

Sustainable mobility and mobility flow within Gelderland

A study explaining mobility flow through individual travel behavior and the perception of sustainable mobility in the spatial context



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Image cover page

Provincie Gelderland (2020) *Visie voor een bereikbaar Gelderland*

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Sustainable mobility and mobility flow within Gelderland: A study explaining mobility flow through individual travel behavior and the perception of sustainable mobility in the spatial context

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Summary

Mobility is a crucial aspect of modern society, affecting many of our daily activities. In the province of Gelderland, the rising number of people using the mobility network has led to increased congestion. This heightened mobility also has adverse environmental impacts. As concerns about the environmental and social effects of current mobility systems and spatial pressures grow, there is a pressing need to transition to more sustainable modes of transport. Despite this, cars remain the primary mode of transportation for most people. Mobility patterns are largely driven by daily commuting, with the interplay between residential and workplace locations shaping travel behaviors. To reduce environmental impact and enhance mobility flow, a shift towards sustainable transportation options may be necessary. This research seeks to understand how individual travel behavior and perceptions of sustainable mobility influence mobility flow. Thus, the research question is: *“How do individual travel behavior of residents and their perception on sustainable mobility, shape the mobility flow within the Province of Gelderland?”*. To prepare for the research, relevant theories and frameworks related to individual travel behavior, sustainable mobility, and mobility flow were reviewed to develop a conceptual model. The primary research method utilizes a framework derived from the literature and applied to the case of Gelderland. Additionally, a policy study on mobility practices in the Province of Gelderland was conducted to gain a comprehensive understanding of the area. The conceptual framework evaluates indicators of individual travel behavior and perceptions of sustainable mobility, elucidating how these factors interact with and influence mobility flow. The study initially analyzed both quantitative – and qualitative data from a broad survey of travelers, followed by the collection of context-specific, qualitative data through interviews with individual travelers. This approach results in a mixed-methods case study design.

Analysis shows that travel modes vary significantly based on socio-economic and demographic factors, as well as the physical environment, including infrastructure, weather, landscape, and climate. Subjective norms, personal attitudes, and habits also influence travel behavior. Sustainability impacts travel behavior both directly and indirectly, affecting overall mobility flow in Gelderland. To understand how travel behavior and perceptions of sustainable mobility shape this flow, it's crucial to examine their interplay. Survey results indicate that travel time, weather, climate, and accessibility are key indicators affecting travel behavior and, consequently, sustainable mobility and mobility flow. Additionally, factors like travel distance, delays, costs, residency, safety, and integration are important determinants.

When choosing a travel mode, individuals consider factors such as travel time, distance, delays, and costs. While cars have certain advantages, shifting social attitudes and improvements in infrastructure can enhance the efficiency and accessibility of sustainable transport, positively affecting overall mobility flow. Individual travel behavior, sustainable mobility, and mobility flow are closely connected. Travel choices influence and are influenced by sustainable mobility trends and transportation network efficiency, impacting accessibility, efficiency, safety, and integration, which in turn affect the mobility flow within Gelderland. Mobility flow factors in their turn influence individual travel decisions and perceptions of sustainable mobility.

Preface

I am pleased to present my Master's thesis, which marks the culmination of my Spatial Planning degree. This study, focused on sustainable mobility, reflects the progress I have made as a spatial planner and academic throughout both my Master's and Bachelor's programs at the Radboud University in Nijmegen. The diverse range of courses and perspectives offered in both my Bachelor's and Master's programs particularly inspired me to focus on mobility for my thesis.

The unexpected final months of my student program significantly impacted the conclusion of my academic journey, including my thesis process and the decision to forego an internship. Many hours of writing and research, originally intended to be completed during designated study periods, were instead managed alongside internship responsibilities. The resulting distractions and challenges extended the process beyond my initial expectations.

Despite these challenges, this period has been highly educational and insightful. I had limited prior experience with many of the theories used in this study. While I was familiar with research methods like surveys and interviews, they offered new experiences distinct from those in my previous academic work and proved to be immensely rewarding. I am deeply grateful for the guidance of my supervisor, Ary Samsura, whose steadfast support and valuable feedback were crucial throughout this process. Additionally, I want to thank my supervisor and my colleagues from the Mobility Department within the Province of Gelderland, who, through my internship, provided me with essential knowledge and learning opportunities.

Lastly, I want to extend my heartfelt thanks to all of my friends, family, and especially my parents, who provided crucial support during this entire time. Without their support I wouldn't have been able to conclude my academic journey.

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Chapter 1: Introduction

1.1 Contextual background and problem statement

The pressure on the housing market has increased drastically over the last few years, causing a huge housing shortage in the Netherlands (Ministry of Binnenlandse Zaken en Koninkrijksrelaties, 2024). Due to the housing shortage, governments on national, regional, and local level are looking at various locations to provide more houses. It is difficult to sum up all developments on the Dutch housing market, especially when looking at the geographical context. On the one hand the housing market is dominated by the discussion about the shortage in house production. On the other hand, there is a discussion regarding the nature of what is produced and what people want. Both problems have an issue concerning the spatial distribution: wanted numbers and types of houses and locations do not correspond enough with how much, what, and where is developed and built (Pellenbarg & Van Steen, 2005). As the demand for new houses rises, new housing areas are being developed on vacant properties in rural areas, but also in highly urbanized areas (BPD, 2024). In Gelderland, several projects are planned to coordinate the development of new housing areas within cities as well as in rural areas (Provincie Gelderland, 2024). For example, Nijmegen is planning to develop 12.500 new houses within the city (Gemeente Nijmegen, 2024) while the municipalities of Ermelo, Harderwijk, Putten and Zeewolde are expecting to develop new housing areas in the rural area (Provincie Gelderland et al., 2023). Brueckner (2000) describes that excessive suburbanization contributes to the decay of central cities by reducing the incentive to redevelop land near the center. Therefore, the Netherlands as well as many other countries in Europe have developed land-use policies for growth management, aimed at the prevention for urban sprawl (Rietveld & Wagtendonk, 2004). And because housing policies in the Netherlands consist of a mixture of national, regional, and local policies (Priemus, 2004), different perspectives are taken into account. And thus, in the Netherlands visions are drafted which describe the social tasks and the core qualities to be protected by a municipality or province (Rijksoverheid, 2023). In these visions, numerous interests are weighed up and approached in an integral manner. This way the local and regional governmental bodies give a long-term vision and development plan (*uitvoeringsagenda*) on the future of an area. These visions contemplate four priority tasks: sustainable economic growing potential, space for climate change and the energy transition, a strong and sustainable city for living, working and travel, and a future-proof sustainable development of the land (Rijksoverheid, 2023). A concept that gains the attention of governments is that of sustainability or sustainable development.

The concept of sustainable development has been widely accepted throughout the years. The understanding of the definition for this concept is diverse among different global perspectives. The World Commission on Environment and Development (1987) defined sustainable development within the Brundtland rapport as ‘development that meets the needs of the present without infesting the needs of future generations’. It emphasizes the intergenerational aspect of sustainability and the equilibration between economic, social, and environmental contemplations. The concept of sustainable development consists of two essential understandings. Namely, sustainability, which

explores the compromising of future generations to meet their own needs; and development, which explains the development that meets the needs of the present (Hák et al., 2016).

The spatial structure of the housing market and new housing areas has presented several issues concerning mobility (Aalbers, 2003). Mobility is a key element of modern-day society. It concerns many daily activities in our lives. In cities, urban mobility is essential for the operational capacity of the city. The last couple of years, more distance has been covered by individuals and it is expected that this will only increase in the nearby future (Werland, 2020). As a result of new housing areas and an increase of residents, mobility congestions arise. The increased level of mobility also has negative consequences for the environment. In 2022, around 30% of CO₂ emissions in the Netherlands was caused by motorized traffic (Rijksoverheid, 2024). As concerns over negative environmental and social impacts of current (urban) mobility systems and spatial pressures increase, more and more governments are therefore seeking to facilitate a transition to sustainable mobility, relating to sustainable development of housing (Loorbach et al., 2021). Most cities still make use of car-based structures within the city instead of focusing on other sustainable mobility ways (Loorbach et al., 2021). Cars are still the main way of transport for most individuals. Research shows that around 50-60% of travelers used the car as a mode of transport in 2015 (Jorritsma et al., 2015). NOS News describes that this use of cars has continued to increase in 2023 and 2024 (Klein, 2024), resulting in more congestion, as can be seen in *Figure 1.1*.

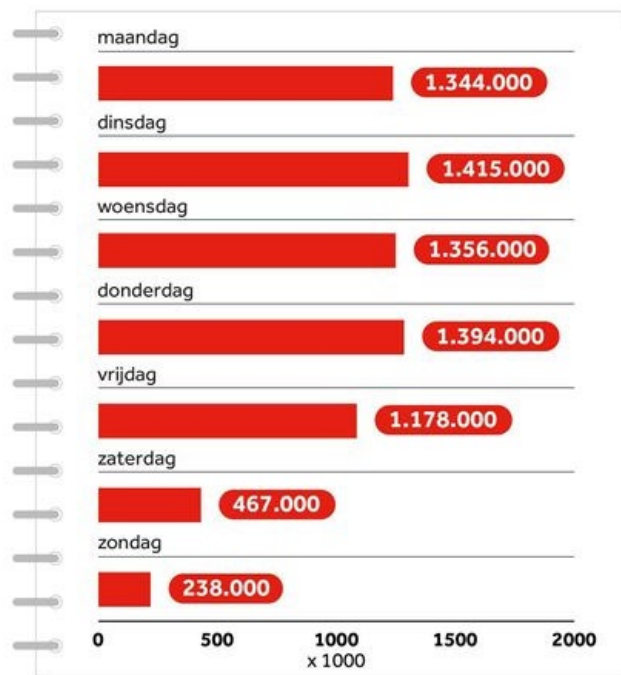


Figure 1.1: Morning rush hour per day of the week (Source: NOS Nieuws, 2024).

Mobility patterns are mostly driven by daily commuting, meaning that the combination of living and working defines the travel pattern of individuals. It is this combination that explains the mobility congestion for the biggest part (Klein, 2024). Reducing the environmental footprint and increasing mobility flow would require a shift to more sustainable modes of transportation.

The Netherlands is currently experiencing a sustainability transition, in which they plan to be carbon neutral by 2050 (Rijksdienst voor Ondernemend Nederland, 2024). The Province of Gelderland has stated that due to the high mobility congestion on (high)ways, it is focused on more accessibility within the whole province. In combination with the sustainability transition, the Province of Gelderland is focusing on traveling faster, smarter, greener, and more sustainable to cope with the number of movements within the area (Provincie Gelderland, 2024). This mobility transition does not only concern the technological and economical aspects, but it also contemplates the changes of dominant mobility discourses present in that area. Living in a big city tends to be characterized by shorter commutes and thus creating an atmosphere suited for other sustainable ways for mobility (Punzo et al., 2022). Cities are however often subject to institutional changes and various policies. In general, as various governmental bodies are often involved in transport or mobility decisions, the different authorities must frame a policy to deliver an appealing and interconnected transport system, as well as to encourage people to make more sustainable mobility choices (Punzo et al., 2022). Transition in the Netherlands is mostly happening via technological or organizational innovation (Farla et al., 2010). Little attention is given to institutional change and behavioral change of individuals' travel modes. It is therefore important to look at how individuals commute.

Therefrom, it is important to investigate travel behavior present amongst individual residents. There are various factors that influence travel behavior. One could distinguish general characteristics, such as age, gender, income, education, and so forth. Then there are fixed characteristics, such as the built environment which refers to the city's spatial structure or infrastructure (Werland, 2020). But there are also factors which influence individual travel behavior through social institutions. Discourses which are shaped through the spatial and social context can determine travel behavior with regard to sustainable mobility. Thus, research on how individual travelers look upon sustainable mobility or sustainable modes of travel should be done in order to analyze whether it is even possible to change towards a sustainable way of mobility. Furthermore, it should be investigated how the mobility flow is shaped. What factors contribute to this and how do different travel modes shape the mobility flow. Consequently, this study tries to investigate how social institutions or discourses among individual residents towards sustainable mobility shape the mobility flow. It does so by focusing on the case of the Province of Gelderland. In this specific context, this research attempts to analyze how the mobility flow is shaped. It investigates to what extent individual travel behavior and the perception on sustainable mobility among residents influences the mobility flow within the province. By investigating the relationship between these concepts or factors, this research attempts to explain the current mobility flow within the spatial context.

1.2 Research aim and research questions

The goal of this research is exploratory in its essence, motivated by the necessity to understand the factors influencing individual travel behavior within the context of the sustainable mobility transition, and how it influences the flow of mobility. Shedding light on this overlooked aspect presents an opportunity for the Province of Gelderland, as well as potentially other governmental bodies, to understand the potential for

sustainable mobility intertwined with social, cultural, economic, and spatial factors influencing individual travel behavior. To fulfill the research objectives outlined above, this study is structured around one main research question accompanied by four subsidiary questions. The primary research question is articulated as follows:

How do individual travel behavior of residents and their perception on sustainable mobility, shape the mobility flow within the Province of Gelderland?

In order to answer this research question, the sub-questions are the following:

- 1) *How is the mobility flow within the Province of Gelderland shaped?*
- 2) *To what extent does individual travel behavior of residents influence the mobility flow within the Province of Gelderland?*
- 3) *To what extent does the perception on sustainable mobility of residents influence the mobility flow within the Province of Gelderland?*
- 4) *What is the relationship between individual travel behavior and perceptions on sustainable mobility from residents in explaining the mobility flow in the Province of Gelderland?*

1.3 Relevance of the research

In this paragraph, there will be a more detailed exploration into the significance, distinguishing between the scientific and societal relevance of the research.

1.3.1 Societal relevance

With climate goals set by the Dutch government, sustainable mobility is increasingly taking center stage on the political and societal agendas. Mobility stands out as a major contributor to climate change, and it is unavoidable that the shift to more sustainable mobility presents a solution (Banister, 2008). Furthermore, sustainable mobility addresses the issue of dwindling public space in urban areas. With urban populations swelling, conventional urban mobility patterns would lead to increased pressure on the infrastructure network (Loorbach et al., 2021). Sustainable mobility would therefore not only contribute to less air pollution, but it would also release pressure on the mobility network. Promoting sustainable mobility would reduce car presence which could affect the attractiveness of cities. Even in the Netherlands where sustainable mobility is increasingly becoming an important way of transport, a significant amount of urban mobility remains based on car use, making it less sustainable. So, there is still a lot of room for improvement.

Considering the advantages it's logical that governmental bodies are increasingly prioritizing sustainable mobility in their mobility strategies. While enhancing infrastructure for sustainable mobility is becoming priority for government and cities, it is important to look at the individuals that are to make use of these mobility or transportation networks. Assessing individual travel behavior, especially how these individuals look at sustainable ways of travel in relation to car use, is therefore crucial in the transition towards sustainable mobility. Thus, this research holds relevance for policymakers by offering detailed insights into the social support among society regarding sustainable mobility and to identify whether it can offer solutions to the mobility flow.

1.3.2 Scientific relevance

The concept of sustainability is not new within existing literature and research concerning mobility. It has been researched extensively throughout the years (Loorbach et al., 2021; Holden et al., 2019; Ettema et al., 2016). The research has mostly been focused on governance practices and there is even literature available on citizen participation and social discourses that shape the spatial context (Clement, 2010). However, little research has been done on what influence these discourses or social institutions have on the transition towards sustainable mobility. The research of individual travel behavior on the local scale is often underrepresented in mobility research (Day, 1997; Martinez, 2011). And even more underrepresented in the literature, is whether the perception of individuals on sustainable mobility has an influence on the mobility flow.

And therefore, as most studies often overlook the influence of social institutions and discourses, the scientific significance of the research outlined here lies in its exploration of the individual dimension within mobility discourses prevalent in society, particularly regarding mobility flow within spatial contexts. Moreover, it examines innovation frameworks and the governance role within networks.

The core of this scientific relevance lies in understanding the mobility transition from the perspective of individual travel choices and behaviors. While theories like the socio-technical system perspective emphasize the link between individual behavior and technological advancements (Geels, 2019; Graham et al., 2003), they often overlook the significance of social and cultural networks. Geels (2005) states that transitions in the past have shown that a transition in a socio-technical system takes a generation or even more than one to become successful, due to the underrepresentation of those which encounter changes. Additionally, theories on mobility flow frequently disregard various determinants concerning individuals shaping transportation decisions. Since transitions typically require entire societies for success, it's crucial to pay attention to the role of behavior in mobility choices. This understanding can aid in supporting transitions effectively, including at higher levels of governance.

1.4 Reading guide

In this chapter, the primary focus of the research has been unveiled, accompanied by an exploration of its scientific and societal significance and their nuances. This clarification reinforces and substantiates the research questions and objectives, paving the way for addressing the problem statement. Subsequently, the second chapter provides the theoretical framework necessary to analyze the dynamics of the mobility transition. Here, more relevant concepts and theories regarding sustainable mobility, mobility flow, and individual travel behavior are examined as part of the structure in this research. Chapter three elaborates on the strategy and research methods, providing detailed insights into the execution of the research. Following this, chapter four presents the case study on the Province of Gelderland. In chapter five this research shows its findings, while chapter six encompasses the conclusion and chapter seven the discussion where recommendations are provided, and the research is critically reflected upon.

Chapter 2: Theoretical framework

This chapter serves to introduce and explore the fundamental concepts and theories pivotal to this thesis. It begins with a literature review delineating theories on mobility flow. Thereafter the concept of sustainable mobility is explained, and different modes of travel are distinguished. Furthermore, perception on sustainability of citizens or individuals is elucidated through the socio-technical approach and the theory on transition management. Then, determinants of individual behavior regarding mobility are reviewed. That review is structured into two primary segments: physical environmental factors, which include both built and natural environments along with trip characteristics, and individual aspects. The latter section is additionally subdivided into population characteristics, including socio-economic status and demography, and perception of the environment, which encompasses the psychological factors influencing travel behavior. Finally, the chapter concludes by presenting a conceptual framework of the research as well as an operationalization of this framework, providing a visual representation of its structure and components.

2.1 Mobility flow

Urban mobility is an important everyday life practice that produces meaning and culture (Jensen, 2009). Creswell (2006) makes a fundamental distinction in seeing mobility through the lens of place, roots, spatial order and belonging which he calls sedentary. Opposed to this is the nomad conception of mobility, which describes the optics that are related to a focus on flow, flux, and dynamism (Creswell, 2006). These two are interrelated and affect each other on the local level as well as on the regional or national level. Flows influence the practices, experiences, and perceptions of place, subjectivity, and identity (Kellermann, 2006). Which means that human individual behavior influences flows, but mobility discourses shape the travel behavior that is rooted within individuals. So, when looking at using the car, it is highly related to social institutions among individuals that make use of this transport or travel mode. Changing mobility networks therefore cause changes in mobility patterns. Furthermore, the discussion of any potential meaningful interaction within mobility and mobility infrastructures or services is thus facing rather severe cultural resistance (Jensen, 2009). Mobility flow typically refers to the ease and efficiency of movement within a system or environment (Astero et al., 2022). It encompasses the movement of people, goods, or information within a certain environment.

Places are to some extent formed through mobility patterns, as the spatial organization of housing is amongst others being defined by the way residents move (Louf & Barthelemy, 2014). Mobility patterns are mostly driven by daily commuting, meaning that the combination of living and working defines the travel pattern of individuals. It is this combination that explains mobility congestion for the biggest part (Klein, 2024). Louf and Barthelemy (2014) state that it is clear that living in various smaller cities rather than big agglomerations would increase the mobility flow. The new urban renewal and housing development in the Netherlands seem to be targeted at the prevention of spatial segregation and aims to connect places whilst providing better accessibility through the use of regulations and rules (Uitermark, 2003). However, the spatial structure of new housing areas almost always brings up issues concerning mobility and

travel (Aalbers, 2003). Moreover, providing good accessibility between places is complicated, especially between highly urbanized density areas and the more rural areas, as requirements for travel modes have increased and continue to do so (Rietveld & Wagtendonk, 2004).

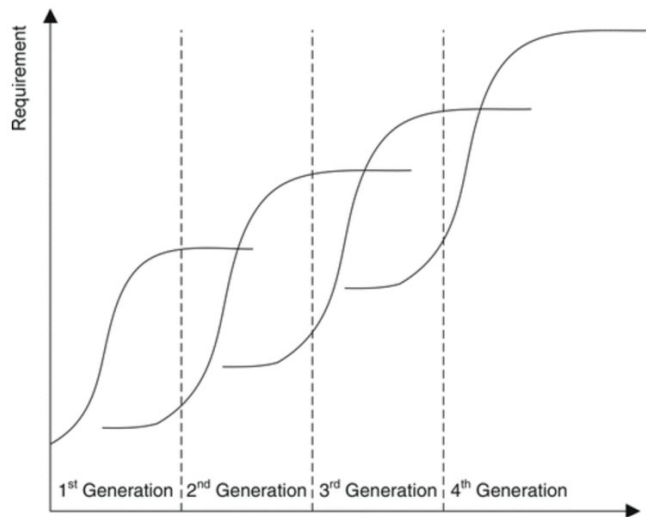


Figure 2.1: Requirements per generation for mobility networks (Mitchell Hess et al., 2001).

David et al. (2014) describes five key elements of mobility flow: efficiency, accessibility, safety, sustainability, and integration. Efficiency refers to the notion that it seeks to minimize friction, delays, and disruptions in movement. It aims to optimize travel or transport from one point to another with the least amount of effort (David et al., 2014). It can be measured in time, cost, energy, resources, and so forth. Accessibility emphasizes that transportation or travel networks and infrastructure should be accessible to all individuals (David et al., 2014). Safety refers to ensuring that travel is secure. Mobility flow aims to be sustainable, meeting current transportation or travel needs without compromising the ability of future generations to meet their own (David et al., 2014; Maldonado Silveira Alonso Munhoz et al., 2020). Environmentally friendly modes of transportation are becoming increasingly important (Loorbach et al., 2021). The concept of integration emphasizes the integration of different transportation or travel modes into a cohesive network, which includes facilitating connection between modes (Astero et al., 2022).

Various drivers of mobility flow can be distinguished. Some common drivers include infrastructure network, technology, urban planning and land use, economic factors, demographic factors, environmental concerns, and policy and regulation (Marchesani et al., 2023). Infrastructure refers to the quality and design of the transportation network. Technological advancements influence mobility flow by providing more efficient routes, reducing congestion, and improving transportation systems (Marchesani et al., 2023; Maldonado Silveira Alonso Munhoz et al., 2020). The layout of cities, zoning regulations, and land-use policies can impact mobility flow. Compact, mixed-use development that encourages walking, cycling, and public transit can promote better mobility flow compared to sprawling, car-dependent developments (Boffi & Colleoni, 2016). Economic conditions can influence travel behavior and mobility flow. For example, access to affordable housing near employment centers can reduce commute times and

improve mobility flow. Demographic factors such as age and household compositions can influence mobility flow, as there are different transportation needs for various individuals. Government policies and regulations, including transportation planning, funding allocations, traffic laws, and environmental standards, can shape mobility flow by influencing investment decisions, mode choices, and travel behavior (Boffi & Colleoni, 2016; Marchesani et al., 2023).

Mobility flow can be measured in different ways, depending on the context. It can be measured by using the number of travelers passing by or traveling from point A to B (Furletti et al., 2014). Or it can be measured by the time it takes travelers to go from one point to another. There are several ways to gathering data for mobility flow analysis. First, one can use traffic counts which require physically counting the number of vehicles passing through a specific point, providing quantitative data on traffic volume (Furletti et al., 2014). Next, there is public data available on transportation/travel via agencies that research the number of passengers, boarding, and frequency of services being used (Furukawa et al., 2011; Furletti et al., 2014). Furthermore, there are crowdsourced data platforms, mobile apps, surveillance cameras, and smart infrastructure sensors that provide data on mobility flow and travelers passing by (Furukawa et al., 2011). When a researcher tries to analyze mobility patterns, preferences, and behaviors in a specific area or on a specific theme, surveys and interviews most often give the best qualitative (also sometimes quantitative) data (Andrienko et al., 2016). Measuring mobility flow refers to the measure of outgoing and incoming links, and in the extreme, a flow situation is a complete graph where each location is linked with every other location (Andrienko et al., 2016). However, simplifying research on mobility flow, researching the spatial flow can offer solutions. It corresponds with time interval, showing the time individuals take to travel from one node (spatial location) to another (Andrienko et al., 2016). The number of these nodes are taken for individuals that travel there and then they are compared to the average weighted time in that area. Moreover, spatial flow can be linked to the element one is researching. Showing the difference between choices made in travel modes, such as sustainable modes of transport and cars, can explain difference in measured sets. In this research, the spatial flow situation will be used in order to measure mobility flow for certain individuals.

2.2 Sustainable mobility

The Dutch transportation system suffers from a number of serious problems, such as emissions, congestion, and accidents for some time now (Farla et al., 2010). As concerns over negative environmental and social impacts of current urban mobility systems and spatial pressures increase, more and more governments are seeking to facilitate a transition to sustainable mobility (Loorbach et al., 2021). However, the intergenerational aspect of sustainability and the equilibration between economic, social, and environmental aspects presents complications (Fujita et al., 1999).

2.2.1 Explaining sustainable mobility

Sustainable mobility can be linked to the concept of sustainable development, which consists of two essential understandings. Namely, sustainability, which explores the compromising of future generations to meet their own needs, and development, which

explains the development that meets the needs of the present (Hák et al., 2016). There has been a plethora of studies on the sustainability of mobility, which encompasses the focus of policies, theories, approaches, and so forth. Holden et al. (2019) show that from 1992 the research and policy focus has changed; it shows a learning from previous generations. *Figure 2.2* shows that sustainable mobility research contemplates various social, economic, and political dimensions.

Dimension	First Generation [1992–1993]	Second Generation [1993–2000]	Third Generation [2000–2010]	Fourth Generation [2010–2018]
Research and (EU) policy focus	limit transport volume	Reduction in transport intensity	+ congestion, equity, competitiveness	+ decarbonisation
Transport's impacts (i.e., sustainability)	environmental impact	+ societal impact (Quality of life)	+ economic impact, accessibility, distribution	all dimensions of sustainability
Travel categories (i.e., mobility)	production travel (work)	+ reproduction travel (non-work travel by car)	+ leisure-time travel (including long-distance travel by car and plane)	+ shared mobility, autonomous driving and electromobility
Scientific disciplines	environmental engineering, planning, transport geography, transport economy	+ sociology	+ psychology, social psychology, anthropology, political science, history, public health (interdisciplinary)	+ innovation studies, sustainability transitions
Methodological approaches [and theories]	environmental impact assessment, quantitative modelling, regression analysis	+ qualitative analysis (scenario building, scenario analysis?)	+ case studies, in-depth interviews, qualitative modelling, institutional analysis, historical interpretive analysis	+ Multilevel Perspective (MLP), Technological Innovation Systems (TIS), big data
Types of research questions	How to increase the efficiency of different modes of transport?	+ How to manage traffic demand?	+ What are the different actors' motivation, opportunities, and abilities to change?	+ How to create synergies between environmental effects and the wider social implications on health and inequality?

