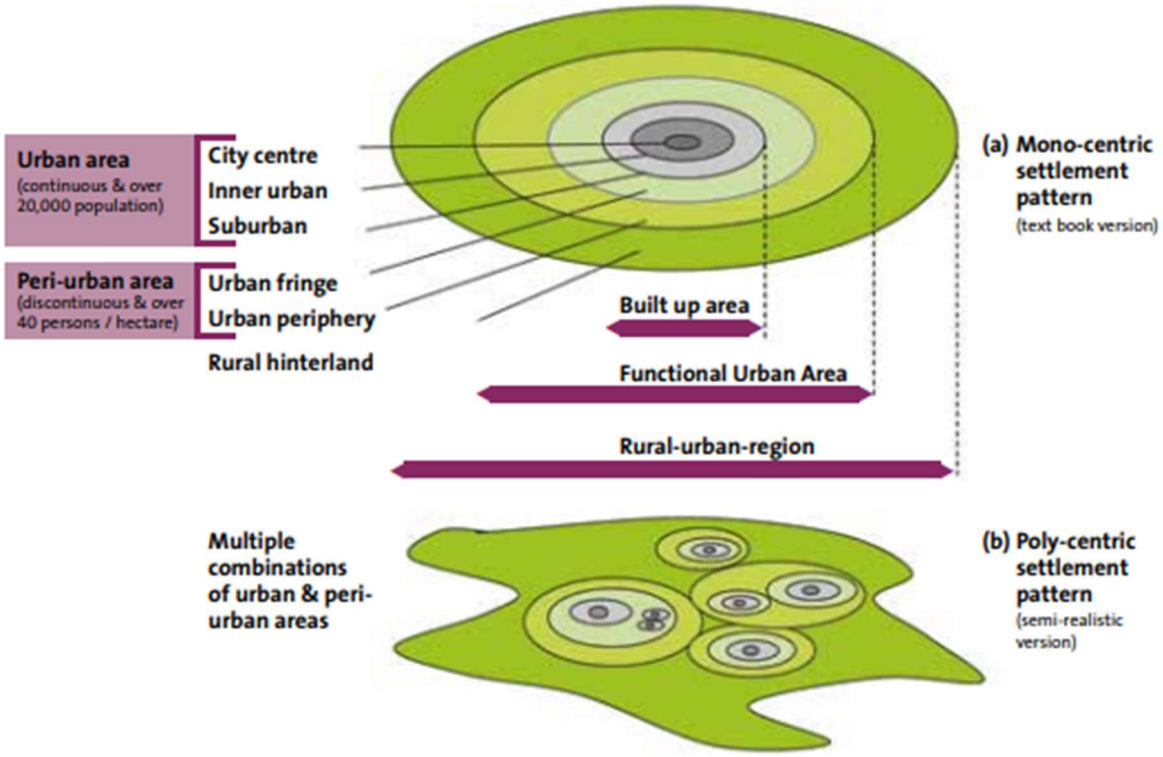
Notwithstanding these advantages, the flexibility offered by a DRT system does still come with its downsides. The flexible schedule that results from the lack of a fixed route makes a journey more unpredictable and is particularly challenging when a transfer is required. The advance notice requirement is also seen a barrier for many potential users (Mageean & Nelson, 2003; Petersen, 2016). And countering the argument made by Thao et al. (2023) that a DRT system does not need to attract all potential users as long as it serves those who rely on it, Mageean & Nelson (2003), Neerven (2018) and Coutinho et al. (2020) point out that the advance notice requirement could be a particularly high hurdle for one of the groups thought to be most reliant on public transport access: elderly people.

Although these arguments back and forth illustrate that a scientific consensus on a preferred public transport system has not yet been reached, it transpires that there is more clarity on the perceived strengths and weaknesses of both DRT and FRT systems. More specifically, the former allows for more boarding and alighting locations and a wider variety of trips; the latter provides a more predictable and easier-to-use service.

2.3 Studying transport systems and equity in a peri-urban environment

The peri-urban environment is a unique environment, which has only come into existence relatively recently. Historically, urban and rural areas had been strictly separated. This changed with the rapid expansion of cities after WOII, causing them to ‘spill over’ into rural areas. This made the border between urban and rural less clear, creating a form of transitional area between the rural and the urban (Pratomo et al., 2022; Idczak & Mrozik, 2018). Due to its recent emergence, the fact that it continues to develop to this day, and its nature of combining urban and rural elements, the term peri-urban is difficult to define. To this day, it still lacks one clear, definitive definition and is being described as “fuzzy” or even “messy” (Meeus & Gulinck, 2008; Rauws & Roo, 2011; Ros-Tonen et al., 2015; Idczak & Mrozik, 2018). This vagueness is illustrated by Piorr et al. (2011), as shown in Figure 4. This graphic shows how in theory, the peri-urban area fits in relatively neatly between suburban areas surrounding one urban centre and the rural hinterland. Piorr et al. (2011) refer to this depiction as the ‘text book version’. However, they argue that this form is rarely seen in the real world, which is often made up of several larger and smaller urban areas which interact with each other. They aim to depict this complexity in their ‘semi-realistic version’ of a rural-urban region, also to be found in figure 4. This illustration, albeit in general less clear than the first one, actually shows a clearer divide between peri-urban and rural areas. The former is shown to still have a clear link with one or more urban centres, while the latter is completely detached from them.

Figure 4
Peri-urban areas within rural-urban regions (Piorr et al., 2011).



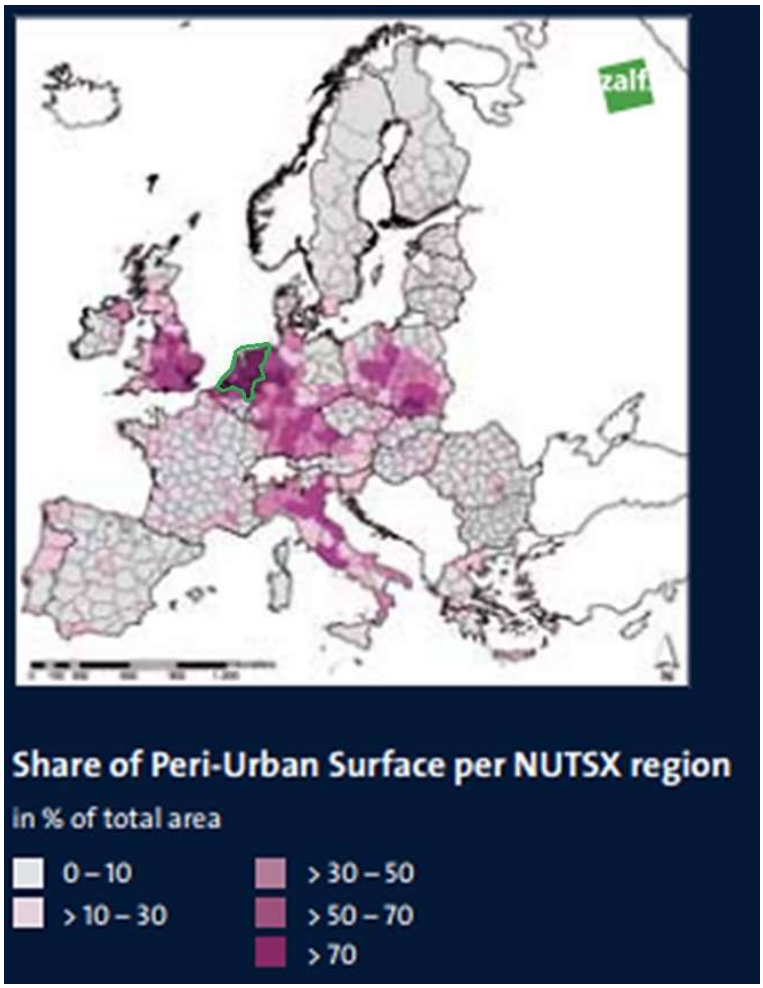
2.3.1 Peri-urban areas in the Dutch context

In addition to the already varying definition of peri-urban areas, Idczak & Mrozik (2018) point out the differences in the nature of these areas from country to country. As this research is conducted in The Netherlands, it is important to discuss the specific nature of Dutch peri-urban areas. The Netherlands is a particularly interesting area to study, given that Piorr et al. (2011) identify the entire country as a hot spot for peri-urbanisation, as shown in Figure 5.

The ongoing process of peri-urbanisation has, it seems, progressed particularly far in The Netherlands. So far, even, that according to OECD standards the country has no rural areas left at all, although this does not match local perception (Haartsen et al., 2003). Given the highly peri-urbanized nature of The Netherlands as a whole, Hornis & Eck (2009) have adapted the concept specifically for the Dutch context. They describe how while traditionally, peri-urban areas are seen as a subordinate part of an urban region, some of them have become more full-fletched parts of wider urban networks. Based on this trend, they devised different types of Dutch peri-urban areas (Hornis & Eck, 2009). In all of these, however, the basic concept remains the same: a peri-urban area is an area which is characterized by a mobility pattern which is strongly focussed on a dominant urban area. Gonçalves et al. (2017) also stress the continued importance of this traditional link. This mobility pattern forms the basis for this thesis, as it tends to result in a lack of local mobility options, at least when it comes to public transport (Ravetz et al., 2013; Thao et al., 2023).

Figure 5

Hot spots of peri-urbanisation in the European Union (Piorr et al., 2011). The borders of The Netherlands have been highlighted in green.

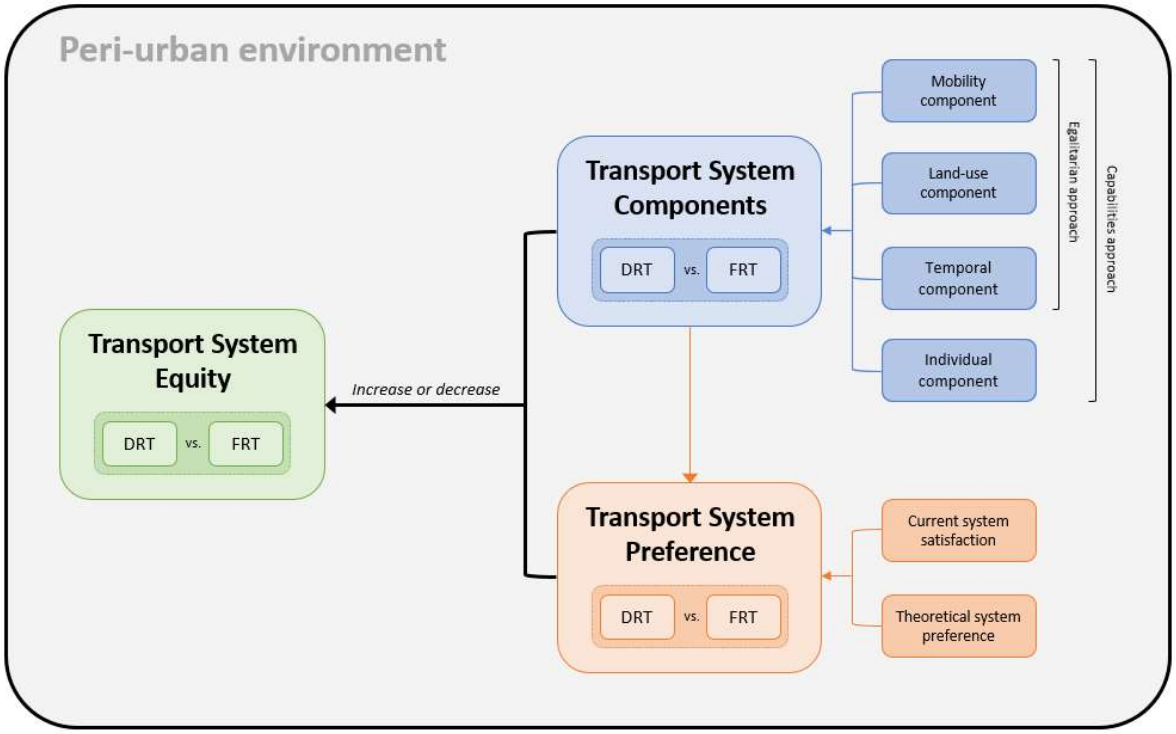


2.4 Conceptual framework

The concepts that have been discussed in this theoretical chapter are captured in a conceptual framework (Figure 6), which illustrates how they relate to the main question of this thesis: how the choice of transport system, DRT or FRT, affects the degree to which local public transport equity is achieved in a peri-urban environment. The framework also highlights the different components of transport systems that have been identified in this chapter.

In addition to systematically analysing the local public transport systems based on the components and aspects discussed in this theoretical chapter, this thesis intends to account for the preferences of the inhabitants – the intended users of these systems. This is particularly relevant because, as Curl (2018) argues, people's perceptions and assumptions about their access to public transport and available transport options in general can influence the extent to which these systems are used. Based on this, and given that residents of Weert and Woerden have experienced and continue to experience a different system, their perspectives are divided into two dimensions in the framework below. First, their satisfaction with the current local public transport system in their city, and second, the preference they express for either a DRT or an FRT system, based on theoretical characteristics. As illustrated in Figure 6, this preference can also be influenced by each component of the transport system.

Figure 6
Conceptual framework (own work).



2.5 Operationalisation

The conceptual framework in Figure 6 has been operationalised for the purpose of data collection and analysis in this research. This operationalisation can be found in Table 2.

The two main concepts represent the two independent variables of the conceptual framework: *transport system components* and *transport system preference*. The dimensions of the transport system components correspond with the four components of Geurs and Wee (2004). The mobility component is further divided into four subdimensions, which are derived from the four aspects on which DRT and FRT systems were found to differentiate in Subsection 2.2.2. The land-use component could have been divided in both *origin* and *destination*, but as the sample will consist solely of residents of the respective neighbourhoods, the assumed origin is always their home. As has also been discussed in Subsection 2.2.2, there are two areas where DRT and FRT systems are likely to differ in the temporal component: operating hours and waiting time. Total travel time will not be considered, as in a DRT system this varies from trip to trip and is thus very hard to establish. Furthermore, given the small size of both cities, travel time will always be limited. For all the aspects of these three components, the importance people attribute to them functions as an indicator. A second indicator consists of the preferences people express within these aspects. This indicator is only included if the preference is not already clear. For instance, while someone might not find it too important to know the exact arrival time, it is not logical that someone would prefer not to know it. Compared with the other three components, the individual component is more complex. The first aspect of this component is *transport demand*. This has been divided into two indicators, based on the two main theories of equity adapted in this research in Subsection 2.1.2: the desire to use local public transport for the egalitarian approach and the need to use local public transport for the capabilities approach. Both rely on self-reporting, as determining this

objectively is very difficult and will always involve some degree of subjective judgement by the researcher. Whether people know someone who needs to use local public transport, is also added as an indicator. In addition to transport demand, the *demographic characteristics* which were identified in Subsection 2.1.3 are also included as a subdimension, with each category forming a separate indicator. Finally, which system the respondent has been *exposed* to (in other words: which neighbourhood they live in) and their *knowledge* of that system are included as subdimensions, as the real-world experiences with their local public transport system can influence people's preferences when it comes to the other three components.

The second main concept, transport system preference, is more straightforward. It is divided into two dimensions which are reflected in the conceptual framework: *theoretical preference* and *satisfaction with the current system*. These two dimensions also function as indicators. The third main concept in the conceptual framework is the dependent variable: *transport system equity*. This variable has not been operationalised in Table 1, as it is not treated as a measurable concept in this thesis. Rather, the other two main concepts are seen as the indicators for transport system equity. The data gathered regarding these two concepts will be presented in Chapter 4, whereas the discussion in Chapter 5 will focus on how these findings impact transport system equity.

Table 1

Operationalisation of the conceptual framework.

Main concept	Dimensions	Subdimensions	Indicators
Components of the transport system	Mobility Component	Network topology	Importance of not having to transfer
		Boarding and alighting locations	Nearest stop
			Distance to nearest stop
			Preferred max. distance to nearest stop
			Importance of distance to nearest stop
		Schedule	Importance of knowing the departure time in advance
			Importance of knowing the travel time in advance
			Importance of knowing the arrival time in advance
		Advance notice requirement	Importance of not having to book in advance
	Land-use Component	Destination	Preference for which locations can be directly accessed
			Importance of having direct access to these locations
	Temporal Component	Operating hours	Preference for times at which the system operates
			Importance of the network operating during these hours
		Waiting time	Preferred max. response time
			Importance of response time
			Preferred min. frequency
			Importance of frequency

	Individual Component	Self-reported transp. demand	Desire to use local public transport
			Need to use local public transport
			Knowing others who need to use local public transport
		Demographic characteristics	Birth year
			Gender
			Migration Background
			Income
			Access to a car
			Requirement of travel aids for walking / cycling
		Knowledge of system	Knowledge of public transport in general
			Knowledge of local public transport in city
			Knowledge of operating hours
			Knowledge of having to book in advance
			Being able to book in advance
		Exposure to system	Living in neighbourhood with certain local public transport system
Transport system preference	Theoretical preference		Preference when offered a choice between a typical DRT system and a typical FRT system
	Satisfaction		Satisfaction with current system

3 Methodology

With the theoretical background and conceptual framework of this thesis having been established, this chapter focuses on the methodology of the research, how it has been executed and how this contributes to answering the research questions. To this end, a research philosophy and strategy are set out and the methods for collecting the required data are specified. This chapter also specifies how the data, once gathered, have been analysed. Finally, it covers any other considerations that have influenced this research, concerning reliability, validity, positioning, and ethics.

3.1 Research philosophy

Based on the definition of different ontological perspectives as provided by Bryman (2016), this research leans more towards a constructionist than an objectivist position. Although the use of and access to public transport can in and of themselves be factually established, as is the assumption of an objectivist position (Bryman, 2016), the relation of transport access to concepts like equity depends on one's definition of what is fair and just (Pereira et al., 2016; Martens, 2017). That definition naturally lies in the eye of the beholder, which is in line with the constructionist position that truth does not consist of facts separate from society, but is shaped by society and its perception of those facts (Bryman, 2016). Translated to the specific content of this research, this means that the focus does not solely lie on the objective truth of data on the transport systems that are being studied. Rather, the starting point of this thesis is the human perception of these systems, with the objective data functioning as important context to these perceptions.

These considerations lead to a more interpretivist epistemological starting point for this research. Whilst hard data is acquired and used when available - a positivist approach which is linked to objectivism (Bryman, 2016) - the emphasis lies on the interpretation of these data. This approach is adopted because the aim of this research is not merely to establish the measurable performance of the two transport systems that are being studied. This research goes a step further, as the aim is to understand the implications these measurable outcomes have in terms of the degree to which the systems equitably deliver local public transport. As the latter cannot be established completely objectively, the interpretation of the data is key in finding answers that fulfil this research aim. This interpretative approach matches the predominantly constructionist position this research takes (Bryman, 2016), and will be reflected in the research strategy that has been selected.

3.2 Research strategy and methods

The selected research strategy for this thesis is a comparative case study. A case study design fits in well with an interpretative approach, as it allows to seek for deeper understanding of a particular case (Yin, 2003; Diaz Adrade, 2009). Furthermore, it is in line with the research aim of understanding the *how* of equitable local public transport provision. As this research seeks to compare two different concepts, DRT and FRT, it makes sense to opt for a comparative case study. An additional advantage is that the structured nature of a comparative case study can help counteract the shortcomings of a case study, primarily its perceived unsuitability for generalisation (Kaarbo & Beasley, 2002; Yin, 2003; Bryman, 2016). For example, if people are satisfied in one case, it is difficult to directly translate these results to other cases. However, if it is known they are more satisfied in one case than another, it is possible to investigate what caused that difference. Those findings could also be applied to cases which were not included in the research.

Since the goal of this thesis is to compare two different concepts, the study will rely on a representative or typical case of each (Bryman, 2016). For this purpose, a comparison of all peri-urban cities in The Netherlands with between 25,000 and 75,000 inhabitants was made. As a result of this comparison, the cities of Woerden (Utrecht) and Weert (Limburg) have been chosen. This selection has been made based on the following criteria:

- Both cities fit within the definition of peri-urban as determined in Chapter 2, being relatively small cities of a similar size (roughly 40,000 inhabitants) that are not directly attached to a larger urban area, but are close to one and have a strong mobility link with it. Specifically, Woerden is served by six trains an hour into Utrecht with an average journey time of 14 minutes, while Weert has four trains an hour connecting it with Eindhoven in 16 minutes.
- Both cities have a similar geographical layout, as is shown in Figures 7 and 8. The railway station, city centre and hospital are all situated in the middle of the cities with residential neighbourhoods surrounding them on all sides. This is crucial when studying local mobility, as it means that in addition to overall size, travel distances within both cities are similar.
- Woerden represents a typical case of a peri-urban city with a DRT system taking care of local public transport. Almost all local FRT services have been scrapped, and the DRT system fits with the 'many-to-many' setup which was found to be typical for 'full' DRT systems in Chapter 2.
- Weert represents a typical case of a peri-urban city with an FRT system, serving most but not all parts of the city. For instance, service has been withdrawn in the Kazernelaan and Graswinkel neighbourhoods. As in many other small cities with FRT systems, there has been talk of replacing it with a DRT system (Arriva Limburg, 2023).

In short, Woerden and Weert are two cities that are similar in a lot of aspects that are relevant to local public transport use, but that at the same time have vastly different local public transport systems. This makes them well-suited for a case study that aims to compare these two different systems.

Figure 7

The geographical layout of Woerden, including the furthest distance from the railway station (own work; map source: Google MyMaps).

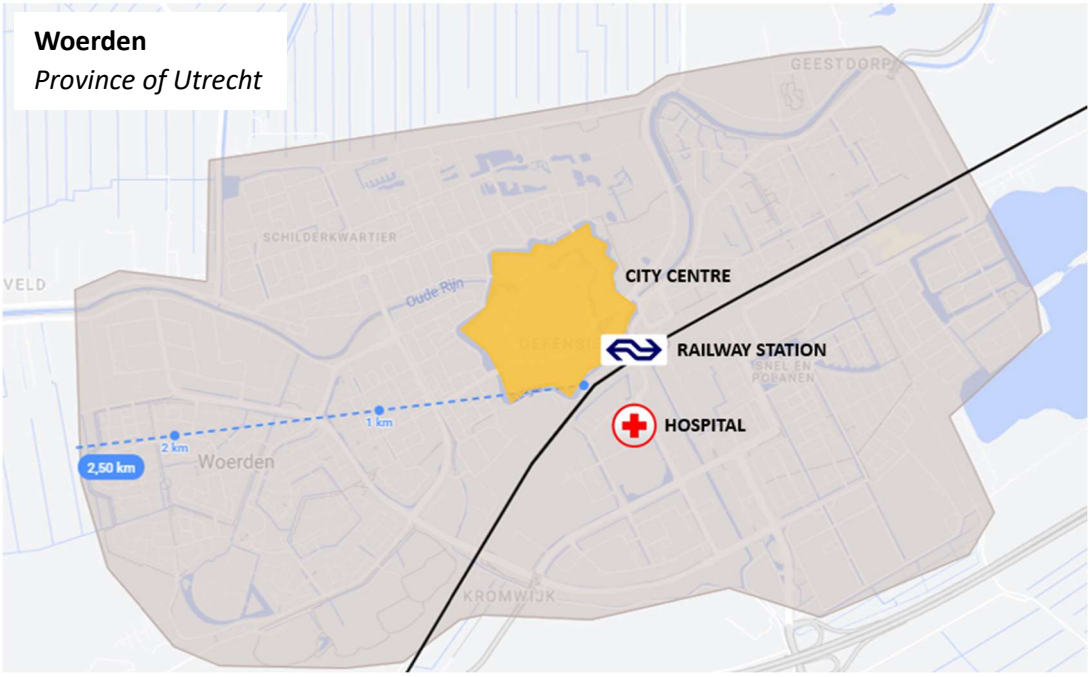
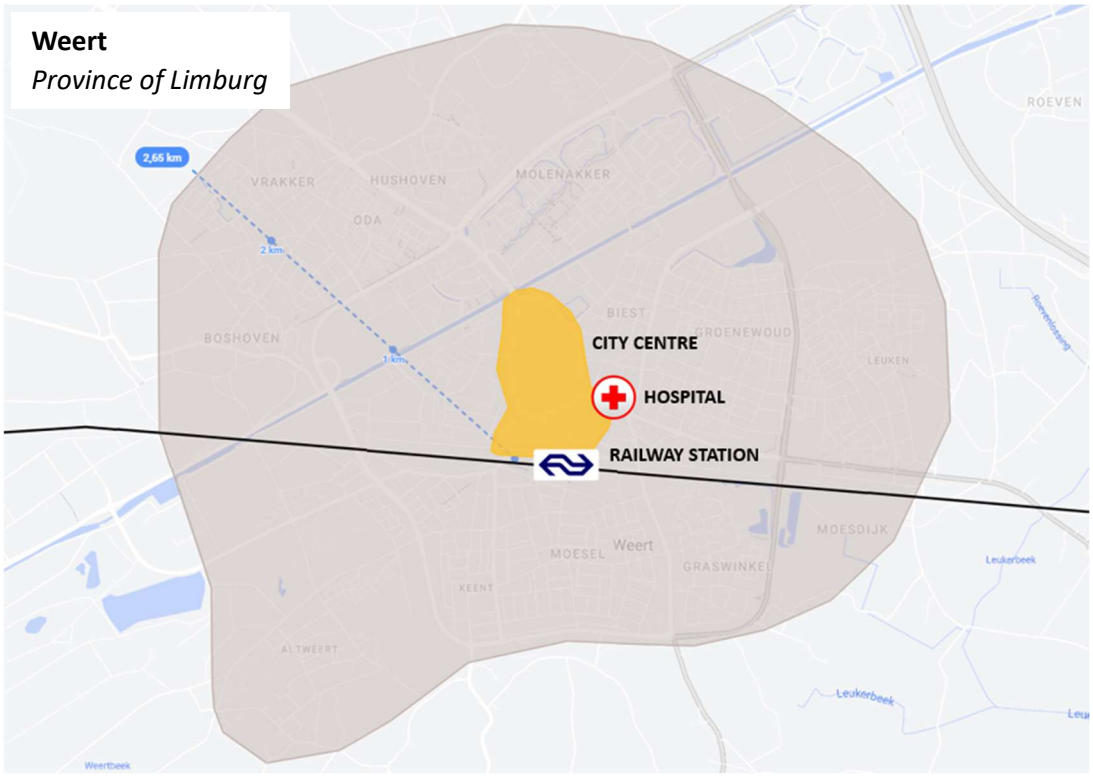


Figure 8

The geographical layout of Weert, including the furthest distance from the railway station (own work; map source: Google MyMaps).



