MSc Programme in Urban Management and Development

Rotterdam, the Netherlands

November 16, 2020

The emergence of E-bikes, an evolution in the cycling culture of the Netherlands.

The effect of travel behavior changes in shifting cycling modes, on the usage of other modes of transport and walking in the Netherlands.

Name: Malak Rahal

Supervisor: Taslim Alade

Specialisation: Managing Infrastructure for Green Cities

Country: Lebanon

Report number: 1403

UMD 16

IHS Making cities work Erasmus

Institute for Housing and Urban Development Studies of Erasmus University Rotterdam

Summary

For the first time, in 2018, the number of E-bikes sold in the Netherlands were higher than conventional bikes. Shifting away from cars is definitely something to be promoted as it would help mitigate CO2 emissions. However, shifting away from conventional bikes and transit use with E-bike is a phenomenon that is worth investigating to assess its implications on the long term. As it stands, there is a call for further research into the subject of electric bikes in the literature (Hendriksen et al., 2008; Loijen, 2011; Lee et al., 2014; de Haaz, 2019). This work aims to assess whether the shift to E-bikes is merely an upgrade of the conventional bicycle, or if it is instilling itself as the new way of transport in the transit world. An explanatory approach is adopted for this study to explicate this specific trend of modal shift and the factors affecting it in a detailed manner. This oversight was addressed by first explaining which factors drive conventional bike users to shifting to an E-bike. Secondly, analyzed the extent to which this shift impacted the individuals' travel behavior change and the travel attitudes they are currently adopting. And lastly, assessed if the travel behavior change has an effect on the usage of other modes of transport. The information required for this research has been collected from the literature. After the factors and the variables have been mapped, a mixed method involving the collection of both qualitative data through semi-structured interviews and quantitative data through a survey. The results show that factors behind owning an E-bike varies from one person to another. Some of the reasons serve practicality; where users are looking for faster and more efficient alternatives or to simply travel longer distances without getting tired, while others are more related to each individual's preference and the way they perceive cycling; being it crucial vs. complementary element for their means of transport. Even though the reasons for adopting an E-bike are varied, the consequences remain the same. The majority of users had similar changes in their travel behaviors. Users are now able to cycle faster, and to longer distances more efficiently even under harsh weather. Despite being more expensive than traditional bicycles, users found it worthy to pay for that extra comfort, and autonomy. However, those advantages are coming at the cost of avoiding public transport. This is because an E-bike is offering the users the ability to reach places more efficiently than while on a bus, tram, or a metro, as there is no wasted time while waiting. Other aspects that contributed to the emergence of E-bikes are city-dependent. An E-bike would be an attractive alternative to the bus in those cities where a tram, or metro are not available. On the other hand, it was shown that the train was the most immune to this transition, as it offers a speed, and an ability to move long distances; features to which an E-bike can't compete, yet, given its limited battery life. Hence, it can be safely assumed that E-bikes are more of a replacement to the Bus, Metro, and Tram rather than being complementary. Many respondents consider their E-bikes as their new mean of transport and not an upgrade of the conventional bike.

[**Keywords:** E-bikes, Conventional bikes, travel behavior, Public transport, Sustainable mobility, micro-mobility, mode choice, displacement behavior, attitudinal segmentation]

Acknowledgements

..

To the memory of my beloved mama.

To Simar, the reason behind everything I am because you loved me.

To Zahraa, my forever strength and weakness.

To Nada, my lifetime support.

To Sanabel, Chady and Daniel, my backbone.

To Aya, the joy of my life.

To Silvia, the highlight of 2020.

To the city of Rotterdam, I hope I am not a stranger anymore.

I dedicate the process of learning, and the outcome of this thesis, to "you".

I hope you are proud of me.

I am thankful for,

My supervisor Taslim Alade, for being there for me even during the hardest times. I value your guidance and the space you gave me to grow.

My second reader Raphaël Smals, for your constructive comments and encouragement.

IHS – Erasmus university of Rotterdam, for this fruitful year, you made me see the world differently.

I couldn't have made it without you.

Cheers to a better future.

November the 16th, 2020.

Malak Rahal

Abbreviations

IHS	Institute for Housing and Urban Development Studies
E-bike	Electric bicycle
COVID 19	Coronavirus disease 2019

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

1.1 Background of the problem:

In an era when every single particle of CO_2 spared is instrumental in our fight against climate change, governments across the world recognized the importance of reducing the impact of the global warming phenomenon. The transport sector is considered as the second major cause of greenhouse emissions in Europe, road transport is responsible for 72% of emissions within the sector (European Union, 2019). These statistics explain the extensive efforts made in promoting changes in road space allocation and encouraging the use of new green modalities for transportation to prioritize and increase the use of walking, cycling and public transport and lower the usage of personal cars. It is postulated that this sustainable, and efficient shift in transport, can reduce the CO2 emissions to 40% by 2050 (Mason et al., 2015).

Over the past decade these efforts have changed the way we think about mobility, and the focus has shifted towards micro-mobility as a mean for green transport. With the emergence of electrical bikes (E-bikes), the world is facing a contemporary trend that can have a huge impact on the future mobility patterns of cities. Since the 2000s, the E-bike is considered as the most adopted alternative for fueled vehicles in the history of motorization (Sun et al., 2020). The continuous sharp growth of E-bike sales in Europe (Jones et al., 2016) set high hopes on E-bikes as the decarbonizer of road transport and a reducer of traffic congestion on the assumption that people are shifting from fueled vehicles to E-bikes (Sun et al., 2020).

Despite this, this trend does not assure a sustainable transition. A study done in 2017 by Maarten Kroesen in the Netherlands, inferred that the effects of E-bikes on other modes of transport differ according to the context. For instance, E-bicycles are attractive and strong competitors in car-centric countries such as Australia and US where dominant modes of transport are not sustainable. However, in European countries where cycling and public transport are well established, E-bike is replacing transit and conventional bikes, albeit at slower rate (Kroesen, 2017). Such a transition poses a greater challenge in Europe as it pits the new E-bike technology against conventional methods of transport that have already demonstrated their effectiveness. For this reason, the local context and the dominant transport mode of the city determines the inertia to introducing E-bike technology. All in all, however, the future of electric bicycles is promising to say the least, as evidenced by the following quote:

In 2010 Extra Energy's Hannes Neupert stated: "Electrification will kill the mechanical bicycle within a few years like it has killed many other mechanical products. Bicycles … will remain as historical items hanging on the wall." (Reid, 2019)

1.2 Problem statement:

In the Netherlands, cycling is the prevalent mode of transport that accounts for 25% of daily mobility (Harms and Kansen, 2018). This generous percentage compared to the other countries is owed to the extensive governmental policies promoting cycling as a way for commuting and/or a complementary tool to public transport. These policies were set to limit the usage of motorized vehicles and promote walking, cycling and public transport as a way for greater connectivity. Across history, cycling was an increasingly attractive alternative to motor vehicles due to the growing rate of traffic congestion and roadside accidents that led to public outrage, and a call to shift from car-centered policies to other modes of transport like cycling. This mode of transport was further popularized for its immunity to political crises that could face a country like that of the oil crisis in 1973 in the Netherlands.

The Netherlands in particular is known to have the largest number of cyclists, while also being the safest place to cycle in the world (Brömmelstroet, 2019). In a country where bicycles outnumber inhabitants, the recent emergence of E-bikes has aroused some concerns. For the first time, in 2018, the number of E-bikes sold in the Netherlands were higher than conventional bikes. The annual sale of E-bikes increased by 228% in the past 11 years (Kroesen, 2017), classifying the country as the biggest market for E-bikes (Jan-Willem van Schaik, 2019). These numbers raise concerns that the shift to E-bikes serves as a potential deterrant from using conventional bikes, rather than tackling the larger issue of vehicular use, which is what the community cares about (Cairns et al., 2017). The online survey done by Kroesen for his study showed that 41% of E-bike owners replaced their conventional bikes and 40% replaced their cars. (Kroesen, 2017) According to Kroesen, the use of E-bikes markedly decreases the usage of conventional bikes and to a lesser extent, reduces the use of cars and public transport facilities. Furthermore, it was shown that the decrease in the use of cars and public transport is greater by E-bikers when compared to conventional bikers (Kroesen, 2017).

Shifting away from cars is definitely something to be promoted as it would help mitigate CO2 emissions. However, shifting away from conventional bikes and transit use with E-bike is a phenomenon that is worth investigating to assess its implications on the long term. Replacing transit can decline the ridership numbers in the long run, in turn creating difficulties with funding the public transportation service and expanding the platform. While conventional cycling in a Dutch context is considered complementary to public transport, the ability to commute autonomously for a longer distance and in a faster way while using E-bikes can be a threat to transit modes such as the bus, tram and metro. E-bikes provide a fast, easy, and efficient mode of transportation, allowing the commuter to travel longer distances, in a shorter time, and with less physical effort, something an old-fashioned bicycle simply could not do.
Strengths aside, the introduction of the E-bike is not without its critics. Jan Gehl (2013) in particular stresses the need to decelerate the city to make it compatible with human speed in order for it to be livable. The faster pace offered by E-bikes creates new safety issues as bikers must get accustomed to those new speeds. Aside from that, another significant thing to take into consideration is the onus placed on the government to resolve the accompanying

environmental issues posed by E-bikes and find a solution for the disposal of E-bikes' batteries (Cairns, Behrendt, Raffo, Beaumont, & Kiefer, 2017). These challenges, however, are beyond the scope of this paper.

As it stands, there is a call for further research into the subject of electric bikes in the literature (Hendriksen et al., 2008; Loijen, 2011; Lee et al., 2014; de Haaz, 2019). This work aims to assess whether the shift to E-bikes is merely an upgrade of the conventional bicycle, or if it is instilling itself as the new way of transport in the transit world. It looks to explore whether the introduction of E-bikes will eclipse the established modes of transport and render them obsolete or if the new technology will simply be an adjunct to what we already have.
A broader question this work also aims to address is if we should really be accepting this shift, a question best answered by a survey of public attitudes and opinions towards this new technology.

1.3 Emergence of E-bike in the Netherlands

The Netherlands have witnessed a sharp increase in the use of electric bicycles as of 2017 (figure 1). Moreover, the recent COVID-19 pandemic has imposed on the entire world new norms and rules. The transportation sector was no exception. Since the outbreak, it was estimated that sales of E-bikes were 38% higher in May 2020 compared to the year before (RAI 2020).
Those new dynamics and figures raise the importance of assessing and analyzing this new situation to be able to be prepared for this new shift in terms of logistics and infrastructure if needed.

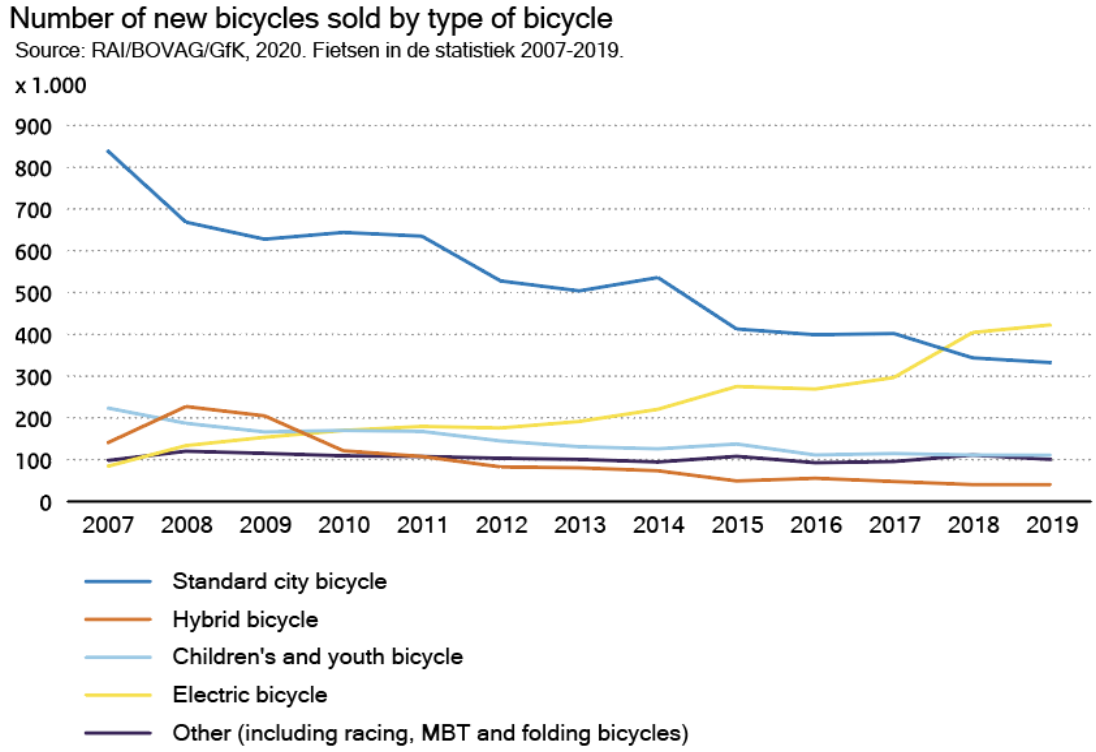


Figure 1 Number of new bicycles sold by type of bicycle. Translated and edited by the author

To accelerate the research on electric bicycles it's crucial to understand what exactly is an electric bicycle. Therefore, below is an overview of what an E-bike is and what are its main features and properties.

1.3.1 What is an E-bike?

The idea of equipping a bicycle with an electric motor already existed hundred years ago. Since then, there have been many variants on electrical assisted bicycles in the market and many new types have been developed in the last decade (Hendriksen et al., 2008). E-bikes are also called Pedelecs. With this type, the electric motor only comes into operation the moment the cyclist starts pedaling. A magnetic or pressure sensor at the pedals controls the motor (Loijen, 2011). The bicycle usually has a switch where the user can adjust the degree of pedal assistance. There are also Electric bicycles where the cyclist does not necessarily have to pedal. The motor can be turned on with a switch without the need for the cyclist to pedal. This type of bicycle is also called E-bike. However, the vast majority of E-bikes that have been on the rise in recent years in the Netherlands are the Pedelec ones (Hendriksen et al., 2008).
This research focuses on the Pedelec type as it is the prevalent type in the Netherlands in recent years, as portrayed by figure 1.

1.3.2 Features and properties of an E-bike:

According Loijen (2011) and Hendriksen (2008) what is known about the type of E-bikes in the Netherlands is that the engine and battery are two distinctive parts of the electric bike. The quality of the battery strongly determines the range and time required for charging. In addition, the motor and battery determine how heavy an E-bike is in comparison to a conventional bike. The Pedelec type is mainly used in the Netherlands, whereas in the rest of the world especially in China E-bikes without pedal assistants are mainly used.
Moreover, the purchase price for electric bicycles in the Netherlands varies enormously. It all depends on the type and the quality of the bike. There are electric bicycles that vary in price from € 900 to € 7,000 and higher (elektrischefietser.nl, 2020). According GFK, consumers spent an average of € 2,026 on an electric bicycle in 2019 (elektrischefietser.nl, 2020). This is a lot more expensive than a conventional bicycle but also sharply decreasing. Due to the relatively high purchase prices, most E-bikes in the Netherlands are insured (Loijen, 2011). The only visual difference between E-bike and a conventional one is the careful integration of the motor and battery into the frame or the hub (thicker only), this design has contributed strongly to its growth in popularity. Conceivably, these alterations on the design of the traditional bicycle will radically change the cycling experience and the particular travel behaviors associated with cycling, as will be explored in this paper.

1.4 Relevance of the research topic

The rise of E-bikes in the Netherlands is a step in the transition towards green livable cities. In order to decide whether this transition should be accepted or not, an assessment is needed to understand its benefits and implications on the future of cities and its implication on the different modes of transit. The focus of studies during the past decade was on the intrinsic benchmarks of E-bikes, be it their performance, design, sales, or effects on the environment, as compared to cars. However, it is only recently that studies have moved towards identifying the motives behind the possession and usage of E-bikes, as well as their influence on citizens' travel attitudes and behaviors (Fishman and Cherry, 2016). Little is known about current E-bike users, as most research studies are not specifically focused on the situation in the Netherlands as per the statement of the ministry of infrastructure and water management (de Haas, 2019). Particularly, not much is known about why people purchase or use E-bikes (de Haas, 2019). It might simply be a case of consumers wishing to try something new, or it could represent a dissatisfaction with the current modes of travel. How this decision affects their relationship with other modes of transportation has also yet to be determined. Do people who buy E-bikes use their cars less, or for different purposes? Do people buy E-bikes because they don't want to use their cars or other alternatives anymore? (Loijen, 2011) has also state that there is very little data available concerning the use of electric bikes, and he called for studies providing quantitative and qualitative information about the property and use of E-bikes to inform our understanding of how the introduction of the electric bicycle will influence consumer behavior and attitudes towards transportation.

(Lee et al., 2014) attempted to address this gap in the literature with a study in the Netherlands exploring the reasons why people made the switch to electric bicycles. The survey presented in this study was not too detailed, and the article served more as a broad overview of the subject rather than an intimate delving into the topic. However, it is a start, and it lays the foundation for future studies to build upon. In fact, the researchers themselves proposed that future research ought to take a closer look into the reasons for E-bike usage, the change over time of characteristics of users, the safety and policy implications of this shift. (Lee et al., 2014) found that people used E-bikes because they are easier and more comfortable than other modalities; a more thorough analysis promises to yield a richer, more enlightening picture. Importantly, studies must monitor key characteristics of E-bike users involving the average age and gender of the individual users, the trip purpose, trip distance, and reason for buying, and trend these variables as they change throughout the time as the amount of E-bike sold in the Netherlands continues to rise.

Hendriksen et al., in 2008 recommended further research to explore the position of E-bike on the regional level and proposed the Haaglanden region as a potential region for analysis. To this day, follow up researches on the subject are still lacking, the significance of this study is that it addresses this overlooked topic and tackles it from both a scientific and a societal perspective, using the experience and recommendations of past research to complete our understanding on the subject. Across this section, we've seen two dynamics at play that the literature heavily recommends investigating: one is the confluence of factors and characteristics that push people to make the transition to an E-bike, and the other is a post-transition analysis

of how the shift to an E-bike changed the individual's travel behavior. This study aims to gather and analyze data pertaining to both dynamics, with a particular focus on the latter.

1.4.1 The scientific relevance:

The main objective of this research is to fill the research gap in the literature on cycling patterns and the transition to E-bikes. The shift to E-bikes is a dynamic process shaped by many factors, and hence, all factors must be taken together as they are all interrelated. Such an approach will help us better understand the available information we have around the topic, by eliminating all sources of bias. The study will be focused to the Dutch context; thus, it will help in painting a distinctive picture of E-cycling in that region.

1.4.2 The societal relevance:

As the emergence of E-bikes is forcing cities to have conversations about their micro mobility infrastructure and planners are even questioning how we perceive streets, and how government should regulate E-bikes. We hope this study will contribute and shed the light on the need for a better management of this sector especially with the difference of speed between the conventional and the electrical one. The consideration of separate cycling lanes according to speed is needed if the trend keeps rising as a way to ensure a safer and sustainable commuting networks.

1.5 Research Objectives

The thesis aims to fill the research gap by evaluating the positive and negative externalities of this modal shift and assess the effect of the usage of E-bike in comparison to conventional bike users on the change of travel behaviors. It hopes to investigate how E-bikes affects the transport demand and the mode of transport choice. Furthermore, its ultimate objective is to guide policy makers and planners in their efforts to promote the usage of E-bikes as sustainable mode of transport.

1.6 Main research question

To what extent do the factors behind the shift from conventional bikes to E-bikes influence the travel behavior change towards the usage of other modes of transport in the Netherlands?

- **Factors behind the use of an E-bike** (independent variables):
    - Sub variables: socio-demographic factors; objective factors; objective individual factors; subjective factors;
- **Travel behavior change** (Mediating variable)
    - Cycling patterns; Attitudinal factors; Attitudinal group segmentation
- **Usage of other modes of transport** (dependent variables):
    - Sub variables: Conventional bike, Bus, Tram, Metro, Train and walking

1.6.1 Research sub-questions

1. What are the factors behind the shift from conventional bikes to E-bikes in the Netherlands?
2. To what extent does the travel behavior change affect the cycling patterns and attitude of users towards cycling?
3. To what extent does the access to E-bike affect the use of other modes of transport?

1.7 Scope and Limitation

Various studies, initiatives, and advertisements have been implemented to encourage car users in shifting to E-bike as it has an extensive benefit on the environment and the reduction of traffic congestion. However, the latter has also attracted commuters who have already adopted cycling as a valuable mode in their daily life.
The purpose of this study is to demonstrate the influence of shifting from what is considered one of the greenest modes for commuting - the conventional bike - to a less safe and more expensive one - the E-bike - and its impact on the usage of other modes of transport including walking.
The scope of this research highlights the mode of choice, and the behavioral and attitudinal factors involved in the usage of E-bike, disregarding the means of access (Possession, Rental, Sharing system) and available policies. This decision serves to facilitate the collection more efficient, consistent, and objective data while expanding the reachability of respondents and reducing the complexity of the subject. However, the depth of the analysis will be limited by the exclusion of some factors; therefore, this study will provide a base for further analysis.
In terms of methodology, the main limitation was the poor response rates. Time and the unfortunate COVID-19 were our limiting factors as we were expecting a lower response rate during the data collection period. Insufficient diversity of types of users may affect the results of the study. For that reason, interviews with experts, retailers, and cycling NGOs were needed to support the analysis and the process of the research.

Chapter 2: State of the art theories/concepts and Literature Review

[**Keywords**: E-bikes, Conventional bikes, travel behavior, Public transport, Sustainable mobility, micro-mobility, mode choice, displacement behavior, attitudinal segmentation]

As previously mentioned, this study aims to examine the shift in consumer preference from **conventional bikes to E-bikes**. The current available body of information on this phenomenon is sparse in the current literature, and relatively little is known about the factors and motives that have promoted this transition. There are many similarities between E-bikes and their traditional counterpart; theories addressing the sales of standard bicycles may be applicable to the sale of E-bikes. However, what such an approach does not address is the *why* of it. We can understand why people would buy E-bikes, but not why they would choose E-bikes over standard bikes. For this reason, there is a need for an investigation of the factors that have prompted this transition to help decipher this recent demand for alternative methods.
This chapter summarizes the available body of literature and comprises three main subtopics. The first section explores the mechanism of the shift from conventional to electric bikes, identifying factors that played a key role in the shift. The second part tackles the emotions and perceptions of individuals towards cycling before, during, and after this shift with the aim of understanding this change in consumer behavior in a wider, psychosocial context. This in turn will allow us to group bicycle users into different consumer groups accordingly. The third and final segment details how the motivational drive of each user group factors in to their travel behavior and how this can ultimately determine their preferred mode of travel.

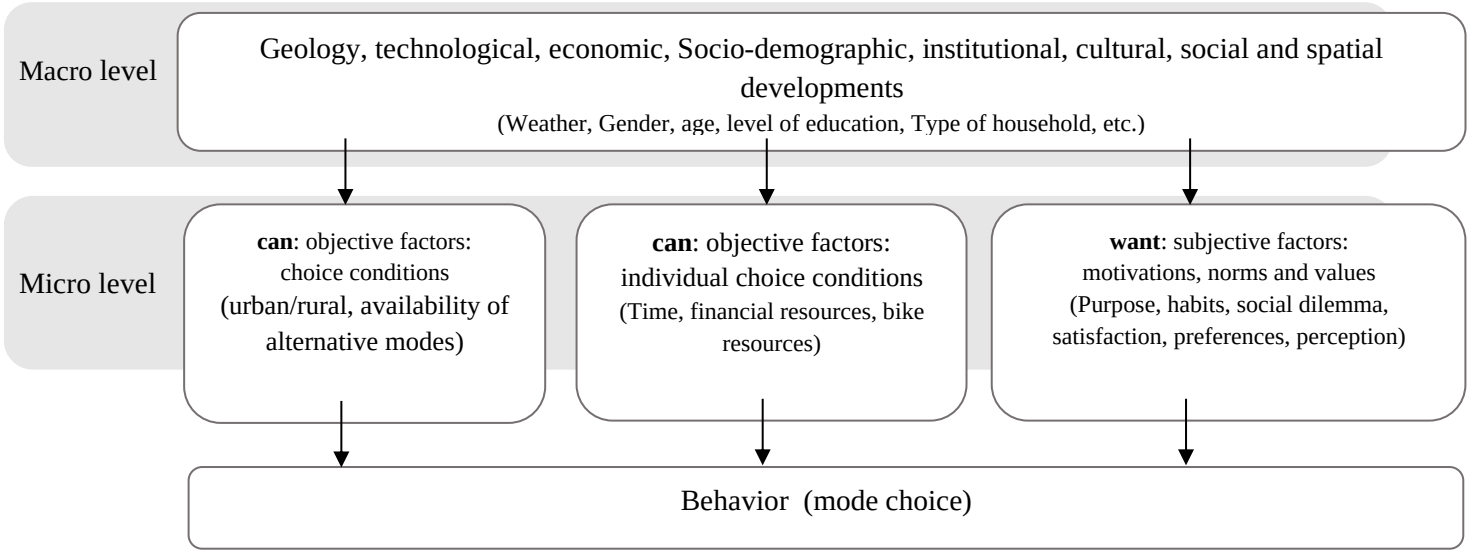
2.2 Reasons behind modal shift:

E-bike usage has the potential to significantly impact their local environments. This potential is moderated to a large extent by two main factors: the number of individuals making the switch to E-bikes, and the original mode of transportation in use prior to the transition (Engelmoer, 2012). As is the case with any other mode of transportation, E-bikes have their strong points and their shortcomings, and in some ways may be inferior to typical bicycles. That notwithstanding, it is crucial to understand that a decision to shift to E-bikes does not only depend on these objectives' quality differences between the two products – such a choice is informed by a complex array of psychological factors making it a highly personal decision unique to each individual (Engelmoer, 2012).

For decades, conventional bikes as a means of transportation was a hot topic for research. A hefty body of literature exists on the subject and, given the undeniable similarities between bicycles and their electronic equivalent, those publications may be used as a foundation to understand the growing popularity of E-bikes. Most of these studies showed that the use of

conventional bikes depends on both subjective and objective factors. Subjective factors are those that are closely associated with behavioral sciences, and objectives factors are shaped by the characteristics of the infrastructure, the traffic and the spatial planning (Engelmoer, 2012). Studies addressing the decisions impacting the mode of cycling have shown a multitude of variables that factor in to the equation. Socioeconomic and demographic factors play a major role in determining the mode of choice (Steg and Kalfs, 2000)., with, safety, the climate, and the weather of the region also having an impact. Other factors particular to each individual include the work conditions culture and facilities each person is exposed to (Heinen et al., 2010; Oakil et al., 2016).

