Effectiveness of Smart Mobility interventions in the city of Amsterdam

A mixed methods approach on the perception of local citizens and trend in CO_2 emissions from road traffic

Abstract
Partly due to climate change, the mobility sector in Amsterdam is shifting and Smart Mobility is an important contributing pillar to this transition since 2016. To make this concept function, the use of ICT and citizen participation is necessary. However, the influence on CO_2 emissions is not yet defined and there is no clear picture of the perception of the local citizens. By analyzing emission data and conducting in-depth interviews with experts and citizens, this thesis answers these problems. Since the implementation of the Smart Mobility Action plan 2016-2018 in the end of 2016, there seems to be a downward trend in the CO_2 emissions from road traffic, for which Smart Mobility seeks to find alternatives. Besides this, the perception of the citizens seems to be generally positive, mainly due to the positive effects on efficiency and sustainability. However, there are some perceptions that could inspire the municipality to improve citizen participation and thus the successfulness of the interventions.

Key words Smart City; Smart Mobility; CO_2 reduction; ICT; Citizen participation; Citizen perception

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1. Introduction

1.1 Background

The existing and exponentially growing issue of global warming is a ubiquitous concern around the globe. Urban areas and their systems are important contributors to this climate change, therefore cities are adapting relevant interventions and policies in order to reduce their footprint (Amsterdam Institute for Advanced Metropolitan Solutions, 2019). One of the concepts that cities adapt in order to tackle climate issues is the concept of the "Smart City", which is a place where digital- and telecommunication solutions are implemented to make networks and services more efficient, which benefits its inhabitants and businesses (European Commission, 2020). The smart city consists of six main pillars that all contribute to the main concept (Augustyn, 2013):

- Smart Economy
- Smart Environment
- Smart Governance
- Smart Living
- Smart Mobility
- Smart People

This bachelor project investigates the specific case of the city of Amsterdam, who have set up aims to become climate-neutral in 2050 and reach zero emission from traffic in 2030 (Municipality of Amsterdam, 2019). In 2016, the Chief Technology Office Innovation Team (2016) from the municipality of Amsterdam has set up a Smart Mobility Action Plan 2016-2018 (hereafter called "SMAP 16-18") in cooperation with several parties and institutions. This program aims to tackle mobility issues in the city by proposing smart interventions and innovative concepts as inclusive as possible (Chief Technology Office Innovation Team, 2016). The municipality of Amsterdam has various plans and official documents on how they want to achieve certain goals regarding climate change. Organizations and teams are even set up for it (Municipality of Amsterdam, 2019). However, the SMAP 16-18 is not specifically set up for achieving these climate goals primarily, while some interventions of the program do contribute to it. It sparks my interest to investigate which interventions of the program contribute to this CO_2 reduction and illustrate if we can nonetheless observe a trend in the reduction of CO_2 emissions from road traffic, ever since the program has been implemented. Furthermore, I am interested to investigate how local citizens perceive the concept of Smart Mobility and these corresponding interventions, because in the end they will have to make use of the new concepts and modes of transport.

1.2 Research Problem

The SMAP 16-18 (Chief Technology Office Innovation Team, 2016) aims to implement smart interventions with objectives regarding understanding, anticipating, encouraging and accelerating technological developments and innovations in the city. As well as strengthening working partnerships with knowledge institutes and privates in order to become smarter as a municipal organization. However, the influences regarding the reduction of CO_2 emissions have not been specified. Besides this, the municipality desires to make Smart Mobility as inclusive as possible, which means incorporating everyone in the city (Chief Technology Office Innovation Team, 2016). It thus seems that citizen participation is highly valued by the municipality. Studies of Simonofski et al. (2019) and Granier & Kudo (2016) yet address the importance of citizen participation in order to achieve a vital smart city. Full functionality of the shift to new or innovated forms of transport in Amsterdam thus demands participation of citizens and their willingness to change. So far, the mobility sector in Amsterdam is still in transition and it is not resolute how citizens of Amsterdam perceive this change and what their willingness is to participate. Therefore, this thesis aims to fill the gap of not knowing how these citizens that should participate actually perceive the concept of Smart Mobility.

In order to do so, the following research question is formulated:

- *To what extent has the Smart Mobility Action plan 2016-2018 influenced the air quality and the perception of local citizens towards Smart Mobility in the city of Amsterdam?*

And the following supportive questions are formulated:

- *Which goals and interventions that contribute to the reduction of CO_2 emissions have been implemented and what is the trend in CO_2 emissions so far?*
- *How do local citizens perceive the change in Smart Mobility interventions in the city?*

This thesis has a two-sided aim. Firstly, to broaden the academic perspective on the correlation between Smart Mobility and CO_2 emissions and to shape a picture of citizens perception to it. Secondly, to provide suggestions for the municipality of Amsterdam and stimulate debates on improving policies.

1.3 Structure of thesis

The thesis is structured as follows: First, I will describe important theories and concepts that form the basis of my research. In this theoretical framework, the concepts of the Smart City and the role of ICT & Technology are briefly explained, as well as the consequences of CO_2 emissions and how Smart Mobility innovations can reduce these emissions and improve overall efficiency. In the subsequent chapter, the data collection, operationalization and methodology are discussed. Hereafter, the results of the study are shown, which subsequently lead to the discussion, conclusion and recommendations from my thesis.

2. Theoretical Framework

2.1 Distinguishing the smart, digital and sustainable city

As mentioned before, the smart city is a place where digital- and telecommunication solutions are implemented to make networks and services more efficient, which benefits its inhabitants and businesses (European Commission, 2020). However, the concept of a smart city is a generally vague term that can be defined and interpreted in several ways. According to D'Auria et al. (2018), the concept of a smart city is closely interrelated with the digital and sustainable city and formulates these three concepts as an evolutionary path. D'Auria et al. (2018) describe the smart city as an evolution of the digital city, that sets the guidelines of a transforming city, where it not only considers technical and innovative aspects, but also implements the human features of city life. To give reference, D'Auria et al. (2018) describe the concept of a sustainable city as a new equitable and balanced approach and philosophy to modern cities. The criteria on how to define to which concept a city belongs, are based on *what*, *how* and *with* (who) a city changes, which differs for the digital, smart and sustainable city. The city of Amsterdam can be considered a smart city, because the main element of change is technology and digital services (Chief Technology Office Innovation Team, 2016). However, the city of Amsterdam also includes elements of the sustainable city as they also pursue the climate goals with measures that do not necessarily incorporate ICT (Team Air Quality, 2019).

