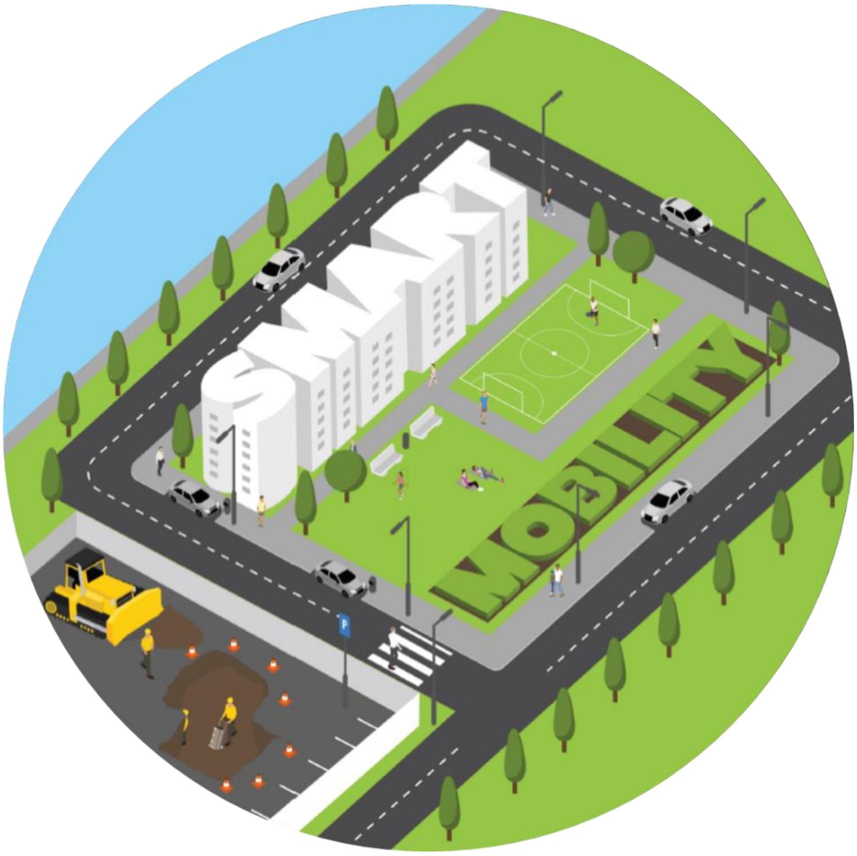
Smart mobility: a strategic solution in urban development

Master Thesis

MSc CONSTRUCTION MANAGEMENT AND ENGINEERING



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Graduation Thesis | CME 2001

MSc Construction Management and Engineering

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March 16, 2018

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GRADUATION THESIS

University	Delft University of Technology
Faculty	Civil Engineering and Geosciences (CiTG)
Master	Construction Management and Engineering (CME)
Course	CME 2001 Master Thesis Preparation and CME 2000 Graduation Thesis

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Figure 1 Transformation into green meeting area. Reprinted from Green envelope, by Arup, 2016

Preface

The start of this master thesis, and especially the chosen subject, came relatively accidentally for me. After two months as a working student at the Real Estate and Partnerships department of Deloitte, I was asked by one of my colleagues if I wanted to help with a research on the effects of smart mobility. After several brainstorm sessions deciding what would be the focus of the research, we chose a scope and topic. I was immediately hooked. Sustainable transport modes and the possible solutions it can offer for challenges in our society were always topics I was really interested in. Therefore, I asked the responsible partner of Deloitte, Frank ten Have, if I could turn the research into my graduation thesis. Luckily, he accepted.

I'm very glad that I had the opportunity to do this research. First of all, it has widened my view on many different aspects. Before this research I found plans to completely ban cars in inner cities too resolute. However, I support these kind of views now more and more. Working on my master thesis not only helped me to broaden my view on society, it also gave me the chance to develop my professional skills. I learned new software, Python and Tableau, and learned how to successfully plan and manage such a research. This will be useful in many different ways.

First, I want to thank Frank Ten Have to give me the opportunity to conduct my master thesis at Deloitte. Although I hadn't worked very long at the Real Estate department, he still gave me the trust and chance to do this research. Furthermore, I want to give special thanks to Wouter de Wit from Deloitte for his guidance. Wouter showed always willing to make time for me and to help me out during difficult parts of the research. It's been very pleasant working together with Wouter. Also, I would like to thank my other colleagues for the always positive and fun working environment they welcomed me in.

Furthermore, I would like to thank all my supervisors, Rients Dijkstra, Jan Anne Annema, and Pablo Nunez Velasco for their ever positive and enthusiastic guidance. The meetings, during which everyone always wanted to be present, and the discussions have helped me greatly structuring and conducting my research. Your sharp and substantiated comments were always very helpful in reflecting and improving my research. Lastly, I would like to thank all the people whom I had the opportunity to interview. Thank you for making time for me, and thank you for the valuable insights.

Figure 2 Transformation into meeting area. Reprinted from www.contemporist.com

Summary

Shared and autonomous vehicles provide municipalities with a strategic solution in urban development. Smart mobility can be a game changer in realizing the ambitions of a safe, livable, sustainable, and attractive city. Former policies on mobility however have resulted in long term undesirable effects. This increases the urgency for municipalities to already consider the spatial implications of smart mobility. A lot of research has been carried out already on the effects of smart mobility, but these focus only on first order local effects. To the best of the authors knowledge, no literature exists on how, where and if the effects of smart mobility can be used for the restructuring and transformation challenges of the public space. The main question of this research is:

"To what extent can autonomous and shared mobility contribute to the restructuring and transformation of the public space and help to achieve a region's public ambitions, taking into account the different mobility scenarios?"

To answer the research question, both a quantitative and qualitative approach were used. First a conceptual model was developed using existing literature and findings out of the expert interviews. Secondly, the conceptual model was used to develop a mathematic model in the programming language Python. The Python model helped to analyze several large datasets for the different scenarios. Subsequently, the Python output was visualized in Tableau. Tableau helped to analyze and discuss the different research questions. It was found that smart mobility can, depending on the scenario, result in a reduction of parking capacity between 0% and 88%. This bandwidth depends on the market share of shared and autonomous mobility, as well as on the change in extra kilometers traveled, the replacement ratio of shared vehicles, and the reduction of the parking footprint per scenario. The reduction in parking capacity results in freed up space, which can be transformed into a new function and contribute to the restructuring and transformation of the public space. How and to what extent smart mobility can contribute depends on the location and type of parking, the dynamics of the housing stock, and the policy of the government. In urban areas with a dynamic housing stock and a relatively large capacity of the different types of parking, smart mobility can contribute the most to both the development of new houses and the improvement of the public space. It can furthermore help to increase the housing density in urban areas, which has a beneficial effect on car use. In more rural areas, where the housing dynamic is lower and where mostly street parking is available, smart mobility can only contribute to the improvement of the public space and the attractiveness of the region. Smart mobility has shown to have an indirect effect on the economic, health, social, environmental, and ecological spatial value. How the maximum spatial value can be realized during a restructuring and transformation challenge, will depend on the ambitions of the municipality, the characteristics of an area, but moreover on the governance of the government. In order to realize the maximum effect, it should dare to significantly change its parking policies, while

acting as a facilitator for smart mobility, in which it solves legal and trust issues, enables innovation and acts as partner in new mobility businesses.

The research discusses several important limitations, regarding the method and model. These need to be taken into account to avoid misjudgments and over-generalization of the results. The limitations regard the scope, the selection of the experts, the chosen municipality for the deep dive analysis, the sensitivity of the transition variables, and the assumptions that had to be made in order to do the analysis. These limitations give grounds for the recommendation for further research. The effect of smart mobility on the road network was set outside the boundaries of this research, however it is expected that it will affect the public space. It is recommended that further studies will be performed on these effects related to transformation and restructuring challenges. Furthermore, it is recommended that future research will analyze the effects on private parking. Also, to reduce the uncertainty that exists with the transition variables extra kilometers traveled and the replacement ratio, it is recommended that further research is conducted on both topics. Finally, it is recommended that the possible increase of the housing density is further analyzed.

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Figure 3 Transformation into public area. Reprinted from www.contemporist.com

Content

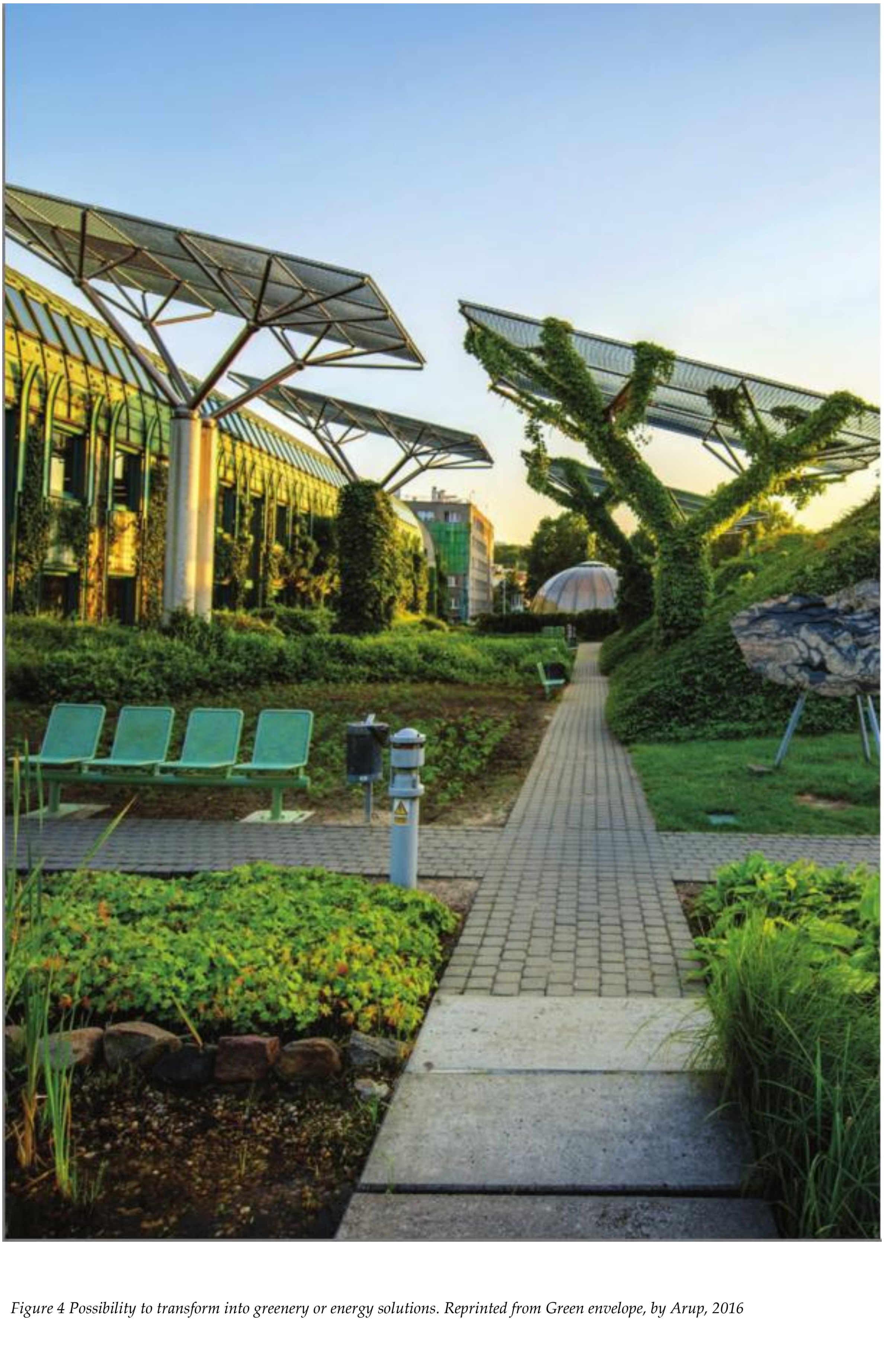

Figure 4 Possibility to transform into greenery or energy solutions. Reprinted from Green envelope, by Arup, 2016

1.0 Introduction

1.1 The research context

Since the mid-1980's, most of the Dutch cities have been increasingly afflicted by spatial issues caused by urban growth (Groenemeijer, 2014). Since that moment, technological innovations like the internet and cellphones, but also current innovations as smart mobility have been continuously introduced in our society. These technological developments have given municipalities the opportunity to actively search for innovative solutions to help them accommodate the urban growth and to minimize its negative impacts; in other words, solutions that can facilitate the ambition of a safe, livable, sustainable, and attractive city.

Smart mobility is one of the recently introduced technological developments, which is said to be one of the strategic options that can help municipalities with smart and spatial solutions within the existing building area (Docherty, Marsden, & Anable, 2017). Solutions within the existing building area are especially important, because the current problems within the city are mainly caused by a lack of public space capacity. Due to a lack of building capacity, the housing market experiences a shortage of affordable housing, mainly in the free rental sector, which affect the middle incomes (DNB, 2017) especially. Due to the capacity constraints on urban road networks, mobility experiences also huge problems. In the following 5 years it is expected that congestion will double in many Dutch cities, on highways an increase of 38 percent is expected, and in inner-cities traffic is expected to double in intensity (CROW, 2016). In economic terms, the current traffic in cities causes an economic loss of approximately 840 million euros. Due to the doubling of the delays in the year 2021, economic damage can reach almost 1.7 billion euros (CROW, 2016).

The challenges and problems municipalities are currently facing, were caused by the policy of the 1980's to steer on urban growth. Policy on spatial planning, urban renewal, urban design and regional governance therefore show to be of great importance to the development of cities (Groenemeijer, 2014). How the effects of smart mobility will affect our society is strongly depended on the policy of the government. Hence, municipalities should already consider the spatial implications of smart mobility if they want to accommodate the transition of smart mobility in their policies (Docherty, Marsden, & Anable, 2017).

1.2 The problem statement

Developing a future proof policy that can integrate both smart mobility and spatial planning is still very complicated. This is caused by the high level of uncertainty smart mobility has. Smart mobility concepts as car sharing and autonomous vehicles are both in the early phase of its development, and still very precarious. Implementation issues, the moment of introduction, the course of change, use and adaptation speed, as well as the effects and implications are still very uncertain.

On the implementation issues, several researches and forecasts have been conducted, but these show a significant bandwidth. Mckinsey expects that, depending on technical, infrastructure, and regulatory challenges, up to 15% of all new vehicles sold in 2030 could be fully autonomous (Mckinsey, 2016). This percentage is verified by a research of Deloitte, which expects around 17% of all vehicles solid in 2030 to be autonomous (Corwin, Jameson, Pankratz, & Willigmann, 2016). Deloitte furthermore expects that 10% of the km's driven in 2025 will be shared (Chase, 2016), while a Morgan Stanley report shows 12% shared km's in 2025 (Morgan Stanley, 2016). According to a research on the development of autonomous vehicles, it is estimated that market introduction will take place between 2018 and 2020 for conditional automation on freeways and between 2027 and 2035 for full automation (Milakis et al., 2017). However, the course of change and the speed at which both smart mobility concepts will be adopted in society is still undetermined and depends on many elements. On the course of change, Deloitte has divided four possible future states of mobility, see Figure 1. These scenarios are according to Deloitte likely to arise unevenly and exist simultaneously, divided over different regions. Because a high level of uncertainty exists on the implementation side of smart mobility, the four scenarios can be used to analyze the effects of smart mobility that could arise in different future states.

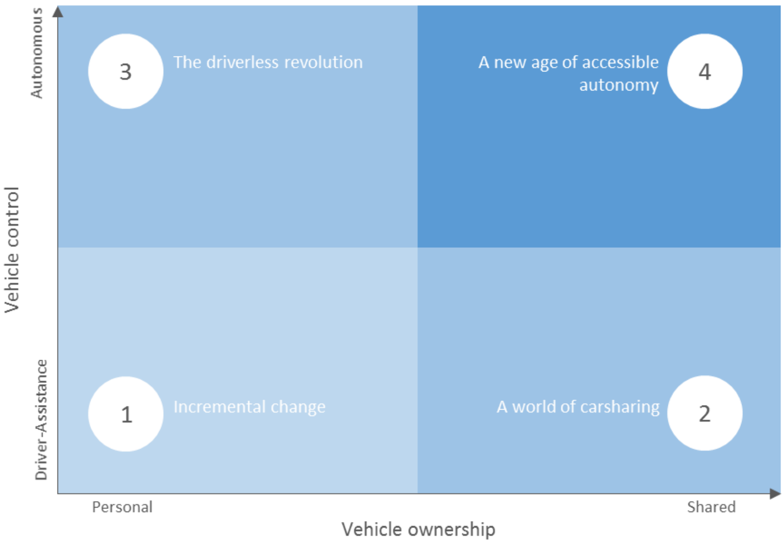

Figure 5 Four state of mobility. Source: Deloitte (2017)

As for the effects of smart mobility, although many uncertainties exists on how quickly the effects will be visible, almost all researches are certain that these concepts will impact society as we know. A shift away from personally owned driver-driven vehicles and toward autonomous and shared mobility is expected (Chase, 2016). Changes will be visible in spatial use, the environment, car ownership, and the use of transport modes (KiM Netherlands Institute for Transport Policy Analysis, 2015a). As stated earlier, municipalities are mostly constrained by the availability of space in conducting their policies. Regarding that issue, especially the spatial effects of smart mobility are important to know and understand. Many researches on shared and autonomous mobility have been carried out already. By using Google scholar, Scopus, Researchgate, and the TU Delft library with the search terms *spatial impact smart mobility*, *benefits/advantages of smart mobility*, *spatial impact shared vehicles/AV*, effects *of smart mobility*, *effects of car sharing/AV*, *restructuring possibilities smart mobility*, *affected space car sharing/AV*, and *effect public space smart mobility* a lot of background information can be found, as later will be shown in Chapter 3. The majority of these researches focus on the possible effects on car-ownership, parking demand, transport planning, environmental effects, and consumer behavior. They indicate possible benefits and impacts, based on a wide variety of empirical studies. However, the findings of these studies are mainly focused on an individual consumer level and on first order effects, and, to the best of the authors knowledge, no literature is available on what these individual effects would mean for second order effects on a larger scale, namely the public space, let alone if this differs per location and over time. In addition, especially the change in parking demand is mentioned to have a significant spatial impact (KiM Netherlands Institute for Transport Policy Analysis, 2015a). However, the existing literature does not clearly distinguish if these parking effects are different per location and per type of parking, nor does it address the feasibility of a parking transition. It can be concluded that literature on large scale both quantitative and qualitative impacts is lacking. Despite its huge prospect, the exploration of the potential of smart mobility for the public space is not addressed for the present, nor for future scenarios.