A psychology paper published by Anable and Gatersleben in 2005 showed that when making a choice to commute to work, individuals tend to focus on objective rather than subjective factors. Convenience and ease were found to be the key determinants for what mode of transport was used in getting to work among the study subjects. Conversely, the mode of transport for leisure purposes was intrinsically tied to the individual's emotional and affective states, as in this scenario relaxation, the sense of freedom, and being "stress-free" took precedence over the drive for efficiency and timeliness experienced in the work-scenario (Anable and Gatersleben, 2005). This shows that the reason for commuting plays an essential role in shaping the decision of the cycler, and hence, must be taken into account in our journey of understanding, as it appears that the choice is greatly influenced by attitudes, and habits.
According to a study done by Linda Steg and Nelly Kalfs on car use, people will only exhibit certain behaviors if they have the means to engage in that behavior, and the desire to do so (Steg and Kalfs, 2000). Individual differences in cycling use may therefore arise from differences in choice circumstances and individual circumstances. The latter can be projected through determined objective behavioral possibilities (being able to/can) and from differences in motivations as subjective factors (want/wish) (Steg & Kalfs, 2000)



Providing an overview of factors that influence or have influenced commuting behavior change can help us understand the process of shift in cyclist's choice of bike. Figure above is based on the factors that influence displacement behavior stated by Steg and Kalfs and modified in accordance to the recommendations of (Oakil et al. 2016) and (Engelmoer, 2012) mode choice model. It presents a simplified representation of relevant factors that influence travel behavior and mode choice. In practice, the relationships between these factors is far more complex; the different factors are all inter-related, and any change in one would unfailingly affect all others. The choice conditions determine the available feasibility and quality of goods and services. Individual circumstances or opportunities are mainly a reflection of the financial and logistical (time, effort) resources that an individual has at his/her disposal. Motivations refer to wishes and preferences of individuals; these are needs, values, norms, preferences and perceptions. Socio-demographic characteristics, such as age, gender and level of education, are believed not to directly influence behavior (Steg and Kalfs, 2000). Although it is very important to know which socio-demographic groups are involved, these characteristics alone do not provide an adequate explanation for differences in behaviors. The observation that there are differences between socio-demographic groups *will* invariably be made, and this immediately raises the question of what mediates these inter-demographic differences. The latter is projected through different choice circumstances and individual circumstances and motivations (objective & subjective factors) across different demographic groups. This means that socio-demographic characteristics influence behavior through the three determinant categories at micro level. The three determinant categories at the micro level are in turn influenced by various social developments at macro level, including technological geological, economic, demographic, institutional, cultural and spatial developments.
This model can be used to verify which factors influence the travel behaviour change of users to shift from conventional bikes to E-bikes in specific situations, distinguished according to for example trip motif, time or place. Changing the choice conditions, individual circumstances and motivations of people can deploy various behavioral changes that trigger displacement behavior for modal shift.

2.2.1 Characteristics of E-bike users

Gender, age, education level, income and ethnicity influence the mobility behavior and mobility choice of the individual. Women, for instance, are more likely to use electric bicycle than men (Kroesen, 2017). Age shows that the older someone is, the greater the chance that that someone will use an electric bicycle (Kroesen, 2017; Loijen, 2011). In addition, the study by Loijen (2011) shows that the majority of electric bicycle users are native Dutch.

2.2. Advantages and disadvantages of the E-bike

Compared to the regular bicycle, the electric bicycle has the advantage of higher speeds that can be achieved with less effort. This allows people with physical disability to continue cycling. In addition, it is also possible to cover longer distances with the E-bike. Research done by Jones et al. (2016) shows that people do more activities at the same time with an electric bicycle because they can cycle longer distances. This means that E-bikes increase their own effectiveness. In addition to the many advantages of the electric bicycle, disadvantages are also

experienced by the users. For example, the high purchase price of the electric bicycle is seen as a disadvantage (Mossel, 2018). Also, it is often mentioned that the electric bicycle is perceived as heavy compared to the regular bicycle. Because the bicycle is heavier, it is more difficult to maneuver the bicycle while parking, and more difficult to lift the electric bicycle over obstacles or, for example, onto the back of a bicycle carrier of a car (Jones, et al., 2016). Another perceived disadvantage of using an electric bicycle is the fact that the electric bicycle needs to be charged. The electric bicycle must be charged in advance otherwise preventing the bicycle from being used mechanically if the battery is not charged. Users also see it as a disadvantage that careful planning must go into the distance traveled; this is because the battery can run down before reaching the final destination (Jones et al., 2016). In addition to the more technical drawbacks of the electric bicycle there are also social disadvantages. It turns out that electric bicycle users sometimes are labeled as 'cheaters' by people in their social circle because they are electrical assisted cycling (Mossel, 2018).

2.3 Safety

Safety is an often-stated reason for not cycling. If there is a higher probability of accidents, the assumption is that there will be less cycling (Dozza et al., 2013). Not only is objective safety seen as an essential factor, but also the subjective perception of safety. It turns out that cyclists mainly remember the unsafe aspects of a route and not the safe aspects. Subjective security is a difficult concept because everyone perceives security differently (Heinen et al., 2010). It turns out that accidents with an electric bicycle are primarily caused by the higher speeds are achieved and because of the electric bicycle's heavier weight (Dozza et al., 2013). When the speed increases, more attention must be paid to the interaction with the other road users. In addition, other road users must become aware that electric bicycles achieve higher speeds on average than normal bicycles. This should factor into other estimates made, for example at an intersection (Dozza et al., 2013).

2.3 Relationship between E-bike and travel behavior

Various studies have investigated how E-bikes are included in travel behavior. It turns out that there are major geographical differences in this. In Asia, one of the first areas where the E-bike is popular, multiple studies have been conducted. This shows that one would mainly use the bus if the E-bike is not available. Here, the E-bike is therefore seen as an affordable and high worthy alternative to public transport (Cherry et al., 2016; Montgomery, 2010). However, when looking at an Asian city where there is no high-quality of public network available, it appears that the E-bike mainly replaces the regular bike (Weinert et al., 2007). Studies that have focused on countries outside of Asia show that the E-bike is a substitute for the car bought. This was concluded from an Australian (Johnson & Rose, 2013) as well a North American (MacArthur et al., 2014) study. (Jones et al., 2016) concluded in a study with a small sample of English and Dutch E-bike owners that the E-bike mainly was bought to replace the regular bicycle, but that after purchase car use also decreased.

A recent study using data from the national travel survey OViN looked into the effect of the E-bike on various indicators of travel behavior (Kroesen, 2017). It shows that the E-bike not only

has a significant effect on regular bicycles, cars and public transport, but that the total travel distance also increases significantly due to the E-bike.

2.3.1 Travel distance and travel time

Travel distance is one of the main determinants that influence mobility behavior, especially with regard to trips by bicycle. This is, according to Heinen et al. (2010), due to the fact that as the distance increases, the effort made also increases significantly. The radius of action, the maximum distance that a traveler is prepared to cycle differs by person and gender. It turns out that women are on willing to cycle on average 6.6 kilometers, while men are prepared to go an average 11.6 kilometers (Heinen, et al., 2010). An advantage of the electric bicycle compared to the regular bicycle is that longer distances can be achieved (Cherry et al., 2016).
The travel time in comparison between different modalities plays a major role in the final choice for a modality. For example, it turns out that if the journey time with the bicycle is 10% faster compared to the same journey by car, then bicycle use could increase by 3.4% (Hendriksen et al., 2010). The travel distance and travel time influence self-efficacy. Because the further the distance is between, for example, the place of residence and the workplace, the less capable the individual feels to cycle to work (Hendriksen et al., 2010).

2.4 Travel behavior change & Attitudinal segmentation:

A study conducted in Norway found that accessibility to E-bikes increased the use of bikes as mode of transportation from 28 to 48% (Fyhri & Fearnley, 2015). Another study conducted in Denmark explored the changes of cycling behaviors after the adoption of E-bikes. It was shown that 64% of bikers substituted their conventional bikes by E-bikes, 49% have used E-bikes for trips they would otherwise take by car. Similarly, 48% of trips usually taken by bus were changed to E-bikes, compared to 26% of trips taken by the metro or train, and 33% of trips usually completed by walking (Haustein and Møller, 2016). Studies on E-bikes where also done in the Netherlands, where one study showed that 77% of individuals who adopted an E-bike affirmed that they are now able to cycle longer distances, and 33% are currently using their E-bikes as a mean of commuting to work instead of using their cars, or public transportations (Hendriksen et al., 2008).
During the last decade, attitudes of individuals towards their mean of transportation have segmented the transport sector. Nowadays, attitudes and perceptions better explain the variability in the choices of means of transportation when compared to socio-economic and demographic factors. This also applies to E-bikes where the specific motives of the cycler, are more pertinent than age for instance to explain cycling behaviors (Haustein and Møller, 2016)

"Attitudinal segmentation" is based on the "Theory of Planned Behavior" which is a psychological theory which implicitly implies and assumes that a particular action within the same attitudinal segment can be changed (Haustein and Møller, 2016). As any change in behavior, the change in cycling behaviors also follows the typical stages of change which include pre-contemplation → contemplation → preparation → action → maintenance (Biehl et

al., 2018). In other words, to voluntarily change a behavior, an individual must start by having an attitude or perspective for that behavior.

In 2013, Dill and McNeil stratified E-bikes cyclers into different groups based on their level of comfort while cycling, their interest in choosing cycling as a mean of transportation, and based on their physical capability to cycle. The first study to stratify E-bikes cyclers based on their affective and emotional attitudes was conducted by Haustein and Møller in 2016. Cyclers were stratified into three categories:

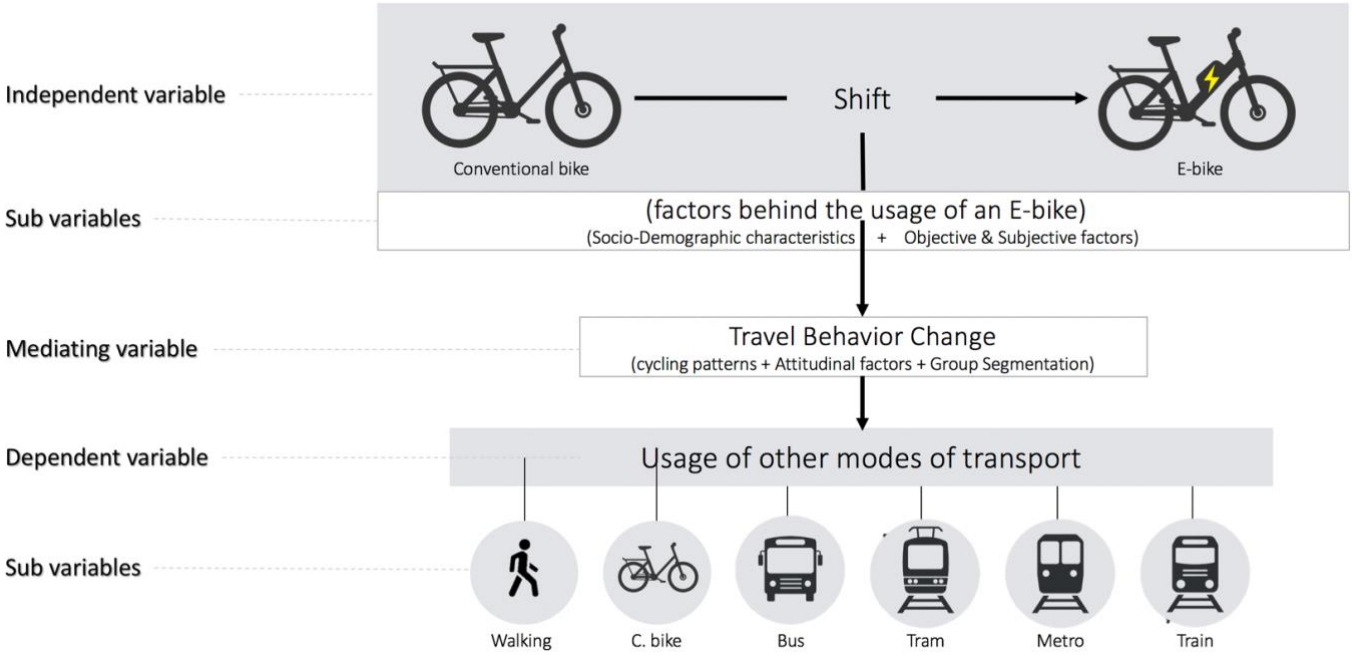
1. **Enthusiastic E-bikers**: Those focus on cycling frequency and convenience as they perceive the E-bike as a mean to increase the distance they can travel, when compared to conventional bikes. Those carry a positive attitude towards E-bikes as they were Enthusiastic to the "Add-ons" it gave to conventional bikes.
2. **Utilitarian E-bikers**: This category groups those that see the positives of E-bikes only in specific situations where an E-bike can add practicality and save time during daily life activities such as shopping or picking up the kids. E-bike is only an optimization to what they previously had, and is used to serve as specific purpose or job.
3. **Recreational E-bikers:** Those individuals use E-bike less regularly than the other groups but excited by the added speed provided by E-bikes, regardless if it serves a purpose or not, it is used mainly for longer travelling distances.

2.5 Impact of E-bike substitution on other mode of transport

No published study is available yet in the Netherlands about the direct effect of the introduction of E-bikes has on the public's utilization of each different modes of public transport Bus, Tram, Metro, Train. What is currently known in the literature is that the effects of E-bikes on other means of transportation depends on the specific local context (Kroesen, 2017). In Australia, Canada, and the US for instance, where cars are the main modes of transport, E-bikes mainly replace trips that usually undertaken by cars. On the other hand, Europe, known for the high use of conventional bikes, has seen E-bikes replacing conventional bikes as well as cars (Kroesen, 2017). A study conducted in Sweden showed that around 50% of trips taken by E-bikes were previously taken by cars, compared to 20% of trips conducted via conventional bikes (Hiselius & Svenssona, 2014). The situation in China shows different numbers as per many studies conducted in that region. For instance, substitution rates of conventional bikes can reach up to 60% in some regions (Weinert et al., 2007), compared to substitution predominated by replacement of trips usually conducted by bus in other regions, depending on the quality of available public transportation (Cherry et al., 2016).
In the Netherlands, a market study conducted on E-bikes by Hendriksen et al. in 2008 showed that E-bikes substituted conventional bikes in 53% of cases, compared to 26% for cars, 13% for public transport, and 8% for motorbikes and scooters (Hendriksen et al., 2008). A subsequent study conducted in 2012, confirmed the same results (Engelmoer, 2012). However, in 2017, a study conducted at Maarten Kroesen of Delft University of Technology in the

Netherlands, showed that individuals in the Netherlands are replacing equally both conventional bikes and cars by the same rate of around 40% (Kroesen, 2017). This aforementioned study, measured the substitution of the different means of transport by E-bikes in the Netherlands by comparing the patterns of travel behaviors of those who own an E-bike, to those of who don't (Kroesen, 2017).

2.6 Conceptual Framework:



Chapter 3: Research design, methods and limitations

3.1 Research Approach and Techniques:

An explanatory approach is adopted for this study to explicate this specific trend of modal shift and the factors affecting it in a detailed manner to compensate for the poor focus of previous studies. This oversight will be addressed by first explaining which factors drive conventional bike users to shifting to an E-bike. Secondly, analyzing the extent to which this shift impacted the individuals' travel behavior change and the travel attitudes they are currently adopting. The attitudinal segmentation of (Haustein and Miller, 2016) will be adopted as a platform to build our understanding of the extent to which each attitudinal segment has influence on the choice of mode transportation and cyclic patterns. It will also help in deciphering the emotional and affective component behind cycling patterns. The latter will serve as a basis to analyze to what extent E-bikes are being used as a substitute or a complement for other modes of transport according to their attitudinal groups of Haustein and Miller (2016).
The information required for this research has been collected from the literature. After the factors and the variables have been mapped, a mixed method involving the collection of both qualitative data through semi-structured interviews and quantitative data through a survey collected sequentially at different stages of the research process were adopted to integrate and support the data for the analysis.
Combining a case study with a survey is appropriate as a strategy for this thesis. As mentioned above, E-bike users are the main target for this study. A high number of users is needed to be contacted to be able to gather new data on people's opinion, behavior and attitudes. Hence, surveys are the best method to achieve a large-scale audience (Van Thiel, 2014).
Moreover, the literature shows the clear co-variate relationship between the dependent and the independent variables. To obtain a vision other than user perspective and a better understanding of human behavior, perceptions and opinions, a number of interviews with the experts, retailers, and cycling NGOs were used as an important complementary method to support and explain the variables mapped from literature. The complex topic of travel behavior entails the need for a comprehensive case study.
To ensure its applicability to the Dutch context, the study is only limited to the users who shifted from conventional bikes to E-bikes in particular contexts.

3.2 Operationalization of variables:

The tables below summarize from the literature the most relevant research concepts, theories, variables, sub-variables, and indicators in which data collection was carried out. Furthermore, since the research topic originates the context of the Netherlands, a number of common factors for the entire country were not assessed in depth in the operationalization (namely: geology, climate, weather and level of urbanization).

Concept/Variable	Sub-variables	Indicators	Source of data
Factors behind the usage of an E-bike (independent variable)	Socio-demographic factors:	**Gender:** women; men	E-bike users survey
		Age: <18; 19-34; 35-49; 50-64; >65	
		Relationship status: Single; Single with children; couple without children; couple with children; couple with children > 18	
		Educational Level:	
		Occupation: student; part time employed; full time employed; unemployed; retired	
		Nationality:	
		Post-code:	
		City:	
	Objective factors:	**Access of E-bikes suppliers:** Retailers; offers	E-bike users survey; secondary data; experts' interview
		Availability of adequate infrastructure: Bicycle lanes; fast bicycle lanes; parking; charging points	
	Objective individual factors:	**Cycling skills:** Beginner; intermediate; advance	E-bike users survey
		Bike resources: Maintenance points; availability of insurance options; private parking	
		Financial resources: Affordability to pay for an E-bike; loans/payment facilities; incentives	
		Reasons of E-bike shift: more comfortable; easier to paddle; ability to cycle longer distances; faster; less sweaty; difficulty in riding conventional one; to cycle easier in windy times; To carry heavy goods/children	
		Main purpose of use: (second & third main purpose of use) Shopping; go to work/education facilities; commuting (multi-purpose rides); access public transport; for work; for physical activity; recreational trips	
		Main Social influence: Trendy; high-tech; more sustainable; Style;	

		positive feedback; to have group rides with friends/family; advertisement	
	Subjective factors:	**Individual perception:** Speed; save time; socioeconomic class; convenient; flexible; fun; Autonomy	E-bike users survey; experts' interview

Table 1 Operationalization of variables to answer sub-question 1: What are the factors behind the shift from conventional bikes to E-bikes in the Netherlands?

Concept/Variable	Sub-variables	Indicators	Source of data
Travel behavior change (Mediating variable)	Cycling patterns (before & after the shift)	**Cycling frequency for each purpose:** Shopping; go to work/education facilities; commuting (multi-purpose rides); access public transport; for work; for physical activity; recreational trips;	E-bike users survey;
		Cycling Speed	
		Cycling Distance	
		New Cycling purposes	
		Impact of COVID 19	
	Perception & attitudinal factors after the shift to E-bike	**Travel identity and norms:** I am taking advantage of opportunities to travel using E-bike; Finding more opportunity to use E-bike for a trip is meaningful to me; It weighs on my conscience if I do not use E-bike for a trip when it is an equitable to use it	E-bike users survey; literature
		Spatial ability: confidence; familiar; motivation to travel to a new location; enjoy trying new routes to reach familiar destination	
		Sense of community: I belong to a community of E-bike users; I enjoy interacting with other E-bike users;	
		Satisfaction of available infrastructure	
		Level of Safety	
	Perceived Attitudinal group segmentation *I consider myself an..*	**Enthusiastic E-biker** (cycling frequency & distance increased)	E-bike users survey; literature
		Utilitarian E-biker (cycling speed increased- less travel time & ability to transport of goods/or children)	
		Recreational E-biker: (cycling for longer distance)	

Table 2 Operationalization of variables to answer sub-question 2: To what extent does the travel behavior change affect the cycling patterns and attitude of users towards cycling?

Concept/Variable	Sub-variables	Indicators	Source of data
Mode of transport (dependent variables) Active travel modes before and after E-bike use	**Conventional bike**	**Replacement:** (full; partial; none)	E-bike users survey;
		Frequency: (monthly, weekly, occasionally)	
	Bus	**Replacement:** (full; partial; none)	
		Frequency: (monthly, weekly, occasionally)	
	Tram	**Replacement:** (full; partial; none)	
		Frequency: (monthly, weekly, occasionally)	
	Metro	**Replacement:** (full; partial; none)	
		Frequency: (monthly, weekly, occasionally)	
	Train	**Replacement:** (full; partial; none)	
		Frequency: (monthly, weekly, occasionally)	
	Walking	**Replacement:** (full; partial; none)	
		Frequency: (monthly, weekly, occasionally)	

Table 3 Operationalization of variables to answer sub-question 3: To what extent does the access to E-bike affect the use of other modes of transport?

3.3 Data Collection and sampling instruments:

3.3.1 Interviews

Interviews were conducted with a selection of seven expertise who I was able to approach for a semi-structured interview/or open-ended conversation through video calls or face to face meetings within the two phases listed below:

1. **Phase 1 (Pre-survey distribution):** To use the knowledge of field experts in choosing the right variables for operationalization and combine them with the adopted variables from literature, as a way to ensure consistency with the context and the study conditions. Accordingly, a few indicators were removed as a retailer felt that the survey was long and confusing to E-bike users.
2. **Phase 2 (Post-survey distribution):** To give more insight for the outcome of the survey for a justified analysis. I have shared the results with key experts from different fields who commented and gave reasons on the outcomes of the survey such as:

- Field experts and bicycle promoters: Roel Lenoir, and Melissa Bruntlett
- Retailers: Donkey republic and E-bike retailer: Hans Hartman and Stijn Grootjans
- Dutch cycling Embassy and e-fiester.nl

3.3.2 Survey

The survey targeted the current E-bike users only in the whole Netherlands. In order to ensure their eligibility to study, a few questions were asked beforehand to make sure the respondents are only those who used to rely on a conventional bike for recreational purposes or commuting before the shift to E-bike and live in the Netherlands.

The surveys were distributed intensively with a referred link that were shared online through ads on social media and on different cycling websites and Social media groups as well as retailers to reach a bigger audience. A participation in a draw for a voucher of 50 euros from bol.com was added to motivate users to participate. A snowball method was adopted by requesting from the founded E-bike users to refer the survey to other eligible E-bike users after they complete filling the survey. Additionally, insurance companies and big brands were approached, without success. Moreover, around 120 Flyers with QR were printed and distributed within Rotterdam, Delft and the Hague in post mails. Also posted on the walls of two trains next to the bicycle section, elevators of Rotterdam Blaak (removed later) and on many traffic lights for bicycles in the Rotterdam area. However, approaching people was really hard and not many respondents accessed the survey through the QR. The process of data collection was really hard and slow even with the use of social media, rewards and paid ads. Few experts shared my survey on their platform on twitter, their reliability helped in bringing trust and motivation to contribute in filling the survey. The challenges imposed with the Corona situation and all efforts put within two months and a half, was not enough to reach the sample size of 400 needed for saturation. Unfortunately, only 175 respondents filled the survey.

Figure 1 Photos taken by the author (bicycle street sign, Train to Amsterdam, Elevator in train station)

A soft copy version posted on social media and used for Ads on Instagram and Facebook with a description and a link to the survey. **https://www.instagram.com/ebike_nl/** Created by the author.

A sample of a soft copy (left) and a printed copy (right) used for flyers and Stickers on walls created by the author.

3.4.2.1 Survey Structure:

Questions were grouped into three categories in order to gain some general and broad insights into the three sub-questions following the operationalization:

- Section 1: **Reasons behind the shift** – Consists of gathering socio-demographic data and factors, with information about the objective and subjective factors that lead a person to seek the usage of an E-bike
- Section 2: **Attitude and behavior change after the shift** - A section to track their cycling patterns before and after the shift, and go through their perception, attitude and satisfaction towards the usage of the E-bike
- Section 3: **The modes of transport that E-bike trips may be replacing** - A section to understand if they are still using other modes of transport with E-bike, the frequency of usage and if there is a partial or complete replacement.

3.4.3 Observation

To acquire a better understanding of the phenomenon and assess the difference between E-bike and conventional bike empirically and if it can have an effect on the travel of the user, I replaced my conventional bike with an E-bike.

I used a conventional bike for 3 to 5 days a week for almost a year. I switched to a city E-bike (25km/h) with gears from Urbee on the 13th of September 2020 (summertime) till the 13th of December 2020 (Autumn time). During this period, besides my short commuting purposes for 3 to 4 days a week, I made five long trips (around 45mins to one hour/one way) within Rotterdam and cities nearby.

Observing this phenomenon as an E-bike user was essential in understanding the comments and the perceptions of survey respondents, assess the operationalization table and the dynamics of this phenomenon.

Figure 2 Current adopted E-bike – photo taken by the author

3.5 Validity and reliability:

To ensure the internal reliability of the research, the consistency of the same results of the indicator within a scale per individuals sharing the same control variables is needed, baseline demographic characteristics will necessarily be homogenized. In other words, there should be no significant difference in demographics of the different attitudinal groups. Hence, the range of respondents in the survey should be high to reach the desired consistency.
This can be achieved by effective operationalization of variables into quantified data to measure the impact. Moreover, triangulation of data by having a high number of surveys, interviews, in addition to secondary data, can help in enhancing the reliability and validity of the study.
Furthermore, online questionnaires can affect the reliability and validity of the research if there is a high percentage of potential respondents that are not willing or not motivated enough to participate in the research (Van Thiel, 2014). it is therefore critical to work on having a clear questionnaire with all the information needed to encourage people to participate. Questionnaires were designed in a way that they can be answered in less than 10 minutes and was available in both languages Dutch and English.

A pilot Survey was conducted as an essential stage beforehand to test the practicability and communicability of the questions and discussed with an E-bike user and retailer. Such a step was a further contribution to the reliability and validity of the research.

3.6 Data analysis methods

We divided the data according to the answers in question 4.5 of the survey, which asked participants to identify themselves as utilitarian, enthusiastic, or recreational cyclists. Sociodemographic, personal, social, practical, and objective variables were then correlated with the said groups to test for possible associations using the chi-square test. Variables were significant if their p-value was < 0.05.
Statistical analysis was conducted using IBM SPSS. As for the interviews, content analysis was conducted to identify recurrent themes and ideas expressed by the different stakeholders, and thus interpreted in light of the findings of the statistical analysis. For the visualization of data, charts, and graphs were plotted via Excel and visually enhanced using Photoshop.
Transcription of the recorded semi-structured interviews was stored into a word-processed document, for editing, coding, and further analysis, to be finally integrated as a support to the quantitative analysis.