2.2 Explaining Smart Mobility

The field within the Smart City where this paper focuses on is Smart Mobility. This area entails basically the elements of a Smart City that represent mobility, broadly defined as the components that, next to the traditional understood transport of people and goods, also comprise the dissemination of information through digital means (Orlowski & Romanowska, 2019). The key objectives of Smart Mobility implementations are, according to Benevolo et al. (2016):

- Reducing mobility costs;
- Reducing air pollution;
- Reducing noise pollution;
- Reducing traffic congestion;
- Increasing safety;
- Improving the speed of mobility.

2.3 The importance of ICT and participation to improve efficiency and services

As mentioned before, Information and Communication Technologies (ICT) are a key element of the Smart City and increasing efficiency and services. ICT is essential for collecting, storing and disseminating information. Besides this, it supports the management of Smart Cities and facilitates the development of applications for projects and interventions (Pla-Castells et al., 2015). According to Dameri (2017), ICT even becomes fundamental for development of Smart Mobility programs when the complexity, integration and extension increases. However, perhaps an even more important element is the participation of citizens. Pla-Castells et al. (2015), Dameri (2017) and Granier & Kudo (2016) all address that participation of citizens is key in order to make the Smart City function properly. Citizens are inevitably involved in the process and can be considered Smart Communities. Simonofski et al. (2019) identify three ways in which citizens can participate, namely as democratic participants, co-creators or ICT users.

2.4 The influence of mobility on CO_2 emissions

According to Quadrelli & Peterson (2007), fossil fuel combustion is the largest human influence on the climate, as it's counting for 80% of anthropogenic greenhouse gas (GHG) emissions. CO_2 (carbon dioxide) is one of the main greenhouse gasses and particularly the GHG this paper focuses on. Fossil fuel combustion is used for various productions, such as electricity and heat, but also in transport, which means that CO_2 is thus released by mobility modes that combust fossil fuels. When for any reason the usage of fossil fuel driven vehicles in a city is reduced, it should thus automatically mean that CO_2 emissions decrease as less fuel is combusted.

2.5 Mobility policy in Amsterdam

Smart Mobility is one element out of many that contributes to reaching the aim of only allowing emission-free cars in the city by 2030 (Municipality of Amsterdam, 2019). As explained by one of the interviewees from this research (which will be discussed with more detail in Chapter 4.3), the mobility plan in Amsterdam consists out of three pillars that all have their corresponding action plans. So to speak, reaching the goal of zero-emission from traffic in 2030 demands a shift in the cities' mobility nature. This thesis focuses on the pillar of Smart Mobility, thus how the municipality aims to make the mobility sector different and innovative.

2.6 Conceptual Model

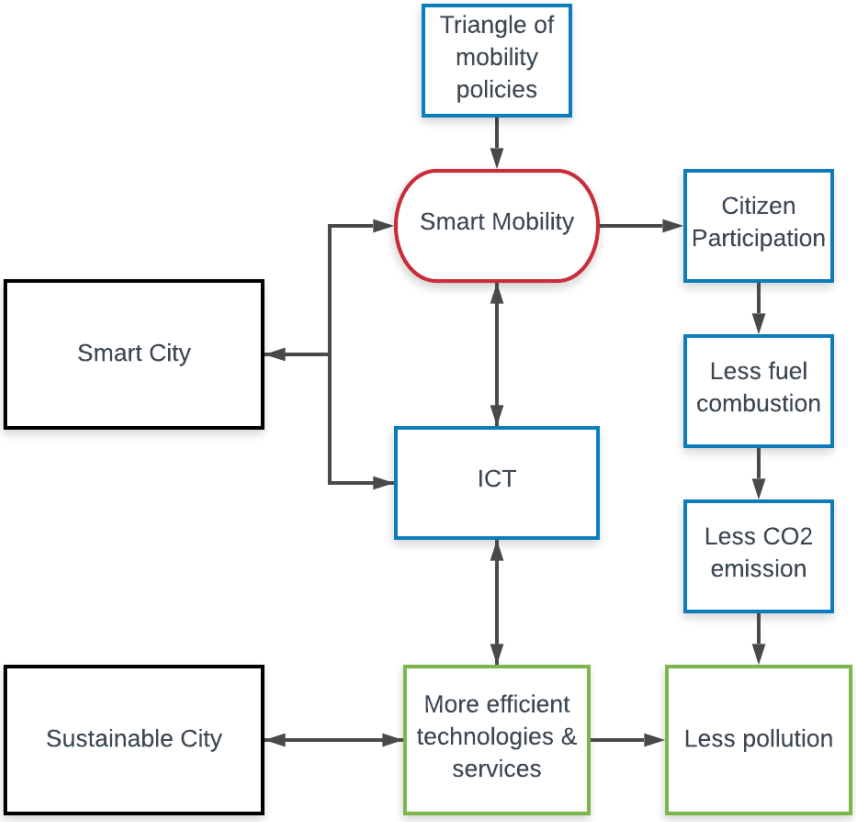

Figure 1: Conceptual Model. The red oval depicts the main concept of the thesis and the black boxes show the side concepts. The blue boxes depict the underlying factors for the green boxes that present the effects.

2.7 Hypotheses

Based on the literature and the fact that the SMAP 16-18 has yet been implemented, several hypotheses can be stated. Firstly, since Smart Mobility discourages the use of fossil fuel driven vehicles, there should be a correlation between the start of SMAP 16-18 and the amount of CO_2 emissions from road traffic. Secondly, as Smart Mobility is yet well established in the city of Amsterdam and citizen participation should have contributed to this, the perception of citizens towards the concept should be generally positive.

3. Methodology

3.1 Methods of data collection

In order to answer the research question stated above, a mixed methods approach is used. As CO_2 emissions and citizen perceptions cannot be both defined with the use of either singly qualitative or singly quantitative methods, rather a mix of both should be applied. This approach is suitable to gain in-depth understanding and corroboration, while offsetting the weaknesses of using one of the approaches by itself (Punch, 2014). During the Methods for Academic Research course, this approach has been taught and practiced, which was an incentive for me to apply this research method again. The first supportive question is answered by gathering quantitative data from the *Klimaatmonitor* (Rijkswaterstaat, 2020) and qualitative data from expert interviews. The second supportive question is answered by gathering qualitative data from citizen interviews.