1.3 The research question

The regional potential that smart mobility can offer, is important for municipalities to include in their policies. It should be known if and where the effects of smart mobility will become visible. If the potential is known and understood, there can be looked at how this can be combined with existing restructuring/transformation measures to achieve government ambitions in the area of accessibility, quality of the living environment, safety and economy (Nabielek, Boschman, Harbers, Piek, & Vlonk, 2012). To achieve the ambitions in a successful and balanced way, it is also important to look how by smart mobility affected area can be improved in terms of spatial value. Different spatial functions, have different effects on the surrounding area. This effect could be a monetarized effect, but could also be a social coherence effect. It is important to understand how the spatial value can change, and how it can be used to achieve the public ambitions.

This study aims to contribute to the existing scientific knowledge by researching if smart mobility has a spatial potential, where the potential will become visible, and what determines both. For this research it will make use of the different mobility scenarios from Figure 5. If the potential of smart mobility is known and per scenario indicated, it can be used for the restructuring and transformation of the public space. Knowledge in the complex interaction between smart mobility and the restructuring/transformation challenges is very valuable for governments in times of a high pressure on the limited space. The study will help governments to reconsider their policy and to develop a future proof one that strengthens the region.

The research will be performed using the following research question, followed by the sub research questions:

"To what extent can autonomous and shared mobility contribute to the restructuring and transformation of the public space and help to achieve a region's public ambitions, taking into account the different mobility future scenarios?"

"How does autonomous and shared mobility affect the current used space within the existing building area, taking into account the different mobility future scenarios?"

"How does autonomous and shared mobility affect the spatial value, taking into account the different mobility future scenarios?"

"How can the potential affected space be utilized and help to achieve the public ambitions of a municipality, taking into account the different mobility future scenarios?"

1.4 Scope of the research

The research questions could relate to many different subjects, locations, theories and suchlike. Due to a time constrain, it is not possible to do a research on all of the effects of smart mobility. It is important to set the scope of the research.

This research focuses on the possible effects of smart mobility in Dutch municipalities. The Netherlands has been chosen mainly because of the data availability. Furthermore, this research is conducted for Deloitte the Netherlands, which will use the results for their local office in Amsterdam.

This research will be conducted on both a national and municipality level. For the municipality analysis, Amsterdam is the chosen municipality. The main reason to choose Amsterdam is that this municipality was able to provide more usable data than other municipalities. It is chosen to do a municipality analysis, because it is important to understand if the effects of smart mobility differ on a neighborhood level and affect the restructuring and transformation potential. Those are important understandings a municipality must have in order to develop a successful policy.

In this research smart mobility is defined as autonomous and shared mobility. In other literature smart mobility contains also other sorts of mobility, but this research will only focus on the effects of autonomous and shared mobility, as these mobility forms are currently expected to have the biggest impact on public space (OECD, 2016). Other smart mobility developments, like the Hyperloop, will also affect public space, but this will mainly have an impact between cities, not solely on space within cities itself.

Shared and autonomous vehicles are expected to have many different effects on society, e.g. on the road network, road footprint, and home-location preferences. However, this research will only focus on the effects of smart mobility on parking demand and on space related to the restructuring and transformation possibilities within the existing building area. This focus has been chosen, because the biggest knowledge gap exists between the effects of smart mobility and the restructuring and transformation challenges. Another reason for this scope it the fact that it is better aligned with the master track. Furthermore, it will be explained how these effects can help in solving the spatial challenges that exists within the municipalities. A final boundary of this research is that only public parking spaces will be included. This focus has been chosen, because it are the only parking spaces municipalities can affect directly, and only data exists on public parking spaces.

1.5 Structure of report

Now that the research direction and scope have been determined, the research approach will be discussed. This can be found in Chapter 2. After the research design, the literature study and the conducted expert interviews will be discussed in Chapter 3. This will help to identify and assess the background knowledge that already exists on the subject. This will be used to develop the conceptual model in Chapter 4. In Chapter 5, the conceptual model will be translated into a mathematic model. The results of this model, will be given in Chapter 6. Chapter 7 will discuss the results, and Chapter 8 will give the conclusion. Chapter 9 will discuss the recommendations and limitations.

Figure 6 Park let transformed into playground. Reprinted from: www.slowottawa.ca

2. Research design

The research design will be discussed in this chapter. The chosen design will help to answer the research question: *"To what extent can autonomous and shared mobility contribute to the restructuring and transformation of the public space and help to achieve a region's public ambitions, taking into account the different mobility future scenarios?"*.

This research was conducted with both a quantitative and qualitative approach. A qualitative approach was used to gather data and background information, but also to validate the quantitative research phases. As can be seen in Figure 7, this research exists of six research phases. Within these phases, several research activities exist. Each of the research phases will be described below.

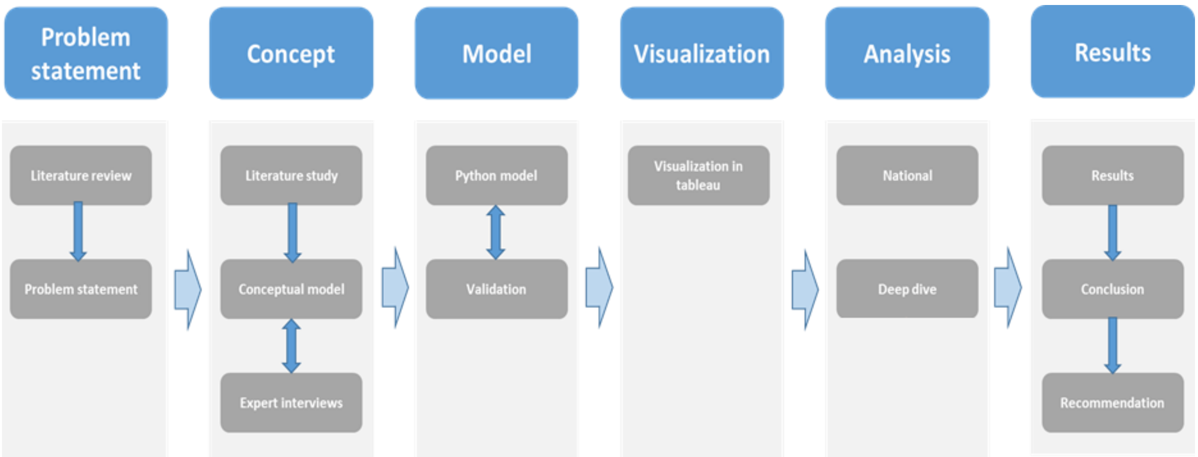

Figure 7 Research phases (Own illustration)

2.1 Diagnosis

2.1.1 Literature review

The first step in this research was the literature review. This activity was done to identify the knowledge gap that existed on this subject. For this review the following sources were used;

- TU Delft online library
- Researchgate
- Scopus
- Google Scholar
- Deloitte internal database

In Appendix I, a list of all the search terms can be found. The period of search is between 10/08/17 and 23/10/17. Searches are carried out in Dutch and English, see Appendix I for a complete list.

2.2.2 Problem statement

After the literature review, the knowledge gap became clear. This knowledge gap could then be translated into a problem statement and corresponding research questions. These are the research questions discussed in Chapter 1.

2.2 Concept

2.2.1 Literature study

After defining the problem statement, the boundaries and directions for this research were set. The next step was to develop the theoretical framework. This helped to determine what important theories, background information, and other knowledge existed on the research subject. The literature study was conducted in a similar way as the literature review, but more specific search terms were used. These search terms are given per research question in Chapter 3, but can also be found in Appendix I. After the literature study, the most important theories and variables that affect or are affected by smart mobility were identified. These could then be used to develop a conceptual model.

2.2.2 Conceptual model

The conceptual model is an important communication tool. It helps describing aspects of the physical and social world around us in order to communicate and represent it to others (Mylopoulos, 1992). The conceptual modelling technique was used to identify the most important relations between the different variables identified in the literature study. These formed the first conceptual model, which was used to discuss the relations during the expert interviews. During these interviews, new relations and variables were identified. These findings were used to adapt the conceptual model iteratively. After the identification of the most important variables and relations, a final conceptual model was developed. This model was used to develop a mathematic model, which performed the quantitative analysis.

2.2.3 Expert interviews

As mentioned, the conceptual model was discussed during several expert interviews. The interviews were used to validate the initial relations and theories, but also to add new knowledge. The experts existed of stakeholders, critics and knowledge institutions, see Table 1. The selection was done as broad as possible in order to collect as much viewings and knowledge on the subject as possible. All experts represented institutions or companies that are actively dealing with smart mobility. The contacted experts were either the spokesperson of the company, or were the people that could tell most about smart mobility related to parking and public space challenges. The abbreviated interview reports can be found in Appendix IV.

Table 1 Interviewed experts

Organization	Interviewee	Type
TU Eindhoven	Auke Hoekstra	Knowledge institution
TNO	Erik de Romph	Knowledge institution
CROW	Marco van Burgsteden	Knowledge institution
RDW	Kees Oudendijk	Knowledge institution
Car2go	Robert Bosman	Stakeholder
Qpark	Sacha Oerlemans	Stakeholder
ANWB	Ronald de Jong	Knowledge institution
Spark	Ed van Savooyen	Critic
De Natuurlijke stad	Walter Dresscher	Critic
Vrije Universiteit	Jos van Ommeren	Knowledge institution
Snappcar	Aron Rigo	Stakeholder
Gemeente Amsterdam	Evelien van der Molen	Stakeholder

2.3 Model

2.3.1 Python

After the identification of the most important variables and the relations between them, the mathematic model was developed. The mathematic model was used to analyze the current situation and possible scenarios. The chosen research tool for the mathematic model is Python. Python is a powerful high-level, object-oriented programming language with a simple easy-to-use syntax (Swaroop). The characteristics of this research, a complex dataset with many different calculation steps, and many different parameter scenarios, make Python the most suitable research tool. The structure of the model exists of transition rate scenarios as input, variables that can be changed by the input, and an output. Each will be discussed briefly.

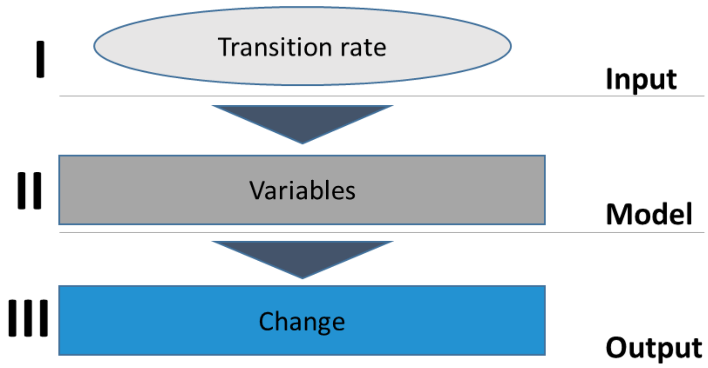

Figure 8 Python model structure (Own illustration)

2.3.2 Input

Figure 9 shows how the input of the Python model, number I in Figure 8, was calculated. The input of the model exists of many different interrelated variables with a lot of uncertainty. In order to incorporate this uncertainty, this research has used a scenario analysis, similar to the future states of Deloitte mentioned in Chapter 1. In total four scenarios are used. For each scenario a different division of market shares per mobility type is given. These market shares affect the scenario variables. The scenario variables are the most important variables that together determine the total parking demand. If these variables change, the total parking demand will change. This results in a transition rate of parking. In total, four different transition rates were used as an input for the Python model. The division of the market shares, the variables that change per scenario, and the different transition rates will be discussed in Chapter 5. A flow chart of the determination of the transition rate can be found in Appendix II.

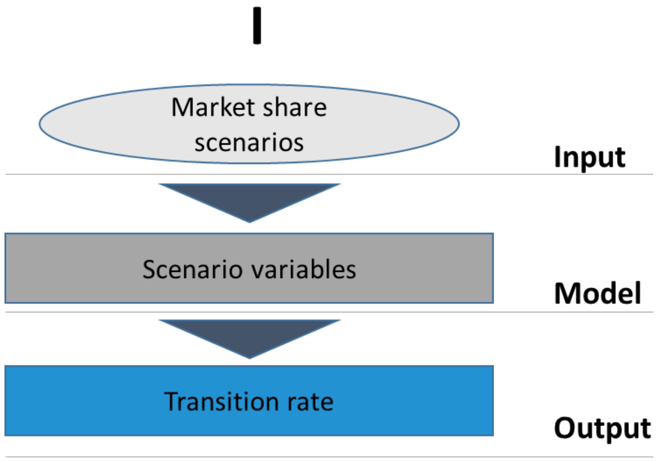

Figure 9 Element I of the Python model (Own illustration)

2.3.3 Model

The transition rates will directly and indirectly affect several variables within the Python model. Figure 10 shows a simplified structure of element II of the Python model. The transition rate will affect the total parking spaces, which will affect the total utilized space for parking. Figure 10 is strongly simplified, but a complete flowchart can be found in Appendix III. The Python calculation code is given in Appendix XIV.

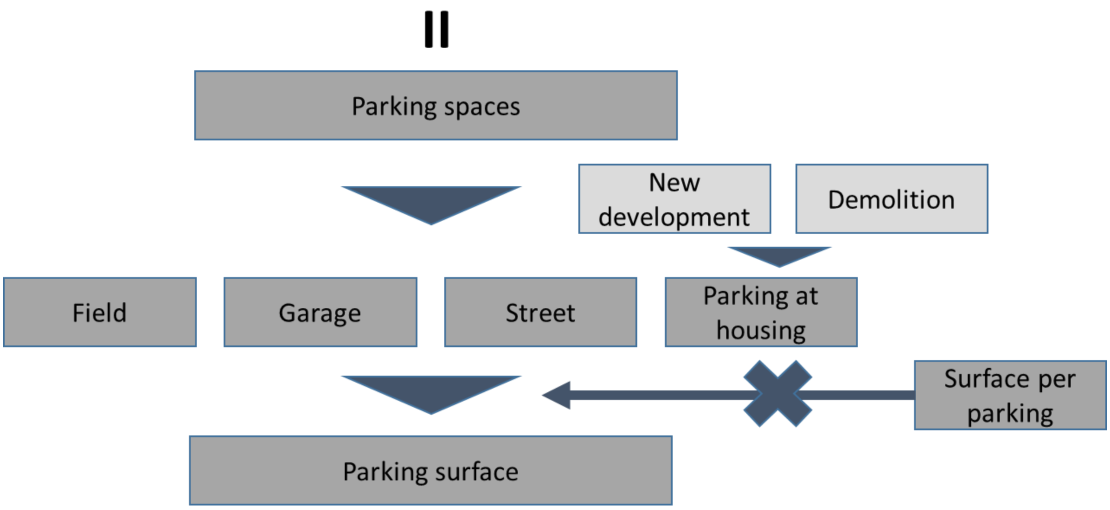

Figure 10 Element II of the Python model (Own illustration)

For each of the variables in element II data was collected. The data collection approach for the Python model can be divided into primary and secondary data collecting. The primary data collecting exists of interviews and the secondary data collecting exists of previous research, official statistics, reports, web information and historical data. Important sources were:

- CBS
- Primos
- RDW
- CROW
- SPARK
- PBL
- Parking reports of municipalities
- Forecasts and reports from consultancy researches

The data can be furthermore divided into data for the current situation, and data for future developments. Data for the current situation came from CBS mainly. This makes it suitable and reliable to use. All CBS data is from 2012 and above, which makes it up to date as no significant changes have taken place. Data for future projections was collected from Primos and PBL. Primos gives forecasts on the population and household developments per municipality, as well as on the housing stock. Primos is a reliable and up to date source, which is also used by the government. The data from PBL provides forecasts on total driven kilometers in the Netherlands up to 2050. This is also used by the government, and can be seen as a reliable source. In Chapter 5 all the different variables of the model and related sources will be discussed.

Deep dive data

For the deep dive analysis, more specific data was necessary than for the national analysis. For the housing development plans, data provided by RIGO Research (RIGO Research en advies, 2017) was used. The data on new development plans is accurate, up to date, and divided per neighborhood, which makes it suitable to use. On the housing demolition plans, average area percentages provided by the municipality of Amsterdam were used (Gemeente Amsterdam, 2017). These percentages were then multiplied by the housing stock in that neighborhood to calculate the total demolition plans per neighborhood. The municipality of Amsterdam provided the total amount of street parking per part of the city (Gemeente Amsterdam, 2016). To calculate the amount per neighborhood, the cars per household, amount of households, and ratio cars over parking were multiplied. For the built facilities and field parking capacities, an assessment was done which facilities existed and where they were located. This assessment was done using the websites www.parkopedia.nl and www.parkeren-amsterdam.com.

2.3.4 Output

The final element of the Python model is shown in Figure 11. The variables in the model are changed by a transition scenario, which results in a different total parking surface and in space freed up for new functions. Not every parking surface is the same, as different type of parking results in different types of surfaces. It is assumed that two types of space can become available: space suitable for all functions, and space suitable for only limited functions. The major difference between these two options is that the space suitable for all functions is big enough to develop buildings on it, while the space suitable for limited functions are often smaller size and odd size plots, which makes it unsuitable for buildings. It is assumed that only parking at built facilities, on fields, and at housing developments can be used for all functions. Parking spaces along the street, which are not related to housing developments, can only be used for limited functions. In Appendix III the flowchart can be found that results in the output.