3.7 Challenges and limitations:

This research challenged by its ability to fill the gap in research (Hendriksen et al., 2008; Loijen, 2011; Lee et al., 2014; de Haaz, 2019) and cover all relevant motives for E-bike usage and modal shift.
Unfortunately, given the COVID-19 pandemic, gathering all the needed responses was challenging. In addition, the pandemic might had lead to a temporary change in travel behavior, hence, it was worthy to add an open-ended question where the respondents can have the chance to express how this pandemic has affected their perception towards E-bike and if they used it as a substitution to public transport as it’s safer.
Finally, reaching the right saturation with repetitive answers in the survey especially for the mentioned three categories was challenging.

Chapter 4: Research Findings

This section provides answers for the research question and sub-questions by presenting:

1. An overview of the area of residence of those who filled the survey within the Netherlands with a map showing the routes taken by respondents while commuting by E-bike from city to another, as well as a comparison of distance that can be cycled by a conventional bike and E-bike within a time period through QGIS.
2. A representation of the findings of the survey and quantitative analysis through SPSS
3. Qualitative analysis via personal observations, interviews done with field experts, users and retailers as well as secondary data that support the findings and data triangulation.

4.1 Spatial representation of respondents of the survey:

4.1.1 Potential E-bike users around the Netherlands.

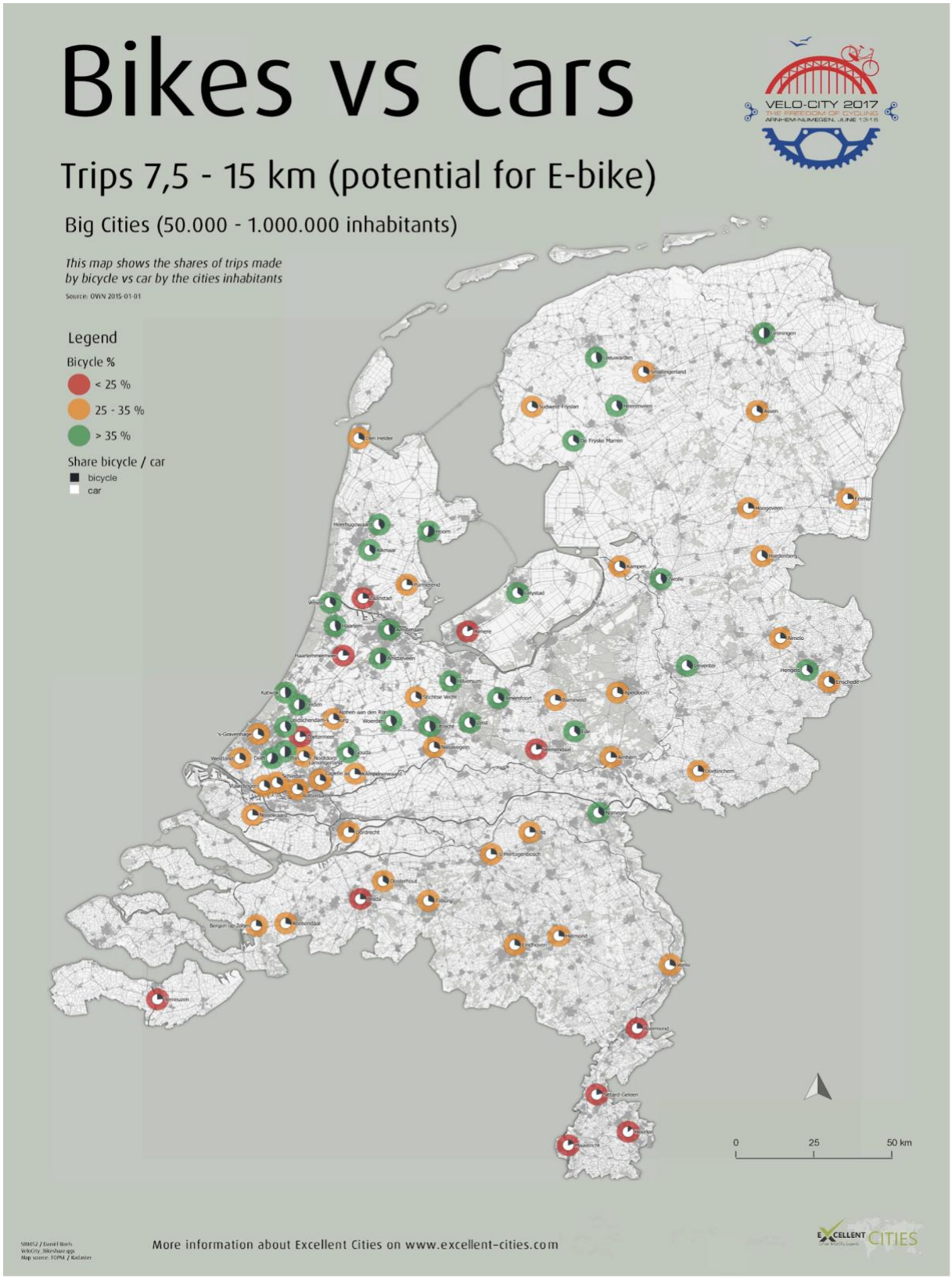


Figure 1 Potential areas for new E-bike users according to shares of trips made by bicycle vs car by the city's inhabitants

E-bike users' residence area

Data collected from the survey

This map shows the distribution of E-bike users who filled the survey around the Netherlands.

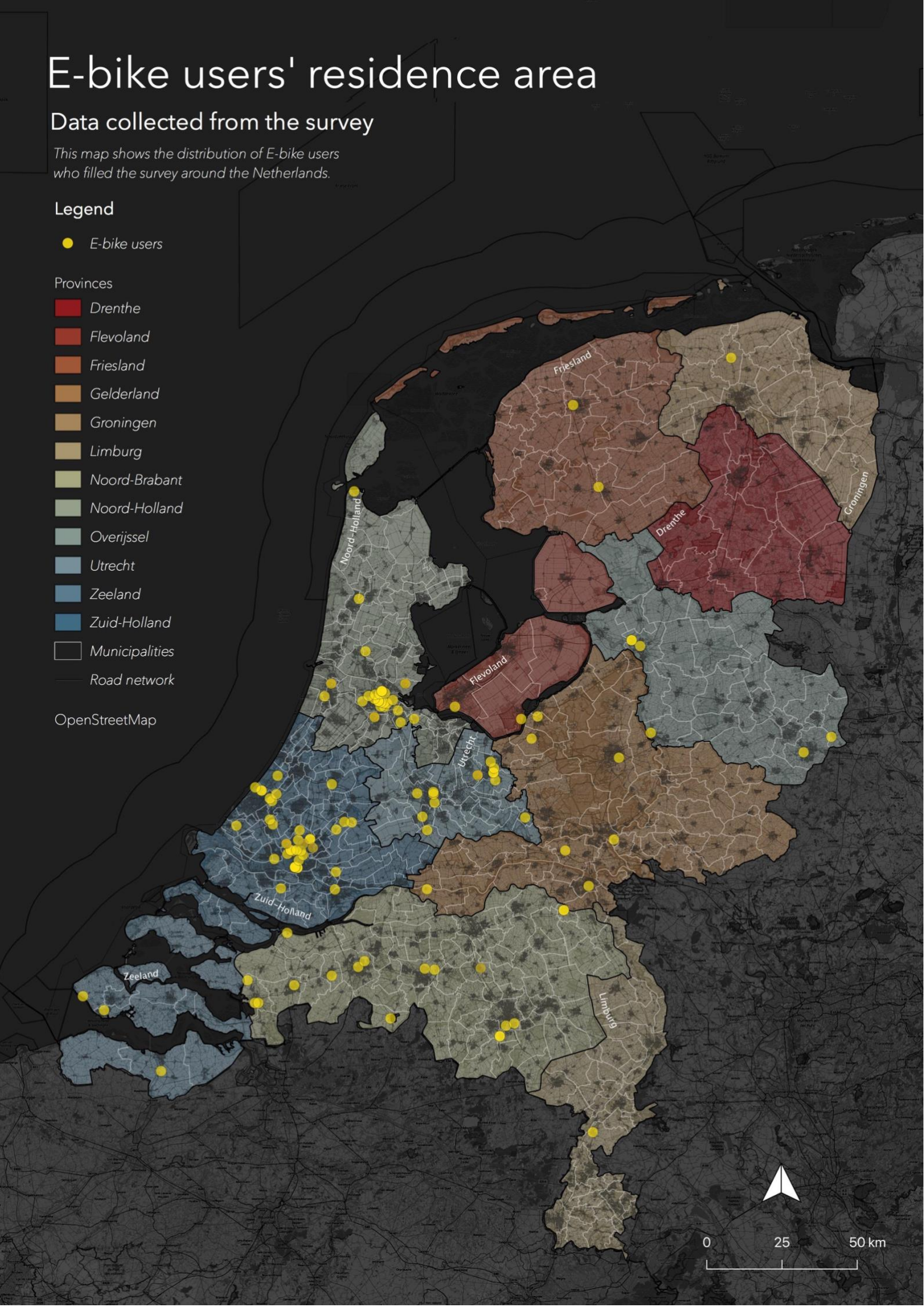


Figure 2 ↑ E-bike users' residence area. Done by author on QGIS

E-bike is not a new phenomenon; it has been around for years and has therefore been well studied (Fishman & Cherry, 2016). A lot of research has gone into identifying potential markets to introduce the E-bike in, and a key factor investigator look for is use of the conventional bicycle. Kroeson (2017) analyzed data from the annual Dutch mobility survey over the years 2013-2015. This survey explores the transit behavior of randomly selected individuals from across the Netherlands. Kroeson found that switching to E-bike significantly reduced use of conventional bicycles, cars, and public transport, but more importantly that in terms of ownership, E-bikes substituted conventional bikes, but not cars. What this means is that the people who previously used conventional bicycles were the ones to become E-bicycle users. This is an important finding because it suggests that areas with a high density of conventional bicycle users are potential markets where introducing the E-bike would be met with success.
Figure 1 shows the results of a 2017 study comparing the use of cars and bicycles across the Netherlands (Rueb, 2017). Figure 2 is a display of the results of my current study, showing the distribution of E-bike users across the Netherlands. A comparison of the two graphs demonstrates a moderate degree of overlap; particularly, there was a concentration of E-bike users in Nord- and Zuid-Holland, with packets located in Utrecht.
These areas were all places with a relatively high prevalence of conventional bicycle usage three years earlier. This finding provides credibility to the earlier assertion that introducing the E-bike to areas rich in conventional bike users would be a successful speculation. Moreover, the fact that there was overlap between the map generated by this study and the one in Figure 1 means that our study was able to achieve some measure of representativeness despite its small sample size. This may be due to the fact that using ads as a means to distribute the survey allowed for a healthy coverage of a large part of the country. However, it must be noted that Rotterdam and its surrounding cities where most of the surveys were distributed in hand show the highest concentration of responses, which may represent a selection bias.

4.2 Survey findings about E-bike users of the Netherlands:

Respondents of the survey were divided into three classes defined a priori, with each respondent deciding on how they identify before completing the survey questions. Participants were thus categorized as either "Utilitarian", "Enthusiastic", or "Recreational" E-bike users. Despite this grouping, a re-assessment of how will each respondent fits into these three categories will be done while going through the users' answers in the coming sections. The three clusters were defined as follows:

1. **Enthusiastic E-bikers**: Individuals who focus on cycling frequency and convenience as they perceive the E-bike as a mean to increase the distance they can travel, when compared to conventional bikes. This group carries a positive attitude towards E-bikes as they were Enthusiastic to the "Add-ons" it gave to conventional bikes.
2. **Utilitarian E-bikers**: Individuals who see the positives of E-bikes only in specific situations where an E-bike can add practicality and save time during daily life activities such as shopping or picking up the kids and commuting. The E-bike is only an

optimization to what they previously had, and is used to serve as specific purpose or job.

3. **Recreational E-bikers:** Individuals who use E-bike less regularly than the other groups but excited by the added speed provided by E-bikes, regardless if it serves a purpose or not, it is used mainly for longer travelling distances.

4.2.1 General characteristics of E-bike users and their E-bike:

To understand the adoption of an E-bike and the factors that triggered the decision to switch from a conventional one, we gathered information from participants about their demographics, cycling skills and frequency, the type of E-bike they use, and the objective and subjective factors that influenced this transition. This data is presented in Tables 1-4.

4.2.1.1 Demographic of E-bike users:

Table 1 Sociodemographic factors

Sociodemographic variables		Total sample (n = 175)	Utilitarian (n = 85)	Enthusiastic (n = 49)	Recreational (n = 39)
Gender	Male	94 (53.7%)	**52** (61.17%)	23 (46.94%)	21 (53.84%)
	Female	77 (44%)	**32** (37.64%)	24 (48.98%)	17 (43.59%)
	Other	4 (2.3%)	1 (1.17%)	2 (4.08%)	1 (2.56%)
Age group	< 18	3 (1.7%)	2 (2.35%)	1 (2%)	0 (0%)
	18-24	14 (8%)	7 (8.23%)	6 (12.24%)	1 (2.56%)
	25-34	**48** (27.4%)	**27** (31.76%)	8 (16.33%)	2 (5.12%)
	35-44	29 (16.6%)	**13** (15.29%)	9 (18.37%)	6 (15.38%)
	45-67	**62** (35.4%)	**29** (34.11%)	**16** (32.65%)	**17** (43.59%)
	> 67	19 (10.9%)	7 (8.23%)	9 (18.37%)	3 (7.69%)
Nationality	Dutch	130 (74.3%)	**62** (72.94%)	38 (77.55%)	29 (74.35%)
	Other	45 (25.7%)	**23** (28.04%)	11 (22.45%)	10 (25.64%)
Children or grandchildren under 5 years of age	Yes	41 (23.4%)	16 (18.82%)	13 (26.53%)	28 (71.79%)
	No	(74.9%)	67 (78.82%)	35 (71.43%)	11 (28.2%)
Occupation	Student	32 (18.3%)	15 (17.64%)	**10** (20.41%)	6 (15.38%)
	Part-time	24 (13.7%)	10 (11.76%)	9 (18.36%)	5 (12.82%)
	Full-time	**72** (41.1 %)	**39** (45.88%)	**13** (26.53%)	**19** (48.71%)
	Freelancer	10 (5.7%)	5 (5.88%)	4 (8.16%)	1 (2.56%)
	Not employed	13 (7.4%)	7 (8.23%)	3 (6.12%)	3 (7.69%)
	Retired	24 (13.7%)	9	**10** (20.4%)	5

The demographic information of the 175 participants is shown in **Table 1**. The participants consisted of 94 (53.7%) males and 77 (44%) females. As for the age distribution, 3 (1.7%) were under the age of 18, 14 (8%) between 18 and 24, 48 (27.4%) between 25 and 34, 29 (16.6%) between 35 and 44, 62 (35.4%) between 44 and 67, and 19 (10.9%) were older than 67. 41 (23.4%) had children or grandchildren under the age of 5, and 130 (74.3%) were Dutch. As for the participant's occupational status, 32 (18.3%) were students, 24 (13.7%) worked part-time jobs, 72 (41.1 %) worked full-time jobs, 10 (5.7%) identified as freelancers, 13 (7.4%) were currently not employed, and 24 (13.7%) were retired. 39 (22.2%) participants studied or worked in an area other than where they lived; they had to commute between cities for this purpose, and a map representing their trip is provided in the coming sections.
The survey respondents demonstrate the variation in people who use an E-bike in the Netherlands. We asked expert Melissa Bruntlett for her insight on the broader distribution in the age range than was present ten years ago, when elders were the ones to use the E-bike most.

"from what I understand of the studies I read before, most of those E-bike purchases are being made by people in a higher age bracket. For them I think it's a matter of maintaining that level of mobility without having to worry about the physical strain of cycling. But also, nowadays, I do see a lot of teens cycling on E-bikes, and more on the intercity connecting bicycle routes. So, I think for them, it's a matter of getting from home to where they need to go at a faster pace (...) in general, it's a matter of allowing people to maintain mobility without having to worry about the time it will take if you're on a regular bike, as most regular bikes here, are with one or three speeds. (…) with the physical toll as we get older, or even for people who are younger what they want or need is to get around, but also they don't want to spend a huge amount of effort getting from where they live to where they need to get to."

Melissa Bruntlett – Expert

Melissa's input goes hand in hand with information provided by Hans Hartmen, an E-bike seller:

"more and more young people are opting for an e-bike to go to school. Working people also find out that an electric bicycle can be used well for commuting"

Hans Hartmen – E-bike seller

From the above table, it should be noted that the vast majority of E-bike users fall into the Utilitarian category. The ratio is skewed towards males in the Utilitarian group, with most users aged between 18 to 67 years old –the reproductive age. In contrast, there is almost a 1:1 female to male ratio among the Enthusiastic and Recreational groups. The Recreational and Enthusiastic groups are dominated by older ages however, which Bruntlett puts down to the decline in their physical abilities, making E-bikes an attractive alternative to traditional cycling.

4.2.1.2 Cycling skills and frequency

Table 2 explores the cycling skills and frequency associated with each group of E-bike user.

Table 2 Variables		Total sample (n = 175)	Utilitarian (n = 85)	Enthusiastic (n = 49)	Recreational (n = 39)
Cycling duration in the Netherlands	< 1 year	16 (9.14%)	7 (8.23%)	4 (8.16%)	5 (12.8%)
	2-5 years	25 (14.28%)	11 (12.94%)	9 (18.36%)	5 (12.8%)
	> 5 years	**128** (73.14%)	**61** (71.76%)	**35** (71.42%)	**29** (74.35%)
Cycling frequency	< 3 days/week	33 (18.85%)	7 (8.23%)	7 (14.28%)	**19** (48.71%)
	4-5 days/week	68 (38.85%)	**47** (55.29%)	15 (30.61%)	6 (15.38%)
	6-7 days/week	72 (41.14%)	**31** (36.47%)	**27** (55.1%)	14 (35.89%)
Cycling proficiency	Beginner	2 (1.14%)	1	0 (0%)	1 (2.56%)
	Intermediate	35 (20%)	13	5 (10.2%)	17 (43.59%)
	Experienced	**136** (77.71%)	71	44 (89.7%)	21 (53.84%)

Concerning cycling duration, 16 (9.14%) participants had been cycling for less than one year at the time of this study, 25 (14.28%) for 2-5 years, and 128 (73.14%) for more than 5 years. 33 (18.85%) participants cycle for less than three days per week, 68 (38.85%) cycle for 4-5 days per week, and 72 (41.14%) cycle for 6-7 days. Additionally, 2 (1.14%) described themselves as beginners, 35 (20%) as intermediate cyclers, and 136 (77.71%) as experienced.

I think for some people, it could be that they've been cycling for years. And now we're just at a point where they want it to be a little bit easier.

Melissa Bruntlett – Expert

From the numbers from Table 2, we can see that the majority of E-bike adopters were cyclists for more than five years, and they considered themselves experienced, cycling frequently between 4-5 & 6-7 days a week. Moreover, more than half the Enthusiastic cyclists cycle almost every day, while half the Utilitarian group cycle a bit less at 4-5 days a week, and Recreational E-bike users even less, with half cycling under 3 days a week.

There was a significant association between being a Utilitarian E-biker, and frequency of cycling ($\chi2$ (2) = 22.22; Cramér's V = 0.36, $p < 0.001$). Similarly, being a recreational cycler was significantly associated with cycling frequency ($\chi2$ (2) = 30.92; Cramér's V = 0.42, $p < 0.001$), in other words the low observed frequencies in the recreational sub-category is a true reflection of being a recreational user who doesn't use the E-bikes as often as the other groups. Additionally, being a recreational cycler was significantly associated with the experience level of the cycler g ($\chi2$ (2) = 18.37; Cramér's V = 0.32, $p < 0.001$).

In our sample, 98 (50.6%) respondents cross elevated areas in their commute. *Even though the Netherlands is a flat country, I noticed a significant difference between E-bikes and regular*

bikes in putting effort to cross elevated areas such as bridges. From my perspective, using an E-bike can make cycling smooth and easy as you do not feel the need to increase your physical effort while cycling as the electrical assistance reacts according to the landscape's need. Therefore, having elevated areas that need an effort to cross for frequent users may be a reason for adopting an E-bike.

166 (94.3%) respondents mentioned that they owned a regular bike prior to purchasing an electrical one. Regular cyclists' tendency to shift to an E-bike is increasing with time, especially that the average price is decreasing. Whether cyclists perceive it as an upgrade or look at it as a new means for transport depends on the purpose of commuting, which we will be elaborating on shortly.

4.2.1.3 Type of E-bikes adopted and means of access

Table 3 Type of E-bike adopted.

Types of E-bike used by respondents	Total sample (n = 175)	Utilitarian (n = 85)	Enthusiastic (n = 49)	Recreational (n = 39)
Electric city bike	104 (59.1%)	53	30	19
Electric folding bike	5 (2.8%)	1	4	0
Electric family bike	7 (4%)	2	2	3
Cargo electric bike	7 (4%)	1	0	6
Transport/delivery bike	12 (6.8%)	8	2	2
Touring/sporty bike	14 (8%)	3	7	4
Speed pedelec	10 (5.7%)	8	1	1
Other	8 (4.5%)	4	2	2

The most commonly used was the electric city bike with 104 users (59.1%). There was a significant relationship between identifying as a recreational cyclist and the type of bike used $\chi 2\ (7) = 21.22$; Cramér's $V = 0.36$, $p = 0.003$), this means a recreational cyclist would be careful in choosing the type of bike he uses.
With regard to how participants had access to E-bikes, the majority 145 (82.4%) owned one. 11 (6.3%) participants subscribed to a monthly rental membership, while 3 (1.2%) made use of the instant shared public E-bike system, and 4 (2.3%) borrowed one. There was no significant difference between access type and type of user.

4.2.1.4 Parking facilities and insurance

Table 4 Parking type

Number and % / Parking	Total sample (n = 175)	Utilitarian (n = 85)	Enthusiastic (n = 49)	Recreational (n = 39)
Personal parking	93 **(52.8%)**	41 **(48.2%)**	29 **(59%)**	20 **(51.3%)**
Shared indoor parking	26 (14.8%)	13 (15.3%)	8 (16.3%)	5 (12.8%)
Shared outdoor parking	7 (21.6%)	21 (24.7%)	11 (22.4%)	6 (15.4%)
Other	9 (5.1%)	4 (4.7%)	0	5 (12.8%)

Table 4 displays data on parking facilities used by E-bike users. 93 (52.8%) participants had their own personal parking space, while 26 (14.8%) utilized indoor shared parking facilities, and 38 (21.6%) had outdoor shared facilities. The latter means that around 68% of respondents have their own safe parking without the worry about their vehicle getting stolen. There was no significant difference between parking and user types. Recreational users were significantly less likely to own insurance, with only 28% of them parking in outdoor facilities ($\chi 2$ (1) = 9.77, p = 0.002)

84 (47.7%) participants reported having insurance on their E-bikes. They were distributed as follows: 45 (53.57%) utilitarian, 28 (33.33%) enthusiastic, and 10 (11.9%) recreational. For Utilitarians, losing their E-bike might affect their ability to carry out their daily activities; this would explain why almost half of the Utilitarian users seek to have insurance despite the added expense.

4.2.2 Reasons behind the shift from conventional bike to E-bike:

4.2.2.1 Objective factors and individual objective factors:

Table 5 Main purpose(s) for using an E-bike

Number and % / Main purpose	Total sample (n = 175)	Utilitarian (n = 85)	Enthusiastic (n = 49)	Recreational (n = 39)
To commute to work, university or school	**120 (68.6%)**	**73 (85.9%)**	**35 (71.4%)**	12 (30.8%)
To access public transport	47 (26.9%)	6 (7%)	**37 (75.5%)**	4 (10.3%)
To use it for work	67 (38.2%)	**50 (58.9%)**	11 (22.4%)	6 (15.4%)
For Physical activity	**100 (57.1%)**	28 (33%)	**37 (75.5%)**	**35 (89.7%)**
For Recreational trips	68 (38.8%)	20 (23.5%)	17 (34.7%)	**30 (76.9%)**
To carry heavy goods / children	47 (26.9%)	**30 (35.3%)**	9 (18.4%)	8 (20.5%)

To commute with multipurpose rides	54 (30.9%)	20 (23.5%)	**22 (44.9%)**	12 (30.8%)
Replace standard bike	66 (37.7%)	20 (23.5%)	17 (34.7%)	**23 (59%)**
Reduce car use	62 (35.4%)	21 (24.7%)	13 (26.5%)	**28 (71.8%)**
As new means of transportation	**74 (42.3%)**	**61 (71.8%)**	7 (14.3%)	6 (15.4%)

When questioned about the main purpose for using an E-bike, 120 (68.6%) participants chose commuting to work or university as a reason, 47 (26.9%) using E-bikes to access public transportation, 67 (38.2%) for work, 100 (57.1%) for exercise and physical activity, 68 (38.8%) for recreational trips, 47 (26.9%) to carry goods or children, 54 (30.8%) for multipurpose rides, 66 (37.7%) as a replacement of the standard bike, 62 (35.4%) to reduce car use, and 74 (42.3%) to use it as new means of transportation. From this data, we can see the association between respondent's objective purposes for using an E-bike and the category they belong to. Being a Utilitarian user was significantly associated with commuting to work as a reason to use the E-bike ($\chi2$ (1) = 22.98, $p < 0.001$), using for work ($\chi2$ (1) = 11.51, $p < 0.001$), carrying heavy goods /children ($\chi2$ (1) = 5.92, $p = 0.014$), commuting with multi-purpose rides ($\chi2$ (1) = 4.59, $p = 0.032$), and using it as a new means of transportation ($\chi2$ (1) = 46.48, $p <0.001$). Being an Enthusiast was significantly associated with accessing public transport ($\chi2$ (1) = 56.81, $p < 0.001$), physical activity ($\chi2$ (1) = 9.37, $p = 0.002$), and multi-purpose rides ($\chi2$ (1) = 5.2, $p = 0.021$). Finally, physical activity ($\chi2$ (1) = 21.77, $p <0.001$), recreational use ($\chi2$ (1) = 8.49, $p = 0.003$), using it as a replacement to a standard bike ($\chi2$ (1) = 9.65, $p = 0.002$), and reducing car usage ($\chi2$ (1) = 29.1, $p < 0.001$) were all significantly associated with being a Recreational user.

According to the above data, we can conclude that **Utilitarian cyclists** seek to adopt an E-bike for practical reasons and to make their journey easier with less waste of time to commute. They consider E-bike as a different mode of transport where the majority use it:

1. To commute to work, university, or school (85.9%)
2. To use it is a new means of transportation (71.8%; this explains why the majority of Speed pedelec E-bikes in table 3 belong to this group).
3. To use it for work (delivery, Logistics, etc.) (58.9%)
4. To carry heavy goods/children (35.3%; this explains why the majority of Transport/delivery E-bikes in table 3 belong to this group).