3.1.1 Secondary data

For the quantitative data, secondary numeric data from the *Klimaatmonitor* (Rijkswaterstaat, 2020) is used. Considering that the Smart Mobility interventions in Amsterdam are mainly focused on usage of private transport modes such as cars, motorcycles and scooters, it is not representative to use the overall statistic of CO_2 emissions from road traffic, as this also incorporates emissions from trucks, delivery vans and other irrelevant modes. Therefore, the database from the *Klimaatmonitor* is narrowed down to CO_2 emissions from passenger cars and two-wheelers within the metropolitan region of Amsterdam between the period of 2014-2017. The data from the years 2018 and 2019 are not yet processed nor published before July 2021. After haven spoken to a representative of the *Klimaatmonitor*, there was no possibility to obtain this data beforehand, so therefore it cannot be used. However, since the SMAP implementations have started in 2016, the data from before the interventions (2014 and 2015) and during the interventions (2016 and 2017) could be used. This was sufficient to give an illustration of the trend in CO_2 emissions since the program has been implemented. The variables used for the illustration are *CO_2 emission from passenger cars* and *CO_2 emissions from two-wheelers.* The unit used is the CO_2 emission in *kilograms*. The complete datasets of the CO_2 emissions and population sizes can be found in appendices III & IV

3.1.2 Primary data collection

The method used for gathering the qualitative data are semi-structured interviews, apart from the information that can already be gathered through consulting the Smart Mobility Action program 2016-2018, hereafter called the 'SMAP' (Chief Technology Office Innovation Team, 2016). These kind of interviews provide flexibility for the way certain topics are presented to the informant and leaves room for a chosen direction by the informant (Clifford et al., 2010). For this research, this means that the interviewees can go in-depth on the discussed interventions and deviate from the open-ended questions, if necessary for supplying comprehensive information about the implementations made in the city of Amsterdam. The first interview was conducted with a member of the organization who set up the SMAP 16-18 in order to gather complete information on what has been implemented and when, and to ensure that no crucial information is missing about interventions regarding Smart Mobility. This interview will thus mainly answer the first supportive question. The second interview was conducted with an employee of the municipality of Amsterdam, in order to investigate what the actual goals of the municipality are regarding reducing air pollution through mobility changes, if they are currently on track and if there have been any other action plans aiming for mobility changes, besides the SMAP 16-18, that should be incorporated in the research. This interview also answers the first supportive question. The detailed interview guides can be found in Appendix II.

The second supportive question is answered through four semi-structured interviews with local citizens who are living in the city of Amsterdam. By interviewing several citizens, patterns were identified in their perception towards Smart Mobility and the corresponding interventions. To get a representative image from the population, all participants were from a different age group. One interview was held with a student, one with an employed person between 30-40 years, one with an employed person between 40-50 years and one with a retired citizen. A detailed interview guide used for these citizens can also be found in Appendix II.

To summarize, six semi-structured interviews are conducted, of which two were expert interviews and four were citizen interviews. The interviews have been held in respectively April and May 2020. The format used to obtain informed consent from the interviewees can be found in Appendix I.

3.2 Methods of data analysis

3.2.1 Quantitative data analysis

To analyze the quantitative data, statistical tests were performed in order to calculate if there is a significant difference in CO_2 emissions in the city of Amsterdam between the period before and after the implementation of the SMAP 16-18, in relation to the amount of inhabitants in the city in both periods. In order to prevent biased results when comparing the different years, the amount of CO_2 emissions were

divided by the amount of inhabitants within the metropolitan region of Amsterdam in that year, making the analyzing variable an amount of *CO_2 emissions per inhabitant in kilograms*.

3.2.2 Qualitative data analysis

To analyze the collected qualitative data, all the interviews were transcribed literally. Both the expert- and citizen interviews were coded through an inductive coding approach. This is a bottom-up approach, which works well when trying to identify patterns and themes from qualitative data without having preconceived notions or expectations on what to find (Kawulich, 2017). This suits well to this research, as the perception of local citizens can not be preconceived and there are no expectations on how the citizens perceive Smart Mobility.

3.3 Final template inductive coding 'Experts'

Main theme	Sub-themes/codes
A. Additional information on content within SMAP 16-18	1. Explanation & aims of interventions that (potentially) contribute to CO2 reduction 2. Confirmation that there are no (relevant) interventions outside the program 3. Extra aims set outside the program 4. Start/end date of the program 5. Successfulness of the interventions 6. Role of ICT & Technology in improving charging station networks 7. Lessons from the past
B. Additional information on general goals & policies within the municipality	8. Requirements for use of green energy 9. Role of SMAP within climate goals 10. Explanation of structure mobility policies 11. Challenges for mobility

Figure 2: Final template 'Experts'

3.4 Final template inductive coding 'Citizens'

Main theme	Sub-themes/codes
1. Positive perceptions	1.1 Has used MaaS before, or would be willing to 1.2 Increase of efficiency 1.3 Sustainability 1.4 Accessibility & convenience 1.5 Affordability 1.6 Acknowledge benefits of self-driving transport
2. Negative perceptions	2.1 Mixed use on cycling lanes 2.2 Has to be convinced about self-driving transport 2.3 Other remarks
3. Striking features in Amsterdam (smart) mobility	3.1 Increase of traffic / pressure on infrastructure 3.2 Dangerous driving behavior of fellow road users 3.3 Scooters on car lane a relief 3.4 Introduction of MaaS concepts 3.5 Quietness of Corona leads to safer traffic situation 3.6 Other remarks

4. Suggestions for Amsterdam (smart) mobility	4.1 Better marketing 4.2 Applications and reporting must be straightforward and simple 4.3 Other suggestions

Figure 3: Final Template 'Citizens'

3.5 Ethical considerations

As incorporated in the *Netherlands Code of Conduct for Research Integrity* (Dutch Research Council, 2018) there are five ethical principles that are required for the integrity of research. Namely honesty, scrupulousness, transparency, independence and responsibility. For this thesis, independence and responsibility is guaranteed through having agreed an informed consent with the interviewees. Transparency, honesty and scrupulousness is ensured by the use of public data and using valid references. As the results do not contain solely positive remarks and that this thesis only intends to stimulate improvements, it will not be published. Publishing could harm the image of certain institutions and does not reconcile with the purpose of this thesis.