'+' indicates that the focus of the previous generation is broadened to include the marked item.

Figure 2.2: Four generations of studies on sustainable mobility (Holden, 2007; Holden et al., 2019).

Research and policies have shifted from predominantly focusing on environmental impacts, towards a broader view which include societal and economic impacts (Holden et al., 2019). The research on sustainable mobility has eventually led to a change in the demarcation of the concept of sustainable mobility. With technological innovations, more knowledge available and changing political circumstances, changes on the level of travel categories have occurred. Sustainable mobility now relates to all sorts of travel, production- and leisure-time travel (Vilhelmson, 1990). Sustainable transportation involves transportation methods that prioritize both social equality and environmental stewardship. More modes of travel have become available, resulting in more ways to strive for sustainable mobility.

The Ministry of Infrastructure and Water Management has started a new approach to accessibility. Citizens must be able to travel from A to B quickly, easily, and comfortably; modern technologies can make transport safer, smoother, and cleaner (Rijksoverheid, 2024). With this, the Dutch government is transitioning towards not only sustainable urban development, but towards a more sustainable mobility network (Ministry of IENW, 2018). This transition focuses on more sustainable urban planning and makes use of sustainable urban mobility plans' (SUMPs). The definition of SUMPs is also aligned with the wider definition of sustainable mobility, which itself relates to the wide range of measures, public involvement and - information, spanning policy boundaries, and demand management (Bannister, 2008; Wolek, 2014). The SUMP framework draws upon good practices in urban areas or cities, national documents or policies, and underpinning research on the barriers to effective planning and on ways of overcoming them (May, 2015; Arsenio et al., 2016).

The SUMP framework describes which elements and activities should take place when implementing new mobility policies or plans (ELTISplus, 2014). The SUMP cycle exists to provide a framework that can define key stakeholders and important actors in order to look beyond only governmental influences (May, 2015). Moreover, active involvement from the public, and actively informing and engaging the public are part of the designed SUMP cycle. However, it is often the case that the public is not involved in urban mobility planning, even though governmental bodies strive for it (Aldred et al., 2019). Thus, presenting an issue in mobility innovation and planning. But as Holden et al. (2019) state:

To go to the very root of the problem—human behavior’, and that doing so requires ‘fundamental changes in human values towards the environment and in patterns of behavior and consumption’.

It is not only the technical issues that present problems, but also the means by which options can be debated with and accepted by the many interested parties (Holden et al., 2019).

2.2.2 Modes of travel

Shifting towards more sustainable modes of transportation is essential for reducing the environmental impact of mobility. Sustainable mobility, often linked with technological advancements and new transportation methods, encompasses innovations like electric or hydrogen-powered cars, green gas-fueled buses, and mobility services related to public transport (Holden et al., 2019). While these innovations play a role, sustainable mobility isn't solely reliant on technology. Active mobility, which includes walking, cycling, and other physically powered modes of transportation, represents a fundamental aspect of sustainable transport. There are various transportation or travel modes which can be distinguished. Key distinguished modes of travel are the use of private motorized vehicles (cars), public transport (train, bus, tram, metro, ferries, trolleybus), and active mobility (cycling, walking). Shared mobility is also considered to provide a more sustainable option than private car use.

Cars (or private motorized vehicles)

The car is still the most used transportation or travel mode. Research shows that around 50-60% of travelers use the car as a mode of transport (Jorritsma et al., 2015). Hagman (2003) explains that the car makes one independent of other means of transport. The use of the car is convenient, allowing people to travel whenever and wherever they want, without relying on other factors. Traveling in the car is therefore also perceived as more flexible, and the car is also perceived as more comfortable for travelers (Hagman, 2003). Using the car makes for travelers to feel safer and to not suffer from weather conditions. The car provides better accessibility, as cars can take you places where public transport might not reach or where it would take public transport a lot longer to take (Hagman, 2003). However, the use of cars offers issues concerning environmental impacts where they contribute to air and noise pollution, as well as greenhouse emissions (Brown, 2017; Loorbach et al., 2021). Cars also cause traffic congestion, especially in urban areas and cars can present safety risks, as car accidents are a leading cause of injury and death (Hagman, 2003; Brown, 2017; Provincie Gelderland, 2020). Reliance on cars

can lead to reduced physical activity. Therefore, car users can suffer from health issues, and it makes communities less resilient to changes in the physical environment (Hagman, 2003).

Public transport

Moreover, there is the increasingly used mode of travel in public transport. Public transport is in most cases more cost-effective than owning and maintaining a private vehicle, especially in dense urban areas (Berg & Ihlström, 2019; Ceder, 2021). Public transport produces fewer greenhouse gas emissions compared to private vehicles, making it more environmentally friendly (Berg & Ihlström, 2019). Public transport also helps in reducing the traffic congestion, realizing a better traffic (or mobility) flow, and reducing travel times (Ceder, 2021). Public transport is generally safer than driving. Public transportation systems are crafted to cater to diverse communities, extending accessibility to individuals with restricted mobility or financial means (Unsworth et al., 2021). Ceder (2021) states that the rapid development of information and communication technology (ICT) modernizes the image of traditional transportation systems and opens the door to dispatch private vehicles whilst pursuing the goal of a well-connected public transport system. These technologies concerning public transport should include five layers of essential elements for having an impact on future urban transportation, according to Ceder (2021).

Social networking is essential to the emergence of alternative (public) transportation methods. Also, travel modes should be extensive and provide enough alternatives in the form of public transportation (Brown, 2017). Moreover, the design of transportation systems should consider various economic factors, such as effectiveness, efficiency, productivity, pricing, and equity (Ceder, 2021). Lastly, the integration of public transport elements and planning processes can produce more advanced, attractive, and reliable services (Brown, 2017; Ceder, 2021).

Public transport does, however, offer some limitations and disadvantages. Public transportation systems might offer limited reach in rural or suburban regions, with insufficient service frequency resulting in prolonged waiting periods and inconvenience for commuters (Berg & Ihlström, 2019; Unsworth et al., 2021). During peak hours, public transport vehicles can become overcrowded and public transport is perceived as less comfortable than private vehicles. Public transportation systems may experience delays and service interruptions (Unsworth et al., 2021). Travelers become highly dependent on schedules of public transportation systems, which may not align with their specific travel needs or preferences.

Active mobility

Active mobility presents several advantages compared to motorized alternatives. Primarily, it generates no detrimental emissions, distinguishing it from various motorized vehicles. Additionally, it enhances local environments by decreasing air pollution in urban settings, fostering cleaner and healthier surroundings (Nalmpantis et al., 2021). Apart from its environmental advantages, walking and cycling also bolster physical and mental well-being. Investments in high quality cycling and walking can help to create transport systems in which people can travel safely in order to create a more

sustainable way of urban mobility (Aldred et al., 2019). Cycling interventions and policies can be highly cost-effective, providing not only transport benefits, but also health, business, and social benefits (Jensen et al., 2013). And as research shows, investments in cycling infrastructure are cheap compared to those of main road upgrades (Aldred et al., 2019). Moreover, active mobility has proven to have a positive effect on mental well-being, reducing stress, anxiety, and depression (Koszowski et al., 2019). Active mobility can foster more interaction with the local community, giving a better sense of belonging. Though, active mobility can pose safety risks, particularly in areas with insufficient infrastructure for pedestrians and cyclists (Aldred et al., 2019). Moreover, active mobility is often weather-dependent. Unfavorable weather conditions can result in people increasingly relying on motorized transportation (Hagman, 2003). Walking and cycling are more typically slower modes of transportation compared to other options. For longer travels, making use of active mobility is less practical. Active mobility also offers some physical limitations due to factors such as age, disability, or health conditions (Azuh et al., 2016). Also, cyclists need secure storages for their bicycles, particularly in urban areas. Limited availability of storage facilities and the risk of thievery can deter people from using the bicycle, leading to increased use of motorized vehicles (Aldred et al., 2019; Nalmpantis et al., 2021).

Shared mobility

Lastly, a more sustainable way of travel is that of shared mobility. Shared mobility services can help reducing traffic congestion, as there are fewer vehicles on the road (Provincie Gelderland, 2020; Provincie Gelderland, 2024). Furthermore, shared mobility services often offer cost-effective alternatives to private ownership, avoiding certain expenses (Machado et al., 2018). Shared mobility leads to more efficient use of vehicles, leading to reduced emissions which can contribute to improved air quality and reduced environmental impact (Provincie Gelderland, 2020; Machado et al., 2018). Shared mobility services can improve access for individuals who are not in possession of an own vehicle or who have limited access to public transportation systems (Narayanan & Antoniou, 2023). Shared mobility can prove to be more convenient than public transport. Shared mobility services often offer more convenient booking, payment, and pickup options making it easier for users (Machado et al., 2018; Narayanan & Antoniou, 2023).

It might encounter issues concerning reliability and availability, especially during peak hours or in areas with low demand (Narayanan & Antoniou, 2023). Safety represents a significant apprehension with shared mobility services, notably in ridesharing scenarios where passengers travel with unfamiliar drivers. Shared mobility services may necessitate investments in infrastructure to bolster operations, such as designated pickup and drop-off points, charging stations for electric vehicles, and dedicated bike lanes for bike-sharing initiatives (Machado et al., 2018; Narayanan & Antoniou, 2023). Shared mobility may not be accessible to all layers of society or the community. Individuals with limited internet access, smartphones, or payment options could encounter issues.

2.2.3 Perceptions on sustainability

In order to discover what drives sustainable mobility choices among residents, it is important to look at how the mobility transition is steered by governance and what role residents, or civil society take in this. The term governance can be explained in different ways. It has been researched over the years what can be understood under terms relating to good governance (Grindle, 2007; Hawkins & Parkhurst, 2016). These researchers have tried to underline the mechanisms of governance and the way in which the different elements of governance interact. Governance processes often refer to the institutional processes and results from governmental actions (Grindle, 2007). Governance can be seen as a key figure in establishing societal well-being, which has become and will become more evident in the future (Grindle, 2007; Hawkins & Parhurst, 2016). Governance is therefore not to be mistaken with the concept of government. Governance is rather the active comprehensive policy of government (Hendriks, 2008). Good governance is very context dependent. To see if good governance is indeed applied to a specific situation, one must look at the interplay between actors. Meaning, one needs to analyze how power relations are structured and how they are applicable in the specific context (Graham et al., 2003).

Promoting sustainable mobility is most often initiated from governmental perspective and makes use of a more top-down approach (Bannister, 2008; May, 2015). The SUMP perspective implies that various levels of government are involved. There is evidence that innovation and/or transition towards more sustainable mobility often takes place within a complex institutional landscape where these different levels of government are influencing and supporting each other in pursuit of policy objectives (Bannister, 2008; Arsenio et al., 2016; May, 2015; Wolek, 2014). The concept of multi-level governance (MLG) has emerged as a conceptual approach to studying the development, implementation, effectiveness, and accountability of policies (Piattoni, 2010). Marsden and Rye (2010) state that policy making and implementing policies occur following a hierarchical set of government layers (international, national, regional, sub-regional, local). The MLG approach dismisses the assumptions that national government is the only dominant policy making unit. It recognizes that non-governmental organizations and social institutions also influence planning and mobility processes. It accounts for discourses present in policy making and contradictions between policies and local needs. Instigating change in the Dutch mobility planning most often follows the SUMP cycle, in order to adopt policies that provide enough feedback and transparent activities (Pucher & Buehler, 2008).

The socio-technical systems approach

Kaghan and Bower (2001) describe that the interaction between people and technology can be defined by the network of actors in big infrastructural projects concerned with the implementation of sustainability techniques. In other words, an approach should possess the element of recognizing that technologies shape behavior. Shifting towards an active approach in sustainability requires individual behavioral change (Sing, 2013). The interaction between technology and human behavior through the socio-technical systems approach helps to gain a better understanding as to how (societal norms and) human behavior influences sustainable initiatives. It is usually the case that the incentive

to initiate sustainable innovation or transition comes from a societal problem or issue which needs to be tackled. These societal functions are addressed in the frame of the Dutch environmental policy (Pucher & Buehler, 2008; Provincie Gelderland, 2024).

Geels (2019) states that fundamental changes in mobility systems, which are conceptualized in shorthand as ‘socio-technical’, are needed since the fulfilment of societal functions involves not only technologies, but are also situated in individual practices, cultural meanings, public policies, models, and infrastructures. He emphasizes the importance of innovations, while accounting for socio-(technical) transitions as defined by multiple social groups who engage in multiple activities in the context of rules and institutions, including belief and norms (Geels, 2019).

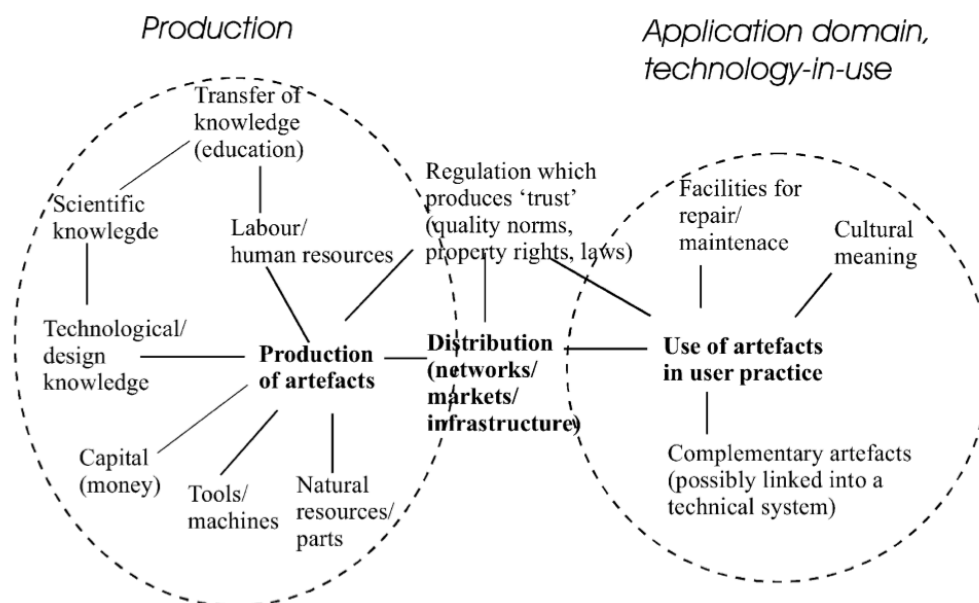


Figure 2.3: Basic elements of the socio-technical systems approach (Geels, 2004).

The elements of the socio-technical systems approach make the distinction between the user practices (soft values) on the right side and the product dimension (hard values) on the left. The production dimension explains the technical aspect where innovations emerge. The application or user dimension describes the social aspects of the system, via cultural meanings. These dimensions cross each other in the middle concerning the distribution and adoption of innovations into society (Geels, 2004). Regular innovation is driven by (human) demand and utility, and the production side focuses on profit and distribution (Paredis, 2009; Geels, 2004), whilst the mobility transition is more characterized by the social and spatial context. As cultural and social settings influence mobility transport, transitions should follow transformative adaptations. Transformative adaptation refers to adaptation strategies that should not only accommodate change, but also offer new alternatives (Geels, 2019). Geographical and spatial context should be accounted for as transition is instigated. Local institutional beliefs and norms play a big part concerning mobility discourses (Moradi & Vagnoni, 2018; Creswell, 2013). The psycho-social perspectives of society on mobility mostly determine travel behavior (Turienzo et al., 2022). The link between behavior or social discourses and technology in the socio-technical systems perspective is challenged. There exist certain flaws in the system, and it continues to be less

applicable to recent and future cases (Kern & Smith, 2008). The approach is not applicable to societies where technological developments for sustainability issues should be translated into behavioral change (Kemp et al., 2007).

Transition management theory

Transition management addresses and offers solutions for structural problems regarding the lack of sustainable short-term policies (Kemp et al., 2007). It explains why it is hard to instigate change due to the politically complex structures. The interaction between governmental bodies and society complicates transitions, especially mobility transitions due to the variety of norms, beliefs, and opinions amongst the public (Smith et al., 2005). Kemp et al. (2007) state that sustainable development requires radical change in not only in governmental policy, but also in systems of governance as well as societal daily (urban) systems. Namely, because every transition consists of processes of co-evolution, entangling changes in needs, cultural institutions, practices, and institutional frameworks (Kern & Smith, 2008).

Change is society wide as its implementations are carried out by members of society themselves. The interaction between multiple members of society influences the dynamics of societal systems leading to irreversible patterns of change (Kemp et al., 2007). Transition management attempts to create flexibility in relation to this irreversible change. It tries to deal with various activities designed by different actors, instruments, and mechanisms whilst steering socio-technical activities into the desired direction. The transition is both internally as well as externally dynamic (Kemp et al., 2007). Transition can be considered as a strategy of governance. It tends to rely on network management (Kemp et al., 2007) and contemplates shifts in society into strategies that are being adopted by governments (Loorbach et al., 2021). However, transition management does not deal with individual human behavior and struggle specifically. Geels (2005) states that transitions in the past have shown that a transition in a socio-technical system takes a generation or even more than one to become successful, due to the underrepresentation of those which encounter changes. Even though mobility problems are in need of fundamental change, it could encounter difficulties on the local scale. Policy development and policy implementation have to be seen as one long-term process instead of two different approaches. Graham (2003) and Hendriks (2008) also state that governance is not only about what direction policies should follow, but also which actors should be involved in the process. Hawkins and Parkhurst (2015) have developed a framework in which they describe the principles of good governance, namely appropriateness, accountability, transparency, and contestability. In the specific case of the mobility transition, which can be seen as a socio-technical transition, it is essential to highlight which actors are involved and how they relate to each other. In mobility developments and practices, the actors that take part are most often the government and other governmental bodies, private actors such as transport companies, community organizations, and others; where the research of individual behavior on the local scale is often underrepresented in mobility research (Day, 1997; Martinez, 2011). Developing governance policy and instigating innovation or transition needs understanding of the actor networks, of the power relations between actors, of governmental goals, and of the most important question of all: whether it is supported by society wide (Hendriks, 2008; Kern & Smith, 2008).

2.3 Travel behavior

There are several reasons why initial travel choices may impact future travel behaviors differently. Firstly, certain modes of transportation may complement each other. For instance, using a bicycle alongside a car could make someone more inclined to transition using public transport (Kroesen, 2014). Second, there exists an idea that individuals who exclusively rely on one mode of travel tend to form different perceptions and attitudes towards other modes compared to those who use multiple modes of travel (Diana & Mokhtarian, 2009). Research has shown that car users often have biased views towards public transport. However, individuals that use both cars and public transport are less susceptible to such biases (An, 2023). Multi-modal travelers may be more adaptable in adjusting their travel behavior. Thirdly, multi-modal behavior itself can reflect a conscious decision-making process regarding transportation choices, as opposed to habitual reliance on a single mode (Pedersen et al., 2011).

The Physical Activity through Sustainable Transport Approaches (PASTA) framework, developed by Götschi et al. (2017), is a comprehensive conceptual framework of (active) travel behavior. It summarizes previous work, and the framework delineates three distinct domains influencing cycling behavior: social context determinants, physical context determinants, and individual level determinants. This research will primarily concentrate on the individual level determinants. However, when analyzing individual level determinants, one should always contemplate the other two dimensions in order to gain a full representation. Although the PASTA framework serves as an in-depth analyzing tool, it is also very elaborated and complex. Therefore, the framework developed by Marquart et al. (2020) on factors that influence mobility (specifically bicycle usage), provides a good conception for determinants of travel behavior.

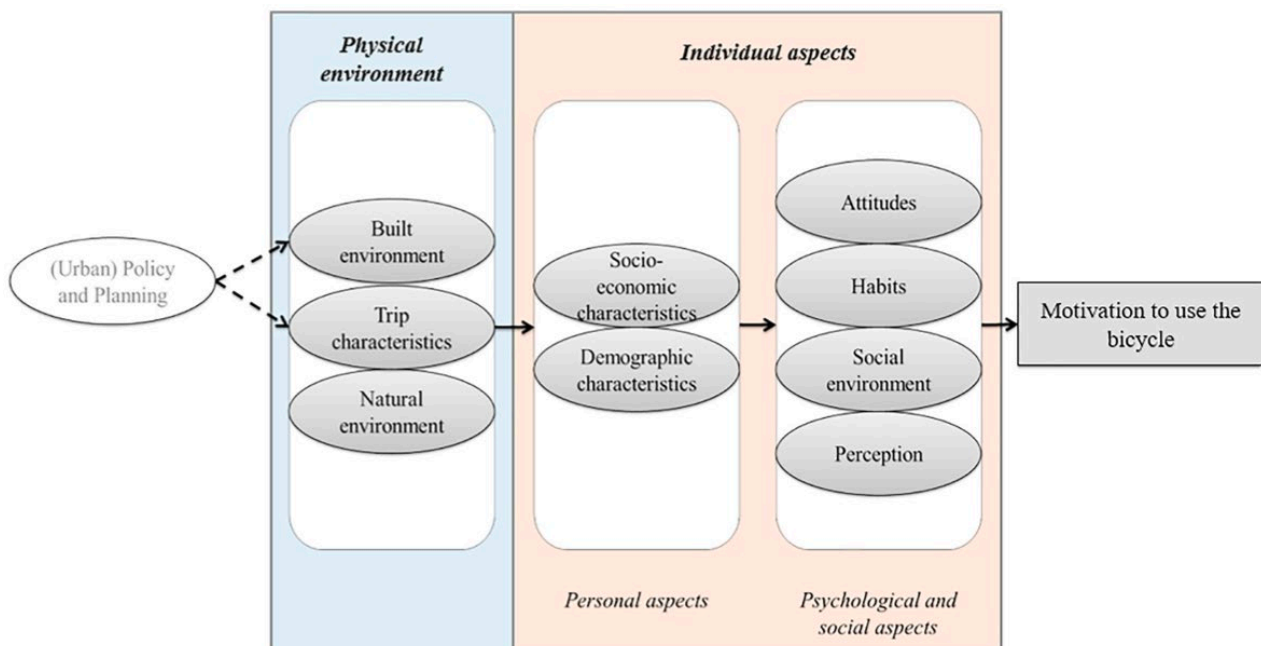


Figure 2.4: Framework on bicycle use, applied for travel behavior (Marquart et al., 2020).

2.3.1 Physical environment

The physical environment can be categorized into three dimensions: the built environment, trip characteristics, and the natural environment (Marquart et al., 2020). While the built and physical environments often overlap since many urban features are interlinked, it is important to distinguish aspects related to trip characteristics and the natural environment. In terms of promoting sustainable mobility, policy and planning can influence both the built environment and trip characteristics. Trip characteristics can only be impacted by changes in the built environment, meaning mobility planning does not directly influence them (Marquart et al., 2020).

Built environment

The built environment refers to that where the natural environment is subject to change from human constructions (Pearce & Vanegas, 2002). It consists of every built construction, not limited to one sort. In other words, the built environment encompasses human-made structures and infrastructure assets that form the physical, natural, economic, social, and cultural capital (Pearce & Vanegas, 2002). It is more than logical that travel behavior of individuals is influenced by the built environment, as it includes factors such as transportation infrastructure, land use patterns, urban design, and accessibility of amenities (Vischer, 2008). The built environment can shape perceptions of safety, comfort, and convenience, which in turn influence travel choices. Urban planning and transportation policies are pivotal in molding the built environment, with choices regarding zoning, street design, investments in public transit, and land use regulations exerting enduring impacts on travel behavior (Vischer, 2008).

Trip characteristics

Distance and travel time stand out as the most crucial factors in explaining travel behavior. Often highly correlated, they are sometimes commutable. There exists general consensus that increased distance leads to less active mobility, making other transport modes more likely choices. Travel time, on the other hand, largely depends on the chosen mode, but longer travel durations tend to diminish the proportion of sustainable mobility (Weaver et al., 2007). These factors are closely tied to the built environment, where elements like mixed land use, density, and infrastructure significantly influence distances and travel times to destinations (Pearce & Vanegas, 2002). Another pertinent trip characteristic is travel costs. Looking at travel costs, various transportation modes show different costs. Additionally, trip purpose and day of the week are notable trip characteristics (Weaver et al., 2007).

Natural environment

The decision for active mobility is, in contrast to motorized transportation, heavily influenced by natural factors such as climate, weather, elevation, and light conditions (Hagman, 2003). Natural factors in the form of elevation or landscape can limit active mobility and result into the choice for more motorized mobility. The natural environments shapes travel behavior through offering opportunities, as well as limitations for various modes of travel.

2.3.2 Socio-economic and demographic characteristics

Individuals can be distinguished on the basis of making rational choices to making habitual, automatic travel choices. Diana (2010) states that multi-modal travelers may be expected to change behavioral patterns rather than those who travel in one way. Kroesen (2014) explains that besides analyzing travel modes, one should contemplate various exogenous variables present with individuals. These variables are for example age, education level, occupational status, residential environment, income, car license holder ship, etc. And thus, travelers can be characterized by different travel needs and patterns (Susilo & Cats, 2014). These needs depend on their commitments and constraints.

Group	Special characteristics	Key factors
Full-time employed workers	Regularly incur more temporal constraints than monetary expenditure	Punctuality, reliability, cost
Female travelers	Travel shy, reassurance seeker and cautious planner. Complex scheduling of activities in terms of both time and space and is likely to bring additional bags.	Safe, reliable, affordable and comprehensive access
Parents with small children	More women than men, traveling with buggies and bags	Accessible vehicle and station, onboard space and supportive attitudes
Low income travelers	Tend to be captive to the cheapest mode alternative and spend a significant proportion of income on travel	Availability, adequacy, cost and safety
Children and young travelers	Smaller children highly dependent on their parents' decisions and preferences. For many young teens, travel represents a gateway to adulthood, enabling independence, socialization and a recognition of maturity	Practicalities (such as cost and speed of journey), flexibility and safety
Elderly travelers	Tend to have more limited ability and strength to move. The feeling of being able to travel independently is closely linked with a sense of self-worth. They have increased difficulty in identifying signs, in reading timetables, listening to loudspeakers and responding	Physical and emotional barriers, affordability, flexibility, reliability and support facilities
Disabled travelers	Have physical or mental impairment which has a substantial and long-term adverse effect on their ability to travel. Lack confidence when traveling, experience a lack of flexibility in their travel choices and difficult to be spontaneous	Physical accessibility and availability, support facilities (including information availability), cost, certainty and security and supportive attitudes
Tourists and unfamiliar travelers	Suffer lost-in-translation problem. Have high mobility needs, but limited spatial and linguistic knowledge	A simpler system, more information provision and more helpful and tolerant staff

Figure 2.5: Characteristics of different traveler groups (Susilo & Cats, 2014).