As for **Enthusiastic cyclists**, adopting an E-bike is a necessary upgrade to increase their cycling frequency as it will help them maintain a certain level of physical activity and connect with public transport when needed. The majority of this group use an E-bike:

1. For Physical activity (75.5%; this explains why the majority of Touring/sporty bike in table 3 belong to this group).
2. To access public transport (75.5%; this explains why the majority of foldable bikes in table 3 belong to this group).

3. To commute to work, university or school (71.4%)
4. To commute with multipurpose rides (44.9%)

For Recreational cyclists, the reason for owning an E-bike was mainly to cycle longer distances for recreational purposes while reducing their car use and maintaining a level of physical effort. The majority of this group use an E-bike:

1. For physical activity (89.7%)
2. For recreational trips (76.9%)
3. To reduce car use (71.8%)
4. To replace their conventional bike (59%

The presented findings show that there is an association between the main purpose of use and which of Haustein and Møller's (2016) attitudinal groups the individual identifies with.

Table 6 Important practical factor(s) in taking the decision to use an E-bike.

Number and % / Practical factors	Total sample (n = 175)	Utilitarian (n = 85)	Enthusiastic (n = 49)	Recreational (n = 39)
Availability of maintenance points	38 (21.6%)	17 (20%)	**13 (26.5%)**	8 (20.5%)
Availability of safe parking	**61 (34.7%)**	34 **(40%)**	**13 (26.5%)**	13 **(33.3%)**
Availability of safe cycling lanes	**72 (40.9%)**	33 **(38.8%)**	2 **(44.9%)**	16 **(41%)**
Availability of diverse E-bike retailers	15 (8.5%)	8 (9.4%)	5 (10.2%)	2 (5.1%)
Availability of charging points	18 (10.2%)	12 (14.1%)	3 (6.1%)	2 (5.1%)
Availability of different insurance plans	8 (4.6%)	6 (7.1%)	2 (4.1%)	0 (0%)
Affordability	**71 (40.3%)**	35 **(41.2%)**	16 **(32.7%)**	20 **(51.3%)**
Access to loan facilities	8 (4.6%)	6 (7.1%)	1 (2%)	1 (2.6%)
Access to incentives	12 (6.8%)	7 (8.2%)	3 (6.1%)	2 (5.1%)

Table 6 measures the practical factors associated with E-bike use. The major two factors contributing to the shift to E-bike were the availability of safe cycling lanes (40.9%) and affordability (40.3%). The factors that contributed least to the decision to use an E-bike were the availability of different insurance plans (4.6%) and loan facilities (4.6%). 35% of participants reported safe parking to be among the reasons they transitioned to an E-bike. From those, the majority were of the Utilitarian group. The Utilitarian group of participants were also

the majority to choose the availability of charging points as a factor contributing to their transition to E-bike. On the other hand, affordability played a bigger role for the recreational group of E-bike users, where 51.3% of the recreational group cited affordability as a factor contributing to their transition.

From my observation, I agree with the survey respondents about the importance of having an affordable market, a safe cycling lane to commute on, and safe parking to protect the bike from getting stolen for the three groups evenly. As these factors were crucial in motivating me to adopt an E-bike.

Table 7 Important Social and Tech factor(s) in taking the decision to use an E-bike

Number and % / Social Factor	Total sample (n = 175)	Utilitarian (n = 85)	Enthusiastic (n = 49)	Recreational (n = 39)
Trendy	25 (14.5%)	13 (15.3%)	4 (8.2%)	8 (20.5%)
Interest in new technology	**49 (28.3%)**	**21 (24.7%)**	**15 (30.6%)**	**13 (33.3%)**
Environmentally friendly compared to cars	**69 (39.9%)**	**34 (40%)**	**26 (53.1%)**	9 (23.1%)
Aesthetically pleasing	25 (14.5%)	12 (14.1%)	8 (16.3%)	5 (12.8%)
Positive feedback from people I trust	**47 (27.2%)**	**22 (25.9%)**	**9 (18.4%)**	**16 (41%)**
Friends/family using similar E-bike	37 (21.4%)	19 (22.4%)	7 (14.3%)	**11 (28.2%)**
Received advertisement	5 (2.9%)	2 (2.4%)	3 (6.1%)	0
Fits with socioeconomic class	25 (14.5%)	12 (14.1%)	7 (14.3%)	6 (15.4%)

Social factors also play a role in choosing to use an E-bike, and as Table 7 shows, being environmentally friendly compared to cars was the most important of these, with 40% of participants reporting it as a reason for riding the E-bike; the Enthusiastic and Utilitarian groups were significantly more likely to cite this as a reason to switch than the Recreationalists ($\chi 2$ (1) = 8.14, p = 0.017, $\chi 2$ (1) = 5.93, p = 0.015 respectively). Additionally, receiving positive feedback from people they trust was a significant social factor in the Recreational group.

For most avoiding the usage of a car for environmental reasons is essential as both cars & bicycles share the same feature of autonomy in commuting. However, E-bike usage reduces the environmental guilt traditionally accompanied with driving a car, and it is heartening to find that people are thinking about the environment.

"I think it's very clear that E-bikes are here to stay and that people see the use of them. (...) you know, the last slide with the consideration for the environment I think that is very promising to see that's a consideration for people."

Melissa Bruntlett – Expert

Although Recreational cyclists seek to reduce their car use, as shown in **table 5**, getting an E-bike for environmental reasons is not that significant. As Recreational E-bikers still cycle less than the other two groups (2 to 3 times a week), they must still use either car or public transport to commute. Moreover, recreational trips are a reason for adopting an E-bike for Recreational cyclists. This explains the increased response rate to "Friends/family using similar E-bike" in Table 7 among Recreational users.

4.2.2.1 Subjective factors:

Table 8 Important personal factor(s) in taking the decision to use an E-bike.

Number and % / Personal Factor	Total sample (n = 175)	Utilitarian (n = 85)	Enthusiastic (n = 49)	Recreational (n = 39)
Less physical effort required to cycle	**80 (46.2%)**	**39 (45.9%)**	**20 (40.8%)**	21 (53.8%)
Increased speed	**86 (49.7%)**	**42 (49.4%)**	**20 (40.8%)**	**24 (61.5%)**
Save time in commuting	70 (40.5%)	29 (34.1%)	18 (36.7%)	23 (59%)
Ability to cycle longer distances	**104 (60.1%)**	**53 (62.4%)**	**23 (46.9%)**	**28 (71.8%)**
Larger carrying/towing capacity	26 (15%)	11 (12.9%)	5 (10.2%)	10 (25.6%)
Ability to carry children with less effort	23 (13.3%)	10 (11.8%)	6 (12.2%)	7 (17.9%)
Ability to cycle easier in windy weather	**101 (58.4%)**	**45 (52.9%)**	**27 (55.1%)**	**29 (74.4%)**
To cycle without getting sweaty	69 (39.9%)	33 (38.8%)	13 (26.5%)	**23 (59%)**
Autonomy of commuting	54 (31.2%)	25 (29.4%)	18 (36.7%)	11 (28.2%)
Health related	10 (5.7%)	7 (9.3%)	3 (6.1%)	0

With regards to personal factors, the majority of participants (60.1% and 58.4% respectively) viewed the ability to cycle longer distances and the ability to cycle more easily in windy weather as key reasons for utilizing the E-bike. Less physical effort required to cycle, increased speed of cycling, time saved in commuting, and the ability to cycle without getting sweaty were also key reasons for utilizing the E-bike among 46.2%, 49.7%, 40.5%, and 39.9% of participants respectively, as per Table 8.

"There are so many excuses around like typography, heat, etc.. Per example, in Australia, a lot of the conversations that we heard were focused on why I can't buy a bicycle ,is because it's too hot or even too cold, all of these excuses that are used a lot of times to not promote cycling, (..) I think E-bike plays a role there in terms of removing a lot of those excuses from the equation and make it possible for people to cycle longer distances without getting too sweaty" ***Melissa Bruntlett – Expert***

"E-bike gives me the opportunity to bicycle for business trips, like distances of 15 or 20 kilometers, which I couldn't do before because I would become all sweaty and smelling bad when I get to my appointment where in that situation I would normally take my car or public transport" ***Roel Lenoir – Expert***

Less common personal factors involved in the decision to use an E-bike were autonomy of commuting and practical reason for specified groups like larger carrying/towing capacity (logistical & delivery employees), and the ability to carry children with less effort (parents), which were factored into the decisions of 31.2%, 15%, and 13.3% of participants respectively. Notably, the ability to cycle with less physical effort, increased speed, for longer distances, and more efficiently in windy weather mattered more to Utilitarian and Enthusiastic users than recreational users of the E-bike. An interesting factor that emerged during data collection was health-related issues n = 10 (5.7%). It was more commonly associated with Utilitarian cyclists (70%), which means having an E-bike can make commuting easy for users who have health problems and want to keep their feet on the pedals.

Identifying as Enthusiastic was significantly associated with wanting to save time in commuting ($\chi 2$ (1) = 7.25, p = 0.027), and wanting to cycle without getting sweaty ($\chi 2$ (1) = 9.61, p = 0.008). Additionally, the ability to cycle longer distances was almost significantly associated with recreational ($\chi 2$ (1) = 5.954 p = 0.051). Wanting to save time was significantly associated with identifying as a Utilitarian cycler ($\chi 2$ (1) = 7.16, p = 0.007), as were ability to cycle in windy weather ($\chi 2$ (1) = 5.29, p = 0.021), not wanting to get sweaty ($\chi 2$ (1) = 7.65, p = 0.006), and increased carrying capacity ($\chi 2$ (1) = 4.44, p = 0.035).There were no significant associations between identifying as Recreational and any personal factors.

Interestingly, receiving advertisement for e-biking was not a major factor involved in riding an E-bike, with only 2.9% of participants admitting to its role in their decision to ride.

4.2.3 Tracking travel behavior change, perception and cycling patterns:

4.2.3.1 Change in cycling patterns, and attitude of users

Table 9 Tracking changes in cycling patterns after using an E-bike

Cycling patterns		Total sample (n = 175)	Utilitarian (n = 85)	Enthusiastic (n = 49)	Recreational (n = 39)
Increase in Frequency:	Going to work or educational facilities	124 (71.7%)	**62 (72.9%)**	**35 (71.4%)**	**27 (69.2%)**
	Visit friends and family	106 (61.3%)	52 (61.2%)	**34 (69.4%)**	20 (51.3%)
	To reach public transport	48 (27.7%)	24 (28.2%)	11 (22.4%)	13 (33.3%)
	To use it as a vehicle for work	73 (42.2%)	32 (37.6%)	22 (44.9%)	19 (48.7%)
	To do shopping / groceries shopping	115 (66.5%)	**56 (65.9%)**	33 (67.3%)	**26 (66.7%)**
	Physical activity	90 (52%)	43 (50.6%)	28 (57.1%)	19 (48.7%)
	Recreational trips	109 (63%)	**54 (63.5%)**	**38 (77.6%)**	17 (43.6%)
	Multi-purpose rides	112 (64.7%)	52 (61.2%)	**34 (69.4%)**	**26 (66.7%)**
Increase in speed		142 (82.1%)	**72 (84.7%)**	**37 (75.5%)**	**33 (84.6%)**
Increase in cycling distance		151 (87.3%)	**71 (83.5%)**	**44 (89.8%)**	**36 (92.3%)**
New cycling purposes		115 (66.5%)	56 (65.9%)	32 (65.3%)	27 (69.2%)
Take advantage of traveling with an E-bike		131 (75.7%)	**67 (78.8%)**	**39 (79.6%)**	**25 (64.1%)**
Spatial ability	Confidence	56 (32.4%)	29 (34.1%)	10 (20.4%)	17 (43.6%)
	Try new locations	136 (78.6%)	66 (77.6%)	40 (81.6%)	30 (76.9%)
	New routes	132 (76.3%)	63 (74.1%)	38 (77.6%)	31 (79.5%)
Community	Belonging	33 (19.1%)	14 (16.5%)	11 (22.4%)	8 (20.5%)
	Interacting	29 (16.8%)	12 (14.1%)	11 (22.4%)	6 (15.4%)

Cycling patterns apparently change when transitioning to an E-bike. Our study aimed to assess the nature of these changes in terms of frequency, speed, distance, and purpose of cycling. The results of this section can be found in **Table 9**. The majority of participants reported an increased frequency of cycling to a multitude of locations, except to public transport facilities and to use it as a vehicle for work, with only 28% and 42% of participants citing increased cycling for such purposes. Interestingly, the frequency of cycling for recreational trips was increased in 63% of participants, mostly among the Enthusiastic group, where 78% of participants belonging to that group reported an increase in recreational cycling.

The destinations with the largest increase in cycling after transitioning to the E-bike were workplaces or educational facilities, with 72% of participants reporting an increased frequency for that purpose.

Overall, our data suggests that E-bike usage increases the frequency of cycling. An increased frequency of recreational trips was observed more often in the Enthusiastic ($\chi 2$ (2) = 11.48;

Cramér's V = 0.182, p = 0.02), and recreational ($\chi 2$ (2) = 8.83; Cramér's V = 0.22, p = 0.012) groups. Taking opportunities to travel more using the E-bike was significantly associated with belonging to the Utilitarian group ($\chi 2$ (2) = 7.17; Cramér's V = 0.2, p =0.028).

4.2.3.2 Effect of COVID 19 on the usage of E-bike

"More Dutch people on e-bike to work due to corona"
"Brand Accell sees the possibility of exercising outdoors as an additional reason for the increased interest in an e-bike in times of pandemic"
(RTL Nieuws, 2020)

"*People are currently more receptive to new ways to travel. This trend was already underway and triggered by Covid-19, in any case it has accelerated the trend"*
Lonneke van der Hors – Expert

"because of the pandemic potential buyers have been paying less attention to money, because their expensive holiday plans, for example, have fallen apart"
Roel Lenoir – Expert

Since the outbreak, it was estimated that sales of E-bikes were 38% higher in May 2020 compared to the year before (RAI, 2020). Because of the Coronavirus, the Dutch were acutely looking for an alternative to public transport. The data of the survey shows 77 (44.5%) participants reported increasing their cycling following the COVID-19 pandemic, while 63 (36.4%) reported a decrease and 33 (19.1%) reported no change, with no significant difference between the three types of cyclists in this regard. As such, it seems the effects of Covid-19 on transport habits are highly individualized, and no conclusive trends may be noted. A follow-up study with a questionnaire targeting participants' post-Coronavirus travel habits may be more suitable in exploring this phenomenon.

4.2.3.3 Spatial ability

Assessing ability for spatial navigation is also important in the transition to an E-bike. To this end, our study assessed confidence while cycling, cycling to new locations, and using new routes to reach previously known locations. Among our participants, only 32% reported increased confidence while cycling using the E-bike, with the majority belonging to the Recreational group (43.6% of Recreational group members). However, 79% and 76% of participants reported cycling to new locations or using new routes, respectively. In terms of increased sense of belonging to the e-biking community, results showed that only 19% of participants felt that they belonged to a community of E-bikers, and only 16.8% of participants interacted as a community of E-bikers.

4.2.3.4 Perception of safety

As part of our study, we also asked about how safe participants felt while using an E-bike. The mean safety rating was 8.06 (σ = 1.4). There was no significant difference in safety rating between the three types of cyclists. Although, the average of safety among users is high, many concerns were expressed by individual respondents:

"You sometimes go quick without even noticing"
"Lots of different traffic on cycle paths and very busy on working days / rush hour"
"Many cyclists, cycle too fast. Do not consider others."
"Sometimes in wet road it makes problem while moving fast with E-bike"
"It is very big ang heavy to fastly stop"
"It goes fast and I think the biggest issue is for everyone to adapt - i.e. Other people (mis) calculating my speed and going out in front of me. It means I am always very careful when I ride and I am on the verge of getting a helmet"
"Increased speed requires more attention"
"I pay close attention myself: experience ensures a lot of safety"
"Great speed difference with "normal" cyclists"
"cycle path not suitable for traffic that drives faster than 20km/hr."

Random respondents' comments – Survey

As can be seen, a significant portion of the safety concerns surrounding the E-bike have to do with its significant speed advantage over traditional bicycles. The comments on the safety of E-bikes were not all bad however; many satisfactory comments were expressed as well:

"The climate for cycling is very good (lots of special lanes)"
"Because I wear a bicycle helmet and I am careful"
"Because I've been cycling since I was little"
"Just as safe as a normal bicycle."
"My route is safe and I adapt in the city"
"I don't feel like I'm losing control because of the speed. Rather, the traffic / other road users have to get used to the speed of the E-Bike"
"I cycle a lot and therefore have a lot of confidence"
"I've been biking for years, so I feel safe in general with all kind if bikes"
"Because I'm in full control of my E-bike, I am not afraid of crashing into something."

Random respondents' comments – Survey

While many expressed concerns for the speed at which E-bikes traveled, others still acclaimed the control it offered. A recurrent theme was the idea that people needed time to get used to using an E-bike rather than a regular bicycle. All in all, the findings of this section can best be summarized by this excerpt from an article by the Telegraaf in 2020):

"Cyclists on a normal bicycle have just as much chance of ending up in the emergency room after an accident as cyclists on an e-bike .(..) the injuries sustained on an electric bicycle are no more serious than those on a 'normal' bicycle. An earlier investigation by VeiligheidNL. A few years ago, we conducted a large-scale study into more than 3000

bicycle accidents. Even then, the e-bike turned out to be no more dangerous than the normal bicycle, neither in the risk nor in the seriousness of the injury."

(Telegraaf, 2020)

4.2.3.5 Perception towards the available infrastructure:

141 (81.97%) participants were satisfied with the available infrastructure, with no significant differences between the three cyclist groups. Although, the percentage of satisfaction is high, we should note that the level of infrastructure differs from one city to the other. Many concerns were thus expressed by respondents:

"Far too many traffic lights where you still have to press a button the old-fashioned way. Not safe reliable (in terms of travel time)."
"Too much attention to cars. Cycling space is too much of an afterthought."
"Too much (slow) bicycle traffic in the center"
"paths should be wider"
"Many parts of the infrastructure have become narrow and Amsterdam lacks sufficient parking for cargo bikes."
"Bumpy bike paths"
"Cycle paths are too small and too crowded, fewer cars need to enter the city!"
"There are no suitable by / fast cycle routes out of the city."
"A lot of roads need to have better cycling lanes especially at the border of big cities"

Random respondents' comments - Survey

with many positive comments as well:

"Many cycle paths so that cyclists are taken into account everywhere"
"Great route, with a few points for improvement such as a bump in the asphalt causing the bike to bounce, traffic lights that are not properly adjusted and an unlit post"
"Excellent cycle paths and sufficient traffic lights"
"Nice hardened roads separated from cars, safe road design, long straight roads"
"it is well developed in the city"
"It is almost perfect"
"Bike lanes could be improved / smoothened, but the overall infrastructure is good"
"Good enough compared to other countries"
"Bicycle highway, 12 km route, I have three traffic lights in the city center"
"There are good cycle paths and the cars also pay attention to cyclists."
"A lot of separate bike paths are available"

Random respondents' comments - Survey

The discourse in this section seems to revolve around the bicycle paths and how well or poorly maintained they are. Respondents to our survey seemed to be divided and offered conflicting answers. Some argued that there were enough bicycle paths around while others said there were too little. Some were happy with the paving of the routes, the lighting, and the concentration of traffic lights along a route, while others criticized those very things. In the end, it seems that this infrastructural aspect is highly variable according to region, and any work on infrastructure would have to identify regional strengths or weaknesses rather than global ones across the entire Netherlands.

4.2.4 Relationship with other modes of transport:

4.2.4.1 The use of E-bike to connect with public transport

Travelling with your bicycle in general inside public transport is not that easy even in a cycling-friendly country like the Netherlands. Buses and trams generally do not allow bicycles. In metros, is it possible to carry your bike with you outside the rush hour during weekdays. Trains have the same rules as the metro except that bicycles are allowed inside on holidays and during the weekends. Luckily, foldable bikes are usually an exception, so they are allowed as long as they are folded in all type of public transport modes.
In the Netherlands there is an extensive effort to make intramodality feasible while commuting. The investment in bicycle parking spots near public transport stations promises to increase both cycle and public transport use while contributing to a sustainable transport system. It would allow individuals to combine the use of the bicycle (Electric or otherwise) and the public transport within the same trip, providing an appealing alternative to car use for longer distance rides. Nonetheless, the option of keeping the bike with you at all stages of your journey would always be preferable.
When assessing usage of the E-bike in combination with other modes of transportation, only a minority of the sample affirmed that they do so, with the majority of them (31.2%) stating that train is their additional method of transportation, followed by metro (12.1%). Remarkably, only 2.9% of participants reported using the bus and Tram in addition to their E-bike yet, most probably this combination is done with a foldable bike or by leaving their bike next to the Bus or tram stop. These numbers reflect the existing difficulty with intermodal transportation as certain public transport services make it almost impossible to bring along another mode of transport.

Table 10 Usage of cycling to connect with other modes of transport

Number and % / In combination with	Total sample (n = 175)	Utilitarian (n = 85)	Enthusiastic (n = 49)	Recreational (n = 39)
Bus	5 (2.9%)	2 (2.4%)	3 (6.1%)	0
Tram	5 (2.9%)	2 (2.4%)	3 (6.1%)	0
Metro	21 (12.1%)	10 (11.8%)	6 (12.2%)	5 (12.8%)
Train	54 (31.2%)	27 (31.8%)	18 (36.7%)	9 (23.1%)
Car	12 (6.9%)	7 (8.2%)	3 (6.1%)	2 (5.1%)

E-bike users' routes between cities

Data collected from the survey

This map shows an approximate route of E-bike users who mentioned that they use E-bike to commute from a city to another.

Users' route	Approx. distance (km)	Approx. duration
R_01	27.193	1 hr 21 mins
R_02	40.871	1 hr 48 mins
R_03	28.74	1 hr 18 mins
R_04	21.71	1 hr 2 mins
R_05	22.1	1 hr 1 mins
R_06	38.349	1 hr 45 mins
R_07	21.94	1 hr 2 mins
R_08	15.23	42 mins
R_09	17.418	50 mins
R_10	21.3	59 mins
R_11	23.1	1 hr 3 mins
R_12	23.1	1 hr 4 mins
R_13	30.476	1 hr 24 mins
R_15	34.45	1 hr 42 mins
R_16	22.69	1 hr 4 mins
R_17	22.16	1 hr 3 mins
R_18	15.78	43 mins
R_19	26.49	1 hr 20 mins
R_20	10.208	29 mins
R_21	21.91	59 mins
R_22	12.79	35 mins
R_23	15.85	54 mins
R_24	31.711	1 hr 30 mins
R_25	8.65	27 mins
R_26	34.35	1 hr 36 mins
R_27	28.151	1 hr 12 mins
R_29	11.65	31 mins

Legend

----- *Fastest cycling route*

Route distance & direction

- *8 - 10 km*
- *10 - 20 km*
- *20 - 30 km*
- *30 - 40 km*
- *40 - 42 km*
- *Road network*

Sub regions

- *Drenthe*
- *Flevoland*
- *Friesland*
- *Gelderland*
- *Groningen*
- *Limburg*
- *Noord-Brabant*
- *Noord-Holland*
- *Overijssel*
- *Utrecht*
- *Zeeland*
- *Zuid-Holland*

Background: OpenStreetMap

Alkmaar
Zaanstad
Haarlem
Amsterdam
Bennebroek
Amstelveen
Almere
Zeewolde
Zwolle
Epe
Deventer
Ermelo
Amersfoort
Soest
Utrecht
Alphen aan den Rijn
Gouda
's-Gravenhage
Zoetermeer
Rijswijk
Moordrecht
Schiedam
Rotterdam
Vlaardingen
Oud-Beijerland
Tiel
Moerdijk
Breda
Tilburg
Boxtel
Bergen op Zoom
Oisterwijk
Goes
Vlissingen
Baarle-Nassau
Eindhoven

0 25 50 km

Map done by Malak Rahal on QGIS + OSR plug-in by openrouteservice.org

Figure 3 ↑ Routes of respondents between cities. Done by author on QGIS

Figure above shows an approximate route that E-bike users take according to their residential location and the destination city they commute to. The route estimation was done on QGIS with a plugin that maps the exact route users take with an E-bike with a maximum speed of 25 km/h. Please note that most routes that take more than 1 hour (above 20 km) are done with a Speed pedelec (faster than 25 km/h) (76%) or with a foldable bike 25km/h (12%) that it seems that they combine it with public transport. Therefore, the time presented for this category is not accurate. The majority of E-bike users of the survey travel between 8 to 28 km to reach their destination for 30min to a maximum of one hour, respectively. Therefore, E-bike provided users the ability to travel between cities easily. The latter was not feasible without the availability of adequate cycling infrastructure and intercity lanes in the Netherlands.

4.2.4.2 Availability of modes of transport at the residence area of E-bike users

Table 11 Non-availability of mode of transport of E-bike users in their residence area

Number and % / Not available in my area	Total sample (n = 175)	Utilitarian (n = 85)	Enthusiastic (n = 49)	Recreational (n = 39)
Bus	4 (2.3%)	4 (4.7%)	0 (0%)	0 (0%)
Tram	70 (40%)	37 (43.5%)	18 (6.1%)	15 (38.4%)
Metro	80 (45%)	40 (47.0%)	23 (12.2%)	17 (43.6%)
Train	15 (8.5%)	6 (7%)	3 (36.7%)	6 (15.4%)

Surprisingly, 45% and 40% of E-bike users do not have access to Metro and Tram in their residence area, respectively. Simultaneously, 38% of Tram and Metro and 5% Tram, Metro, and Train are not available in their areas, which means that E-bike was adopted by these users to fill the transit sectors' gap. Many reasons can limit the level of development of public transport in those areas. It can be the area's typology (islands), urbanization level, or lack of demand that prevents a greater development level.

47% and 43% of those who consider themselves Utilitarian cyclists cannot use Tram and Metro, respectively, in their residence area. Relying on the bus to commute can be challenging and time-consuming. Adding to that, owning a car can be expensive for some users. E-bike can hence provide an efficient and affordable alternative that can help them travel long distances with less effort and faster pace with the car's autonomy.