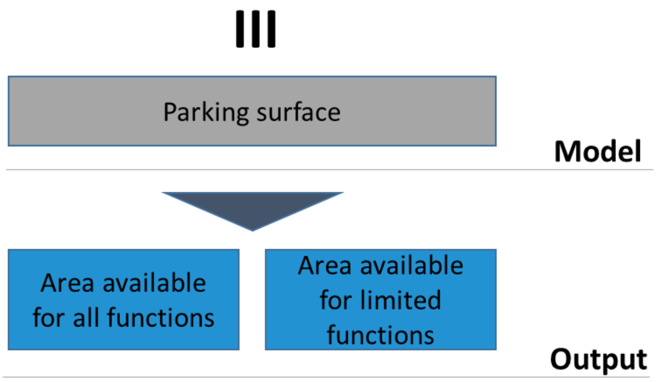

Figure 11 Element III of the Python model (Own illustration)

2.3.5 Validation of the model

The model and the code itself were validated by two different persons of Deloitte. This helped to reduce the chance of errors in the programming language. Furthermore, it was important to check whether the model output was in line with what could be expected. The output for the current situation was validated with parking reports of several municipalities. Because a lot of uncertainty exists with the different transition scenarios, a sensitivity analysis was done. This helped to assess which variables could strongly affect the transition rate if unexpected events would occur. This sensitivity and related uncertainty were important to take into account in the conclusion phase. The output of the sensitivity analysis is discussed in Chapter 5.

2.4 Visualization

When pure data is transformed to visuals, this will help to understand the results and to improve the discussion and analyses possibilities. The output of the Python model has been visualized in Tableau. Tableau is a data visualization software focused on business intelligence. It has the ability to perform complex data visualization in an easy manner. Furthermore, it has the advantage that it includes a mapping functionality, in which latitude and longitude coordinates are connected to spatial files (Tableau, sd). Besides the analyzation possibilities, the visualization step helped to validate the output of the Python model. When certain areas have a relative unexpected outcome, this can indicate that the Python model contained an error.

2.5 Analysis

2.5.1 Analysis Tableau

After the validation and visualization phase, the analysis phase was conducted. The analysis is done on a national level, as well as on a municipality level for the deep dive analysis. A visualization was made for the most important output variables of the Python model, i.e. space for all functions, space for limited functions, and the related variable potential new housing developments. These were then used to analyze the potential spatial effects of smart mobility, and to analyze how these effect were divided over the different locations.

2.5.2 Spatial value analysis

The next step in the analysis phase is the assessment of the effect of smart mobility on the spatial values. The effect on the economic value, health value, ecological/environmental value, and social value was analyzed. The calculation of the effects on all but economic value have a straightforward approach, a change in area use result in a direct effect. What the exact relations are, will be discussed in Chapter 6. However, for the economic value a more challenging approach had to be chosen.

For the calculation of the economic spatial value, two important assumptions were made. The first assumption is about the increase in property value. The property value will increase by the extra availability of public greenery close to the property. However, it is yet unknown where the greenery will be located and which houses will profit from it. Therefore an important calculation assumption was made, see Figure 12. For this assumption data from CBS on the average distance to greenery in a neighborhood was used. If the properties in a neighborhood were already within 300 meters to greenery, the model assumes that extra greenery will not affect the property values. If the properties are outside the 300 meter range, the model looks how many small parks of 9000m2 could be placed on the freed up space for limited functions. It is assumed that every extra park will reduce the average distance to greenery by 0.1km. This reduction is not based on literature, as no information exists on this relation. It is an important assumption that can significantly affect the spatial value. The next step is to reduce the average distance to greenery by the amount of parks that can be placed on the freed up space.

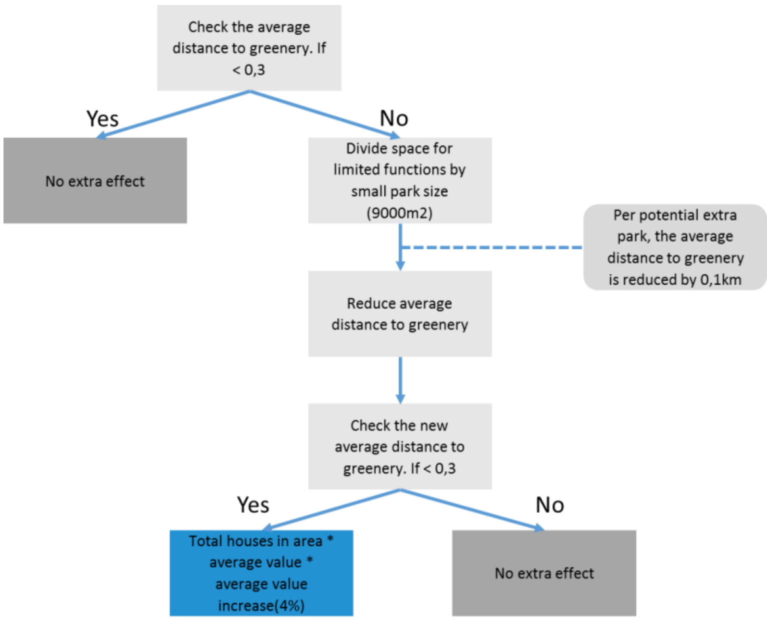

Figure 12 Flowchart calculation effect extra greenery (Own illustration)

If properties are now located within the 300 meter range, the amount of houses that are located in that area are multiplied by the average value and by a value increase of 4%. The bandwidth of possible value increases will be discussed in Chapter 3. For this calculation the lower bound of the increase in property value has been chosen, because this calculation methods is already quite simplified and comes with several uncertainties. After the previous steps, the calculation then results in the economic spatial value by increase in property value. For the calculation of the economic value by extra properties sold, it was also assumed that these properties would have the same average value as the other properties located in that neighborhood. The value is determined by the extra potential houses sold multiplied by the average value in that area.

2.5.3 Spatial function analysis

How the freed up space will be utilized, depends on the ambitions of a municipality. An assessment of the ambitions was done, which will be discussed in Chapter 3. The assessment helped to identify new functions that could support the municipality in realizing its ambitions. The different functions will be discussed in Chapter 6.

2.6 Results

Conclusion, discussion and recommendation

The final step of this research was writing the discussion, conclusion and recommendations. The findings have been discussed, but also the scope, data, and methods were critically assessed. If during the research new or out of scope issues arose, these were included in the recommendations for further research.

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Figure 13 Possibility to transform into relaxation area. Reprinted from Green envelope, by Arup, 2016

3. State of the art

The State of the Art, also known as the Literature study, will be discussed in this chapter. After the identification of the knowledge gap and boundaries of this research, the next step is to develop the theoretical framework. This is important to determine what theories, background information and ideas exist in relation to this research, and to critically assess the existing knowledge. The theoretical framework will furthermore help to form a well-informed and coherent view for the rest of this research, and it will set the base for the conceptual model. Only background information that is related and necessary for the other steps of this research will be discussed. For each of the research questions, the related topics are given below which will help to identify the most important variables and to eventually be able to answer the question.

"How does autonomous and shared mobility affect the current used space within the existing building area, taking into account the different mobility future scenarios?".

An understanding on several topics is necessary to answer this research question, including; the positive and negative effects of smart mobility, the influencing factors of smart mobility, success factors for car sharing and autonomous vehicles, and finally, the forecasts of the market share of smart mobility. These topics will be discussed in Section 3.1 to 3.4 mainly.

"How does autonomous and shared mobility affect the spatial value, taking into account the different mobility future scenarios?".

For this research question the following topics are important; the economic and social value of blue and green in a city, and the valuation of public space. In addition, the cost and location of parking, and the effect of parking requirements on (residential) development and feasibility will be discussed. This will mainly be done in Sections 3.5 to 3.6.

"How can the potential affected space be utilized and help to achieve the public ambitions of a municipality, taking into account the different mobility future scenarios?"

The research question also contains a policy and feasibility part. For this research question the topics are; parking policies, governance of smart mobility, parking (price) elasticity, and market pricing parking. These topics will be discussed in Section 3.4. Finally, also the public ambitions of the municipality of Amsterdam will be identified. These will be discussed in Section 3.7.

The State of the art was complemented with the findings out of the expert interviews. The most important findings will be discussed in Section 3.8. Section 3.9 will give an overview of the most important variables found in both the literature study as the expert interviews.

3.1 Trends in society

Several new trends are visible in our society. All that have a great impact on our values and expectations. The first important trend is the change from ownership to paying for use, also known as the sharing economy. In the sharing economy, one person uses the possessions, facilities or knowledge from another party. This increases the resource efficiency and reduces costs. This shift to the sharing economy has been accelerated by the increasing importance of the information technology. Internet, but also newer concepts like the internet-of-things, facilitate this information exchange (CROW, 2015). Related to smart mobility, the information technology has resulted in digital platforms, which have expanded and diversified the car sharing market (KiM Netherlands Institute for Transport Policy Analysis, 2015a).

A second influencing trend is the change to a more sustainable society. The rise of a more critical, well-educated, creative and more participating society is according to the CROW institute critical in a tilt to a more sustainable society (CROW, 2015). A sustainable society in its turn leads to less car use and ownership. Shared mobility is in such societies seen as a useful substitute for owning a car.

A third trend is the growth of urban areas and the change in transport mode. Urban areas have a fairly good, fine-grained public transport network. In addition, amenities are in urban areas usually nearby. This makes public transport, walking and the bicycle as a frequent used mode in urban areas. The reduction in car use in urban areas is also caused by a younger population. Where former generations worked hard to increase living standards, young people don't value property as the previous genereations. It is far mor important being able to use it when needed (CROW, 2015). This leads to a higher preference towards shared mobility, but also towards mobility as a service.

All three trends indicate that preferences in our society are changing. That makes it important to actively anticipate and react on these changes. The development of autonomous vehicles and the rise of shared vehicles are adherent to these new trends.

3.2 Autonomous vehicles

Autonomous vehicles are categorized on the level of automation. In literature this categorization is divided into six levels: non-automated (level 0), assisted (level 1), partial automation (level 2), conditional automation (level 3), high automation (level 4), and full automation (level 5) (Milakis, Snelder, Van Arem, Van Wee, & De Almeida Correia, 2017). Depending on the level of automation, autonomous vehicles are expected to have an impact on our society as we know. However, the moment when the impact becomes visible is yet uncertain. As mentioned earlier, the range of estimation for market introduction varies between 2018 and 2020 for conditional automation on freeways and between 2027 and 2035 for full automation (Milakis et al., 2017). When the different levels will be implemented depend on different factors, such as the speed of technological developments, the speed at which various barriers are eliminated, government incentives, vehicle life, vehicle purchase costs and subscription costs of necessary services to drive in autonomous vehicles (Litman, 2012). An overview of the most important factors that influence the transition speed will be discussed in Section 3.8.

Many different positive and negative effects of autonomous vehicles are mentioned in the existing literature. The effects of Level 5 are for this research the most important effects to highlight. In level 5, mobility is expected to become a service, which is accessible at any time at any place (KIM, 2017). Full automation will allow for robot taxis that can be called at any moment, so no personal owned cars are necessary. Another important advantage of level 5 autonomous vehicles is that they can optimize the location of day parking, relieving downtown land for other uses (Zakharenko, 2016). Zakharenko shows in his research that the demand for daytime parking will be shifted to the periphery, allowing the increase of the density of economic activity and the rise of downtown land rents. However, he also shows that rent might decline outside of the city center. Zakharenko expects that dedicated parking belts will emerge, where most commuter autonomous vehicles will be day-parked. Regardless the automation level of autonomous vehicles, benefits are an improved efficiency of the vehicle use, reduced vehicle size, reduced per-kilometer cost of commute and reduced greenhouse gas emissions (Greenblatt & Shaheen, 2015). Also the advantage of smaller parking spaces is mentioned, as autonomous vehicles can park themselves. When passengers no longer need to be physically present within the car, this can reduce the needed parking space per vehicle. A recent study shows that driving lanes can become narrower, elevators and staircases at car parks become obsolete, and the required room for opening a vehicle can be eliminated (Nourinejad et al., 2017). In the research of Alessandrini the reduction in space is mentioned to be 75% (Alessandrini, Campagna, Site, Filippi, & Persia, 2015), but the study by Nourinejad and others, shows an average of 60% and a maximum of 90% (Nourinejad et al., 2017).

However, also negative effects of autonomous vehicles are mentioned. Table 2 shows an overview of benefits and problems mentioned in the research of Litman on autonomous vehicles implementation (Litman, 2014). This overview shows the uncertainty that exists on the possible effects of autonomous vehicles. Benefits as reduced cost and increased road capacity are likely to go together with the problems as increased external costs and induced travel.

How the effects of autonomous vehicles will affect our society are strongly depended on the policy of the government. Again, this makes it important to steer in an early stage on the desired outcome. A weak aspect of the existing literature is that they, to the best of the authors knowledge, only look at the effects of autonomous vehicles in general, although the effects are most likely not the same for every location or region. The effects of autonomous vehicles on spatial planning and urban design, other than road and curbside design, are rarely discussed.

Table 2 Benefits and problems of AV as mentioned in Litman's research "Autonomous Vehicle Implementation Predictions,2014"

Benefits ✓	**Costs/Problems** ✗
Reduced driver stress. Reduce the stress of driving and allow motorists to rest and work while traveling.	Increases costs. Requires additional vehicle equipment, services and maintenance, and possibly roadway infrastructure.
Reduced cost. Reduce costs of paid drivers for taxis and commercial transport.	Additional risks. May introduce new risks, such as system failures, be less safe under certain conditions, and encourage road users to take additional risks (offsetting behavior).
Mobility for non-drivers. Provide independent mobility for non-drivers, and therefore reduce the need for motorists to chauffeur non-drivers, and to subsidize public transit.	Security and Privacy concerns. May be used for criminal and terrorist activities (such as bomb delivery), vulnerable to information abuse (hacking), and features such as GPS
Increased safety. May reduce many common accident risks and therefore crash costs and insurance premiums. May reduce high-risk driving, such as when impaired.	Induced vehicle travel and increased external costs. By increasing travel convenience and affordability, autonomous vehicles may induce additional vehicle travel, increasing external costs of parking, crashes and pollution.
Increased road capacity, reduced costs. May allow platooning (vehicle groups traveling close together), narrower lanes, and reduced intersection stops, reducing congestion and roadway costs.	Social equity concerns. May have unfair impacts, for example, by reducing other modes' convenience and safety.
More efficient parking, reduced costs. Can drop off passengers and find a parking space, increasing motorist convenience and reducing total parking costs.	Reduced employment and business activity. Jobs for drivers should decline, and there may be less demand for vehicle repairs due to reduced crash rates.
Supports shared vehicles. Could facilitate car sharing (vehicle rental services that substitute for personal better walking and transit improvements, pricing reforms and vehicle ownership), which can provide various savings.	Misplaced planning emphasis. Focusing on autonomous vehicle solutions may discourage communities from implementing more cost-effective transport solutions such as better walking and transit improvements, pricing reforms and other demand management strategies.
Increase fuel efficiency and reduce pollution. May increase fuel efficiency and reduce pollution emissions	

3.3 Car sharing

The trends in society, as mentioned in Section 3.1, are important trends that enhance car sharing. However, car sharing is currently done by only 90.000 users, representing just 1% of the Dutch potential market (Jorritsma, Harms, & Berveling, 2015). This 1% exists of many different types of car sharing, as the following types can be distinguished: roundtrip car sharing, p2p, oneway car sharing, local communities and business car sharing. All have known an increase in users, but especially p2p has increased significantly. As can be seen in the figure below, p2p has increased from 0 cars in 2012 to 25.000 in 2017. This increase is mainly realized in strongly urbanized regions, as the G4 (KpVV, 2017). How this demand will develop in the future is uncertain, but due to the shifts in society, it is expected to grow.

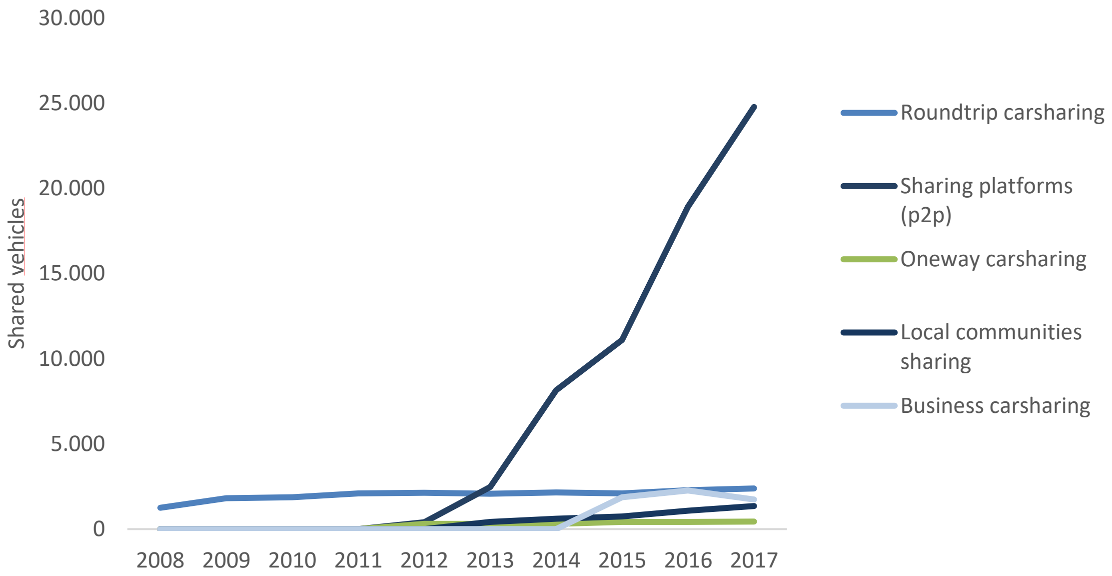

Figure 14 Growth of shared vehicles. (Own illustration)

Deloitte is one of the few that has tried to estimate how the sharing market will develop, and developed a forecast on the US shared and autonomous vehicle market. In their research they assumed that the adoption of shared and self-driven vehicles would follow a similar pattern as other recent technologies, like the adoption of smartphones and the internet (Corwin, Jameson, Pankratz, & Willigmann, 2016). They chose to use these technologies for their research as sufficient information and data was available, but more important, they showed important similarities to the technology of shared and autonomous vehicles. They all have the similarity of being expensive when first introduced, required significant infrastructure investments, and showed strong network effects. However, the research team of Deloitte also shows important differences as the automobile is a fixed capital asset with a low turnover rate. Combining these similarities Deloitte has developed the following forecast, see the figure below.