The distinctions made above, contemplate various (socio-demographic) characteristics that explain the different travel needs and patterns of certain groups. Findings by Susilo and Cats (2014) suggest that specific traveler demographics, including women, young individuals, those with low income or unemployed, exhibit distinct factors influencing satisfaction across different stages of travel for various modes of transportation. Satisfaction levels for travelers using different travel modes are influenced by varying factors. Public transport research indicates that ease of transfer, station environment, and onboard comfort are pivotal determinant of travel satisfaction (Susilo & Cats, 2014). Demographic factors influence travel behavior in choices made for transportation, which correlate with accessibility, satisfaction, efficiency, safety, and sustainability (Susilo & Cats, 2014; Bratt et al., 2015). The most important socio-economic and demographic characteristics are those of age, gender, ethnical background, income, education, occupational status, and household status (Susilo & Cats, 2014).

2.3.3 Psychological and social aspects

Lanzini and Khan (2017) describe that intentions are the closest antecedents of behavior and have three main predictors: attitudes (Att), subjective norms (SN), and perceived behavioral control (PBC). This theory is called Theory of Planned Behavior (TPB). Attitudes represent the personal desirability of behavior, or the feeling of being more or less favorable towards performing the activity (Lanzini & Khan, 2017). Subjective norms (also social environment) pertain to the social pressures we encounter, how other individuals look at our choices. Perceived behavioral control accounts for the perceptions of how difficult or easy it is to perform a certain type of behavior (Lanzini & Khan, 2017). Perceived behavioral control does not only influence intentions, but it also influence behavior indirectly (Schoenau & Mueller, 2017). Moreover, there are studies that state that feelings of moral obligation and habits have a great effect on (travel) behavior. Moral obligations represent the personal norms, moral norms, or values that individuals possess which serve as guiding principles in the life of an individual, steering their choices (Schwartz, 1994). Moral obligations can often be related to the public discourses on mobility. Whereas habits refer to the process when individuals frequently perform a given behavior in response to a specific goal, and intentions no longer act as the main predictor of behavior of that individual (Bamberg & Schmidt, 2003).

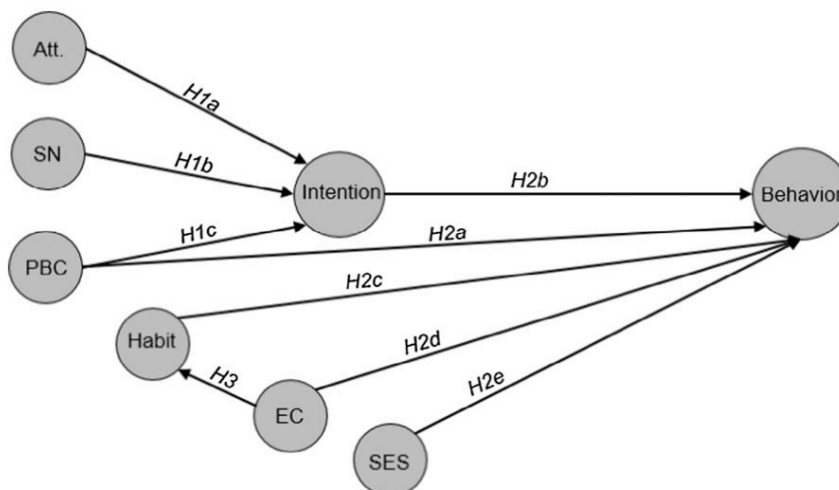


Figure 2.6: Theory of planned behavior (Schoenau & Mueller, 2017).

In the context of mobility, Schoenau and Mueller (2017) added the influence of habits (Habit), socio-economic status of individuals (SES), and the external costs (EC) related to mobility behavior. Where external costs have an effect on habits present with individuals, as can be seen in *Figure 2.6*. The lower the costs for one travel mode, the easier the realization is of a certain behavior concerning the individual. An important notion made by Marquart et al. (2020) and Schwartz (1994) is the fact that perception always play a big part. Perceptions are the result of psychological and socially influential factors.

2.4 Individual behavior in the sustainable mobility context

There are various innovation theories or frameworks developed over the years in order to analyze (environmental or) spatial change processes. Changing towards a more sustainable way of travel relates to social discourses and institutions present with individual residents (Ettema et al., 2016). Therefore, this research contemplates various theories and frameworks in order to analyze sustainable innovation and what role social institutions and discourses play.

2.4.1 The Institutional Analysis Development (IAD) framework

Clement (2010) describes that there is a major challenge in spatial planning as we need to reform or draft new institutions that are contextually grounded. Analyses of decentralized policies need to go beyond the understanding of how centralized policies are designed and how they affect civil society as a whole. The meanings and contextual surroundings of local networks are to be analyzed, so that there exists a transparent process from the policy design stage until the arena where the final resource users make decisions (Clement, 2010). It requires a multi-level approach that can link the decisions and dynamics of actors across institutional levels (Andersson & Ostrom, 2008). Clement posits the Institutional Analysis and Development (IAD) framework which offers a multi-level structure, linking the operational level, where actors make decisions, to the collective choice and constitutional levels, where actors form their values and beliefs (Ostrom, 1999; Ostrom et al., 19994 from Clement, 2010).

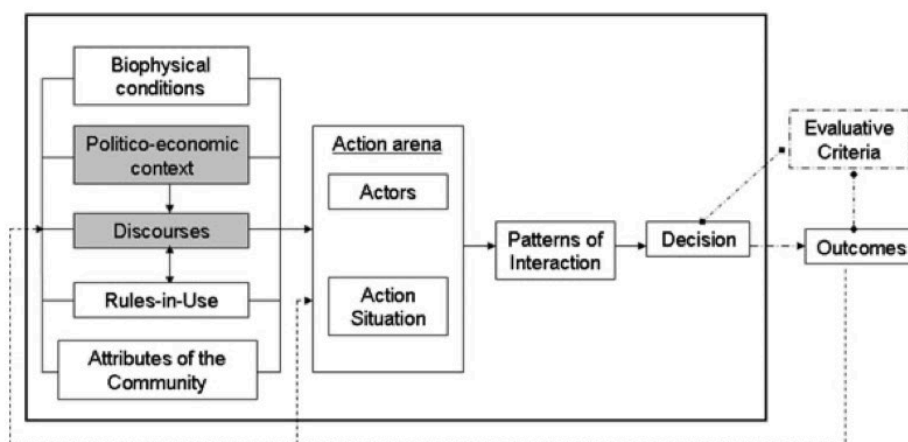


Figure 2.7: The (extended) IAD framework (Clement, 2010).

The framework provides a comprehensive tool for understanding complex interactions and dynamics involved in sustainable governance innovations. The concepts on the left are the units that influence the action arena and the actors within. The physical conditions focus on the characteristics of the physical attributes in the specific spatial context (Ostrom, 1999; Clement, 2010). The rules-in-use refer to the governance systems in place and explains how the rules and regulations, norms, and institutions are designed. The attributes of the community focus on the individuals or groups involved, including values and interests (Ostrom, 1994; Ostrom, 1999). Clement (2010) offers two new concepts: politico-economic context and discourses, which are meant to bring the

researcher to explicitly consider power and values within the action arena. He explains it as:

The politico-economic context is to be examined under a dynamic perspective to understand how power has been distributed among actors who take decisions and how political and economic interests have driven actors' decisions within a particular set of rules-in-use (Clement, 2010).

The examination of rules-in-use can offer an insight into how it affects power distribution and whether institutional change can lead to more equitable outcomes. Discourses are linked to the rules-in-use because discourses affect institutions, and the emergence and persistence of discourses depend on the institutional and politico-economic context (Hajer 1995). The other way around, institutions influence discourses as the latter depend on the institutional practices in which they are embedded (Hajer 2005). Accounting for discourses emphasizes the role of beliefs that actors use to make decisions. This is highly important, considering Ostrom (1999) stresses that individuals make select choices influenced by the specific context in which they find themselves in. Relevant planning practices and evolution or change processes occur on the local scale, and therefore the values in land and spatial context are always the subject of negotiated meaning (Hillier, 2005). Cause individual cultures, continuously pressed by contextual factors, are interacting in certain institutional environments (Gullestrup, 2006). Thus, looking at individual human behavior on the local level offers insights into travel behavior and how the mobility network is shaped (Ostrom, 1994; Hajer, 2005).

2.4.2 Sustainable transitions and citizens

Physical and institutional infrastructures of the current mobility system tend to favor the existing technologies and incremental change of these technologies (Farla et al., 2010). Even though the physical infrastructure has changed over the last few years, looking at more sustainable ways of travel, the Dutch transportation or mobility network is still being shaped for most part by the dominant discourses focused on the use of the car (Kuipers, 2013). Ivanova et al. (2016) state that mobility accounts for, together with nutrition and energy consumption, 70-80% of environmental impacts in industrialized countries. In order to instigate transition, institutional change embedded in social and cultural structures is needed. Not only with those who are to compose the transition views and visions, but also with those who are to use the transportation network (Farda et al., 2010). Most important is that citizens are a fundamental part when it comes to the action arena, where they carry out policies as they are designed. They play a key part in policy development as well as in policy implementation. As stated before, transitions require society wide support in order to be successful. In order to analyze whether sustainable mobility is supported by members of society, it is important to investigate how individual travel behavior shapes mobility currently. The physical environment influences individual travel behavior, but it also has an effect on socio-economic and demographic characteristics which in turn also have a direct effect on individual travel behavior (Diana, 2010). Furthermore, it needs to be researched how the relationship between this behavior and the perception on sustainable mobility among members of society is shaping the mobility.

2.5 Conceptual framework

The theoretical framework culminates in the conceptual model depicted in *Figure 2.8*, seamlessly links various theories and literature to present a clear and understandable synthesis.

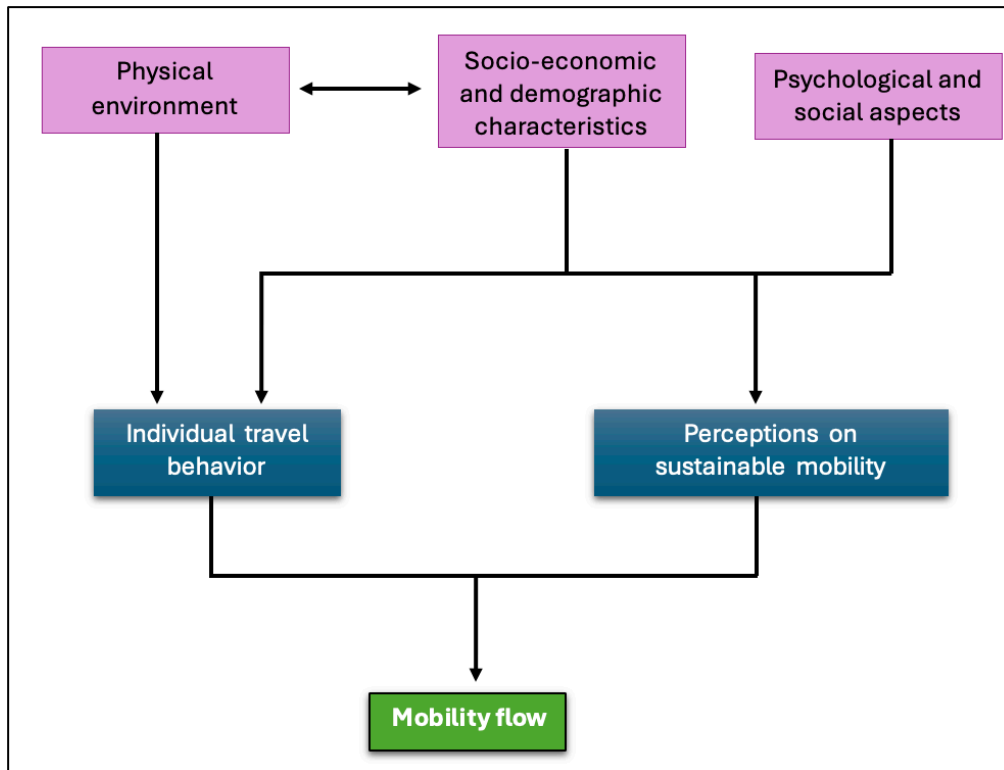


Figure 2.8: Conceptual framework/model (own design, 2024).

The framework highlights the aim of this research. According to Marquart et al. (2020), the physical environment, as well as individual aspects are determinants for individual travel behavior. The physical environment influences individual travel behavior, but it also has an effect on socio-economic and demographic characteristics which in turn also have an effect on physical environment (Diana, 2010).

The model takes into account for social discourses or institutions which determine the context where actions take place (Graham et al., 2003; Geels, 2004; Clement, 2010; Geels, 2019). Both psychological and social aspects and socio-economic and demographic characteristics confine perceptions towards sustainable mobility. Therefore, in order to analyze perceptions towards sustainable mobility, the psychological and social aspects will be investigated.

Consequently, the effect of individual travel behavior and perceptions on sustainable mobility among individuals on mobility flow, will be analyzed and investigated. This framework is the outline and guidance for the research as performed.

2.6 Operationalization

The operationalization chapter of a conceptual model is where you define and describe how the concepts or variables in your model will be measured or operationalized in practical terms (Verschuren & Doorewaard, 2015). It delineates the precise steps or procedures for transforming abstract concepts or constructs into tangible, measurable indicators. The concept operationalization table describes how the concepts have turned into measurable indicators (see *Appendix 1*).

2.6.1 Mobility flow

Mobility flow can be measured in different ways. This research follows the theories of David et al. (2014), which describe five measurable variables of mobility flow:

- *Efficiency*: Efficiency refers to the notion that it seeks to minimize friction, delays, and disruptions in movement. It aims to optimize travel or transport from one point to another with the least amount of effort. It can be measured in time, cost, energy, resources, and so forth.
- *Accessibility*: Accessibility emphasizes that transportation or travel networks and infrastructure should be accessible to all individuals.
- *Safety*: Safety refers to ensuring that travel is secure.
- *Sustainability*: Mobility flow aims to be sustainable, meeting current transportation or travel needs without compromising the ability of future generations to meet their own.
- *Integration*: The concept of integration emphasizes the integration of different transportation or travel modes into a cohesive network, which includes facilitating connection between modes.

These five variables can be used to measure mobility flow in a qualitative way. What the influence of individual travel behavior is to mobility, measured through the choice for sustainable mobility or other unsustainable ways of mobility. In order to analyze the quantitative numbers of the research, the theories of Andrienko et al. (2016) and Furletti et al. (2014) are applied. These theories state that mobility flow can be measured by using the number of travelers passing by from point A to B. Moreover, it can be measured by the time it takes travelers to go from one point to another. The number of these nodes are taken for individuals that travel there, showing the difference between these two measured time sets and number of travelers for different modes of transport. Therefore, analyzing the difference between sustainable modes of transport and unsustainable modes of transport.

2.6.2 Perceptions on sustainable mobility

Perceptions on sustainable mobility will be measured in a qualitative way through analyzing psychological and social aspects present with individuals: what are the attitudes, subjective norms (moral obligations), habits, external costs, and perceived behavioral control present with individuals? Later on, the effect it could have on mobility flow will be analyzed through a quantitative scope combined with a qualitative scope, as the conceptual model (*Figure 2.8*) shows.

2.6.3 Individual travel behavior

Individual travel behavior will be analyzed by using the framework and theories developed by Marquart et al. (2020).

Physical environment

The physical environment will be analyzed through three various aspects using a qualitative approach:

- *Built environment*: The built environment encompasses human-made structures and infrastructure assets that form the physical, natural, economic, social, and cultural capital.
- *Trip characteristics*: Travel time, distances, travel costs, trip purpose, and day of the week are notable trip characteristics.
- *Natural environment*: The natural environment encompass natural factors such as climate, weather, landscape, elevation, and light conditions.

Psychological and social aspects

Psychological and social aspects are analyzed in a qualitative way through the theories designed by Schoenau and Mueller (2017). As the conceptual model shows, there are five concepts which determine the psychological and social aspects present with individuals:

- *Attitudes*: Attitudes represent the personal desirability of behavior, or the feeling of being more or less favorable towards performing the activity.
- *Subjective norms*: Subjective norms pertain to the social pressures we encounter; how other individuals look at our choices. Moral obligations represent the personal norms, moral norms, or values that individuals possess which serve as guiding principles in the life of an individual, steering their choices.
- *Habits*: Whereas habits refer to the process when individuals frequently perform a given behavior in response to a specific goal, and intentions no longer act as the main predictor of behavior of that individual.
- *External costs*: The lower the costs for one travel mode, the easier the realization is of a certain behavior concerning the individual.
- *Perceived behavioral control*: Perceived behavioral control accounts for the perceptions of how difficult or easy it is to perform a certain type of behavior.

Socio-economic and demographic characteristics

The distinctions made on behalf of characteristics present with individuals, contemplate various socio-economic and demographic aspects that explain the different travel needs and patterns of certain groups (Kroesen, 2014). The demographic dimension contains various indicators in this research: *age, gender, ethnicity, residency, occupational status, education, household status*. Whereas socio-economic are measured through the *income* of respondents measured quantitative as well as qualitative, accounting for the social environment relating to the income.

Chapter 3: Research methodology

This chapter will provide a better understanding of the methods and procedures used to conduct the research. The research methodology will help the reader to get a clear picture on how the was collected and analyzed when using certain methods (Blijenbergh, 2016).

3.1 Research philosophy

Research philosophy is the system of beliefs and assumptions about the development of knowledge (Muhaise et al., 2020). It refers to the approach a researcher takes when conducting the research. The choice for a particular research philosophy can influence how the research is drafted, which methods and techniques are used, and how results are constructed. Therefore, understanding the research philosophy is essential. Moon and Blackman (2014) distinguish three fundamental elements of research philosophy, namely ontology, epistemology, and theoretical perspective.

Ontology is the field of philosophy that copes with the nature of being, existence, and reality (Saunders et al., 2009). Ontology deals with how reality is perceived. It explores what exists and what the fundamentals of existence are. It seeks to understand the nature of substances, the relations between them, and different categories in which they fall. Ontologies are used to define concepts and relationships within a particular domain (Saunders et al., 2009). There are several concepts to understand the nature of existence, as Moon and Blackman describe (2014). Bounded relativism describes that our perceptions and interpretations are influenced by cultural, historical, and spatial context, but that there is still room for objectivity (Moon & Blackman, 2014). Therefore, bounded relativism is a suited approach for this research. In this research several objective factors, such as the provision of certain infrastructure, are present. However, various subjective factors concerning the behavior of residents in their modes of travel explain that different interpretations of certain phenomena at different places can appear (Bates & Jenkins, 2007).

Epistemology refers to the area of philosophy that deals with the nature and attainment of knowledge, how it is gained and what methods are used (Bates & Jenkins, 2007). It is concerned with the study of belief and justification. It asks questions such as: What is knowledge? What are the sources of knowledge? How do we assess the validity and reliability of our knowledge or beliefs? Moon and Blackman (2014) explain that there are three different views concerning epistemology, namely objectivism, constructivism, and subjectivism. Constructivism is suited for this research, as it focuses on the nature of knowledge and emphasizes the idea that knowledge is constructed by individuals rather than passively received from an external reality (Creswell, 2009). In other words, knowledge is subjective and shaped by the individual itself and the surrounding environment. Concerning this research, the construction of behavioral mobility (of individuals) is actively related to the external reality.

Lastly, the theoretical perspective refers to the general theoretical framework used by a researcher in order to provide an answer to the research question. The theoretical perspective explains which concepts, methods, and theories are relevant to the research and affects how data is collected, analyzed, and interpreted (Bates & Jenkins, 2007). In this research, a combination of social constructivism and structuralism is applied. These perspectives focus on understanding systems of

underlying structures that govern human behavior, culture, and language; that reality is shaped by human interpretation and social processes (Creswell, 2009; Creswell, 2013). By using a constructivist approach, a better notion of behavior concerning modes of travel used by residents can be gained and offer a possible explanation for change in modes of travel and mobility flow. Namely, because social constructivism and structuralism underscore the social structures, processes, and patterns in society influencing human behavior and actions (Creswell, 2009; Creswell, 2013). Both perspectives shape the theoretical approach used in this research in order to identify behavioral change concerning modes of travel and whether it influences the mobility flow.

3.2 Research strategy

This research aims to explore whether behavior of residents concerning modes of travel influence the mobility flow, with a view to develop recommendations that can contribute to the literature, policies, and individuals regarding sustainable mobility. In order to provide a clear answer to the main research question, various options can be made concerning research approaches. A qualitative research approach is the collection and interpretation of research material in order to make statements and/or conclusions about a (social) phenomenon (Blijenbergh, 2016). A quantitative approach tries to address the collected data in numbers, tables, and graphs (Field, 2015). A combination of both methods is what we call a mixed methods approach (Creswell, 2012).

To conduct comprehensive research, various research methods can be considered. Verschuren & Doorewaard (2015) outline several research strategies: survey, grounded theory approach, desk research, and a case study. Surveys are particularly suited for quantitative research as they allow reaching a large number of respondents, thus enhancing the validity of the research (Verschuren & Doorewaard, 2015). In contrast, experiments are designed to explore causal relations through interventions (Babbie, 2013), though they may have limitations regarding external validity. The grounded theory approach focuses on developing new theories, making it inherently theory-centric (Verschuren & Doorewaard, 2015). Desk research, on the other hand, involves gathering data from external sources. In a desk study, the researcher utilizes materials produced by others to gain new insights and gather more information about the subject through reflection, analysis, and literature review (Verschuren & Doorewaard, 2015). Reports can be examined from various perspectives, including legislation, regulations, and visions. All types of documents are considered valuable sources of information and will be used for data analysis, ensuring reliability and transparency (Bryman, 2012). Creswell (2012) defines a case study as a research approach in which the researcher investigates specific phenomena or processes within one or multiple cases, utilizing various forms of data to create a comprehensive understanding. Case studies often provide the opportunity to gain contextual and in-depth insights into complex phenomena within a limited timeframe (Verschuren & Doorewaard, 2015). However, Yin (2014) notes significant concerns with this approach: the method is rigorous, extrapolating from a single case can be problematic, and it has an unclear comparative advantage over other research methods. This research employs a mixed-methods design, utilizing triangulation, which involves combining different data collection methods (Blijenbergh,

2016). By conducting interviews with various respondents, researchers can gain deeper insights into the case due to the qualitative nature of the data.

The research begins with an exploration of various theories forming the foundation of the theoretical framework. This framework is used to construct a conceptual model that can be operationalized, allowing theoretical concepts to be transformed into measurable and observable variables (Van Thiel, 2014). Initially, the characteristics, advantages, disadvantages, and barriers of different travel modes are explained. Following this, theories regarding mobility flow are described. The research then delineates theories related to current governance frameworks and mobility transition processes. Which explain the influence of social and cultural discourses present in society. Innovation models are explained according to existing literature. Additionally, theories regarding behavioral context and factors are examined. Finally, models or frameworks on behavior, which investigate residents' travel mode choices, are explained based on the literature.

The operationalization follows a three-step procedure, as designed by Babbie (2013). First, the concepts are defined in the theoretical framework. Next, the variables are identified. Finally, the values of these variables are determined. This research employs quantitative and qualitative data from a survey conducted among residents in Gelderland. Subsequently, semi-structured in-depth interviews are conducted to obtain qualitative data, allowing for a comprehensive analysis of the cultural and societal elements of the research. Finally, after analyzing the results from these different methods, a discussion and final conclusions, including recommendations for future research, are presented.

3.3 Research methods and data collection

As stated before, the research questions require an understanding of the views, perceptions, and behavior of the residents' mobility choices. This research makes use of a mixed-methods approach which consists of three steps. In phase 1, a literature study on documents and theories from existing literature was performed. In phase 2, a survey was distributed among residents within the Province of Gelderland. In phase 3, several semi-structured in-depth interviews with various residents were conducted.

3.3.1 Literature study

Before embarking on the empirical data collection process, it is essential to lay the groundwork by reviewing existing scientific literature. Initially, a thorough examination of available literature is conducted to gain insights into sustainable mobility, mobility flow, and individual travel behavior. This literature review phase enables us to precisely delineate the research scope (Verschuren & Doorewaard, 2015). Various theories and concepts are analyzed to establish a framework for conceptual development. Sustainability and sustainable innovation theories proposed by Clement (2010), Rivolin (2012), and Arts et al. (2006) are scrutinized, along with insights from the socio-technical systems approach and the theory of transition management, which shed light on the crucial role of different actors in sustainable innovation, emphasizing the interplay between human behavior and technological advancement (Geels, 2019). Additionally, an analysis of individual travel behavior is conducted to identify influential factors comprehensively.

The literature review forms the foundation of the empirical research phase, providing a solid base of existing theoretical knowledge and insights from previous studies (Verschuren & Doorewaard, 2015). However, its significance goes beyond theoretical elucidation. Literature, including policy documentation, offers valuable insights into the societal dimensions of mobility. Provincial visions and agendas reflect the societal perspective on mobility, providing insights into current policies and their implications for residents, as well as their impact on sustainable innovation. By combining robust theoretical foundations with policy documentation, we establish a bridge between existing knowledge and the potential for new discoveries.

3.3.2 Survey

In order to gather descriptive quantitative data, a survey was drawn up and distributed. The survey was a large-scale approach with a significant number of respondents, which is a characteristic of this type of research (Field, 2015). Furthermore, anonymity in surveys encourages honest responses, reducing social desirability bias. Surveys ensure that each respondent is asked the same questions in the same manner, enhancing data reliability (Field, 2015). They are ideal for quantitative data collection, allowing for the identification of trends, as surveys can be designed to gather various types of information using multiple question formats. The data that followed the survey was automatically saved and stored. However, surveys can be affected by non-response bias and self-selection bias, impacting the representativeness of the data (Field, 2015; Creswell, 2012). Respondents may misunderstand questions, leading to inaccurate responses. Also, surveys may not capture the context behind responses, making it hard to understand the underlying reasons. Even though, surveys are a powerful tool for collecting data efficiently from large populations. However, researchers must design surveys carefully to minimize biases and data quality issues and need to use qualitative methods for deeper insights.

3.3.3 Interviews

Following the survey, interviews were arranged to delve deeper into the qualitative aspects of the research. A semi-structured interview format was adopted, combining predetermined structures with flexibility (Clifford et al., 2010). This approach allows for a more casual interviewing style, facilitating a richer exchange of information on pertinent topics for both the interviewer and interviewee (Longhurst, 2010). Opting for in-depth (semi-structured) interviews becomes imperative to grasp the perspectives, ideas, and actions of diverse stakeholders (Mason, 2007). Compared to structured or unstructured (focused) interviews, this method offers greater adaptability and efficacy. Semi-structured interviews entail specific questions outlined in an interview guide, yet the researcher engages in dialogue with respondents to understand their reactions and behaviors (Bryman, 2012). While providing a framework, it also permits respondents to share insights on their own terms, recognizing each interaction's unique context. However, a drawback lies in the time-intensive task of transcribing recordings, underscoring the importance of establishing selection criteria in advance. Research questions should guide the sampling process, aiming to capture a diverse range of perspectives, particularly focusing on residents (Bryman, 2012). This study employs purposive sampling to ensure maximal variation and diversity within interview groups along specific dimensions.

3.4 Data analysis

The analysis and sampling of the methods are concerned with the inductive perspective on the relationship between the theory and research.