"we talk a lot about how public transport is very well connected in the Netherlands, but I think there is communities in and around our bigger city centers that where public transport maybe isn't an option. And so, the E-bike gives them that alternative, to be able to have that independent mobility to get from, X to Y relatively quickly, without having to worry about relying on public transport that maybe isn't as prevalent in those communities. (...) I think those are the bigger factors in terms of why people are

switching or maybe adding to their bike collection to have an E bike as well"
Melissa Bruntlett – Expert

4.2.4.3 Frequency of usage of other modes of transport before getting an E-bike

This is in coherence with the statistic that prior to E-bike, 73% of participants used to use the standard bicycle on a daily basis. Nevertheless, our data shows a decrease in the number of participants who utilize another method of transportation after obtaining an E-bike, with regards to bus, tram, and metro usage, with a decrease in daily-weekly usage from 29% to 2.9%, 29% to 2.9%, and 30% to 12.1% pre- and post E-bike respectively. Interestingly, 8.1% of participants who currently use an E-bike had never used a standard bicycle for transportation. The majority of participants report using the standard bicycle, bus, tram, metro, and car less after obtaining an E-bike (78.6%, 68.3%, 60.7%, 57.3%, and 48.6% respectively). 10% of participants report walking more after using an E-bike. The following sections will analyze in depth the Effect of E-bike on each mode of transport.

4.2.4.4 The effect of E-bike on the usage of Bus

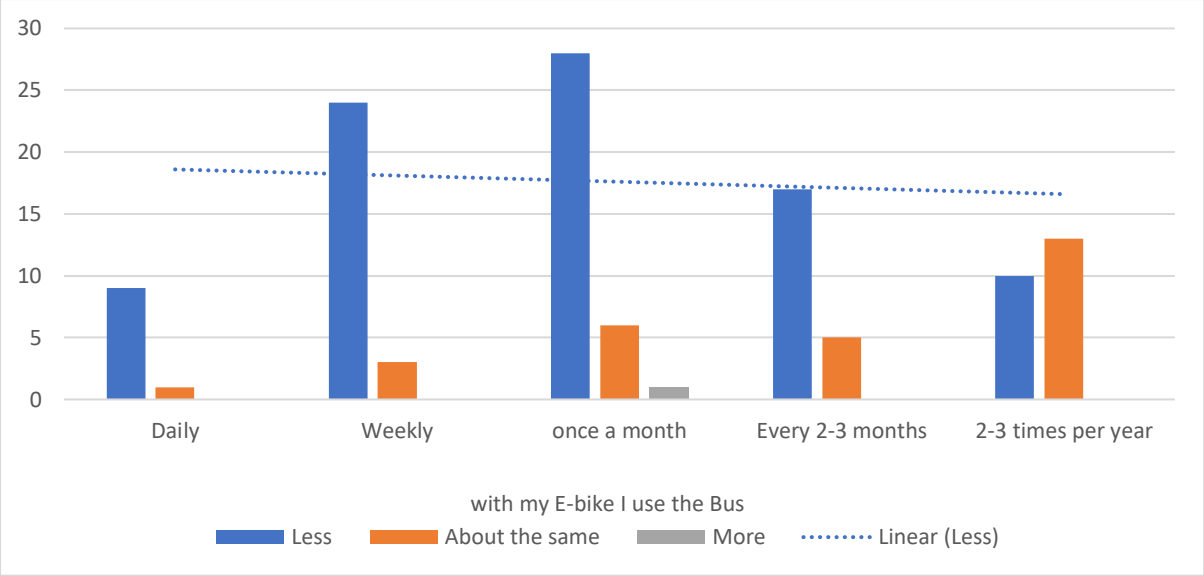


Figure 4 The usage of Bus after the adoption of an E-bike according to their previous frequency of usage

In order to understand the effect of adopting an E-bike on Bus utilization, we asked respondents to assess the mode by answering, "with my E-bike I use the Bus … less, more or about the same. 68% of participants who previously used the bus report a decrease in usage after obtaining an E-bike, while others reported no change. Since almost half of the E-bike users (45%) have access to the bus or/and train in their area, Figure 4 exhibits the diverse use frequencies. Individuals who previously used the bus daily, weekly, monthly, or every 2-3 months reported a decrease in bus usage after the shift to E-bike, as opposed to those who rarely used the bus prior; this latter group reported no change in bus usage after introduction of the E-bike, which is to be expected.

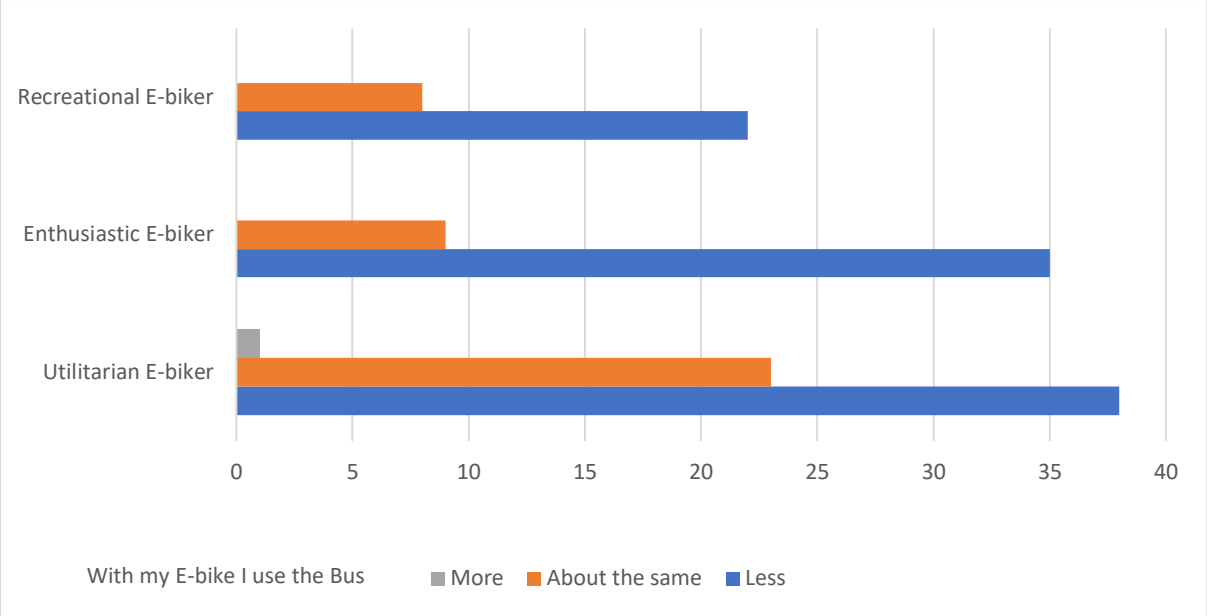


Figure 5 The usage of Bus after the adoption of an E-bike according to attitudinal groups

E-bike users from all attitudinal groups used the bus less as can be seen in Figure 5. What's interesting is that the ratio between answers of less and about the same for the Enthusiastic E-bikes is higher than Recreational and Utilitarian E-bikers. Enthusiastic E-bikers are looking for an E-bike to increase their cycling frequency, which would explain the higher ratio among this group. E-bike can substitute the bus as it offers the users a convenience of autonomy in not waiting for a crowded bus as frequent stops can be time-consuming, allowing Enthusiastic E-bike users to stick to a specified commuting schedule. Arguably, we ought to see a similar finding among Utilitarian users given the importance they place on functionality. However, this was not the case.

4.2.4.5 The effect of E-bike on the usage of Tram

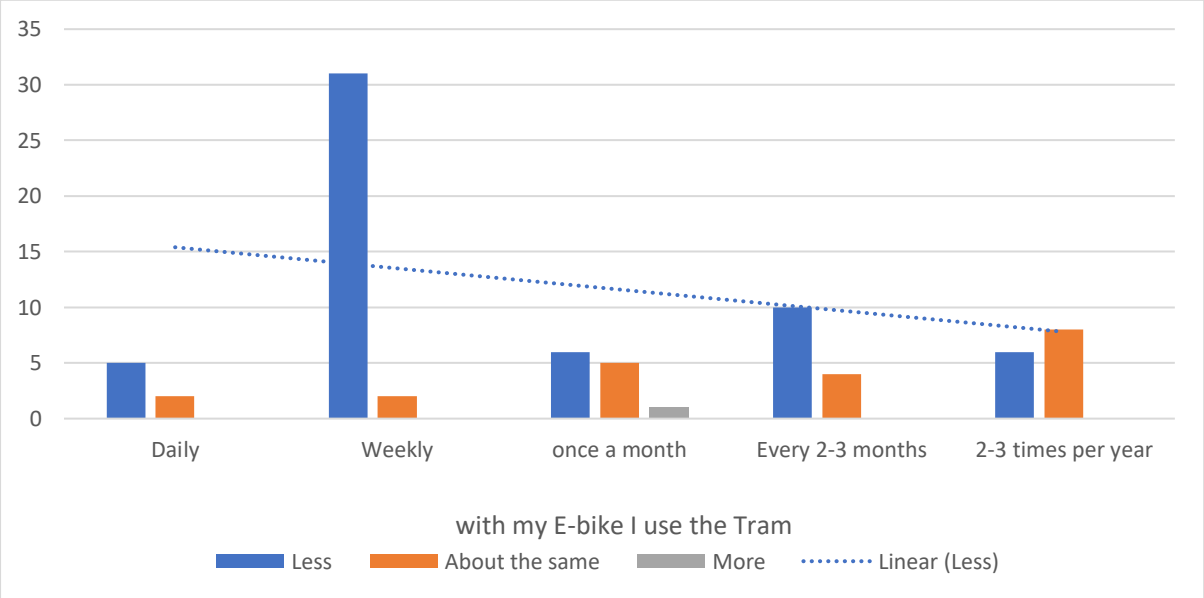


Figure 6 The usage of Tram after the adoption of an E-bike according to their previous frequency of usage

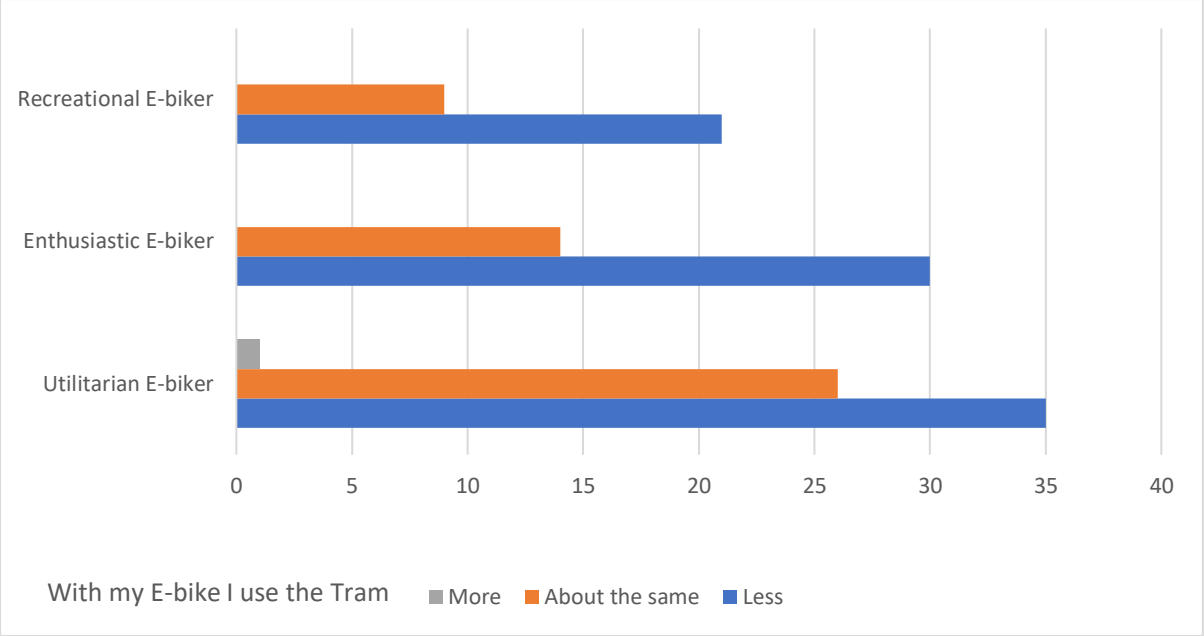


Figure 7 The usage of Tram after the adoption of an E-bike according to attitudinal groups

60.7% of tram users report a decrease of use after obtaining an E-bike, whereas others reported no change. As per Figure 6, the majority of E-bike users previously used the tram weekly. Those who previously used the tram daily, weekly, monthly or every 2-3 months reported a decrease in tram usage after the shift. In contrast, those who rarely used the tram continued to use it rarely, similar to the example of the bus.

Users of all attitudinal groups used the tram less. However, the ratio between answers of less and about the same for the Enthusiastic E-bikes is higher than Recreational and Utilitarian E-bikers respectively, mirroring the trend for bus use. In fact, the tram is very similar to the bus in its efficiency and convenience which explains the similar trends between the two.

4.2.4.6 The effect of E-bike on the usage of Metro

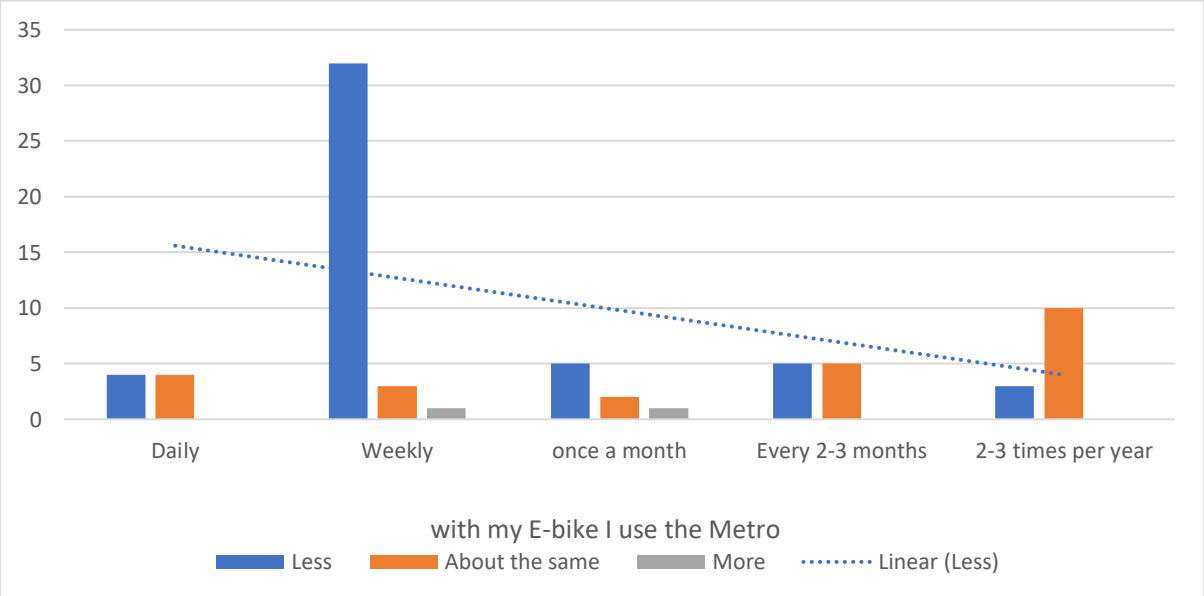


Figure 8 The usage of Metro after the adoption of an E-bike according to their previous frequency of usage

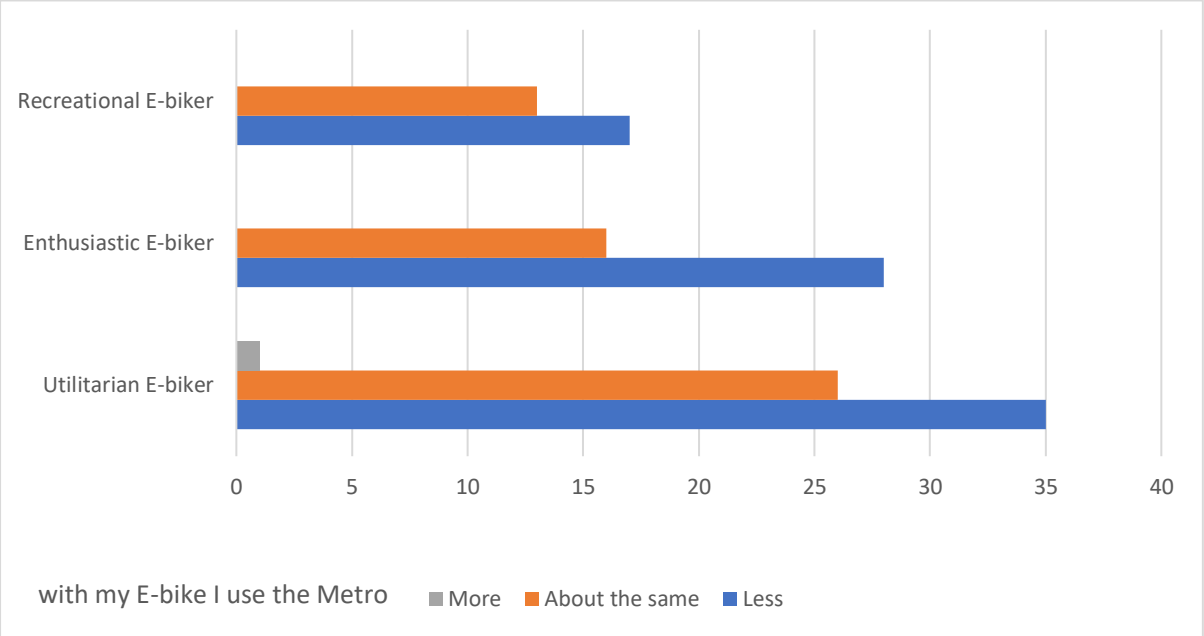


Figure 9 The usage of Metro after the adoption of an E-bike according to attitudinal groups

57.3% of Metro users report a decrease in usage after obtaining an E-bike, while others reported no change. Figure 8 shows that the majority previously used the Metro on a weekly basis. The results show trends for the Metro that parallel those of the bus and tram: people who rarely used this type of public transport exhibited no change in behavior after switching to the E-bike, while those who used it more regularly (every 2-3 months, to weekly) reported decreased usage after the shift.

Users across all attitudinal groups used the Metro less, with the ratio between answers of "less" and "about the same" higher among Enthusiastic E-bikers than the other two groups. Metro can reach destinations faster than bus and tram. *From a personal experience, in cities were the Metro network is well developed, the duration needed to commute by Metro is almost the same or a slightly more than an E-bike.* The latter explains the decreased ratio of the two answer choices among the attitudinal groups.

4.2.4.7 The effect of E-bike on the usage of Train

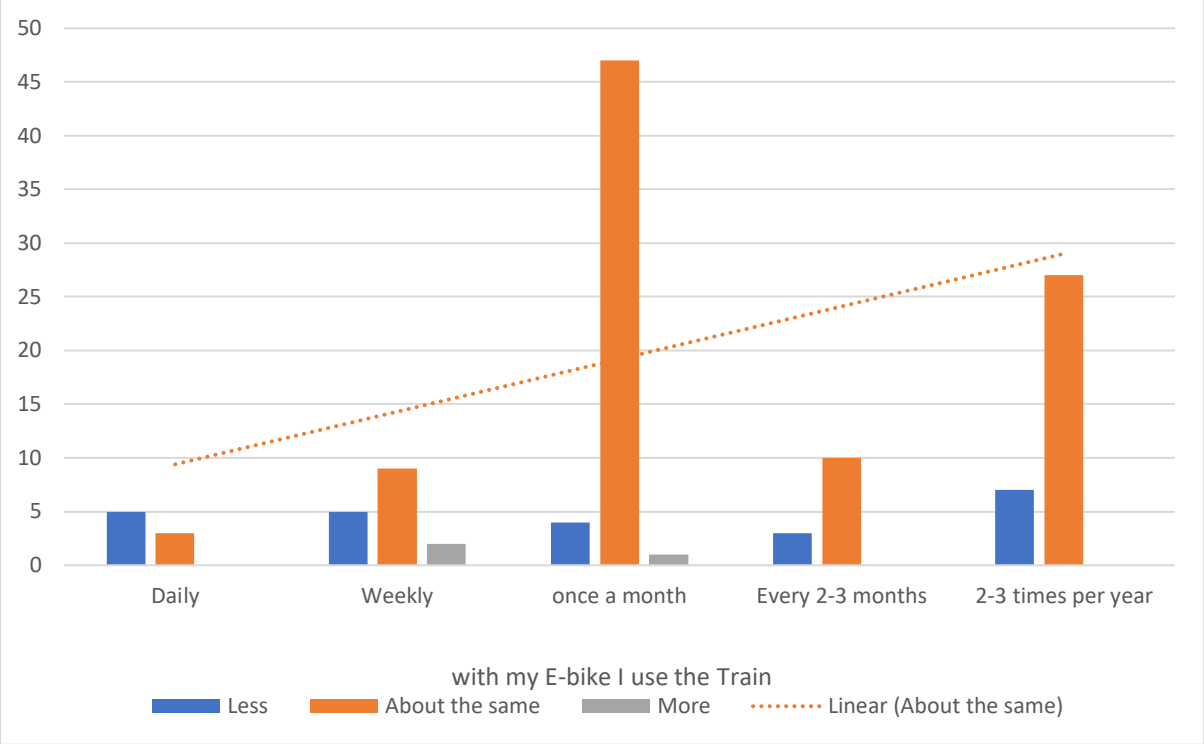


Figure 10 The usage of Train after the adoption of an E-bike according to their previous frequency of usage

Figure 10 indicates that most participants use the train monthly or from 2-3 times a year. Interestingly, in contrast to what was found for other modes of transportation, the majority 69.4% of participants reported no change in the frequency of train use after adopting the E-bike. Those who used the train weekly, monthly, or every two to three months reported no change in their use of the train. Conversely, 62% of previously daily train users reported decreased usage after switching to the E-bike. This suggests that daily train users use the E-bike to cover the distance they used to cover by train. An additional consideration is the fact that daily use of the train can be very expensive, so from a financial level the E-bike is a logical and economic substitute.

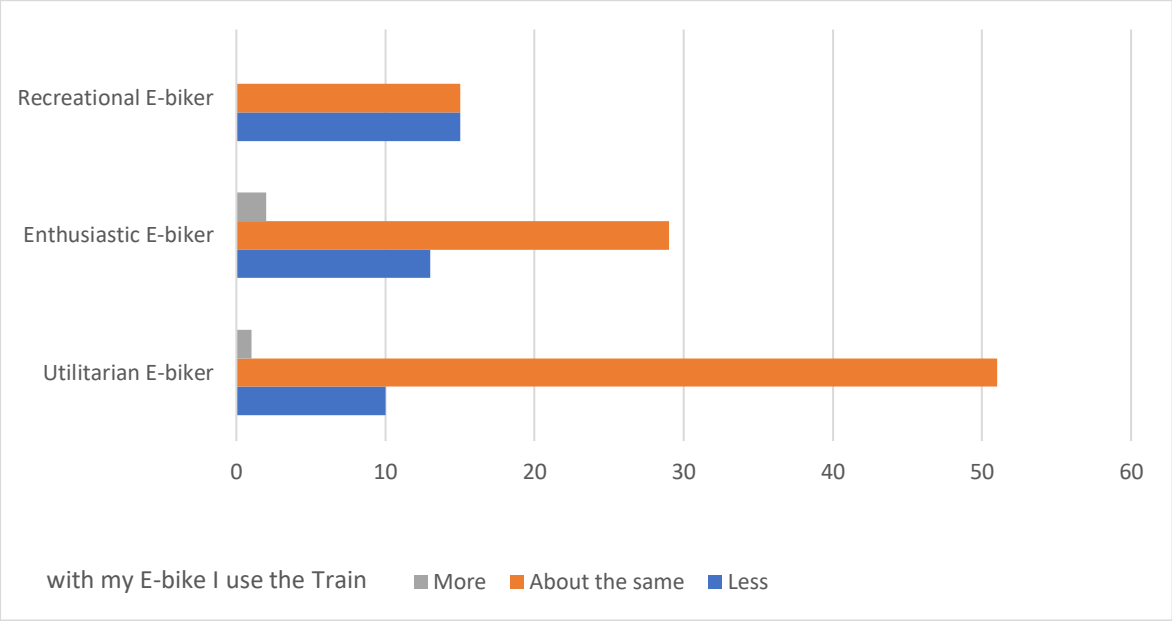


Figure 11 The usage of Train after the adoption of an E-bike according to attitudinal groups

In terms of attitudinal groups, most Enthusiastic and Utilitarian E-bikers showed no change in the usage of the train after buying an E-bike. Meanwhile, 50% of Recreational E-bikers report a decrease in train use after getting an E-bike. Recreational use of an E-bike can be a reason for people in this group to use a train less. For example, this group may have used the train to reach previous recreational activities. With an E-bike, these same individuals were able to engage in a different set of recreational activities that didn't require train use.
The ratio between answers of "about the same" and "less" for Utilitarian riders is worth mentioning. Since the majority of this group only use the train monthly, the need of Utilitarian for an E-bike (to use it as a different mode of transport for commute to work in example) does not have an impact on the purpose of using the train. In other words, the train is not used frequently enough for purposes relevant to the Utilitarian (like work) for it to be entirely substituted by the E-bike. The same explanation may apply to weekly users as well.

"I think it is encouraging however to see that even if in Bus, Tram and Metro and Train, there are people that use it less now. They're still like about half of your respondents that they still use it about the same."

"I speculate that E-bike wouldn't be something that would cannibalize the opportunities for more public transport in areas we call them death suburbs, especially since we're seeing growth in these more, where people will need those transport options because they can't afford to live in the city near where they work. (…) Although there is a culture here of riding in all weathers, I think they will still be people that will ride when it's nice for the longer distances but want that public transport option in case it's not. (..) so if we're thinking about people that are below the driving age, or above the driving age, or people that don't have the financial means to purchase any bike or purchase a car there, yeah, there will always be that need for public transport"

Melissa Bruntlett – Expert

While it is encouraging that people are relying on public transport less, decongesting the system and potentially promoting an eco-friendly transportation environment, Melissa Bruntlett's thoughts are worth considering. Even though many of the respondents in this study reported decreased use of public transport following the transition to an E-bike, there will always be a need for public transport for a variety of reasons. E-bikes are expensive and not everyone will be able to afford them, leaving some people to rely on public transport. E-bikes may face difficulties in certain circumstances, especially bad weather conditions – people in these cases may also feel the need to turn to public transport. In this way there will always be a need for public transport, so at best we can hope for an ecosystem where the two modalities operate in tandem.