4. Situation overview, policies and goals

4.1 Current trend in CO_2 emissions from passenger cars and two-wheelers

The graph below shows the current trend in CO_2 emissions, derived from data of the *Klimaatmonitor* from Rijkswaterstaat (2020). The vertical axis shows the average CO_2 emission per inhabitant in kilograms and the horizontal axis shows the year. Each value is based on cumulative numbers of all the emissions from passenger cars and two-wheelers within the municipality of Amsterdam, divided by the amount of inhabitants in Amsterdam that year (Central Statistics Office, 2020).

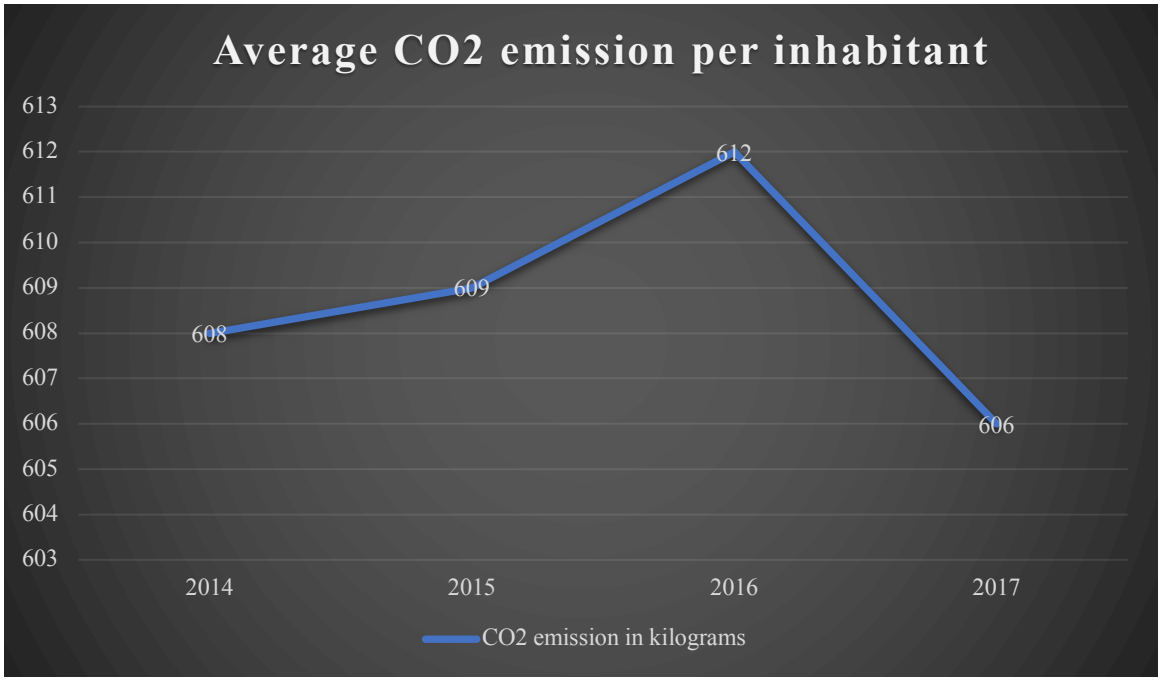

Figure 4: graph of CO_2 emission trend

The graph above illustrates that there was an upward trend of CO_2 emissions in the city of Amsterdam until 2016, which stagnates in 2017 when the *SMAP 16-18* was implemented. Hence, it seems that since the implementation of this program, the trend of CO_2 emissions from passenger cars and two-wheelers in the city of Amsterdam is shifting downwards.

4.2 In-depth on the Smart Mobility Action plan 2016-2018

The SMAP 16-18 put up by the Chief Technology Office Innovation Team (2016) of the municipality of Amsterdam is the policy plan that this thesis refers to. The following information is derived from what has been found in the program document and an interview with the manager of the program who was responsible for the final product (Expert 1). The action plan consists of four main themes and projects:

- Internet of things
- Clear picture of the city and smart use of space
- Mobility as a Service (MaaS)
- Self-driving transport

This research aimed to investigate the themes that (potentially) contribute to the reduction of CO_2 emissions. According to the program manager, Mobility as a Service and Self-driving transport are the most important themes in this. Mobility as a Service is a concept that encourages car sharing and having less private vehicle ownerships. This contributes to the reduction of CO_2 emissions, because reducing the amount of ownerships and increasing the occupancy of transport leads to less vehicle movements. Besides this, most initiatives of sharing services are operating with electric vehicles, which also contributes to the reduction of CO_2 emissions, as long as the electricity used comes from green origins.
Self-driving transport is not yet physically introduced as an intervention, but could be potentially contributing to the reduction of CO_2 emissions as it will be electrically powered and also encourage less private vehicle ownerships.
This implementation of interventions in this program have started in the last quarter of 2016. The official ending phase of the program was between the last quarter of 2018 and the first quarter of 2019, as a new action plan outlined for 2019-2025 was taking over. However, projects like MaaS and Self-driving transport continued regardless of the action plan ending, as they were successful to a sufficient extent.
As to be found in the document and mentioned before, the objectives of these themes and projects are to understand, anticipate, encourage and accelerate technological developments and innovations in the city, as well as to strengthen working partnerships with knowledge institutes and privates in order to become smarter as a municipal organization. Besides this, the program manager mentioned that there is an objective to make the interventions inclusive, which means incorporating all citizens and making it accessible for everyone. Hence, we can ascertain there are no specific measures set within the SMAP 16-18, regarding the reduction of CO_2 emissions.
According to the program manager, the successfulness of the interventions is variable. Some interventions have become business as usual and some have been interrupted due to insufficient perspective. However, the program manager addressed that the municipality can improve the successfulness in the future by directly cooperating with partners to organize innovations.

4.3 General goals and policies within the municipality

The following information is derived from the *Routekaart Amsterdam Klimaatneutraal* (Municipality of Amsterdam, 2019) and an interview with an expert on air quality within the municipality of Amsterdam.
The goal of the municipality is to reach zero emission from traffic in the city by 2030. To reach this goal, the mobility sector has to shift and this track is guided by three main programs: *Clean Air* (Team Air Quality, 2019), *Car-free* (Municipality of Amsterdam, 2020) and *Smart Mobility* (Chief Technology Office Innovation Team, 2016) . These three action plans together should lead to cleaner, less and different use of mobility. Hence, the role of *Smart Mobility* within reaching the climate goals is to facilitate by generating innovative concepts and ideas to this triangle policy and thus contribute to reaching only emission-free traffic in 2030. Thus, SMAP 16-18 is expected to contribute to the reduction of CO_2 emissions, but there are no specific numeric requirements to what extent they should.