3.4.1 Survey

Numbers and quantitative data were derived from the survey which was distributed among users of the mobility network in Gelderland. From this survey some descriptive data was used in order to analyze the demographic characteristics of these users. Furthermore, (social and cultural) discourses among the respondents of the survey were analyzed through questions with an ordinal scale of measurement. Thus, showing data in a descriptive manner. It shows how respondents with different socio-economic and demographic characteristics think on mobility discourses. It also demonstrates what travel behavior these respondents show.

3.4.2 Interviews

In order to derive generalizable conclusions from the interviews and survey findings, thorough data analysis is indispensable (Verschuren & Doorewaard, 2015). After recording the interview data, it was transcribed and subsequently summarized for coding and analysis via the ATLAS.ti program. This transcription serves as a dataset on which the analysis takes place. Leveraging this coding software enables the generation of a structured overview, allowing for the presentation of data on chosen topics and concepts. This process facilitates the research on diverse views, opinions, topics, and perspectives.

3.5 Reliability and validity

In this section, the reliability and validity of the research is discussed. This research contemplates the use of a mixed-methods approach, the combination of a qualitative-quantitative method (Verschuren & Doorewaard, 2015). The research methods consist of online literature sources and (governmental) documents. Also, surveys and multiple interviews with several residents were taken. The aim is to ensure that the validity and reliability are as high as possible.

Regarding the validity of the research, a distinction can be made between internal validity, external validity, and construct validity. Internal validity is described as that what a researcher really wants to measure and where one can say with absolute certainty that relationships cannot be explained by other factors (Blijenbergh, 2016). A high internal validity explains that there is a strong connection between the dependent and independent variable. Internal validity is considered as the most important criterium within research (Blijenbergh, 2016). The research data was collected from more than one source through literature, documents, a survey, and interviews. The collection of data through one source can be biased. Therefore, within this research, preference was given to the collection of information through a variety of techniques. By applying different techniques, it was possible to compare and validate qualitative results from interviews and literature sources. This way the validity was increased. External validity refers to the generalizability of the results (Blijenbergh, 2016). The external validity is increased as the research contemplates multiple respondents.

Reliability refers to the extent to which the results are not distorted by coincidental deviations and if a consistent method has been used (Blijenbergh, 2016). In other words, when doing the same research one should come to the same results. Regarding the reliability of the research, there was specific focus on the choice of participants, methods of data collection, data interpretation, and the recording of the data. This research used semi-structured interviews. In order to increase the reliability of the interviews, they were taken within the same setting. Moreover, the interviews were recorded and saved. The data of the interviews were compared to the data from several literature documents and the survey which improved the internal reliability of the results and the qualitative data itself. To enhance the credibility and dependability of this thesis, the principle of triangulation plays a pivotal role in the research strategy. Triangulation involves the use of multiple methods in the research process. By employing two or more methods, each can validate the reliability of the others (Creswell, 2009). This mixed-method approach within the case study improves both reliability and external validity.

3.6 Ethical considerations

Confidentiality and privacy are core principles in research, essential for safeguarding participant rights and maintaining research integrity (Blijenbergh, 2016). Prior to participation, participants were provided with comprehensive information about the study's purpose, procedures, risks, and benefits. They voluntarily consented to participate after understanding the research's implications. Participants' identities are protected by assigning unique identifiers or codes, ensuring that individual identities are not disclosed. Data was analyzed and reported in aggregate form without linking responses to specific individuals. In order to safeguard participant information, protocols were established. There is restricted access to the results for the researcher only. Physical and electronic data storage systems are secured, and sensitive information is encrypted, or password protected. Access to participant data is granted only to those with a legitimate need, minimizing the risk of unauthorized disclosure. By adhering to these measures, the research maintains confidentiality and privacy, fostering trust with participants and upholding ethical research practices (Creswell, 2009; Blijenbergh, 2016).

Chapter 4: Study on Gelderland

This study centers on the Province of Gelderland, exploring its distinctive features, particularly those related to its physical, social, and demographic characteristics. These characteristics contribute to Gelderland's uniqueness. Consequently, the specific findings on mobility in this study may not readily generalize to every other urban area. Nonetheless, the analyzed factors and their prioritization could provide valuable insights for evaluating mobility flow in various contexts. The approach in this research enables a bigger survey of the population, increasing the generalizability of the research.

4.1 Geography

Gelderland is positioned in the central-eastern reaches of the Netherlands and is bordered by six other provinces. It showcases a varied terrain characterized by undulating hills, expansive woodlands, and fertile river valleys. It covers around 5.136 square kilometers of surface. As the largest province in the Netherlands by land area, Gelderland is subdivided into several distinctive regions. The capital of Gelderland is Arnhem, and the area counts 51 municipalities.



Figure 4.1: Regions in Gelderland (Provincie Gelderland, 2020).

In the north and west, Gelderland features the Noord-Veluwe, an extensive wooded expanse celebrated for its heathlands, sandy dunes, and diverse fauna. Further south, the region of Foodvalley can be distinguished with cities such as Ede, Veenendaal, and Wageningen. Transitioning to the province's central and southern reaches, the landscape evolves into a blend of agricultural plains, river valleys, and softly rolling hills. To the east of Noord-Veluwe, there is the region of Stedendriehoek, where we encounter cities such as Apeldoorn, Deventer, and Zutphen. In the east, Gelderland's border is demarcated by the meandering course of the IJssel river and the region of Achterhoek is adjacent to the borders of Germany. In the south, there are regions of Rivierenland and Arnhem-Nijmegen. In essence, Gelderland's geographical tapestry offers a rich array of natural landscapes. There are 876 acres of industrial estates and 115.427 acres of forest and open terrain (Provincie Gelderland, n.d.).

4.2 Mobility

Gelderland has an extensive road network of 20.936 kilometers of which there are 1.346 kilometers of provincial roads. Trajectories around Arnhem, Nijmegen, Tiel, Apeldoorn, Deventer, and Harderwijk are experiencing much traffic resulting in much congestion. There are three road types which can be distinguished, namely national highways, provincial roads, and municipal roads (Provincie Gelderland, 2020). All this can be seen in *Figure 4.2*.

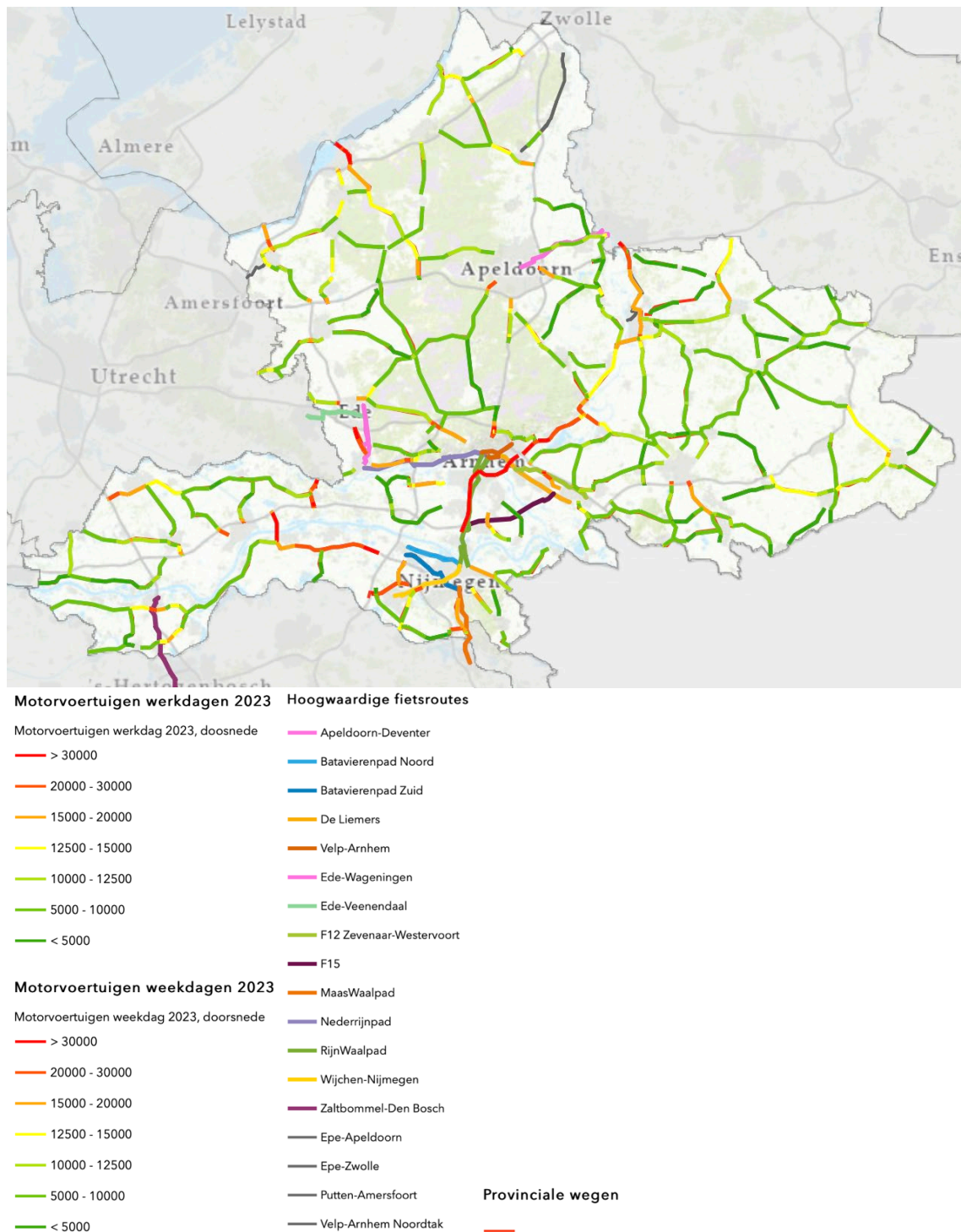


Figure 4.2: Roads used in Gelderland for motorized vehicles and bicycles in 2023 (Provincie Gelderland, n.d.).

In 2022 there were around 14 thousand traffic accidents in Gelderland. There is one car per 218 square kilometer in Gelderland and Gelderland counts around 37 thousand electric cars in April 2024 (Allecijfers, n.d.; CBS, 2024). In 2024 there are around one million passenger cars of which their energy source is petrol. In 2023 traffic on provincial roads in Gelderland has increased around 2% pertaining to 2022 (Provincie Gelderland, n.d.).

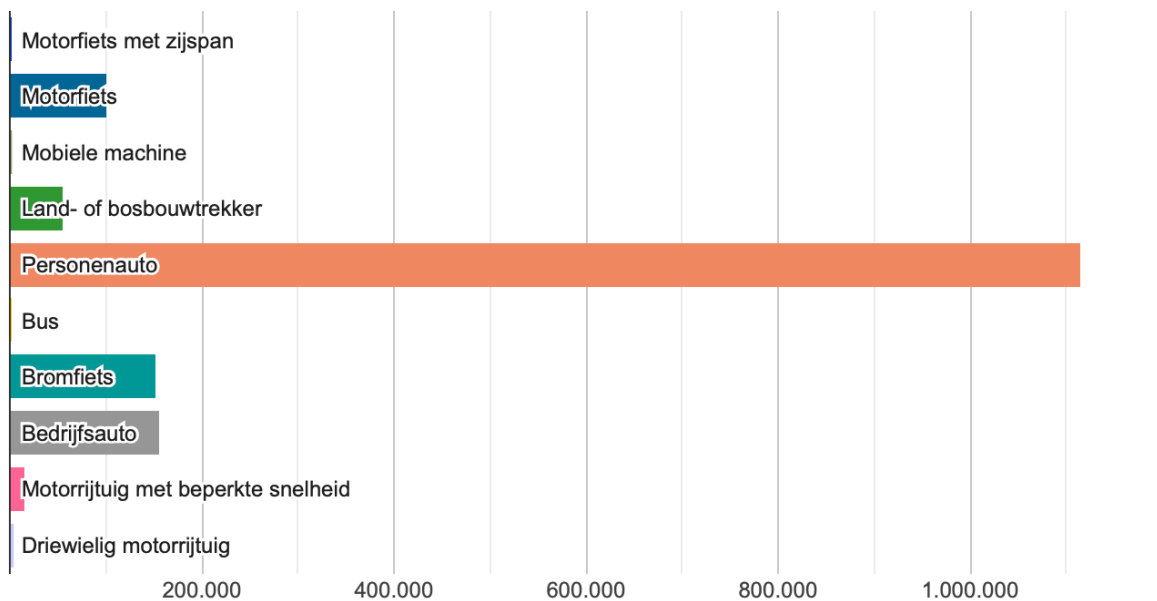


Figure 4.3: Vehicles by type in Gelderland in 2024 (Allecijfers, n.d.).

Gelderland features a robust public transport system complemented by extensive infrastructure for active mobility, such as cycling and walking (Provincie Gelderland, n.d.). The province of Gelderland is well-served by both regional and intercity trains operated by Nederlandse Spoorwegen (NS) and other regional rail operators (Provincie Gelderland, 2020). Major train stations function as multimodal transport hubs, integrating bus, bike, and car-sharing services, facilitating easy transfers and promoting the use of public transport (Provincie Gelderland, 2020). Gelderland has an extensive network of dedicated bike paths, separate from motor vehicle traffic, ensuring safety and convenience for cyclists. Secure bike parking facilities are common at train and bus stations, and bike-sharing schemes are available in cities like Arnhem and Nijmegen, encouraging short-distance travel by bike. Urban areas in Gelderland feature pedestrian-friendly streets and zones, often with traffic-calming measures to enhance safety, making walking a viable and pleasant option for short trips and daily commutes (Provincie Gelderland, n.d.). Many buses in Gelderland are electric or hybrid, reducing emissions and contributing to cleaner air. The combination of well-organized public transport and a strong emphasis on active mobility makes Gelderland a model of sustainable and efficient transport. The seamless integration of trains, buses, cycling, and walking paths ensures that residents and visitors can travel conveniently while minimizing environmental impact.

4.3 Policy on mobility

The focus of the province lies on accessibility throughout the whole of the area. It encompasses all of the movements present in the province and is currently experiencing a transition towards more sustainable mobility (Provincie Gelderland, 2023).

Accessibility or mobility is in the center of other ambitions and goals present at the Province of Gelderland.

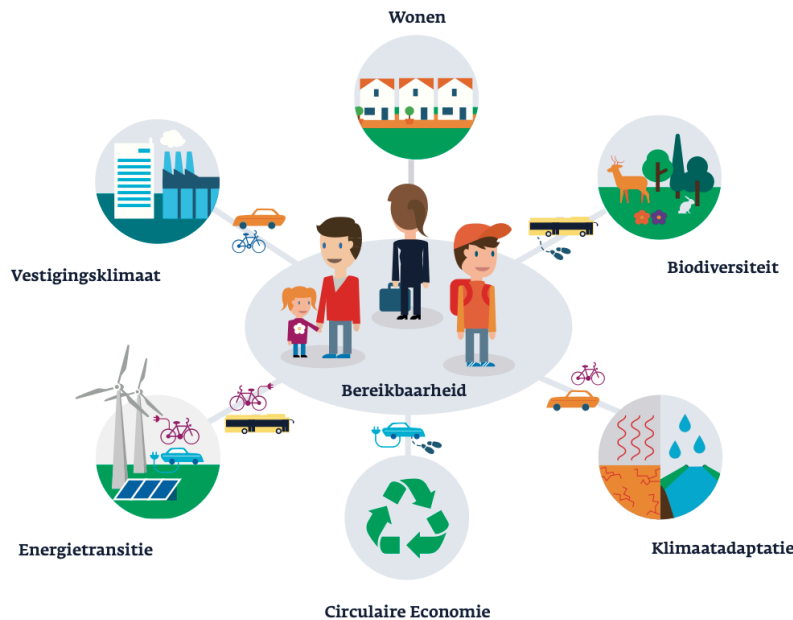


Figure 4.4: Accessibility in combination with other ambitions and goals (Provincie Gelderland, 2023)

The number of movements is continuously increasing which results in mobility bottlenecks and more traffic related accidents (Provincie Gelderland, 2023). In combination with the sustainability challenge, it requires changes in the mobility network. In relation to accessibility and mobility, the province plays a crucial part in the international corridors with links to Germany and the Randstad. Moreover, regional challenges concerning connection between both big cities and the rural area arise due to the developments on the housing market. More people results in more movements which causes congestion around the big cities.

The focus for 2030 is on investing in new infrastructure, as well as smart usage of the current infrastructure network while putting the traveler in the center (Provincie Gelderland, 2023). The province aims at improving the connection between areas (cities), stimulating more sustainable ways of travel or transport, and changing mobility or travel behavior towards more sustainable mobility. In order to achieve these three aspirations, the Province of Gelderland (2023) has its focus on five building blocks: 1) realizing high-quality hubs in the right locations; 2) focus on cycling on short distances; 3) optimizing capacity over longer distances 4) further strengthening our freight transport 5) promoting road safety.

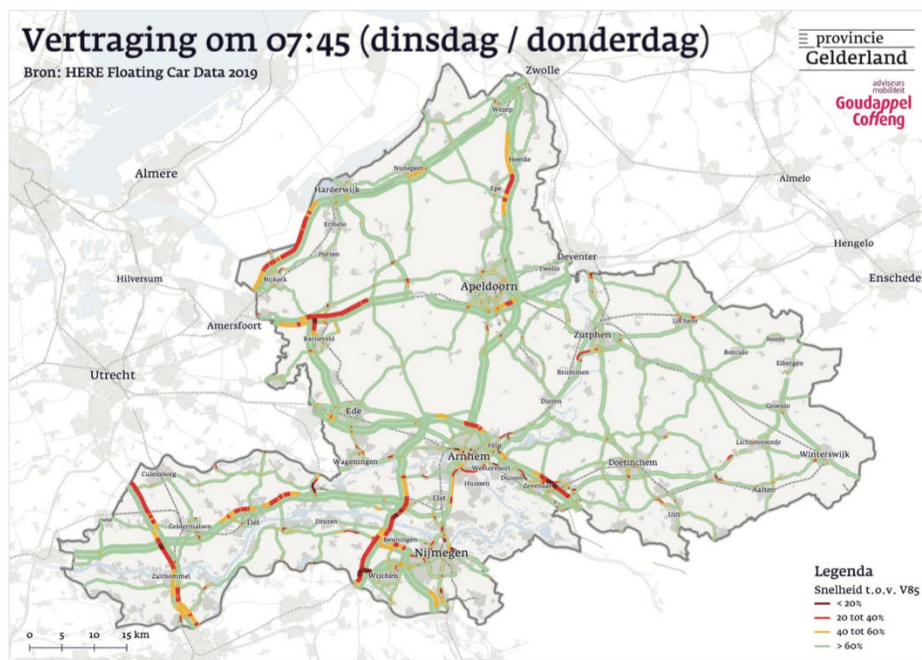


Figure 4.5: Delays in morning traffic in Gelderland (Provincie Gelderland, 2023)

At the core of the vision of Gelderland are hubs, pivotal links that seamlessly connect travelers to various transportation modes and facilitate the smooth movement of goods in an environmentally sustainable manner (Provincie Gelderland, 2023). By 2030, Gelderland is committed to establishing a flexible hub network, enhancing the cohesion of the mobility infrastructure. To boost health and accessibility, the use of bicycles will be prioritized for short trips, spanning up to 15 km. By 2030, objective is for 35% of all journeys in Gelderland to be conducted via bicycles (Provincie Gelderland, 2023). Collaborative agreements with municipalities are forged to bring about crucial segments of the main cycle network. The goal for 2030 is to optimize public transport and road capacities for longer trips (Provincie Gelderland, 2023). The province concentrates on improving urban network accessibility and tackling key challenges. As users of public transport, High-Quality Public Transport (HOV) and metro buses will be explored. Expanding road and rail capacities wherever necessary are still on the agenda. Another primary focus is on advancing the Gelderland corridor, enhancing the competitive stature of the Logistics Valley, and promoting eco-friendly practices in freight transportation (Provincie Gelderland, 2023). By 2030, significant strides will have been made, including the establishment of the Gelderland Rail Terminal (RTG) and the fortification of three pivotal regional logistics hubs within Gelderland. The efforts of the province are geared towards achieving more sustainable freight transport within the region, with the ultimate goal of achieving emission-free transportation by 2050. They collaborate closely in partnerships, exchanging knowledge and expertise, and offering financial incentives as needed to drive progress. The province aims for a reduction in road fatalities and injuries across Gelderland. By 2030, they will implement a proactive, risk-based strategy for road safety (Provincie Gelderland, 2023). Enhancements to safety measures on both roads and cycle paths are underway, with municipalities receiving support in the form of expertise and analyses to enhance their own road and cycle networks. Priority is given to cyclist safety, acknowledging their heightened vulnerability in accidents.

The Province of Gelderland works with an agenda, set for a period of time. This agenda provides the guidelines from which the province operates. It shows in what direction visions can be steered towards a successful outcome. In general, the work agenda encompasses four main project categories: network enhancement, technology, behavior influence, and services and data (μconsult, 2024). The predominant focus of projects in the 2023 work agenda was on influencing behavior. This includes initiatives such as regional employer strategies or corridor approaches.

Under the mobility work agenda, the province is engaged in projects across four key areas (μconsult, 2024; Provincie Gelderland, 2024):

- 1) *Network Strengthening*: Here, the Province of Gelderland acts as a pivotal network partner, fostering collaborations among various stakeholders to facilitate knowledge exchange and experience sharing.
- 2) *Technology*: These projects focus on leveraging innovative techniques and fostering user engagement.
- 3) *Behavior Influence*: Projects within this category aim to encourage travelers to make smarter choices in their transportation habits. This involves promoting a shift towards more sustainable and efficient travel options, challenging individuals to reconsider their routines and outlook on commuting.
- 4) *Services and Data*: These projects are geared towards supporting national objectives outlined in the Joining of Forces Smart Mobility initiative.

Chapter 5: Research results

This chapter lists and analyzes the most important results. The results are categorized into four sections, each elaborating on one of the sub-questions. Relevant data is derived from the analysis of the survey as well as the interviews that were conducted during the fieldwork. A total of seven interviews were conducted. The variety of respondents allows to draw an extensive image of individual travel behavior and their perception on sustainable mobility. And thus, it is seen how different actors make use of the mobility network in Gelderland.

5.1 Mobility flow

Mobility flow in Gelderland is mainly shaped by use of the car and public transport. Policy study on the province of Gelderland shows that there are more than a million cars in use within the province. These are only the cars from residents living in the province, not accounting for the cars which are used by residents of other provinces making use of the road network of Gelderland. The province of Gelderland experiences many delays caused by use of cars, especially on tuesdays and thursdays. Moreover, the province has an extensive train network which is used daily by many passengers. The trains are experiencing an increase in users, causing delays. Furthermore, the mobility network of Gelderland shows an extensive bicycle network. Prioritizing bicycling on short distances is desirable for the Province over car-use. Delays and congestion are mainly caused by traffic of which its destination is work related. Next to work destinations, the survey shows that other destinations such as residency, sport, healthcare or education have a big role in shaping the mobility flow on short trips.

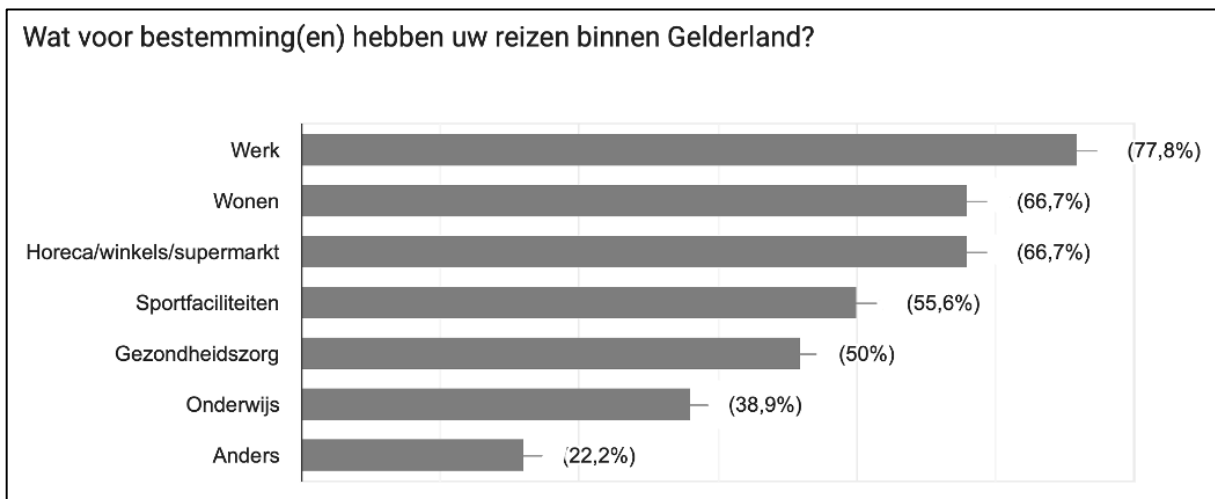


Figure 5.1: Travel destinations of respondents within Gelderland (Survey, 2024)

However, whereas people who travel to work are expected to mainly be using cars, the survey and interviews show that trips where individuals make use of public transport combined with active mobility for longer commutes are increasing.

“Further away to big cities, I always go by train” (Interview 1, personal communication, 2024).

Also, the survey shows that respondents are still mainly using the car, but for work destinations respondents are continually using active mobility if work is nearby. Active mobility is even sometimes being combined with using the car.

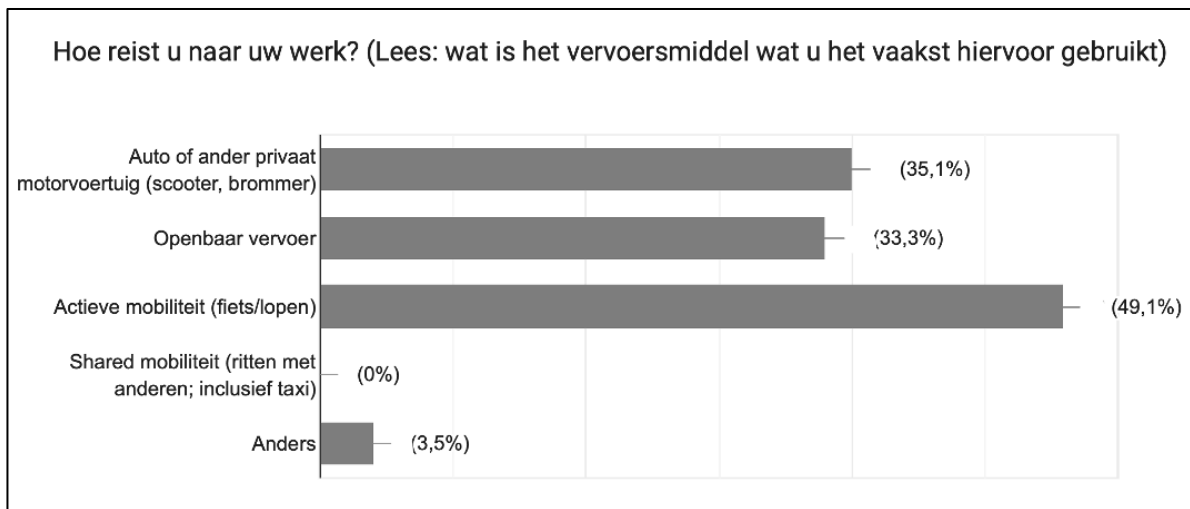


Figure 5.2: Modes of travel used for work (Survey, 2024)

However, even though there is an increase in active mobility for work commutes, the car still remains the most important travel mode. Accessibility and efficiency often limits the choice (or even possibility) for other ways of travel. Industrial states for example often do not provide a well-connected travel network for public transport or active mobility. Respondents state that some locations are simply not well connected enough in order to reach it in an efficient manner by not using the car.