4.2.4.8 The effect of E-bike on the usage of Conventional bike

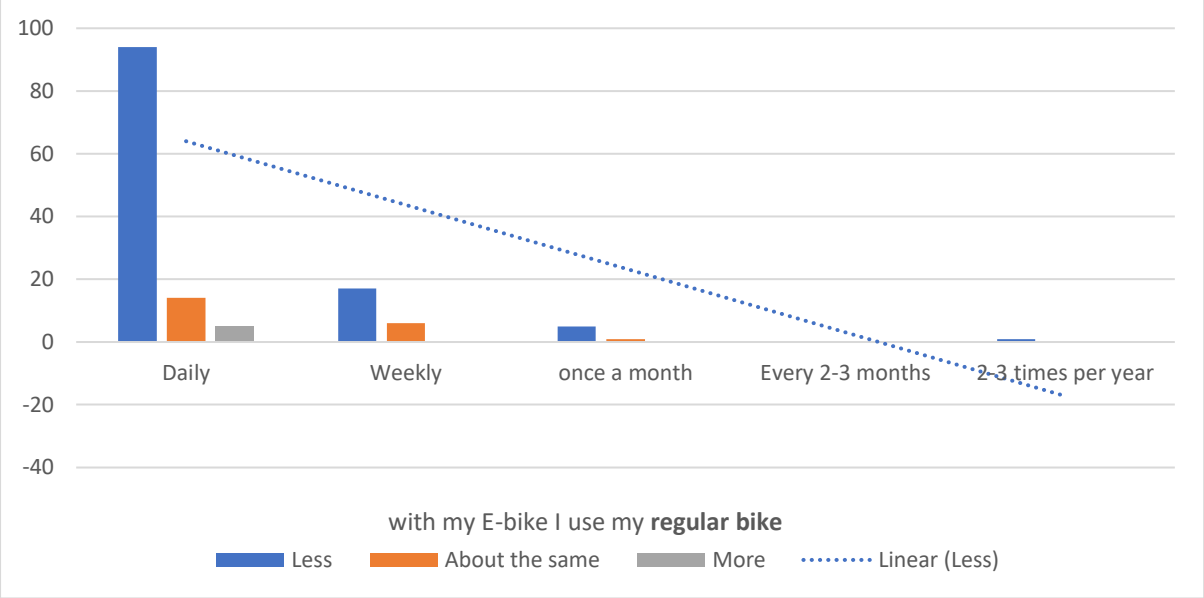


Figure 12 The usage of Conventional bike after the adoption of an E-bike according to their previous frequency of usage

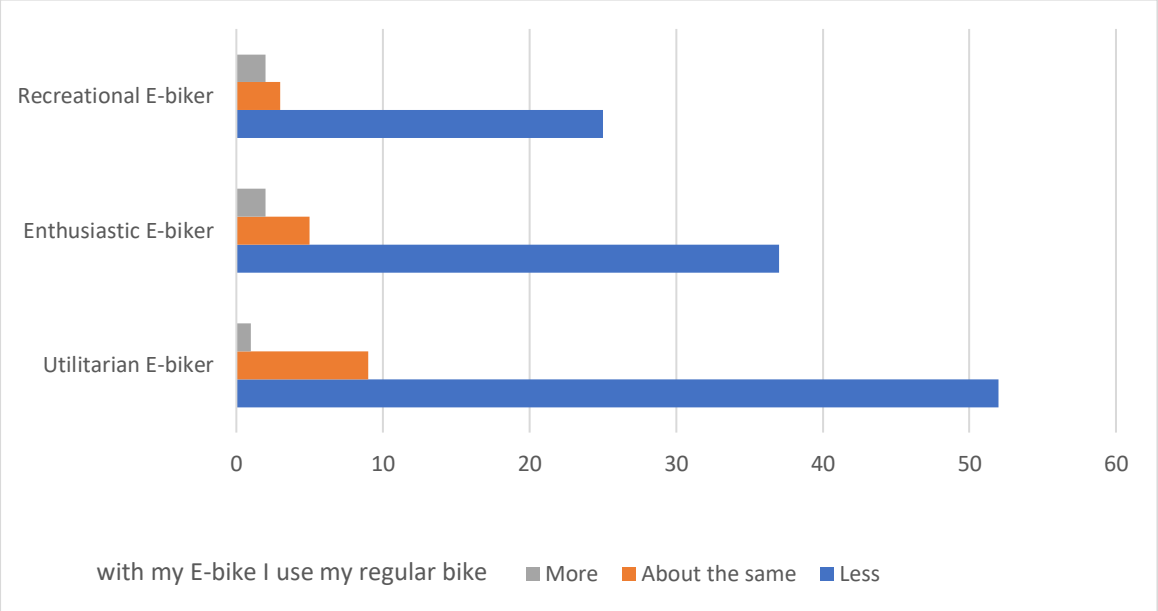


Figure 13 The usage of Conventional bike after the adoption of an E-bike according to attitudinal groups

78.6% of E-bike users report a decreased use of their conventional bike after their shift to an E-bike. Ten percent of respondents still rely on their own conventional bike aside from their new E-bike. Expert Lenoir for instance owns a Speed pedelec that he only uses for business trips to avoid getting sweaty while cycling for longer distances to other cities. Figure 12 shows that, for the most part, only frequent cyclists decided to invest in adopting an E-bike. These daily riders expressed a sharp decrease in their use of a conventional bike after they made the switch. This finding was consistent across all attitudinal groups, as can be seen in Figure 13.

The above results can be explained through the difference in distance that can be covered by E-bike as opposed to a conventional bike in Figure 14. E-bikes can provide extra features that conventional bike cannot. E-bike can thus be considered as an upgraded version of the conventional bike. For Enthusiastic E-bikers, owning an E-bike allows them to increase their frequency and keep pedaling on the road. As for Utilitarian E-bikers, the E-bike is considered as a new means for transport that especially caters to their practical needs and fills any gaps in the effectiveness of public transport. Recreational E-bikers on the other hand buy an E-bike because it allows them the joy of cycling for longer distances without the need to devote the physical effort required in conventional cycling, bearing in mind that cyclists who desire this physical effort tend to adopt sport bikes.

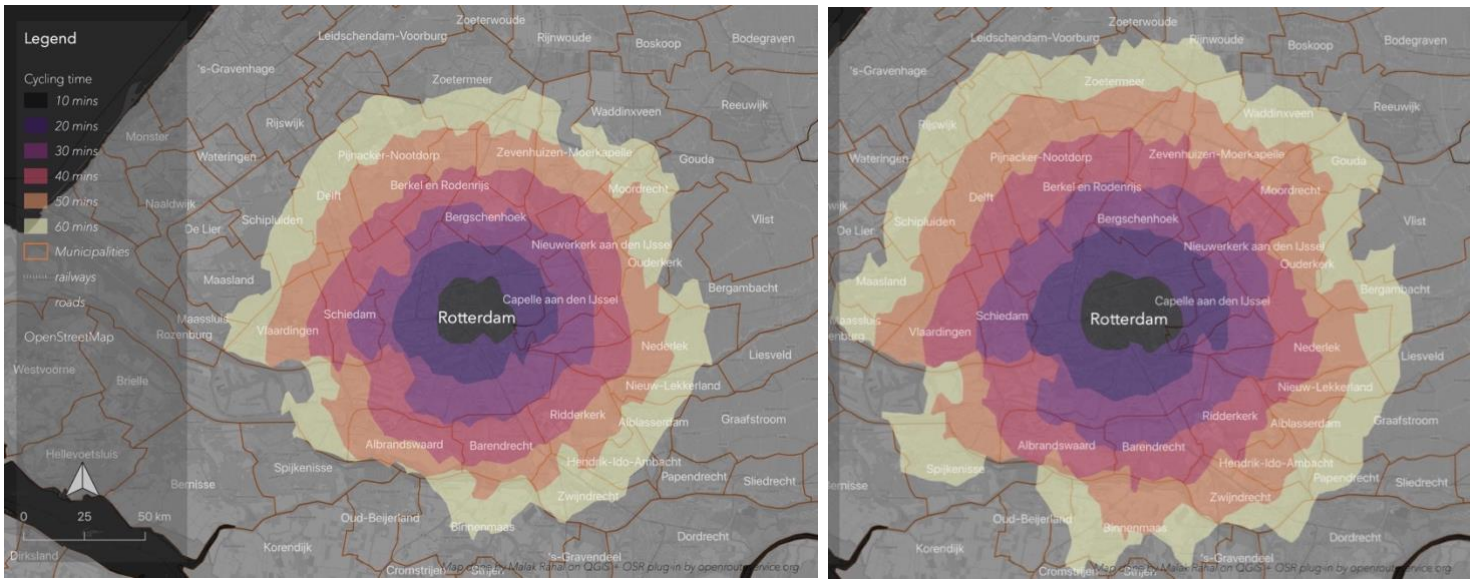


Figure 14 Area that could be covered by an E-bike (left) vs Conventional bike (right) – done by the author with QGIS

The map shown in Figure 14 is an example of the area that can be covered by an E-bike at a maximum of a one-hour ride from the biggest cities of the Netherlands. With the introduction of the E-bike, it is now possible to commute to neighboring cities without getting tired or sweaty.

According the figure 15 below, an E-bike can reach up to eight neighboring cities in under an hour. Having fast cycling lanes between cities could be an important factor that inclines users to stray away from public transport as E-bike can now connect big cities together without the need to adhere to rigidly defined transit schedules. With an E-bike one can easily travel between Rotterdam, Delft and the Hague, or from Tilburg to Breda; this explains the extensive investment in fast cycling lanes at intercity connections by the government.

"People are very aware of the potential that these E-bikes play. I think what needs to happen at this point is, at a planning level, at the city level, or even a national level, when we're thinking about intercity connections, I think that's more consideration will need to be placed in the years to come to make sure that we can keep facilitating more traditional bicycle use, but also allow people that want to make the switch to have those opportunities."

Melissa Bruntlett – Expert

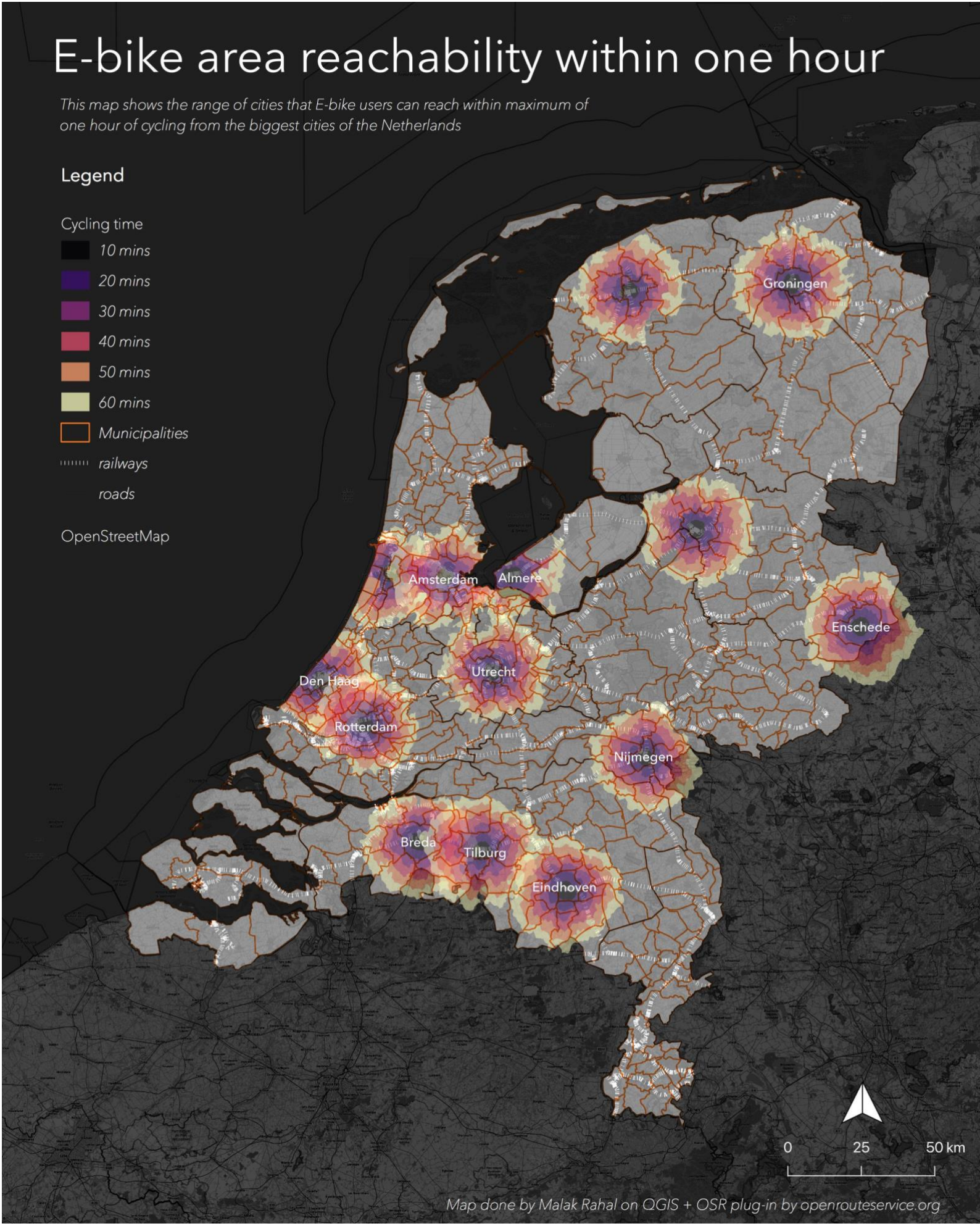


Figure 15 E-bike coverage after maximum one hour of travel. Done by author with QGIS

4.2.4.9 The effect of E-bike on Walking

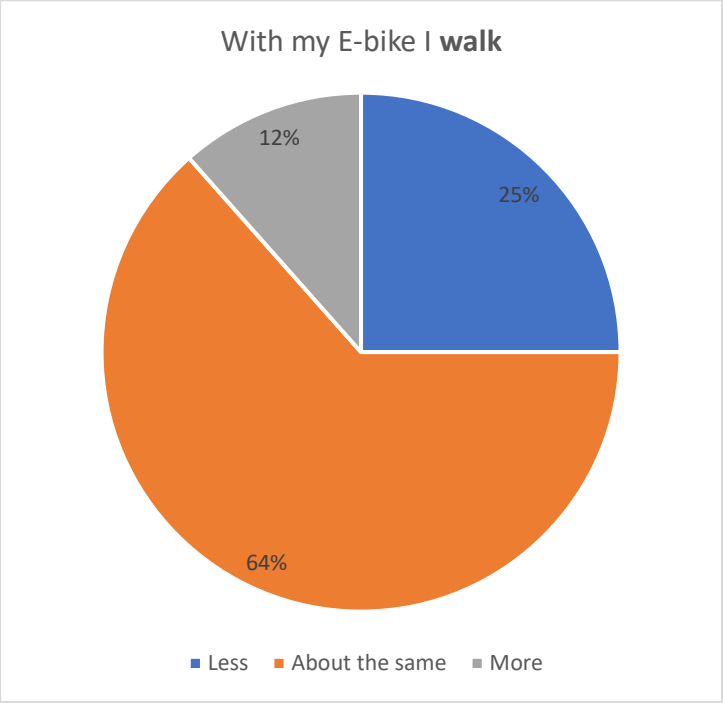


Figure 16 Effect of E-bike use on walking habits

Figure 16 shows the shift in walking habits in individuals after purchasing an E-bike. We would expect that people may walk less as E-bikes are convenient, saving both the time and effort of walking in commuting and multipurpose rides. However, my results show that most people were not affected by the switch to E-bike, with 64% of respondents saying that they walked about the same amount after buying the bike. Nonetheless, a quarter of participants did in fact report walking less after purchasing the bicycle, so there may be some weight to my hypothesis. One way to explain this phenomenon would be to look at the kinds of trips people walk. Arguably, when people go for walks, the trips are usually short and not too far. The hassle of getting the E-bike ready, finding a safe parking space, and the concerns that accompany the ride of the E-bike including concerns for the individual's safety and for theft of the bike, may simply make it not worth using the E-bike for such journeys. Expert Bruntlett echoes this though:

> *"It's interesting that the walking trips didn't change that much. Most people when they walk they're walking very short distances. So, a bike isn't going to make much sense."*
>
> ***Melissa Bruntlett – Expert***

4.3 Initial observation and reflection on E-bike

This section represents personal insights on E-bikes reached through observation of and interaction with the environment and cycling services. Secondary data was included to support my findings.

4.3.1 Access to E-bikes suppliers

The market of the E-bike in the Netherlands is large and competitive. Today, a wide range of brands and sellers are willing to give offers and financial leases for people planning to purchase their own bike. With the increase of E-bike users, owning a second-hand E-bike became as easy as owning a conventional one. One of the means of reaching E-bike users was through social media, looking for current users planning to sell. Some of the reasons that would push a user to change his/her old E-bike was to upgrade for a lighter one, or one with a longer battery life. Other users are selling their E-bikes after moving from suburbs to bigger cities, where they have less use for them. Renting an E-bike is becoming easy as well. Almost all shared bicycle platforms like Swapfiest, Donkey Republic, Blackbikes provide instant E-bike rental. Additionally, many E-bike companies provide monthly rental for customers and companies who need it for delivery purposes, such as Urbee, and Ebiketogo.

Due to the availability of a large market of suppliers and dealers in addition to having the possibility to store the E-bike safely, it was relatively easy to purchase an E-bike myself for the observational process.

4.3.2 Availability of adequate infrastructure

On top of the social influence of the cycling culture, one of the factors that encouraged cycling in the Netherlands was the availability of adequate and safe cycling lanes that made trips faster and more comfortable. The importance of safe cycling infrastructure became more apparent when cycling in areas where the infrastructure is not optimal. This lag and discrepancy in cycling infrastructures in different regions of the Rotterdam could be influenced by the proportion of cyclers in each region; the higher their number, the better the infrastructure. However, it is worth asking which should come first, the biker or the infrastructure?

From a personal experience, it is crucial to reduce traffic lights for cyclists by introducing safe roundabouts. One of the most enjoyable trips I had was on the way to Delft where the cycling lanes were optimal, the scenery next to the Schie river was enjoyable, and only three traffic lights stalled my journey.

Of the hundreds of millions of euros invested by the government to boost cycling in the Netherlands, 345 million euros are dedicated to ultrafast cycling routes and cycling highways between cities (Waterstaat, 2018). This emphasizes the importance placed on boosting cycling in the Netherlands. Safe cycling is equally important, and can be achieved by separating bike lanes from car traffic. Although it is not fully achieved yet in the Netherlands, safe cycling lanes are already available in a good amount. A network of bicycle lanes with no dead ends is essential to keep cyclists on the road. Providing sufficient and well-planned infrastructure to cyclists is therefore essential to give consumers the will to invest in a better and more expensive bike such as an E-bike.

4.3.3 Comfort

The rented E-bike has a similar sitting position to the previous conventional bicycle with a good pedal that ensures tight steering. Pedaling is needed to activate the pedal assistance of the E-bike. However, it has no suspension and therefore responds nicely and directly with a smooth transition. It is less comfortable on sub-optimal roads since with increasing speeds one would be bumped about on the seat, not unlike a yo-yo.

Trips that are longer than an hour can be made smoothly and easily, mostly due to the ability to pedal comfortably with a higher speed and less physical effort compared to the conventional one. The process of accelerating is really fast and smooth, to the point where you reach a higher speed without realizing how fast you are. Unfortunately, this also makes the process of stopping harder. The only feature of E-bikes that is more complicated than the traditional bicycle is the need to use both brakes to handle higher speeds very well, and sometimes a longer time is needed to slow down to a stop on an E-bike.

4.3.4 Performance

The range of an E-bike determines how many kilometers can be traveled a full battery, without having to recharge in between. The range of a bicycle depends on the bicycle itself (the motor and battery), but also on the circumstances in which you cycle (the weather, the road and the selected assistance mode). This imposes on the E-bike maintenance fees to keep it in good shape. Moreover, driving the E-bike when it runs out of battery is equivalent to performing a high intensity workout given its heavy weight.

An E-bike can go 5 to 10 km/h faster than a conventional bike (15 km/h average), this is not very impressive when compared to Speed Pedelec (> 35 km/h) and moped (50 km/h). However, the ability to maintain constant and higher travel speed given the E-bike's increased performance makes the real difference. As a fit person, I was able to bike at an average of 15 to 20 km/h on a conventional bike. However, after using the E-bike, I needed to adjust my pedaling pace to avoid reaching a speed that is not convenient within the city where there are more bicycles around and many traffic lights. One way to adjust the speed was to make the gears really high, so the pedaling became harder, and the speed is more controlled. Although cycling was convenient for me with this setting, the physical effort was a bit more than what you'd expect from an E-bike but still less than the conventional bike. During my experience, I realized that there is no room for cycling with a higher speed in city centers as there is a lot of obstacles such as traffic lights, waiting for pedestrians to cross streets or crowdedness within cycling lanes that keep you varying your speed with a maximum of around 20 km/h that you can safely maintain at any given time.

What is noticeable is that the distance you can cycle without feeling tired is significant enough to motivate you to cycle more even at a lower speed within the city. Additionally, having fast-cycling lanes makes your E-bike usage valuable as you can take advantage of the mode's benefits.

4.3.5 Cycling frequency for each purpose

Since I adopted an E-bike during the pandemic, I could not take advantage of the bike as much or experience its usage in ordinary settings. However, the enjoyment I received in my first

experience with a long-distance trip made me take advantage of the E-bike to have more when it was possible, which I did not use to have with the conventional bike. Distance is no longer a barrier, and avoiding the waste of time in waiting for the metro or tram became easier.

4.3.6 Weather conditions

Technically when the wind is against you, the engine has to work harder, which will run out the battery sooner. Cold also has much influence if it is colder than 10 ° C, then the capacity of your battery can decrease by up to 20% and even to 30% if the temperature is below 0° C (E-bike retailer, Stijn Grootjans).

Within the period of observation, I was lucky to experience harsh windy weather, and wind free sunny days. Surprisingly, I found E-bike a good means to keep people cycling on the road and not seek to use a car or public transport even in severe weather. An E-bike can make your trip smooth with less physical effort even when facing a harsh wind; you start to feel empowered as you brave the literal storm and pedal through whatever obstacles come your way. Also, there is no need to worry about sweating on sunny days when the temperature is high as you the E-bike ensures arrival at your destination faster, with less hassle.

4.3.7 The difference with a conventional bicycle in perceiving the city:

With an E-bike, you will almost always enjoy an effortless bike ride. Not only you spared the effort of pedaling hard, you also automatically go a lot faster. Riding an E-bike actually changed the way I perceived the city; in my experience, surprisingly cycling without thinking about your performance or the physical effort you're putting in, really allows you to join the scenery and the environment more so than you can with the conventional bike. Moreover, when I used to cross the Erasmus bridge with a conventional bike, I couldn't help but focusing entirely on the physical effort it took me to cross the bridge. This is in stark contrast to the first time I crossed the same bridge on an E-bike; this latter was a freeing experience where I could truly lose myself in the moment and my environment without being preoccupied with physical fatigue (or negative thoughts).

Chapter 5: Conclusion

The use of E-bikes is a newly emerging phenomenon that is growing increasingly popular by the day. This study investigated the effects of switching to an E-bike has on travel behavior and attitudes towards the usage of other modes of transportation including conventional bikes, buses, tram, metro, and train. The underlying motives were examined by exploring the reasons behind the shift from conventional bike to E-bike utilization and its effect on cycling patterns and travel behavior. We also looked at the extent to which attitudinal groups had an influence on mobility behavior change.

5.1 Characteristics of E-bike users:

The survey shows how demographically diverse the users of E-bikes in the Netherlands are. The majority of these survey respondents are aged between 25-34 years and 45-67 years. Those of a Utilitarian attitude encompass the vast majority of E-bike users; Utilitarian users are mostly aged 18 to 67 years, i.e. of a reproductive age. On the other hand, users of older ages belong to the Recreational and Enthusiastic groups. A reduction in their physical abilities that comes with their older age makes E-bicycles an attractive alternative for cycling. Contrary to the findings of Kroesen (2017), who found that women were more likely to use electric bicycle than men, our study population showed the opposite, with 53.7% of our participants being males and 44% females. The echoes Loijen's (2011) data that showed that the majority of electric bicycle users in the Netherlands were native Dutch, with 74.3% of the participants in our study sharing that characteristic. In addition, the majority of E-bike adopters were cyclists for more than 5 years. They can be considered experienced given the frequency of their cycling most of them cycle between 4-5 and 6-7 days per week. Moreover, since 50.6% of E-bike users ride over elevated areas in their commute, many of them turned to E-bikes as a way of reducing the physical effort needed to cross elevated areas. Furthermore, the most commonly used E-bike was the electric city bike as it was the most accessible. Another important finding was that the majority of E-bike users have safe parking spaces, thereby reducing the risk of theft and reducing the need for insurance. To note, this contradicts a finding in an earlier study that showed that most E-bike users actually do purchase insurance (Loijen, 2011).

5.2 Response to study questions

Q.1:

What are the reasons behind the shift from conventional bikes to E-bikes in the Netherlands?

The reasons behind owning an E-bike differ from a person to another. Some of the reasons serve practicality where users are looking for faster and more efficient alternatives, while others are related to each individual’s preference and their perception of cycling; be it an essential or a complementary element as a mean of transportation. To answer the questions posited by this

thesis, E-bikers were segmented into three categories according to their attitudes: Utilitarian, Enthusiastic, and Recreational E-bikers. Utilitarian E-bikers could be mothers who want to carry their children more comfortably and with less effort. Utilitarian E-bikers could also be individuals who want to commute to work or to another city while preserving their autonomy and saving money and time. Enthusiastic E-bikers are those who love cycling regardless of the "how" or "why". Enthusiastic E-bikers who are no longer able to cycle due to health issues, would resort to E-bikes as an alternative. Enthusiastic E-bikers include individuals who enjoy cycling to work but prefer not to sweat on their way there. Although Recreational E-bikers do not cycle as much as the aforementioned categories of bikers, they enjoy the sense of community, and hence, enjoy biking with their families and friends for recreational purposes. Most recreational E-bikers own cars for their daily commuting.

During their early rise, E-bikes were the resort of the elderly who were no longer able to cycle. However, the demographics have shifted recently where we notice a higher adoption of E-bikes by the younger generation, especially among those seeking practicality and comfort.

The complexity of our daily life forces miscellaneous reasons to underlie the decision of switching from regular bikes to E-bikes. With regards to the subjective reasons for adopting an E-bike, all respondents agreed that they perceive the E-bike as better than the conventional bike. That is due to the ability to cycle for longer distances without getting sweaty or tired, and to cycle at significantly faster speeds owed to the pedal assistance, with harsh wind that no longer being an obstacle for cycling. Other reasons for the transition include their interest in innovation and the positive feedback they received from trustworthy people which pushed them to make the decision. In addition, the Netherlands' rich cycling culture and the government's extensive efforts to provide adequate cycling infrastructure and services provided a platform for cyclists that ensured a safe cycling environment, spaces for parking everywhere, and to an extent a safe personal parking for everyone, which contributed to encouraging cyclists to adopt the relatively new E-bike. From a financial perspective, the competition in the E-bike market in the Netherlands and the wide range of available models result in E-bikes being cheaper and more affordable than ever. All participants presented a positive attitude towards E-bike's environmental friendliness compared to cars. According to them, it is essential to avoid using cars for environmental reasons, especially that both cars and bicycles share the same feature of autonomy in commuting. Hence, E-bikes reduce their environmental guilt.