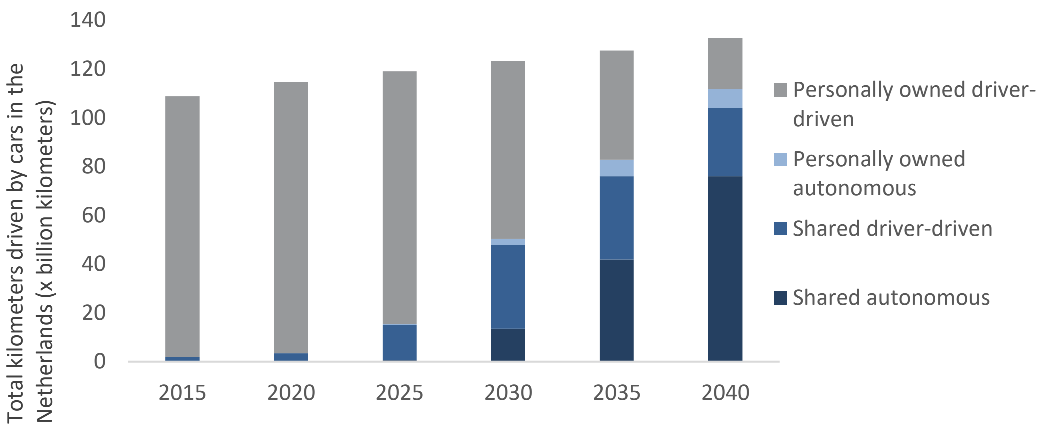

Figure 15 Deloitte expectations transition of mobility. Reprinted from www.deloitte.com

The expected growth as shown by the Deloitte research is in accordance with several other forecasts. They differ in growth rate, but all show an increase, see Figure 16. Although, the different forecasts are done for different markets (US, Europe and globally), it is assumed that they are comparable and all usable for the Dutch market. The European and especially the Dutch car sharing market have a relatively large share (Loose, 2009b; Morgan Stanley, 2016), it can be assumed that they will follow at least the same growth pattern.

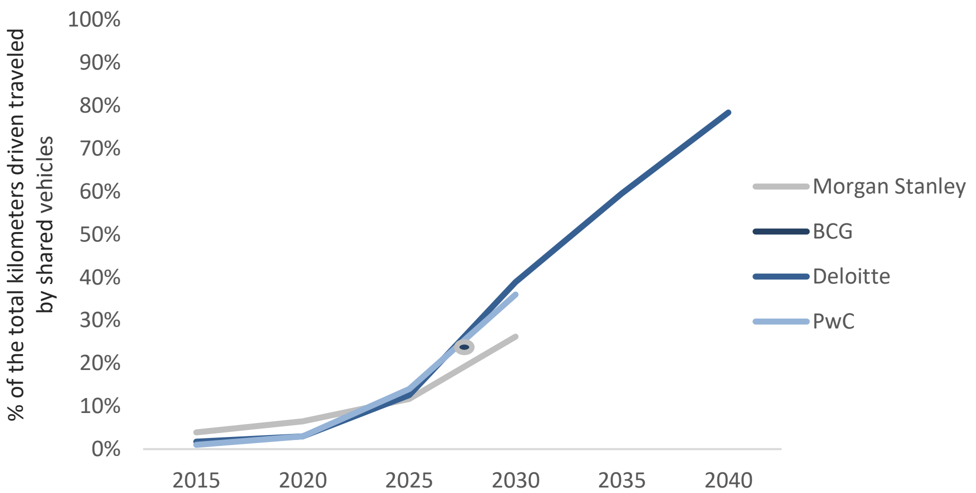

Figure 16 Forecasts market share shared mobility. (Own illustration)

No literature was found that forecasted a decrease in shared mobility. However, an empirical research on the willingness to use car sharing shows that only 20% of the Dutch population is acceptant towards car sharing (Jorritsma, Harms, & Berveling, 2015). This could suggest that the forecasts in Figure 16 are too optimistic. The reactions on the forecast out of the expert interviews were bilateral. Non of the experts was certain and able to do a prediction, but some found the Deloitte prediction way too optimistic, while other found it feasible, depending on the policy by the government. It again shows the uncertainty in the development of shared mobility.

How the transition speed of shared mobility will develop depends on several factors. A study conducted in the Netherlands found that convenience is an important success factors, as cheap and flexible free floating car sharing services with reserved parking places affect the use of car sharing (Berg, 2017). Another research conducted on factors influencing the use of car sharing adds that the influence of collaboration with public transport companies, availability on public street space, and hidden subsidies of car ownership and driving can affect the use significantly (Loose, 2009b). Also demographic characteristics are mentioned as influencing factors, as high density locations and people with a higher education level and younger in age tent to use car sharing more (Jorritsma et al., 2015). Finally, a state-of-the-art platform and telematics are mentioned as success factors for car sharing (Deloitte, n.d.).

Similar to the impact on society by autonomous vehicles, also shared mobility will have its effects. The Netherlands Institute for Transport Policy Analysis (KiM) has done a research for the Dutch Ministry of Infrastructure and the Environment on the impact of car sharing on mobility and environmental quality. The research indicates that car sharing affects car ownership, car use, and the environment (KiM Netherlands Institute for Transport Policy Analysis, 2015a). Each will be discussed briefly.

Car sharing decreases car ownership. The average level of car ownership fell from 0.85 cars per household to 0.72 cars per household (KiM Netherlands Institute for Transport Policy Analysis, 2015a). The reduction in car ownership is supported by several other studies; the study by Loose shows that 16-40% of car sharers sell or dispose of at least one car (Loose, 2009a), while another study shows that each shared car can replace up to 20 privately owned cars (Shaheen, Cohen, & Martin, 2009). As can be seen in the Table 3, the bandwidth of the reduction factor is large and ranges from a minimum of 3 conventional cars to a maximum of 20 conventional cars per shared vehicle. The studies vary in scope, as different type of car sharing and different locations were used. In the existing literature, a reduction in car ownership is the main cause for a reduction in parking demand and for freed up public space (KiM Netherlands Institute for Transport Policy Analysis, 2015a). However, the existing literature lacks to indicate which type and location of parking will be reduced. Nonetheless, this is important information when looking at the effects on public space.

Table 3 Replacement ratio shared mobility

Source	Type of carsharing	Location	Min	Max
(Shaheen et al., 2009)	One-way carsharing	North America	4,6	20
(Loose, 2009)	Not defined	Europe	4	8
(Spark, 2016)	Not defined	Europe	3	20
(KiM Netherlands Institute for Transport Policy Analysis, 2015a)	Not defined	The Netherlands		3,14

(Fagnant & Kockelman, 2014)	Shared autonomous vehciles – One way	Not defined		11
(Nijland, Meerkerk, & Hoen, 2015)	Not defined	The Netherlands		30% less car ownership
(Balac, Ciari, & Axhausen, n.d.)	Not defined	Zurich		13
(Greenblatt & Shaheen, 2015)	Roundtrip carsharing	North America	9	13
(KiM Netherlands Institute for Transport Policy Analysis, 2015b)	Not defined	The Netherlands		30% less car ownership

The second impact is on car use. Car sharers drove on average about 9.100 km per year before they started sharing. Now they drive on average about 7.500 km per year, a significant decrease (KiM Netherlands Institute for Transport Policy Analysis, 2015a). However, the research shows another important finding as 16% of car sharing kilometers do not replace trips made by another form of transport, and can be seen as additional mobility. The report concludes that car sharing has a positive impact on car use, but the effects could be counterproductive in the long run, as innovations may turn out differently than first intended.

If less car use and ownership is assumed, this has a positive impact on the environment. The reduction number of car kilometers traveled and the shift in transport mode due to car sharing, leads to an annual reduction in carbon dioxide emissions of 90kg (KiM Netherlands Institute for Transport Policy Analysis, 2015a). If car ownership is also included into the environmental impact calculation, then car sharing will lead to a reduction of 85-175 kg per household per year.

As for the literature on the effects of autonomous vehicles, the existing literature on the effects of car sharing also lack to point out the effects on a greater scale. Most of the researches lack to do a quantitative or qualitative analysis of the effects on a national or local scale. In some literature (International Transport Forum / OECD, 2015) they show what the decrease in parking demand would mean for the municipality as a whole, but they lack to indicate how these effects are spatially distributed over the municipality, what the determining factors are behind this distribution, and how it differs per type of parking.

3.4 Parking policies

Parking policies set the preconditions for the success and demand of car sharing. Policies aimed to make parking more expensive and scarce will increase the demand for car sharing (CROW, 2017). The demand can be further increased when parking spaces are reserved especially for car sharing, and when parking requirements for new construction projects are lowered and replaced for shared vehicles (CROW, 2017). Currently, car sharing is mainly done in cities that have a population greater than 100.000, high quality public transport and bike facilities, and a high population density. In such cities, the reduction of parking requirements can already be up to 10% (Spark, 2016). According to a research on commuter parking, car sharing is also influenced by parking restrictions, charges and cash-out initiatives (Marsden, 2006).

In order to incorporate car sharing in the parking policy, it is useful to understand how parking policies have developed over time. The availability of parking spaces has been the leading factor of the municipal parking policies for decades. Until the end of seventies, the Dutch parking policies were aimed to provide as much parking space as possible, as parking was seen as an important source of income (Dijken, 2002). This policy got changed when the increase in car-use endangered the accessibility of city centers, and studies showed that few land uses exists that generate less revenue. Parking policies became a tool to limit car-use, as several studies showed that parking policy measures considerably influence modal choice and parking location (Feeney, 1989). Recently, an even more fierce change has taken place in different European cities. Parking policies are now an important tool to achieve the environmental, safety, accessibility, social and economic goals of municipalities. Both economic and regulatory mechanisms like pricing and supply caps are introduced to achieve these goals. If market pricing was applied for parking, this would have a significant beneficial effect on society. Three recent studies show that if a market price was paid for parking, this would result in less traffic, more transit use, and a greater tax revenue (Groote et al., 2016). A research by the Chicago Metropolitan Agency for Planning adds to these advantage that fewer spaces would be needed, the population density would be increased, and people would walk more (CMAP, 2016). This will help to reduce traffic congestion, roadway costs, and pollution. A research by Litman shows that prices reflecting the full cost of providing these parking facilities typically reduce automobile commuting by 10-30% (Litman,2017). Car demand is also reduced by longer waiting durations for permits. This waiting duration affects the price elasticity of car demand by about -0.8 (Groote et al., 2016). It can be concluded that a change in parking pricing affects trip frequency, route, mode, destination, scheduling, vehicle type, parking location, type of service selected, and location decisions (Litman, 2017). The often rare space that is needed for parking is now considered to be changed for more valuable uses (Kodransky, M. & Hermann, G., 2011). In the Netherlands, the municipality of Amsterdam has announced that for new buildings, no new parking spaces will be provided (Gemeente Amsterdam, 2016).

3.5 Effect of parking policy on housing

Parking requirements do not only have a spatial effect, but also an economic effect. Several studies show that parking requirements affect the affordability of housing. The affordability is affected as the feasibility of a project changes on both the supply and demand side. Both will be discussed using two researches on each of the sides.

Two types of parking can be defined; on-street and off-street. On-street parking is defined as parking your vehicle on the street, anywhere on or along the curb of streets, in contrast to off-street parking, which is parking anywhere but on the streets. Off- street parking requirements are needed to prevent on-street parking to become overcrowded. Parking spaces for both on- and off-street require land, building materials and equipment. This increases the costs of a project and the price of housing (Jia & Wachs, 1999). A research on the affordability on the demand side shows that the price of single family houses and condominiums in San Francisco were more than ten percent higher if they included off-street parking (Jia & Wachs, 1999). Parking requirements decrease the accessibility of housing for lower to mid-class incomes, as especially these households will have a difficulty qualifying for home mortgages.

On the supply side, parking requirements affect the development cost. According to the research of Litman on the impacts of parking requirements, one parking space per unit increases the cost by 12,5% in comparison with no off-street parking. Or this could lead to higher costs, or to less units developed. These parking development costs can be distinguished into the following: cost for land, construction and maintenance cost, reduced development density, higher retail price targets, and environmental and aesthetic cost (Litman, 2011). The amount of land needed for parking is in proportion often higher than the land devoted to the buildings. Furthermore, Litman indicates that construction financing agencies often require that new building retail prices be at least 3 times the original land costs. The result is, as Litman indicates, that developers target higher end markets, as they cannot afford to build a simple lower priced housing when their land costs increase. In addition, due to the high parking requirements, developers often get pushed to locations on the edge of a city to comply with parking requirements at a lower price. This decreases housing densities and increases the car-use. Furthermore, Litman shows that also on the supply side parking requirements can result in an unfair policy instrument for the lower income households. Lower income households normally own fewer cars, so they pay a relatively higher percentage of the development costs for parking.

The findings of the research above were for the American residential market, but it can be assumed that the same mechanism applies for the Dutch market. They can be used during this research for the determination of spatial value.

3.6 Value of green and blue in a city

Dutch cities are expected to grow over the following decades (CBS, 2016), which means that more and more people will live in urban areas. This increase in population density affects the amount of green per inhabitant. The Dutch government has set a standard of 75m2 green per dwelling (Compendium voor de leefomgeving, 2010). However, this standard is rarely realized and is due to the densification under even more pressure. Although green has been often underestimated in area development, it has significant advantages. It is beneficial in economic, environmental and social ways.

Research has shown that green in the environment reduces the chance on depression and other diseases (Maas, 2009). A view on green even helps people to recover faster, reduces the number of hospitalization days and the use of painkillers (Maas, 2009). Neighborhood green within a distance of 300 meters is of great social value. It gives people the opportunity to meet and to enjoy recreation. In addition, people who live close to green feel less lonely and less often experience a lack of social support. Attractive neighborhood green and parks are therefore essential for a society (Maas, 2009).

The economic value of urban green is also significant. According to the research of Luttik and Jókövi, it results in a value increase between the ranges of 4% to 12%, depending on the type of house and the quality of the urban green. Furthermore, they show that buyers are willing to pay 7% more for their home if it is directly connected to public green or water, that a clear view on urban green leads to 12% value increase and that the presence of attractive nature near a property leads to an increase in value of 5% to 10%. This increase in value is both beneficial for the owners and the municipality, as a higher value leads to more tax income (Luttik & Jókövi, 2003). A green urban environment also increases the attractiveness of a region. Highly educated people, knowledge-intensive and international companies find the availability of neighborhood green an important factor determining the location of a business (Maas, 2009).

3.7 Urban ambitions of Amsterdam

The urban ambitions of Amsterdam have been identified using the Structural Concept Amsterdam 2040 ("*Structuurvisie Amsterdam 2040*"). The goals of Amsterdam are to be economically strong and sustainable (Gemeente Amsterdam, 2011). Sustainable means a future proof city, with an intent care for the environment. To make the city future proof, it needs to anticipate climate change, make the air, soil and water cleaner, the city greener, quitter and more energy-efficient. Therefore, three main subjects are important regarding this research; greenery and attractiveness of the city, adaptations regarding the climate, and mobility. Each will be discussed briefly.

As mentioned in Section 3.6, the availability of greenery and water has a significant beneficial influence on the residents of a city and on the attractiveness of an area. Availability of greenery showed to be an important prerequisite for choosing the place to live or establish a business.

Greenery becomes an important economic factor. Because of the economic, social, and health effects Amsterdam wants to invest in making the greenery and water in and around the city more attractive, and making the experience and use of it better (Gemeente Amsterdam, 2011).

Besides the beneficial effects on health and recreation, water and greenery are also important for other functions of the city regarding sustainability and climate proof functions. For the sustainability functions, water and greenery improve food production and biodiversity. Regarding climate proof functions, water and greenery are beneficial for water storage, air quality, and urban heat. Water storage is a growing problem, as paved surfaces increase and due to climate change more rain is expected. Water and greenery can help to collect water, hold it and slowly discharge it to the groundwater. In addition, it helps to improve the air quality, as greenery reduces the concentrations of NO2 and CO2. Lawns, trees, parks, fountains and water squares help to reduce urban heat and to humidification of the air, making the city climate more pleasant (Gemeente Amsterdam, 2011).

The ambitions regarding mobility are to facilitate modes of transport that involve relatively little nuisance and space. Therefore, the city of Amsterdam wants to improve the public transport and bicycle network. In order to have more connections in and to the city, the public transport network needs to be extended with more and faster lines, and more stops. On short distances within the city, the bicycle fulfills an increasingly share of the total mobility need. This requires broader path, more space for storage facilities on the streets and in buildings, and more comfort (Gemeente Amsterdam, 2011).

3.8 Findings out of the expert interviews

Kees Oudendijk from RDW mentioned several important factors that determine the demand and success of smart mobility (Oudendijk, 2017). He expects car sharing to happen, but indicates that this will strongly depend on how well the platforms will be developed, and how legal liability issues are regulated. This first factor was also mentioned by Erik de Romph from TNO (Romph, 2017). The legal liability factor was mentioned during the interview with Snappcar, as it became clear that proper leasing conditions can facilitate car sharing, while insurance issues currently hinder it (Rigo, 2017). Kees Oudendijk however states that the claim from scientific literature of less cars needed because of car sharing is not immediately true. He indicates that especially the location of new housing will determined the demand for mobility. New buildings in the vicinity of rail infrastructure facilities, trams, trains, and metros, will decrease car ownership. He also indicates that the level of education and the age affect the demand more than car sharing. People with a higher education use the car less, while people between the age of 30 and 55, who leave the city for their children, use the car more. He emphasizes the importance of urban planning to responds to this. Regarding self-driving vehicles, Kees Oudendijk expects that it will take at least 20 years before self-driving cars are mainstream. Besides, he points out that it will only become mainstream if people learn to trust self-driving cars. Technically it could all be possible, but he sees people themselves as the current limiting factor. Younger people are used to dealing with technology, but especially the older generation, who are much less used to technology or the use of public transport want to use their own car. He does expect that cars will already start parking themselves between 2020 and 2025.