“If you know, for example, there is an industrial estate, there are also connections between it. You want to keep residential areas easily accessible, but make sure that there are also direct lines to industrial estates. Because then you get that the people who work there can also use public transport more quickly (Interview 6, personal communication, 2024)”.

The survey shows that for other destinations than work, people still mainly make use of the car, as can be seen in *Figure 5.2*. However, active mobility is also being used often. Results from respondents of the interviews show that it is often related to accessibility of travel destinations.

“If I have to go shopping, I do it by car. I live in a village without facilities, so I have to go to Oosterbeek. Then I do it once a week, so I only go there once a week. And then I stock up for the whole week (Interview 1, personal communication, 2024).”

For work or education, people primarily use cars or public transport, while those heading to supermarkets mostly drive. For other trips, such as leisure activities, active mobility is more common. Accessibility issues often limit transport options for work-related destinations, leading people to choose cars for convenience and speed.

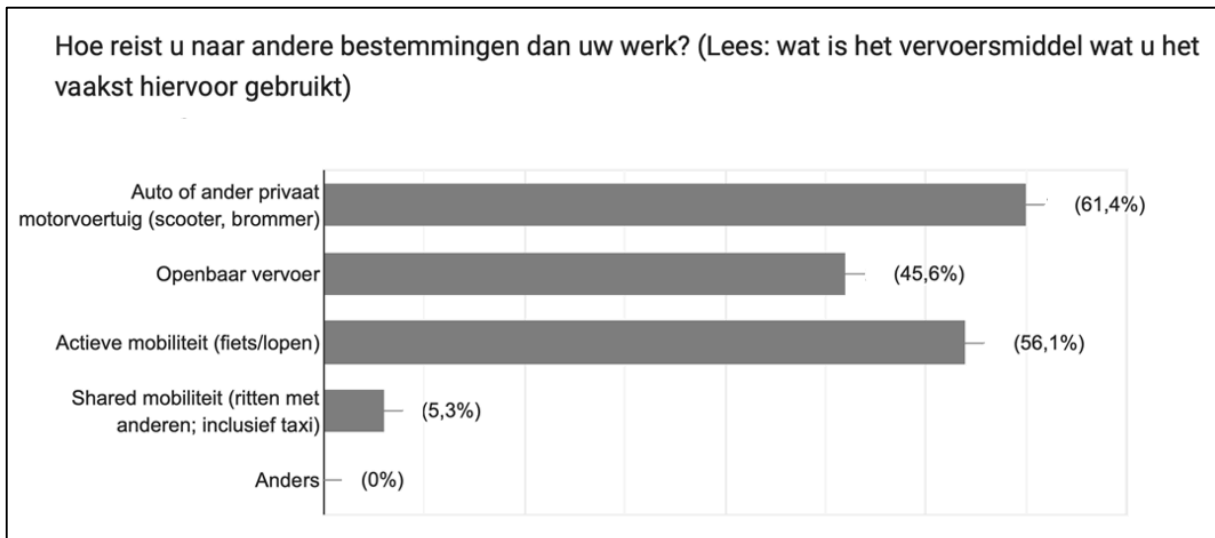


Figure 5.3: Modes of travel used for other destinations than work (Survey, 2024)

Furthermore, travel time and travel distance play a big part in explaining the mobility flow. Efficiency refers to the notion that delays in movements are minimal and that travel from one point to another can be done with the least amount of effort. It is usually measured in travel time.

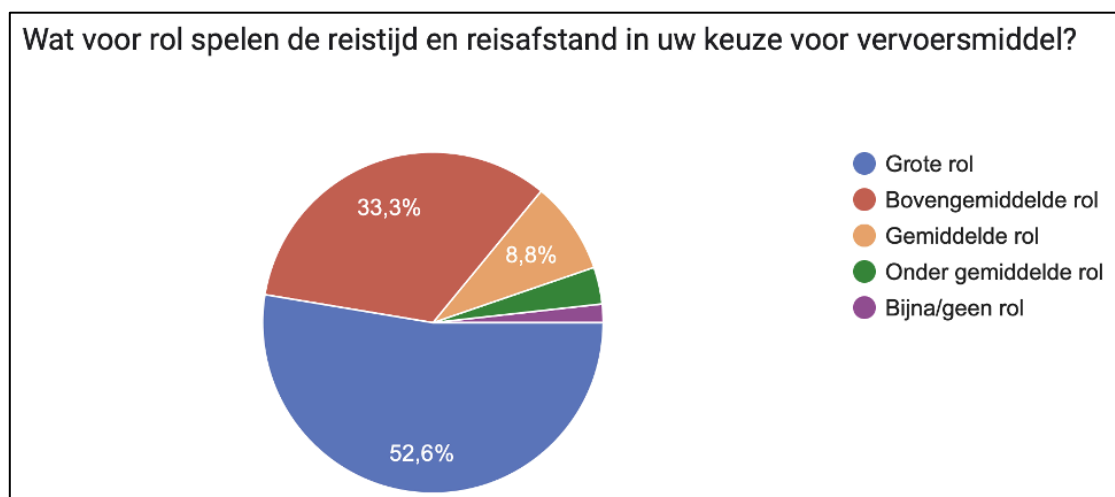


Figure 5.4: Influence of travel distance and travel time on choice of travel mode (Survey, 2024)

Figure 5.4 shows that travel distance and travel time play a big part in explaining the choice for certain travel modes. Travel distance and travel time are often paired with accessibility for a travel mode. Especially people with travel destinations for work purposes.

“Comfort, costs and time are for me the most important reason to choose which travel mode I’m going to use” (Survey, personal communication, 2024).

“Distance to my destinations. This is always more than 5km and I have got no time to take another travel mode than the car” (Survey, personal communication, 2024).

Lastly, study on the case of the province shows that destinations within Gelderland are not accessible to all modes of transport. Therefore, the mobility flow experiences delays to car use on most roads.

5.2 Individual travel behavior

There are three distinct domains influencing individual travel behavior: socio-economic and demographic context determinants, physical context determinants, and psychological and social level determinants.

5.2.1 Socio-economic and demographic characteristics

Respondents from the survey and interviews are from different age classes. It differs from 19 to 78, with an average age of 36. The distribution of gender was almost equal.

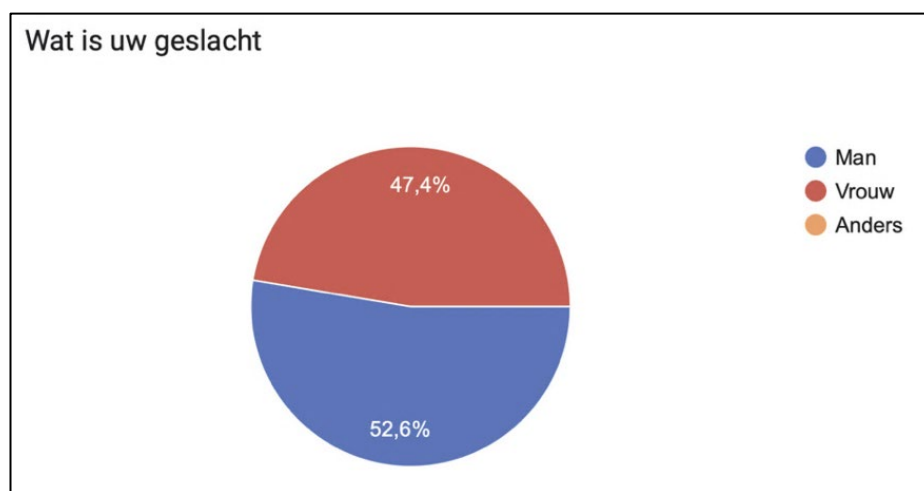


Figure 5.5: Gender of respondents (Survey, 2024)

Moreover, there is a remarkable distinction between men and women, as around 77,8% of the respondents that state they use the car for work destinations within Gelderland are men. And thus only 22,2% of the respondents that state they use the car for work destinations within Gelderland are women. However, woman make use of the car more for other destinations than work compared to destinations with work purposes. One respondent describes that woman use the car for mostly shopping, grocery shopping, hospitality industry, and sport facilities.

Age influences travel choices as older people can travel less comfortable and easily through activity related travels. It is difficult for elderly people to travel from place to place by walking or cycling.

“I don't cycle at all, because after that stroke I became far too unstable for that ... And walking, that's going to hurt more and more ...” (Interview 7, personal communication, 2024).

People with an older age can often still make use of the car. However, respondents of the survey and interviews state that using public transport is easier, more comfortable and less energy consuming. Some respondents also state that from a certain age it can be difficult to make use of the car due to traffic. Shared mobility sometimes provides a

solution through taxi's and buses. Younger people make use of active mobility for short commutes and use public transport for longer commutes, especially students. However, results also show that respondents of a younger age make use of the car as it provides more comfort and ease. It can be less time consuming than active mobility and can get you to places more quickly.

“But very often my work clothes are also at my parents' house. And then my car, or my parents' car, is easy to take to work” (Interview 3, personal communication, 2024).

The ethnical background of respondents was mostly Dutch. Only 1 respondent had a Western migration background, and 1 other respondent had a non-Western migration background. This shows that most of the respondents are either familiar with or live in a Dutch cultural environment.

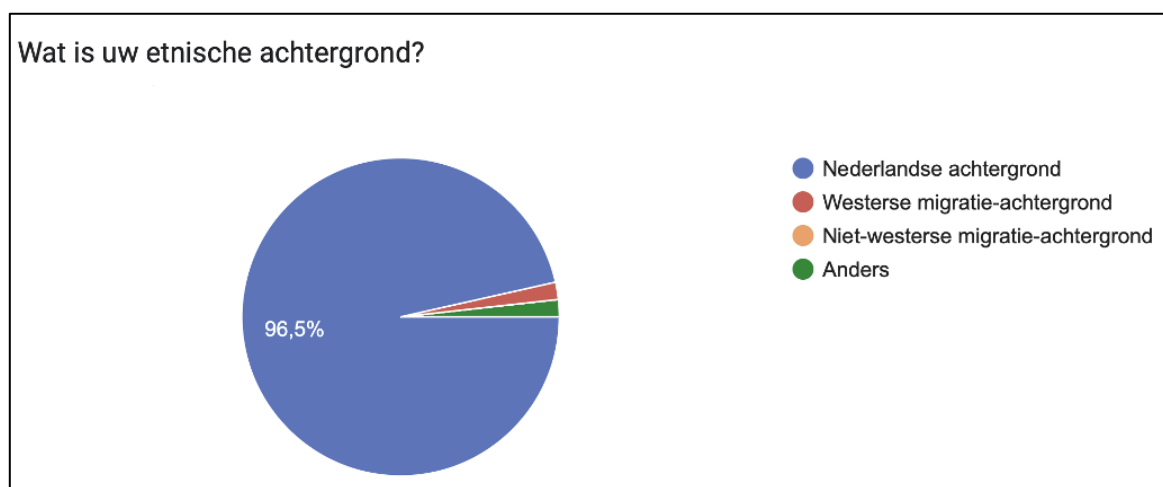


Figure 5.6: Ethnical background of respondents (Survey, 2024)

Furthermore, results from the survey show that almost all male respondents have a high level of education while some females show a lower level of education. Not only for themselves, but also the education level of their parents/guardians. Education is related to travel behavior as results show that higher educated people think more about impact on the environment than less educated people.

“In my circle of friends, they make the same choice. There are more, say, highly educated people living in the city. Yes. But in my family and so on, people who live a bit further away, yes, they do everything by car. They cycle very little” (Interview 4, personal communication, 2024).

However, results from the survey show that respondents with a high education level still make use of the car. They try to make use of public transport and active mobility more but make use of the car for other destinations for work as it is more convenient, comfortable and less time consuming.

“Yes, usually when I go further away, that does play a role. If it's longer, I'll quickly take the car ... But on the other hand, if possible, I would like to take the train or even take the bike ... Yes, for me personally, I would prefer to do everything sustainably. Yes ...

And what I said that trade-off is really there. So, if I take the car, then I also take the train for my business trip sometimes. To take the train every now and then” (Interview 6, personal communication, 2024).

Car use is still a convenient and comfortable way of travel for many people. However, discourses around sustainability and sustainable ways of travel are eminently present nowadays. Especially respondents with a high level of education show that they think about this, while this is less present with those that have a lower level of education.

The survey shows that most of the respondents are working. With a small number of respondents which stated they are looking for a job, unfit for work or retired.

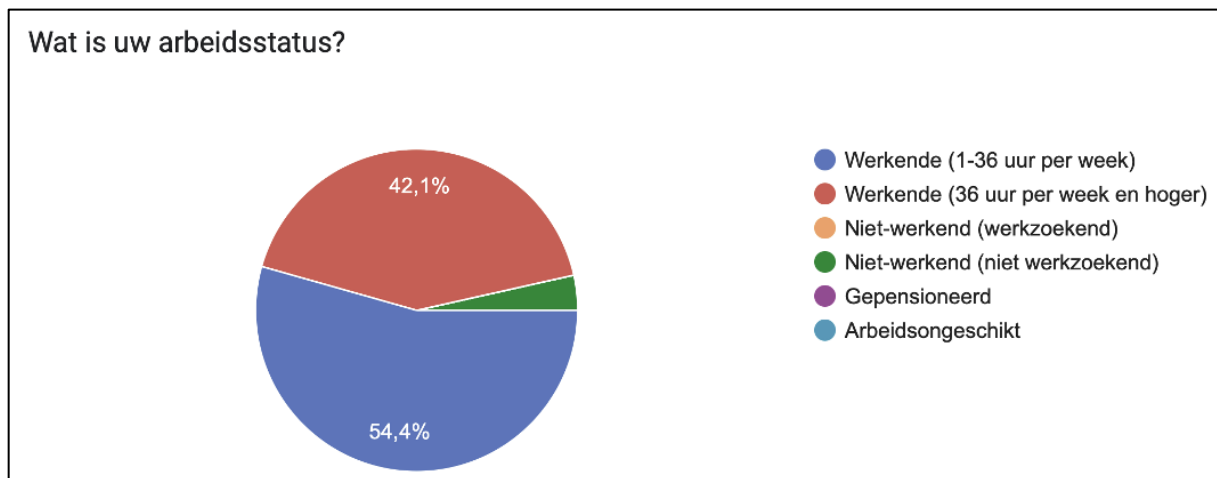


Figure 5.7: Employment status (Survey, 2024)

Furthermore, the average age of respondents which state they use the car for work destinations is 36. The results from the survey show that these respondents that use the car as a travel mode all work full-time. However, it is notable that these respondents are not all working on location all days of the week. It varies from 2 to 5 days working on location. Most people make use of public transport or active mobility in order to get to work.

“But also, at short distances. If I have to go from Nijmegen to Arnhem. The train will then reach Arnhem within 12 minutes. And I know that when I'm by car. Then there is a chance that there is a traffic jam, and I can be late. There can often be traffic lights in the way. I think I almost always give public transport the priority” (Interview 3, personal communication, 2024).

As stated before, for other destinations besides work, respondents make use of the car more often than for work destinations. The results show a small difference between people who live in a (bigger) city and people who live in a (smaller) village. Residency seems to be influencing people’s travel behavior in such a way that nearby services are further away for people in villages compared to those in cities. Respondents of the survey have various household status. Most respondents have stated they live with their partner or with their partner and kids. Next to that, most respondents live with roommates or alone. Only a small percentage live in a different situation.

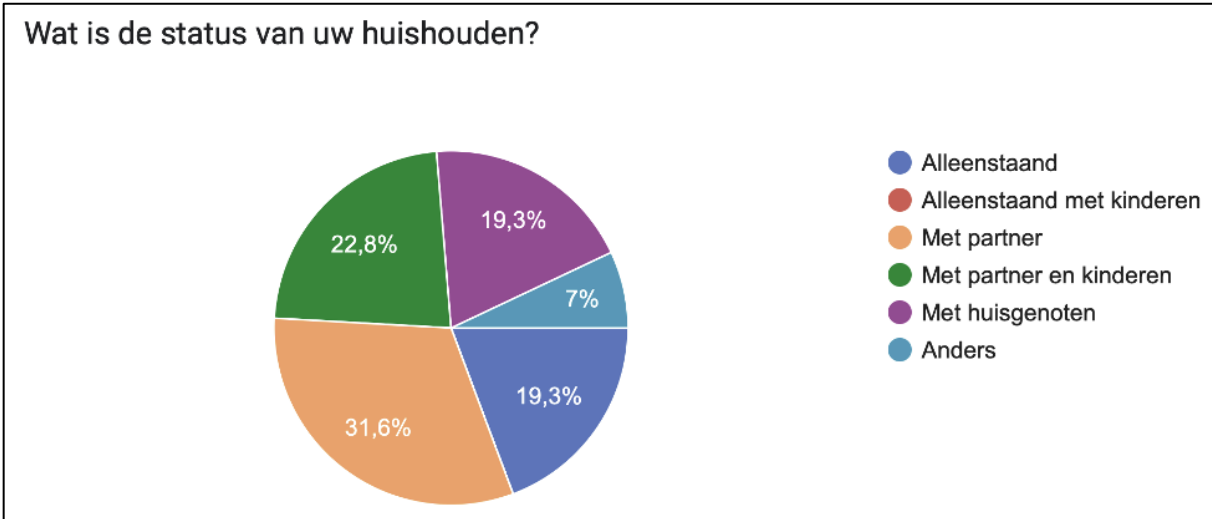


Figure 5.8: Household status (Survey, 2024)

It is interesting that most car users live with their partner or their partner and children. These respondents state that their choice in travel mode is namely based on time and comfort. While respondents who live alone or with roommates state that their choice for travel mode is based on comfort, safety and especially weather conditions.

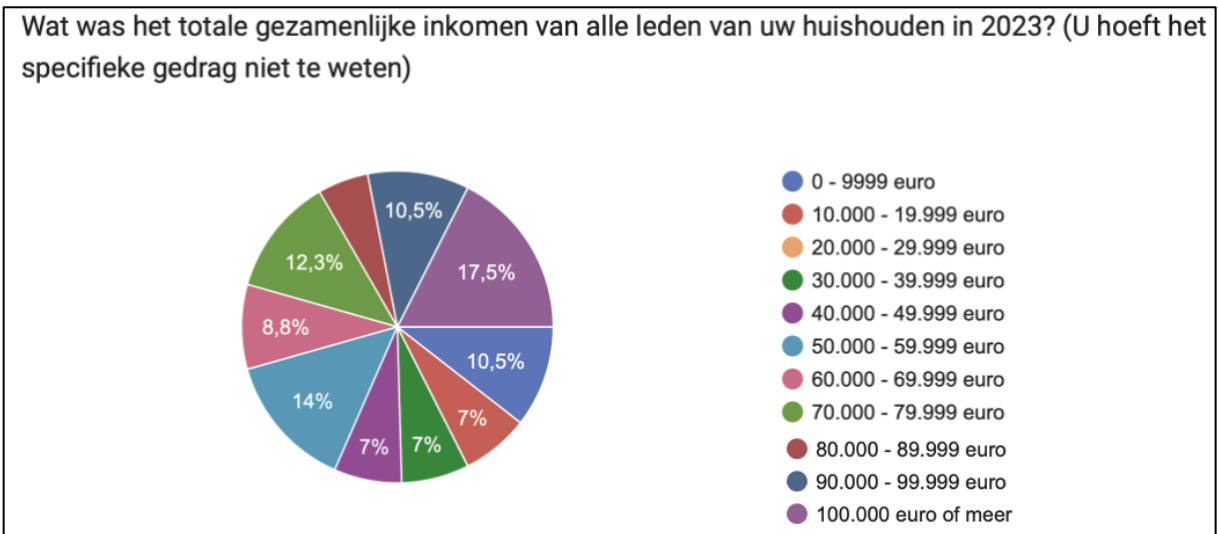


Figure 5.9: Average income per household (Survey, 2024)

Income has a significant effect on travel behavior. Students can travel with public transport for free, and thus car use will be expensive for them compared to public transport. Elderly (retired) people can sometimes travel with public transport for free and are therefore more easily inclined to use public transport instead of using the car.

“I would really like to, but I have that with a lot of sustainability measures. I can't pay them. I am a single earner. I still have a daughter who is studying. It's just too expensive for me” (Interview 1, personal communication, 2024).

However, most middle-aged people can't travel with public transport for free. They find public transport expensive and are less inclined to use it solely, as the car is still more comfortable and provides better accessibility for workplaces.

“And in terms of public transport, what usually holds me back is simply the price. That's why I never actually take public transport during the week” (Interview 2, personal communication, 2024).

Travel costs can determine whether people choose a certain mode of travel. The higher the costs for one travel mode, the more individuals are inclined to make another choice. The survey shows that most people will make another choice concerning travel modes when one travel mode has high costs.

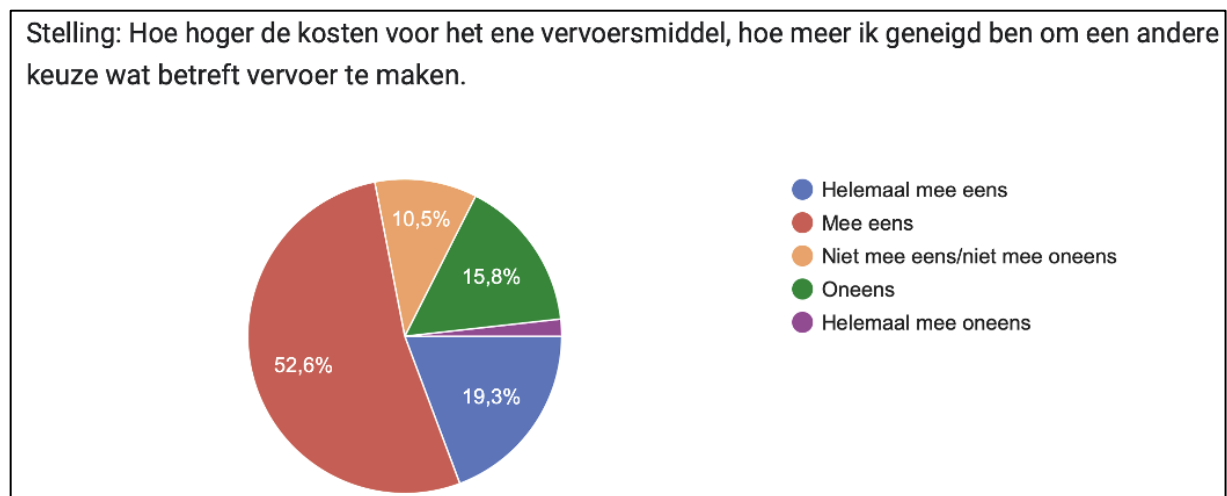


Figure 5.10: Role of infrastructure related to travel choice (Survey, 2024)

Also, the notion that most jobs offer lease-contracts for cars while not all jobs offer travel declarations for public transport emerges from the interviews. Students are inclined to use public transport in combination with active mobility after their education time, when work compensates it. However, most jobs offer compensation for cars resulting in more individuals using the car. Moreover, elderly people are more eager to make use of shared mobility (through taxi services and district buses) or public transport if they were cheaper than they are now. Travel costs for those options have a direct effect on the choice of using the car.

5.2.2 Physical environment

The physical environment has been analyzed through three concepts, namely the built environment which encompasses human-made structures and infrastructure assets that form the physical, natural, economic, social, and cultural capital. Furthermore, travel distances, trip purpose and day of the week which can be seen as notable trip characteristics. Lastly, the natural environment which encompasses natural factors such as climate, weather and landscape.

The built environment plays a significant part in explaining and determining travel behavior. *Figure 5.11* shows that around the majority of the respondents, around 42%,

believes that infrastructural circumstances play an average part in their choice of travel mode.

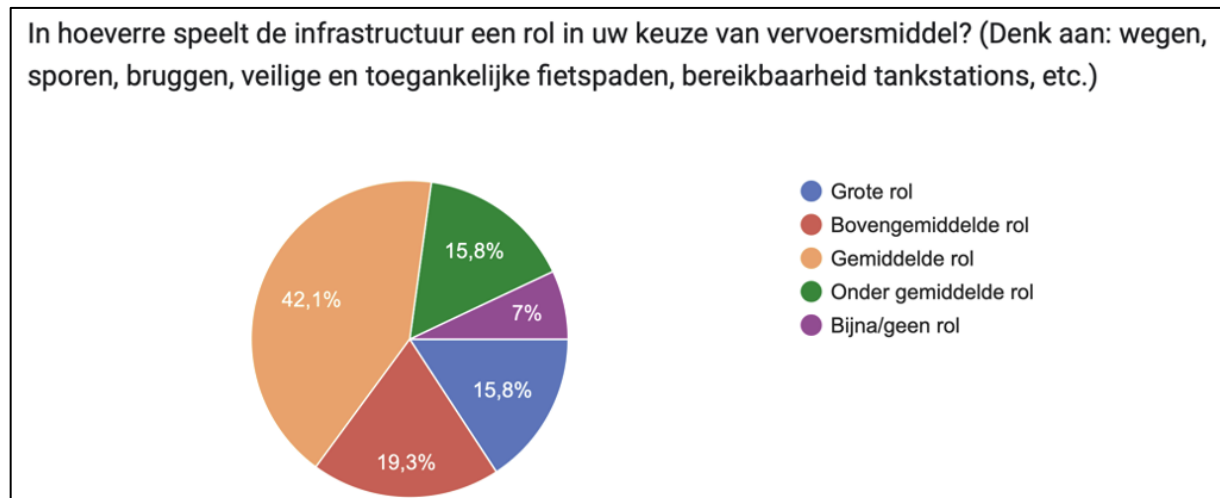


Figure 5.11: Role of infrastructure related to travel choice (Survey, 2024)

However, with the increasing housing market and thus expansion of housing sites more people are living in new residential areas. Respondents also state that living in such new residential areas is often accompanied by little to no access to public transport in a direct manner. Therefore, they are forced to make use of the car in order to travel to work or other destinations.

“I live in a new-build area with no public transport nearby, so I can only travel by car” (Survey, personal communication, 2024).

“Public transport is not an option due to accessibility to home and my destinations” (Survey, personal communication, 2024).