4.4 Requirements for the use of green energy

Within the SMAP 16-18 there are no specific policies set for the use of green energy for charging station networks. However, this is covered by the *Action Plan Clean Air* (Team Air Quality, 2019), as they have set up requirements that all charging stations for electric vehicles in the city are equipped with green and durable energy. Which is crucial, as electric vehicles can be pseudo-sustainable if the electricity used comes from fossil power plants that emit CO_2 and other particulates into the air.
Another durable fuel for mobility is Hydrogen, however the production of hydrogen in a sustainable way is still a big challenge.

5. Results and discussion

Through having conducted four semi-structured interviews with local citizens, certain patterns were identified in the perception of local citizens towards the concept of Smart Mobility in general and the specific measures of MaaS and self-driving transport. The main characteristics of the respondents are summarized in the table beneath:

Citizen	Age	Living in the city since	Occupation
1	68	1951	Retired
2	23	2016	Student
3	47	2004	Employed
4	37	2011	Employed

Figure 4: Main characteristics of respondents

		Count		Respondents			
Main label	Final code	#	%	Citizens			
				C1	C2	C3	C4
1. Positive perceptions	1.1 Has used MaaS before, or would be willing to	4	100%	1	1	1	1
	1.2 Increase of efficiency	4	100%	1	1	1	1
	1.3 Sustainability	4	100%	1	1	1	1
	1.4 Accessibility & convenience	3	75%	0	1	1	1
	1.5 Affordability	3	75%	1	0	1	1
	1.6 Acknowledge potential benefits of self-driving transport	2	50%	0	1	0	1
2. Negative perceptions	2.1 Mixed use on cycling lanes	2	50%	0	0	1	1
	2.2 Has to be coaxed about self-driving transport technology	3	75%	1	1	1	0
	2.3 Not accessible for people who are not familiar with digital resources	2	50%	1	1	0	0
	2.4 Other remarks	1	25%	0	0	1	0
3. Striking features in Amsterdam (smart) mobility	3.1 Increase of traffic / pressure on infrastructure	4	100%	1	1	1	1
	3.2 Dangerous driving behavior of fellow road users	3	75%	1	0	1	1
	3.3 Scooters on car lane is a relief	3	75%	0	1	1	1
	3.4 Introduction of MaaS concepts	2	50%	0	1	1	0
	3.5 Quietness of Corona leads to safer traffic situation	2	50%	1	0	1	0
	3.6 Other remarks	4	100%	1	1	1	1
4. Suggestions for Amsterdam (smart) mobility	4.1 Better marketing	4	100%	1	1	1	1
	4.2 Applications and reporting must be straightforward and simple	2	50%	1	1	0	0
	4.3 Other suggestions	3	75%	1	1	1	0

Figure 5: Summary of results from citizen interviews. This matrix shows the large quantity of positive perceptions and repetitiveness of certain remarks that shapes patterns in the perception of the citizens.

5.1 Positive perceptions towards Smart Mobility

5.1.1 Has used MaaS before, or would be willing to

All of the respondents mention that they have made use of MaaS before, or that they would be willing to if it ever proves to be necessary for them, because they admire the concept. Only one respondent had never used it before, but said the following:

> "If I might ever not have my own car anymore, I would definitely be willing to try MaaS." – Citizen 1

To summarize, the key element of citizen participation as addressed by various authors seems to be present among the respondents.

5.1.2 Increase of efficiency

All of the respondents mention that Smart Mobility and MaaS in specific entail a giant efficiency improvement.

> "I think that, especially in a city like Amsterdam and many other European medieval cities, you don't want to a lot of cars to be parked there. It simply doesn't work. And with all these sharing cars, sharing bikes and sharing scooters, you make use of these modes more efficiently, because a vehicle is not parked all day to drive 20 minutes twice, but it is in use all day. So yeah, it is a giant efficiency increase, I think. And you reduce the wrong emissions, while you are actually not disadvantaging your capacity and consumption" – Citizen 4

Furthermore, the efficiency of Smart Mobility even seems to outweigh other functions of usual mobility.

> "For me it's about getting somewhere, not about if I own a car or not. That doesn't matter to me, I don't see it as a status symbol or something" – Citizen 3

To summarize, MaaS seems to be seen as a necessary intervention in order to improve efficiency, which is in line with the key objective of Smart Mobility to increase the speed of mobility (Benevolo et al., 2016).

5.1.3 Sustainability

All of the respondents mention or acknowledge the sustainable benefits that Smart Mobility (potentially) entails.

> "I think it already makes a huge difference on itself. Apart from the fact that vehicles are electric, so that it saves 100%, but even if it were all fuel driven cars, I think it would still help a lot." – Citizen 4

To summarize, this emphasizes the importance of Smart Mobility for reducing fuel combustion, which is in line with the explanation of Quadrelli & Peterson (2007) that this reduces CO_2 emissions and thus has a positive impact on the environment.

5.1.4 Accessibility & convenience

3 of the 4 respondents mention the easy accessibility and convenience of Smart Mobility concepts such as MaaS.

> "From what I have seen, because I often ride with friends in those sharing cars, that they are very widely spread. So I never had to walk far in order to find one, or something." – Citizen 4

Furthermore, the ease of getting access with help of ICT and Technology seems to be appreciated.

> "Very simple, yes. I indeed see that my friends just swipe their telephones in front of the window, and the thing opens!" – Citizen 4

To summarize, this emphasizes the importance of ICT as addressed by Dameri (2017) and implies that the citizens of Amsterdam mainly participate in the concept as ICT users, rather than as democratic participants or co-creators (Simonofski et al., 2019).

5.1.5 Affordability

3 of the 4 respondents mention the fiscal benefits of Smart Mobility concepts such as MaaS

> "And then of course the big advantage with such a service, is that you don't have maintenance costs, purchase costs and things like that" – Citizen 3

To summarize, there seems to be a fiscal attractiveness for the short distance, which is in line with the key objective that Smart Mobility should reduce mobility costs (Benevolo et al., 2016).

5.1.6 Acknowledge potential benefits of self-driving transport

Half of the respondents mention or acknowledge potential benefits of self-driving transport

> "Look, it's not that I expect self-driving transport to be perfect and flawless from day one, but I can tell you now, that people, sitting behind the wheel in cars, are making a lot of mistakes." – Citizen 4

Furthermore, potential benefits for disabled people are addressed.