These factors were common among all E-bike users, yet many other major objective reasons behind this shift were personalized according to their attitude towards cycling and commuting. Utilitarian cyclists use E-bikes for practical reasons; they seek to make their journey easier and less time-consuming. They use their E-bikes for commute, work, and to carry either heavy goods or children. This is another reason why they consider E-bikes as new means of transportation compared to regular bikes which are not as convenient for long distances. Enthusiastic cyclists use E-bikes as a way to increase their cycling frequency which would help them maintain a certain level of physical activity. They also use them to connect with public transportation as necessary and to commute with multipurpose rides. Recreational cyclists use E-bikes to cycle for longer distances for recreational purposes; their aim would be to reduce their car usage and maintain a certain level of physical activity. It is noteworthy to mention here that recreational cyclists are the only group whose users cycle for less than three days per week.

Q.2:

To what extent does the travel behavior change affect the cycling patterns and attitudes of users towards cycling?

Although the reasons for adopting an E-bike are diverse, the consequences remain the same. The majority of E-bike users had similar changes in their travel behaviors. These users are now able to cycle faster and to travel for longer distances more efficiently. E-bikes are also adopted for recreational purposes, although they were previously thought to be exclusively adopted for their utility. Despite being more expensive than traditional bicycles, users found that E-bikes are worth the payment for the added comfort and autonomy.

All participants noticed an increase in speed, cycling distance, and the development of new cycling purposes. 79% and 76% of the participants reported cycling to new locations and using new routes, respectively. This was observed as a change in their cycling patterns following their transition to using E-bikes. The majority of participants took advantage of traveling with an E-bike by increasing their frequency of cycling to a multitude of locations, especially in commuting to work or educational facilities, to shop, to visit friends and family, and for recreational trips. However, an absence of the sense of community was expressed by E-bikers as conventional bikes still dominate the cycling mode of transportation.

The attitude towards the safety of E-bike cycling is a bit controversial, although on average participants rated safety highly (8 out of 10). Many respondents mentioned their concerns with regard to the E-bike's speed even though studies show that the risk of injury with an E-bike is the same as regular ones. 82% of participants are fine with the current cycling infrastructure that reinforces the emergence of E-bikes by creating a convenient and safe to cycle pathing in the Netherlands. This shows that although the intentions/reasons behind using E-bikes are different amongst users and attitudinal groups, the effect of E-bike use on the travel behavior change is homogenous across all groups.

Q.3:

To what extent does the access to E-bikes affect the use of other modes of transportation?

Alas, these aforementioned advantages are coming at the cost of decreased use of public transportation. This is because the E-bike is offering its users the ability to reach places more efficiently than a bus or a tram or a metro could offer, especially considering that E-bikes waste no time with queues and waiting. For instance, Enthusiastic E-bikers are no longer using public transportation like they used to before the emergence of E-bikes. This is not surprising as cycling has always been their preference, and an electrical bike would only be considered an upgrade to their routine.

Other aspects that contributed to the emergence of E-bikes are city-dependent. An E-bike would be an attractive alternative to the bus in those cities where a tram or a metro are not available. On the other hand, it was shown that the train was the most immune to this transition to E-bikes. This is because trains offer speed and an ability to commute for long distances which are features that E-bikes can't compete against yet given their limited battery life. It can thus be safely assumed that E-bikes are more of a replacement to the bus, tram, and metro

rather than being complementary. Many respondents consider their E-bikes to be their new mean of transportation. However, we must bear in mind that this does not apply to the train which still stands as an independent modality that is difficult to replace, except maybe by car.
When assessing the usage of the E-bike in combination with other modes of transportation, only a minority of the sample affirmed that they do so, with the majority (31.2%) stating that the train is their additional method of transportation, followed by the metro (12.1%). Surprisingly, 45% and 40% of E-bike users of the survey do not have access to the metro and tram in their residence area, respectively. 38% of users do not have access to both, which means that E-bikes were adopted by these users to fill their transit sector's gap. We can here note that the adoption of an E-bike is seen as a replacement of the unavailable transit mode and considered a different mode of transportation than the regular bike. Our data shows a decrease in the number of participants who utilize other means of transportation after obtaining an E-bike. In general, the effects observed among the attitudinal groups were slightly noticeable; however, tracking their previous frequencies for each mode of transportation was beneficial in assessing who is substituting the transit modes with the E-bike and who is not.
With regard to the effect on bus use, E-bikes can substitute the bus because it offers the users a convenience of autonomy; they do not have to wait for a crowded bus, to adhere to a specific schedule to commute, and to have frequent stops which can be time-consuming. That is why 68% of participants who previously used the bus report a decrease in its usage after getting an E-bike, the rest reported no change. Frequent users who previously relied on the bus to commute decreased their frequency with the adoption of the E-bike, with Enthusiastic E-bikers topping the list in the degree of change of their travel behavior.
With regard to the effect on the tram, the tram has similar characteristics to the bus which explains why it can easily be substituted by an E-bike as well. 61% of tram users report a decrease of use after getting an E-bike, the rest report no change. Also, only weekly and daily users were the ones to changed their travel behavior and stop relying on the tram.
With regard to the effect on the metro, since the network of the metro connects larger areas, reaches other cities, and is somehow faster than both the tram and bus, the metro is still considered a competitor of E-bikes. 57.3% of metro users report a decrease in usage after obtaining an E-bike. Only weekly users were the ones to changed their travel behavior and stop relying on the metro.
With respect to their effect on the train, E-bikes cannot compete with the distance that can be covered by trains. This explains why 70% of participants reported no change in the frequency of train use after the adoption of the E-bike. However, the few users who used the train daily were the ones to report a decrease in train use; that is because taking the train daily can be expensive which is why it is economical to choose the E-bike as a substitution. We can conclude that the previous frequent users of transit modes were the only ones who changed their travel behavior and started reducing their frequency using these modes after adopting an E-bike and appreciating its efficiency.
With regard to the effect on conventional bikes, what can be done on a regular bicycle is the same as that can be done on an E-bike. E-bikes share the same shape, size, and act of riding as regular bikes except for the innovative feature of the electrical push in the back. E-bikes can therefore be a better version of a bicycle to cycle for longer distances in a faster speed without getting sweaty or tired. It is expected to observe that people who adopt an E-bike would stop

or reduce their use of the conventional one. Even though many users within the survey intended to replace their regular bike with an E-bike, many others were just looking for another mode of transportation that can meet their needs. However, the latter subconsciously end up replacing their regular bike as well. 79% of E-bike users report a decrease in the usage of their conventional bike after the shift.
Currently, E-bikes are not limited for elders to use and the stigma of not being able to ride a mechanical one without assistance still persists. In accordance to Mossel, (2018) many E-bike users, especially those belonging to the young generation, try to find excuses in order to avoid being perceived as lazy for not using a conventional bike. Examples of these excuses include: "Oh, I have kids and I want to take them with me anywhere easily" or "I am commuting for long distances every day, if I have to keep using the bike, then I must have a bicycle that I can ride with less effort" among others.

Overall question:
To what extent do the factors behind the shift from conventional bikes to E-bikes influence the travel behavior change towards the usage of other modes of transportation in the Netherlands?

When looking at the motives for electric cycling, convenience remains the most important factor. Since longer journeys can be undertaken with much less effort on the electrical bicycles, the user's own effectiveness increases. We also looked at the extent to which attitudinal groups influence mobility behavior change. If we look at the effect of the electric bicycle on travel behavior change, it appears that, similar to Fyhri and Fearnley (2015), Jones et al. (2016) and Fishman and Cherry (2016), users cycle more often and longer on an electric bicycle than normal bicycles. In contrast to Cairns et al. (2017), it appears that the electric bicycle does not primarily replace journeys by car, but rather particular journeys that were previously made on the normal bicycle. In fact, the replacement of car journeys appears to be very limited in this study even though both Enthusiastic and Utilitarian respondents expressed their environmental concerns towards the car. Most of these studies showed that the use of conventional bikes depends on both subjective and objective factors. Subjective factors are those that are closely associated with behavioral sciences, and objectives factors are shaped by the characteristics of the infrastructure, traffic and spatial planning (Engelmoer, 2012). A psychology paper published by Anable and Gatersleben in 2005 showed that when making a choice to commute to work, individuals tend to focus on objective rather than subjective factors. Convenience and ease were found to be the key determinants for what mode of transport was used in getting to work among the study subjects. Conversely, the mode of transport for leisure purposes was intrinsically tied to the individual's emotional and affective states, as in this scenario, relaxation, the sense of freedom, and being "stress-free" takes precedence over the drive for efficiency and timeliness experienced in the work-scenario (Anable and Gatersleben, 2005). In addition, the study conducted by Kroesen (2017) shows that E-bikes not only have a significant effect on regular bicycles, cars and public transportation, but also on the total travel distance, increasing it considerably. Here, my study has presented similar results, but looked more in-depth at the factors behind that.

5.3 Study limitations:

This study entails multiple limitations mainly due to circumstances faced while conducting our research and the quantitative nature of the research. Given the COVID-19 pandemic, gathering all the needed responses was challenging. Moreover, it was confusing to the survey respondents that their travel behavior change is assessed before the pandemic, as many mentioned that COVID-19 had an impact on their commuting frequency.
Many secondary elements were needed to understand this phenomenon from the user's perspective. However, the need to design a survey that can be answered within 10 minutes was challenging, especially for gathering all the information that are needed for a better assessment. During the analysis, many findings could not be explained empirically which is why focus groups were needed to understand the underlying reasons. In addition, finding E-bike users was time consuming. It would have been more convenient to focus on a smaller region, in order to have a better assessment of the level of public transportation and infrastructure of that region. However, the slow response rate to the survey limited the ability to have a proper representation of the targeted sample which obliged me to expand my research scope. Additionally, many improper representations were faced within the sample that limited the level of analysis that can be done. For example, the majority of the E-bike users used only one out of the seven types of E-bike, therefore, I was not able to check whether the type of E-bikes adopted has an impact on the travel behavior and the usage of transit mode or not.

5.4 Further research and recommendations:

E-bikes are a hot topic today, publications and market studies are released on a daily basis.
Unique to this study is that it specifically investigated the effect of the E-bike has on each type of modes. As per previous publications, public transport was perceived as one entity. Moreover, the study attempted to address the gap in the literature about why people purchase or use E-bikes (Hendriksen et al., 2008; Loijen, 2011; Lee et al., 2014; de Haaz, 2019). We hope that we were able to provide some answers through this study.
This research embodies a broad overview of the phenomenon, and rises further questions about E-bike usage in the Netherlands. A recommended direction for studies would be to focus on smaller areas where the level of urbanization and the available transport alternatives can be defined in more depth or on specific group of users. Additionally, the disproportionate representation of E-bike type within the study could be a more specific element to investigate as it definitely has differential impact on the environment.
Furthermore, I believe studying the change in travel behavior by surveying users cannot be accurate instead, the research should be studied through GPS tracking and travel diaries before and after the adoption of an E-bikes, introducing another potential area of research.
One thing to keep an eye on when it comes to E-bikes is the accompanying environmental and safety challenges they pose. Even though many were excited about the emergence of E-bikes,

not everyone would advertise them given those yet-to-be-addressed challenges (even experts who I had the chance to question).
Many respondents mentioned that they don't see themselves as a threat for regular cyclists on cycling lanes. Rather, they consider the presence of Moped vehicles a more pressing threat, considering their speed. Hence, further studies are warranted to assess those challenges and address them.
It is no doubt we are reaching a point where E-bikes will become a crucial part of our daily lives. The process is similar to the evolution of many devices that entered the world and imposed new norms and values such as mobile phones for example. In the process of evolution, investors are bidding on the development of solar, self-charging batteries, and solar wheels that would promote greener environments and establish themselves as the "Darwinian fittest".
There is a pressing need for cities to acknowledge and recognize this new trend and be prepared by establishing better cycling infrastructures that can accommodate the increasing numbers and speeds of cyclers. There is need to provide a smother experience for cyclists. Reducing traffic lights and introducing more roundabouts with priority for pedestrian and cyclists will have a huge impact in boosting cycling of all types and not only E-bikes. While some are worried about the future of public transport facing this new emergence, it is important to note that because the development of that sector is gradual - especially in the less-developed areas - it is less likely that profitability and functionality of other sectors would be affected.

On a personal level, I have always admired the rich cycling culture of the Netherlands. When first facing the emergence of E-bikes, I was somehow reluctant to accept this new transition. However, as I started working on my thesis, I decided to switch myself to an E-bike to better understand this phenomenon. I find it hard now to switch back to a regular bike as I got used to the new pace, and the innovation of the E-bike. Imagine if everyone gave it a try and felt the same!

Bibliography

An, K., Chen, X., Xin, F., Lin, B. et al., 2013. Travel characteristics of e-bike users: Survey and analysis in Shanghai. *Procedia-Social and Behavioral Sciences*, 96pp.1828-1838.

Anable, J. and Gatersleben, B., 2005. All work and no play? The role of instrumental and affective factors in work and leisure journeys by different travel modes. *Transportation Research Part A: Policy and Practice*, 39(2-3), pp.163-181.

Beirão, G. and Cabral, J.S., 2007. Understanding attitudes towards public transport and private car: A qualitative study. *Transport Policy*, 14(6), pp.478-489.

Biehl, A., Ermagun, A. and Stathopoulos, A., 2018. Modelling determinants of walking and cycling adoption: A stage-of-change perspective. *Transportation Research Part F: Traffic Psychology and Behaviour*, 58pp.452-470.

Cairns, S., Behrendt, F., Raffo, D., Beaumont, C. et al., 2017. Electrically-assisted bikes: Potential impacts on travel behaviour. *Transportation Research Part A*, 103pp.327-342. 10.1016/j.tra.2017.03.007 Available at: http://dx.doi.org/10.1016/j.tra.2017.03.007 .

Cherry, C.R., Yang, H., Jones, L.R. and He, M., 2016. Dynamics of electric bike ownership and use in Kunming, China. *Transport Policy*, 45pp.127-135.

De Haas, M.C., Hoogendoorn, R.G., Scheepers, C.E. and Hoogendoorn-Lanser, S., 2018. Travel mode choice modeling from cross-sectional survey and panel data: the inclusion of initial nonresponse. *Transportation Research Procedia*, 32pp.268-278.

de Haas, M. 2019. Het gebruik van de e-fiets en de effecten op andere vervoerwijzen - The e-bike: user groups and effects on travel behaviour. The Hague, The netherlands: Ministry of Infrastructure and Water Management. Available at: https://www.kimnet.nl/actueel/nieuws/2019/12/02/gebruik-e-fiets-in-nederland-flink-toegenomen .

Dill, J. and McNeil, N., 2013. Four types of cyclists? Examination of typology for better understanding of bicycling behavior and potential. *Transportation Research Record*, 2387(1), pp.129-138.

Dozza, M., Werneke, J., Mackenzie, M. (2013). E-bikeSAFE: A naturalistic cycling study to understand how electrical bicycles change cycling behavior and influence safety.

Engbers, L.H. and Hendriksen, I.J., 2010. Characteristics of a population of commuter cyclists in the Netherlands: perceived barriers and facilitators in the personal, social and physical environment. *International Journal of Behavioral Nutrition and Physical Activity*, 7(1), pp.89.

Engelmoer, W. 2012. The E-bike: opportunities for commuter traffic. The potentials of using electric bicycles and –scooters in commuting traffic in relation to energy use, local emissions and the accessibility of a compact Dutch city. Available

at: https://www.openaire.eu/search/publication?articleId=narcis_____::6f9d6cc3aef77c720e6dc29bade4f794 .

Ettema, D., Friman, M., Gärling, T. and Olsson, L.E., 2016. Travel Mode Use, Travel Mode Shift and Subjective Well-Being. Available at: http://urn.kb.se/resolve?urn=urn:nbn:se:kau:diva-41897 .

European Union. 2019. EU transport in figures. 2019Available at: https://data.europa.eu/doi/10.2832/729667 .

FISHMAN, E., Wolt, K.K. and Schepers, P., 2018. The safety of e-bikes in the Netherlands.

Fishman, E. and Cherry, C., 2016. E-bikes in the Mainstream: Reviewing a Decade of Research. *Transport Reviews,* 36(1), pp.72-91. 10.1080/01441647.2015.1069907 Available at: http://www.tandfonline.com/doi/abs/10.1080/01441647.2015.1069907 .

Fyhri, A. and Fearnley, N., 2015. Effects of e-bikes on bicycle use and mode share. *Transportation Research Part D,* 36pp.45-52. 10.1016/j.trd.2015.02.005 Available at: http://dx.doi.org/10.1016/j.trd.2015.02.005 .

Fyhri, A., Heinen, E., Fearnley, N. and Sundfør, H.B., 2017. A push to cycling—exploring the e-bike's role in overcoming barriers to bicycle use with a survey and an intervention study. *International Journal of Sustainable Transportation,* 11(9), pp.681-695.

Fyhri, A. and Sundfør, H.B., 2020. Do people who buy e-bikes cycle more? *Transportation Research Part D: Transport and Environment,* 86pp.102422.

Gehl, J. 2013. Cities for people. Island press.

Gehl, J. 2011. Life between buildings: using public space. Island press.

Gijsbert Termaat. 2020. E-bike net zo (on)gevaarlijk als fiets. *Https://Www.Telegraaf.Nl,* Available at: https://www.telegraaf.nl/nieuws/1123339665/e-bike-net-zo-on-gevaarlijk-als-fiets .

Harms, L. and Kansen, M., 2018a. Cycling Facts. *Netherlands Institute for Transport Policy Analysis (KiM).Den Haag: Ministry of Infrastructure and Water Management,* .

Harms, L. and Kansen, M., 2018b. Fietsfeiten. The Hague: Ministry of Infrastructure and Water Management.

Haustein, S. and Møller, M., 2016. Age and attitude: Changes in cycling patterns of different e-bike user segments. *International Journal of Sustainable Transportation,* 10(9), pp.836-846.

Heinen, E., Wee, B. van & Maat, K. 2010. Commuting by Bicycle: An Overview of the Literature. Transport Reviews 30-1: pp. 59-96.Jan-Willem van Schaik. 2019. E-Bike Now Biggest Category in the Netherlands.

Hendriksen, I., Engbers, L., Schrijver, J., van Gijlswijk, R. et al., 2008. Elektrisch fietsen. *Marktonderzoek En Verkenning Toekomstmogelijkheden [E-Bikes.Market Research and Explorationof Future Possibilities].TNO Kwaliteit Van Leven, Leiden, .*

Jones, T., Harms, L. and Heinen, E., 2016. Motives, perceptions and experiences of electric bicycle owners and implications for health, wellbeing and mobility. *Journal of Transport Geography*, 53pp.41-49. 10.1016/j.jtrangeo.2016.04.006 Available at: http://dx.doi.org/10.1016/j.jtrangeo.2016.04.006 .

KIM. 2019. Mobiliteitsbeeld 2019. The hague: Ministry of Infrastructure and Water Management.

Kroesen, M. 2017. To what extent do e-bikes substitute travel by other modes? Evidence from the Netherlands. *Transportation Research Part D,* 53pp.377-387. 10.1016/j.trd.2017.04.036 Available at: http://dx.doi.org/10.1016/j.trd.2017.04.036 .

Leeuwarder Courant, 2020. Nederlanders fietsen meest wereldwijd, steeds meer gebruik e-bike. Leeuwarder Courant. Available at: https://www.lc.nl/binnenland/Nederlanders-fietsen-meest-wereldwijd-steeds-meer-gebruik-e-bike-26101682.html?harvest_referrer=https%3A%2F%2Fwww.google.com%2F [Accessed November 11, 2020].

Ling, Z., Cherry, C.R., MacArthur, J.H. and Weinert, J.X., 2017. Differences of cycling experiences and perceptions between e-bike and bicycle users in the United States. Sustainability, 9(9), pp.1662.

Loijen, J. 2011. Elektrische fiets in Haaglanden. Onderzoek naar hat gebruik van de elektrische in Haaglanden.

Mason, J., Fulton, L. and McDonald, Z., 2015. A global high shift cycling scenario. *Retrieved From, .*

Mathijs de Haas. 2019. De e-fiets: gebruikersgroepen en effecten op het reisgedrag. The Hague, The netherlands: Ministry of Infrastructure and Water Management.

Mathijs de Haas. Het gebruik van de e-fiets en de effecten op andere vervoerwijzen.

Mossel, J.R. 2018. Elektrisch fietsen in het landelijk gebied. Available at: https://frw.studenttheses.ub.rug.nl/id/eprint/1657 .

Oakil, A.T.M., Ettema, D., Arentze, T. and Timmermans, H., 2016. Bicycle commuting in the Netherlands: An analysis of modal shift and its dependence on life cycle and mobility events. *International Journal of Sustainable Transportation,* 10(4), pp.376-384. 10.1080/15568318.2014.905665 Available at: http://www.tandfonline.com/doi/abs/10.1080/15568318.2014.905665 .

Plazier, P.A. 2018. Power to the pedals. *Perspectives on the Potential of E-Bike Mobility for Sustainable and Active Transport Systems [Thesis].Groningen, University of Groningen,* .

Popovich, N., Gordon, E., Shao, Z., Xing, Y. et al., 2014. Experiences of electric bicycle users in the Sacramento, California area. Travel Behaviour and Society, 1(2), pp.37-44.

Pucher, J., Buehler, R. 2008. Making cycling irresistible: Lessons from the Netherlands, Denmark and Germany . Transport Reviews , 28 (4), 495–528.

Reid, C. 2019. E-Bike Domination Will Not Last Say Fans Of The Mechanical Bicycle, A Transportation Cockroach. Available at: https://www.forbes.com/sites/carltonreid/2019/04/03/e-bike-domination-will-not-last-say-fans-of-the-mechanical-bicycle-a-transportation-cockroach-2/ [Accessed Mar 30,].

RTL Nieuws, 2020. 'Meer Nederlanders op e-bike naar het werk door corona'. RTL Nieuws. Available at: https://www.rtlnieuws.nl/tech/artikel/5161346/e-bike-woon-werk-verkeer-elektrische-fiets [Accessed November 11, 2020].

Schaap, R.L. 2015. No title. *Experience of Cycling,* .

Schepers, P., Klein Wolt, K. and Fishman, E., 2018. The Safety of E-Bikes in The Netherlands. Paris: OECD Publishing.

Steg, E.M. and Kalfs, N., 2000. Altijd weer die auto! .

Sun, Q., Feng, T., Kemperman, A. and Spahn, A., 2020. Modal shift implications of e-bike use in the Netherlands: Moving towards sustainability? *Transportation Research Part D*, 78pp.102202. 10.1016/j.trd.2019.102202 Available at: http://dx.doi.org/10.1016/j.trd.2019.102202 .

Termaat, G., 2020. E-bike net zo (on)gevaarlijk als fiets. Telegraaf. Available at: https://www.telegraaf.nl/nieuws/1123339665/e-bike-net-zo-on-gevaarlijk-als-fiets [Accessed November 13, 2020].

van Oijen, J., Lankhuijzen, R. and van Boggelen, O., Goed zicht op de elektrische fiets.

Van Thiel, S. 2014. Research methods in public administration and public management: An introduction. Routledge.

Wei, Li Zhibin1 Yang Chen1 Wang and Guojun, J., 2012. Bicycle commuting market segmentation analysis using attitudinal factors [J]. *Journal of Southeast University (Natural Science Edition),* 4.

Winslott Hiselius, L. and Svensson, Å, 2014. Could the increased use of e-bikes (pedelecs) in Sweden contribute to a more sustainable transport system? Available at: https://lup.lub.lu.se/record/5305011 .

Index

Annex 1: Survey Flow

Start of Block: Introduction

Q1.1 Wijzig voor de Nederlandse taal de instelling hierboven aan de rechterkant.

Q1.2 Are you an **E-bike user**?

- yes (1)
- no (2)

Q1.3 Hi, this is Malak Rahal, a Master's student at the Erasmus University of Rotterdam, studying Urban management and development with a specialization in managing infrastructure for green cities.

In a country where 84% of the population own a bicycle, the electric bicycle (E-bike) has been recorded as the most sold bicycle type in the Netherlands for the second year in a row. Following those statistics, I have decided to conduct a research to further understand and examine this phenomenon.

What is happening here exactly? Is this new phenomenon good for the city? Is it environmentally friendly? Do we need to upgrade our cycling infrastructure to fit this growing trend? Are we replacing cars, standard bicycles, or public transportation? Are E-bikes a new mean of transportation?

Please help me answer these questions by completing my survey and sharing it with other E-bike users of the Netherlands. This survey requires a maximum of 12 minutes.
Filling my survey will also give you the chance to win a 50 euro gift voucher at bol.com !

Start of Block: Section One: Background information
Q2.1 I am aware that the following questions are personal. However, these questions are important to me to understand by whom and how E-bikes are used!
Please note that all your answers will be kept strictly confidential and anonymous, and the data collected will only be used to conduct this study and there is no way to reach you later unless you like to.

Q2.2 What is your **gender**?

- Male (1)
- Female (2)
- Other (3)

Q2.3 What is your **age**?

- Under 18 (1)
- 18-24 (2)
- 25-34 (3)
- 35-44 (4)
- 45-67 (6)
- 67 or older (5)

Q2.4 Do you have children or grandchildren under 5 years old?

- Yes (1)
- No (2)

Q2.5 What is your **current occupation**?

- Student (1)
- Part-time employed (2)
- Full-time employed (3)
- Freelancer (4)
- Currently not employed (5)
- Retired (6)

Q2.6 Nationality:

- Dutch (1)
- Other(s): (2) _____

Q2.7 In which city do you **live** in the Netherlands?
_____

Q2.8
What is your **postcode**? I would like to emphasize again, that all your answers will be kept strictly confidential and anonymous, and the data collected will only be used to conduct this study.
_____

Q2.9 Do you **study or work** in the same area as where you live?

- Yes (1)
- No (2)
- I don't study or work (3)

Q2.10 In which city of the Netherlands do you **work or study**?
If you commute to many cities pick the one that you travel to the most.
_____

Start of Block: Section Two: Your cycling experience and your Electric Bicycle (E-bike)

Q3.1 In general, how long have you been **cycling** in the Netherlands?

- < 1 year (1)
- 2 – 5 years (2)
- > 5 years (3)

Q3.2 On average how many days per week do you use a **bicycle** (any type)?

- Less than 3 days a week (1)
- 4 - 5 days a week (2)
- 6 - 7 days a week (3)

Q3.3 In general, what type of cyclist do you consider yourself?

- Beginner (1)
- Intermediate (2)
- Experienced (3)

Q3.4 Do you need to cross any elevated areas while commuting by bicycle? If yes, where?
With elevated areas, I mean bridges, dunes, etc.

- Yes (1) _____
- No (2)

Q3.5 Did you use a **standard bicycle** before switching to an **E-bike**?