Public transport infrastructure is often not provided in new-build residential areas. Moreover, infrastructure also contemplates stations, not only railroads, as those are also not present in a lot of areas. Preventing people to make use of public transport and instead make use of the car.

“The range of public transport is limited in our village. And our municipality has no bus or train station. That’s why I almost never take public transport” (Survey, personal communication, 2024).

Furthermore, not only public transport infrastructure plays a big part in determining travel behavior. Also cycling roads play a part in determining whether people will choose active mobility or make use of the car.

“So that it really becomes an acceptable alternative to that car. Good cycle routes. And we are all working hard on that. Only yes, that just takes a while” (Interview 1, personal communication, 2024).

If respondents travel by car, they state that roads in bad conditions doesn’t bother them as much as when they are traveling by bicycle. Especially those making longer

commutes, want the cycling roads in good condition in order to travel comfortably and without delays. Respondents also state that road works almost always hinders the cyclists the most, while car traffic is prioritized in order to keep the mobility flow going. Furthermore, bicycle roads aren't always safe. As respondent states:

“I grew up in Brabant and cycled through polder roads there. And then you occasionally have dangerous roads. And in Nijmegen you have really red cycle paths that are intended to make cycling safer” (Interview 3, personal communication, 2024).

There is a difference between cycling in villages and cities. Whereas cities seem to prioritize cycling over car traffic, people are more eager to make use of active mobility instead of using the car for short commutes. Villages seem to be well connected through motorways but not through bicycle roads which lead to less safe and comfortable roads, thus resulting in people taking the car instead of traveling via active mobility.

“And other places are easier to reach with that red cycle path. Wherever you have that, I think indeed, the cyclist is king. So that certainly plays a major role” (Interview 3, personal communication, 2024).

Cities are becoming less car friendly and thus respondents also state that they're less willing to make use of the car when traveling towards a city center. Moreover, besides roads and stations respondents state that moving car parking towards the edge of cities instead of providing those in the heart of the city could stimulate the mobility flow.

“No, not enough. I think this could really be improved a step further. An initiative like the park-and-ride type, so you can park just outside the center and possibly take a metro. There is, but it all still feels a bit in its infancy. And not if there is something reliable about it. That's just what it says, you can rely on it in that list” (Interview 6, personal communication, 2024).

Next to the built environment, the natural environment determines travel behavior through climate, weather, and landscape. From the survey 33,3% of respondents answered that natural circumstances have an above average role on choice of travel mode and 22,8% of respondents answered that natural circumstances have a big role on choice of travel mode. It is notable that with both natural and infrastructural elements exactly 77,2% respondents answered that it either has an average effect, an above average effect, or a big effect on their choice of travel mode. Showing the importance of the physical environment.

Wat voor rol speelt de natuur in uw keuze voor vervoersmiddel? (Denk aan: weersomstandigheden, landschap, nacht/overdag)

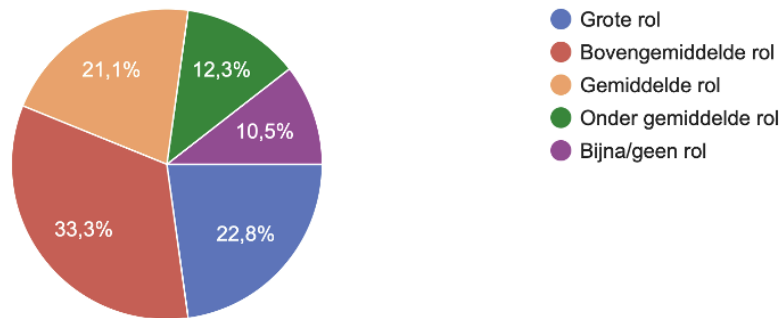


Figure 5.12: Role of nature related to travel choice (Survey, 2024)

The natural environment encompasses climate, weather and landscape. The climate and the weather are significant determinants for travel behavior. Especially in the Netherlands, where rain is very common.

“Within Nijmegen I also travel by bus. So, I go to the library sometimes. And then when the weather is nice, I take the bike. And in bad weather, or if I am indeed lazy, I take the bus. So, in that sense weather or climate also plays a very important role. Yes, I really think about that. When I look at it this way, every day plays a role in my life” (Interview 3, personal communication, 2024).

The climate very much determines whether one is traveling by foot or bicycle, or whether one is traveling by bus, train, tram, car, etc. People also find it uncomfortable to use active mobility in combination with public transport when the weather is bad. They are more inclined to the car when the weather is bad. This increases the car use, resulting in more car traffic on the road in Gelderland.

“And if I have to go further away. I can easily go through the drizzle a few times, this week I cycled through the drizzle a few times to Twello, five kilometers, that's what I'll do. But yes, if things get faster, or I have to go further, I sometimes jump in the car” (Interview 4, personal communication, 2024).

Next to that, travel destinations determine for a big part what mode of travel individuals will choose. Under normal weather conditions, longer commutes for work and education purposes are mostly using public transport. However, when a certain work destination is not accessible to all modes of travel, people make use of traveling by car. As stated before, villages are more accessible to cars while cities are accessible to all modes of travel.

“Except within the region. If I have to go to Beuningen or Wijchen, I take the car. That's easier, faster and sometimes too much hassle with public transport from Wolfheze. It's just only 1 train. There is nothing else” (Interview 1, personal communication, 2024).

Moreover, a trip characteristic such as travel time has a big effect on travel behavior. Respondents answered in the survey that travel time, next to comfort and weather, is the most important determinant for their choice on travel mode.

“And I often go to Elst by car, because it is faster for me than by train. Then I have to switch again. I depend on a sprinter, and he only runs twice an hour. And I have a bad connection. Then the car is much easier” (Interview 1, personal communication, 2024).

Results from the interviews show that using the car instead of public transport for work purposes are mainly for less travel time. However, commutes by bus and not by train often have much more travel time than the car due to bus transfers.

“But sometimes the travel time is so long that it is simply not convenient to take the bus ... As the crow flies, it's really less than half an hour by car. And by bus it can really take an hour and a half. And I'm not even in the village itself, so to speak. So then, if you were to call that a long-distance ride, it does make a difference” (Interview 5, personal communication, 2024).

Furthermore, travel delays can have a big effect on travel behavior. Traffic congestion on motorways can result in more travel time, meaning individuals are less likely to make use of the car the next time.

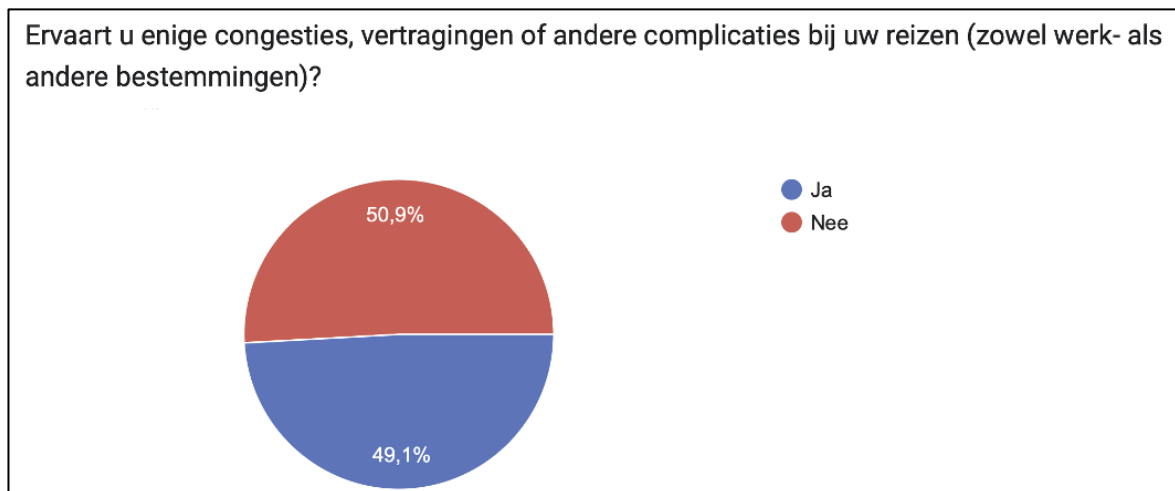


Figure 5.13: Travel delays and congestion (Survey, 2024)

However, as it turns out from the results of the in-depth interviews, congestion on motorways are seen as obstructive and inhibitory but are often not the cause of switching towards other modes of transport. Delays in public transport and active mobility can be causation for switching towards using the car.

“With my driving behavior I adapt somewhat to avoiding rush hour. Yes. That already helps. At the same time, I don't mind if you have a ten-minute, fifteen-minute delay or whatever. I'm in my car anyway, I usually have something like a podcast on, so I'm in my own bubble. So that's fine, that's nice” (Interview 6, personal communication, 2024).

Especially longer commutes by bus are seen as uncomfortable and time consuming as here often travels are delayed resulting in more travel time. For work purposes individuals therefore make use of active mobility, especially short commutes, as they are least likely to be subject to delays. For other destinations individuals have more time and are therefore more inclined to make use of the car where they are more comfortable when experiencing delays than public transport.

5.2.3 Psychological and social aspects

There are some concepts which determine the psychological and social aspects present with individuals. Firstly, there are attitudes, which represent the personal desirability of behavior, or the feeling of being more or less favorable towards performing the activity. Moreover, subjective norms pertain to the social pressures we encounter; how other individuals look at our choices. Moral obligations represent the personal norms, moral norms, or values that individuals possess which serve as guiding principles in the life of an individual, steering their choices. Whereas habits refer to the process when individuals frequently perform a given behavior in response to a specific goal, and intentions no longer act as the main predictor of behavior of that individual. Lastly, perceived behavioral control accounts for the perceptions of how difficult or easy it is to perform a certain type of behavior.

As stated earlier, respondents of the survey answered that time, comfort and weather are the most important determinants for individuals regarding travel behavior. The survey shows that most respondents travel by bike or walk to work destinations. From the interviews it has turned out that the bike is indeed an important travel mode for individuals. It is therefore remarkable that respondents state that although the bike is an important travel mode for them, the car still remains the most important one. Even ones that are almost not traveling by car. It seems that people consider their car to be the most favorable travel option, even though they are traveling to work by foot, bike and/or public transport.

“Yes, at the moment it is still the car. But really in second place is my bike”
(Interview 1, personal communication, 2024).

The car is considered to be more comfortable and most individuals state that it provides freedom and independency. They can travel by car at any time and any place possible. Moreover, because of the well installed infrastructure network for motorways, the car can travel easily towards its destination. Bicycles require good bike lanes and – roads, and not every place is connected with a good bike lane. However, as the policy study on the province of Gelderland shows, these bike lanes have been developed over the years and are still being developed. The results from both the survey and the interviews show that individuals are more inclined to use the bicycle. Respondents believe the exercise is good for their health and, when the weather is in good condition, are even choosing the bike over the car.

“I do believe I am thinking about that consciously, I think. For example, I know that when I go to work. And then I’m first taking the train and then the car. That makes me

seem quite lazy. While I can also just do it walking. And sometimes I think, I can just cycle. So, I am consciously working on it” (Interview 3, personal communication, 2024).

The results show that subjective norms have shifted over the years. Respondents from the middle-age class state that the car is their most important mode of travel, while a younger audience believes that public transport and active mobility are the most important ways to travel. Personal affection towards public transport comes from the fact that many students can travel for free via public transport and are set on traveling by public transport. While individuals from the middle-age class are set on values and beliefs that the car is the number one travel mode to be used.

“And also, when I look at my father and my mother. In principle, my mother has to travel the same distance to Nijmegen, to my house, as I do. But she would still prefer the car. And my father too. While the travel time by train is shorter than by car” (Interview 3, personal communication, 2024).

And our values and beliefs are not only changing on an individual level, respondents from that middle-age class are also noticing the change in perspective. In such a manner that their environment is looking at more sustainable ways to travel instead of making use of the car. Their perspectives are also changing, whether it is directly from their own personal beliefs or indirectly as their environment changes, they change as well.

“Yes, you hear stories about how people go on holiday, how they do things, what is more environmentally friendly. While twenty years ago everyone automatically boarded planes when they went on holiday, so to speak, I notice that I am in an environment where people now make different choices. And then you hear other stories and that makes you think” (Interview 4, personal communication, 2024).

It is no wonder that this influences travel behavior for individuals. Results from the survey show that 43,9% of the respondents believes that values and beliefs have an average effect on their travel behavior, 22,8% believes that values and beliefs have an above average effect on their travel behavior and 12,3% believes that values and beliefs have a big effect on their travel behavior. Only 21% of the respondents believe that subjective norms have an under average or (almost) no effect on their travel behavior.

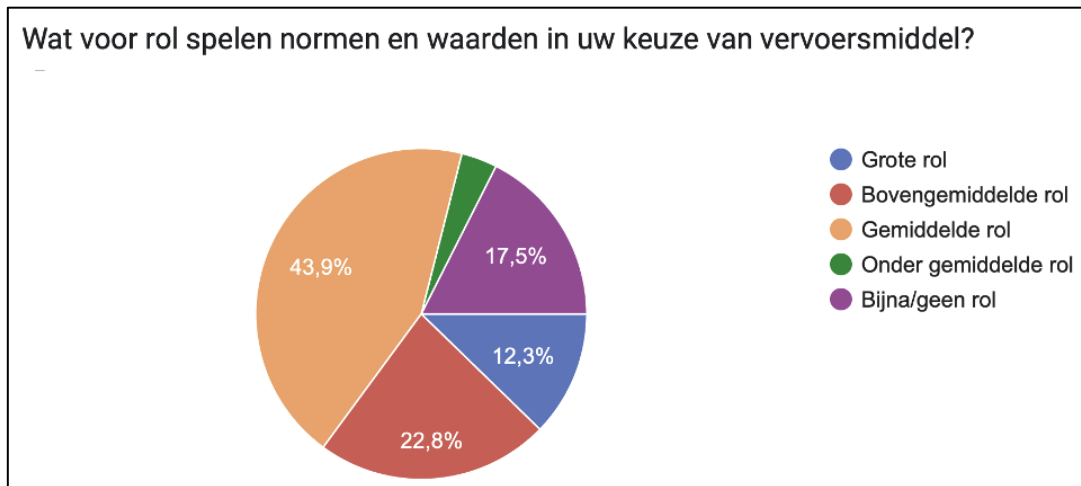


Figure 5.14: Role of values and beliefs related to travel choice (Survey, 2024)

Subjective norms have shifted perspective from solely or mostly car use towards more use of active mobility and public transport. However, personal attitudes towards public transport can have a direct effect on individuals' travel behavior. Respondents mostly state that trains, subways or trams are easy and comfortable while making use of the bus is accompanied by more travel time, less comfort, more delays and more difficulties.

“That if I go back to my village. Because it is so difficult to reach. And I actually had the bus just not show up yesterday. And then I really think so. Yes, this is really a 20-minute drive by car. And you can really spend two hours by bus. At least with a transfer and everything. So, then I would rather take the car” (Interview 5, personal communication, 2024).

People who live in cities rather than (smaller) villages make use various travel modes. Results from the survey show that car users inside cities are making use of active mobility, public transport and even shared mobility when they are traveling with their partner(s), co-workers or roommates. Car users from villages are mostly using the car for work destinations as well as other destinations. Villages are less accessible to different modes of travel making the car the most important mode for travel.

“My fellow students often travel by public transport. Also because of the student product. But I also have a number of friends from villages who already work. They look at me really strangely because I prefer to travel by train. They simply have their own car and prefer to do everything by car. So, you really see a significant difference there” (Interview 3, personal communication, 2024).

“But just because those villages are so far apart. For example, many people also go out to another village. And then you have to go back by car. Just as public transport would be better organized. Then I think that would really reduce car use quite a lot” (Interview 5, personal communication, 2024).

Moreover, habits seem to influence travel behavior directly and indirectly. Respondents state that when making use of the public transport and/or active mobility, they have to

know their daily schedule and plan their day ahead. When making use of the car, they can be more flexible in their planning resulting in more comfort when traveling.

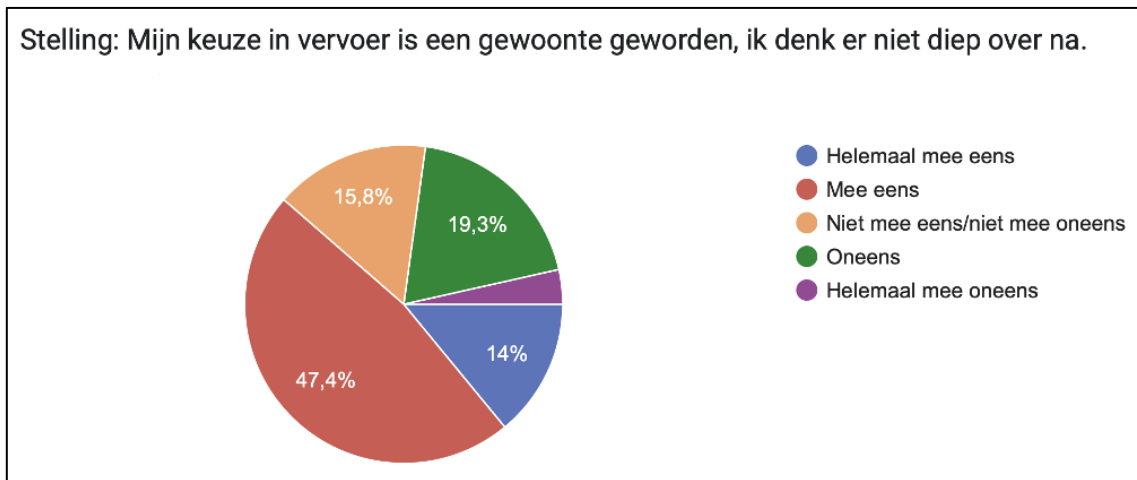


Figure 5.15: Role of habits related to travel choice (Survey, 2024)

As *Figure 5.15* shows, most respondents believe that their travel choice has become a habit. While 14,5% of the respondents believe their travel behavior has not become a habit. People state that traveling to destinations for work or education purposes is accompanied by thinking about their travel behavior and what travel mode is not only most comfortable and provides the least time travel, but also which is more sustainable. For other destinations individuals mostly travel by car, such as shopping, catering industry or groceries shopping. For short commutes with destinations such as sport or other destinations inside a city center, most individuals seem to travel by foot or bike. However, most decisions seem to be related to the expenses individuals make. Travel costs are an important indicator for travel behavior.

5.3 Perceptions on sustainable mobility

Sustainability is a concept which is becoming more present among individuals. Respondents state that sustainable ways of travel is being promoted more by work, as well as in their social environment.

“Yes, from my work perspective it is natural. I have to travel as sustainably as possible and I support that” (Interview 1, personal communication, 2024).

Namely the mobility network in cities is more focused on sustainable travel rather than cars. The infrastructure being developed is designed for giving priority to public transport and active mobility, and not the car.

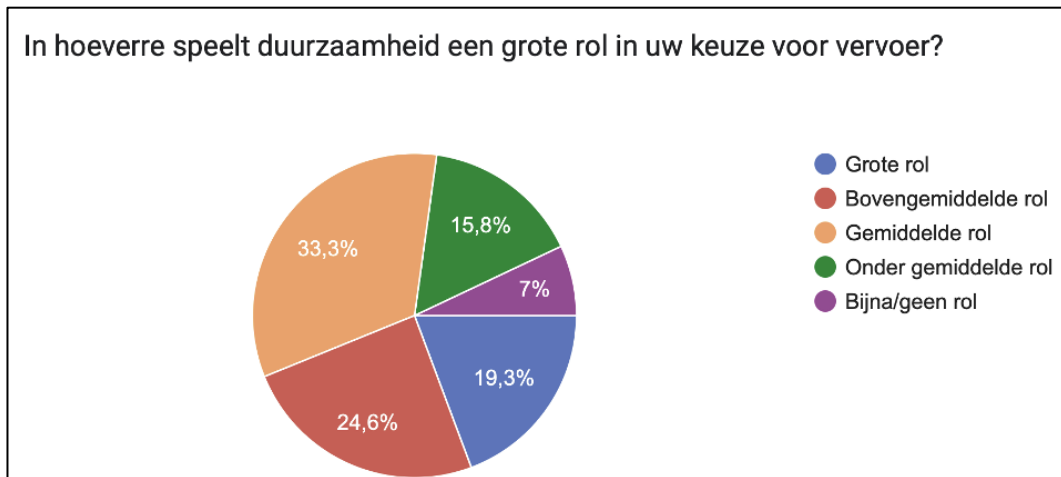


Figure 5.16: Role of sustainability related to travel choice (Survey, 2024)

Around 19,3% of survey respondents state that sustainability has a big effect in their travel behavior. 24,6% of the respondents believes it has an above average effect and 33,3% believes it has an average effect on their travel behavior. 15,8% of the respondents believes it has an under average effect on their travel behavior and only 7% believes it has almost no to no effect on their travel behavior. Sustainability shapes the mobility flow in such a way that individuals will travel more with more sustainable ways of transport, such as public transport, shared mobility and active mobility. In order to get to work, active mobility seems to be the most popular among the respondents, highlighting the switch to more sustainable mobility rather than taking the car. Moreover, public transport seems to be used for longer commutes rather than the car, making it more sustainable. Respondents state that sustainable travel has their priority, but that it is not always possible.

“And in terms of climate, I am very concerned with that. So that does help. So, I think so. That's why I always cycle everywhere at home” (Interview 2, personal communication, 2024).

“Yes, for me personally, I would prefer to do everything sustainably” (Interview 6, personal communication, 2024).

Individuals with a higher education level, travel more sustainably resulting in less car use. Individuals with a lower education level who live in villages rather than cities are traveling more by car. Results from the survey show that these people are also experiencing more delays by car traffic and congestion. Moreover, people who live in green areas are more inclined to use the bicycle for work destinations as well as other leisure destinations. Sustainable ways of travel can however be costly, making it so that some individuals are less inclined to travel in a sustainable way.

“I just think it's terribly expensive actually. At least that's real, for me that's something that stops me ... from taking public transport more often when it's not free for me” (Interview 2, personal communication, 2024).

Sustainable ways of travel are also not always experienced as comfortably and can be time consuming. Individuals are more likely to travel by train but feel that there are not

always enough bikes that one can take from the station. Moreover, individuals are traveling more sustainable inside cities than between. Traveling between cities and inside cities is more comfortable by using public transport. Traveling between cities and villages is more comfortable by using the car. In order to reach those places, individuals must use buses or taxi's. Taxis are mostly being used by elderly people but can be expensive and are not used by young or middle-aged people. Buses are highlighted as the number one public transport service to reach villages but are characterized by a lot of travel time and are often accompanied by delays.

5.4 The relationship between individual travel behavior and sustainable mobility

It is very different as to what is the most important travel mode for individuals. Certain characteristics such as socio-economic and demographic determinants explain this travel behavior. Moreover, the physical environment, in the form of built infrastructure, weather, landscape and climate describes why individuals show a certain behavior. Subjective norms and beliefs, and personal attitudes have a direct as well as an indirect effect on individual travel behavior. Habits also form travel choices, as they pertain to how people show habitual behavior when it comes to mobility. Sustainability also has a direct and indirect effect on travel behavior. Travel behavior therefore has an effect on the mobility flow within Gelderland. In order to understand what way travel behavior and perceptions on sustainable mobility shape the mobility flow, it is important to look at the relationship and combination between those two concepts. The results from the survey show that travel time, the weather and climate and accessibility are the most important indicators to travel behavior which in turn show an (in)direct effect on sustainable mobility and mobility flow. Furthermore, travel distance and – delays, travel costs, residency, feeling of safety, integration and travel costs are important determinants.

Firstly, it is noticeable that individuals who are traveling with active mobility is increasing. Travel time mostly determines whether people use the car or a more sustainable way of travel. Not all places are accessible for public transport while individuals can travel there by car more easily. Trains are considered to be a good alternative for the car, while buses are seen as less comfortably. Namely buses between villages and cities. Accessibility is a big determinant in stating the mobility flow.

“That sprinter only runs once an hour in the evening and only runs until about half past twelve. So, I just don't come home anymore. So that's also a reason why I take the car” (Interview 1, personal communication, 2024).

The car provides more freedom and flexibility, thus being an easier choice rather than public transport over this sort of commutes. Longer commutes for work destinations seem to be, when easily accessible for public transport, more suitable for public transport than the car. Most respondents make use of this option next to the car on a daily basis, resulting in less cars on the roads and thus less traffic congestion. Villages do not always have good connections to the public transport infrastructure, which result in more travel time. Therefore, residency and the related travel time are determinants for travel behavior, as these individuals are more inclined to use the car resulting in more car traffic. This way the mobility flow decreases.

“Arnhem and Nijmegen are never a problem. You can just go there by train. But especially those smaller villages” (Interview 1, personal communication, 2024).

It is seen that younger and higher educated individuals who are living in a city are more inclined to use public transport than middle-aged and lower educated individuals. Moreover, those same younger and higher educated individuals who are living in a city are more inclined to use public transport than younger and higher educated individuals who are living in a village. Individuals living in a village are more inclined to use the car, even though they experience delays and congestion. Delays and congestion with the car are less of a nuisance than with public transport or active mobility.

Active mobility is seen as a good sustainable alternative for the car by most individuals. However, most respondents of the survey and interviews state that for longer commutes public transport can be suitable, but cars provide more comfort. Especially the weather can ensure that individuals who are inclined to use active mobility on short commutes, will also make use of the car instead.

Travel costs for public transport are considered to be pretty high by respondents, as well as those for cars. All the same, cars provide certain features public transport does not, and therefore individuals are willing to pay that for cars and not for public transport. If public transport were cheaper, more individuals would make use of it rather than the car simply because of the costs. Also, for shopping destinations, individuals are using shared mobility. Although there are still many options for shared mobility, individuals are less likely to use it.

Respondents of the survey as well as the interviews are mostly positive towards the shift from cars to sustainable ways of travel. As policy study on the province of Gelderland shows, there is a transition where active mobility and public transport are stimulated while trying to discourage more car use. Bike roads and public transport infrastructure are considered to be more important than construction on motorways on the short term. 82,5% of the respondents of the survey stated that they are agreeing that this transition is good. 14% doesn't agree or disagree and only 3,5% disagrees. Those 3,5% of respondents are individuals with low educated parents or guardians who live in a village and who travel solely by car or active mobility and don't make use of public transport.

Stelling: Het is goed dat er een transitie van de auto naar duurzame alternatieven voor vervoer plaatsvindt.

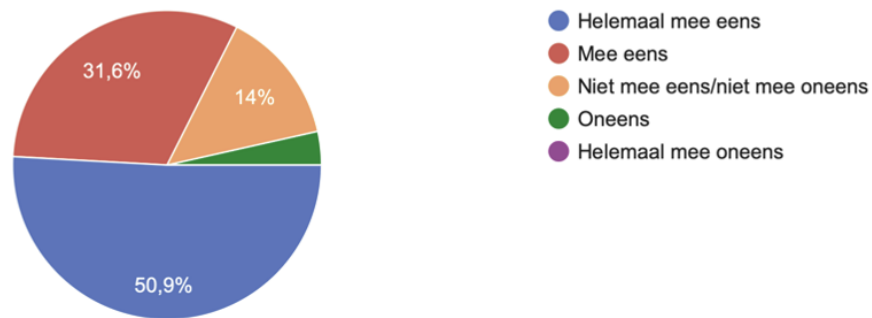


Figure 5.17: Respondents' opinion on the sustainability transition (Survey, 2024)

One important feature which explains why people are more inclined to use the car rather than public transport or active mobility is that of safety. Some respondents also state that cycling at night or using public transport at night comes with a lot of uncertainty. They don't always feel safe at that time and are therefore using the car for their travel.