> "But I work in the health care sector, and there are a lot of people who are not able to make use of public transport, for whom such a self-driving car could be very convenient. And if it also would be electric..." – Citizen 2

To summarize, self-driving transport is seen as a positive development by some respondents and could even be an outcome for certain target groups. The acknowledgement of these novelties also corresponds with the role of Smart Mobility as innovator in the triangle mobility policy as explained by Expert 2.

5.2 Negative perceptions towards Smart Mobility

5.2.1 Mixed use on cycling lanes

Half of the respondents mention the increase of mixed use on cycling lanes, such as sharable e-bikes, as a threat for safety.

> "I'm just worried again, now that you've got all those electric bikes, VanMoof for example. I see them a lot now and you don't even notice that it is an electric bike, they just go very fast." – Citizen 3

Furthermore, the mix of people using the cycling lanes is also addressed.

> "That the bike paths are actually much more shared by, let's say, commuters, local residents, as well as a lot of tourists and outsiders." – Citizen 4

To summarize, a wide variety of modes and users seems to have a negative impact on the safety of cycling lanes, which contradicts with the key objective that Smart Mobility should increase safety (Benevolo et al., 2016).

5.2.2 Has to be coaxed about self-driving transport technology

3 of the 4 respondents mention that they would have to be coaxed about the technology of self-driving transport, before they would be willing to make use of it.

> "Well, you must have a lot of faith in that technology, huh? I think that's quite a thing." – Citizen 3

To summarize, there seems to be some reluctance in the population about self-driving transport, which could form a hindrance for citizen participation.

5.2.3 Not accessible for people who are not familiar with digital resources

Half of the respondents mention the bad accessibility of Smart Mobility and MaaS in specific for people who are not familiar with digital resources, such as elderly people.

> "It's not very clear to me. Because I'm just not, uh, very good with the Internet." – Citizen 1

To summarize, the use of ICT & Technology for MaaS seems to possibly form a barrier for retired and elderly people, which could form a hindrance for the goal to make Smart Mobility inclusive (Expert 1).

5.2.4 Other remarks

The following negative perceptions towards Smart Mobility have been mentioned once, such as questioning the privacy policies and business models.

> "How's the privacy? And who earns what? The idea is good, but often there are still very bad business models behind it."– Citizen 3

Furthermore, the disadvantages of MaaS for the long distance are addressed.

> "Then you're stuck on that long distance, that if I want to go away for the weekend, I still need a car. So it's not quite a replacement for the private car yet." – Citizen 3

To summarize, one respondent seems to have doubts about some mechanisms behind MaaS.

5.3 Striking features in Amsterdam (smart) mobility

5.3.1 Increase of traffic / pressure on infrastructure

All of the respondents mention the increased traffic in the city and the pressure on the infrastructure that it entails as a striking feature in the cities' mobility.

> "Downtown is just... I don't go there anymore, it's too crowded." – Citizen 3

To summarize, the increase of traffic in the inner city seems to be a general annoyance and suggest that the objective of Smart Mobility to reduce traffic congestion is not yet satisfied (Benevolo et al. 2016).

5.3.2 Dangerous driving behavior of fellow road users

3 of the 4 respondents mention the dangerous driving behavior of fellow road users as a striking features in the cities' mobility.

> " Because of the crowds, people are pulling really weird tricks that make it dangerous."
> – Citizen 1

Furthermore, dangerous behavior of taxi drivers is addressed.

> "And taxi's, yes… Taxi's just flout the traffic rules. Something that also causes a lot of accidents, so." – Citizen 4

To summarize, the rush in the city seems to lead to dangerous behavior of road users, which suggests that the key objective of Smart Mobility to increase safety is not yet satisfied (Benevolo et al., 2016).

5.3.3 Scooters on car lane is a relief

3 of the 4 respondents mention that the translocation of scooters to the car lane is a relief for the cities' mobility

> "I really think it's an improvement. You just feel a lot safer, and I also really think there'll be fewer accidents." – Citizen 2

Furthermore, the responsibility for scooter drivers is touched upon.

> "Because I think that in this case, the most vulnerable are protected and the people who cause the danger, have to think a bit more about it." – Citizen 4

To summarize, scooters on the car lane seems to be.a relief for people who frequently use the cycle lanes with other modes and thus increases their perception of safety.

5.3.4 Introduction of MaaS concepts

Half of the respondents mention the introduction of MaaS and other electric vehicles as a striking feature in the cities' mobility.

> "I'm noticing more and more of those things coming up like Felyx and Car2go." – Citizen 2

To summarize, some of the respondents notice that MaaS is being encouraged, which means that citizens perceive the renewals that Smart Mobility should entail (Expert 2).

5.3.5 Quietness of Corona leads to safer traffic situation

Half of the respondents mention that traffic has become more quiet since the outbreak of Covid-19 and that they see the safety it entails as a striking feature in the cities' mobility.

> "You notice that in this period, it is a lot more pleasant to drive, and much safer." – Citizen 1

To summarize, respondents seem to perceive a decrease in bustle as a safer environment.

5.3.6 Other remarks

The following striking features have been mentioned once by one of the respondents, such as the discouragement of private car use.

> "So I do notice that it is being discouraged to go by car and also parts in the city that are becoming forbidden for cars that were not before." – Citizen 2

Furthermore, the shift to electric pleasure cruising on the canals is noticed.

> "That sailing on the canals has been adapted to electric sailing. Yeah, I used to sail on the canals on a regular basis. So I have really noticed, that that is really different now." – Citizen 2

Furthermore, the fact that most delivery vans still run on fossil fuels is being noticed.

> "You really see a lot of delivery vans. I think people just really order a lot online. You see that a lot, and they're all just vans that aren't electric. So that would be nice if they can drive electric, for example." – Citizen 2

Furthermore, the lack of accessibility to the lightrail network in the Rijnbuurt is noticed.

> "And yes, the lightrail, I don't have the best connection, so I'd like it if the trams, for example, just drive a bit further along the edges of the city. So that you can just use them more easily."
> – Citizen 2

Furthermore, the changed image of 'senior cars' like the Biro is being noticed.

> "And now you have Biro, but you see a lot more people, driving in some kind of quasi-vehicle. So that also tells me that it is becoming socially acceptable, because it used to be an 'old wives car'. And now you see people of all ages in it." – Citizen 4

Furthermore, the positive impact of the Noord/Zuidlijn is noticed.