To conduct this comparative case study, a mixed-methods approach has been adopted, combining two different types of quantitative data with qualitative data. This is in keeping with the balanced research philosophy outlined earlier. The mixed-methods approach also aims at increasing both the internal and external validity of the research. By combining different methodologies, the weak points of one research method can be offset by the other (Thiel, 2014; Bryman, 2016). To this end, the following two research methods have been applied:

- *Primary data collection* in the form of a survey, providing insight into people's perceptions of the mobility, land-use, and temporal components of equitable transport access, as well as into how these perceptions vary based on the individual component. This survey provides part of the quantitative data for this research, as well as the qualitative data.
- *Secondary data collection* of available data on local public transport availability and usage. These quantitative data provide important context when establishing how the mobility, land-use and temporal components of both transport systems contribute to or hinder the provision of equitable local public transport.

The survey data are referred to as the primary data, as these are the data most directly aimed at answering the main research question. As such, the survey is set up based on the operationalisation of the main concepts in Section 2.5, as is discussed in more detail in the next section. The qualitative part of the survey and the quantitative secondary data serve to verify the interpretation of the survey results. They respectively indicate what could be the reasons respondents give certain answers, and to what degree these answers actually correspond with real-world outcomes when it comes to the use of both local public transport systems. Thus, these data offset two disadvantages of surveys: the fact that

answers are not explained, and the fact that they depend on the reliability of the answers provided by the participants, rather than direct real-world measurements (Verschuren & Doorewaard, 2007). For example, secondary data can provide information on the amount of people that actually use local public transport to access the local swimming pool, if many respondents to the survey express a desire to do so. The way in which these different research methods are deployed in this research aligns with the embedded mixed-methods research design as defined by Creswell and Plano Clark (2011), as the secondary data serve to provide a more complete answer to the main research question, rather than merely to check whether the answers provided by the primary data are correct.

3.3 Data collection and sampling

The previous section explains how this research is based on two separate forms of data collection: primary data collection through a survey, and secondary data collection of available data on the local public transport systems. This section states specifically for both of these methods which data have been collected, and what sampling methods have been applied.

3.3.1 Primary data collection

The survey has been set up as a stated preference survey, asking respondents about their preferences regarding all the aspects included in the operationalisation in Section 2.5. Focussing on respondents' preferences is in line with the constructionist research philosophy of this study as set out in Section 3.1, as well as being useful considering that respondents have only experienced either a DRT or and FRT system in recent years. This means that it is unlikely that many of them will be able to share real-life experiences with both types of system, making a focus on stated preference a logical choice (Mayas & Kamargianni, 2017; Parvaneh et al., 2014). As a result of this approach, the survey provides quantitative data on the preferences of all respondents when it comes to the key differentiating aspects between DRT and FRT systems, allowing for a meaningful comparison. Nonetheless, as has been argued in Section 2.4, the actual experiences that respondents have had are equally valuable in trying to understand the equity implications of both systems. Therefore, respondents were also asked directly about their opinion on the system currently in place in their city, and whether they would generally prefer a DRT or an FRT system. These questions were asked after the stated preference questions, to minimize the degree to which the answers to these questions were influenced by the fact that respondents have experienced one system but not the other. The final question in the survey is an open question, allowing respondents to give their opinion on any given subject regarding either their hypothetical preferences or their experience with the local public transport system in their city. Not only do these answers help with interpreting the gathered quantitative data, they also provide insight into which aspects of the transport systems are most important to respondents, as well as giving them an opportunity to point to aspects the survey may have overlooked.

The survey data which have been detailed above, have been collected in the field by visits to the respective cities. By collecting the surveys through field work, I was not only able to gather the required data, but I also saw first-hand how both systems functioned, and had many insightful conservations with both residents and bus drivers along the way. As these conversations usually happened by chance, these data were not collected in an organized manner. Nonetheless, talking with people about their experiences with their local public transport system did help me to gain deeper insight into the subject matter. This was helpful, particularly considering the importance of the interpretative aspect of this research, which has been highlighted in Section 3.1. The downside of using field work for data collection

is that it is rather labour-intensive. Albeit relatively small, both cities still have over 40,000 inhabitants. Reaching all of them through fieldwork is impossible, meaning that the area in which the field work was conducted had to be narrowed down. This does comes with a risk, as the access offered by each local public transport system varies greatly from neighbourhood to neighbourhood. To still gain a representative insight into the full research population, the field work has been focussed on two neighbourhoods in each city: the one which appears to benefit the most from the current transport system, and the one which appears to benefit the least from it. The selected neighbourhoods are *Molenvliet-West* and *Snel en Polanen* in Woerden, and *Boshoven-Vrakker* and *Graswinkel* in Weert. Their characteristics are specified in Table 2.

Table 2

The characteristics of the sampled neighbourhoods in Woerden and Weert.

	Woerden	Weert
Most advantage from current transport system	**Snel en Polanen** • ~ 5,500 inhabitants • Closer to city centre • Local bus service was withdrawn in 2011 but was re-instated through the DRT system.	**Boshoven-Vrakker** • ~ 5,500 inhabitants • Furthest from city centre • Served by a relatively frequent, FRT bus service all week.
Most disadvantage from current transport system	**Molenvliet-West** • ~ 5,500 inhabitants • Furthest from city centre • Served by a frequent FRT bus service, until it was almost fully replaced with a DRT system.	**Graswinkel** • ~ 2,500 inhabitants • Closer to city centre • Local FRT bus service was withdrawn in 2017.

Within these four neighbourhoods, the surveys have been gathered through convenience sampling: trying to reach as much of the population as is required for the research through whatever means available (Bryman, 2016). The reasoning behind this approach is twofold. First, reaching people in very specific areas is relatively difficult. Second, the survey weighs various individual characteristics, and all of these have to be represented in the survey data. Given both these points, using all methods available to reach respondents makes the most sense. To produce a representative sample, a goal was set of at least 100 surveys per neighbourhood. This is a reasonable goal, that also ensures that the total number of surveys surpasses the recommended sample size for a total research population of about 85.000 people (Korzilius, 2000), which is the combined number of inhabitants of Weert and Woerden. The initial aim was to gather as much of these surveys as possible through online means, specifically through local media, local organizations and social media groups, as this is the most time-efficient way to reach potential respondents. This resulted in an article in the local newspaper in Woerden (Woerdense Courant, 2024) and a mention on the neighbourhood platform of Molenvliet-West (Wijkplatform Molenvliet, 2024). Unfortunately, no local media or organizations responded in Weert, and none of the social media groups in any of the four neighbourhoods responded either. As a result, this method of data gathering only yielded 26 completed surveys, which albeit a nice start was nowhere near enough.

Hence, most of the surveys have instead been gathered using more traditional methods: through letters with a link asking residents to fill out the survey (a sample can be found in Appendix C1) and through door-to-door canvassing. Based on initial tests of the response rate for each method, it seemed most efficient to spread the letters through all of Molenvliet-West, Snel en Polanen and Boshoven-Vrakker, and apply the door-to-door method in much smaller Graswinkel, where reaching a representative sample would require a higher response rate. Eventually, 5,203 households have been contacted in either of these ways, resulting in 603 completed surveys, with the bar of 100 respondents being cleared in all four neighbourhoods. This methodology ensures that all addresses in the four neighbourhoods – except those legally exempt[2] – have been contacted, maximizing the survey's representativeness. Unlike selective street sampling or online surveys, this approach reduces bias and increases the likelihood of reaching the small group relying on the low-demand services that this thesis focuses on.

3.3.2 Secondary data collection

The secondary data consist of data on both local public transport availability and usage. Just like the qualitative data from the survey, these data provide important context when trying to interpret the quantitative survey data. After all, people's perception of local public transport availability does not necessarily need to match actual availability, nor is it a given that all preferences and perceptions translate into actual, real-world usership. The secondary data on both these aspects have been gathered through desk research. Data on the availability of local public transport could simply be acquired by studying the websites of the transport operators in the respective cities, and by comparing this information with timetables from previous years. However, data on the usage of local public transport systems are not publicly available. As such, the data required to conduct this part of the desk research had to be acquired through corporation with other parties.

As the operation of all transport services in The Netherlands is commissioned by local government to private contractors, contact has been sought with the respective operators in Woerden and Weert to acquire as much relevant secondary data on both local public transport systems as possible. Both Keolis,[3] responsible for SyntusFlex in Woerden, and Arriva,[4] responsible for all buses including local buses in Weert, have been very cooperative. They both were able to provide datasets showing all trips that were made during a certain period of time, although these datasets are not completely identical due to the different nature of both systems. The data from Woerden include each trip that was booked with SyntusFlex in the first six months of 2024, including date, planned arrival or departure time (at the time, users could select one of the two), departure stop, arrival stop, number of people on the booking and whether or not the trip went ahead as planned. The data from Weert stem from November 2023, and include a so-called 'HB-matrix' for each of the four city bus lines, showing the average number of trips per weekday between every possible combination of stops on a line for each direction of travel. The total number of trips for each line and for the whole month can also be derived from these data. The dataset also includes the vehicle occupancy in the 80th percentile. This means it is possible to see how many people were in a bus at each stop for the 80th-percentile busiest trip of each scheduled service, providing an estimate of higher-end occupancy levels rather than daily averages.

[2] Dutch municipalities offer stickers which prohibit the use of a doorbell or letterbox for marketing purposes.
[3] The Province of Utrecht has awarded Keolis Nederland the right to operate all public transport by bus in the concession Provincie Utrecht, which includes Woerden, under the brand name Syntus Utrecht for the period 2017-2025. Keolis introduced the SyntusFlex DRT system in 2018 (Keolis Nederland, 2018; Mobiliteit.nl, 2022).
[4] The Province of Limburg has awarded Arriva Personenvervoer Nederland the right to operate all public by bus in the concession Limburg, which includes Weert, for the period 2016-2031 (Mobiliteit.nl, 2015).

Although these two datasets are not identical, they provide insight into the same aspects of the respective local public transport systems, and through the analysis of the data it was possible to compare them nonetheless. This analysis is explained in more detail in the next section. Together, the datasets provide valuable insight into the mobility, land-use, and temporal components of the local public transport system in Woerden and Weert. Ideally, insight would have been gained in the individual component as well. However, as the booking system used for Woerden's DRT system registers no individual data at all, the decision was made not to request this data for Weert either.

3.4 Data analysis

Different strategies have been applied for the analysis of the data that have been gathered according to the specifications in the previous section. The steps followed in this analysis are detailed below for each of the two datasets, and the results of the analyses are presented in Chapter 4.

3.4.1 Primary data analysis

The dataset that resulted from the collection of the surveys consists of 603 fully filled out surveys. The data gathered by these surveys align with the different indicators presented in the operationalisation in Section 2.5. The specific questions can be found in Appendixes C2 and C3. Most of the analyses regarding the survey have been conducted by studying graphs derived directly from the survey dataset, meaning no further analysis was required. However, the individual component, satisfaction with the system and theoretical system preference have been analysed further by the means of regression analyses. In the case of the individual component, this was done to determine which demographic characteristics can predict an increased likelihood of people either wanting or needing to use local public transport. For the satisfaction with the current system, the aim was to establish whether or not there is a relationship between system satisfaction and the neighbourhood the respondent lives in, while accounting for uneven sampling by including the demographic data in the regression analysis.[5] Finally, the regression analysis for theoretical system preference includes all indicators, in order to establish which ones can predict how likely a respondent is to prefer a DRT system to an FRT system.

In order to conduct these analyses, as a first step all the variables have been categorised. This categorisation can be found in Appendix D3. The full SPSS Syntax of the analyses can be found in Appendix D2 and the underlying dataset in Appendix D1. Subsequently, all variables have been dichotomised to create dummy variables to allow for the regression analysis, except for the variables indicating importance. These are interval variables, and dichotomising them would needlessly remove information. Even though age is a ratio variable, this has been dichotomised into two variables, one for people below 25 and one for people of 65 and older. This was done for two reasons. First, because the other demographic variables were already nominal, and second, because the expectation was that both younger and older people would be more likely to need local public transport. As a final remark on the variable of age, it is good to note that respondents were asked to fill out their year of birth rather than age. In order to estimate age, their year of birth was subtracted from the year 2024. As a final preparation, some variables measuring the importance of certain aspects were combined after testing their internal consistency using Cronbach's Alpha. This was done because there was a very large number of variables measuring importance, and some of them could be deemed comparable. In the

[5] It is good to note that the demographic indicator of household income has been excluded from all regression analyses, given the limited number of respondents that provided an answer to this question.

end, the importance attributed to the local public transport system providing direct access to the railway station, city centre and hospital were combined into a variable for importance of direct access to 'major' destinations. The Cronbach's Alpha value for these three variables was 0.731, indicating sufficient internal consistency to combine them. Similarly, the variables measuring the importance of direct access to all other destinations were combined into a variable measuring the importance of direct access to 'minor' destinations with a Cronbach's Alpha value of 0.871. The importance attributed to knowing the arrival, departure and travel times in advance was combined into the importance attributed to a fixed schedule, with a Cronbach's Alpha value of 0.788.

In addition to the quantitative data described above, the survey also generated qualitative data through a final open-ended question. This allowed respondents to share remarks on the survey topics, with 168 participants providing input. Relevant findings are presented in Chapter 4.

3.4.2 Secondary data analysis

The datasets for the secondary data analysis consist primarily of usership data provided by the operators of the local public transport systems in Weert and Woerden. As explained in Subsection 3.4.2, the main challenge has been combining these two different datasets. Several steps have been undertaken to allow for a reliable comparison; these are explained in this section. The first step was narrowing the data down to a specific period. The dataset from Weert contained data from weekdays in November 2023, while the dataset from Woerden contained data from all days in the first six months of 2024. As such, the analysis has focussed on weekdays only. To allow for a fair comparison, a month also had to be selected from the available data in Woerden which most closely resembles November. Based on month-to-month passenger numbers from the Dutch railway company from 2019, so undisturbed by lockdowns and other COVID-related matters, March is the month which most closely resembles November, and therefore this month was selected (Nederlandse Spoorwegen, 2023).

As a further complication, the data from each city were provided in very different ways. The data from Weert contained an HB-matrix, showing the number of trips made between any two stops, while the data from Woerden contained a list of every single trip made during the specified period (these data can be found in Appendixes E1 and E3). In order to compare the two, a similar list had to be created in Weert by extracting these data from the HB-matrix. This was complicated by the fact that three of the bus routes in Weert run in a loop at the end of their route and have what is known as a *fictive terminus* in the middle of that loop. In the dataset, all trips start and end at this stop, whereas in fact, trips can be made beyond that point to a stop further down the loop. As a result, all trips to a stop on the loop *past* the fictive terminus are registered as two trips: one from the origin to the fictive terminus, and one from the fictive terminus to the destination. Based on the available data, it was possible to determine what the actual trips must have been. This required quite a few steps, which have been specified in Appendix E2. By following these steps, it was possible to construct a list for Weert similar to the one for Woerden, showing the number of trips made between any two stops on the system. Based on this, the data for each neighbourhood could also be derived. From that point, each trip has been classified based on which 'travel relation' it represented: between the railway station and the city centre, the hospital, or a neighbourhood; between the city centre and the hospital or a neighbourhood; between the hospital and a neighbourhood; or between two neighbourhoods.

Before being able to conduct the analysis, a few final steps had to be taken. For instance, both systems serve a few stops outside of the city border, and these have been excluded. In Woerden, users of the system could select either a fixed departure time or a fixed arrival time in March 2024. Since it is not possible to determine the one based on the other, as the travel time is not available, these have both

been treated as the departure time. This is not entirely accurate, but it allows for an analysis of the times at which trips were made, which is a very important piece of information. And given the limited size of Woerden, the departure time will not have been more than about 15 minutes before the arrival time in most cases. Also in Woerden, each trip has been manually classified based on whether or not it would have been possible to make it in the old network. This classification can be found in Appendix E4. Finally, bus line 4 in Weert was excluded from the 'travel relation' analysis. This decision was taken because bus line 4 is operationally linked to other bus lines to ensure direct access to the city centre and hospital. However, the available data were not sufficient to determine for how many trips this actually was the case.

3.5 Reliability

The data-analysis described above should provide an answer to the main research question. However, it is of course crucial that this answer is reliable; in other words, that a similar answer would be found if someone were to replicate this research (Bryman, 2016). The first step in ensuring reliability is replicability, meaning that the research can actually be repeated. Although case studies can sometimes be difficult to replicate (Thiel, 2014), this should not be an issue with this particular research. The methods have been clearly described, and in theory, someone could come back later and approach everyone in the same neighbourhoods with the same survey. It helps in this regard that the case study actually consisted of four separate neighbourhoods. Because of that, a standardised approach had to be used for each, which Thiel (2014) argues improves replicability. However, some caution has to be preserved when it comes to the stability of the subjects that have been studied. Stability in this case refers to the degree to which the subjects of the research are expected to remain unchanged over time. For this research, that is not necessarily the case. First, transport systems have a tendency to change over time, as is already demonstrated by the change in booking system that occurred near the end of this study, which is discussed in Subsection 4.1.3. Second, the research population changes over time too, not only through natural demographic processes, but also given the geographical boundaries, as people move in and out of the neighbourhoods. This is particularly relevant in the three neighbourhoods which saw a recent change in local public transport system, as the amount of people who have experienced the old system as well the new one gradually declines. This potentially influences people's perception of the new system. In short, while this research could quite easily be replicated, there are reasons to assume that the outcomes of such a replicated study could start to deviate more from the outcomes presented in this thesis as time passes.

3.6 Validity

Besides reliability, it is also important to ensure the validity of the results, described by Bryman (2016) as the integrity and correctness of the conclusions drawn from a study. Bryman (2016) distinguishes four aspects that should be considered. First, the measurements ought to be valid and measure what they are intended to measure. This mainly relates to quantitative data (Bryman, 2016), which in this research is comprised of the survey data and the secondary data on local public transport usership. The secondary data are rather straightforward, as they simply consist of the number of trips made between all stops. The only two concerns relating to measurement validity are the loops at the end of lines and the time at which journeys were made. Both these concerns have been addressed in Subsection 3.4.2. To ensure that the questions in the survey actually measured what they were supposed to measure, they were tested with the help of several people unfamiliar with the topic and the cases. Any unclarities they reported, were resolved before the start of the distribution of the survey.

Next, there is the matter of internal validity. This concerns the question whether the causal relationships drawn in this research are actually causal (Bryman, 2016). For this study specifically: do the transport system components and transport system preferences actually have a causal relationship with transport system equity? As detailed in Section 3.2, this research uses three different methods to attain as complete a picture as possible of the different relationships that do or do not exist. Applying triangulation in this way increases both the validity and reliability of the research, as the weak points of one method are compensated by the other (Thiel, 2014). Thiel (2014) mentions another threat to internal validity that specifically concerns case studies, namely the fact that the existence of sub-units within a case can create a distorted image. In this research, this has been obviated by the sampling of specific neighbourhoods, as is explained in Section 3.3.

The third aspect listed by Bryman (2016) is external validity, which refers to the degree to which the results can be generalised. This is a particular concern for case studies, as any case knows many context-specific elements. This research aims to maximise generalisability by selecting the most typical case of both a DRT and FRT system in an equally typical peri-urban city, as described in Section 3.2. Furthermore, Section 3.3 highlights the ambitious target set and achieved in this research regarding the *n* of the surveys, which also increases its external validity (Thiel, 2014). A survey with a large *n* allows for the consideration of other independent variables which can influence the perception of equity, in particular variables concerning the individual component. Including these in the survey makes it possible to produce, for example, representative outcomes for both older and younger participants. This makes it easier to translate the outcomes of the research to other cases, where the composition of the population is likely to be different.

Finally, Bryman (2016) calls attention to the ecological aspect of validity. This regards the degree to which the setting in which the data are gathered matches the real world. In line with the argument presented by Verschuren and Doorewaard (2007), Bryman (2016) argues that this is particularly relevant for surveys. Since a survey relies on respondents to provide information rather than direct measurement, there might be a gap between what is reported and reality. As explained in Section 3.2, these concerns are also addressed by applying triangulation.

3.7 Positioning, ethical considerations and data processing

As with any research, it is important to reflect critically on my own position as researcher, on ethical considerations that came up during the research, and on responsible data processing. The former is even more critical in this particular study, given how interpretation plays an important part in it.

First on my own positioning. Although I do not live in either Woerden or Weert, I do feel closely connected to issues regarding public transport. Not only am I a frequent user of public transport myself, I also work as a bus driver for Qbuzz, another public transport operator currently active in Utrecht. Furthermore, I volunteer for a local community bus service in Woerden, which connects the city with several villages in the surrounding countryside. I also live close to Woerden, and as such do occasionally use public transport there, including SyntusFlex. Beyond these practical aspects, I have also been involved in public transport advocacy over the past few years. Besides taking part in public consultations, this involved organizing a petition against the scrapping of certain stops and bus lines in the city of Utrecht (De Utrechtse Internet Courant, 2019), as well as more recently presenting the province of Utrecht and operator Qbuzz with a long-term vision for public transport in my own village. Currently, I am part of the Passenger Advisory Council (RAR) for the Vervoerregio Amsterdam. As a result of these experiences, I certainly have opinions on what public transport equity looks like, and I strongly feel the importance of the research I am conducting. However, these opinions do not

necessarily stretch into the specific topic of this research. In fact, I have long been unsure as to whether the overall impact of switching from an FRT to a DRT system in low-demand environments is positive or negative. After all, DRT allows for the number of stops served to remain intact or expand, but at the same time it makes using public transport less easy. These were the two main issues I tried to address with the aforementioned petition. Furthermore, for someone who has studied public transport for years, a new innovation like SyntusFlex is of course exciting. More than anything, this uncertainty and curiosity lead me to be eager to find out what results this research will produce.

From an ethical standpoint, the risk of this research veering into unethical territory is limited. Nonetheless, it is important to also consider the potential real-world impact research such as this might have. This study directly compares two public transport systems that people actually rely on. While it is the aim to establish which of these systems provides public transport most equitably, it is clear from the outset that a switch from one system to the other would always result in negative outcomes for certain groups of people. After all, both systems benefit some groups more than others. Although an outcome that is clear enough to help spark a switch in system must mean that such a switch benefits most people, there will always be a negative impact for some groups. It is important both to acknowledge these consequences, and to implore that they are taken into account in any future decision making.

Furthermore, given how important these issues can be to people, it is essential to guarantee anonymity for those answering the survey. Otherwise, people might not feel comfortable giving certain answers, for instance that they do not feel a bus is required during some times of the day, when others might have a strong contrary opinion. The measures taken to ensure anonymity in the survey were explained at the start of it. They include the option to skip any question that asks about personal characteristics, and a guarantee that personal data like IP-addresses and email-addresses would not be included in the dataset. Respondents were given the option to leave their email-address in the survey to be kept informed of the outcomes of the study, but this information is not included in the dataset and will be permanently deleted after set outcomes have been shared. Finally, respondents were made aware of and asked to agree to the fact that the rest of the survey responses would be uploaded to the servers of the Radboud Universiteit, together with the final thesis.

4 Results

This chapter presents all the relevant results gathered through the methods laid out in Chapter 3. The chapter is organised along the lines of the conceptual framework, which can be revisited in Figure 6. The first four sections cover the four components of the respective transport systems of Weert and Woerden. Each of these sections first briefly introduces the transport systems of both Weert and Woerden in respect to that particular component. This introduction is followed by the survey results for this component, showing respondents' preferences, before finally presenting the performance of both systems based on the available secondary data. The last two sections present the survey results for the two dimensions of transport system preference: satisfaction with the current system and theoretical system preference.

4.1 The mobility component

This section introduces the mobility component of the local public transport systems in Weert and Woerden and presents the results for the mobility component from the surveys, as well as the performance figures that arose from the analysis of the available secondary data. Each of these segments is based on the four aspects of the mobility component that were identified as showing the clear differences between DRT and FRT systems in Chapter 2:

- **network topology:** in a 'full' DRT system, each stop can be reached directly from every other stop, whereas in an FRT system, a transfer might be required;
- **boarding and alighting locations:** a DRT system has the potential of serving more stops than an FRT system, as not all stops have to be served all the time;
- **schedule:** in an FRT system, the departure, travel, and arrival times are all fixed, whereas in a 'full' DRT system, they are all flexible;
- **advance notice requirement:** a DRT system has an advance notice requirement, an FRT system does not.

4.1.1 Introducing the mobility component of the local public transport systems in Weert and Woerden

The city bus network of Weert is shown in Figure 9.[6] The local bus routes are arranged in four lines, all of which run out from the railway station into the different parts of the city. The *network topology* has remained largely unchanged since 2006, although several sections of lines have been withdrawn. First, in 2009, local bus service was withdrawn from the Kazernelaan neighbourhood and the western side of the city centre. This was followed by a withdrawal of local bus service in the Moesel and Graswinkel neighbourhoods in 2016. A rural bus line took over the route through Moesel, but no replacement was offered in Graswinkel. These changes resulted in a reduction of the number of *boarding and alighting locations* in the southeast of the city. The *schedule* aspect remained unchanged, as buses still run at set times from each stop, and no *advance notice requirement* is in place.