Jos van Ommeren from the Vrije Universiteit Amsterdam expects that car use will decrease in cities. Cities will not accommodate extra traffic, so governments are going to implement such policies that car-use will decrease. He expects that a decrease in car ownership will only be realized by shared vehicles if they are autonomous as well. He mentions that another benefit of the self-driving car is that a higher occupancy rate can be achieved thanks to the fact that cars can park closer to each other (Ommeren, 2017). This is confirmed by Auke Hoekstra from the TU Eindhoven. He also expects that the more cars are shared, the smaller the vehicles will be (Hoekstra, 2017).

The role of the government is addressed by Marco van Burgsteden from CROW and Walter Dresscher from de Natuurlijke stad. The potential of smart mobility can only be recognized if policies are designed to stimulate car sharing (Dresscher, 2017). He emphasizes that governments should dare to take hard measures. Marco indicates that efficiency both in mobility and parking can only be improved if data is shared, and governments have a directing role in doing so (Burgsteden, 2017). Evelien van der Molen from the municipality of Amsterdam also confirms the importance of information provision (Molen, 2017).

The techniques and information from the use of car sharing are important for the development of autonomous vehicles, and will set the foundation for the self-driving car (Bosman, 2017). This is mentioned by Robert Bosman from Car2Go. He expects that more car sharing will result in fewer car owners, which will decrease the demand of parking. He does expect that parking garages will always be used by visitors from outside the city and will continue to exist. This is confirmed by Sacha Oerlemans from Qpark (Oerlemans, 2017) and by Ed van Savooyen from SPARK (Savooyen, 2017).

Ronald de Jong from ANWB expects a change to private lease and mobility as a service (Jong, 2017). Especially on demand services will become potentially cheap in the city, but less in the rural areas. An interesting price coupled with sufficient reliability will decrease car use he thinks.

3.9 Overview determining factors smart mobility

In sections 3.1 to 3.6, several determining factors for car sharing and autonomous vehicles were identified. These have been complemented with the findings out of the expert interviews. Figure 17 shows an overview of the most important factors that were found. These can now be used to develop a conceptual model. This will be done in Chapter 4.

Government, laws and regulations

Governmental measures with regard to:
- **Investments in infrastructure** – Section 3.8
- **Taxes on different transport modes** – Section 3.3 and 3.4
- **Legislation regarding data use** – Section 3.8
- **Spatial stimulation smart mobility** –Section 3.3
- **Parking policy** – Section 3.3 and 3.8

Demographic characteristics

Development of demographic characteristics with regard to:
- **Population growth** – Section 3.4
- **Urbanization** – Section 3.4 and 3.8
- **Aging** – Section 3.1, 3.3, 3,8
- **Population density** – Section 3.4 and 3.8

Technological developments

Technological developments with regard to:
- **AV technology and interoperability** – Section 3.3 and 3.8
- **Internet of things** – Section 3.3
- **Tracking and navigation technology** – Section 3.3
- **Peer-2-peer platforms** – Section 3.1, 3.3, and 3.8

Market developments

Market developments with regard to
- **Availability of insurances for new transport concepts** – Section 3.8
- **Quality of public transport** – Section 3.4 and 3.8
- **Quality of bike facilities** – Section 3.4 and 3.8
- **Vehicle purchase and subscription cost** – Section 3.2

Social preferences

Development of social preferences with regard to:
- **Relation human and machine** – Section 3.8
- **Sustainability** – Section 3.1
- **Ownership and use** – Section 3.1
- **Safety and control** – Section 3.8

Privacy and cyber security

Privacy and security developments with regard to:
- **Cybersecurity and development of communication protocols** – Section 3.2 and 3.8
- **Security of personal data travelers** – Section 3.2 and 3.8

Figure 17 Factors affecting transition speed. Based on Deloitte figure from state of state survey, 2017 (Own illustration)

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Figure 18 Transformation into pedestrian area. Reprinted from: www.zucchiarchitetti.com

4. Conceptual model

This research investigates to which extent smart mobility can contribute to the restructering and transformation of the public space. In Chapter 3, the most important variables that affect smart mobility have been identified, but these do not yet show the underlying relationships. In order to develop the mathematic model of Chapter 5, the variables identified in Chapter 3 need to be related to each other. This chapter will connect the different variables and gives an overview of the relationships in the conceptual model. Each of the relationships will be discussed and explained using the findings of Chapter 3.

4.1 Conceptual model

The general topics of Figure 17 are shown in the conceptual model below. Each of the relations will now be elaborated on.

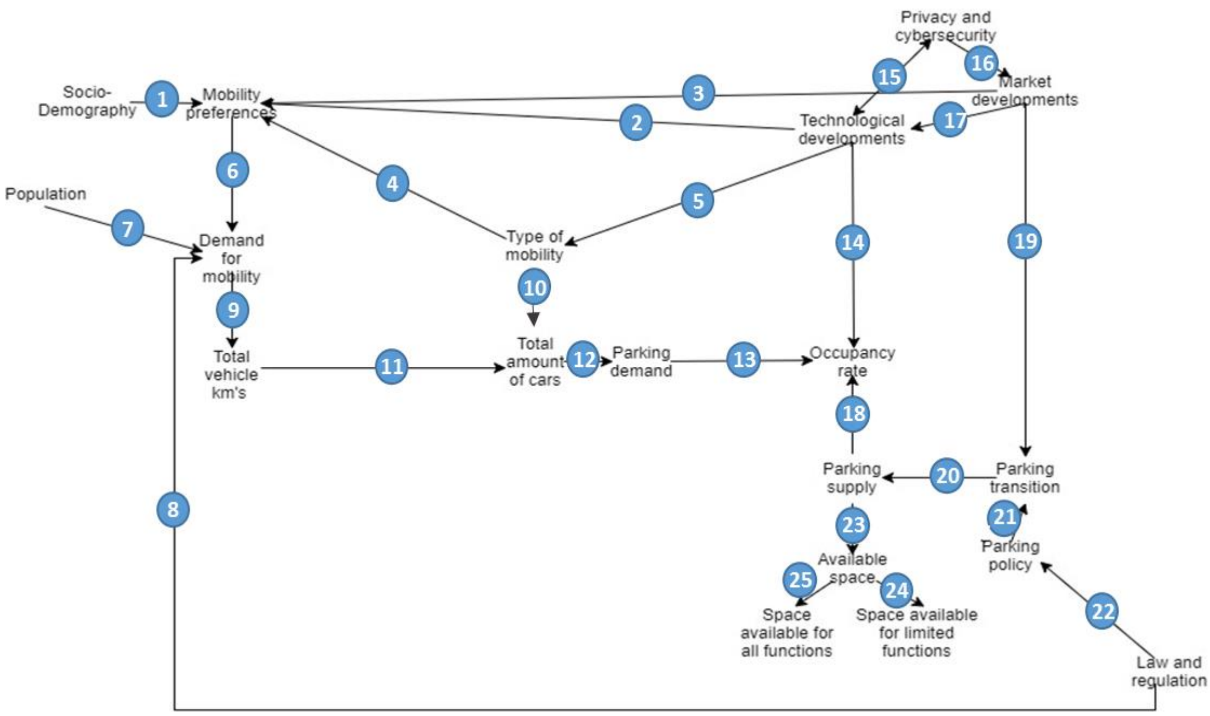

Figure 19 Conceptual model (Own illustration)

The first relation, number 1, exists between socio-demographic characteristics and the mobility preference of people. The research by CROW shows that age and education, but also the attitude towards sustainability and sharing determine mobility preferences (CROW, 2015), this was confirmed during the expert interview with RDW (Oudendijk, 2017). Other demographic factors, like population density and urbanization, have also been identified as positive influencing factors for smart mobility (SPARK, 2016). Relationship 2, between technological developments and mobility preferences, has been identified in several researches and interviews. CROW indicates that information technology and the internet-of-things facilitate smart mobility preferences (CROW, 2015). If a certain mobility type becomes safer or more convenient, this can increase the preference towards the mobility type (Deloitte, n.d.). This relationship has been confirmed in the interview with RDW (Oudendijk, 2017). RDW also indicated that trust between human and machine is an important factor. This means that technological developments that enhance this trust, has a positive effect on social preferences (Oudendijk, 2017). Technological developments in its turn determine the types of mobility that exist, relation 5. The techniques and information from the use of car sharing are important for the development of autonomous vehicles, and will set the foundation for other mobility types (Bosman, 2017). If mobility types change, for example when a mobility type is added, the preferences will most probably change, as people can choose from more options, relation 4. This is not a relation that has been identified by literature, but is established by logical reasoning. The fourth relation that affect the mobility preferences is market developments. The research by Litman has shown that vehicle purchase cost and subscription costs are important drivers for autonomous mobility (Litman, 2012). This is confirmed by ANWB (Jong, 2017) and by the research of Berg (Berg, 2017). A Deloitte data research furthermore shows that the second hand market significantly determines the preferences of mobility (Deloitte, 2017). If a mobility type loses value rapidly, then people aren't willing to buy it, as in such case an investment is considered not safe. Insurance and liability issues are other market factors that have been identified. RDW and Snappcar showed that these are important factors that determine the preferences (Oudendijk, 2017) (Rigo, 2017). The final market factors that determine the preferences are the quality of public transport and bike facilities. Both factors facilitate car sharing, because the last mile can be traveled without problem (Spark, 2016).

The mobility preference in its turn, affects the total demand for mobility, relation 6. This is caused by the fact that different mobility types result in a different total demand for mobility. If people only travel by car, they can reach their destination with one type of mobility. If public transport is used, the chances are higher that they need to use different types of public transport or that they need to walk. The interview with RDW has shown that especially rail infrastructure can decrease car demand (Oudendijk, 2017). The total demand is also influenced by the size of the population. If the population increases, it can be expected that the demand increases. This is relation 7. The final factor that can affect the demand is law and regulation, relation 8. This can be done with taxes to decrease demand, but certain mobility types can also be subsidized. The research by Loose has shown that hidden subsidies of car ownership and driving can affect the use significantly (Loose, 2009b).

The demand for mobility determines the total vehicle km's, relation 9. Different types of mobility result in a different amount of total vehicle km's driven. The KiM Netherlands Institute for Transport Policy has shown that car sharing decreases car use and the total vehicle km's (KiM Netherlands Institute for Transport Policy Analysis, 2015a). However, if people who used public transport before all switch to car sharing, it increases the total vehicle km's. The total vehicle km's factor and the factor type of mobility together determine the total amount of cars, relation 10 and 11. Dividing the total vehicle km's by the average driven km's per mobility type gives the total amount of cars needed to facilitate the mobility demand. On average, a passenger car drives around 12.000 km's a year in the Netherlands (CBS, 2017), but a shared car or even an autonomous shared car are expected to have much higher average mileages (Hoekstra, 2017). It is expected that smart mobility can have a diminishing effect on the total amount of cars needed (Spark, 2016). This has been confirmed by TNO (Romph, 2017), Car2Go (Bosman, 2017), and the municipality of Amsterdam (Molen, 2017).

Literature shows that a decrease in car ownership can result in a reduction of parking demand (KiM Netherlands Institute for Transport Policy Analysis, 2015a), relation 12. This has been confirmed during the interviews with TU Eindhoven (Hoekstra, 2017), Car2Go (Robert Bosman, 2017), and the Vrije Universiteit Amsterdam (Ommeren, 2017). If the parking demand changes, the occupancy rate, assuming a constant supply, will change, relation 13. Vice versa, a changing parking supply can also affect the occupancy rate, relation 18. The occupancy rate can on its turn be affected by technological developments, relation 14. Development like the internet-of-things will help to increase the occupancy rate. A large part of the parking capacity currently has a low occupancy rate (Ommeren, 2017) (Deloitte, 2017). Digital platforms and the internet-of-things will help to make private parking spaces available to third parties, as interviews with CROW (Burgsteden, 2017), Car2Go (Bosman, 2017), the municipality of Amsterdam (Molen, 2017) and the Vrije Universiteit Amsterdam showed (Ommeren, 2017). Developments in autonomous vehicles will help to increase the occupancy rate even further as cars can be parked autonomously, resulting in space savings of up to 90% per parking space (Nourinejad et al., 2017). This effect was also mentioned by the TU Eindhoven (Hoekstra, 2017) and the Vrije Universiteit Amsterdam (Ommeren, 2017).

Technological developments can affect privacy and cybersecurity, relation 15. It can improve security, but can also negatively affect security. As technology changes and develops, so do the cybercrimes and possible new threats. If people feel safe and secure, this is beneficial for the market developments, relation 16. Market developments in its turn facilitate technological developments, relation 17. Investments and funding from private and public parties can stimulate innovation.

Market developments affect the parking transition, relation 19. If other land uses than parking can generate more income, this gives governments an incentive to overthink their policies (Dijken, 2002). If land becomes scarcer, the value increases and the chances are higher that parking is transformed into a more valuable use of the ground. This relationship has also been mentioned by the Vrije Universiteit Amsterdam (Ommeren, 2017). The transition of parking is not only affected by the market, but also by local government policy, as they can determine the amount and pricing of public parking spaces, relation 21 (Feeney, 1989). According to the municipality of Amsterdam, local governments can normally decide themselves what kind of policy they want to implement (Molen, 2017), but laws and regulations set by the national government could influence the parking policy on a municipality scale, relation 22. If the parking supply is decreased, this would result in freed up land, and in a higher availability of space, relation 23. However, it depends on the location and type of parking if it will become available and if the newly available land can be used for limited or all functions. This relation has been indicated during the interviews with the Vrije Universiteit Amsterdam (Ommeren, 2017), CROW (Burgsteden, 2017), Car2Go (Bosman, 2017), and SPARK (Savooyen, 2017).

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Figure 20 Transformation into public space. Reprinted from: www.architecturea.com

5. Model

After the identification of the variables in Chapter 3, and setting the relations in Chapter 4, the mathematic model in Python can be developed. This chapter will elaborate on that model. First, the structure of the model will be explained. The different elements of the model, like the variables, assumptions and the transition scenarios are discussed next. Finally, the limitations of the model are presented.

5.1 Structure of the model

Figure 21 shows the simplified structure of the model. The model works as discussed in Chapter 2. Each of the elements of the model will now be discussed, starting with the transition scenarios in Section 5.2, followed by the model variables in Section 5.3, and finally the assumptions in Section 5.4. The output of the model will be discussed in Chapter 6. Appendix III shows the complete flowchart of how the inputs affect the variables and result in the output.

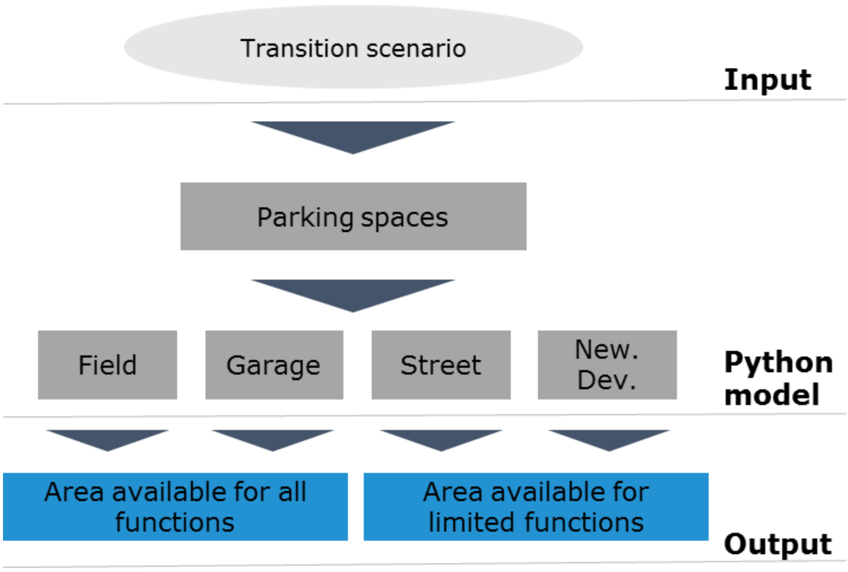

Figure 21 Structure of the Python model (Own illustration)

5.2 Transition scenarios

The conceptual model has shown that a lot of the factors that determine the demand for mobility are interrelated. This results in a high uncertainty level, as all of those factors have a lot of possible future states. The uncertainty of these factors not only affects the implementation of the different mobility types but also the speed of transition. In order to implement this uncertainty, this research will use a scenario analysis, similar to the future states of Deloitte, as mentioned in Chapter 1. The transition scenarios are divided into two axes, the level of vehicle control and the level of vehicle ownership, see Figure 22. Three variables can change within these scenarios; the total driven kilometers, the replacement ratio, and the footprint per parking space. These variables have shown to determine, directly or indirectly, the demand for parking the most, as discussed in Chapter 4. The variables together determine the transition rate, see Appendix II for the flowchart, and Appendix XIII for the calculation output. An overview of the variables are shown in Figure 22. How these variables change per scenario and how they affect the transition rate will now be elaborated on.