> "For me, the Noord/Zuidlijn is a big outcome. Really ideal. It's very fast, very efficient. It just makes it a lot easier to move around the city." – Citizen 4

To summarize, there is a wide range of things that are striking for citizens in the cities' mobility.

5.4 Suggestion for Amsterdam (smart) mobility

5.4.1 Better marketing

All of the respondents suggests that the marketing for Smart Mobility and its concepts should be improved in order to encourage the use of it.

> "When I hear you interviewing, I think: what!? Is the municipality working on this? That surprises me."– Citizen 3

Furthermore, the communication tool for marketing is being contested for certain age groups.

> "I certainly think with my generation, that letters and so on, don't really make sense. Because I sometimes get a letter from the municipality about something in the neighborhood being updated, but then I actually read it half way through and don't find it interesting, so I throw it away. So yeah, Maybe something like a nice commercial on TV would work. Or these days you have those screens on the street where commercials are projected on, that's just a kind of TV screen." (Referring to Billboards) – Citizen 2

To summarize, citizens do not seem to get the impression that Smart Mobility is being encouraged by the municipality, which does not benefit citizen participation and inclusivity of Smart Mobility.

5.4.2 Applications and reporting must be straightforward and simple

Half of the respondents suggest that the applications and reporting of Smart Mobility should be straightforward and simple.

> "I think that the apps should just be really basic and straightforward, so not too many bells and whistles. Because in fact, you don't need that anyway, because you just want to book something quickly. You want to start it quickly and when you finish, you want to stop it quickly again. So I sometimes notice with some apps, that you get a lot of those pop ups. That you think, alright, click through as fast as possible, because you want to turn it off. I think that's a bit of a threshold, and I think if the apps are really easy, it's also easier for people to understand them." – Citizen 2

To summarize, making applications straightforward and simple seems to make MaaS feel more user-friendly, which could improve citizen participation and help making it inclusive.

5.4.3 Other suggestions

The following suggestions have been mentioned once by one of the respondents, such as getting access for seniors through dialing, in stead of using applications.

> "Yes, but then it must also be very clear that you can also reach someone on the phone, because that's at a lot of companies, so you can't reach them on the phone either. And I like that very much." – Citizen 1

Furthermore, physical assistance or a course for seniors is suggested.

> "And it's all going way too fast for me, so it has to go slowly or have them call with a clear explanation or come by if necessary, or a course for seniors." – Citizen 1

Furthermore, a more transparent cost-benefit consideration between MaaS and private car-ownership is suggested.

> "I really think it's somewhere on the psychological level, because if you're actually going to calculate your costs, so what a car costs and what you could spend per month for those Smart cars, scooters and so on.. I think that balance just needs to be a little bit more insightful." – Citizen 3

To summarize, these suggestions could support the degree of citizen participation and inclusivity.

6. Conclusion

To conclude, this thesis aimed to define which interventions of the SMAP 16-18 contribute to the reduction of CO_2 emissions and illustrate the trend of CO_2 emissions since the plan has been implemented, as this was not specified. Besides this, the perception of local citizens towards Smart Mobility is assessed, as citizen participation is a key requirement in order for the concept to properly function. To answer these problems, a mixed-method approach was put in place. Quantitative analysis of numeric data has given a brief illustration of the trend in CO_2 emissions, but could not determine an undisputed correlation with the start of SMAP 16-18, as other factors could have influenced thsee numbers. Qualitative analysis of semi-structured interviews has provided an in-depth understanding on the perceptions of individual citizens towards Smart Mobility, but it might not be a representation of the entire population, as only four citizens were interviewed. Nevertheless, all these findings suggest that since the implementation of the SMAP 16-18, there is a downward trend in CO_2 emissions from road traffic and there is a generally positive perception under the responding citizens towards the concept of Smart Mobility. However, some critical comments suggest that the concept could be further improved, particularly in the field of accessibility for seniors, confidence in technologies and wider encouragement. This thesis has given insight in perceptions from different age groups in the population and might inspire the municipality to improve their interventions, but future research could be conducted on how to make accessibility of Smart Mobility more inclusive or measure the exact influences of Smart Mobility on CO_2 emissions.

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Appendices

Appendix I – Informed consent interviews

Concerns: Bachelor Thesis | This research aims at investigating to what extent the implementation of the Smart Mobility Action Program has influenced the air quality and the perception of local citizens towards Smart Mobility in the city of Amsterdam.

Hereby I declare to have been informed clearly about the nature, method and aim of the research project.

I understand that:
O I can stop my cooperation to this research at any moment and without giving a reason.
O Data will be processed anonymously, without being traceable to the person.
O The voice-recording will be destroyed after elaboration of the interview.

I declare that I:
O Join this research project completely voluntary.
O Allow the results of this interview to be used in a report or scientific publication.
O Grant permission to record this interview by way of a voice-record on a mobile phone.

Signature: ……

Name: ……..

Date: …….

Researcher: I gave verbal explanation about the nature, method and aim of the research project. I declare myself as being prepared to answer up-and-coming questions properly.

Signature: ……

Name: ……..

Date: …….

Appendix II – Interview guides

Interview Guide Expert 1

Introduction	Thank for participating in the interview.
Introduce myself	Last year student of BSc Spatial Planning & Design at the Rijksuniversiteit Groningen.
Topic	Bachelor thesis about effectiveness of smart mobility interventions in Amsterdam regarding the trend in CO_2 emissions and the perception of local citizens
Goal of research	With this in-depth interview, I would like to gain more insight on the smart mobility interventions that are related to the reduction of CO_2 emissions and what the organization is aiming to achieve with regards to the reduction of CO_2 emissions through smart mobility.
Anonymity	Emphasize that everything said will be anonymous and cannot be traced back to interviewee. The information will only be used for educational purposes
Consent	Inform that this interview will be recorded in order to examine it further, after it has taken place. Before we begin, ask to get voluntary permission to document the conversation → sign informed consent
*start recording	
Permission	Ask again for permission
Introducing questions	
	What is your current position and expertise?
	How long have you been working for the municipality?
	- How long have you been working on this program? - What motivated you to work on this action program? - Have you worked on a related project before?
In-depth questions with sub-questions	
1	Which interventions from the Smart Mobility Action Program 2016-2018 could potentially contribute to reducing CO_2 emissions?
a	Are there any interventions implemented that were not incorporated in the action program? If yes, what are they?
b	When did the implementation of the SMAP started? And when did it end? Or is it planned to end?
c	What are the results from the interventions so far?
d	How succesfull are the interventions overall?
2	What is the role of the SMAP with regards to achieving the climate goals of the municipality?
a	What are the guidelines regarding the energy that is used for electric (smart) mobility?
b	How can ICT & Technology play a role in improving the electric charging network?
c	How could the implementations be improved overall?
Closing questions	
Finishing	Remark end of the interview is near
Additional remarks	Is there anything left to add or discuss?
Last remarks	
Thanking	Thank for time and participation in this interview
*stop recording	
What happens next?	Tell what will happen next with the recordings. That it will be typed out and compared with the other interview and that it will lead to a research paper where I aim

	to illustrate the trend in CO_2 emissions and describe the perception of local citizens towards Smart Mobility in Amsterdam.
Contact information	Inform that I will be available to contact and that interviewee could get the final product of the research.