Figures 10 and 11 [6] show the local public transport network in Woerden, with Figure 10 showing the old FRT-based network and Figure 11 the new DRT-based network, which was introduced in 2019. For the old network, the network that was in place between 2013 and 2017 is used as a reference, as some rapid changes occurred between 2017 and 2019. These changes eventually culminated in the full introduction of the SyntusFlex DRT system. A comparison between Figures 10 and 11 [6] shows a clear

[6] Figures 9, 10 and 11 can be found in Appendix B.

shift in *network topology*. In the old network, all stops were connected by regular, fixed bus lines, either local or rural. These services covered all parts of the city, although local bus service was withdrawn in phases: first in the Schilderskwartier neighbourhood, later followed by Snel en Polanen and Waterrijk. The new network shows only stops, as the route the bus takes is flexible based on demand. Only a few stops see regular service from a rural bus line, although the local bus lines from the old network continue to run a limited rush hour service as well. This change in *network topology* allowed for an increase in the amount of *boarding and alighting locations*, as the new system boasts 16 new stops that were not served before. Out of those 16 stops, 11 are situated in the neighbourhoods Vogelwijk, Snel en Polanen, Bedrijventerrein Polanen, and Waterrijk, which were not served by local buses in the old system. The other new stops increased the stop density in neighbourhoods that were already served by local buses. The *schedule* also shifted, with buses now running at flexible times based on demand, rather than according to a fixed schedule. It should be noted that in the case of SyntusFlex this flexibility is somewhat limited: there is a 10-minute margin for both departure and arrival time.

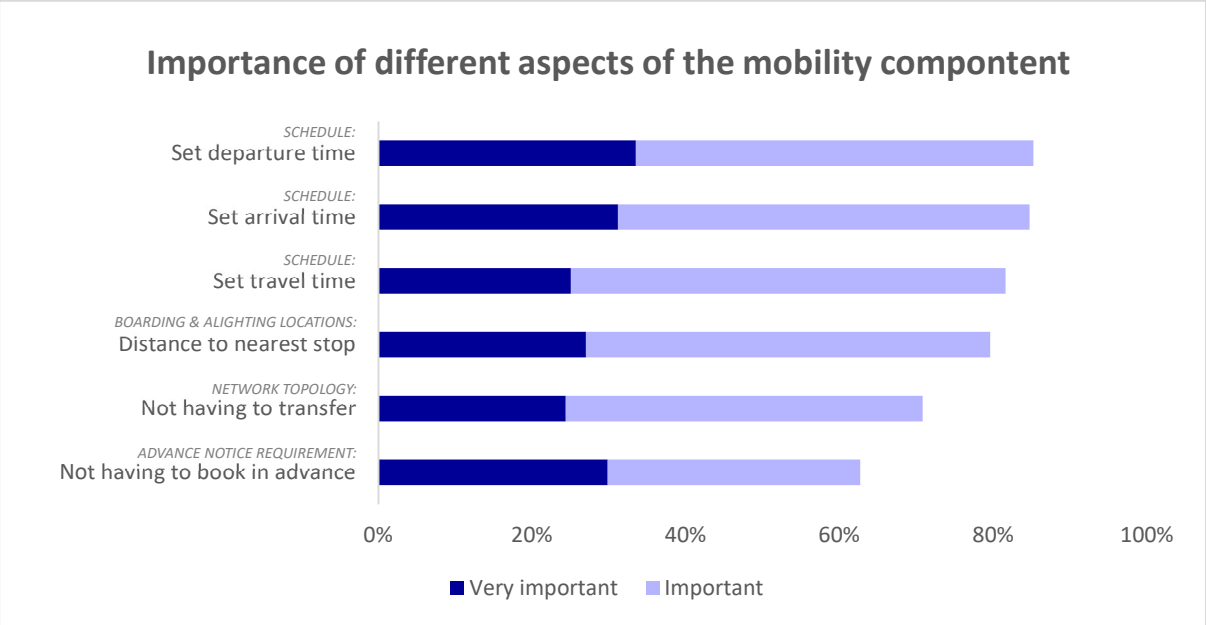
4.1.2 Analysing respondents' preferences on the mobility component of local public transport systems

In the survey, respondents were asked about their preferences on each of the four aspects of the mobility component: *network topology*, *boarding and alighting locations*, *schedule,* and *advance notice requirement*. To prevent confronting respondents with these technical terms, they have been translated for the purpose of the survey to the perspective of a (potential) public transport user. As such, *network topology* became 'not having to transfer', *boarding and alighting locations* became 'distance to nearest stop' and *advance notice requirement* became 'not having to book in advance'. The *schedule* aspect was split up in three separate aspects: 'fixed departure time', 'fixed arrival time' and 'fixed travel time'. This distinction was made as depending on the type of DRT system, one or more of these can be fixed, just not all of them. For each of these aspects, respondents were asked to indicate on a Likert scale whether they deemed them not at all important, not very important, neither important or important, important, or very important. Figure 12 shows how many times 'important' and 'very important' were selected for each of the aforementioned aspects. All six aspects are rated as either important or very important by a majority of respondents. The aspects related to the *schedule* score the highest, closely followed by the distance to the nearest bus stop (*boarding and alighting locations*). Not having to transfer (*network topology*) scores a little bit lower, and the *advance notice requirement* is seen as important by the least amount of respondents, with just over 60% indicating it is either important or very important to them.

Whereas the data for all respondents show that *schedule* and *boarding and alighting locations* are deemed important most often, a different image arises when a distinction is made between all respondents, those indicating they want to use local public transport, and those indicating they need to use it. This is shown in Figure 13, which shows the same data as Figure 12, but with the results having been divided into these three groups. In general, the pattern is similar for all aspects: each of them is seen as important a bit more often by people wanting to use local public transport, and again a bit more by people needing to use local public transport. However, there is one noticeable aspect where the outcomes show a stronger difference between these groups: the *advance notice requirement*. Not having to book in advance is seen as important by fewer respondents than any of the other aspects. But when looking at respondents who want to use local public transport, the difference is smaller, and when looking at respondents who need to use local public transport, it has almost disappeared. Indeed, almost 60% of the latter group deemed not having to book *very important*, which was more than for any other aspect.

Figure 12

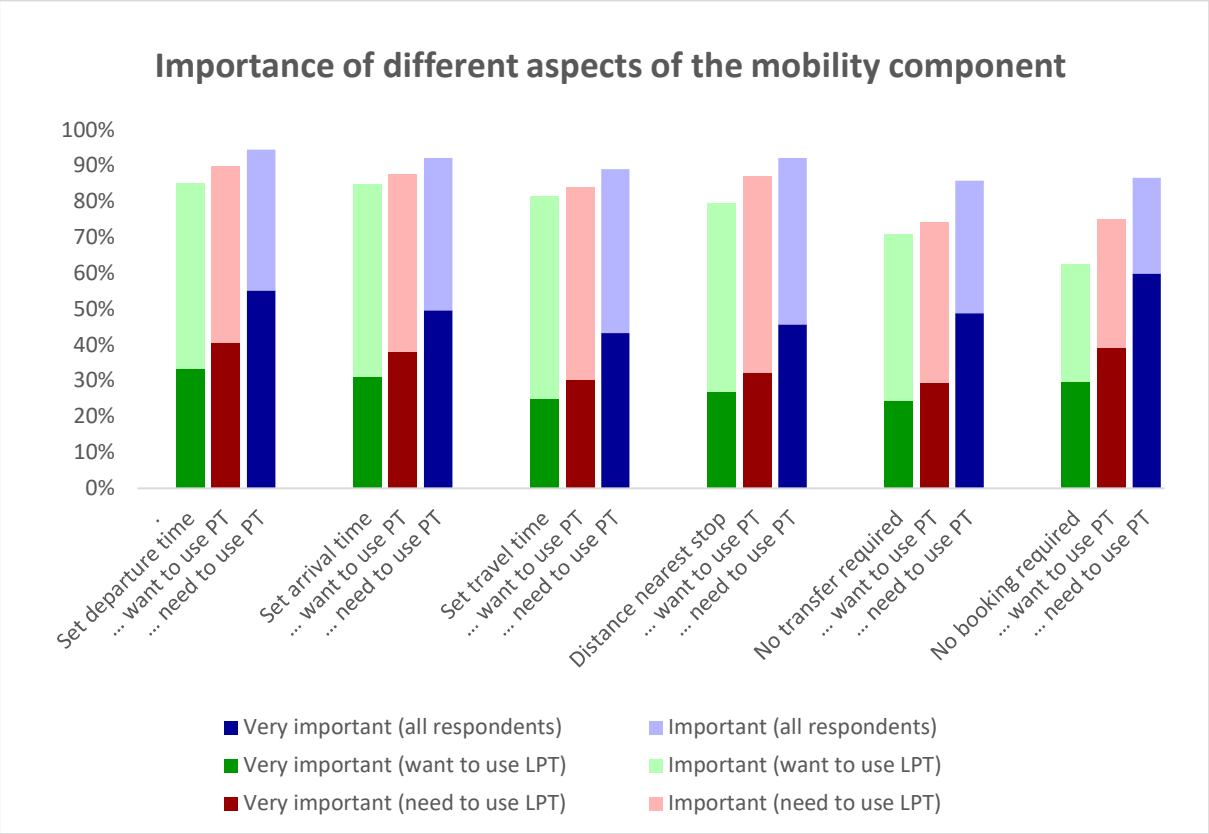
Importance attributed to different aspects of the mobility component by survey respondents.



N = 603.

Figure 13

Importance attributed to different aspects of the mobility component by survey respondents (LPT = local public transport).



All respondents: N = 603; want to use LPT: N = 345; need to use LPT: N = 127.

The particular importance of the *advance notice requirement* to a specific part of respondents is underlined further by the responses to the last question of the survey, which was an open question allowing respondents to leave any additional comments on the topic. A total of 34 respondents – 32 of which were from Woerden, where the DRT system is currently in place – used this open question for a negative comment on the principle of an *advance notice requirement*. Their responses fall into two categories: people indicating that an *advance notice requirement* stops them personally from using public transport, and people who worry that it forms too high a barrier for those who need local public transport, especially elderly people, resulting in isolation. One respondent (Molenvliet-West, Female, 32) said her household "used public transport all the time, but stopped doing so almost completely since SyntusFlex was introduced", referring to the *advance notice requirement* as cumbersome and threshold-raising. She also expressed concern for the plight of those who depend on public transport: "I find it unacceptable that the bar is raised for people who really depend on public transport to participate in society." This sentiment is echoed by a respondent indicating she actually does depend on it (Molenvliet-West, Female, 18): "I would really like for the buses to have regular hours and stops so I don't have to depend on my parents to get me to the train station, which for medical reasons I cannot reach by bike."

There were also 7 positive comments on the *advance notice requirement*. One of these respondents (Snel en Polanen, Male, 46) noted: "I think it is cheaper to have a bus run on demand with an intelligent booking system than have an empty bus run in circles, that is an outdated approach." Another respondent (Molenvliet-West, Female, 71) indicates that she is satisfied with the current system, but said she would "still prefer a regular bus service, as you know in advance the bus will always run." The total number of comments on the *advance notice requirement* was 41, whereas no other aspect discussed in the theoretical chapter received more than 11 comments. This underlines the importance of this aspect. In comparison, a more limited number of 6 people used the open survey question to comment on the *schedule* aspect. All of these were negative comments from Woerden, and all concerned the perceived incompatibility of the flexible nature of SyntusFlex with fixed train timetables. In addition to the *advanced notice requirement* and the *schedule*, it is also worth to take a closer look at the aspect of *boarding and alighting locations*. Where the other aspects concern binary issues (a transfer is required or not, the schedule is fixed or it is flexible, and there is an advance notice requirement or there is not), the preferences for *boarding and alighting locations* are not immediately apparent. People logically would prefer a bus stop to be closer rather than further away, but what distance is deemed close enough? Respondents were asked what they would like the maximum distance to their nearest bus stop to be, the results of which are shown in Table 3. Among all respondents, the average result is 355 metres, which aligns pretty well with the most commonly used benchmark in The Netherlands of 400 metres (Kampert et al., 2019). For those who would like to use local public transport, it is a little bit lower, and for those who indicate they need to use local public transport the average is 291 metres, considerably below the 400-meter benchmark.

Table 3

Respondents' preferred maximum distance to the nearest bus stop (LPT = local public transport).

Group of respondents	N	Average preferred maximum distance to nearest bus stop
All respondents	502	355 m
… would like to use LPT	303	327 m
… needs to use local LPT	109	291 m

4.1.3 Analysing the performance in the mobility component of the transport systems in Weert and Woerden

The performance of each component of the local public transport systems in Weert and Woerden have been analysed based on the available secondary data. These data consists of publicly available information on how each system functions – which is discussed in the introduction segment of each component – and usership data for both systems, provided by the respective operators in Weert and Woerden. This section will analyse the usership data through the lens of each aspect of the mobility component: *network topology*, *boarding and alighting locations*, *schedule,* and *advance notice requirement*. When possible, the usership data have been complemented by information that respondents to the survey provided on the performance of the system in place in their city. They were given the opportunity to do so through the open question at the end of the survey.

In terms of *network typology*, Woerden's shift to a DRT system means that it is now possible to travel directly to and from each stop, which was not the case in the old FRT system, or in Weert's current FRT system. This makes it interesting to examine which trips in Woerden could already be made in the old network, which was relatively comparable to the current network in Weert, and which were made possible by the new system, which offers connections between each and every stop. To this end, each trip made with SyntusFlex in March 2024 has been categorized accordingly. The results are shown in Table 4. As this table shows, roughly three-quarters of trips could also have been directly made in the old network. However, about one quarter of trips would not have been possible in the old network, at least not as a direct trip. Only after the introduction of the DRT system, it became possible to make these trips directly.

Table 4

Trips made with SyntusFlex (Woerden) in March 2024 that would / would not have been possible in Woerden's old FRT system.

Trip characterization	**Trips in March 2024**	
Trip would have been possible in old network	1267	74.4 %
Trip would not have been possible in old network	437	25.6 %
Total	**1704**	**100,0 %**

In order to better understand the added value of this change in *network typology*, it is worth looking in further detail at the quarter of trips that have been made possible by that change. The analysis of these trips, shown in Table 5, shows that the trips that would have been possible in the old FRT system are predominantly trips between neighbourhoods and the railway station, while most trips that were not possible in the old system are directly between neighbourhoods. In the latter category trips between neighbourhoods and the railway station still make up a significant share. These are trips between the railway station and stops that did not exist in the old network. Among trips that would not have been possible in the old network, there is also a relatively high share of trips going to the hospital, and a relatively low share to the city centre. It transpires, then, that the opportunities offered by the new system are used disproportionately for trips between neighbourhoods, and to a lesser extent between neighbourhoods and the hospital, although trips between the station and newly added stops also make up a significant portion.

Table 5

Specification of types of trips made with SyntusFlex (Woerden) in March 2024 that would / would not have been possible in Woerden's old FRT system.

Trip would have been possible in old network	Trips in March 2024		Trip would not have been possible in old network	Trips in March 2024	
Neighbourh. <> Railway st.	993	78.4%	Neighbourh. <> Railway st.	165	37.8%
Neighbourh. <> Neighbourh.	117	9.2%	Neighbourh. <> Neighbourh.	220	50.3%
Neighbourh. <> City Centre	112	8.8%	Neighbourh. <> City Centre	14	3.2%
Neighbourh. <> Hospital	42	3.3%	Neighbourh. <> Hospital	38	8.7%
Station <> City Centre	2	0.2%	Station <> City Centre	-	- %
Station <> Hospital	1	0.1%	Station <> Hospital	-	- %
City Centre <> Hospital	-	- %	City Centre <> Hospital	-	- %
Total	**1267**	**100.0%**	**Total**	**437**	**100.0%**

As mentioned previously, the change in *network typology* has also allowed for a change in the *boarding and alighting locations* in Woerden, with more stops being added. Figures 14 and 15 [7] show the areas in Weert and Woerden that lie within 400 metres of a bus stop, the typical benchmark for the preferred maximum distance to a bus stop in The Netherlands (Kampert et al., 2019). In Woerden, a distinction is made between the areas that were already within 400 metres of a bus stop when it still had an FRT system like Weert, and the areas for which this only applies since the introduction of the SyntusFlex DRT system. This clearly shows that the introduction of a DRT system has significantly increased the amount of people that have a bus stop near their house. More specifically, the number of addresses that has access to a bus stop within 400 metres has increased from 57.7 percent in the old system to 85.7 percent in the new system. In Weert, which still has an FRT system, this figure sits at 68.9 percent. Although the newly added stops have thus had a significant impact on the service area of the local public transport system in Woerden, the number of people using these new stops varies. Figure 16 [7] shows that the three best-performing new stops are situated in the west of the city. These are all stops that were added in neighbourhoods that were already served by the old FRT system, but in parts of those neighbourhoods where walking distances previously exceeded 400 metres. There are also three somewhat well-used stops in the south of the city, located in the previously unserved industrial area Bedrijventerrein Polanen. All other new stops were hardly used in March 2024. These are predominantly stops that were added in residential neighbourhoods that had no bus service before, like Snel en Polanen and Vogelkwartier. So, while the newly added stops in industrial areas and in neighbourhoods that were already served by local public transport see significant usership, it appears this is not the case for stops connecting new neighbourhoods to the system.

These findings are in line with those presented in Table 6, which shows that there is little difference in the distribution of trips throughout the city in the FRT system of Weert and the DRT system of Woerden. The share of trips to and from the railway station is similar, and both cities have one neighbourhood which sees significantly higher usage. In both cases, this is the neighbourhood situated furthest from the railway station, city centre and hospital. On the other hand, both systems also have three neighbourhoods which see little to no use of the local public transport system at all, in spite of them not being served by any other form of public transport. In Weert's FRT system, these neighbourhoods are not served by local public transport either, making the fact that they are not used rather obvious. However, in spite of the fact that in Woerden, every neighbourhood receives local public transport, this

[7] Figures 14, 15 and 16 can be found in Appendix B.

city still has three neighbourhoods where the system is hardly used. It is also worth looking specifically at the neighbourhoods which have been sampled for the survey. These have been highlighted in Table 6. They were selected because, theoretically, they benefit the most and the least from each transport system. Even though Molenvliet-West benefits the least from the DRT system, as it was best served by Woerden's old FRT system, over a quarter of trips is made to and from this neighbourhood. This is similar to the share of trips made to and from Boshoven-Vrakker in Weert, which benefits most from its still-in-place FRT system. Naturally, the number of trips to and from Graswinkel in Weert is 0, as it is not currently served by the FRT system. However, the number of trips to and from Snel en Polanen in Woerden is only marginally higher, with a mere 16 trips made in all of March 2024. This means that the number of trips to and from Molenvliet-West is 57,6 times higher than in Snel en Polanen, in spite of the fact that both neighbourhoods have a similar number of residents and receive the same level of service under the DRT system. To compare, an old FRT bus line through Snel en Polanen that was scrapped in 2011 averaged 29 trips each workday (ROCOV Utrecht, 2010).[8]

Table 6

Number of trips made to and from each neighbourhood in Weert in November 2023, and in Woerden in March 2024.

Neighbourhoods of Weert	**Passengers in November 2023**		**Neighbourhoods of Woerden**	**Passengers in March 2024**	
Railway station*	3446	38.1%	Railway station	1161	34.1%
Boshoven-Vrakker	**2491**	**27.5%**	**Molenvliet-West**	**922**	**27.1%**
Leuken	703	7.8%	Schilderskwartier	408	12.0%
Weert-Centrum*	623	6.9%	Molenvliet-Oost	203	6.0%
Maaspoort*	577	6.4%	Middelland-Noord*	150	4.4%
Centrum-Noord	438	4.8%	Binnenstad	127	3.7%
Groenewoud-Zuid*	207	2.3%	Bloemen- & Bomenkwartier	114	3.3%
Molenakker	180	2.0%	Bedrijventerrein Polanen	111	3.3%
Keent	166	1.8%	Middelland-Zuid	108	3.2%
Laarveld	126	1.4%	Staatsliedenkwartier*	55	1.6%
Biest*	97	1.1%	Waterrijk	24	0.7%
Groenewoud-Noord*	-	- %	**Snel en Polanen**	**16**	**0.5%**
Industrieterrein Leuken*	-	- %	Vogelkwartier	9	0.3%
Industrieterrein Boshoven*	-	- %			
Kampershoek*	-	- %			
Moesel*	-	- %			
Kazernelaan*	-	- %			
Graswinkel	**-**	**- %**			
Fatima	-	- %			
Industrieterrein Fatima	-	- %			
Total	**3408**	**100.0%**	**Total**	**9054**	**100.0%**

***** *Neighbourhood has at least one rural bus line running through it that sees at least an hourly service on weekdays during the day.*

[8] This data was not part of the data collection specified in Chapter 3, but this particular number happened to be mentioned in a publicly available document.

Whereas the *network topology* and *boarding and alighting locations* are theoretically aspects which show the benefits of a DRT system over an FRT system, the *schedule* and *advance notice requirement* are aspects where an FRT system is theoretically more advantageous. Although there is no real performance element to these aspects –a bus either departs at a fixed time or it does not, and there either is an advance notice requirement, or there is not – it is interesting to look at the total number of users of each system. As can be seen at the bottom of Table 6, the total number of trips made with the system in Weert is 2.7 times higher than in Woerden.[9] The lower number of trips in Woerden will not be caused by users not having to transfer there or by the fact that more stops have been added, making it more likely that the flexible *schedule* and/or the *advance notice requirement* have a significant impact on the lower usage of the system in Woerden. This particularly applies to the *advance notice requirement*, which as previously mentioned received the most (41) comments from survey respondents out of any aspect, predominantly negative ones. The flexible *schedule* also garnered some negative comments, albeit considerably less than the *advance notice requirement* (6). However, it is also possible that there are other aspects that influence this difference, and at least one such potential aspect emerges from the open question in the survey. This is the aspect of *reliability,* which was the second-most named aspect after the *advance notice requirement.* All 28 of these comments were negative, and again, most (24) came from Woerden. The main concerns are buses not showing up or buses not being available for booking at the desired time. A respondent from Molenvliet-West (male, 38) says of SyntusFlex: "It's a good idea, to be able to book a bus in advance, but it doesn't work in practice. Buses don't show up and bookings sometimes don't go through." Another concern is the punctuality of the vehicles. For instance, a respondent from Snel en Polanen (male, 49) complains that buses are "difficult to book, and subsequently arrive way too early or late, but never on the right time." There were also 4 comments from Weert on the issue of *reliability*, all concerning people being left behind at stops due to capacity constraints. A woman (70) from Boshoven-Vrakker explains: "Sometimes the bus is full, and you are not allowed on. You don't know that in advance, which is unpleasant." Another respondent (22) indicates that they experiencing this frequently, and calls this "unacceptable." This is supported by the data on bus occupancy, also provided by the operator in Weert. Table 7 shows the occupancy rate of the busiest trip for each line in the 80th percentile, providing a good insight into occupancy on a regular busy day. Particularly bus line 1, which runs in Boshoven-Vrakker, is operating at or even over capacity.

Table 7

Occupancy rates of the different bus lines in Weert's FRT system in November 2023.

Bus line and direction	Occupancy in the 80th percentile of the busiest trip
1 towards Railway Station	112.5%
1 towards Boshoven	97.5 %
2 towards Railway Station	50.0 %
2 towards Laar	62.5 %
3 towards Railway Station	50.0 %
3 towards Leuken	75.0 %
4 towards Railway Station	37.5 %
4 towards Altweerterheide	62.5 %

[9] It is important to re-iterate that there is also a limited FRT local public transport service running in Woerden during rush hour. The difference between Weert and Woerden is of such magnitude however, that the unknown number of passengers for the rush hour service is unlikely to completely annihilate it.

Judging by the comments, particularly the system in Woerden seems to have *reliability* issues. However, there were also a few positive comments. These concerned the introduction of a new SyntusFlex app, which replaced the old one in July, just after the survey collection started. While 11 people commented negatively on the old app, there were also 2 comments indicating that *reliability* had improved with the new app. One respondent from Molenvliet-West (male, 23) said that with the old app "you would book a ride and have a 50/50 percent chance of whether it'd arrive to pick you up or not." He adds that "SyntusFlex nowadays works significantly better", although he uses some expletive language indicating that he would still strongly prefer a regular bus line.

4.2 The land-use component

The previous section on the mobility component described the differences in how the respective systems work and how they transport people. These differences have an impact on the land-use component of transport: the places people can access by using it. In theory, any stop on the network can usually be accessed from any other stop eventually, but that does not necessarily mean that this journey is easy or convenient. Given the scope of the respective cities, the focus for this research lies on the number of locations that can be reached with one single trip.