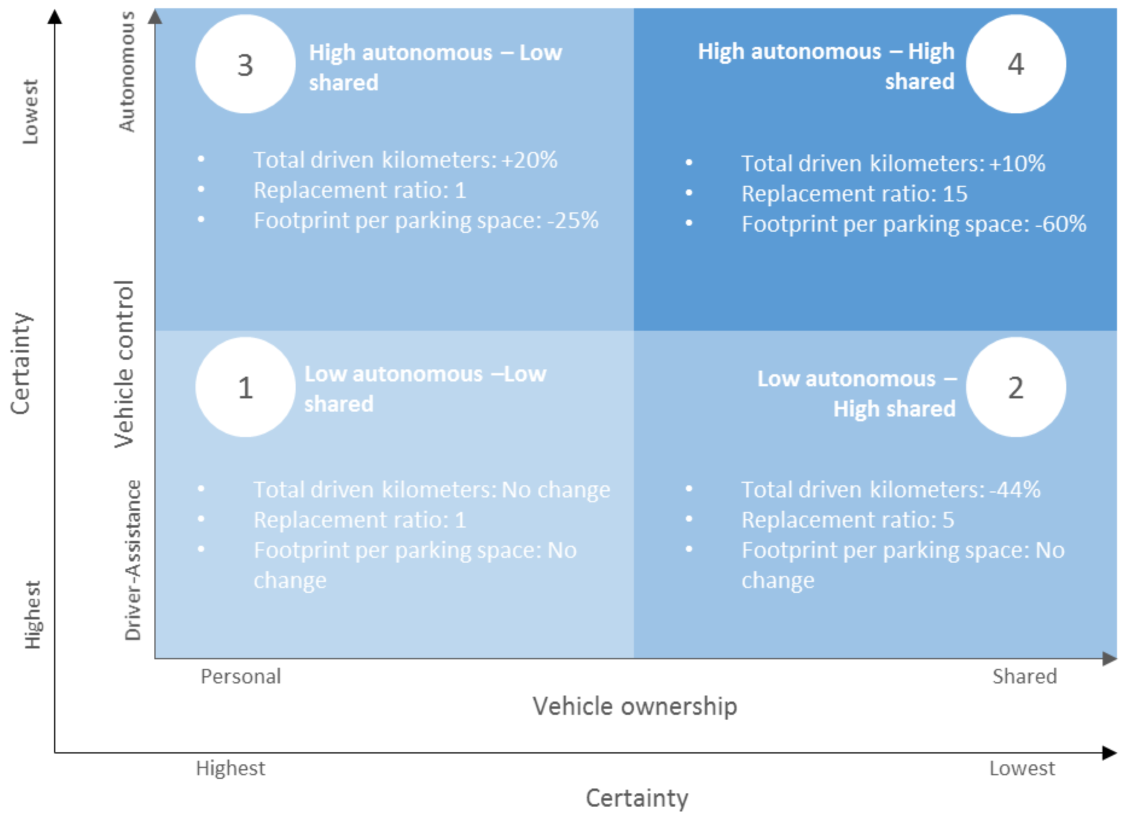

Figure 22 Scenarios with certainty indication. (Own illustration)

5.2.1. Transition variables

Total driven kilometers

Chapter 4 has shown that if the total driven kilometers increase, more vehicles are needed, resulting in a higher demand for parking. The total driven kilometers are assumed to change because of shared and autonomous mobility. As can be seen in Table 4, the change caused by autonomous vehicles is projected to lay between +3% and +20%. For purely shared driving, the total driven kilometers is assumed to decrease with 44%. For scenario 4, the total driven kilometers are projected to increase by 10%. Scenario 2 will only be affected by shared mobility, resulting in a decrease of 44%. Scenario 3 has a high level of automation, resulting in a maximum increase of 20%.

For the calculation of the transition rates per scenario, all four types of mobility, shared self-driven and autonomous, and privately self-driven and autonomous, are included in the calculation. It is assumed that for all scenarios the mobility types will have the increase in kilometers corresponding to their scenario. E.g. in scenario 2, the mobility type shared autonomous has an increase of 10% of the kilometers, but due its minimum market share, the effect is negligible.

Table 4 Bandwidth Total driven kilometers

Source	Caused by	Min	Max
(Litman, 2014)	AV	+3%	+9%
(Shaheen, Cohen, & Martin, 2009)	SV		-44%
(Fagnant & Kockelman, 2015)	SAV		+10%
(Fagnant & Kockelman, 2015)	AV		+20%
(Litman, 2017)	AV		+11%

Replacement ratio

According to the studied literature, only shared mobility results in a reduction of the total amount of private cars. However, autonomous vehicles can be seen as a facilitating factor. The higher the level of automation, the more mobility will move towards taxibots and the higher the replacement ratio will be. Replacement ratio is defined as the amount of cars that will be replaced by one shared vehicle. As seen in Table 3, the replacement ratio has a large range in literature, ranging from 3 to 20. The expert interviews have shown that 3 as a minimum, but also 20 as a maximum are quite high (Hoekstra, 2017). The shared replacement ratio range is assumed to vary between 1 and 15. Scenario 1 and 3 have no shared mobility, and get a ratio of 1. Scenario 2 is high shared, but low autonomous, resulting in no extra facilitating effect and a ratio of 5. In scenario 4, mobility will be mainly autonomous taxibots, resulting in the maximum replacement ratio of 15.

In all scenarios the different mobility types exist next to each other. This means that e.g. in scenario 4 a market share of shared autonomous exists, but also a market share for privately owned autonomous vehicles. Each mobility type has a different replacement ratio. These different ratios are all included in the calculation. However, the mobility type with the largest market share will have the most dominant effect on the transition rate. The ratio in Figure 22 shows the ratio of the mobility type with the biggest market share.

Footprint per parking space

Only autonomous vehicles will allow for more efficient parking. Therefore, only scenario 3 and 4 have a change in footprint per parking space. In addition, it is assumed that only parking destined for autonomous vehicles will reduce in size. As one parking spot per vehicle is assumed, see Section 5.4, only the parking capacity corresponding to the autonomous market share will change. Several possible surface reductions have been mentioned in literature. Alessandrini mentioned that this reduction could be up to 75% (Alessandrini et al., 2015), while the study done by Nourinejad and others shows an average of 60% and a maximum of

90% (Nourinejad et al., 2017). In scenario 4, cars can be parked in a random order near to each other. Scenario 4 has the maximum percentage of reduction, and is assumed to follow the average of 60%. Scenario 3 has a low level of shared cars, meaning that people still own their own car and cars can't be parked in a random order. When someone needs his or her car, it would be inconvenient if a car is parked in the middle of a lot and other cars would have to move first. The reduction of the parking footprint is assumed to be significantly lower than in scenario 4, and follows the reduction expectations by van Ommeren (Ommeren,2017).

5.2.2 Market shares per scenario

The effect of the transition variables depends on the percentage market share of shared and autonomous mobility. Therefore, these percentages need to be determined. Tables 5 to 8 show the past and projected market shares per type of mobility. The percentages are not based on literature or earlier researches, but are assumed. However, because literature shows that autonomous vehicles will not or barely be introduced before 2030, the market shares of autonomous cars before 2030 are assumed to be nearly zero, but will increase significantly from there on. The other market shares depend on the axis illustrated in Figure 22. Scenario 1 is low autonomous and low shared, hence the personally owned driver-driven has the largest market share. Scenario 2 is low autonomous and high shared, hence the shared driver-driven has an increased market share, decreasing the share of personally owned driver-driven. Scenario 3 is high autonomous and low shared, therefore, starting from 2030, personally owned autonomous has an increasingly larger share. A low amount of shared is assumed in this scenario, but will probably not be completely zero, therefore a low percentage for shared driver-driven and autonomous is assumed. Scenario 4 is high autonomous and high shared, consequently the percentage of shared driver-driven increases until 2030, but loses share to autonomous personally owned and shared after 2030. Shared autonomous is assumed to have the largest market at the furthest projection for this scenario.

Table 5 Market shares scenario 1

Scenario 1	2015	2020	2025	2030	2035	2040
Personally owned driver-driven	100%	99%	98%	96%	93%	91%
Personally owned autonomous	0%	0%	0%	0%	0%	0%
Shared driver-driven	0%	1%	1%	3%	5%	6%
Shared autonomous	0%	0%	0%	1%	2%	3%

Table 6 Market shares scenario 2

Scenario 2	2015	2020	2025	2030	2035	2040
Personally owned driver-driven	100%	95%	85%	74%	58%	42%
Personally owned autonomous	0%	0%	0%	0%	0%	0%
Shared driver-driven	0%	5%	15%	25%	40%	55%
Shared autonomous	0%	0%	0%	1%	2%	3%

Table 7 Market shares scenario 3

Scenario 3	2015	2020	2025	2030	2035	2040
Personally owned driver-driven	100%	95%	95%	85%	72%	45%
Personally owned autonomous	0%	0%	1%	10%	20%	42%
Shared driver-driven	0%	1%	2%	3%	4%	5%
Shared autonomous	0%	0%	1%	2%	4%	8%

Table 8 Market shares scenario 4

Scenario 4	2015	2020	2025	2030	2035	2040
Personally owned driver-driven	100%	95%	83%	65%	25%	10%
Personally owned autonomous	0%	0%	1%	10%	15%	20%
Shared driver-driven	0%	5%	15%	15%	20%	10%
Shared autonomous	0%	0%	1%	20%	40%	60%

5.2.3. Transition rates

The different transition variables together with the market shares determine the transition rate. The transition rate affects 4 types of parking:

- Street parking
- Field parking
- Built facility parking
- Parking at new housing developments

However, the transition rate is not similar for all the different types of parking and analyses. On a national level, it is assumed that the built facility parking will not be changed until 2030. The current policy of municipalities is to first remove parking from the streets and to then facilitate extra capacity in the built facilities (Molen, 2017). Furthermore, according to the expert interviews and literature, the built facilities will always serve as parking for visitors and possibly as a hub from which the smart and autonomous mobility can operate (Bosman, 2017) (Zakharenko, 2016). For the other types of parking on a national level, the transition rate is assumed to be the same, resulting in the transition rate scenarios below. For the deep dive analysis, the transition rate for built parking facilities is assumed to be the same as for the other parking types. A capacity assessment of the built parking facilities in Amsterdam has shown that only 11 out of the 64 public built parking facilities are currently above ground. It is assumed that underground facilities will serve as a hub and won't be changed, but that the 11 above ground facilities will be changed at the same transition rate as the other parking types.

Table 9 Transition rates scenario 1

Scenario 1	2020	2025	2030	2035	2040
Street parking	0%	0%	0%	0%	0%
Field parking	0%	0%	0%	0%	0%
Built facility parking	0%	0%	0%	0%	0%
Parking new housing	0%	0%	0%	0%	0%

Table 10 Transition rates scenario 2

Scenario 2	2020	2025	2030	2035	2040
Street parking	0%	-6%	-15%	-34%	-55%
Field parking	0%	-6%	-15%	-34%	-55%
Built facility parking	0%	0%	-2%	-3%	-5%
Parking new housing	0%	-6%	-15%	-34%	-55%

Table 11 Transition rates scenario 3

Scenario 3	2020	2025	2030	2035	2040
Street parking	0%	0%	0%	-1%	-2%
Field parking	0%	0%	0%	-1%	-2%
Built facility parking	0%	0%	0%	-1%	-1%
Parking new housing	0%	0%	0%	-1%	-2%

Table 12 Transition rates scenario 4

Scenario 4	2020	2025	2030	2035	2040
Street parking	0%	-5%	-12%	-64%	-82%
Field parking	0%	-5%	-12%	-64%	-82%
Built facility parking	0%	0%	-5%	-5%	-5%
Parking new housing	0%	-5%	-12%	-64%	-82%

5.2.4. Sensitivity analysis

The tables below show the sensitivity analysis for the different parameters per scenario. The high level of uncertainty increases the importance of assessing the sensitivity. It is important to know the order of the effect of a deviating parameter. For each of the scenarios, the replacement ratio and the extra kilometers show to be strongly influencing parameters. This is as expected, as these parameters affect the total amount of cars the strongest. This variable in its turn determines the parking demand. For scenario 1 and 2, the extra kilometers show the largest bandwidth, while for scenario 3 and 4 the replacement ratio shows the largest bandwidth. The uncertainty that exists in these large bandwidths needs to be taken into account further in this research.

Table 13 Sensitivity analysis scenario 1

Scenario 1	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Replacement ratio 1	0%	0%	0%	0%	0%	0%
Replacement ratio 20	0%	0%	0%	0%	0%	0%
Extra kilometers -50%	0%	-65%	-61%	-58%	-55%	-51%
Extra kilometers +50%	0%	79%	89%	93%	94%	96%
Footprint per parking space +10%	0%	0%	0%	0%	0%	0%
Footprint per parking space +80%	0%	0%	0%	0%	-1%	-1%

Table 14 Sensitivity analysis scenario 2

Scenario 2	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Replacement ratio 1	0%	0%	0%	0%	0%	0%
Replacement ratio 20	0%	0%	-3%	-6%	-10%	-14%
Extra kilometers -50%	0%	0%	0%	0%	-1%	-1%
Extra kilometers +50%	0%	0%	4%	7%	12%	18%
Footprint per parking space +10%	0%	0%	0%	0%	0%	0%
Footprint per parking space +80%	0%	0%	0%	0%	0%	0%

Table 15 Sensitivity analysis scenario 3

Scenario 3	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Replacement ratio 1	0%	0%	0%	0%	0%	0%
Replacement ratio 20	0%	0%	0%	0%	-14%	-51%
Extra kilometers -50%	0%	0%	0%	0%	0%	-21%
Extra kilometers +50%	0%	0%	0%	0%	0%	0%
Footprint per parking space +10%	0%	0%	0%	0%	1%	1%
Footprint per parking space +80%	0%	0%	0%	-1%	-1%	-3%

Table 16 Sensitivity analysis scenario 4

Scenario 4	2015	2020	2025	2030	2035	2040
Replacement ratio 1	0%	0%	1%	9%	57%	72%
Replacement ratio 20	0%	0%	0%	-1%	-2%	-2%
Extra kilometers -50%	0%	0%	0%	-1%	-3%	-5%
Extra kilometers +50%	0%	0%	0%	1%	1%	2%
Footprint per parking space +10%	0%	0%	0%	1%	2%	4%
Footprint per parking space +80%	0%	0%	0%	0%	-1%	-1%

5.3 Variables and parameters

The following table shows the variables used in the Python model, the related sources and the source date. For some variables no direct data or information was available, so assumptions were made. These assumptions will be further explained in Section 5.4.

Table 17 Parameters of Python model

Model parameters	Source	Comment
Street parking	National level: (SPARK, 2014) Deep dive: (Gemeente Amsterdam, 2016)	
Field parking	National level:Spark Deep dive: Deloitte research	
Built facility parking	National level: (RDW, 2018) Deep dive: Deloitte research	
Total amount of cars	(CBS, 2017)	
Parking requirements residential	National level: (CROW, 2012) Deep dive: municipality	CROW is used as an input to determine requirements per municipality. See assumptions.
Avg. surface street parking	(Gemeente Hilversum, 2008)	
Avg. surface field parking	(Gemeente Hilversum, 2008)	
Avg. surface garage parking	(Gemeente Hilversum, 2008)	
Minimum availability of green	(Compendium voor de leefomgeving, 2010)	
Housing density	(CBS, 2017)	
G4 Multiplier		Assumption based on literature.

Table 18 Variables of Python model

Model variables	Input/output	Source
Households	Input	(CBS, 2017)
Cars per household	Input	(CBS, 2017)
Housing demolishing	Input	(Rijksoverheid, 2016)
Housing stock	Input	(Rijksoverheid, 2016)
Housing under development	Input	(Rijksoverheid, 2016)
Housing on space for all functions	Output	Model calculation
Space for all functions contribution to housing need	Output	Model calculation
Space for limited functions	Output	Model calculation
Space for limited functions contribution to green need	Output	Model calculation
Amount of green	Output	(CBS, 2012)
Green need	Output	Model calculation
Reduced street parking	Output	Model calculation
Reduced built facility parking	Output	Model calculation
Reduced field parking	Output	Model calculation
Reduced parking at new housing developments	Output	Model calculation
Total amount of cars	Output	Model calculation

5.4 Assumptions

For several variables and parameters, no data or literature was available during this research. For these gaps assumptions were made. Each assumption will be discussed briefly.

Assumption 1: Division street, field, built facility parking

On the national level, the total parking capacity is uncertain. Only a few municipalities have done research on their municipalities parking capacity. For the built parking facilities a dataset of RDW was available that contained all the built facilities in the Netherlands including its location and capacity. However, for field and street parking it was necessary to make an assumption on national scale. According to SPARK, a leading parking consultancy firm in the Netherlands, The Netherlands have about 10.000.000 public parking spaces (SPARK, 2014). These can be divided into 8.000.000 street parking spaces, 1.790.000 field parking spaces, and 210.000 built facility parking spaces. The assumption in the Python model is that all municipalities and neighborhoods within these municipalities have the same percentage of street and field parking as exists on national level.

Assumption 2: Total parking

As mentioned in assumption 1, the Netherlands has about 10.000.000 public parking spaces. To calculate the capacity on a municipality scale, a dataset of CBS containing the number of households and the average amount of cars per household was used. It was then assumed that every car needed one parking place, so both variables could be multiplied to calculate the capacity on a municipality and neighborhood level.

Assumption 3: G4 multiplier

According to the expert interviews and the reviewed literature (Spark, 2016) (Rigo, 2017) (Romph, 2017), car sharing is currently done mainly in the larger and densely populated cities. It is assumed that the transition will be 10% higher in these regions. This percentage is assumed, but was validated during the expert interviews.

Assumption 4: Demolish rate

The data source ABF Research provides a forecast on the population and housing developments on a municipality scale. For every municipality it is known how many houses will be demolished in a certain time period. Because no data is available on a CROW has provided a report with key figures on parking requirements for different types of areas and urbanities (CROW, 2012). The type of urbanities are known for all the neighborhoods in the Netherlands, publicly available at CBS. However, in what kind of area (center, outside the center, periphery) is not known. For this model, the area of the neighborhood is determined by the population density, which is provided by CBS. The areas with the highest density are in the center, middle is outside the center and the lowest are in the periphery area. The key figures were used for an average single family house in the Netherlands (Rijksoverheid, 2017).

The different parking requirements were then validated with a sample of 17 municipalities, including the 3 largest municipalities and 14 other medium and small municipalities. The validation showed two things. First, it showed that the requirements were too high for Amsterdam, Rotterdam and The Hague. Because of the influence of these municipalities on a national level, the parking requirements of these municipalities were then adjusted to the exact requirements as provided by the municipalities. Secondly, the validation showed that the requirements for the other municipalities were on average 13% too high for all areas and this percentage was implemented as a reduction.

Assumption 6: Housing density

CBS provides a datasheet with the amount of addresses per hectares. This information has been used to calculate how many houses can be developed on the freed up space by smart mobility, assuming a constant housing density.

Assumption 7: Space allocated for housing

It is assumed that only space for all functions is allocated for housing if the municipality has development plans. If no plan exist, there is no need for new housing, meaning the space for all functions can better be used for other functions.

Assumption 8: Deep dive built parking facilities

Amsterdam only has 11 above ground parking facilities in Amsterdam, as mentioned in Section 5.2.3. It is assumed that the 52 below ground facilities can facilitate the changed parking demand, and that the above ground facilities can be removed following the same transition rate as the other types of parking.