Interview Guide Expert 2

Introduction	Thank for participating in the interview.
Introduce myself	Last year student of BSc Spatial Planning & Design at the Rijksuniversiteit Groningen.
Topic	Bachelor thesis about effectiveness of smart mobility interventions in Amsterdam regarding the trend in CO_2 emissions and the perception of local citizens
Goal of research	With this in-depth interview, I would like to gain more insight on the complete picture from the municipality regarding CO_2 emissions and the role of Smart Mobility in this issue.
Anonymity	Emphasize that everything said will be anonymous and cannot be traced back to interviewee. The information will only be used for educational purposes
Consent	Inform that this interview will be recorded in order to examine it further, after it has taken place. Before we begin, ask to get voluntary permission to document the conversation → sign informed consent
*start recording	
Permission	Ask again for permission
Introducing questions	
1	What is your expertise and current position?
2	How long have you been working for the municipality?
3	How long have you been working on this specific program?
4	What motivated you to work on this program?
In-depth questions / main questions	
1	What are the goals of the municipality with regards to the CO_2 emission through road traffic in the city of Amsterdam?
a	How is the current trend in CO_2 emissions through road traffic?
b	What is the role of Smart Mobility in this trend and in specific the Smart Mobility Action Program 2016-2018?
c	What are the developments regarding the use of smart mobility modes in the city?
2	What is the effect of the CO_2 reduction on the city in general?
a	What are the guidelines with regards to the use of green energy for the electric charging station network?
Closing questions	
Finishing	Remark end of the interview is near
Additional remarks	Is there anything left to add or discuss?
Last remarks	
Thanking	Thank for time and participation in this interview
*stop recording	
What happens next?	Tell what will happen next with the recordings. That it will be typed out and compared with the other interview and that it will lead to a research paper where I aim to illustrate the trend in CO_2 emissions and describe the perception of local citizens towards Smart Mobility in Amsterdam.

Contact information	Inform that I will be available to contact and that interviewee could get the final product of the research.

Interview Guide Citizens

Introduction	Thank for participating in the interview.
Introduce myself	Last year student of BSc Spatial Planning & Design at the Rijksuniversiteit Groningen.
Topic	Bachelor thesis about effectiveness of smart mobility interventions in Amsterdam regarding the trend in CO_2 emissions and the perception of local citizens
Goal of research	With this in-depth interview, I would like to gain more insight on the perception that local citizens have towards Smart Mobility in the city of Amsterdam.
Anonymity	Emphasize that everything said will be anonymous and cannot be traced back to interviewee. The information will only be used for educational purposes
Consent	Inform that this interview will be recorded in order to examine it further, after it has taken place. Before we begin, ask to get voluntary permission to document the conversation → sign informed consent
*start recording	
Permission	Ask again for permission
Introducing questions	
1	If I may ask, how old are you?
2	How long have you been living in the city?
3	What is your current occupation?
4	To what extent are you familiar with the concept of Smart Mobility?
In-depth questions / main questions	
1	*describe interventions → What do you think of these interventions?
a	Are you currently making use of one them? If not, would you be willing to?
b	What do you think of the accessibility to these interventions? How could they be made more accessible?
c	What is your motive or what would be your motive to make use of these interventions?
d	What would you think of the idea of to sit in a self-driving car?
2	What have you noticed or considered striking in the cities' mobility over the past few years?
a	Is there a certain aspect in the cities' mobility that you think should be improved?
b	How have you been informed about changes over the past few years? Or how could this communication be improved?
Closing questions	
Finishing	Remark end of the interview is near
Additional remarks	Is there anything left to add or discuss?
Last remarks	
Thanking	Thank for time and participation in this interview
*stop recording	
What happens next?	Tell what will happen next with the recordings. That it will be typed out and compared with the other interview and that it will lead to a research paper where I aim to illustrate the trend in CO_2 emissions and describe the perception of local citizens towards Smart Mobility in Amsterdam.
Contact information	Inform that I will be available to contact and that interviewee could get the final product of the research.

Appendix III – CO2 emissions from passenger cars and two-wheelers

CO2 emissions from passenger cars and two-wheelers within municipality of Amsterdam between 2014-2017				
	2014	**2015**	**2016**	**2017**
Inside built-up area passenger car (gasoline)	164.510	172.199	178.094	180.771
Inside built-up area w/ passenger car (diesel)	43.712	45.204	44.742	44.245
Inside built-up area w/ passenger car (lpg)	4.759	4.718	4.332	3.906
Inside built-up area w/two-wheeler	9.030	8.239	8.266	8.513
Outside built-up area w/ passenger car (gasoline)	37.212	53.723	55.451	55.828
Outside built-up area w/ passenger car (diesel)	13.636	19.720	19.589	19.656
Outside built-up area w/passenger car (lpg)	1.759	2.438	2.260	2.033
Outside built-up area w/ two-wheeler	1.755	2.389	2.404	2.326
Highway w/ passenger car (benzine)	134.217	120.157	123.063	124.924
Highway w/ passenger car (diesel)	79.396	71.151	71.190	68.361
Highway w/ passenger car (lpg)	6.579	5.468	4.911	4.359
Highway w/ two-wheeler	3.352	2.963	2.985	2.719
Total	499.917	508.368	517.286	517.641

Unit tons

Appendix IV – Population sizes in the city of Amsterdam

		Bevolking
Regio's		Bevolkingssamenstelling op 1 januari
		Totale bevolking
Perioden		aantal
Amsterdam	2015	821 752
	2016	833 624
	2017	844 947
	2018	854 047

Bron: CBS