4.2.1 Introducing the land-use component of the current local public transport systems in Weert and Woerden

The differences in the mobility component of the local public transport systems of Weert and Woerden have an impact on which locations can and cannot be accessed directly. Due to the flexible *network component* of the DRT system in Woerden, this system provides direct access to any other location in the city, provided a stop is present. The same does not apply to the city bus system of Weert, as there are four separate bus lines running to and from the railway station. However, as Figure 9 [10] shows, the three local bus lines running to the north of the city do pass the city centre (where the town hall is also situated) and the hospital on their route. The final line, which runs from the south, is always operationally linked to another bus line, meaning it also provides direct access to these locations. Direct trips between residential neighbourhoods or to other significant destinations in the city, however, are only possible if those destinations happen to be on the same line. Transferring to other lines is possible at the railway station, but a quick study of the timetable (Arriva Limburg, 2024) reveals that the arrival and departure times do not align well with such transfers. In using and observing the city bus network of Weert for the duration of this research, I found that bus lines 2, 3 and 4 are all operated by one single vehicle, which explains why their arrival and departure times aren't synchronised to allow for easy transfers. Overall, the setup in Weert is comparable to the old FRT system in Woerden (see Figure 10 [10]), which also featured bus lines that provided the neighbourhoods it served with direct access to the railway station, the city centre, the town hall and the hospital.

4.2.2 Analysing respondents' preferences on the land-use component of local public transport systems

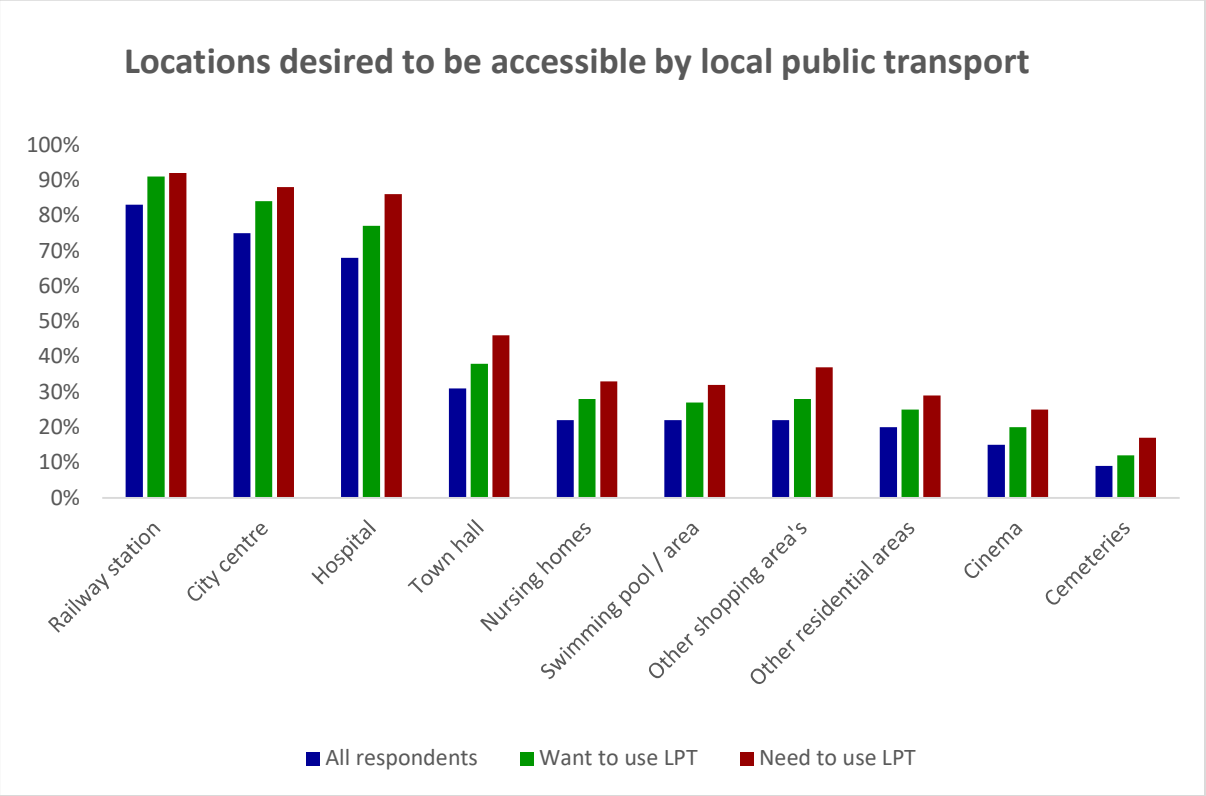
Respondents to the survey were asked what locations in their respective cities they would like to be able to access with local public transport. The results in Figure 17 show that these locations can be divided into major and minor locations, with access to the railway station, city centre and hospital all

[10] Figures 9 and 10 can be found in Appendix B.

scoring comparably high, and all the other locations scoring comparably low. It is also worth noting that this pattern is generally consistent among the three distinguished groups: all respondents, respondents who indicate they want to use local public transport, and respondents who indicate they need to use local public transport. There is a slightly larger share of people who need to use local public transport that would like to access each location, but the differences seem to be marginal. Overall, it appears that this group does not desire access to more or different locations than others. Instead, their preferences seem to align largely with those of all respondents as a whole. Possible exceptions are access to the town hall and to other shopping areas outside of the city centre, where the difference between all respondents and those who need to use local public transport is slightly bigger. There were no comments in the surveys on the land-use component.

Figure 17

Locations survey respondents would like to be able to access by local public transport (LPT).



All respondents: N = 603; want to use LPT: N = 345; need to use LPT: N = 127.

4.2.3 Analysing the performance in the land-use component of the local public transport systems in Weert and Woerden

With the survey data having provided insight into what locations the residents of Weert and Woerden would like their local public transport system to provide access to, the available usership data make it possible to analyse what locations the local public transport systems are actually used for to access. Table 8 shows a summary of what locations people travelled to and from in the respective systems.

Table 8

Number of trips made in Weert in November 2023, and in Woerden in March 2024, split out by trip type.

Trip types in Weert*	Number of trips November 2023		Trip types in Woerden	Number of trips March 2024	
Neighbourh. <> Railway st.	3122	71.5%	Neighbourh. <> Railway st.	1159	68.0%
Neighbourh. <> Neighbourh.	52	1.2%	Neighbourh. <> Neighbourh.	337	19.8%
Neighbourh. <> City centre	537	12.3%	Neighbourh. <> City centre	126	7.4%
Neighbourh. <> Hospital	479	11.0%	Neighbourh. <> Hospital	79	4.6%
Hospital <> Railway st.	89	2.0%	Hospital <> Railway st.	2	0.1%
Hospital <> City centre	9	0.2%	Hospital <> City centre	1	0.1%
City centre <> Railway st.	77	1.8%	City centre <> Railway st.	-	- %
Total	**1704**	**100.0%**	**Total**	**4365**	**100.0%**

**These data do not include bus line 4, as while it does not serve the city centre and hospital directly, passengers could stay in same the bus to reach them. It is not possible to say how many do so.*

It is not possible to have the table show all the distinctions that were made in the survey, as for instance the bus stop next to the cinema in Woerden is also serving other amenities, making it unclear whether people using the stop actually used it to get to the cinema. The stops serving the railway station, city centre and hospital – the locations classified as 'major' based on the results from the survey – can, however, be clearly distinguished. This makes it possible to analyse how many trips were made to and from each of these locations. All other stops have been classified as 'neighbourhood', as it is not possible to deduct from the usership data of the stop whether people were for instance travelling to a home or a local shopping centre. As Table 8 shows, there is a clear difference in the types of trips that are made in each system. In both systems, the number of trips to and from the railway station is roughly equal, accounting for about two-thirds of all trips. However, the FRT system in Weert is used more for trips between neighbourhoods and the city centre and hospital than the DRT system in Woerden. On the other hand, the FRT system in Weert is hardly used at all for trips between neighbourhoods, accounting for only 1 percent of all trips, compared to 20 percent of all trips in Woerden's DRT system. In short, the DRT system seems to be a less attractive option for those wishing to travel between neighbourhoods and the city centre or hospital, while a relatively large share of travellers makes use of the increased opportunities it offers for direct trips between different neighbourhoods.

The apparent significance of 'neighbourhood-to-neighbourhood' trips in Woerden's DRT system merits a further examination of these trips. Table 9 shows for each neighbourhood of Woerden what share of all trips and what share of neighbourhood-to-neighbourhood trips that was made to and from that neighbourhood. It then compares the two by means of the difference in percentage points. Compared to all trips, the neighbourhood-to-neighbourhood trips are notably more evenly distributed over the city. Almost half of all trips were made to or from Molenvliet-West, but this applies only to about one in six neighbourhood-to-neighbourhood trips. On the other side of the equation are Middelland-Noord, Middelland-Zuid and Bedrijventerrein Polanen, which together account for 14.0 percent of all trips, but for 34.5 percent of neighbourhood-to-neighbourhood trips. These three neighbourhoods are the only ones in Woerden which consist predominantly of industrial areas, while all other neighbourhoods are predominantly residential. Thus, it appears that people travelling to and from local industrial areas are a considerable driving force behind the high share of neighbourhood-to-neighbourhood trips in Woerden.

Table 9
Comparison of the total number of trips and the number of neighbourhood-to-neighbourhood trips made to and from each neighbourhood of Woerden in March 2024.

Neighbourhoods of Woerden	All trips March 2024		Neighbourhood-to-neighbourhood trips March 2024		Difference
Molenvliet-West	922	45.2%	119	17.7%	-27,6 pp
Schilderskwartier	408	20.0%	134	19.9%	-0,1 pp
Molenvliet-Oost	203	10.0%	60	8.9%	-1,1 pp
Bloemen- & Bomenkwartier	114	5.6%	51	7.6%	2.0 pp
Bedrijventerrein Polanen	111	5.4%	95	14.1%	8.6 pp
Middelland-Zuid	108	5.3%	71	10.5%	5.2 pp
Middelland-Noord (excl. the hospital)	68	3.3%	67	9.9%	6.6 pp
Staatsliedenkwartier*	55	2.7%	48	7.1%	4.4 pp
Waterrijk	24	1.2%	9	1.3%	0.2 pp
Snel en Polanen	16	0.8%	13	1.9%	1.1 pp
Vogelkwartier	9	0.4%	7	1.0%	0.6 pp
Total	**2038**	**100.0%**	**674**	**100.0%**	

***** *Neighbourhood has at least one rural bus line running through it that offers at least an hourly service on weekdays during the day.*

4.3 The temporal component

Discussing the mobility and land-use components of the transport systems of Weert and Woerden has provided insight into *how* the respective systems transport people, and *where* they transport them to. The temporal component focuses on *when* people travel and how long it takes them. As has been discussed in Chapter 2, the focus for this research lies on the following two aspects of the temporal component:

- **operating hours:** the times at which a transport systems operates, which could be easier to do efficiently during quieter hours with a DRT system, whilst it might be more difficult to provide a DRT system efficiently during the busiest hours of the day;
- **waiting time:** how long users have to wait for a bus to arrive, which depends on the frequency in an FRT system, and on how quickly a bus arrives after booking in a DRT system.

4.3.1 Introducing the temporal component of the current local public transport systems in Weert and Woerden

The operating hours of the systems in Weert and Woerden are similar for most of the week, with three exceptions, as Table 10 shows. First, Weert's FRT system runs during the morning rush hour on weekdays, whereas Woerden's DRT system does not. It should be noted that two FRT lines provide a replacement for some, but not all trips that can be made with Woerden's DRT system during these hours. On the other hand, operation in Weert ceases after 21:30, whereas in Woerden buses run until 00:00. The final clear difference is that only a part of Weert's FRT system operates on Sundays, while Woerden's FRT system is fully operational all days of the week.

Table 10

Operating hours for the local public transport systems in Weert and Woerden in 2024 (Arriva Limburg, 2024; Syntus Utrecht, n.d.).

	Operating hours																	
	6:30 to 7:30	7:30 to 8:30	8:30 to 9:30	9:30 to 10:30	10:30 to 11:30	11:30 to 12:30	12:30 to 13:30	13:30 to 14:30	14:30 to 15:30	15:30 to 16:30	16:30 to 17:30	17:30 to 18:30	18:30 to 19:30	19:30 to 20:30	20:30 to 21:30	21:30 to 22:30	22:30 to 23:30	23:30 to 00:30
Weekdays																		
Weert																		
Woerden																		
Saturdays																		
Weert																		
Woerden																		
Sundays																		
Weert*																		
Woerden																		

**only bus line 1 runs on Sundays.*

The frequencies of the FRT system in Weert can be derived from the 2024 timetable (Arriva Limburg, 2024), and are consistent across all operating hours, with buses always running every 30 minutes on bus line 1, and every 60 minutes on bus lines 2, 3 and 4. This results in an average waiting time of 15 minutes for line 1, and an average waiting time of 30 minutes for lines 2, 3 and 4. The waiting times of a DRT system are more difficult to establish as they are different for every trip. However, through extensive use of the SyntusFlex v2 app, which was introduced on July 1st, 2024 (Syntus Utrecht, 2024), I was able to determine the parameters within which the system operates. It transpired that vehicles have to be booked at least 30 minutes in advance. There are two possible departure times an hour, and there is a 10-minute margin for the departure time. This means that, from the moment of booking, buses can take between 30 and 70 minutes to arrive, making for an average waiting time of 50 minutes. However, trips can also be booked further in advance. When not taking into account the 30 minutes the bus has to be booked in advance, the waiting time is 0 to 40 minutes, or 20 minutes on average. This information is summarized in Table 11.

Table 11

The minimum, maximum and average waiting times for the local public transport systems in Weert and Woerden from July 1st, 2024.

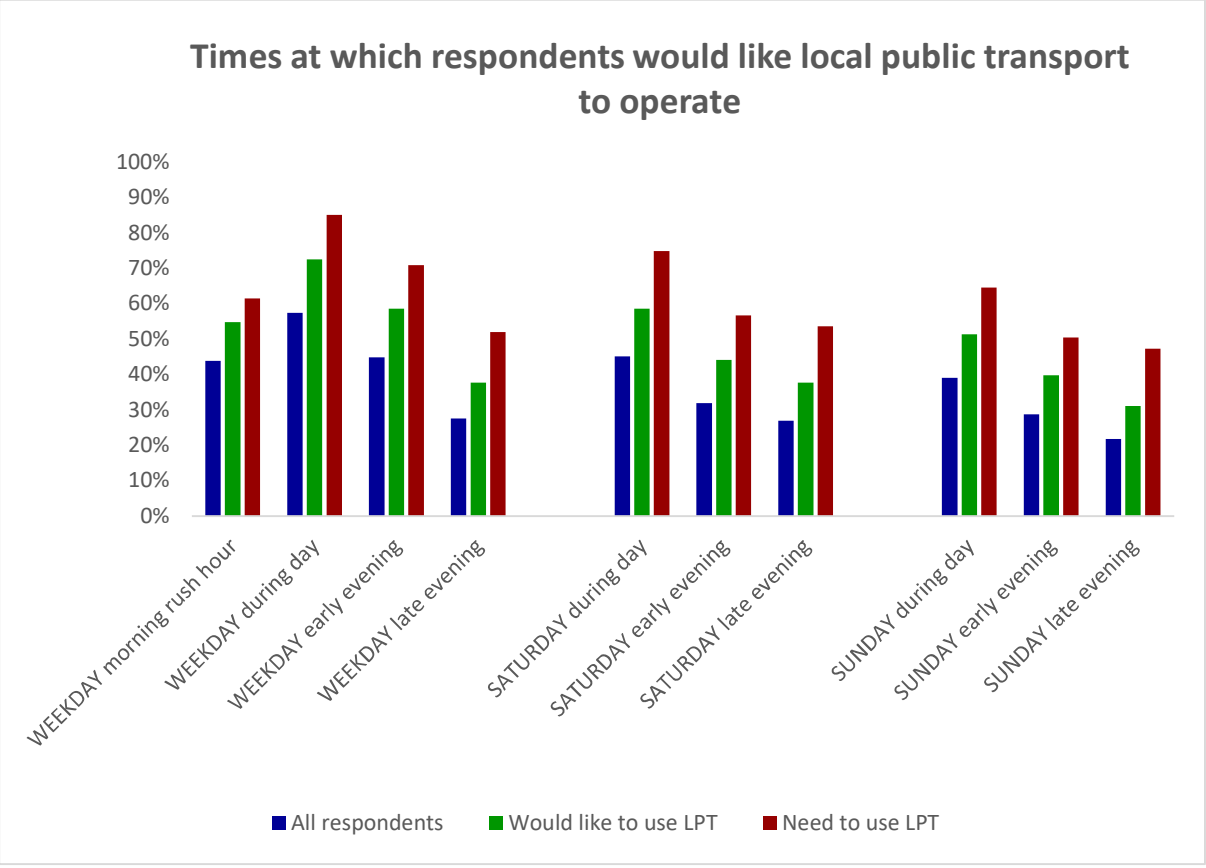
Local public transport network	**Minimum waiting time**	**Maximum waiting time**	**Average waiting time**
Weert *Bus line 1*	0 minutes	30 minutes	15 minutes
Weert *Bus lines 2, 3 and 4*	0 minutes	60 minutes	30 minutes
Woerden *Counting having to book 30 minutes in advance*	30 minutes	70 minutes	50 minutes
Woerden *Not counting having to book 30 minutes in advance*	0 minutes	40 minutes	20 minutes

4.3.2 Analysing respondents' preferences on the temporal component of local public transport systems

For the temporal component, respondents were asked to indicate at what times they would like local public transport to be available, as well as what maximum waiting time they would find acceptable. As for the times at which respondents want local public transport to be available, Figure 18 shows that – just as with the landscape component – there are no large differences between the preference of all respondents, those who want to use local public transport and those who need to use local public transport. Among all three groups, the time most respondents want local public transport to be available is during the day on weekdays, closely followed by during the day on Saturdays and Sundays and the morning rush hour on weekdays. When trying to distinguish between the three different groups of respondents, only the morning rush hour stands out. Here, the difference between all respondents and those who want and need to use local public transport is smaller, meaning its importance is relatively lower among respondents in these latter groups, and relatively higher among respondents in the first group. The most interesting finding from this survey question, however, is the fact that there are no really low scores among respondents who need to use local public transport. At least 50 percent of respondents in this group would like it to be available at all given times, expect for late evenings on Sundays.

Figure 18

Importance attributed to different aspects of the mobility component by survey respondents (LPT = local public transport).

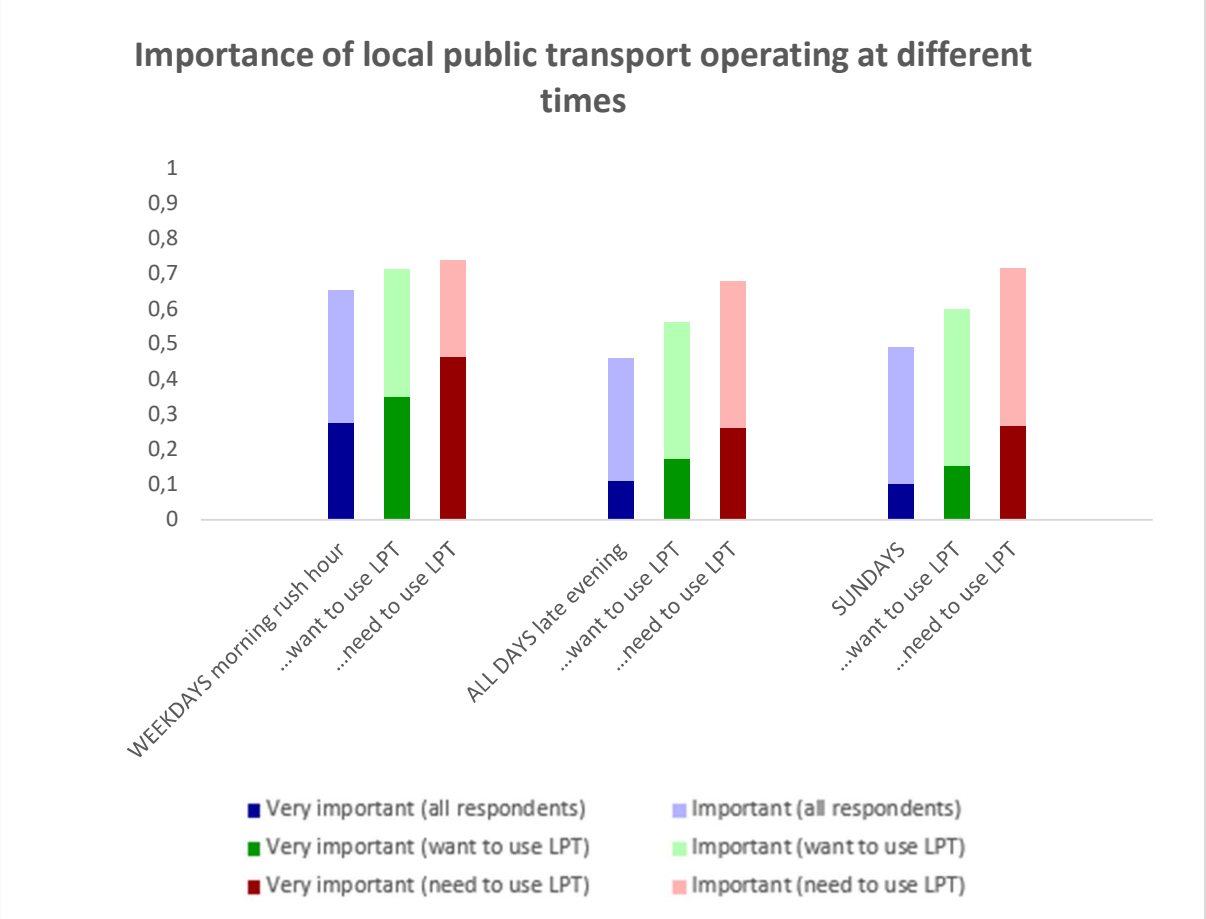


All respondents: N = 603; want to use LPT: N = 345; need to use LPT: N = 127.

As mentioned, the key differences between the operating hours of the DRT system in Woerden and the FRT system in Weert are that the former does not operate during the morning rush hour, while the latter does not operate during the late evenings and only partially on Sundays. Respondents were also asked specifically how important the availability of local public transport is for them at each of these three times, the results of which are shown in Figure 19. Among all groups of respondents, including those indicating they need public transport, the availability of the system during the morning rush hour is seemingly more important than during the late evenings and on Sundays. In particular, the share of respondents ranking the availability of local public transport during the morning rush hour as *very important* is at least twice as high as for availability during late evenings and on Sundays, among all groups of respondents. It should be noted, however, that there is still a significant group for whom availability during the late evenings and on Sundays is important as well, as is illustrated by the comments in the open question of the survey. There were 4 respondents from Boshoven-Vrakker who specifically indicated that they see the lack of late-night bus service as a shortcoming of the system, with one woman (64) adding that service during this time would "hopefully persuade people who are drunk to take the bus." There was also 1 respondent from Snel en Polanen who reported missing the bus service during the morning rush hour.

Figure 19

Importance attributed by survey respondents to local public transport (LPT) operating during the morning rush hour, on late evenings and on Sundays.

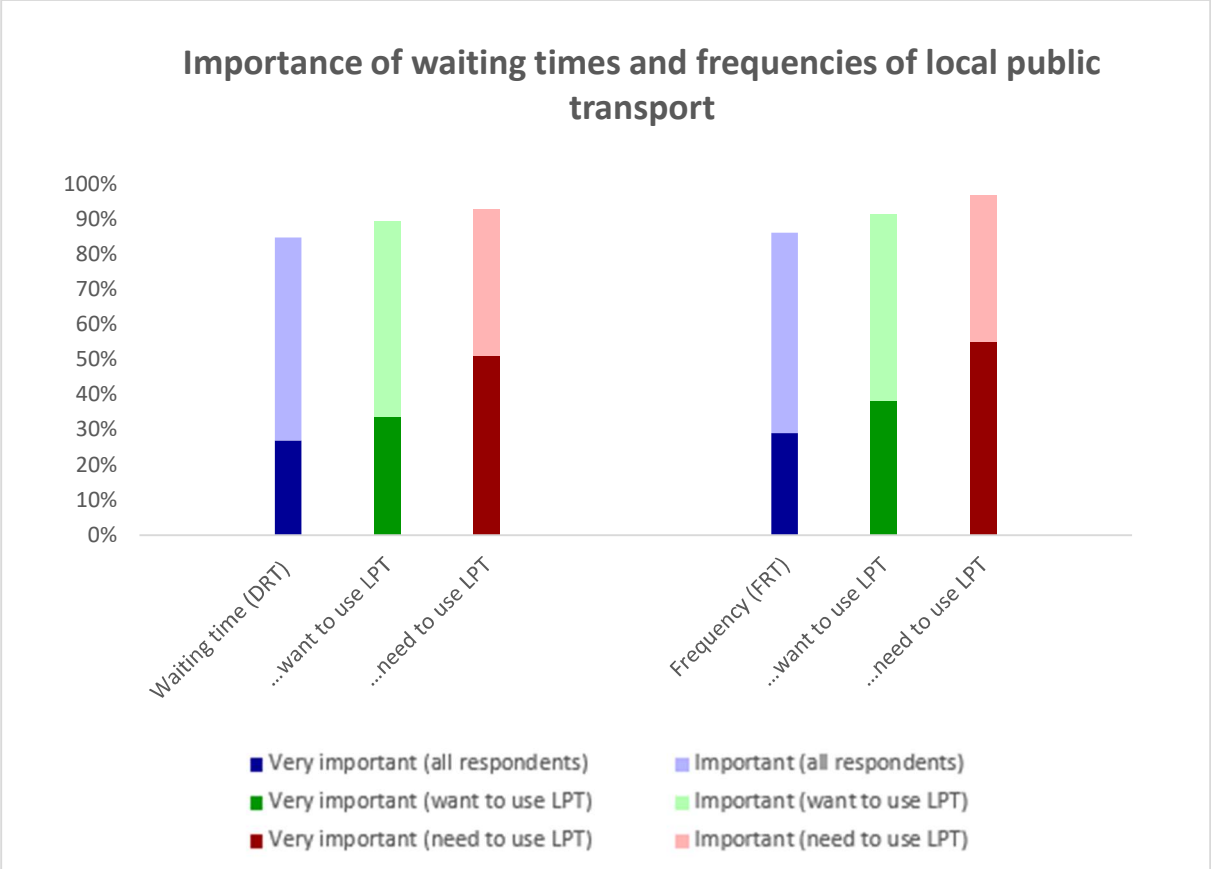


All respondents: N = 603; want to use LPT: N = 345; need to use LPT: N = 127.