Assumption 9: Transition rate for demolished houses

For scenario 2, 3 and 4 a 100% transition rate is assumed for the parking spaces that are related to the demolished houses. It can be expected that if a municipality wants to reduce the parking capacity, it will start with the spaces that will already be removed. Therefore, spaces that will be removed when houses are demolished, are not assumed to be rebuilt.

5.5 Limitations of the model

The main limitations to the model designed for this research are caused by a lack of available data and by the means that data was collected. The first limitation, lack of available data, resulted in the fact that as much as 9 assumptions had to be made. These assumptions were validated during the expert interviews, but this is not an absolute certainty that they are correct. Giving the impact if an assumption was incorrect, this is seen as an important limitation. Also the lack of data on market share forecasts is assessed to be an important limitation. To minimize the consequence, different scenarios were used. However, the four scenarios researched here are not mutually exclusive, and collectively exhaustive.

The third limitation is related to how the data has been collected, especially the conducted expert interviews. Interviews were only conducted from a selected group of people. They had a generally positive attitude towards smart mobility, which may have led to different results and assumptions than if more critical persons had been interviewed. Also the framing of the research questions could have resulted in different answers. The findings of these interviews set the basis for both the conceptual and the Python model, so if these would have been changed, this would significantly affect the results.

A fourth limitation concerns the transition rate. As shown in the sensitivity analysis, the replacement ratio and extra travelled kilometers have a strong effect on the transition rate. However, both factors are still uncertain and can turn out differently over the investigated years than expected. A second limitation to the transition rate is the fact that the same rate is assumed for the different types of parking. However, the preferences of people to park somewhere in the future could affect the transition rate division per parking type. Furthermore, it is assumed that all locations within a region have the same transition rate. This is a strong limitation, as parking within a city will probably be changed differently than parking on the suburbs of a city. The current method does not account for this difference, but it does show the maximum potential that can be achieved by smart mobility. The maximum rate is assumed for all the areas, so this method shows the maximum potential for all areas.

Figure 23 Transformation into bike facilities. Reprinted from: www.contemporist.com

6. Results

The results of the mathematic Python model can now be visualized and discussed. This will be done in this chapter. An overview of the results will first be given in Section 6.1. These will be further specified in Section 6.2 for the national results and in Section 6.3 for the deep dive results. The deep dive results will be used in Section 6.4 to assess the potential changes in spatial value.

6.1 Overview results

The national results of the different scenarios are shown in Table 19. The Table contains the output of the variables *Space for all functions*, *Space for limited functions*, *Potential new homes*, and *All function spare space.* Scenario 4 shows the highest results, with space for all functions of 2.866 ha, space for limited functions of 7.974 ha, spare space of 164 ha, and more than 50.000 potential new homes. Scenario 2 shows the second highest results, followed by scenario 3. The results show that depending on the scenario, smart mobility can result in space for all functions between 471 ha and 2.866 ha, space for limited functions between 202 ha and 7.974 ha, spare space between 24 ha and 171 ha, and potential new homes between 10.640 and 50.720 houses.

Table 19 Overview results national analysis

National level	All functions	Limited Functions	New homes	Spare space
Scenario 1	0	0	0	0
Scenario 2	2.073 ha	5.350 ha	37.412	121 ha
Scenario 3	471 ha	202 ha	10.640	24 ha
Scenario 4	2.866 ha	7.974 ha	50.720	165 ha

Table 20 shows an overview of the results on a deep dive level. It indicates that that scenario 4 also has the highest output for every variable. Depending on the scenario, the deep dive results show an output of space for all functions between 48 ha and 345 ha, space for limited functions between 7 ha and 292 ha, spare space between 43 ha and 57 ha, and potential new homes between 2.286 and 3.331 houses.

Table 20 Overview results deep dive analysis

Amsterdam	All functions	Limited Functions	New homes	Spare space
Scenario 1	0	0	0	0
Scenario 2	69 ha	196 ha	3.021	53 ha
Scenario 3	48 ha	7 ha	2.286	43 ha
Scenario 4	345 ha	292 ha	3.331	57 ha

The results of this overview differ per location and per scenario. On a national level the results can differ per municipality, while the results on a deep dive level will differ per neighborhood. The following sections will further discuss how the results are divided over different areas.

6.2 National results

Following the overview of the results in Section 6.1, this section will show the results of the Python output and visualization on a more in-depth level. Each of the scenarios will be discussed separately.

6.2.1 National results scenario 1

Scenario 1 has no transition rate. Therefore, the current situation will not be changed and no visible results are generated. Figure 24 shows the results of scenario 1. Because scenario 1 has no findings, it will not be further discussed.

Figure 24 Scenario 1 2040 - Space for all functions (Own illustration)

6.2.2 National results scenario 2

Figure 25 shows the output of space for all functions for scenario 2. The total amount of space that becomes available for all functions is over 2.000 ha. The largest amount becomes available in the G-4 cities, with 107 ha in Amsterdam, 96 ha in Rotterdam, 76 ha in The Hague, and 41 ha in Utrecht. The rest of the space for all functions becomes available mainly in large urban areas, as can be seen by the highlighted areas in Figure 25. The total amount that becomes available of space for limited functions is over 5.300 ha. The largest amounts of space for limited functions also become available in the G-4 cities, with 170 ha in Amsterdam, 162 ha in

Rotterdam, 132 ha in The Hague, and 81 ha in Utrecht. However, space for limited functions shows a lot more areas highlighted compared to spare for all functions, and shows a higher amount for the rest of the municipalities. When both outputs are compared, it can also be seen that the sequence of the cities with the highest outputs are different. The output of potential new homes, shows more highlighted areas than space for all functions, but less than space for limited functions. The areas that are highlighted are mostly similar to the areas of space for all functions. In total over 37.000 potential new homes can be built in scenario 2. Again, the G-4 cities account for the highest amounts, with Amsterdam for 5.351 potential new homes, Rotterdam for 3.400, The Hague for 3.246, and Utrecht for 1.295. It stands out that Groningen and Haarlem are in the top 10 of potential new homes, which are not in the top 10 of space for all functions. When looked at the output of spare space, it can be seen that both the highlighted areas, as the top 10 sequences are completely different compared to the other outputs. The output of Figure 27 is mostly located in the more rural areas of the Netherlands. In total 121 ha of spare spaces becomes available in scenario 2.

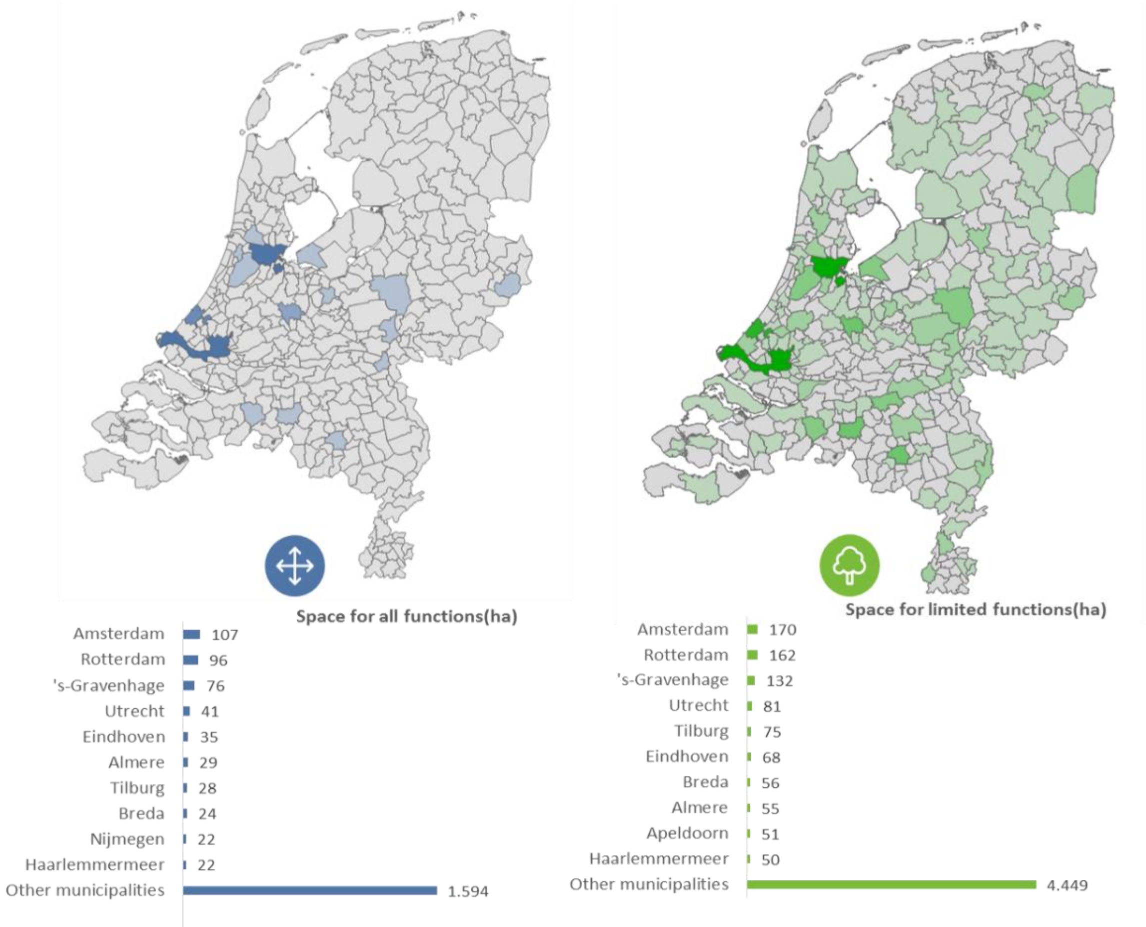

Figure 25 Scenario 2 2040 – Space for all functions and space for limited functions (Own illustration)

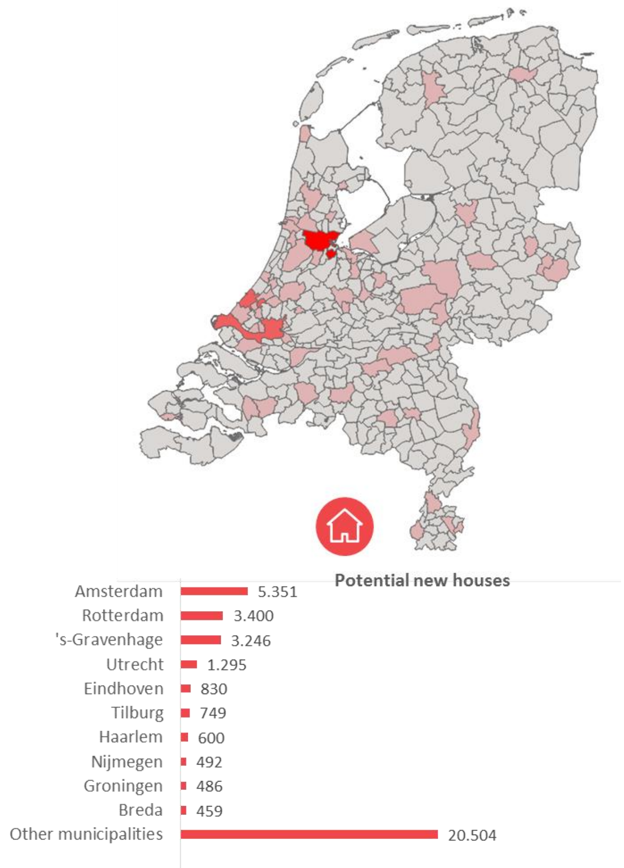

Figure 27 Scenario 2 2040 - Potential new homes (Own illustration)

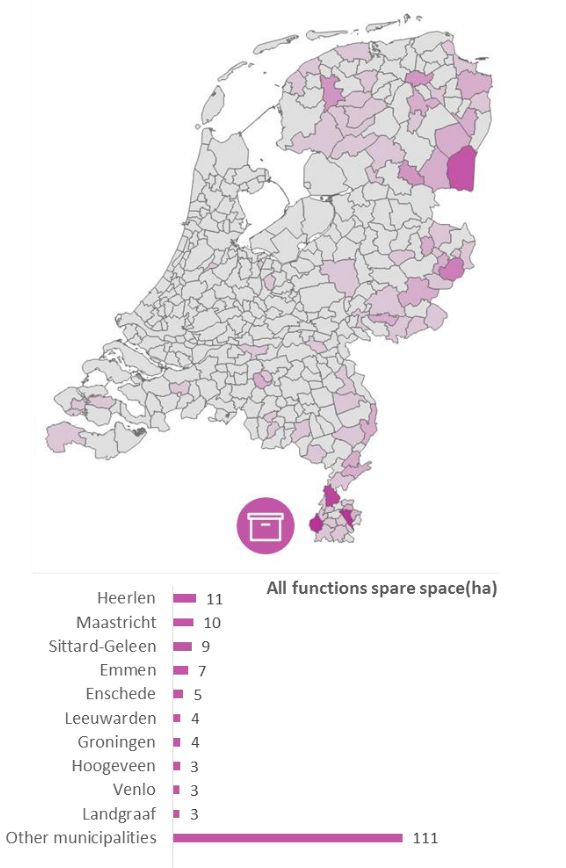

Figure 26 Scenario 2 2040 - All functions spare space (Own illustration)

6.2.3 National results scenario 3

The output of the different variables for scenario 3 is considerably lower compared to scenario 2. The space for all functions is in total 471 ha, of which is 47 ha in Amsterdam, 38 ha in Rotterdam, 29 ha in The Hague, and 12 ha in Eindhoven, see Figure 28. What stands out is that Utrecht has a significantly lower position compared to scenario 2, while Heerlen and Dordrecht have climbed to the top 10. The space for limited functions is also significantly lower than in scenario 2, with in total 202 ha, of which 6 ha in Amsterdam, 6 ha in Rotterdam, 5 ha in The Hague, and 3 ha in Utrecht. Figure 29 shows that the output of space for limited functions is highlighted in less areas than in scenario 2. The top 10 sequence is not different compared to scenario 2. In scenario 3 more than 10.000 potential new homes can be developed, see Figure 30. Amsterdam accounts for 2.460 homes, Rotterdam for 1.383 homes, The Hague for 1.249 homes and Eindhoven for 282 homes. In scenario 3, the municipalities Schiedam, Dordrecht and Enschede have replaced Groningen, Breda, and Haarlem in the top 10 for potential new homes. As for the space for all functions, the position of Utrecht has lowered compared to scenario 2. The total spare space that becomes available in scenario 3 is 24 ha. The spare space is divided over the country similar to scenario 2, mainly in the more rural areas, as can be seen in Figure 31.

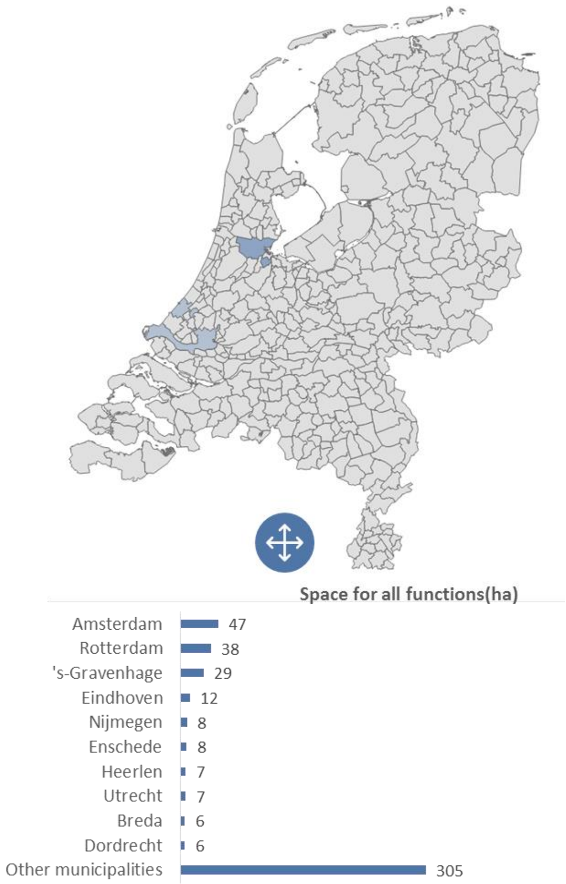

Figure 28 Scenario 3 2040 – Space for all functions (Own illustration)

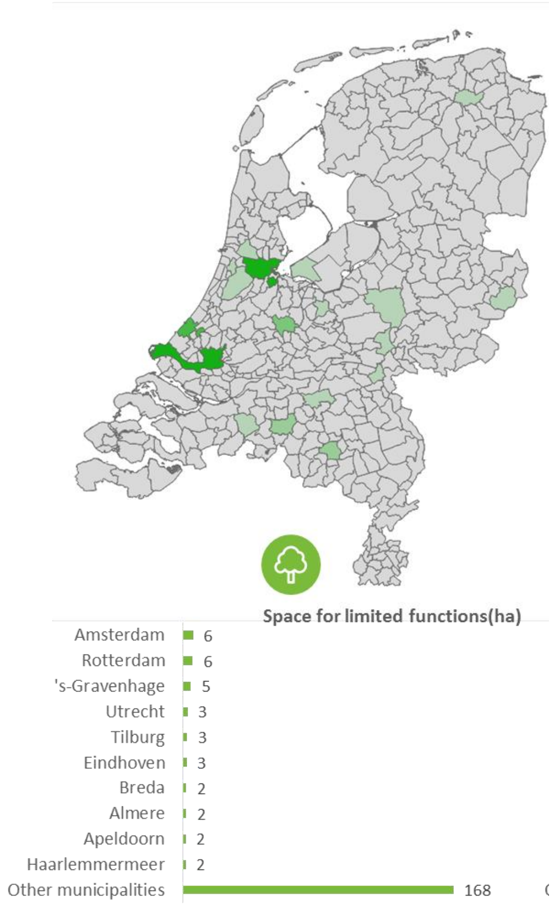

Figure 29 Scenario 3 2040 – Space for limited functions (Own illustration)