“And I don't always think it is safe to use public transport ... So, I just find the evening hours very annoying. Yes, and safety also plays a major role” (Interview 1, personal communication, 2024).

“I would also take the car earlier in the evening. That I won't be up late at night. Say you have to wait at that remote bus stop. And there might not be a bus. That is also from a safety point of view” (Interview 5, personal communication, 2024).

The relationship between individual travel behavior and sustainable mobility lies within the choices people make about how they travel, as their choices directly affect the sustainability of transportation systems. Therefore, this relationship affects the mobility flow within Gelderland.

Chapter 6: Conclusion

This chapter presents the conclusions by addressing the sub-questions and the main research question. These conclusions are based on the results from the survey data, the interview analyses and theoretical framework.

How is the mobility flow within the Province of Gelderland shaped?

Mobility flow describes the movement patterns of people and vehicles within a transportation network, encompassing the speed, density, and distribution of traffic across various modes of transport. Mobility flow in Gelderland is primarily shaped by the use of cars, public transport, and active mobility. The province is home to over a million cars owned by residents, not including vehicles from other regions that also use Gelderland's road network. Car usage leads to significant delays, particularly on Tuesdays and Thursdays. Additionally, Gelderland has an extensive train network, which is increasingly popular but also faces rising delays due to higher ridership. Cycling is becoming more common, especially for short distances, and Gelderland boasts a comprehensive bicycle network. Traffic congestion is mainly driven by work-related trips, but other destinations such as homes, sports facilities, healthcare centers, and educational institutions also significantly influence mobility flow, especially for shorter trips.

While cars remain the dominant mode of transport, there is a growing trend of combining public transport with active mobility for longer commutes. For work-related trips, individuals increasingly rely on active mobility when their workplace is nearby, sometimes even combining it with car use. Despite this shift towards more sustainable options, the car continues to be the preferred mode of transport, largely due to issues of accessibility and efficiency. Industrial areas, for instance, often lack well-connected public transport or active mobility options, making car travel the most viable choice for many.

Efficient mobility is crucial for achieving a good flow. Gelderland has well-coordinated public transportation systems in the form of trains, that minimize bottlenecks and delays and attract more users, reducing dependence on private cars. On the other hand, frequent delays, especially buses, are deterring people from using sustainable transport options. Moreover, persistent traffic congestion are encouraging people to seek alternative routes or switch to modes of transport like cycling or public transit. However, if public transportation is more consistently reliable and efficient, more people may opt for it over driving.

People traveling for work or education typically rely on cars or public transport, while trips to the supermarket are mostly done by car. For other purposes, such as leisure activities, active mobility is the preferred mode of transport. Efficiency, which refers to minimizing delays and effort in getting from one point to another, is often measured in travel time. Efficient travel time and distance are key factors in shaping mobility flow, particularly for those commuting to work. Individuals who are traveling to work or

education are namely seeking to minimize their travel time and delays. Individuals who are traveling for other purposes are less concerned with minimizing travel time.

Not all destinations within Gelderland are accessible by all modes of transport, leading to delays in mobility flow, particularly for car traffic on most roads. Travel time and distance to nearby services are influencing mobility flow, with cars predominantly used for commutes longer than 25 kilometers. For destinations within 25 kilometers, individuals mainly rely on active mobility. Gelderland boasts an extensive public transport network, with trains frequently used, while the bus network, despite being popular, faces delays that push people toward less sustainable transportation options. Shared mobility has a minimal impact on overall mobility flow, primarily used by the elderly through taxi services or car-sharing. Some workers also share rides with colleagues. Overall, the mobility flow in Gelderland is shaped mainly by car use, public transport, and active mobility. Both cars and public transport experience frequent delays, while active mobility is generally preferred for shorter commutes, with cars and public transport better suited for longer distances.

To what extent does individual travel behavior of residents influence the mobility flow within the Province of Gelderland?

Three distinct domains influence individual travel behavior: socio-economic and demographic factors, physical environment factors, and psychological and social factors. These behaviors, in turn, shape the mobility flow in Gelderland through the various modes of travel people choose to use.

A notable distinction exists between men and women in their car usage for work destinations within Gelderland. Men are more likely to use the car for work-related travel, while women use the car less for work and more for other purposes. Women predominantly rely on the car for activities such as shopping, grocery runs, visiting hospitality venues, and traveling to sports facilities. Men contribute to traffic congestion on motorways primarily on workdays, while women are more likely to cause congestion on weekends. Consequently, men are responsible for higher congestion levels during weekdays, which reduces mobility flow, whereas women contribute to congestion on weekends through shorter car commutes, leading to a lower impact on overall mobility flow.

Age significantly influences travel choices, as older individuals often find it more challenging to travel comfortably and easily through active modes like walking or cycling. Elderly people may still drive, but many find public transport easier, more comfortable, and less energy intensive. Some believe that driving becomes more difficult with age due to traffic, making public transport a preferred option. Shared mobility, such as taxis and buses, can also provide a viable solution for older adults, which results in an increase in mobility flow. Younger people tend to use active mobility for short commutes and rely on public transport for longer journeys, particularly students. However, they also use cars for the comfort and convenience they offer, as driving can be quicker and less time-consuming than active mobility. The average age of individuals who report using a car for work-related travel is 36. Notably, many of these

respondents do not work on-site every day. All of these individuals work full-time, though their on-site workdays vary from 2 to 5 days per week. Most people rely on public transport or active mobility to commute to work, resulting in an increase of mobility flow. However, younger people using the car have a negative impact on the overall mobility flow in Gelderland.

Education is linked to travel behavior, with higher-educated individuals showing greater concern for environmental impact compared to those with less education. While highly educated people still use cars, they are more inclined to opt for public transport and active mobility when possible. However, they often rely on cars for non-work-related trips due to the convenience, comfort, and time savings they offer. Car travel remains a popular choice for many, but discussions around sustainability and eco-friendly travel options are increasingly prominent. Individuals with a higher education level are traveling more sustainably, resulting in an increase in the overall mobility flow, while those with a lower education level are traveling more by car, which reduces the mobility flow within Gelderland.

There is a slight difference in car usage between residents of larger cities and those living in smaller villages. It appears that living in a village influences travel behavior, as nearby services are often farther away compared to those in urban areas. It is interesting that most car users live with their partner or their partner and children. Their choice in travel mode is namely based on time and comfort. While individuals who live alone or with roommates state that their choice for travel mode is based on comfort, safety and especially weather conditions. Residency shapes the mobility flow, as individuals living in villages are mainly using the car, which reduces the mobility flow. While residents of cities are more inclined to use more sustainable ways of travel, resulting in an increase of mobility flow.

Income significantly influences travel behavior. Students can travel for free on public transport, making car use relatively expensive for them. Similarly, elderly or retired individuals may also have access to free public transport, making them more likely to choose it over driving. In contrast, most middle-aged people do not benefit from free public transport and often find it costly. As a result, they are less inclined to rely solely on public transport, preferring the convenience and accessibility of cars for commuting to work, which negatively impacts mobility flow. Travel costs can influence the choice of transportation mode. Higher costs for one mode often lead individuals to opt for alternatives. For many, public transport is expensive, leading to increased car use and subsequently more road congestion. This, in turn, reduces mobility flow within Gelderland.

Infrastructure plays a significant role in shaping individual travel behavior and mode choices. In new residential areas, the lack of public transport infrastructure often leads to increased car use. Additionally, the absence of essential facilities like stations, not just railroads, in many areas within Gelderland further discourages the use of public transport. As a result, people are more likely to rely on cars, which leads to reduced mobility flow. Poor road conditions can be a significant issue for cyclists, particularly those on longer commutes, who prefer well-maintained cycling paths for a more comfortable and efficient journey. In Gelderland, infrastructure often prioritizes car

traffic over cycling, which can hinder cyclists. Additionally, bicycle paths are not always safe. There is a noticeable difference between cycling conditions in villages and cities. Cities generally prioritize cycling infrastructure, making active mobility a more attractive option for short trips. In contrast, villages are well-connected by motorways but lack adequate cycling infrastructure, resulting in less safe and comfortable bike paths. This leads many people in villages to choose cars over active mobility for their travels. As a result, more individuals in cities opt for active mobility, leading to increased mobility flow. In contrast, those traveling by car from villages experience a less efficient mobility flow.

Climate and weather also significantly influence travel behavior. The weather often determines whether individuals choose to walk or bike, or opt for public transport such as buses, trains, trams, or cars. Poor weather conditions make active mobility and combining it with public transport less appealing, leading people to favor driving instead. This increased reliance on cars results in higher traffic volumes in Gelderland, which in turn reduces overall mobility flow.

Travel time is a major factor influencing travel behavior, alongside comfort and weather conditions. It is a key determinant in choosing a mode of transport. People often prefer driving over using public transport for work-related trips primarily to save time. Buses, which often involve transfers, can result in significantly longer travel times compared to cars. Delays in public transport and active mobility can prompt individuals to switch to car travel. Longer bus commutes, in particular, are perceived as uncomfortable and time-consuming due to frequent delays, leading to a preference for driving. Using public transport and active mobility increase the mobility flow, as they result in less traffic which reduces travel time and delays.

The car is often seen as more comfortable and offers a sense of freedom and independence, allowing individuals to travel anytime and anywhere. With a well-developed motorway infrastructure, cars can easily reach their destinations. In contrast, bicycles require well-maintained bike lanes and roads, which are not always available everywhere. Although bike lanes have improved over the years and continue to be developed, many people are increasingly inclined to use bicycles in the future. They value the health benefits of cycling and, in good weather, are likely to choose the bike over the car, which can increase the mobility flow as they reduce the number of cars on the road network of Gelderland.

Subjective norms around mobility have evolved over time. Middle-aged individuals often regard the car as their primary mode of travel, while younger people prioritize public transport and active mobility. Students, in particular, are inclined to use public transport due to the benefit of free travel. There is a noticeable shift in attitudes towards mobility, with growing interest in more sustainable travel options rather than relying solely on cars. Personal attitudes towards different modes of transport significantly impact travel behavior. For instance, trains, subways, and trams are generally viewed as easy and comfortable, whereas buses are often associated with longer travel times, less comfort, more delays, and greater inconvenience. These changing attitudes result in less car traffic within Gelderland. Habitual behavior seems to be decreasing, with people thinking more consciously on mobility discourses.

To what extent does the perception on sustainable mobility of residents influence the mobility flow within the Province of Gelderland?

The concept of sustainability is increasingly influencing people's lives. Sustainable mobility is gaining more attention, both in the workplace and within the broader social environment. Urban mobility networks, in particular, are shifting their focus from car-centric travel to more sustainable options. Infrastructure development is now prioritizing public transport and active mobility over private car use.

Residents utilizing the mobility network in Gelderland report that sustainability is having a growing impact on their travel behavior. This shift is steering individuals toward more sustainable modes of transportation, such as public transit, shared mobility, and active travel. For commuting to work, active mobility has become particularly popular, underscoring a move away from car dependency. Additionally, public transport is increasingly favored for longer commutes, further enhancing sustainability.

While most individuals express a preference for sustainable travel, they acknowledge that it is not always feasible. Those who do adopt sustainable modes often experience fewer delays compared to car users. However, cars still offer better accessibility to certain locations not well-served by the sustainable mobility network. Sustainable mobility positively influences traffic flow by reducing car usage, leading to decreased traffic congestion and more evenly distributed commutes.

Individuals with higher education levels tend to travel more sustainably, leading to reduced car usage. In contrast, those with lower education levels, particularly those living in villages rather than cities, rely more on cars and, as a result, face more traffic delays and congestion. Additionally, people living in green areas are more likely to use bicycles for short work commutes and leisure trips.

People that are traveling for work or education, carefully consider their travel options, weighing not only comfort and time efficiency but also sustainability. However, for other activities like shopping, dining, or running errands, the car is often the preferred mode of transportation. For short trips, such as going to sports activities, walking or biking is more common. Nonetheless, the primary factor influencing these decisions appears to be cost, making travel expenses a key determinant of travel behavior. The cost of sustainable travel options can be a barrier, making some individuals less inclined to choose these modes of transportation.

Sustainable travel options are not always perceived as comfortable and can be time-consuming. While public transport offers a more comfortable experience for traveling within and between cities, traveling between cities and villages is often more convenient by car. Although sustainable mobility can be more expensive and take longer than driving, it does improve traffic flow by reducing congestion. Active mobility seems to boost the mobility flow, especially for short commutes. However, not all sustainable travel options are well-integrated into the mobility network, making certain locations less accessible without a car. Sustainable mobility practices can improve traffic flow by decreasing the number of vehicles on the road, resulting in smoother traffic conditions, less congestion, and more efficient use of transportation networks.

What is the relationship between individual travel behavior and perceptions on sustainable mobility from residents in explaining the mobility flow in the Province of Gelderland?

As previously mentioned, those who commute short distances for work are increasingly relying on active mobility, leading to reduced car traffic and emissions, and improving overall mobility flow. Additionally, more people are opting for public transport for longer commutes, which further decreases the number of vehicles on the road, resulting in smoother traffic, less congestion, and more efficient use of the transportation network.

The factors influencing individuals' travel mode choices vary widely. Socio-economic and demographic characteristics play a key role in shaping travel behavior, as do aspects of the physical environment, such as infrastructure, weather, landscape, and climate. Subjective norms, personal beliefs, and attitudes also have both direct and indirect impacts on how people choose to travel. Additionally, habitual behaviors significantly influence travel decisions. Sustainability further affects travel behavior, creating a complex relationship between individual choices and environmental considerations. In Gelderland, these intertwined factors of travel behavior and sustainable mobility significantly influence the overall mobility flow.

Travel time, weather, and accessibility are key factors influencing travel behavior, directly and indirectly affecting sustainable mobility and overall traffic flow. Additionally, travel distance, delays, costs, and place of residence are significant determinants, closely tied to accessibility, safety perceptions, and the connectivity of the sustainable mobility network.

As noted earlier, the use of active mobility is on the rise. Travel time is a key factor in choosing between a car and a more sustainable option. While some areas are easily accessible by car, public transport isn't always convenient. Trains are viewed as a good alternative to cars, but buses, especially between villages and cities, are seen as less comfortable. Cars offer more freedom and flexibility, making them preferable for some commutes. For longer work commutes, public transport is often favored when easily accessible, reducing road congestion. However, poor public transport connections in villages lead to longer travel times, making residents more likely to rely on cars, which negatively impacts traffic flow.

Younger, more educated city dwellers are more likely to use public transport compared to middle-aged or less educated individuals. City residents in this group also prefer public transport over their peers living in villages. Village residents tend to use cars more, despite facing delays and congestion, which they find less troublesome than the issues associated with public transport or active mobility. Travel costs for both public transport and cars are seen as high. Despite this, cars offer benefits that public transport lacks, making people willing to pay more for them. Lower public transport costs would likely increase its use. Although shared mobility options are available, they remain less popular. People generally support the shift from cars to sustainable travel options. However, safety concerns play a significant role in their preference for cars over public transport or active mobility. Many respondents feel unsafe cycling or using public transport at night, leading them to choose cars for these journeys.

How do individual travel behavior of residents and their perception on sustainable mobility, shape the mobility flow within the Province of Gelderland?

The connection between individual travel behavior and sustainable mobility is evident in how travel choices impact the sustainability of mobility systems. This relationship influences the overall mobility flow in Gelderland, encompassing decisions on transport modes, travel timing, routes, and trip frequency and distance. Collective travel choices shape the movement of people and vehicles within the network. Many people driving during peak hours can cause congestion, while choosing public transport can ease traffic flow. Active mobility and public transport are increasingly favored for work commutes. Factors such as travel destinations, time, distance, and delays are linked to the physical environment, affecting the accessibility and efficiency (both indicators for mobility flow) of sustainable travel options. For commutes to other destinations the car still remains the most important travel mode, as it provides less travel time, more comfort, and more feeling of safety.

When individuals opt for sustainable travel choices like public transportation, carpooling, walking, or cycling, they help reduce environmental impact, improve air quality, and alleviate congestion. Changes in individual travel behavior can lead to broader improvements in mobility flow and sustainability. The growing use of cycling reduces traffic congestion and emissions, contributing to a more sustainable transportation system and smoother traffic flow. Changing subjective norms and attitudes are leading to increased use of these sustainable travel methods. As cars face more traffic delays and congestion, active mobility and public transport are experiencing fewer issues. This relationship between subjective norms, personal attitudes, and habitual behavior explains the observed changes on a physical level. Determinants like residency, personal beliefs, education, and age influence individuals to make more sustainable travel choices. This relationship between individual travel behavior and sustainable mobility highlights opportunities to enhance the mobility flow in Gelderland. Increased use of sustainable transport can reduce car congestion and improve overall traffic flow.

When choosing a travel mode, individuals always consider trip characteristics such as travel time, distance, delays, and costs. While cars offer certain advantages over other sustainable transport options, shifting social perspectives and ongoing improvements in infrastructure can make sustainable transport more efficient and accessible. As a result, sustainable mobility can positively influence overall mobility flow. In summary, individual travel behavior, sustainable mobility, and mobility flow are closely interconnected. Individual travel choices both impact and are influenced by sustainable mobility discourses and the efficiency of transportation networks, resulting in a complex interplay that affects the sustainability and effectiveness of mobility networks. This interplay illustrates how travel behavior and perceptions of sustainable mobility impact accessibility, efficiency, safety, and integration, all of which are determinants for the overall mobility flow within Gelderland. Mobility flow factors are in turn influencing decisions made on the individual travel level and are influencing how people look at sustainable mobility.

Chapter 7: Discussion

This chapter reviews the study's findings and methodology, addresses its limitations, and offers recommendations for future research. Additionally, it provides suggestions for policy and practice improvements in Gelderland.

7.1 Reflection on the research results

The research was based on results from the survey and the interviews. There were a total of 7 interviews conducted, and the survey had 57 respondents. The quantitative data from the survey was purely used as descriptive and not used for regressions. The qualitative data from the survey and the interviews were analyzed and coded.

The survey sample included a range of socio-economic and demographic characteristics: gender, age, residency, household status, occupational status, ethnicity, education level, and income. Data analysis demonstrated that all these characteristics influenced mobility flow, encompassing aspects such as accessibility, efficiency, safety, and integration. While existing literature indicates various connections between these characteristics and behavior, perceptions of sustainable mobility are less explored. Therefore, it is reasonable to expect similar relationships concerning perceptions.

Furthermore, existing literature generally suggests a limited connection between socio-economic and demographic characteristics and individuals' social and psychological aspects. However, this research reveals evidence of meaningful relationships between these factors. Additionally, while the literature often posits that the physical environment does not impact perceptions of sustainable mobility, the findings from the interviews and survey indicate otherwise. The physical environment not only affects perceptions of sustainable mobility but also influences individuals' psychological and social aspects by shaping the social atmosphere in which they live.

The limited relationships found between age, gender, and travel behavior may stem from the small sample size. Expanding the sample size or concentrating on specific demographic groups, such as the elderly or low-income individuals, could reveal different perceptions and highlight the importance of various indicators. Similarly, conducting surveys in diverse types of neighborhoods or focusing on more localized areas rather than the entire province might offer a broader range of insights.

My experience with sustainable mobility was beneficial throughout this process, as it allowed me to understand the various considerations people make when choosing between car travel and more sustainable options. My familiarity with mobility and infrastructure policies in Gelderland also helped me assess the challenges faced by residents. However, this familiarity may also introduce bias, potentially affecting the objectivity and internal validity of the research.

The interview results were somewhat surprising, as they diverged from the prevailing views in the literature and the findings from the study on the Province of Gelderland. Generally, perspectives on sustainable mobility were positive, and the results revealed a connection between factors influencing travel behavior and individuals' perceptions of

sustainable mobility, while existing literature states that sustainable mobility is limited due to existing mobility discourses among individuals on car use. This research finds its strength in analyzing the social, psychological, and demographic characteristics among individuals within the spatial context as well as the physical environment.

The research results essentially build on existing literature and affirm the appropriateness of the Province of Gelderland's mobility policies, which aim to promote more sustainable transportation options to reduce car usage. Less reliance on cars leads to decreased traffic, fewer delays, and reduced congestion. Additionally, the findings indicate that certain characteristics and indicators of travel behavior can shift attitudes and subjective norms in favor of sustainable travel. The interconnected relationships between individual travel behavior, its determinants, and perceptions of sustainable mobility highlight how improving mobility flow can be achieved by expanding the transportation infrastructure to include various modes of travel.

7.2 Reflection on data collection

This study primarily relies on data gathered through surveys and interviews. In addition, governmental data was considered using the Province of Gelderland's database, and insights from existing literature were also incorporated. The survey results were used to give a descriptive overview of the respondents' answers. The interviews were then analyzed by transcribing and coding the responses to identify the key concepts and indicators that emerged. This approach allowed the interview results to offer in-depth insights into the psychological and social characteristics that influence specific travel behaviors. Additionally, the interviews shed light on the underlying attitudes and subjective norms shaping individuals' perceptions of sustainable mobility. These insights clarify why people prefer certain modes of travel and how these preferences impact mobility flow within Gelderland.

The survey offered descriptive data on the socio-economic and demographic characteristics of the respondents. It also revealed insights into psychological and social factors, the impact of the physical environment on travel behavior, the influence of travel costs on decision-making, the effect of congestion on travel patterns, and how sustainability considerations shape individual travel behavior. The data was however limited, as the number of respondents was lower than expected. The sample size could therefore encounter difficulties in the generalizability and reliability of the data. However, the small sample size provided some profound insights which would otherwise be overlooked.

The challenges in data collection primarily stemmed from difficulties in participant recruitment, as many individuals were reluctant to participate despite the survey being relatively brief and straightforward. While the survey could have been shorter, doing so might have prevented the research from fully addressing all the questions it aimed to explore. The interviews provided deep, insightful connections to the quantitative descriptive data from the survey, enabling the researcher to draw meaningful conclusions and effectively address the research (sub)questions. The interviews were semi-structured, providing a clear framework to explore the various concepts. While

open interviews might have offered different insights, they could have led the research off-topic, potentially hindering the ability to find appropriate answers.

Prior to participation, participants were given detailed information about the study's purpose, procedures, risks, and benefits. They voluntarily consented to participate after understanding the research implications. To ensure confidentiality, participants were assigned unique identifiers or codes, and their identities were not disclosed. Data was analyzed and reported in aggregate form, without linking responses to specific individuals. These practices upheld ethical standards throughout the data collection process. While the methods used were consistent with standard practices in the field, in-depth interviews offered a qualitative perspective on the social and spatial dimensions of mobility flow, differing from more quantitative approaches. This offers other results and insights in the subject than that of other research.

7.3 Limitations and recommendations for future research

Like most research, this study has some limitations. First, the findings may be difficult to generalize to other regions, as Gelderland's unique spatial context, with its distinct social and physical characteristics, differs from that of other large Dutch cities. As noted in the conclusion, individual travel behavior is shaped by both the physical and social contexts. Nonetheless, the conclusions of this research may still be valuable for regions within the Netherlands and other Western European countries, as they offer insights into the relationship between sustainable mobility and individual travel behavior. The research findings related to mobility flow, in particular, are more broadly applicable. In summary, the external validity of the study depends on the scale of the results, which is common in this type of research. However, the methodology used to develop these theories is widely applicable and can be utilized in future research to evaluate mobility flow in other regions.

Secondly, this research combines descriptive survey data with in-depth insights from interviews. Consequently, the study is limited by its small sample size, which may reduce its applicability to other contexts and affects the generalizability of the findings. Furthermore, while the survey provides quantitative data descriptively, future research could employ regression analysis to examine correlations and relationships between individual travel behavior, sustainable mobility, and mobility flow. However, the findings of this research offer insights that diverge from the existing literature and could, therefore, suggest a revised conceptual framework for future research.

The findings of this research indicate that there are connections between the physical environment and the psychological and social aspects of individuals. While existing literature suggests that the physical environment influences individual travel behavior, this research reveals that factors like infrastructure, and weather also impact individuals' perceptions of sustainable mobility. Perceptions of sustainable mobility, in turn, influence the physical environment through the development of infrastructure that supports more sustainable travel options. Mobility flow is shaped by individual travel behavior and perceptions of sustainable mobility, while these factors are also influenced by the determinants of mobility flow. Therefore, this research provides the following revised conceptual framework which can be used for future research.

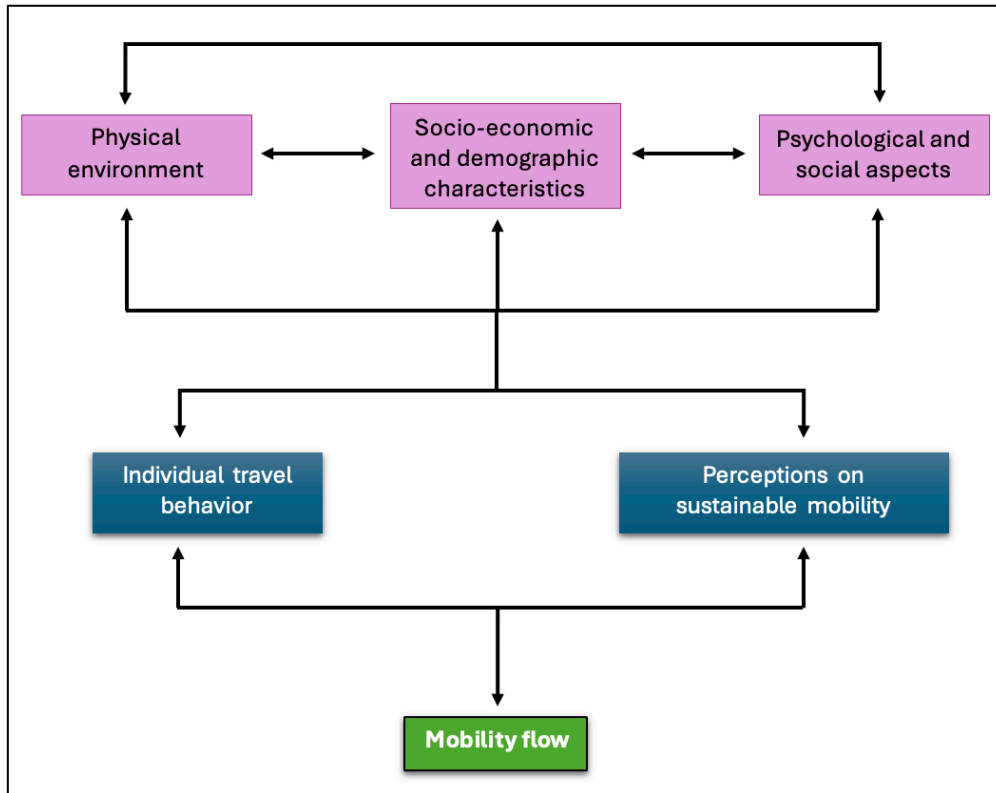


Figure 7.1: Revised conceptual framework (own design, 2024)

To achieve a deeper understanding of this topic, future research should involve a larger sample size for surveys or questionnaires. This would allow for regression analyses that were not possible in this study, which had a limited timeframe and fewer participants. Some questions remain unanswered, as this research focused on the social environment and individual travel behavior, providing insights into daily life and its impact on mobility flow. However, it did not fully explore the broader effect of sustainable mobility on overall mobility flow within the province.