The other aspect studied in the temporal component is waiting time. Figure 20 shows the importance of this aspect, displaying a pattern that very closely follows that of the aspects in the mobility component. Waiting time and frequency, which determines waiting time in an FRT system, are seen as important by over 80 percent of respondents, and by over 90 percent of those who need to use local public transport. In the latter group, more than half of respondents mark waiting time and frequency as *very important*. Respondents were also asked what they think is the maximum amount of time it should take a bus to arrive after being booked in a DRT system, and what they think the minimum frequency should be for a bus in an FRT system. The preferences for each system are remarkably similar, with people on average wanting a bus to depart at least every 31 minutes on a schedule, or at most 27 minutes after booking. It thus appears that the expectations people have from a local public transport system on this front are consistent, regardless of whether it is a DRT system or an FRT system.

Figure 20

Importance attributed by survey respondents to the waiting time after booking in a DRT system and to the frequency in an FRT system (LPT = local public transport).



All respondents: N = 603; want to use LPT: N = 345; need to use LPT: N = 127.

4.3.3 Analysing the performance in the temporal component of the local public transport systems in Weert and Woerden

An analysis of the available usership data provides insight into implications of the differences between the respective systems in the temporal component. The impact of the diverging *operating hours* can be analysed by looking at the number of people who use the respective services during the different

times of the day. Unfortunately, while this information is available for Woerden, it is not (directly) available for Weert. What is available, however, is the occupancy rate of each vehicle in the 80th percentile, which shall be used to fill this gap. Although occupancy rate is not equal to the number of passengers, the very limited number of neighbourhood-to-neighbourhood trips on the one hand, and equally limited trips between the railway station, hospital and city centre on the other means that the *maximum* occupancy rate during a trip should approach the total number of passengers on that trip. Hence, Table 12 shows the average number of trips during each part of the day in Woerden's DRT system, and the average maximum occupancy rate during each part of the day for the FRT system in Weert. Because the occupancy is derived from the usership in the 80th percentile, which is above average, the proportional differences within each system have been calculated. This allows for an accurate comparison between the systems. Albeit derived from two different types of datasets, the data presented in Table 12 provide an interesting insight into the use of the respective systems during different times of the day. During times when both systems operate it is noteworthy that trips are spread more evenly throughout the day in Woerden than in Weert. Thus, the use of the system in the early evening is relatively higher in Woerden than in Weert when compared to during the day. It is important to note that the total number of trips in the early evening in Weert could still be as high as or higher than in Woerden, given the stark difference in the overall number of trips discussed in Subsection 4.2.3. It is also interesting to examine the usership of each system during times when that system operates while the other system does not. During the morning rush hour, when Woerden's DRT system does not run,[11] the average maximum occupancy rate in Weert's FRT system is almost equal to what it is during the day. In the late evenings, when the system in Weert does not run, the average number of trips each hour in Woerden sits at two-thirds of the number during the day, but is almost equal to usership during the early evenings. Data for Sundays, when parts of the FRT system in Weert are not operational, are not available.

Table 12

Local public transport usership during different times of the day in Weert in November 2023 and in Woerden in March 2024.

	Weert		**Woerden**	
	Average maximum occupancy rate in November 2024	**Proportion to "during the day" in %**	**Average number of trips per hour in March 2024**	**Proportion to "during the day" in %**
Morning rush hour (6:30-8:30)	2.7	95.0%	N/A	N/A
During the day (8:30-18:00)	2.8	100.0%	5.8	100.0%
Early evenings (18:00-22:00)	1.2	43.2%	4.5	76.3%
Late evenings (22:00-00:00)	N/A	N/A	3.8	65.9%

[11] In discussing the morning rush hour, it remains important to reiterate that in Woerden, FRT lines do offer a replacement for parts of the DRT system during that time. The DRT system itself does not run, however.

Analysing the performance on *waiting time* in each of the respective systems is more challenging. In Weert's FRT system, the frequency is given in a pre-published timetable. The capacity issues that came to light in Subsection 4.1.3 could result in an increase in the actual *waiting time* for users of the system, but there is no data available for this. The same lack of data applies in Woerden. As discussed in Subsection 4.3.1, the *waiting time* ought to be between 30 and 60 minutes after booking, but data for the actual waiting times are not available. However, the open survey question offers an indication of how the DRT system is performing on this aspect. A respondent from Molenvliet-West indicated frequently having to wait longer than the maximum 60 minutes after booking. However, another comment hinted at improved waiting times since the introduction of the new app. This ties in with the findings of a respondent (male, 44) from Snel en Polanen who is also a member of the Dutch passenger association ROVER. He has sampled the waiting times for SyntusFlex after booking for several months, and explains that while he found no change in the average waiting time, the waiting time did become more predictable. Before July 1st, when the new app was introduced, he observed waiting times usually ranging from 0 to 90 minutes, and some instances of waiting times of over 120 minutes. After July 1st, however, the waiting time was between 30 and 60 minutes in almost all instances. This might be an indicator that the introduction of the new app resulted in both more consistent waiting times and fewer excessively long waiting times.

4.4 The individual component

The previous sections have covered the how, where and when of the transport systems. With the individual component, the focus shifts to *who* the local public transport system is for. As discussed in Chapters 2 and 3, this research centres specifically on systems with lower usership. This makes it difficult to focus solely on those who actually use the local public transport system. Instead, this study distinguishes three different groups: all respondents, those who indicate they want to use local public transport, and those who need to use local public transport. Based on Subsection 2.1.3, people who fall into the following demographic categories are more likely to belong to this latter group:

- **Young people**
- **Elderly people**
- **Female people**
- **People with a migration background**
- **People with a lower income**
- **People without access to a car**
- **People who need travel aids**

The setup for this section deviates from the sections discussing the other components. Introducing the individual component of the local public transport systems of Weert and Woerden is redundant, since anybody can use them. Furthermore, analysing the performance of the systems is not possible, as there is no secondary data available on the individual characteristics of those using the respective systems. As a result, the analysis of the individual component will rely solely on the survey responses.

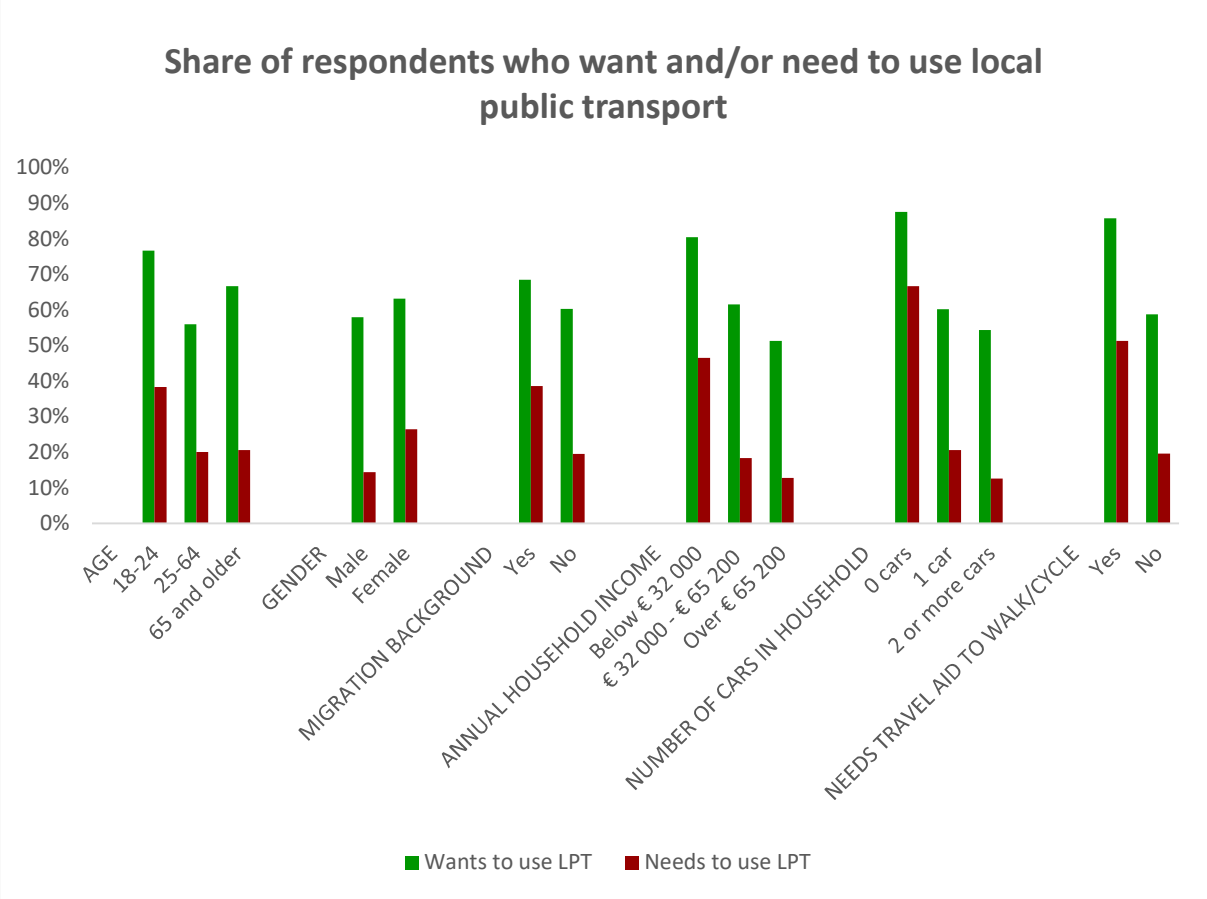
4.4.1 Analysing which respondents indicate that they want or need to use local public transport

Figure 21 shows, for each of the seven aforementioned demographic categories, the share of respondents that indicate they want and/or need to use local public transport. Six out of seven categories do indeed have an above-average share of respondents indicating this: people below the

age of 25, female people, people with a migration background, people with an annual household income below € 32,000 ,[12] people in households without a car and people who need travel aids to walk and/or cycle. Elderly people (age 65 and over) form the only exception. While there are relatively more elderly respondents who indicate they want to use local public transport, the share of elderly respondents who indicate they need to use it equals that of the age group 25-64. The category that sees the highest share of respondents indicating that they both want to and need to use local public transport is that of people in households without a car. Almost 90 percent of them indicate that they want to use local public transport, and two-thirds indicate that they need to. The categories of people who need travel aids to walk and/or cycle, have a lower household income, or are younger than 25, also have a considerably higher share of respondents indicating that they want to or need to use local public transport. In the categories of people who are female, or who have a migration background, the difference is more modest.

Figure 21

Share of survey respondents who indicate that they want and/or need to use local public transport (LPT), split out by demographic category.



Age: N = 553; gender: N = 585 [13]; migration background: N = 583; annual household income: N = 373; number of cars in household: N = 574; needs travel aid to walk/cycle: N = 587.

[12] It should be noted that the question on household income had a response rate of only about 60 percent.

[13] In addition to the 585 respondents who identified as either 'male' or 'female', 2 respondents selected 'other'. This category is excluded from Figure 21 due to its lack of statistical significance.

The responses to the open question in the survey offer an interesting insight into which demographic groups are *perceived* to have an increased need to use local public transport. Many people clarified that while they do not want or need to use local public transport themselves, they do recognize its importance to other groups of people. Most frequently, 13 times to be specific, these respondents pointed out people who have a mobility impairment and/or need travel aids when walking or cycling. People without access to a car, the group of respondents most likely to report themselves that they need to use local public transport, were mentioned 5 times. Notably, the category of elderly people was brought up 9 times, even though the survey results do not seem to support this. A woman (42) from Molenvliet-West voices her dissatisfaction with the current system by saying: "I mainly find it appalling for elderly people […] you see how the flexbus can result in isolation." Several others share the sentiment of a man (68) from Snel en Polanen who says: "I have no demand for it now, but it is reasonable to expect that to change when I get older." This interesting disparity between perceived demand and reported demand is discussed further in Chapter 5. Another group, not belonging to any of the seven demographic categories included in the survey, was also brought up several times, namely 'people from out of town'. There were 6 comments that a DRT system is or would be particularly difficult for people visiting their city as they are not familiar with it.

Interestingly, the category of people below the age of 25 was not mentioned by any respondent from outside that group. As anticipated, respondents within this category do themselves more frequently indicate that they want or need to use local public transport. In the open question, 6 of them elaborated on their answer, explaining that they usually travel by bike, but need local public transport under specific circumstances. For example, a female respondent (24) from Boshoven-Vrakker says: "I only use the bus when it rains and I need to get to the railway station." Another respondent from (24) from Molenvliet-West explains they need local public transport when travelling back to their parents if "due to circumstances it is less practical to have a bike at the railway station." Two other respondents from other demographic categories mentioned that they also occasionally need local public transport for practical reasons, specifically when carrying heavier loads such as suitcases.

4.4.2 Predicting respondents' likelihood to indicate whether they want or need to use local public transport

In discussing these different demographic groups, it is important to note that some people may belong to more than one of them. For instance, a younger person can also live in a household without a car, and someone with a migration background can also require travel aids for walking or cycling. In order to create more certainty on what factors are actually important, regression analyses have been run to see which of the discussed indicators could predict a higher likelihood of wanting or needing to use local public transport. As has been discussed in Subsection 3.4.1, the indicator of income has not been included in any regression analysis, given the limited number of respondents that answered this question in the survey. Table 13 shows the results for both regression analyses. The regression analysis predicting whether a respondent wants to use local public transport shows some of the six remaining predictors to have predictive value, namely: the respondent being under 25 years old, 65 years or older, not having access to a car and needing a travel aid to walk and/or cycle.[14] The model also has a low predictive value, meaning that these six predictors only contribute a small amount to successfully predicting whether or not someone wants to use local public transport.

[14] It should be noted that while all of these outcomes are significant at the $p < 0.05$ level, none of them are at the significant at the $p < 0.01$ level, meaning the evidence for a causal relationship is not as high as it could be.

Table 13

Regression coefficients for predicting the likelihood that a survey respondent indicates that they want or need to use local public transport (LPT).

Predictor	Want to use LPT (odds ratio)	Need to use LPT (odds ratio)
Respondent is less than 25 years old	2.476*	2.855**
Respondent is 65 years or older	1.735*	1.349
Respondent is female	1.191	2.031**
Respondent has a migration background	1.325	2.627**
Respondent does not have access to a car	3.575*	7.906**
Respondent needs a travel aid to walk/cycle	3.638*	4.178**
Constant	*0.905*	*0.088***
N	493	497
Nagelkerke R^2	0.087	0.212
Model Sig.	<0.001	<0.001

**p < 0.05; **p < 0.01.*

The regression analysis predicting whether respondents to the survey need to use local public transport, which can also be found in Table 13, has a higher predictive value. Five out of six indicators represent an increase in the chance that someone needs to use local public transport.[15] The only indicator that does not represent a significant increase in the chance of a respondent needing to use local public transport is that respondent being older than 65 years old. This matches the finding in Subsection 4.4.1 that it is more likely that respondents of 65 years or older want to use local public transport, but that it is not more likely that they need to. Out of the other five indicators, the two representing the highest chance that a respondent needs to use local public transport are that respondent needing a travel aid to walk and/or cycle and the respondent not having access to a car. The respondent being less than 25 years old, being female, or having a migration background all also increase that chance, albeit to a lesser extent.

4.5 Satisfaction with the current system

The previous four sections give insight into how the respective FRT and DRT systems in Weert and Woerden function, where they provide access to, when they do so, and who wants and/or needs to use them. Together, they compose the first main independent variable in the conceptual framework: transport system components (see Section 2.4). Based on these components, it will be determined in Chapter 5 which of the two system types is better suited for providing equitable local public transport to peri-urban cities in The Netherlands. The respondents themselves, however, were also asked to weigh in on this, and their answers fill in the second main independent variable in the conceptual framework: transport system preferences. The conceptual framework identifies two dimensions to transport system preferences: satisfaction with the system currently in place in their city, and theoretical preference between a DRT system and an FRT system. This section will focus on the satisfaction with the current system.

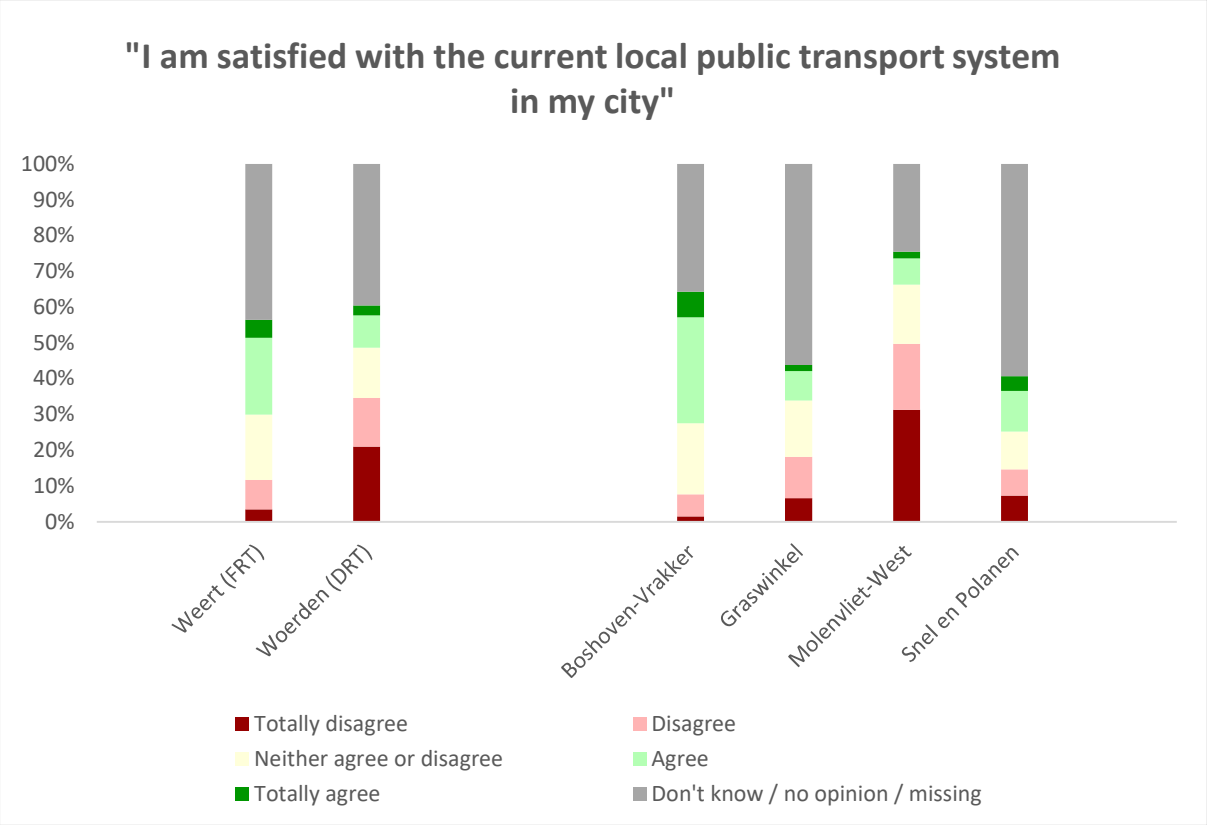
[15] All of these outcomes are significant at the higher p < 0.01 level, indicating a high likelihood of accuracy.

4.5.1 Analysing respondents' satisfaction with the local public transport system currently in place in their city

When aiming to establish people's satisfaction with system currently in place in their city, it is of course essential in which of the two cities they live. Figure 22 shows how many people agree with the statement that they are satisfied with the current local public transport system in their city, both for Weert, which currently has an FRT system, and for Woerden, which has a DRT system. First of all, it must be noted that a large share of respondents to the survey did not indicate any opinion on this issue. When looking at those who did, however, it becomes clear that respondents from Weert are predominantly satisfied, while those from Woerden are predominantly unsatisfied. To be specific, the share of respondents that do not agree with the statement is about 2.5 times higher in Woerden than it is in Weert, and over 5 times higher when looking specifically at those who strongly disagree with it.

Figure 22

Satisfaction of survey respondents with the current local public transport system in their city, split out by city and by surveyed neighbourhood.



N = 603.

However, that does not mean that satisfaction and dissatisfaction are equally distributed throughout each city. As has been detailed in Subsection 3.3.2, the surveys have been conducted in the neighbourhoods that theoretically see the most and the least advantage from the current local public transport system in both cities. Figure 22 also shows the data split out by these neighbourhoods. Here, it becomes apparent that the difference in satisfaction mainly comes down to a difference between Boshoven-Vrakker in Weert and Molenvliet-West in Woerden. In Subsection 3.3.2 it was established

that these two neighbourhoods are of similar size and furthest away from the railway station, city centre and hospital. It was also established that Boshoven-Vrakker benefits most from Weert's FRT system, while Molenvliet-West benefits least from Woerden's DRT system. This is clearly reflected in the satisfaction figures, as the number of respondents who indicate that they are not satisfied with the current system is over 5 times higher in Molenvliet-West than in Boshoven-Vrakker. This goes up to 17 times when looking only at those who answered 'strongly disagree'. Remarkably, the reverse does not seem to apply when comparing Graswinkel in Weert and Snel en Polanen in Woerden. These are both neighbourhoods which are situated closer to the railway station, city centre and hospital. But even though Snel en Polanen does currently receive local public transport service and Graswinkel does not, there does not appear to be a large difference in either satisfaction or dissatisfaction. The number of respondents who indicate that they are unsatisfied with the current local public transport system is only 1.2 times higher in Graswinkel at. The number of those who strongly disagree with the statement is even marginally higher in Snel en Polanen. For those who indicate that they are satisfied, there does appear to be a bit of a difference, since that figure is 1.6 times higher in Snel en Polanen than in Graswinkel.

4.5.2 Predicting respondents' likelihood to indicate that they are satisfied with the current local public transport system in their city

It is important to note, however, that the makeup of the group of respondents can vary by neighbourhood, which can influence the outcome for each neighbourhood. A regression analysis can undercut this problem by including not only the indicators city, neighbourhood, and satisfaction with the current system, but also the demographic data gathered in light of the individual component. The results of the regression analysis can be found in Table 14, both on the city level and on the neighbourhood level. In addition to the six demographic groups discussed in Section 4.4, knowledge of the local public transport system has been added as a seventh compounding variable. After all, people's familiarity with their local public transport system could well influence their perception of it. Like in Section 4.4, the indicator for income is not included in the regression analysis due to the lower number of responses.

When examining the results in Table 14, it transpires that compared to Weert, which functions as the reference category, a respondent from Woerden is indeed much less likely to indicate that they are satisfied with the current local public transport system.[16] However, it should be noted that the predictive value of the model is not too high. Compared to the model distinguishing between the two cities, the model distinguishing between the four sampled neighbourhoods has a considerably higher predictive value. In this model, Boshoven-Vrakker was selected as the reference category, as this is the only neighbourhood where the local public transport system has seen no change at all in recent years. Compared to living in Boshoven-Vrakker, both living in Graswinkel and living in Molenvliet-West represent a lower chance of being satisfied with the current local public transport system.[16] Interestingly, while the decrease in likelihood of satisfaction is already high in Graswinkel, it is considerably larger in Molenvliet-West, even though the latter does still receive local public transport service and the former does not. The model does not find a significant relationship between living in Snel en Polanen and current system satisfaction, at least when compared to living in Boshoven-Vrakker. This contrasts with the finding from Figure 22 that the level of satisfaction seemed similar in both Snel en Polanen and Graswinkel. It is possible that the perceived similarity was caused by differences in

[16] All of these outcomes are significant at the higher $p < 0.01$ level, indicating a high likelihood of accuracy.

sampling, which might have been cancelled out by the inclusion of the demographic groups in the regression analysis. Finally, it is worth noting that familiarity with the current system shows a significant positive correspondence with the likelihood of system satisfaction. This indicates that those who are more familiar with the system are also more likely to be satisfied with it, making its inclusion in the models important to increase their reliability. As this finding does not help with answering the research questions, it will not be explored further.

Table 14

Regression coefficients for predicting the likelihood that a survey respondent is satisfied with the local public transport system in their city.

Predictor	**City (odds ratio)**	**Neighbourhood (odds ratio)**
Respondent lives in Weert	*N/A (reference)*	
Respondent lives in Woerden	0.296**	
Respondent lives in Boshoven-Vrakker		*N/A (reference)*
Respondent lives in Graswinkel		0.256**
Respondent lives in Molenvliet-West		0.102**
Respondent lives in Snel en Polanen		0.736
Respondent is less than 25 years old	0.902	0.815
Respondent is 65 years or older	1.263	1.437
Respondent is female	0.688	0.813
Respondent has a migration background	0.882	0.677
Respondent does not have access to a car	0.439	0.396
Respondent needs a travel aid to walk/cycle	1.302	1.293
Respondent is familiar with current system	2.217**	2.244**
Constant	*0.834*	*1.117*
N	306	306
Nagelkerke R^2	0.148	0.274
Model Sig.	<0.001	<0.001

$*p < 0.05$; $**p < 0.01$.