- Yes (1)
- No (2)

Q3.6 What **type** of E-bike do you currently use/own?

- Electric city bike (2)
- Electric folding bike (4)
- Electric family bike (5)
- Cargo electric bike (6)
- Electric transport / delivery bike (7)
- Electric touring / sporty bike (8)
- Speedpedelec (+ 35km/h) (9)
- Other: (10) _____

Q3.7 How do you **access** the E-bike that you are using?

- I own one (1)
- I have a monthly rental membership (2)
- I make use of instant shared public E-bike (OV-Fiets, Donkey Republic, Urbee, etc..) (3)
- I borrow it from someone I know (4)
- Other: (5) _____

Q3.8 What is the **brand** of your E-bike?
If you have many consider the one that you use the most

_____

Q3.9 Do you have an **insurance** for your E-bike?
If "yes", please write the name of the company.

- Yes (1) _____
- No (2)
- I don't know (3)

Q3.10 Where do you usually **park** your E-bike?

- Personal parking (1)
- Shared indoor parking facility (2)
- Shared outdoor parking facility (3)
- Other: (4) _____

Q3.11 Pick your **main purpose(s)** for using an E-bike.
You can select one or more as applicable

- To commute to work, university or school (1)
- To access public transportation (2)
- To use it for work (3)
- For physical activity (4)
- For recreational trips (5)
- To carry heavy goods / children (6)
- For commuting with multi-purpose rides (7)
- To replace my standard bicycle (8)
- To reduce the usage of my car (9)
- To use it as a new means for transportion (10)
- Other: (11) _____

Q3.13 Which practical factor(s) are / were important to you in taking the decision to use an E-bike?
You can select one or more as applicable

- Availability of maintenance points
- Availability of safe parking
- Availability of safe cycling lanes
- Availability of diverse E-bike retailers
- Availability of charging points
- Availability of different insurance plans
- Affordability
- Access to loan / payment facilities
- Access to incentives (discount from work)
- Other: _____

Q3.12 **Which** personal factor(s) are / were important to you in **taking the decision** to use an E-bike?
You can select one or more as applicable

- Less physical effort required to cycle
- Increased speed
- Save time in commuting
- Ability to cycle longer distances
- Larger carrying/towing capacity
- Ability to carry children with less effort
- To cycle easier in windy weather
- To cycle without getting sweaty
- Autonomy of commuting
- Other: _____

Q3.14 How **safe** do you feel using an E-bike?

0
1
2
3
4
5
6
7
8
9
10

Q3.15 **Why** do you (not) feel safe using an E-bike?
_____

Q3.16 Are you satisfied with the current cycling infrastructure available in your city? Why?

- Yes (1) _____
- No (2) _____

Q3.17 Below are a number of statements regarding the social influence of shifting to an E-bike.
Please tick one or more statements that are relevant to you.

Why did you pick the E-bike that you are using?
You can select one or more as applicable

- It is trendy
- I am interested in new technology
- It is more environmentally friendly than a car
- It is more aesthetically pleasing

- I got positive feedback from people I trust
- I have a lot of friends / family who are using a similar E-bike
- I received a lot of advertisement
- It fits with my socioeconomic class
- Other(s): _____

Start of Block: Section Three: Travel behaviour change

Q4.1 Amazing!
I would like you to help me understand if your travel behaviors changed after you shifted from a standard bicycle to an E-bike and how do you feel about it.
Could you please compare your cycling habits from when you used a standard bicycle with habits after you started using an E-bike.

Below are a number of statements that will help me assess if your cycling patterns changed. Please indicate if you agree or disagree with each statement.

Q4.2 After shifting from a standard bicycle to an E-bike, I started to cycle more than before
Agree (1) Disagree (2) Not applicable (0)

- To go to work or educational facilities
- To visit friends and family
- To reach public transport
- To use it as a vehicle for work
- To do shopping / groceries shopping
- For physical activity
- For recreational trips
- To commute with multi-purpose rides

Q4.3 After shifting from a standard bicycle to an E-bike, _____
Agree (1) Disagree (2) Not applicable (0)

- I started to cycle faster
- I started to cycle longer distances
- I started to have new cycling purposes
- I try to take advantage of opportunities to travel using an E-bike more

Q4.4 After shifting from a standard bike to an E-bike, _____
Agree (1) Disagree (2) Not applicable (0)

- I feel more confident while cycling
- I feel more motivated to cycle to new locations
- I am more often trying new routes to reach familiar destinations

- I feel that I belong to a community of E-bike
- I enjoy interacting with other E-bike users

Q4.5 I consider myself an:

- Enthusiastic E-biker (I shifted to an E-bike because I want to increase my cycling frequency & distance) (1)
- Utilitarian E-biker (I shifted to an E-bike because I want to increase my cycling speed with less travel time & be able to transport of goods/or children) (2)
- Recreational E-biker (I shifted to an E-bike because I want to cycle for longer distance) (3)
- Other: (4) _____

Start of Block: Section Four: My relationship with other modes of transport

Q5.1 Wooow we are almost done!
In the last section I want to understand if using an E-bike is affecting the use of other modes of transport.

Q5.2 Do you usually use cycling to connect with other modes of transport?

- Yes (1)
- Sometimes (2)
- No (3)

Q5.3 What are the mode of transports that you usually combine with cycling to commute?
You can pick several options

- Bus (1)
- Tram (2)
- Metro (3)
- Train (4)
- Car (5)
- Other: (6) _____

Q5.4 Before getting an E-bike.
How often did you use the following modes of transport to commute?
Daily (1) Weekly (2) Once a month (3) Every 2-3 months (4) 2-3 times per year (5) Never (6)

- Bus
- Tram
- Metro
- Train
- Car
- Standard bicycle

Q5.5 On average, how much time does it take you to reach the nearest station by standard bicycle?
1-5 mins (1) 5-10 mins (2) 10-15 mins (3) 15-20 mins (4) > 20 mins (5) Not available in my area (6)

- Bus
- Tram
- Metro
- Train

Q5.6 While using your E-bike, have you changed your usage of other modes of transport?

With my E-bike, _____
Much more (1) Somewhat more (2) About the same (3) Somewhat less (4) Much less (5)

- I walk
- I use a standard bicycle
- I use the bus
- I use the tram
- I use the metro
- I use the train
- I use the car

Q5.7 Has your **cycling frequency** changed after the COVID-19 pandemic started?

- Yes, it increased (1)
- Yes, it decreased (2)
- No, nothing changed (3)

Q5.8 Would you like to add anything?
_____

Start of Block: FInal note!

Q6.1 Do you know anyone who uses or owns an E-bike?

- Yes (1)
- No (2)

Q6.2 Could you please share it with him/her/them ?
Insert your email or phone number if you are interested in participating in the draw for 50 euro gift voucher at bol.com!

- Yes, I will! (1) _____

- No! (2)

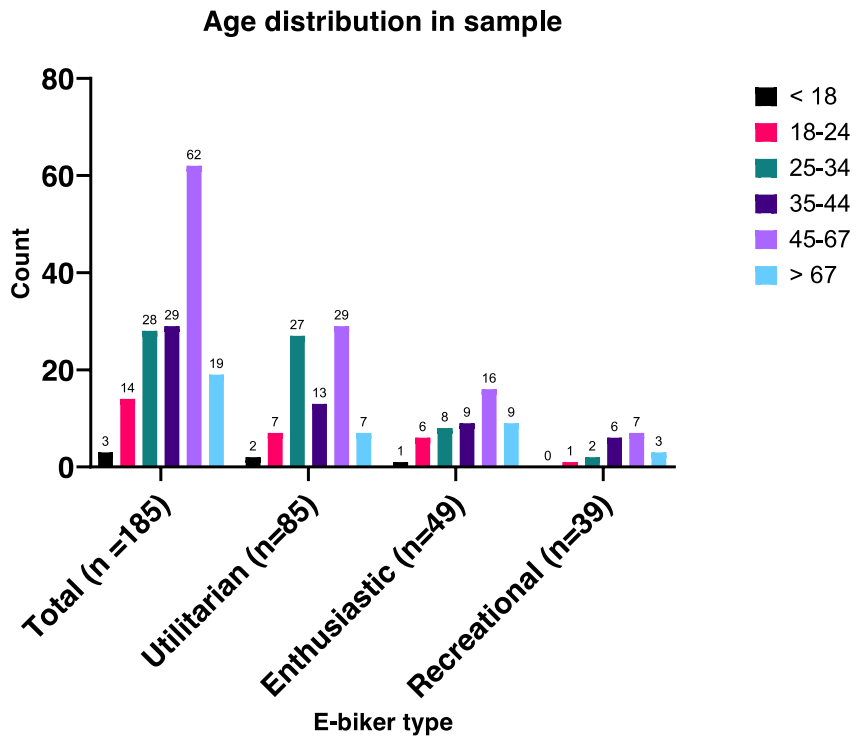
Q6.3 I really thank you for your time and patience to fill my survey.
You are amazing! I hope you win.

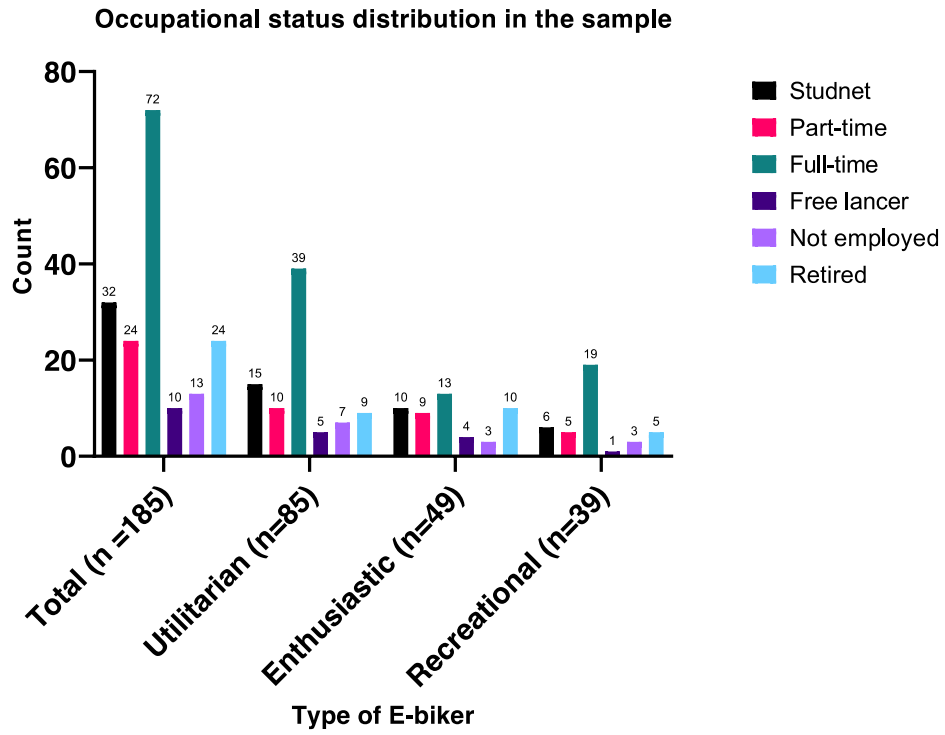
Q6.4 If you are interested in participating in the draw for 50 euro gift voucher at bol.com, please insert your email or phone number

Q6.5 I really thank you for your time and patience to fill my survey.
You are amazing! I hope you win.

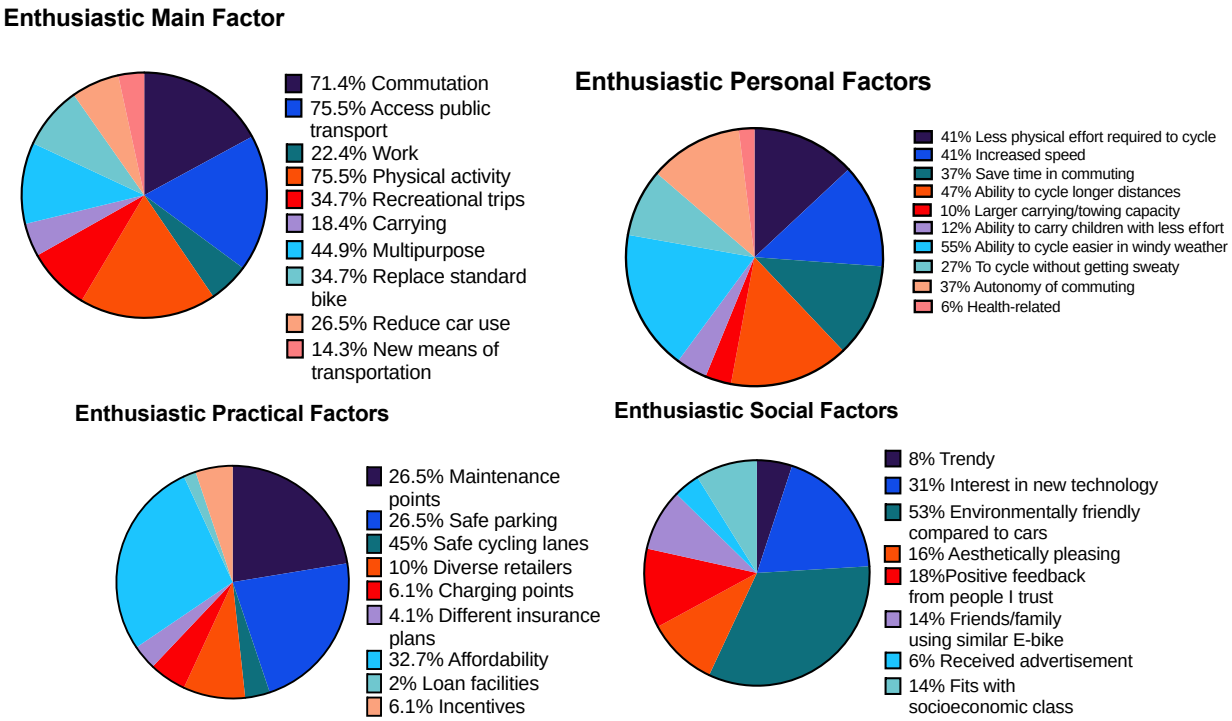
Annex 2: SPSS Output

Figures:

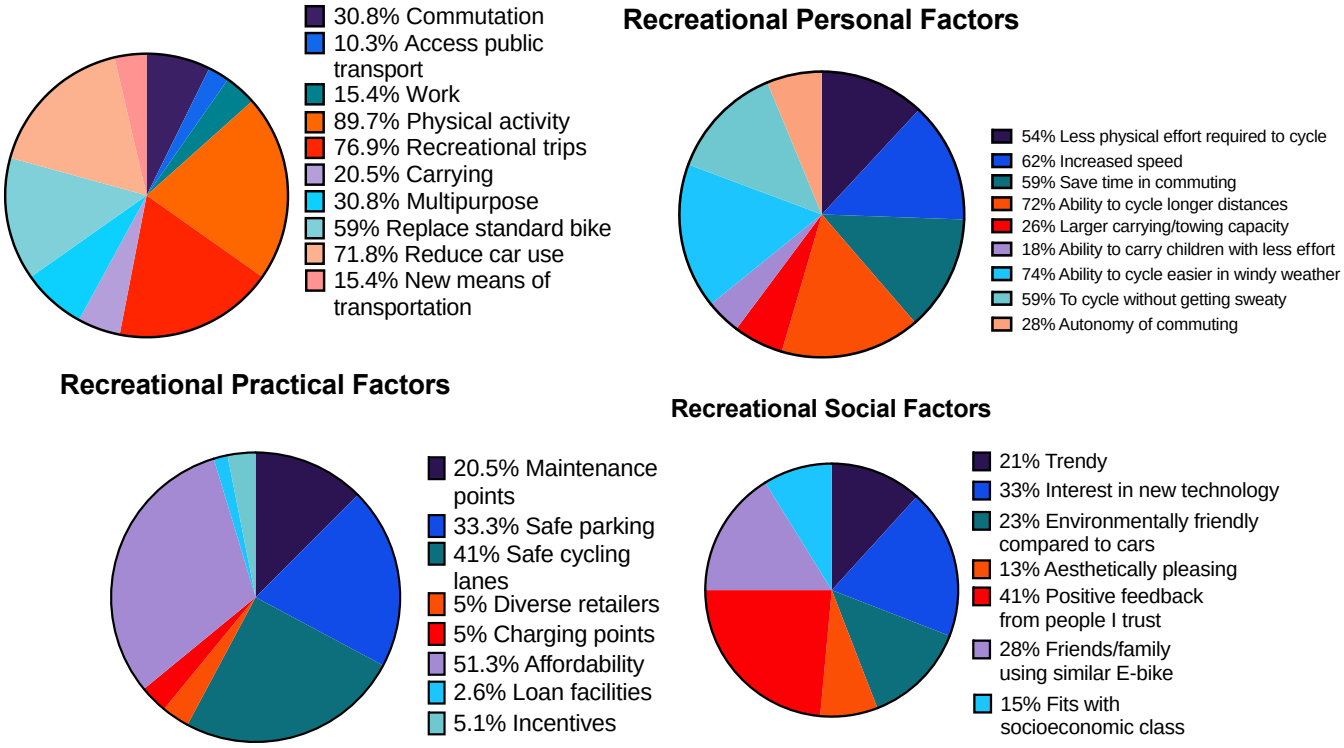




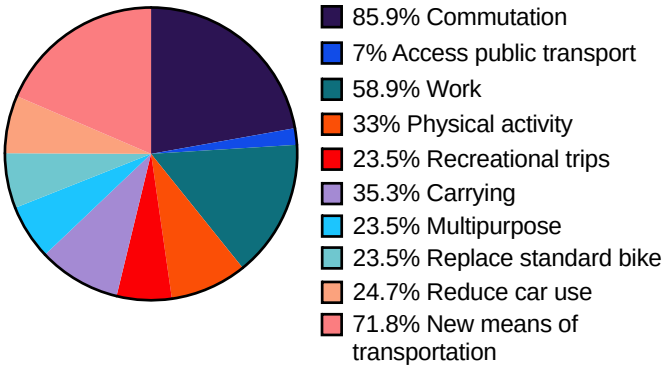
Enthusiastic E-biker:



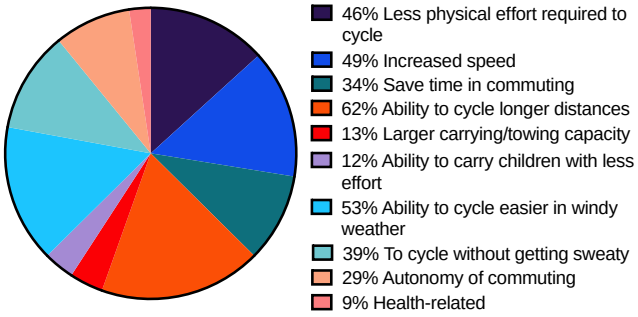
Recreational E-biker:



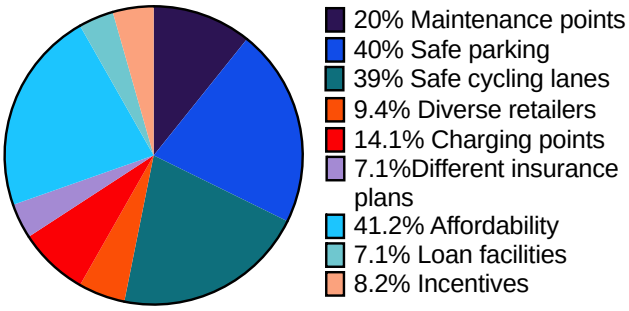
Utilitarian E-biker:



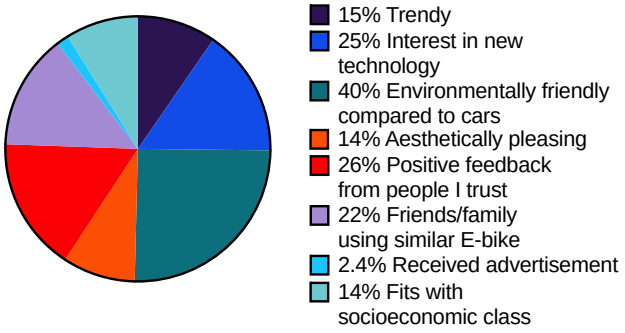
Utilitarian Personal Factors



Utilitarian Practical Factors



Utilitarian Social Factors



I consider myself an * Average use a bicycle Crosstabulation

			Average use a bicycle					
			0	4 – 5 days a week	6 – 7 days a week	less than 3 days a week	Less than 3 days a week	Total
I consider myself an	non utilnarian	Count	0	21	36	1	23	81
		% within I consider myself an	0.0%	25.9%	44.4%	1.2%	28.4%	100.0%
		% within Average use a bicycle	0.0%	30.4%	49.3%	100.0%	71.9%	46.0%
	Utilitarian E-biker	Count	1	48	37	0	9	95
		% within I consider myself an	1.1%	50.5%	38.9%	0.0%	9.5%	100.0%
		% within Average use a bicycle	100.0%	69.6%	50.7%	0.0%	28.1%	54.0%
Total		Count	1	69	73	1	32	176
		% within I consider myself an	0.6%	39.2%	41.5%	0.6%	18.2%	100.0%
		% within Average use a bicycle	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	17.702[a]	4	.001
Likelihood Ratio	18.861	4	.001
N of Valid Cases	175		

a. 4 cells (40.0%) have expected count less than 5. The minimum expected count is .46.

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.317	.001
	Cramer's V	.317	.001
N of Valid Cases		175	

Annex 3: IHS copyright form

In order to allow the IHS Research Committee to select and publish the best UMD theses, participants need to sign and hand in this copy right form to the course bureau together with their final thesis.
Criteria for publishing:

1. A summary of 400 words should be included in the thesis.
2. The number of pages for the thesis is about 50 (without annexes).
3. The thesis should be edited

Please be aware of the length restrictions of the thesis. The Research Committee may choose not to publish very long and badly written theses.
By signing this form you are indicating that you are the sole author(s) of the work and that you have the right to transfer copyright to IHS, except for items cited or quoted in your work that are clearly indicated.
I grant IHS, or its successors, all copyrights to the work listed above, so that IHS may publish the work in *The IHS thesis series*, on the IHS web site, in an electronic publication or in any other medium.
IHS is granted the right to approve reprinting.
The author(s) retain the rights to create derivative works and to distribute the work cited above within the institution that employs the author.
Please note that IHS copyrighted material from *The IHS thesis series* may be reproduced, up to ten copies for educational (excluding course packs purchased by students), non-commercial purposes, providing full acknowledgements and a copyright notice appear on all reproductions.
Thank you for your contribution to IHS.

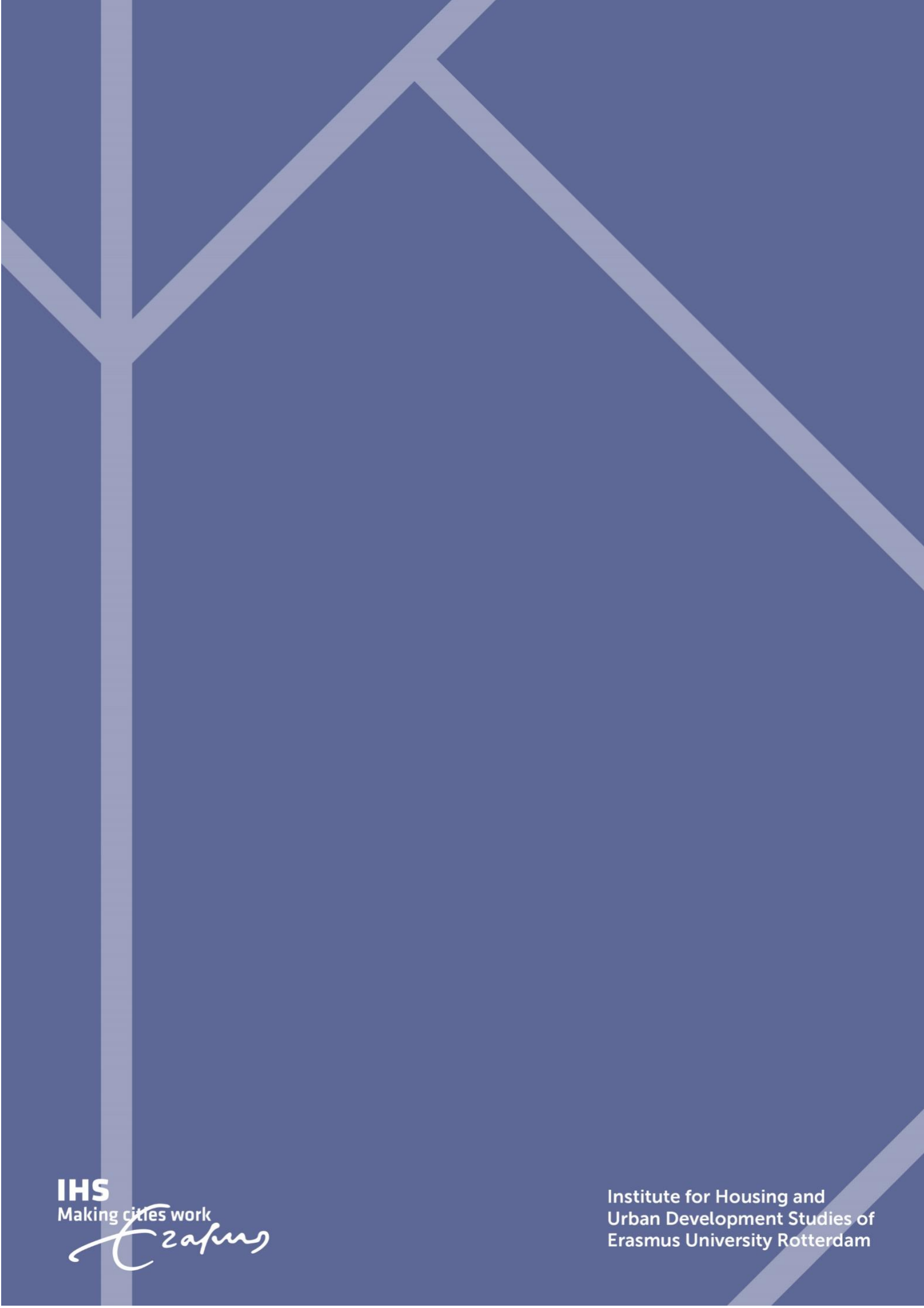
Date : 16 Nov. 2020

Your Name(s) : Malak Rahal

Your Signature(s) : 

Please direct this form and all questions regarding this form or IHS copyright policy to:

The Chairman, IHS Research Committee Burg. Oudlaan 50, T-Building 14th floor, 3062 PA Rotterdam, The Netherlands	j.edelenbos@ihs.nl Tel. +31 10 4089851


IHS
Making cities work
Erasmus
Institute for Housing and
Urban Development Studies of
Erasmus University Rotterdam