7.4 Recommendations for policy and practice

The findings and conclusions of this research offer useful insights for policymakers and individuals interested in travel behavior and planning. First, specific recommendations for improving mobility practices are presented. Then, a general recommendation for the implementation of sustainable mobility within Gelderland is provided.

Providing infrastructure for other ways of travel

Gelderland boasts an extensive road network that facilitates easy car travel throughout the province, along with a comprehensive public transport system. Additionally, cycling paths are being developed to enhance bike travel comfort. However, this research reveals that people tend to prefer driving due to its comfort and convenience. To promote more sustainable travel, infrastructure development should prioritize improvements in cycling routes, bus stations and stops, train stations, and hubs for transferring between travel modes. Providing facilities such as bike rentals at stations could also encourage sustainable travel. By focusing on the connectivity of these areas,

infrastructure can better support sustainable transportation, reduce car dependency, and decrease road congestion, ultimately enhancing overall mobility flow. For example, public transport could be more connected to new housing areas providing more options for individuals in those areas besides car use.

Making places more accessible and providing safe travel

In urban areas, public transport and active mobility options are easily accessible and are growing in popularity. However, smaller rural areas often lack public transport options, and residents who try to use active mobility report concerns about road safety. Introducing separated cycling lanes could encourage more people to travel by bike or on foot. Additionally, establishing more bus stations and improving information on public transport schedules could boost public transport use. Travel delays in public transport often drive people to choose cars instead. Addressing these issues would likely lead to increased use of public transport, thereby enhancing overall mobility flow.

Compensating travel costs

Many people find public transport to be costly and perceive sustainable improvements as too expensive. Despite the high costs of owning a car, it often appears to offer more benefits than public transport. Addressing the cost issue and promoting public transport and active mobility could reduce car usage and improve overall mobility flow. Encouraging the use of public transport and active mobility, especially for short trips, is crucial as it can significantly reduce car traffic. Travel costs are highly important to people. Providing compensation for sustainable ways of travel could increase use of public transport, active mobility, or even shared mobility in order to decrease the number of travelers on the motorways. It could be applied through work, or even demographics such as age could be used to determine compensation and stimulate sustainable mobility more.

Education of sustainable mobility

Sustainability is becoming an increasingly significant concept in Dutch society. However, many people focus solely on the environmental benefits and overlook how sustainable practices can enhance mobility flow, improve travel comfort, reduce delays, and contribute positively to society. It is crucial to educate people through workplaces, schools, and community initiatives about how sustainable mobility can improve overall travel efficiency, reduce congestion, and enhance comfort.

Implementation of sustainable mobility within Gelderland

The findings and methodologies of this research offer valuable insights for policy developers and those involved in travel and transport planning. Adopting sustainable mobility practices using indicators of individual travel behavior provides a solid foundation for understanding travel patterns in a region. However, to be truly effective for policymakers and planners, these practices must be adapted to the local context. This requires a careful analysis of local factors to accurately interpret the spatial and physical environment, thereby avoiding misinterpretations and incorrect assumptions.

To enhance practical planning and mobility flow, a specialized data package should be developed. This package would provide the quantitative data necessary for precise measurement of mobility flow, overcoming the limitations faced in this study. Since individual travel behavior and perceptions of sustainable mobility can vary widely depending on the local context, municipalities and provinces should also take qualitative factors into account. Engaging residents to understand their views on sustainable mobility could be achieved through methods such as consulting neighborhood councils or conducting online surveys. A larger respondent base would improve the reliability of the survey results. Additionally, targeting specific groups (such as the elderly or young professionals) could yield focused insights into how to increase sustainable mobility for these populations, ultimately boosting overall mobility flow.

Furthermore, the approach employed to analyze individual travel behavior determinants, sustainable mobility factors, and mobility flow indicators could be applied to other areas of travel practices. It could serve as a broad framework that integrates both qualitative spatial and social context with quantitative data. This framework would facilitate effective and adaptable planning, aligning with the legislative goals of the Province of Gelderland.

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Appendices

Appendix 1: Concept operationalization table

Concept	Dimension	Indicators	Measure
Mobility flow	Efficiency	<i>Travel distance</i>	Quantitative/ Qualitative
		<i>Travel time</i>	Quantitative/ Qualitative
		<i>Travel delays</i>	Quantitative/ Qualitative
	Accessibility	<i>Travel distance (to nearby services)</i>	Quantitative/ Qualitative
	Safety	<i>Feeling of safety</i>	Qualitative
	Integration	<i>Connectivity of travel modes (network)</i>	Qualitative
Perceptions on sustainable mobility	Mode of travel	<i>Car or other private vehicles/public transport/active mobility/shared mobility/other</i>	Quantitative/ Qualitative
	Sustainability discourse	<i>Influence on mobility choice/importance of mobility transition</i>	Quantitative/ Qualitative
Physical environment	Built environment	<i>Infrastructure influence</i>	Quantitative/ Qualitative
	Trip characteristics	<i>Travel destinations</i>	Quantitative/ Qualitative
		<i>Travel time</i>	Quantitative/ Qualitative
		<i>Travel costs</i>	Quantitative/ Qualitative
		<i>Travel distance</i>	Quantitative/ Qualitative
	Natural environment	<i>Climate</i>	Qualitative
		<i>Landscape</i>	Qualitative
		<i>Weather</i>	Qualitative
Psychological and social aspects	Attitudes	<i>Personal affection</i>	Quantitative/ Qualitative
	Subjective norms	<i>Subjective norms</i>	Quantitative/ Qualitative
	Habits	<i>Habitual behavior</i>	Quantitative/ Qualitative
	External costs	<i>Costs related to expenses</i>	Quantitative/ Qualitative

Socio-economic and demographic characteristics	Economics	<i>Income</i>	Quantitative
	Demographics aspects	<i>Age</i>	Quantitative
		<i>Gender</i>	Quantitative
		<i>Ethnicity</i>	Quantitative/ Qualitative
		<i>Residency</i>	Quantitative/ Qualitative
		<i>Education</i>	Quantitative/ Qualitative
		<i>Occupation</i>	Quantitative/ Qualitative
		<i>Household</i>	Quantitative/ Qualitative

Appendix 2: Survey

The survey was conducted with Google forms and was distributed among Dutch residents.

Informatie over het onderzoek

Inleiding

Ik vraag u of u mee wilt doen aan deze enquête over mobiliteit. Met uw antwoorden helpt u mee aan mijn onderzoek voor de studie Spatial Planning aan de Radboud Universiteit te Nijmegen. Voordat u beslist of u mee wilt doen aan het onderzoek, krijgt u enkele uitleg over wat dit onderzoek inhoudt.

Beschrijving en doel van het onderzoek

De overheid heeft in de laatste paar jaren verkeer en mobiliteit als een van de factoren aangewezen die bijdragen aan milieuvervuiling. Daarom wordt er steeds vaker gekeken naar andere vormen van vervoer dan de auto. Maar wat bepaalt de keuze voor vervoer? Het doel van dit onderzoek is om te verkennen welke factoren voor u belangrijk zijn met betrekking tot vervoer en reizen. Dit kan kansen bieden voor de provincie Gelderland om hun beleid omtrent mobiliteit duurzamer te maken.

Wat wordt er van u verwacht?

In dit onderzoek gaat u enkele vragen beantwoorden die te maken hebben met (reis)gedrag, duurzaamheid en mobiliteit. U zult ook vragen krijgen over uw etnische, culturele/sociale en academische achtergrond. Daarnaast kunt u ook enkele algemene vragen verwachten, zoals uw geslacht en leeftijd. Het invullen van deze vragenlijst zal ongeveer tien minuten duren.

Vrijwilligheid

U doet vrijwillig mee aan dit onderzoek. Daarom kunt u op elk moment tijdens het onderzoek uw deelname stopzetten en uw toestemming intrekken. U hoeft niet aan te geven waarom u stopt. Afzien van - of stoppen met deelname heeft dan ook geen nadelige gevolgen voor u in enkele zin. U kunt tot twee weken na deelname ook uw onderzoeksgegevens en persoonsgegevens laten verwijderen. Dit kunt u doen door contact op te nemen via onderstaande gegevens.

Wat gebeurt er met mijn gegevens?

De onderzoeksgegevens die verzameld worden, zullen alleen gebruikt worden voor academische doeleinden. Deze gegevens zullen volledig anoniem worden gepresenteerd in de resultaten van dit onderzoek. De persoonsgegevens worden op beveiligde wijze volgens de richtlijnen van de Radboud Universiteit te Nijmegen, gewaarborgd. Alle ingevulde gegevens zullen direct na afronding van dit onderzoek vernietigd worden.

Vragen over het onderzoek?

Wanneer u vragen over het onderzoek heeft, meer informatie over het onderzoek wilt hebben, of graag op de hoogte gehouden wilt worden, kunt u contact opnemen via teije.vanmourik@student.ru.nl

Toestemmingsverklaring

Door op 'volgende' te klikken geeft u aan dat u minimaal zestien jaar oud bent, de bovenstaande informatie goed heeft doorgelezen en dat u instemt met deelname aan het onderzoek. U geeft hierbij toestemming dat uw gegevens die gevraagd worden in deze vragenlijst, verzameld en gebruikt mogen worden binnen dit onderzoek.

Alvast bedankt voor uw deelname en vriendelijke groet,
Teije van Mourik

Vragen over algemene gegevens

De volgende vragen gaan over enkele algemene gegevens van u.

Vraag 1: Wat is uw leeftijd?

Vraag 2: Wat is uw geslacht?

- a) Man
- b) Vrouw
- c) Anders

Vraag 3: Wat is uw etnische achtergrond?

- a) Nederlandse achtergrond
- b) Westerse migratie-achtergrond
- c) Niet-westerse migratie-achtergrond
- d) Anders

Vraag 4: Wat is uw woonplaats?

Vraag 5: Wat voor bestemmingen hebben uw reizen binnen Gelderland?

- a) Werk
- b) Wonen
- c) Horeca/winkels/supermarkt
- d) Sportfaciliteiten
- e) Gezondheidszorg
- f) Onderwijs
- g) Anders

Vraag 6: Wat is uw hoogst genoten opleiding?

- a) Wetenschappelijk onderwijs (universiteit)
- b) Hoger beroepsonderwijs (hbo)
- c) Middelbaar beroepsonderwijs (mbo)
- d) Voortgezet onderwijs (middelbare school)
- e) Anders

Vraag 7: Wat is de hoogst genoten opleiding van uw ouder(s)/voogd(en)?

- a) Wetenschappelijk onderwijs (universiteit)
- b) Hoger beroepsonderwijs (hbo)
- c) Middelbaar beroepsonderwijs (mbo)
- d) Voortgezet onderwijs (middelbare school)
- e) Anders

Vraag 8: Wat is uw arbeidsstatus?

- a) Werkende (1-36 uur per week)
- b) Werkende (36 uur per week en hoger)
- c) Niet-werkende (werkzoekend)
- d) Niet-werkende (niet werkzoekend)
- e) Gepensioneerd
- f) Arbeidsongeschikt

Vraag 9: Hoeveel dagen per week werkt u op locatie?

- a) 1 dag
- b) 2 dagen
- c) 3 dagen
- d) 4 dagen
- e) 5 dagen of meer
- f) Anders

Vraag 10: Wat is de status van uw huishouden?

- a) Alleenstaand
- b) Met partner
- c) Met partner en kinderen
- d) Met huisgenoten
- e) Anders

Vraag 11: Wat was het totale gezamenlijke inkomen van alle leden van uw huishouden in 2023? (*U hoeft het specifieke gedrag niet te weten*)

- a) 0-9.999 euro
- b) 10.000-19.999 euro
- c) 20.000-29.999 euro
- d) 30.000-39.999 euro
- e) 40.000-49.999 euro
- f) 50.000-59.999 euro
- g) 60.000-69.999 euro
- h) 70.000-79.999 euro
- i) 80.000-89.999 euro
- j) 90.000-99.999 euro
- k) 100.000 euro of meer

Vragen over vervoer en de omgeving

De volgende vragen gaan over uw keuze van vervoer en welke fysieke omstandigheden hier een rol bij spelen. Het betreft ook de rol die reistijd en reisafstand spelen.

Vraag 11: Hoe reist u naar uw werk? (Lees: *wat is het vervoersmiddel wat u het vaakst hiervoor gebruikt*)

- a) Auto of ander privaat motorvoertuig
- b) Openbaar vervoer
- c) Actief (fiets/lopen)
- d) Shared mobiliteit (ritten met anderen)
- e) Anders

Vraag 12: Hoe reist u naar andere bestemmingen dan uw werk? (Lees: *wat is het vervoersmiddel wat u het vaakst hiervoor gebruikt*)

- a) Auto of ander privaat motorvoertuig
- b) Openbaar vervoer
- c) Actief (fiets/lopen)
- d) Shared mobiliteit (ritten met anderen)
- e) Anders

Vraag 13: In hoeverre speelt de infrastructuur een rol in uw keuze van vervoersmiddel? (Denk aan: *wegen, bruggen, veilige en toegankelijke fietspaden, bereikbaarheid tankstations, etc.*)

- a) Grote rol
- b) Bovengemiddelde rol
- c) Gemiddelde rol
- d) Onder gemiddelde rol
- e) Bijna/geen rol

Vraag 14: Wat voor rol spelen de reistijd en reisafstand in uw keuze voor vervoersmiddel?

- a) Grote rol
- b) Bovengemiddelde rol
- c) Gemiddelde rol
- d) Onder gemiddelde rol
- e) Bijna/geen rol

Vraag 15: Wat voor rol speelt de natuur in uw keuze voor vervoersmiddel? (Denk aan: *weersomstandigheden, landschap, nacht/overdag*)

- a) Grote rol
- b) Bovengemiddelde rol
- c) Gemiddelde rol
- d) Onder gemiddelde rol
- e) Bijna/geen rol

Vragen over vervoer en de sociale omgeving

U krijgt enkele vragen over sociale normen, waarden en gedrag die eventueel een rol spelen in uw keuze van vervoer. Ook wordt u gevraagd naar eventuele gewoonten die u vertoont.

Vraag 16: Wat voor rol spelen normen en waarden in uw keuze van vervoersmiddel?

- a) Grote rol

- b) Bovengemiddelde rol
- c) Gemiddelde rol
- d) Onder gemiddelde rol
- e) Bijna/geen rol

Vraag 17: Stelling: Mijn keuze in vervoer is een gewoonte geworden; ik denk er niet diep over na.

- a) Helemaal mee eens
- b) Mee eens
- c) Niet mee eens/niet mee oneens
- d) Oneens
- e) Helemaal mee oneens

Vraag 18: Stelling: Hoe hoger de kosten voor het ene vervoersmiddel, hoe meer ik geneigd ben om een andere keuze wat betreft vervoer te maken.

- a) Helemaal mee eens
- b) Mee eens
- c) Niet mee eens/niet mee oneens
- d) Oneens
- e) Helemaal mee oneens

Vragen over duurzame mobiliteit en doorstroming

De volgende vragen hebben betrekking tot het onderwerp duurzaamheid en uw kennis hierover. Verder wordt uw mening gevraagd over het onderwerp en krijgt u enkele vragen over de keuzes van (lokale/regionale/nationale) overheden in verband met de duurzaamheidstransitie.

Vraag 19: In hoeverre speelt duurzaamheid een grote rol in uw keuze voor vervoer?

- a) Grote rol
- b) Bovengemiddelde rol
- c) Gemiddelde rol
- d) Onder gemiddelde rol
- e) Bijna/geen rol

Vraag 20: Stelling: Het is goed dat er een transitie van de auto naar duurzame alternatieven voor vervoer plaatsvindt.

- a) Helemaal mee eens
- b) Mee eens
- c) Niet mee eens/niet mee oneens
- d) Oneens
- e) Helemaal mee oneens

Vraag 21: Wat is voor u de belangrijkste afweging bij uw keuze van vervoer?

Vraag 22: Kunt u inschatten voor elk van de volgende bestemmingen hoeveel kilometer (enkele rit) u gemiddeld van thuis naar deze bestemmingen reist?

- Werk: ...

- Supermarkt: ...
- Andere winkels: ...
- Horeca: ...
- Sportfaciliteiten: ...
- Gezondheidszorg: ...
- Onderwijs: ...

Vraag 23: Kunt u inschatten voor elk van de volgende bestemmingen hoeveel uw gemiddelde reistijd (enkele rit) van thuis naar deze bestemmingen is?

- Werk: ...
- Supermarkt: ...
- Andere winkels: ...
- Horeca: ...
- Sportfaciliteiten: ...
- Gezondheidszorg: ...
- Onderwijs: ...

Vraag 24: Ervaart u enige congesties, vertragingen of andere complicaties bij uw reizen (zowel werk- als andere bestemmingen)?

- a) Ja
- b) Nee

Vraag 25: Bij welke reizen (werk, horeca, sport, etc.) ervaart u de meeste hinder en waarom?

Vraag 26: Zijn er, naast de besproken eigenschappen, andere ruimtelijke of sociale factoren die u van belang vindt of die een rol spelen in uw keuze voor vervoer? Als dit niet het geval is, mag u deze vraag overslaan.

Eindwoord

Hartelijk dank u voor het deelnemen aan het onderzoek. Voor verdere vragen of informatie over het onderzoek kunt u contact opnemen via: teije.vanmourik@student.ru.nl. Zoals eerder vermeld, zullen al uw antwoorden anoniem blijven en zullen de gegevens alleen gebruikt worden voor dit onderzoek en haar academische doeleinden.

Appendix 3: Interview guide

Interview guide

Interviewer: Teije van Mourik

Type of interview: semi-structured

Subject: influence of individual travel behavior on mobility flow (with a focus on perceptions of sustainable mobility)

Introductie	
<i>Introduceren onderwerp, tijd en opname</i>	<p>Allereerst, wil ik zeggen dat ik erg verheugd ben dat u wilde deelnemen aan dit interview en dit onderzoek. Wij hebben al kort contact gehad van tevoren, waar ik u liet weten wie ik ben en wat dit onderzoek omvat. Heeft u daar nog vragen over voordat wij starten? Heeft u nog vragen over het onderzoek voordat wij starten?</p> <p>Het interview zal ongeveer 45 minuten duren. Wanneer er vragen zijn die u niet wilt beantwoorden, kunt u dat altijd melden gedurende het interview. Wanneer u het interview wil stoppen, kunt u dat altijd aangeven gedurende het interview. Ik zou u willen vragen om alle vragen zo open mogelijk te beantwoorden.</p> <p>Ik zou u ook willen vragen om uw naam, leeftijd, geslacht, hoogst genoten opleiding, arbeidsstatus, status van uw huishouden en woonplaats in te vullen op de pagina die voor u ligt, voordat wij het interview starten?</p> <p>Dan zou ik u als laatste willen vragen of u ermee akkoord bent dat dit interview wordt opgenomen?</p> <p>Dan, als dat akkoord is voor u, zou ik graag beginnen met het interview.</p>
Onderwerp 1: individueel reisgedrag	
<i>Socio-economische en demografische karakteristieken</i>	<p>Voordat wij het interview zijn gestart, heb ik u om enkele demografische gegevens gevraagd. Graag zou ik hier nog enkele vragen over willen stellen.</p> <p>[Afhankelijk van de arbeidsstatus]</p> <p>Vraag 1: In hoeverre zou u uw inkomen tot laag, middel, of hoog indelen?</p> <p>Vraag 2: Hoe vaak per week werkt u op locatie?</p>
<i>Manieren van vervoer</i>	<p>Vraag 4: Hoe reist u naar uw werk?</p> <p>Vraag 5: Waar reist u, naast uw werk, vaak naartoe?</p> <p>Vraag 6: Hoe reist u naar deze gelegenheden?</p> <p>Vraag 7: Wat is voor u het belangrijkste vervoermiddel in uw dagelijks leven?</p>
<i>Psychologische en sociale aspecten</i>	<p>Vraag 8: Wat is voor u de belangrijkste reden wanneer u een keuze moet maken in vervoer?</p>

<i>Fysiek milieu</i>	<p>Vraag 9: In hoeverre spelen uw eigen normen en waarden een rol in deze keuze?</p> <p>Vraag 10: In hoeverre ervaart u sociale druk van hoe anderen kijken tegenover de manier waarop u reist?</p> <p>Vraag 11: Is de keuze voor uw manier van vervoer een gewoonte geworden of denkt u er bewust over na?</p> <p>Vraag 12: In hoeverre spelen de kosten van bepaalde vervoersmiddelen een rol in uw keuze van vervoer?</p> <p>Vraag 13: Zijn deze kosten voornamelijk van invloed op het vervoersmiddel dat u gebruikt in uw dagelijks leven of niet?</p> <p>Vraag 14: Speelt de inrichting van de stad, straten, en provinciale wegen een rol bij uw keuze in vervoer?</p> <p>Vraag 15: In hoeverre beïnvloedt reistijd uw keuze in vervoer?</p> <p>Vraag 16: Is uw keuze in vervoer voor lange ritten hetzelfde als korte ritten?</p> <p>Vraag 17: In hoeverre bepaalt de reden van uw reis uw vervoerskeuze?</p> <p>Vraag 18: Speelt het klimaat, weer of landschap een rol in uw keuze van vervoer?</p>
Onderwerp 2: perceptie duurzame mobiliteit	
<i>Duurzaamheid</i>	<p>Vraag 19: In hoeverre is er bij u bekend welke vervoersmiddelen duurzaam zijn en welke er negatieve gevolgen hebben voor het milieu?</p> <p>Vraag 20: Van welke duurzame vervoersmiddelen maakt u gebruik; van welke niet duurzame vervoersmiddelen maakt u gebruik?</p> <p>[Bij beantwoording vraag 8 'duurzaamheid': vraag 21 overslaan]</p> <p>Vraag 21: Speelt duurzaamheid een belangrijke rol in de keuze van uw vervoer?</p> <p>Vraag 22: Hoe kijkt u tegen duurzame mobiliteit aan? (Lopen, fiets, ov, shared mobiliteit)</p>
Onderwerp 3: overheidstransitie	
<i>Duurzaamheid</i>	<p>Vraag 23: Bent u op de hoogte van de duurzaamheidstransitie die plaatsvindt binnen overheidsinstellingen?</p> <p>[Bij antwoord nee vraag 23: toelichting geven]</p>
<i>Participatie</i>	<p>Vraag 24: Hoe kijkt u tegen de duurzaamheidstransitie binnen overheidsinstellingen aan?</p> <p>Vraag 25: Bent u van mening dat het publiek (samenleving) genoeg inspraak/participatie gelegenheden heeft voor besluitvorming omtrent mobiliteit beslissingen?</p>
<i>Verandering</i>	<p>Vraag 26: Zou u geneigd zijn om te veranderen van autogebruik naar andere soorten van vervoer?</p> <p>Vraag 27: Waarom? Wat zou daarvoor nodig zijn?</p>
Onderwerp 4: mobiliteitsdoorstroming	

<i>Efficiëntie</i>	Vraag 26: Ervaart u vertragingen, congesties, of andere complicaties bij het vervoer met de auto of andere motorvoertuigen die u bezit? Vraag 27: Hoe ervaart u dit bij andere vormen van vervoer? (Lopen, fiets, ov, shared mobiliteit).
<i>Bereikbaarheid</i>	Vraag 28: In hoeverre speelt bereikbaarheid een grote rol bij keuze voor uw vervoer? Ondervindt u hinder bij andere soorten vervoer dan de auto?
<i>Veiligheid en integratie</i>	Vraag 29: In hoeverre speelt het gevoel van veiligheid een rol bij uw keuze van vervoer? Vraag 30: Vindt u dat verschillende vormen van vervoer, naast autogebruik, genoeg verbonden zijn met elkaar?
Afsluiting	
<i>Einde, dank en contact</i>	<p>Dit waren alle vragen van het interview. Is er iets wat u nog zou willen toevoegen aan dit interview/deze conversatie? Dan stop ik bij deze de opname.</p> <p>Ik wil u allereerst hartelijk danken voor uw contributie aan mijn onderzoek. Zijn er eventueel dingen die u nog kwijt wilt, die u liever niet ziet inbegrepen in dit onderzoek? Wat vond u zelf van het interview?</p> <p>Dit interview wordt geanalyseerd aan de hand van de opname. Vervolgens worden de resultaten hiervan opgenomen in het onderzoek. Wanneer ik de resultaten van het onderzoek heb, zouden deze mogelijk gedeeld kunnen worden met u?</p> <p>Mocht ik nog verdere vragen hebben, zou ik u dan nog kunnen contacteren? Als u nog vragen heeft, kunt u altijd contact opnemen met mij via de gegevens op de uitnodiging.</p> <p>Dan bij deze nogmaals, hartelijk dank.</p>

Appendix 4: Code groups (Atlas.ti)

Code groups	Dimension	Codes
Mobility flow	Efficiency	<i>Travel time</i>
		<i>Travel distance</i>
		<i>Travel delays</i>
	Accessibility	<i>Travel distance to nearby services</i>
		<i>Connectivity of travel network</i>
		<i>Feeling of safety</i>
	Integration	<i>Connectivity of travel network</i>
		<i>Travel costs</i>
Perceptions on sustainable mobility	Mode of travel	<i>Car or private motorized vehicle use</i>
		<i>Public transport</i>
		<i>Active mobility</i>
		<i>Shared mobility</i>
	Sustainability discourse	<i>Influence of sustainability on mobility choices</i>
Physical environment	Built environment	<i>Infrastructure</i>
	Trip characteristics	<i>Travel destinations</i>
		<i>Travel time</i>
		<i>Travel costs</i>
		<i>Travel distance</i>
	Natural environment	<i>Climate</i>
		<i>Weather</i>
		<i>Landscape</i>
Psychological and social aspects	Attitudes	<i>Personal affection/attitudes</i>
	Subjective norms	<i>Subjective norms (moral obligations)</i>
	Habits	<i>Habits</i>
	External costs	<i>Travel costs (for modes of travel)</i>
Socio-economic and demographic characteristics	Economics	<i>Income</i>
	Demographics/social aspects	<i>Age</i>
		<i>Gender</i>
		<i>Ethnicity</i>
		<i>Residency</i>
		<i>Education</i>
		<i>Occupation</i>
<i>Household</i>		