The results from the regression analyses are mirrored in some of the responses to the open survey question. This particularly applies to the low system satisfaction in Woerden. As has been discussed in several previous sections of Chapter 4, there were a lot of negative comments on system performance. Almost all of these negative comments came from Woerden, and most from Molenvliet-West. Two respondents indicate that they felt forced by the introduction and performance of Woerden's DRT system to buy a car, a need which they had not previously felt. One of these two, a woman (50) from Molenvliet-West, motivates her choice as follows: "We chose to live in Woerden in part because of the railway station. I eventually bought a car last year, while I prefer traveling with public transport. That choice is bad for the environment. I think it is a bad thing that public transport has become so poorly accessible in a city like Woerden." Another respondent from Molenvliet-West (male, 55) goes even further, calling SyntusFlex "absolutely the single biggest downside of Woerden and even a factor to think about moving." While not collected through any formal means of data gathering, it is also worth

noting the differences in response to this research while I was conducting field work on the street. In all neighbourhoods, people would sometimes stop and ask me what I was working on. Having provided a brief summary of the research, there was a very clear difference in the responses I received. In Snel en Polanen, Boshoven-Vrakker and Graswinkel, even though some people shared a personal positive or negative experience with the transport system, the majority of the responses was neutral. On the other hand, all responses in Molenvliet-West were negative, without a single exception. These negative responses often related to negative experiences people themselves or people close to them had had, and many were very eager to discuss them. I encouraged these individuals to complete the survey, so their sentiments are likely to be reflected in the results. Nevertheless, this difference in initial reactions provides an indication of the general sentiment towards the transport system as well as the intensity of those sentiments, which appear to be stronger in Molenvliet-West.

Based on Figure 22, it seemed that the introduction of a DRT system in Snel en Polanen hardly caused any improvement on system satisfaction, in spite of providing it with the local public transport access it previously lacked. On the other hand, the outcome of the regression analysis in Table 14 might point to some positive effects after all. That is, the model could not find a negative correspondence between living in Snel en Polanen and system satisfaction. This is compared to the reference category, Boshoven-Vrakker, where people are most satisfied with their current system. It thus appears that the attitude of respondents from Snel en Polanen towards their local public transport system is less negative than the attitude of those from Graswinkel and from Molenvliet-West. This does not come as a surprise when looking at some of the comments by respondents from Graswinkel, Weert's counterpart of Snel en Polanen. Like Snel en Polanen before the DRT system was introduced, Graswinkel does not have any access to its cities' FRT system. There were 5 comments from respondents living in Graswinkel indicating that they find the lack of local public transport problematic. One respondent (male, 40) says it has significant consequences for him: "Due to a serious accident, I can no longer drive a car (properly). I now miss the bus that runs through the neighbourhood with which I could go to town, for example."

4.6 Preference between a DRT system and an FRT system

So far, the results have been focussed on the present situation, with Sections 4.1 through 4.4 providing a detailed insight in each component of the local public transport systems in Weert and Woerden, and Section 4.5 showing how satisfied respondents are with the current local public transport system in their city. This final section of the results, however, focusses on the future. At the end of the survey, respondents were presented with a choice between a fictional DRT system and a fictional FRT system, and were asked for their preference. The fictional DRT system shared its characteristics with the DRT system in Woerden, and the FRT system shared its characteristics with the FRT system in Weert. The responses to this question can help understand which respondents feel they are best served by which system, as well as which components of each system determine their choice.

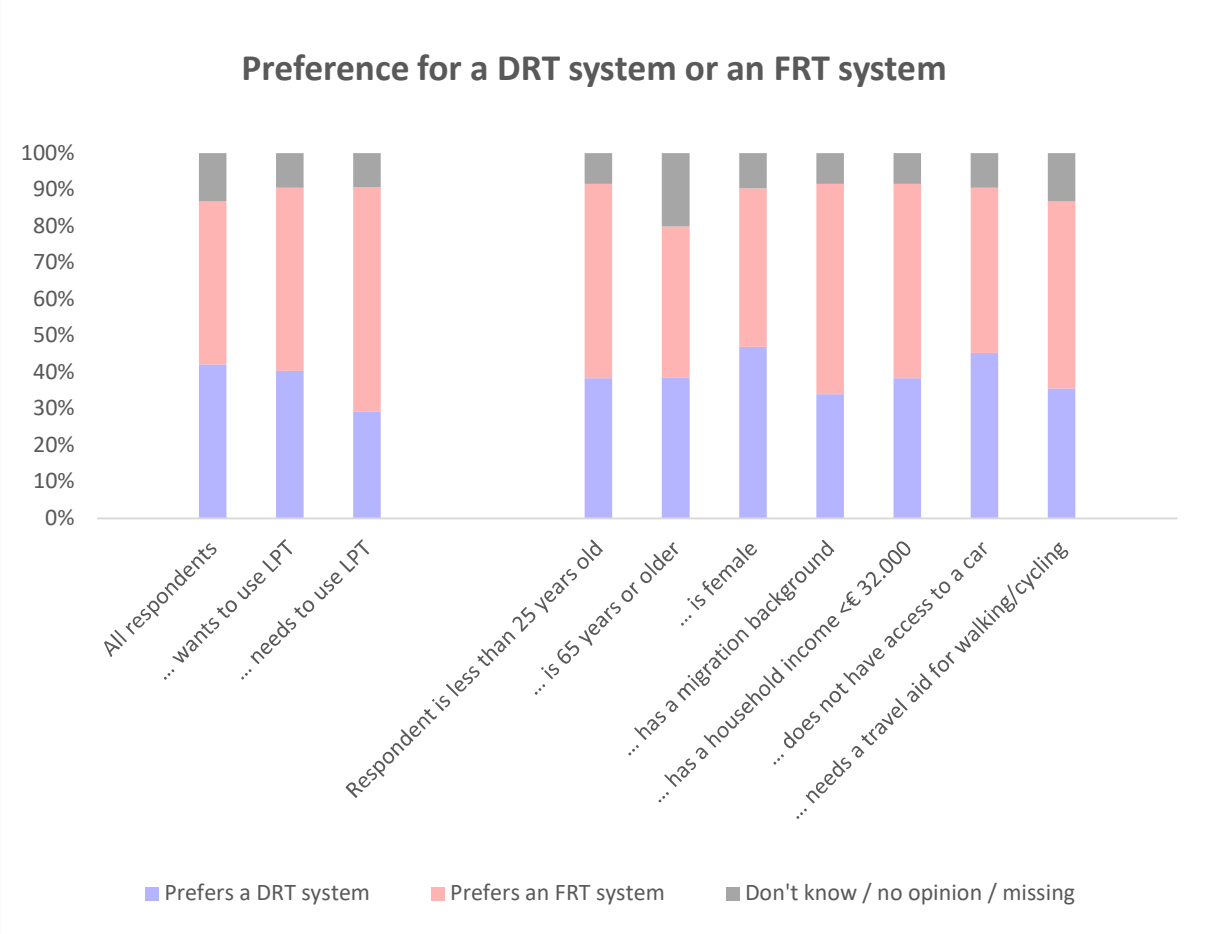
4.6.1 Analysing respondents' theoretical preference between a DRT system and an FRT system for a local public transport system

As stated above, respondents were asked whether they would prefer a DRT system or an FRT system in their city, the results of which are shown in Figure 23. First of all, it is notable that when looking at respondents overall, their preferences are almost exactly split between a DRT system and an FRT system. When looking at respondents who want to use local public transport, a small tilt towards

preference for an FRT system seems to emerge; among respondents who need to use local public transport, a clear majority favours an FRT system. By deduction, that means that those who do *not* want or need to use local public transport favour a DRT system. Given that a majority of respondents who need to use local public transport indicate a preference for an FRT system, it might be logical to assume that the seven demographic groups which, theoretically, have a higher chance of needing to use local public transport show a similar preference. That does not necessarily prove to be the case, as the pattern that emerges from Figure 23 is more mixed. A majority of respondents who are less than 25 years old, have a migration background, have a household income of below € 32.000 annually and/or need a travel aid when walking/cycling do indeed have a preference for an FRT system. However, among female respondents a plurality prefers a DRT system, while among respondents who are 65 years or older and/or do not have access to a car there is no clear favourite. It should be noted of course that people over 65 were actually found not to be more likely to need local public transport, at least not in the sample of this study.

Figure 23

Preference of survey respondents when given the choice between a theoretical DRT system and a theoretical FRT system for providing local public transport (LPT) in their city, split out by respondent type and demographic group.

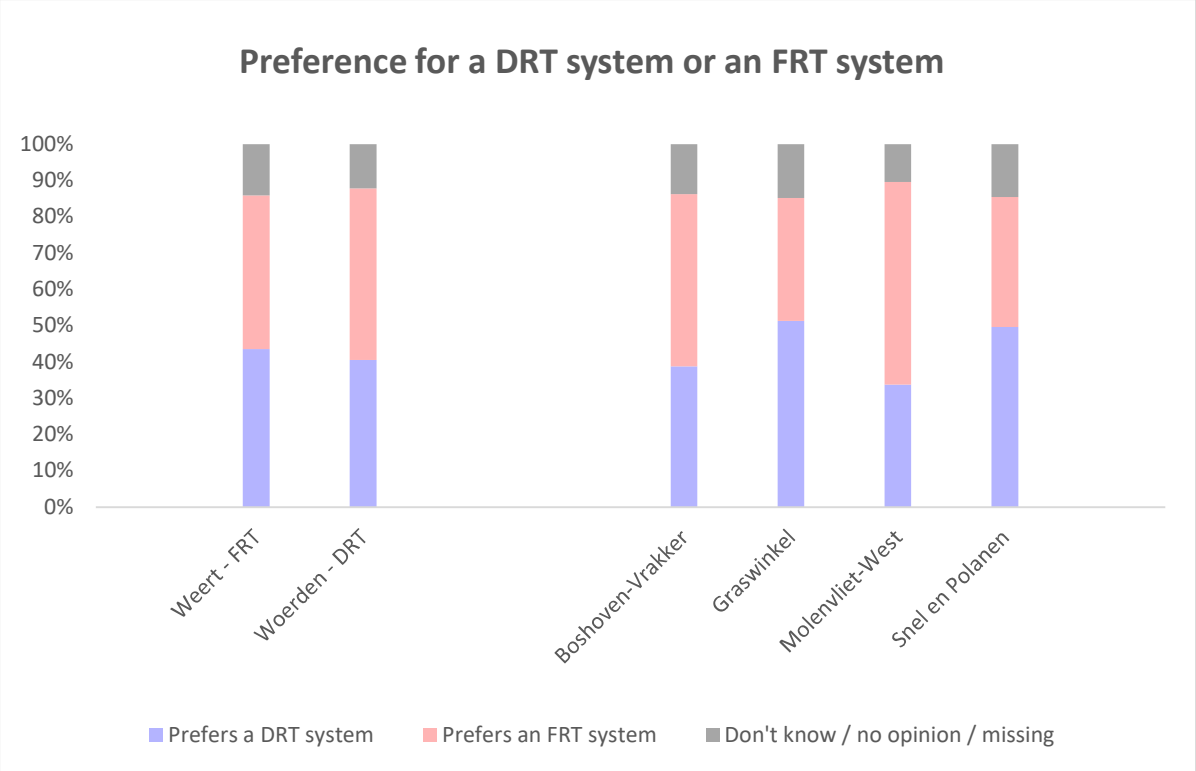


All respondents: N = 603; want to use LPT: N = 345; need to use LPT: N = 127; respondent is under 25 years old: N = 47; 65 years or older: N = 159; female: N = 341; migration background: N = 59; household income <€ 32.000: N = 47; no access to car: N = 42; needs a travel aid: N = 45.

In addition to demographic groups, it is of course possible that the experiences respondents have had with their current local public transport system feed into their preference. To get a clearer picture of that, Figure 24 shows respondents' preference between a DRT system and an FRT system split out by city and neighbourhood instead of demographic group. Interestingly, the preference is almost exactly split in both Weert and Woerden, seemingly rejecting the notion that current experiences were a factor in the choice respondents made. When looking at the neighbourhood level however, a distinction does start to emerge. In both Boshoven-Vrakker and Molenvliet-West, a plurality of respondents prefers an FRT system, while in Graswinkel and Snel en Polanen, a plurality prefers a DRT system. Nonetheless, the results are still quite mixed. Considering that Graswinkel is not served at all by Weert's FRT system while Snel en Polanen regained local public transport access because of Woerden's DRT system, one might have expected clearer preferences from these neighbourhoods in particular.

Figure 24

Preference of survey respondents when given the choice between a theoretical DRT system and a theoretical FRT system for providing local public transport (LPT) in their city, split out by city and sampled neighbourhood.



Weert: N = 317; Woerden: N = 286; Boshoven-Vrakker: N = 196; Graswinkel: N = 121; Molenvliet-West: N = 163; Snel en Polanen: N = 123.

4.6.2 Predicting respondents' likelihood to prefer a DRT system over an FRT system for a local public transport system

To be able to draw more reliable conclusions on which of the relationships observed in Subsection 4.6.1 actually exist, a regression analysis has been run comprising all these variables, the results of which are shown in the first column of Table 15. The outcome of this analysis reflects the balanced results that were found in Subsection 4.6.1. In contrast to the regression analyses predicting current system

satisfaction, the neighbourhood in which a respondent lives did not turn out to have any significant predictive value for the theoretical system preference between a DRT system and an FRT system. None of the demographic groups form a significant predictor either, except the respondent being female. In line with Figure 23, a respondent being female represents a higher chance of that respondent favouring a DRT system.[17] The only other predictor with a significant outcome is the respondent needing to use local public transport. These respondents have a lower chance of preferring a DRT system.[18]

Table 15

Regression coefficients for predicting the likelihood that a survey respondent prefers a DRT system over an FRT system for local public transport (LPT) in their city.

Predictor	**Step 1 (odds ratio)**	**Step 2 (odds ratio)**
Respondent lives in Boshoven-Vrakker	*N/A (reference)*	*N/A (reference)*
Respondent lives in Graswinkel	1.293	1.257
Respondent lives in Molenvliet-West	0.735	1.001
Respondent lives in Snel en Polanen	1.242	1.081
Respondent wants to use LPT	0.859	0.838
Respondent needs to use LPT	0.445**	0.423*
Respondent is less than 25 years old	0.787	0.762
Respondent is 65 years or older	0.939	0.874
Respondent is female	1.580*	1.733*
Respondent has a migration background	0.710	0.987
Respondent does not have access to a car	2.122	2.073
Respondent needs a travel aid to walk/cycle	0.627	0.775
Respondent is familiar with current system	0.717	0.649
Importance of not having to transfer		1.141
Importance of distance to nearest bus stop		1.079
Importance of a fixed schedule		1.099
Importance of not having to book		0.448**
Importance of having access to major dest.		0.972
Importance of having access to minor dest.		1.057*
Importance of service morning rush hour		1.003
Importance of service late evenings		1.180
Importance of service Sundays		1.192
Importance of response time (DRT)		1.059
Importance of frequency (FRT)		0.803
Constant	*1.054*	*0.967*
N	425	353
Nagelkerke R^2	0.104	0.257
Model Sig.	<0.001	<0.001

**p < 0.05; **p < 0.01.*

[17] It should be noted that this correlation is only significant at the p < 0.05 level, not at the p < 0.01 level.

[18] This outcome is significant at the higher p < 0.01 level, indicating a high likelihood of accuracy.

As explained at the beginning of this section, it is possible to not just look at who prefers which system, but also at which components influence that choice. As such, the second column of Table 15 shows the outcomes of a regression analysis which also included the importance attributed by respondents to the different aspects of each component. First of all, this does not seem to significantly impact the outcome for the predictors that were already included in the first step, with the only real change being that the significance level for the predictor 'respondent needs to use local public transport' decreased slightly. This means that the chance that the model erroneously indicates a negative relationship between a respondent needing to use local public transport and their chance to prefer a DRT system slightly increases, but it remains low. As for the newly added predictors, most turn out not to have significant predictive value for how likely a respondent is to prefer a DRT system, with two exceptions. First, a respondent attributing more importance to having access to minor destinations[19] in the city represents a marginally increased chance of that respondent preferring a DRT system.[20] The second exception is the importance attributed to not having to book for a trip.[21] A respondent who finds this aspect of the mobility component important, is considerably less likely to prefer a DRT system over an FRT system.

In summary, there are four indicators which play a key role in predicting whether or not a respondent prefers a DRT system: whether the respondent needs to use local public transport, whether the respondent is female, how much importance the respondent attributes to having access to minor destinations in their city, and how much importance the respondent attributes to not having to book in advance. Of those four, female respondents and respondents attributing a higher importance to having access to minor destinations are more likely to prefer a DRT system, while respondents who need local public transport and respondents attributing a higher importance to not having to book are more likely to prefer an FRT system.

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[19] All destinations included in the survey except for the railway station, city centre and hospital.
[20] It should be noted that this correlation is only significant at the $p < 0.05$ level, not at the $p < 0.01$ level.
[21] This outcome is significant at the higher $p < 0.01$ level, indicating a high likelihood of accuracy.

5 Discussion

The extensive set of results that has been acquired through the data gathering specified in Chapter 3 is presented systematically in Chapter 4. Chapter 5 discusses these findings and explores how they contribute to our understanding of what equitable local public transport access in Dutch peri-urban cities entails, and how well-suited DRT systems and FRT systems are for providing it. Four main takeaways have been identified, which are discussed below.

5.1 The target groups for equitable local public transport differ from expectations

As established in Chapter 2, there are two different ways of defining the target group of an equitable local public transport system. The egalitarian approach by Rawls (1999) is based on the maximin criterion, which entails that the aim should be to deliver as high a minimum level of local public transport as possible to everyone. This means that anyone who wants to use local public transport should be able to do so. The capabilities approach by Sen (2006), on the other hand, considers every individual's capabilities and focusses on providing local public transport to those who need it most. In this respect the research results yield two main takeaways. First, based on the capabilities approach, more focus ought to be placed on young people, people from out of town and female people, and less on elderly people. But second, somewhat diminishing the importance of the first takeaway, results show that the preferences of those who need to use local public transport are actually not that different to those of the overall population. This raises the question whether the difference between the egalitarian approach and the capabilities approach is as significant for transport-related issues as was assumed in the theoretical chapter based on Pereira et al. (2016). After all, if the preferences of those who rely on local public transport match those of the population as a whole, does it really matter on which one of the two one focusses?

Nonetheless, it is interesting to further discuss the first takeaway, as it uncovers a key misconception about which people actually rely on local public transport. Throughout this thesis, everyone from survey respondents to Jain et al. (2017) argued that local public transport is particularly important to elderly people. The only ones who seem to disagree with that assessment are elderly people themselves, as they were the only demographic group not more likely to indicate a need for using local public transport than the average respondent. This might be explained by looking at the two *best* predictors for needing local public transport: not having access to a car and needing to use travel aids. I believe many respondents associate these characteristics primarily with elderly people, and as such expect that group to be the most dependent on local public transport. In reality however, there are people with physical impairments or without access to a car in every age group. One might contest the significance of this finding. After all, does it really matter whether people need local public transport because they are elderly or because they, for instance, do not have access to a car? I would argue that it does, as it helps to explain the other important takeaway mentioned in this section: that the preferences of those who need to use local public transport turned out to be very similar to those of respondents overall. This makes more sense knowing that elderly people are not overrepresented in the group who needs to use local public transport. After all, being elderly comes with a different lifestyle, in which school and/or work often no longer play a part. This different lifestyle could logically result in different preferences for a local public transport system. The other six demographic categories are not so clearly linked to a specific lifestyle that differs from the rest of the population, so it also makes less sense for people in these categories to have unique preferences for local public transport. This challenges the argument that DRT systems might be better suited to serve the specific needs of those who depend on local public transport, since these specific needs do not appear to exist.

Slightly contrasting this point, the results do point towards some demographic groups whose need for local public transport is actually underappreciated. The first of these are young people. Jain et al. (2017) identify them as being more likely to need local public transport, but they were not mentioned at all by other respondents to the survey. An explanation for this discrepancy might be that respondents assume that young people can use their bicycle as an alternative while some elderly people cannot. Regardless of how accurate this explanation is, it is clear that young people do not share this view, as a large number of them indicated a need to use local public transport in the survey. Some of them explained that while they see the bicycle as their first option, there are situations in which they see they use of public transport as unavoidable. This is echoed by some other respondents from outside this demographic group, which proves that not everyone who indicates a need to use local public transport depends on it all of the time. The argument that a bicycle is not always a viable alternative for public transport might also explain the mentioning by several respondents of another possible target group, which was not identified by Jain et al. (2017): people who live outside their city. The reason local residents bring up this particular group is possibly that they do not just want access from their homes to other places, but also want other people to be able to access their homes. In fact, several respondents specifically indicated this.

A final potential target group for local public transport consists of female people. Unlike people living outside the city, this group was included in the research, on the basis of Buehler and Pucher (2012). Their role in the provision of equitable local public transport is of particular interest as they were the only demographic group to show a clear preference for a DRT system over an FRT system. While none of the data from this research provided any indication as to why that might be, one hypothesis could be that as public transport is generally less safe for women than for men, the option of travelling directly from one place to another might be relatively more attractive to them, as might having a stop closer to home. The option for DRT systems to be available during more times of the day, particularly the late evenings, could also be significant from this perspective. Either way, the role of female people in equitable public transport provision warrants further research, as is also argued by Buehler and Pucher (2012).

5.2 Woerden's DRT system has some clear advantages, but the impact they have is debatable

As explained in Chapter 2, a DRT-based local public transport system has many potential advantages. However, this research shows that the degree to which these advantages have an impact on equity is mixed. For example, while the direct trips made possible in Woerden's DRT system are well-used, they do not actually seem to be that important to people with a need or desire to use the system. And although the advantages of the additional boarding and alighting locations vastly expanded the number of people with access to the system, the stops added in neighbourhoods without previous local public transport access are barely used. The fact that these advantages are limited is not necessarily a problem, so long as no one suffers any disadvantages from shifting to a DRT system. After all, even if these advantages have a smaller impact on equity than previously thought, they clearly are still advantages. However, if it were to be the case that a system change would also come with significant downsides, it is worth asking: can a few trips per month really justify that change?

Those possible negative outcomes will be addressed in the next discussion point, but first, it is valuable to discuss further why exactly the equity impact of the advantages of SyntusFlex, Woerden's DRT system, is so limited. After all, the results presented in Chapter 4 show that the system capitalizes well on many of the theoretical advantages that DRT has to offer. The number of addresses within walking distance of a bus stop has increased by no less than 28 percentage points, and the option to travel

directly between any two stops seems to have tapped into some demand, as the number of neighbourhood-to-neighbourhood trips is much higher than in Weert's FRT system. But although these are positive outcomes, They do not necessarily contribute to a more equitable system. That would require these benefits to be of importance to the groups who either want or need to use local public transport, and other results give reason to doubt whether this is the case. For example, while the increased possibility for neighbourhood-to-neighbourhood trips is well-used, access to minor destinations[22] was characterised as important by fewer respondents than any other aspect. This also holds true specifically for respondents who want or need to use local public transport. But why do so few people regard these trips as important, when the data clearly show that people do actually make them? I see two potential explanations for this. First, it is possible that people who want or need to use local public transport have more alternatives for these particular trips, than for others. The most logical explanation for that might be that those other trips stretch further, ruling out the alternatives of walking and cycling. The fact that the vast majority of trips are made to and from the railway station, and thus presumably extend beyond the city borders, supports this. If correct, this would mean that even to those who rely on local public transport, it is mainly important as part of the interurban transport system. A second option is that they do not have alternatives for these trips, but that they do not really care whether they are able to make them. Either way, the negative impact on equity of these neighbourhood-to-neighbourhood trips not being possible would be limited. This does not necessarily mean that they are completely without value. In fact, the importance attributed to access to minor locations correlates strongly with respondents preferring a DRT system. It seems therefore that while neighbourhood-to-neighbourhood trips are not important in providing equitable local public transport, they might contribute to the success of DRT systems in general. Before drawing that conclusion however, there is another possibility that needs to be considered. A relatively large share of neighbourhood-to-neighbourhood trips in Woerden was made to and from industrial areas, a category not included in the survey. So, with no knowledge on the importance respondents attribute to this specific aspects, it could be that the option for direct trips to and from industrial areas specifically does contribute to more equitable local public transport provision.

The additional boarding and alighting locations that a DRT system allows for might more definitively contribute to equity in this case. After all, large parts of both Weert does not have a bus stop nearby, as was the case for Woerden before the in introduction of SyntusFlex completely turned this around. However, even though this advantage was specifically stated in the survey, the importance respondents attribute to distance to the nearest bus stop does not significantly increase the likelihood of them preferring a DRT system. This could be an indication that even to those who mark this aspect as important, it is often not the key determining factor, meaning there must be another aspect that causes many of them to prefer an FRT system regardless. So while the added stops improve local public transport equity by connecting more people who want or need to use local public transport, there appears to be a negative aspect to a DRT system that weighs heavier for that same group. Furthermore, even though the added bus stops appear far more important than neighbourhood-to-neighbourhood trips to people who want or need to use local public transport, their equity impact might also be lower than anticipated. Not all new stops are actually that well used, and usership of stops added in residential neighbourhoods without previous local public transport access could be even described as outstandingly low. The most extreme example is formed by Snel en Polanen, where the survey was conducted, with only 16 trips in an entire month. The reason for this could be that there is simply no demand for public transport in this neighbourhood. That could be because the demographics set it apart from other neighbourhoods, or because of its closeness to the railway station. However, the

[22] Minor destinations are all destinations outside of the railway station, city centre and hospital. Trips between these minor destinations are classified as neighbourhood-to-neighbourhood trips in this research.

usership of the old FRT line through Snel en Polanen, which was already scrapped in 2011, indicates at least some demand. This makes it somewhat remarkable that the number of users the DRT system managed to attract here is so extremely low. This might be an indication that while a DRT system can hold on to existing users – like in Molenvliet-West, where the FRT system was directly replaced by DRT – it struggles to attract new ones. If correct, that would be very worrying for the future of DRT systems in peri-urban cities such as Weert and Woerden. After all, a system that only holds on to existing users and does not attract any new ones is certain to see a gradual decline in usership. This would tie in with the finding of Currie and Fournier (2020) that DRT systems do not tend to survive very long. Concerning as that may be, low usership is not necessarily a problem from an equity point of view. From an egalitarian perspective, the DRT system in Woerden fits in well with the objective of providing everyone with at least a minimum level of local public transport access. And when maintaining the capabilities approach, some of the survey responses from Graswinkel show that a neighbourhood not having any local public transport access can cause serious problems for individuals with limited capabilities. At the same time, it is undeniable that the number of people benefitting from this more equitable local public transport access is very low indeed.

5.3 Weert's FRT system outperforms Woerden's DRT system in three critical areas

The previous section laid out how the main advantages of Woerden's shift to a DRT system have less of an impact on equity than one might have assumed based on theory. This in itself would not be too problematic if the introduction of the DRT system was without downsides, equity-wise at least. However, the theoretical chapter also points out two areas where these downsides might occur: the flexible schedule and advance notice requirement, with reliability emerging as a third potentially negative aspect from the survey results. In all of these aspects, a traditional FRT system is expected to fare better, and they are precisely the ones which were most important to the survey respondents. Given this, these three aspects are likely the main reasons why respondents from Woerden are less satisfied with their local public transport system than respondents from Weert. In addition to that, the performance of Woerden's DRT system in these aspects have a clearly negative impact on equity. This applies when using an egalitarian approach to equity, as they are important to all respondents who *want* to use local public transport, but even more so when using the capabilities approach. It turns out that the advance notice requirement is a particularly high hurdle for those who *need* to use local public transport, and the same might be argued for reliability. While the previous section shows that an expanded number of boarding and alighting locations can result in significant equity improvements, the very limited use of the extra stops makes it questionable whether in this case it outweighs the aforementioned downsides.

As mentioned, the first of these downsides is the flexible schedule. Having a fixed schedule is seen as the most important aspect of a local public transport system by respondents in general, and those who want and/or need to use local public transport in particular. In spite of this, the regression analyses do not show any significant correlation between attributing importance to a fixed schedule and a smaller chance of preferring a DRT system. This could mean that even though respondents find a fixed schedule important, there might be other aspects that are more decisive in determining their system preference. The lack of a significant outcome might in this case also be caused by the fact that there are hardly any respondents who do not find the schedule aspect important. Responses to the open survey question do in fact point towards a key role for this aspect. Respondents point specifically towards what they perceive as a mismatch between the flexible schedule of the DRT system and the fixed schedule of the connecting trains. This corresponds with the findings from Roding et al. (2024), who studied several DRT systems during the same period as this study. So even though no significant correlation could be

found in this research, there are indications that the schedule aspect bears importance in determining preference for an FRT over a DRT system. This would mean that the flexible schedule of a DRT system also has negative equity implications. That holds true regardless of which approach to equity is used, in light of the importance attributed to this aspects by both respondents who want and respondents who need to use local public transport.

Although there is still some unclarity as to how large a part the schedule aspect plays exactly, there can be no ambiguity about the importance of the advance notice requirement, which runs as a common thread through this research. First of all, attributing importance to the advance notice requirement is the predictor with the highest significance for a respondent being less likely to prefer a DRT system. This indicates that it is one of the primary reasons why people would prefer an FRT system, like in Weert, even more so considering that most other aspects differentiating the two systems did not show any significant correlation with system preference. The advance notice requirement also garnered the most comments in the open survey question, the vast majority of them negative. All of this points to the presence of an advance notice requirement in a DRT system being such a hurdle, that it overshadows many of the advantages a DRT system might have. As a majority of those who want and need to use local public transport do find it important that there is no advance notice requirement, this aspect too has a negative impact regardless of which definition of equity is used. However, the negative effect is strongest when using the capabilities approach, as the survey data showed that those who need to use local public transport are significantly more likely to find it important than the average respondent. This is noteworthy as Thao et al. (2023) posed that a DRT system would be suitable for peri-urban environments as they can be tailored to the needs of this specific group, but supports similar findings by Mageean and Nelson (2003), Neerven (2018) and Coutinho et al. (2020).

The third aspect working to the disadvantage of Woerden's DRT system also emerged from the open survey question: reliability. This aspect was the second-most commented on in the survey. Once again, almost all comments came from Woerden and all of them were negative, although reliability was one of the few aspects that also received some complaints from Weert. Nevertheless, there is a remarkable difference in the number of complaints from each city. A possible explanation could be that the operational standards in Woerden are lower, for example due to lack of staff, unreliable vehicles or a booking system that does not work as it is intended. In fact, some respondents note that reliability in Woerden has improved since a new booking system has been introduced. However, it is also possible that the experienced unreliability is inherent to a DRT system. This could either be because such a system is by nature more difficult to operate, as is argued by Enoch et al. (2004) and Petersen (2016), or because people have higher expectations of it than it can actually meet. Some data in the survey responses support this second claim. In Woerden's DRT system, it is possible for a bus to arrive within the time frame that respondents find acceptable, but the maximum waiting time far exceeds this. In Weert, on the other hand, the busiest bus line meets the minimum frequency that respondents require, even if the other lines do not. In the latter case travellers do know in advance that they will have to wait longer, thanks to the fixed schedule. The suggestion that Woerden's DRT system falls short of expectations might be supported by the difference in negativity between respondents from Molenvliet-West and Snel en Polanen. Unlike in Snel en Polanen, many people in Molenvliet-West actually use the system. Thus, they are much more likely to feel let down by it than the people from Snel en Polanen, who do not yet have such real-life experience. The equity implications of this aspect are a bit more difficult to determine. After all: should it be the actual system performance that takes precedence, or people's perception of it? In line with Curl (2018), I would argue that the perception at least bears equal significance, as it is the perception that determines whether people think they have the option to make a trip or not. Furthermore, I would say that the negative equity implications once again weigh heavier when using the capabilities approach to equity. Those who want to use local public transportation but

do not need to, can compensate their initial disappointment with the knowledge that they have alternatives to avoid it. For those who need to use local public transport, on the other hand, the first disappointment induces more uncertainty for future trips, which they nonetheless cannot avoid. Again, this is in line with the findings of Roding et al. (2024), who concluded that DRT systems are the least suited for those who need to rely on them regularly.

5.4 A rigid choice for either one of the systems might not be the optimal solution

So far, it seems as if Weert's FRT system outperforms Woerden's DRT system both in terms of general performance and in terms of equitable local public transport access. One aspect of the systems is yet to be discussed however: the operating hours. Briefly recapping both systems in this regard, Woerden's DRT system does not operate during the morning rush hour, while Weert's FRT system does not operate on late evenings and only partially on Sundays. This is not uncommon for these types of systems, with FRT services being easier to provide when demand is highest, while DRT systems can more easily be provided when demand is lower.

Based on the regression analyses, the importance attributed to the local public transport system operating at any one of these times does not prove to be a reliable predictor of a higher or lower chance of preferring a DRT system. This indicates that it might not be as decisive as some of the aspects working in favour of an FRT system. Nonetheless, there are some indicators that this aspect is still important, both in general and concerning equity. While not available for Sundays, the usership data from the respective systems show the importance of systems operating both during the morning rush hour and during the late evenings. That results are clearest for the morning rush hour, which in Weert shows a level of usership that is almost identical to that during the day. Notably however, in Woerden the hourly number of trips in the late evenings is almost identical to that in the early evenings. This means that Weert's FRT system operating during the morning rush hour and Woerden's DRT system operating during late evenings both contribute notably to the general performance of both systems. This is particularly relevant to the discussion on equity. In the egalitarian approach, which aims to deliver at least some local public transport service to as many people as possible, the fact that the system does not operate at all hours might be considered of secondary importance if it means that the total number of people that is served by it can be increased. When maintaining the capabilities approach however, the responses to the survey indicate that the system being available at all times is quite significant. As previously touched upon, this is the aspect with the clearest difference between the preferences of in particular respondents who need to use local public transport and of all respondents overall, with the former group attributing considerably more importance to the system operating at all times than the latter. As discussed in Section 5.2, respondents who need to use local public transport do not necessarily wish to be able to travel to all places, but they do want to be able to travel at all times.

So, while the previous section pointed towards some key areas in which the FRT system in Weert outperforms the DRT system in Woerden, the fact that Woerden's DRT system is available during all times of the week is an important counterargument, particularly when using the capabilities approach to equity. This might suggest that rigidly choosing for either a full DRT system or a full FRT system might not be the best approach to providing equitable access to local public transport. While some key disadvantages of a DRT system might make a system based around FRT more opportune, using DRT during quieter times could help to make the system available at every time of the week. As it turns out, perhaps unsurprisingly given this analysis, that is exactly the type of service that Arriva Limburg is offering in all other smaller cities it serves (Arriva Limburg, 2024).

6 Conclusions

The aim of this research was to compare a Demand Responsive Transport (DRT) system and a Fixed Route Transport (FRT) system, in order to see which one is better suited for providing an equitable local public transport system, specifically in smaller, peri-urban cities. To this end, a comparative research has been conducted in the cities of Weert and Woerden, two otherwise very comparable cities which respectively boast an archetypical FRT system and DRT system. The data that have been gathered, presented, and analysed in the previous chapters will now be used to answer first the subquestions, and finally the main research question.

6.1 Answering the five subquestions

In order to be able to answer the main research question, I will first answer the subquestions that have been formulated in Section 1.3. These subquestions have once again been stated below, followed by the answers that the data analysis can provide for them.

1. "*How are Transport Equity, Demand Responsive Transport (DRT) and Fixed Route Transport (FRT) defined and what are their characteristics?*"

The data for this first research question have been gathered through desk research of the available literature. Therefore, the outcomes were presented in Chapter 2, the theoretical chapter. Based on the available literature, I adopted two different definitions for transport equity: one following the egalitarian approach as set out by Rawls (2001), and the other following the capabilities approach by Sen (2006). From an egalitarian standpoint, transport equity is defined as striving to deliver at least a minimum level of local public transport to everyone and aiming to raise this minimum as high as possible. When maintaining the capabilities approach, transport equity is defined as specifically aiming to provide local public transport to those who do not have any alternatives, and as such depend on it.

In this thesis I compared two different types of local public transport system on the basis of how well they are suited to fulfil these aims: the more traditional Fixed Route Transport system and the more innovative Demand Responsive Transport system. FRT is defined as a transport system based on vehicles that serve the stops in the network following fixed routes and fixed timetables. As a more recent innovation, DRT is not yet so clearly defined, but for this thesis the *many-to-many* definition has been adapted. This form of DRT is also called 'full DRT', and entails a system in which direct trips can be made between any two stops in the system, but only upon request. Based on theory, I identified the key differences between the two types of systems in each of the components of a transport system as defined by Geurs and Wee (2004). In the mobility component, the flexible network and option for more boarding and alighting locations are advantages of a DRT system, whereas the fixed schedule and lack of an advance notice requirement work in favour of an FRT system. The option for more boarding and alighting locations should also give DRT systems an edge in the land-use component, as it can serve more different places. In the temporal component, there are differences in the aspects of operating hours and waiting time, although it is not clear which system is more beneficiary in these respects. The individual component, comprised of the people who could potentially use the system, does not change based on what system is in place, but is essential for the capabilities approach to equity. It is theorised by some scholars that based on these differences, a DRT system is better suited due to its flexible nature to serve specifically those who need to use local public transport system, while others question this assessment.

2. *"How does each aspect of the respective transport systems in Weert and Woerden perform?"*

With the use of secondary data, primarily on usership, I analysed the performance of both systems in each of the aspects that came forth from the answer to the first subquestion. First, in the mobility component, the flexible *network component* of the DRT system in Woerden clearly taps into some demand, as a quarter of all trips made would not have been possible in the old FRT network. The newly added *boarding and alighting locations* significantly increased the number of addresses in Woerden with a bus stop nearby, now far outperforming the coverage offered in Weert. However, usership of these new stops varies greatly. Some of them, such as stops in industrial areas and stops which were added to reduce walking distance in neighbourhoods already served by local public transport, are being used frequently. Others, like stops in previously unserved neighbourhoods, are hardly used at all. Despite all the advantages that came with the introduction of the DRT system, the overall number of trips is much lower in Woerden than in Weert. This could be due a number of reasons, such as the uncertainty presented by the flexible schedule, the much complained about advance notice requirement, or the fact that users are disappointed by the *reliability* of Woerden's DRT system. That last aspect was not identified beforehand, but proved very important nonetheless. The differences in the mobility component also influence the performance of both networks in the land-use component. The flexible network and newly added boarding and alighting locations have resulted in Woerden's network being far more frequently used for trips to other neighbourhoods, particularly industrial areas. However, there are relatively fewer trips to the city centre and hospital than in Weert, showing that both systems have their own strengths when it comes to the land use component. The same applies for the *operating hours* in the temporal component. The FRT system in Weert is used about as much during the morning rush hour (when Woerden's DRT system does not run) as during the day, while the DRT system in Woerden sees about as many trips during late evenings (when Weert's FRT system does not run) as during early evenings, showing the significance of local public transport being available during all these times. When it comes to *waiting times* however, Weert's FRT system seems better able than Woerden's DRT system to meet expectations.

3. *"To what extent does each aspect of the respective transport systems in Weert and Woerden meet the demands of inhabitants, particularly those reliant on local public transport?"*

The primary dataset of this thesis is formed by the results to the survey, which show to what degree the design and performance of both systems align with the demands of the inhabitants of the four neighbourhoods that were surveyed. To allow for the proper consideration of both approaches to equity adopted in this study, three groups of respondents are distinguished: respondents overall, those who want to use local public transport, and those who need to use local public transport. The second group forms the focus group for local public transport when using an egalitarian approach to equity, while the third group is the focal point when using the capabilities approach. Before diving into the survey results for each of these groups, it is good to recap the analysis of the demographic make-up of them. Based on the survey, it transpired that people who are younger than 25, 65 or older, female, have a migration background, have a lower household income, do not have access to a car and/or need travel aids want to use local public transport more often. However, unlike the other mentioned demographic categories, people of 65 and older are not more likely to indicate an outright need to use it. On the other hand, several respondents suggested another group that might be more likely to have such a need: people visiting the city who do not live there.

In the mobility component, all aspects were found to be important by the vast majority of respondents, regardless of what group they belonged to. Deemed important by most respondents is a fixed *schedule*, which is offered by Weert's FRT system. However, this is closely followed by *distance to the nearest bus stop* and not needing to transfer (*network component*), and Woerden's DRT system performs better in

both these aspects. The pattern for the *advanced notice requirement* is different, as it is less frequently seen as important by respondents overall, but more often by those who need to use local public transport. On the aspect of *reliability,* which as mentioned before only became apparent during the research, comments from respondents indicate that the system in Woerden performs far worse than the system in Weert, although no hard data are available to corroborate this. For the land-use component, there is also hardly any difference between the three groups of respondents, with access to the railway station, city centre and hospital being important far more often to respondents in each group than access to any other destinations. Access to these three places is offered by both systems, negating the advantage a DRT system should theoretically have in this component. However, the survey did not include industrial areas, and the usership of stops in industrial areas in Woerden suggests its DRT system may yet hold the edge in this component. Finally, the temporal component shows the clearest difference between respondents overall and those who want and/or need to use local public transport. For the former group, it is primarily availability during the morning rush hour and during the day that is important, while for a majority of the latter, availability is important at all times. As only Weert's FRT system is available during the morning rush hour and only Woerden's DRT system is available during late evenings, as well as being fully available on Sundays, both systems have their positives and negatives when it comes to this component. In this instance however, the priorities of Woerden's DRT system seem to align better with those needing to use local public transport, while those of Weert's FRT system seem better aligned with respondents overall.

4. *"Do inhabitants of Weert and Woerden prefer a Demand Responsive Transport (DRT) system or a Fixed Route Transport (FRT) system, and which aspects influence their preference?"*

In addition to asking respondents about the different components of local public transport system, they were also asked for their preference if they had to choose directly between an archetypical DRT system and an archetypical FRT system. The results are remarkably mixed, and almost equally split in both Weert and Woerden. Although there are differences at the neighbourhood level, these proved to be insignificant in the regression analysis, which instead identified some other key predictors. Female people are clearly more likely to prefer a DRT system. To a lesser extent, the same applies to people who find having access to minor destinations important, although that group is relatively small. On the other hand, two aspects represent a much larger chance of a respondent preferring an FRT system. These are a respondent attributing importance to not having to book in advance and, rather crucially, a respondent indicating that they need to use local public transport. This matches the raw data collected in the survey, as preferences are split about equally between the two systems among both respondents overall and respondents who want to use local public transport, while a clear majority of those who need to use local public transport prefers an FRT system.

5. *"How satisfied are inhabitants of Weert and Woerden with the current local public transport system in their respective cities?"*

Finally, the survey inquired into the satisfaction of respondents with the system currently in place in their city. While only just over half of respondents filled out this question, as many were not familiar enough with or did not have an opinion on the system, it produced some very telling results. The main finding: a clear plurality of those who responded in Weert have a favourable opinion of their FRT system, while a clear plurality of those who responded in Woerden have a negative opinion of their DRT system. This result stands when correcting for demographic characteristics through the regression analysis, with a respondent living in Woerden representing a much smaller chance of that respondent being satisfied with the current local public transport system in their city. Looking at the neighbourhood level, it turns out that this comes down entirely to respondents from Molenvliet-West. Respondents from Snel en Polanen do not have a significantly smaller chance to be satisfied than those from

Boshoven-Vrakker, the sampled neighbourhood where nothing changed. This is perhaps unsurprising, as Woerden's old FRT system did not serve Snel en Polanen at all. Respondents from Molenvliet-West have a markedly smaller chance of being satisfied than those from Boshoven-Vrakker, and even considerably smaller than respondents from Graswinkel, which is no longer served by public transport at all. This sentiment was echoed by comments from survey respondents, some of whom indicated that they bought a car because of the system change or that they are considering moving away from Woerden altogether.

6.2 Answering the main research question

In the previous section, the five subquestions have been answered based on the data presented in Chapter 4. Answering the main research question, restated below, entails weighing these outcomes against the two adopted definitions of equity, which can be done based on the discussion in Chapter 5. As explained in Section 1.3, the main research question of this thesis is as follows:

> *"To what extent and how do Demand Responsive Transport (DRT) systems and Fixed Route Transport systems (FRT) succeed in providing equitable access to local public transport in peri-urban cities?"*

This study has produced several relevant findings that contribute to answering this question. First and foremost, it transpires that the preferences of those who need to use local public transport actually do not differ all that much from the preferences of those who want to use it or even all respondents as a whole, which raises the question how logical or even achievable it is to design a local public transport system that specifically targets the first group. Secondly, in some of the areas where preferences do not align, it is actually the FRT system that best fits the preferences of those who need to use local public transport. The best example of this is the advance notice requirement, which is seen as more problematic by and for this specific group. So rather than providing local public transport specifically to those who need it the most, as the capabilities approach to equity prescribes, the advance notice requirement seems to achieve the opposite: putting up a barrier that is hardest to overcome for that very group. Besides the advance notice requirement, the FRT system in this research also has an edge on the important aspects of fixed schedule and reliability, regardless of which approach to equity is adopted. The DRT system counters this with several other advantages, but the significance of these advantages is questionable. On the one hand, the option to travel to all destinations without a transfer is quite well-used, but access to many of these locations is not seen as important by most respondents, thus limiting its contribution to equity. On the other hand, the additional boarding and alighting locations clearly improved the overall number of people who have access to the system, particularly relevant when maintaining an egalitarian approach to equity. However, many of the new stops are hardly used, particularly those added in neighbourhoods which previously did not have any local public transport access. While this research shows that there are people who need to use local public transport in these areas, it appears that access through a DRT system is not an adequate solution for them, for the reasons listed above. There is one aspect in which the DRT system does clearly improve equitability, and that is in providing local public transport during quieter hours, which is deemed particularly important by those who need to use local public transport.

To conclude, while the advantages of a Demand Responsive Transport (DRT) system ensure that more people have access to at least some form of local public transport, aligning well with an egalitarian approach to equity, this mainly seems to benefit people who do not need or even want to use it. Fixed Route Transport (FRT) systems appear more suitable to those who want to use local public transport and, crucial when maintaining a capabilities approach to equity, even more so to those who need to

use it. Overall it seems that, based on this research, Fixed Route Transport systems are able to provide equitable access to local public transport to a larger extent than Demand Responsive Transport systems, primarily by being better aligned with the preferences of people who depend on it.

Figure 25
A vehicle operating on bus line 1 in Boshoven-Vrakker, Weert (own work).

7 Reflections and limitations

The previous chapter provided an answer to the subquestions and main research question, concluding this research. In order to be able to fully grasp the value that this thesis can bring to the field of equitable local public transport in peri-urban areas, it is important to reflect critically on each aspect of it. This reflection is offered in this chapter and is organised along the lines of three discussion points.

7.1 Reflections on the operationalisation

First, although the framework by Geurs and Wee (2004) proved to be suitable for a comprehensive analysis of all components of a transport system, the responses to the survey brought up a few aspects which were not included during the operationalisation of the different concepts from the conceptual framework. This was in part due to these aspects not being mentioned in the theory used to operationalise Geurs and Wee's (2004) components, and in part due to choices I myself made in this operationalisation. The most important missing aspect was the role of industrial areas in the land-use component. The questions on this component were supposed to list all locations of any importance in each city, but industrial areas were not included. This is unfortunate, given the important role that industrial areas turned out to play, which as a result remains a bit more difficult to interpret. In addition, two other aspects which turned out to be significant were also left out of the survey: the aspect of reliability in the mobility component and the aspect of people from out of town in the individual component. The former was not included in the four aspects of a public transport system identified by Papanikolaou et al. (2017), while the latter was not mentioned by Jain et al. (2017) as a group more likely to rely on public transport. Jain et al. (2017) also failed to include female people in this list, but that group was included in the research based on the argument of Buehler and Pucher (2012).

Besides these aspects, the survey also did not ask whether or not respondents actually used the local public transport system. This choice was made deliberately, as local public transport systems in peri-urban areas are defined by their low usership, making it more difficult to find a representative number of users of the local public transport system. However, particularly the responses to the open question in the survey showed that many respondents did in fact use the system, albeit not all regularly. While this omission does not influence any of the outcomes that *were* found, the inclusion of such a question would have allowed for further analysis, potentially expanding the number of interesting findings from the research. On the other hand, I would argue that while it would be generally interesting to compare the preferences of those who use the system to those who do not, this is not actually too relevant to the issue of equity. After all, those who use the system may do so out of need, but may also do so out of convenience. They may well have had perfectly good alternatives at the time, or they might not have. So, while the information on whether respondents use the local public transport system would have provided some interesting context, the questions on whether respondents want and/or need to use local public transport remain the essential ones for this thesis.

7.2 Reflections on the sampling

In addition to reflecting on which data have been gathered, it is also important to discuss the way in which this occurred, as this is essential to the reliability of the outcomes. Overall, I would say the collection of survey data through flyers, which was the predominant method used in this research, is one of the more reliable and unbiased ways to collect the data. After all, only one selection criterium has really been used to determine who did and did not receive the flyer: whether or not someone had

a sticker at their door making it illegal to either use the letterbox or the doorbell. Unless this aspect significantly impacts peoples' attitudes to local public transport, which seems unlikely, this means that a very representative sample of the population has been presented with the survey. The same would not necessarily have applied had digital means been used to gather the surveys, as was initially the plan. This would have involved a third party communicating about the survey, posing risks which are well-illustrated by the one online article which was posted, an article by newspaper Woerdense Courant. They were kind enough to try and help with distributing the survey and asked some questions about the research for the accompanying article. While I aimed to and I think succeeded in providing neutral and objective answers, the headline of the article quoted one segment of an answer saying "the voice of users critical of the system is important" (Woerdense Courant, 2024). This might have caused relatively more people with a negative opinion of the system to respond. In the end, this article gathered only a relatively small number of responses, and the vast majority came in as a result of the distribution of the flyers. Nonetheless, this event stresses the importance of considering negativity bias in those who actually choose to fill out the survey. However, I would argue that in the case of this survey, this has been undercut by the selection of multiple cases. Moreover, the attitude of respondents to the respective systems is not analysed on its own. It is only compared to the attitude in the other system.

Finally, while the number of surveys that has been collected in this way exceeded the targets that had been set, an optimal analysis would have required even more data. Beforehand, the intention was to conduct separate regression analyses in each of the four sampled neighbourhoods, showing how different aspects might play a role in each one. However, the number of respondents was not sufficient to allow for such an analysis, as the different demographic categories become too small when only looking at one neighbourhood. While regrettable, resolving this issue would have required gathering an unrealistically high number of filled-out surveys.

7.3 Reflections on the qualitative data gathering

As a final point of reflection, it is worth mentioning that the intention was to collect one further set of qualitative data, in the form of interviews with survey respondents. However, this phase eventually had to be scrapped due to time constraints. This is unfortunate, not in the last place because no less than 92 people had already indicated that they were willing to participate in an interview. The interview data would have been valuable for multiple reasons. First, this thesis is based for a large part on peoples preferences for a transport system, as well as their perception of the one currently in place. It now relies mainly on quantitative data to establish what those preferences and perceptions are, but to understand precisely where they come from and what implications they have, qualitative data are also required. Interviews could have helped to deepen the understanding of the underlying patterns that culminated in the quantitative data that were eventually gathered. Second, the data that were gathered unveiled a few phenomena which could not fully be explained based on the available theory, such as the important role of reliability and the clear gender divide. Not only would the interviews have allowed for a further exploration of these phenomena, they could also have led to the discovery of more of them. These are all reasons why conducting the interviews might have allowed me to rely less on speculation in the discussion of the data, as well as to draw more definitive conclusions. While the wide variety of responses to the open question at the end of the survey has certainly helped to fill that gap, there is no doubt that the interviews would have had added value. In hindsight, had I known that the interviews would not take place, I could have gathered more qualitative data by adding a few more open questions in the survey. Given the rather extensive answers many respondents provided in the one open question that was included, this probably would have been enough for this research.

8 Recommendations

This final chapter aims to draw some recommendations from the conclusions in Chapter 7 of this thesis. These recommendations concern both opportunities for further research and lessons that can aid public transport operators.

8.1 Recommendations for further research

The recommendations for further research based on this thesis fall apart into two categories. Naturally, there are opportunities to build on this research and further the understanding of equitable local public transport. However, there are also some other interesting points that came up in this study, but that could not be investigated further due to the limitations discussed in Section 7.3. While not all of these are directly related to the main aim of this thesis, they still warrant further research.

To start off with the latter category, the first and perhaps most important of these points is the reliability of DRT systems. As was discussed in Section 5.3, reliability issues are not uncommon for these types of system, which raises the question whether these issues in Woerden are down to poor operational standards or are inherent to a DRT system. This is particularly interesting given that Currie and Fournier (2020) found that while many DRT systems are introduced, most of them end up failing. Based on the findings in this thesis, it would be interesting to see similar research to that of Currie and Fournier (2020) comparing multiple DRT systems specifically on the issue of reliability, to see if a system can be found that has resolved these issues.

A second point worthy of closer research is the role of industrial areas within transport in peri-urban areas. This has been partly overlooked at the start of this research, but based on its outcomes, it seems to bear some significance. In that light, perhaps, the role of people who do not live in the city, but who do use the system also merits further inquiry. They were also not included in this research, but came up as people from within the cities expressed the desire to be able to receive visitors. However, people who do not live in the city might of course wish to visit it for business purposes as well. The role of this group is particularly interesting with regard to DRT systems, which are more complicated to use.

Finally, this research underlines that the specific role of the female experience in public transport related issues warrants further research. This thesis not only re-iterated that female people are more likely to need local public transport, but it also found that they are the only demographic group to which this applies in which a majority prefers a DRT system to an FRT system. None of the results of this thesis could provide a fitting explanation for this phenomenon, but understanding how it comes about could deliver a considerable contribution towards gaining a better insight in the female public transport experience.

Regarding the main theme of this research – establishing how different types of local public transport systems achieve different levels of equitable local public transport provision – an important recommendation is that the local public transport system best equipped to do so might not be a full DRT or full FRT system, but rather some form of hybrid variant. This aligns with the findings of Roding et al. (2024), who came to a similar conclusion in a comparative research on Dutch DRT systems that was conducted around the same time as this research. A study comparing different hybrid alternatives could help advance the search for the best way to provide equitable local public transport in peri-urban areas. The other aspect of this main theme I think warrants further research is the geographical distribution of usership. One of the findings that I found most surprising in writing this thesis was that this geographical distribution was almost as unequal in Woerden, where the DRT system serves all parts

of the city, as it was in Weert, where the FRT system does not serve some neighbourhoods at all. Further research on this topic could help answer the main question this raises: can this discrepancy be written down to an inadequate local public transport system, or is demand in some neighbourhoods so minimal that there is no need for a local public transport system to serve them, even if that system strives for equitable access? It would be particularly helpful if a meta-study were conducted that compares the findings of different case studies into DRT systems in peri-urban areas all around the world, to see if any general patterns emerge.

8.2 Recommendations for local public transport operators

Besides the academic contribution, this thesis also provides some valuable information for local public transport operators who wish to improve their network, both in terms of performance and in terms of equitability. I have aimed to summarize this information into four main takeaways, which have been detailed below.

1. Given the importance attributed by respondents to distance to the nearest bus stop, it is worth considering whether it is possible to add additional stops to a network to increase stop density, particularly in neighbourhoods already served by the system. For local public transport systems in peri-urban environments, it might be wise to prioritise stop density over speed, given that potential users prioritising the latter are likely to use the bicycle anyway. This is supported by some respondents indicating that they only need to use local public transport in certain circumstances and use their bicycle or car at other times.

2. Creating more direct connections in the network between places outside the railway station, city centre and hospital might not be too important from an equity point of view, but as shown by the analysis of usership data in this thesis, it can generate more usership. Particularly connections between residential neighbourhoods and industrial areas could prove effective. In this light, it will be interesting to see how the renewed local bus network in Alphen aan den Rijn performs. In this city, which in spite of being twice as large shares many characteristics with Weert and Woerden, local public transport operator Qbuzz introduced a new FRT network that offers direct connections between every part of the city (Qbuzz Zuid-Holland Noord, 2024).

3. When considering implementing a DRT system, building in as much certainty as possible for users should be the number one priority, with both the flexible schedule and reliability issues being seen as major downsides of such a system by the respondents to this survey. It is imperative to find a way to leave as little uncertainty as possible when it comes to departure and arrival times within the flexible nature of a DRT system, also to ensure at least some compatibility with the rest of the public transport network. Operators should also be aware of and hopefully learn from the considerable reliability issues that typically plague DRT systems and try in advance to find ways to undercut these issues from the start.

4. Finally, any local public transport operator considering introducing a DRT system should consider the substantial degree to which an advance notice requirement is a hurdle to overcome for local public transport users, particularly for those who rely on the service. As a consequence, a switch to a DRT system can result in a significant decrease in usership of the system, as is supported not just by this thesis, but also by the previously mentioned parallel research by Roding et al. (2024). Operators would do good to not just consider switching to a full DRT system, but also to contemplate hybrid options, with the DRT system ensuring access during quieter hours while an FRT system remains the backbone when demand is higher.

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Appendix A: Appendix overview

To ensure full transparency and replicability, all sets of data as well as the documents used to analyse them are attached to this thesis as an appendix. All these appendixes together with this thesis will be stored in the same dataset, of which this appendix provides an overview. Appendix B, which includes all the figures that contain maps, is not stored separately but included in this document.

List of appendixes:

Appendix B: Figures containing maps

Contains:

Figure 9

The public transport system in Weert as of 2025, including all local and rural bus lines operating at least hourly on weekdays during the day.

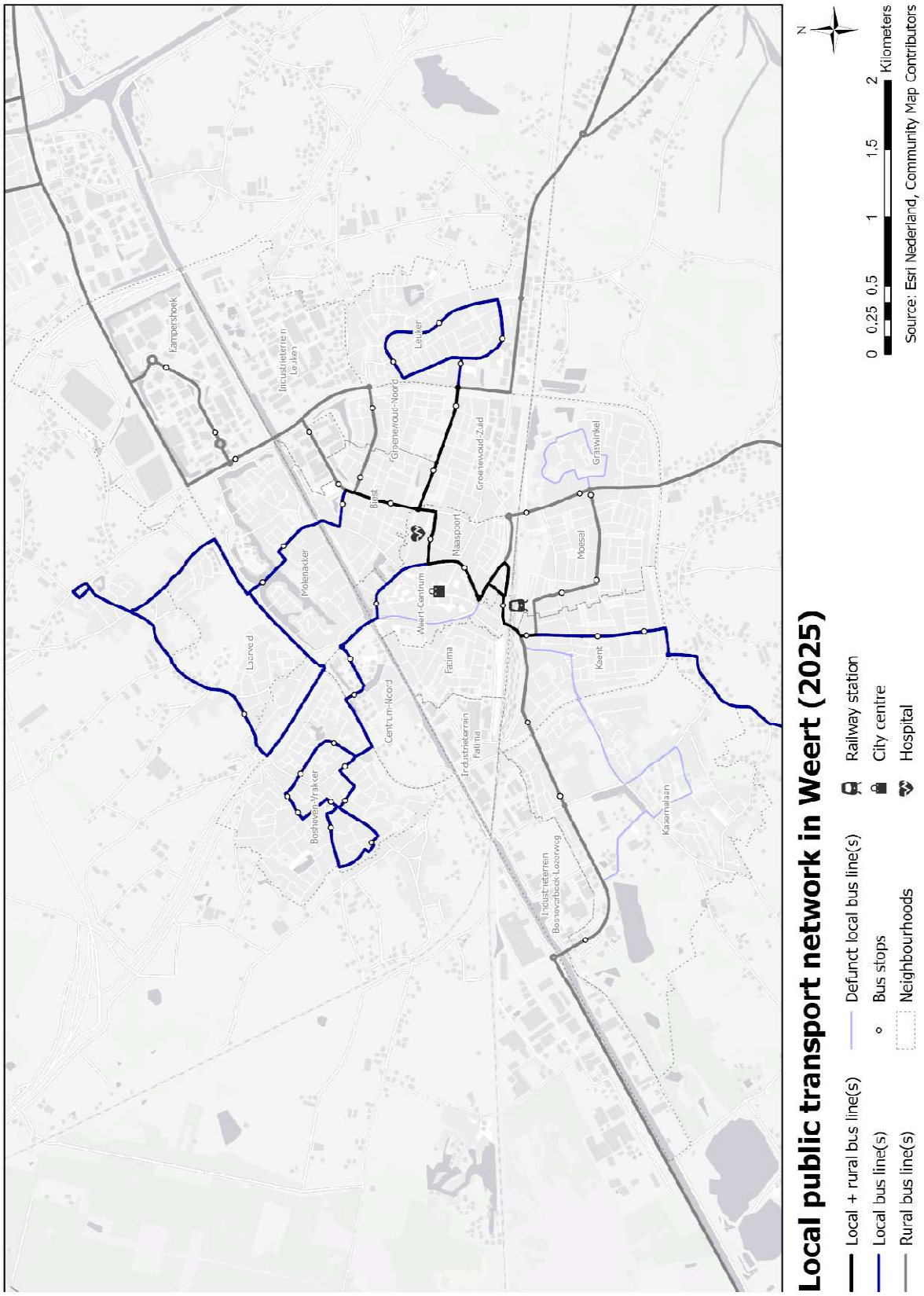

Figure 10

The public transport system in Woerden between 2013 and 2017, including all local and rural bus lines operating at least hourly on weekdays during the day.

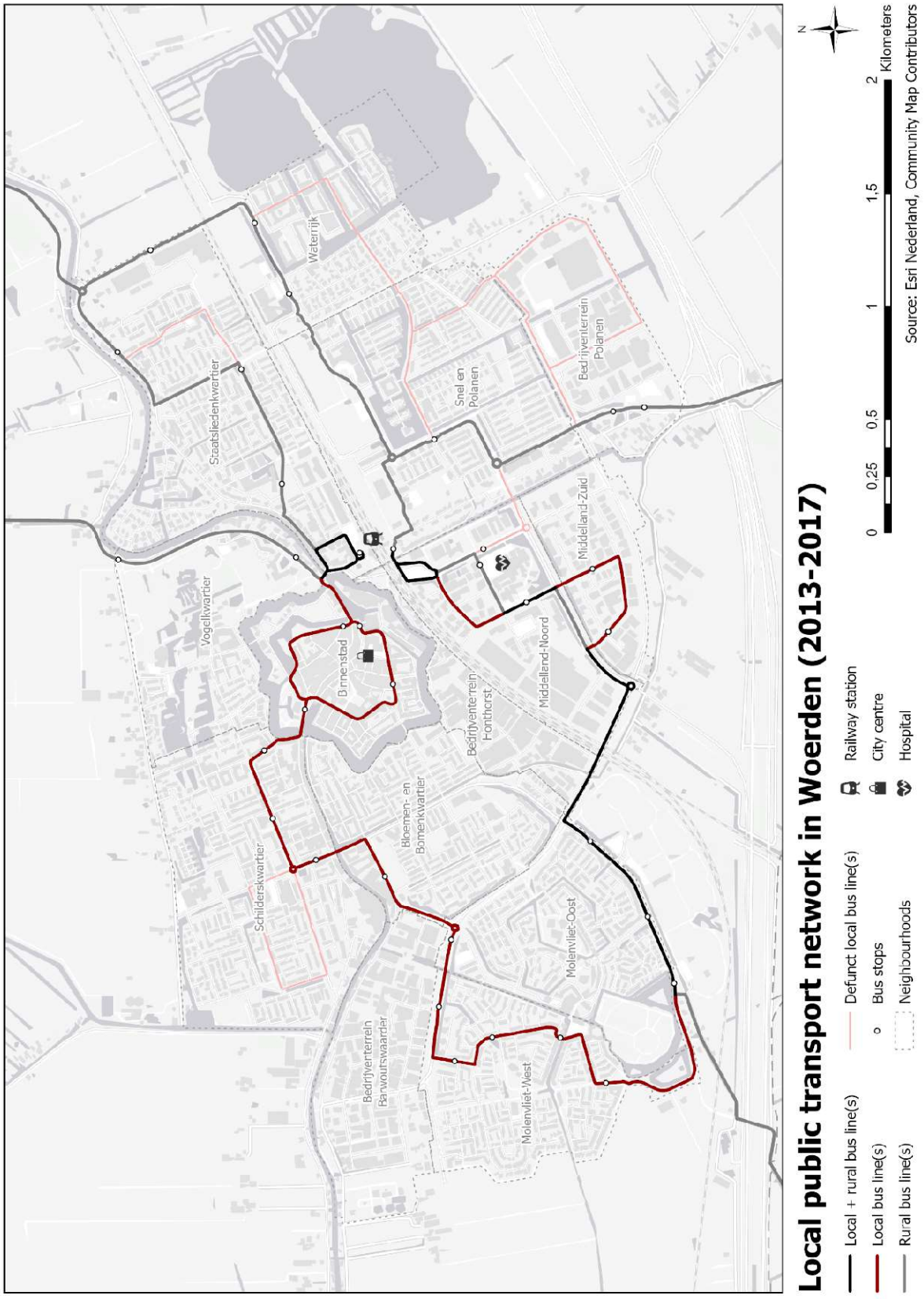

Figure 11

The public transport system in Woerden as of 2025, including all rural bus lines operating at least hourly on weekdays during the day and all stops in the city served by the SyntusFlex DRT system.

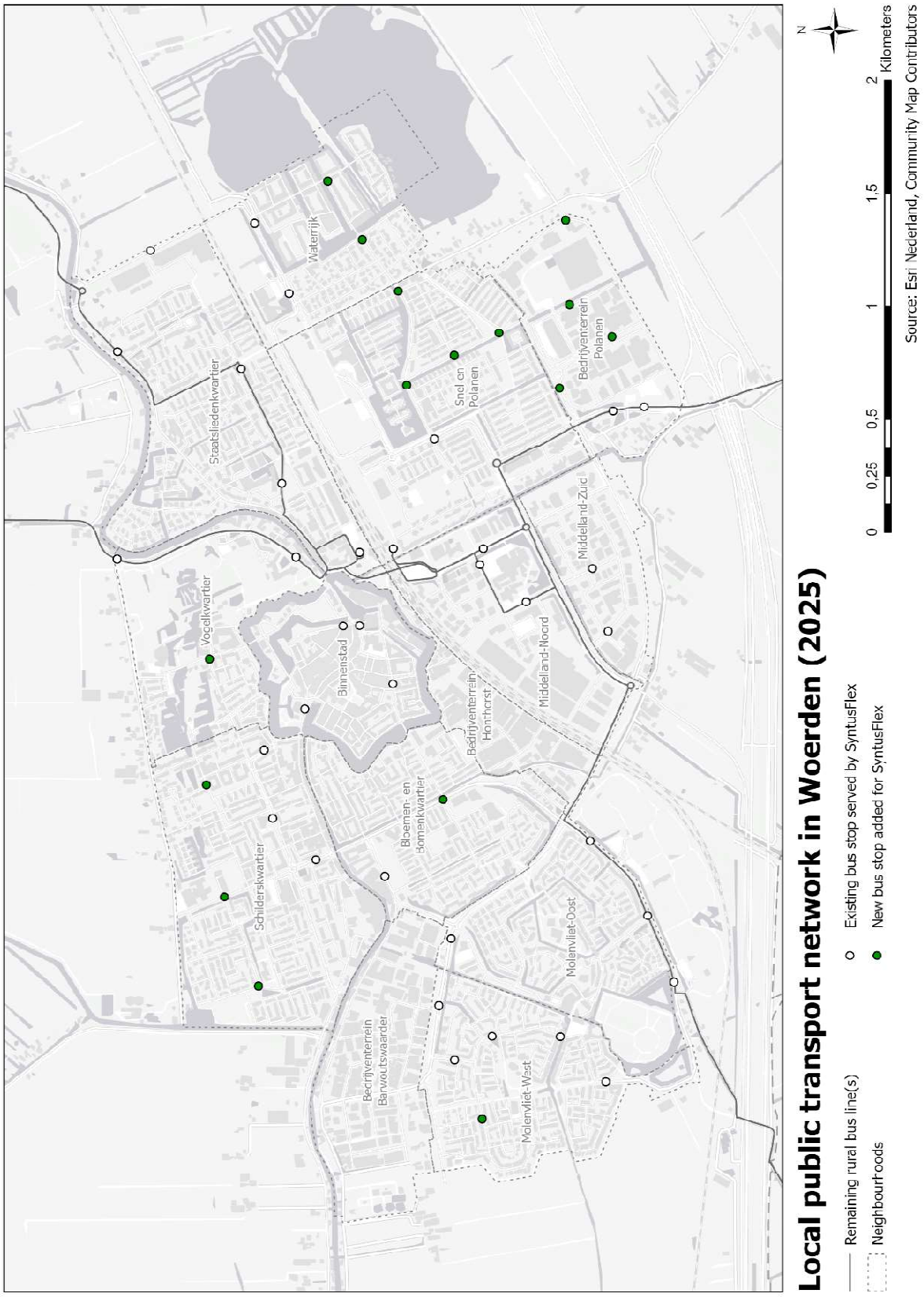

Figure 14

Service area of 400 metres for all bus stops in Weert.

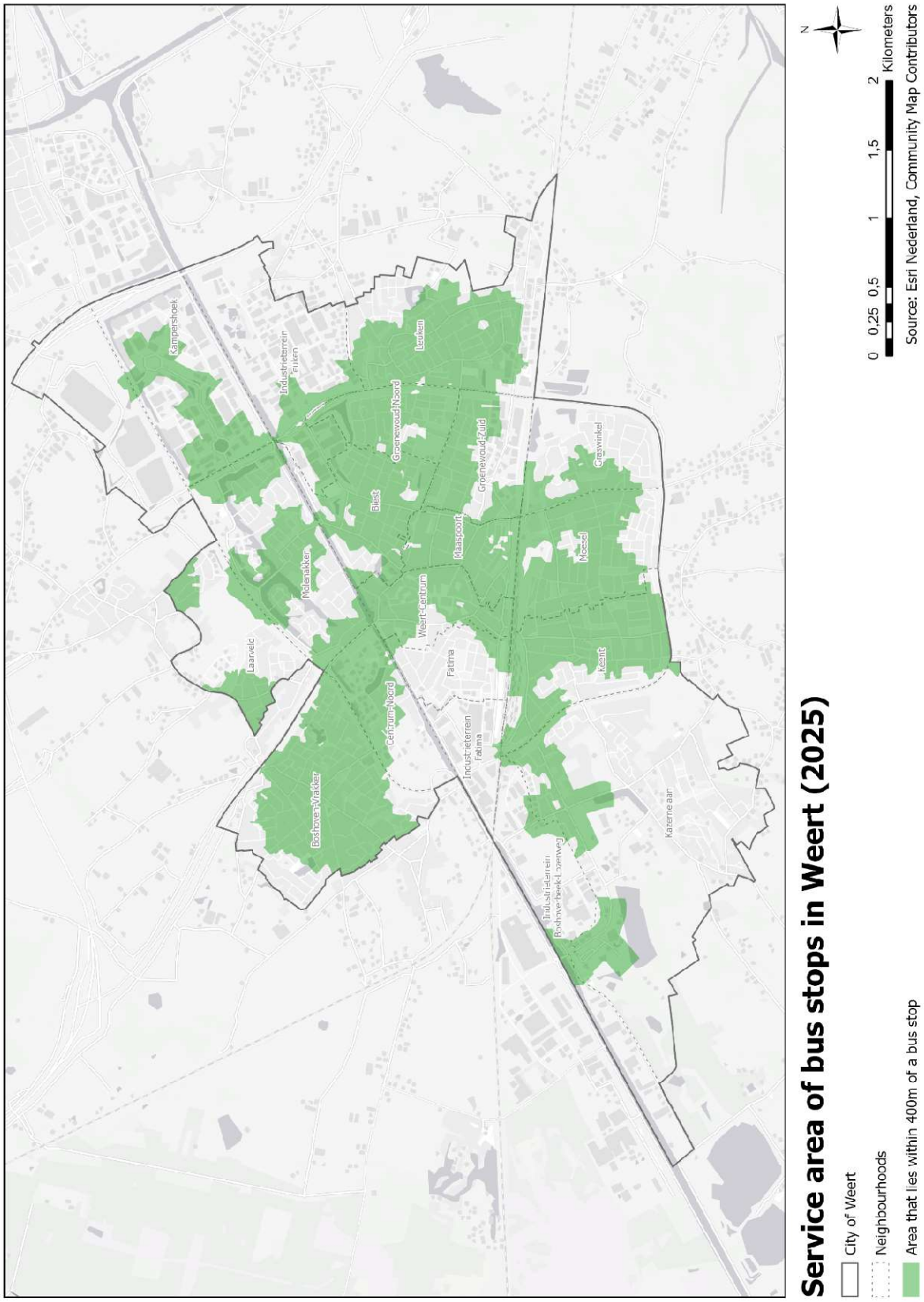

Figure 15

Service area of 400 metres for all bus stops in Woerden, before and after the introduction of the SyntusFlex DRT system.

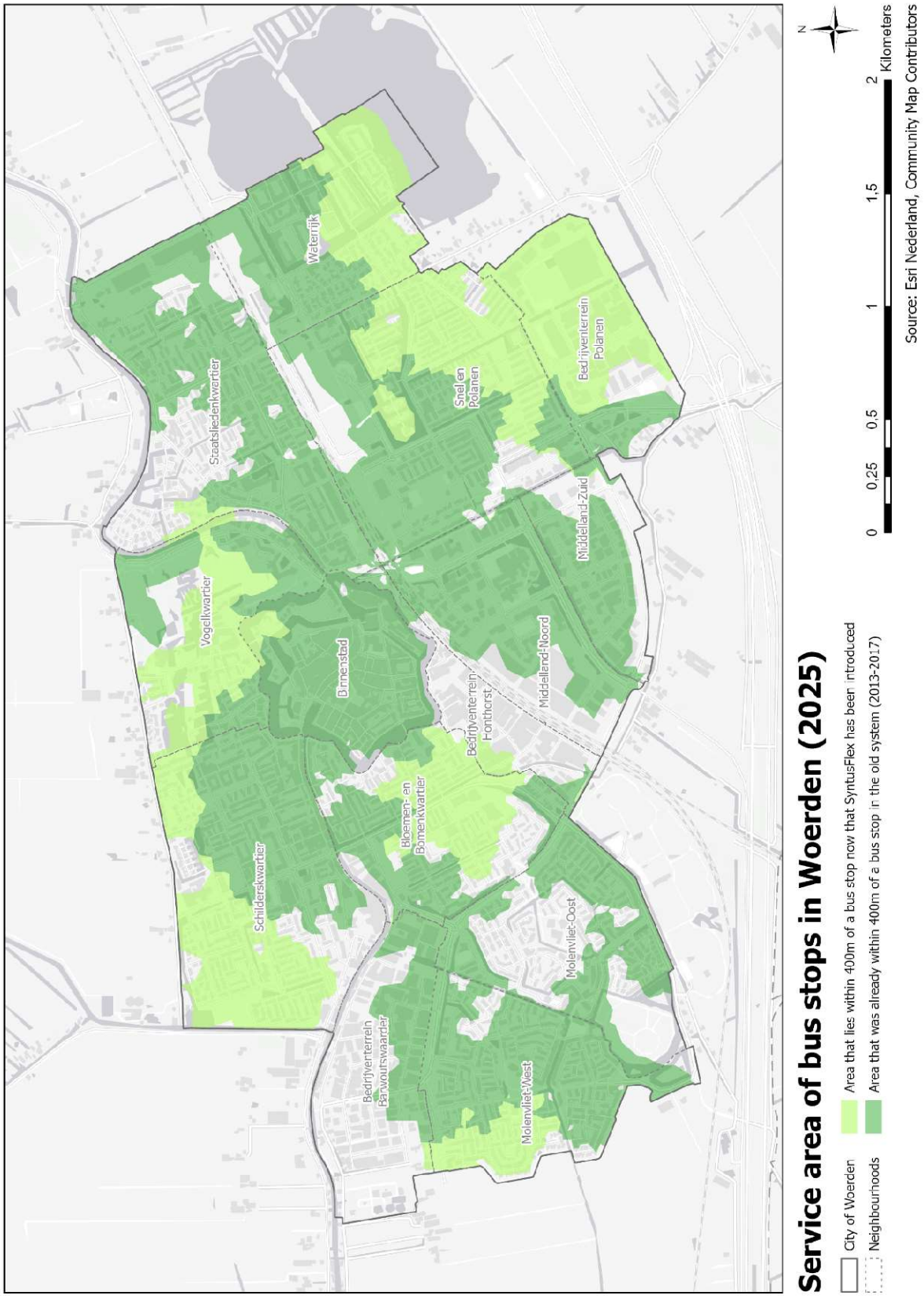

Figure 16

Total number of trips made with the SyntusFlex DRT system within the city of Woerden in March 2024 by bus stop.