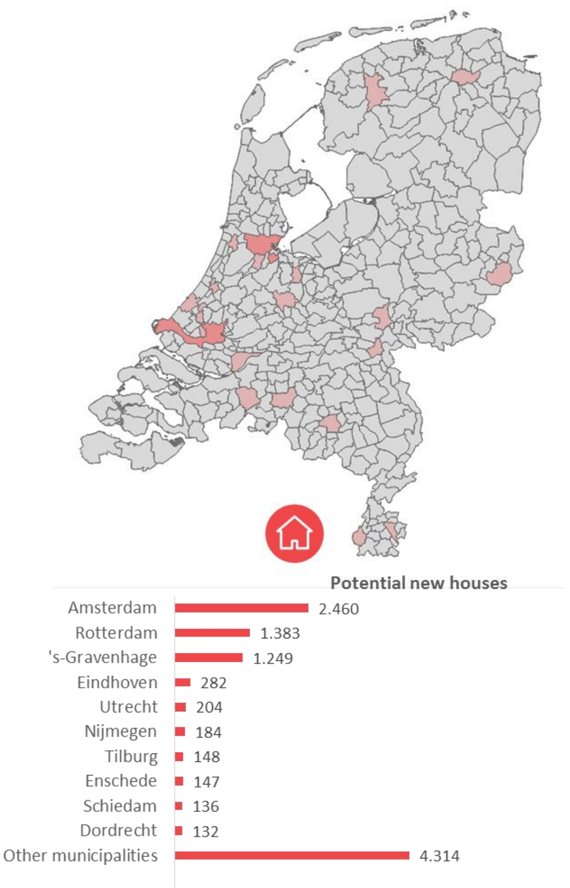

Figure 30 Scenario 3 2040 – Potential new homes (Own illustration)

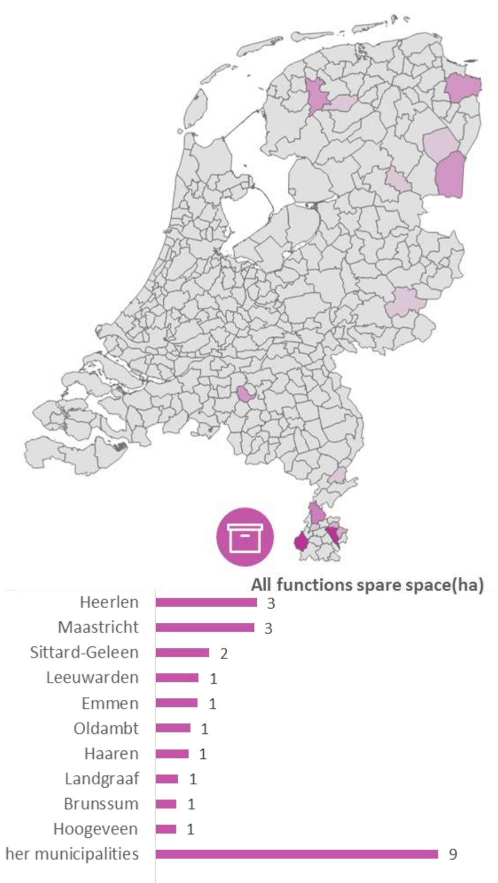

Figure 31 Scenario 3 2040 - All functions spare space (Own illustration)

6.2.4 National results scenario 4

Compared to all the other scenarios, scenario 4 has the largest output for all variables. In scenario 4 there is a total amount of space for all functions of 2.866 ha, see Figure 32. Similar to the other scenarios, Amsterdam accounts for the largest amount with 137 ha, followed by Rotterdam with 126 ha, then The Hague 99 ha, and finally Utrecht with 54 ha. The top 10 of space for all functions is similar to scenario 2, but in scenario 4 Zaanstad has replaced Nijmegen. As can be seen in Figure 33, scenario 4 results in a total amount of space for limited functions of 7.974 ha, of which 254 ha is in Amsterdam, 242 ha in Rotterdam, 197 in The Hague, and 121 in Utrecht. The other municipalities account for 6.500 ha of space for limited functions. Also a lot more areas are highlighted compared to the other scenarios. This means that in scenario 4 the space for limited functions is again divided over a large part of the country. In total 165 ha of spare spaces becomes available in scenario 4, with the same top 10 municipalities as the other scenarios. The total amount of potential new homes is over 50.000, of which 6.800 are in Amsterdam, 4.400 in Rotterdam, 4.249 in The Hague, and 1.825 in Utrecht. The top 10 sequence of potential new homes is similar to scenario 2. The total amount of spare space is 165 ha, and has a similar sequence as the other scenarios, see Figure 35.

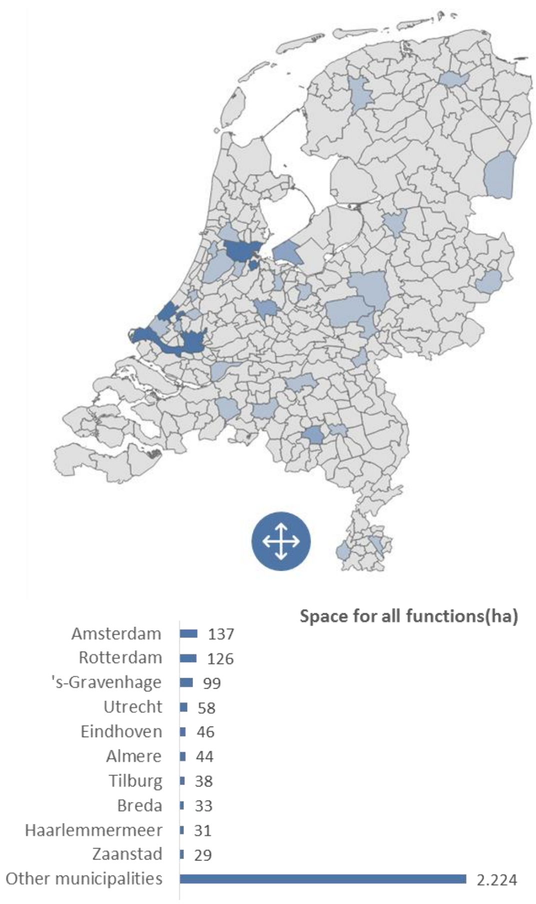

Figure 32 Scenario 4 2040 - Space for all functions (Own illustration)

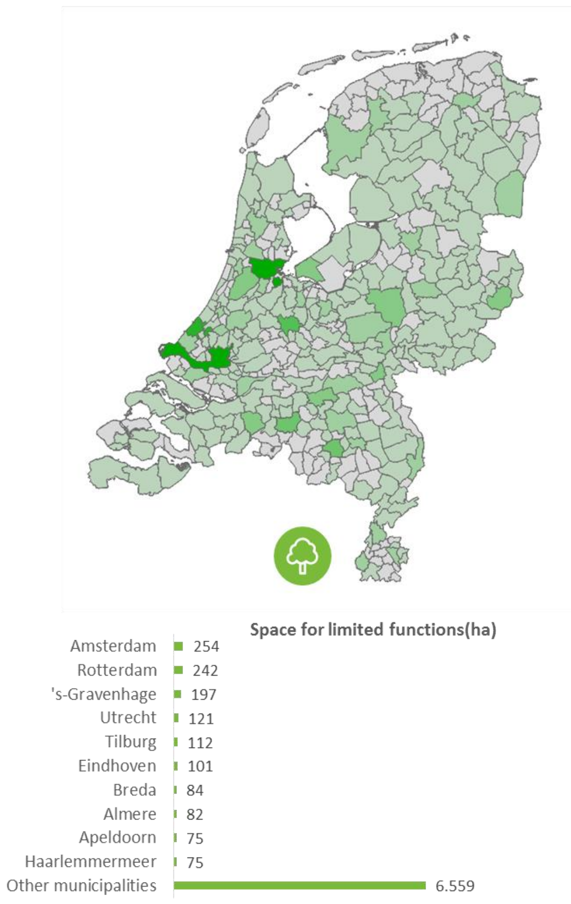

Figure 33 Scenario 4 2040 – Space for limited functions (Own illustration)

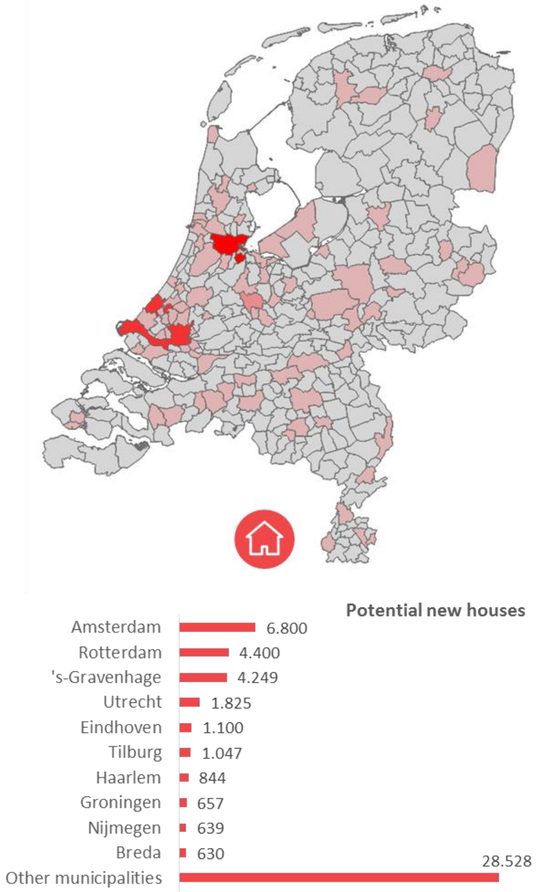

Figure 34 Scenario 4 2040 - Potential new homes (Own illustration)

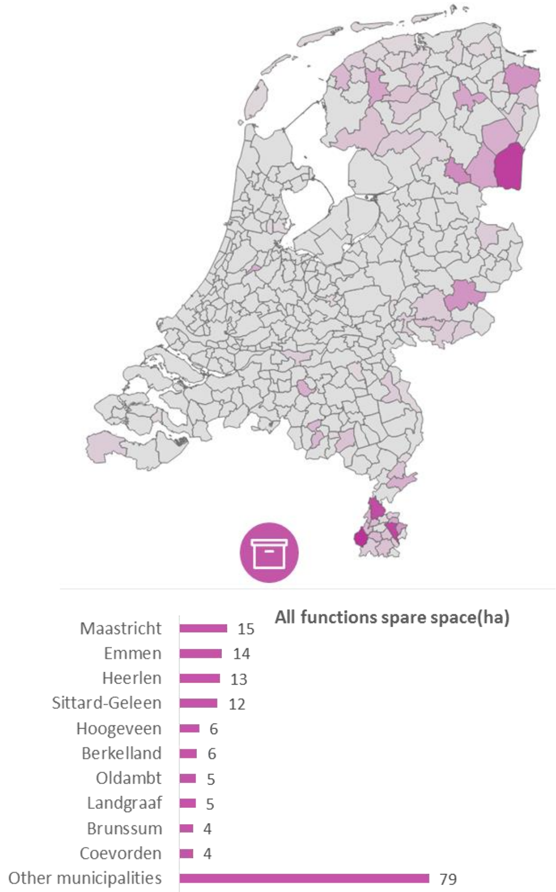

Figure 35 Scenario 4 2040 - All functions spare space (Own illustration)

6.3 Deep dive results Amsterdam

For the deep dive analysis, a same method and approach have been used, only the transition level for built parking facilities has been changed, as mentioned in Section 5.2. Again, the four main variables *Space for all functions*, *Space for limited functions*, *Potential new homes*, and *All function spare space* will be discussed.

6.3.1 Deep dive results scenario 1

Similar to the analysis on national level, for scenario 1 no transition is assumed. Hence, no effect on the current situation is expected and no results are visible. Figure 36 shows how the 100 neighborhoods in Amsterdam are divided.

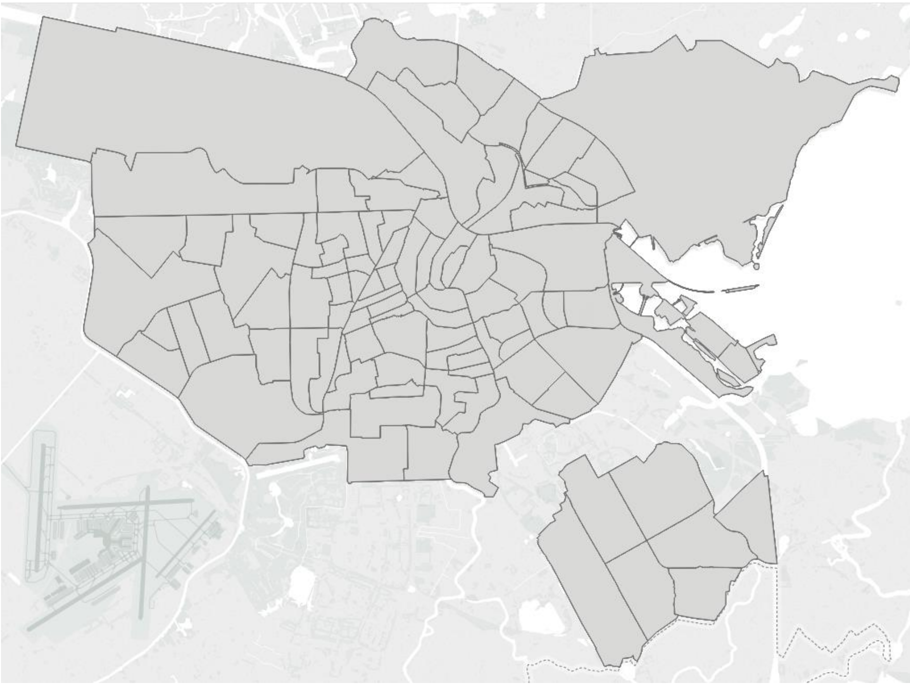

Figure 36 Deep dive scenario 1 (Own illustration)

6.3.2 Deep dive results scenario 2

Figure 37 shows the output space for all functions for scenario 2. The total amount of space that becomes available for all functions is 69 ha. The area Zuid-as has the largest amount that becomes available but does not differ much from the other top 10 neighborhoods. As can be seen in Figure 37, a large part of the west and south-west of Amsterdam is highlighted. However, it can also be seen that the area Jordaan in the center of Amsterdam has relatively a lot of space for all functions. The total amount of space for limited functions is 196 ha in scenario 2. Compared to the top 10 sequence of the space for all functions, it can be concluded that the neighborhoods are different. Also, when looked at the highlighted areas, the space for limited functions shows a lot more highlighted areas than the space for all functions. In total there is an amount of 53 ha of spare space in scenario 2, which has largely the same neighborhoods as space for all functions. In total 3.021 potential homes can be developed in scenario 2. Comparing Figure 37 and Figure 39, it can be seen that they have a significant different top 10. The largest amounts potential new homes are in de Jordaan with 298 homes, followed by the Zuidas with 172 homes, and then de Grachtengordel-West with 118 homes.

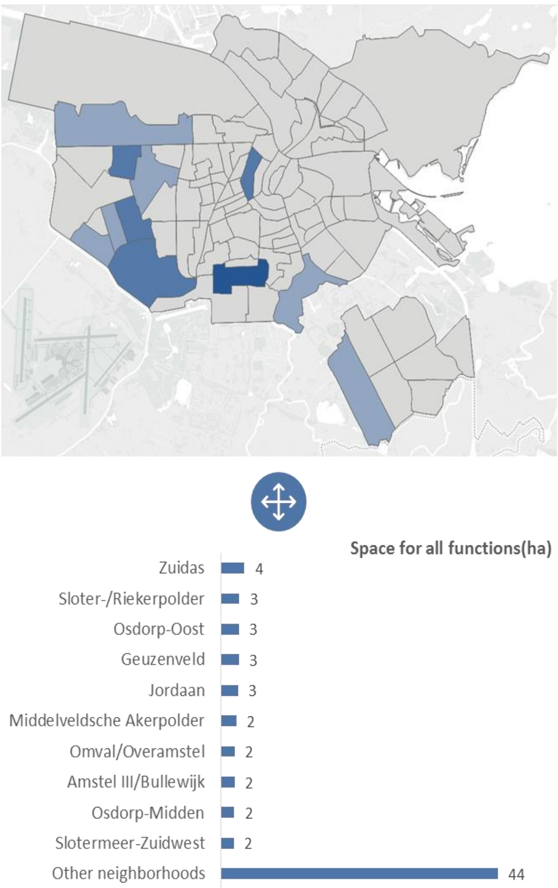

Figure 37 Deep dive scenario 2 - Space for all functions 2040 (Own illustration)

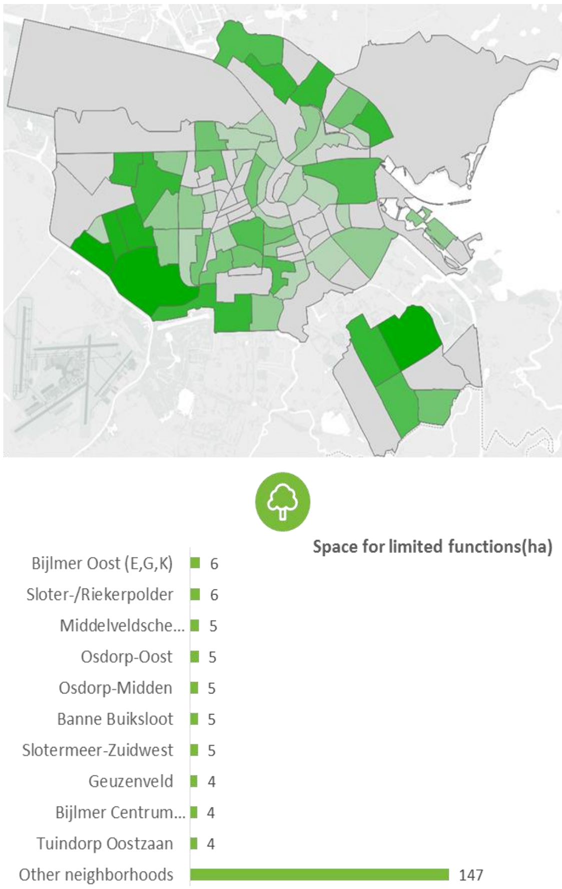

Figure 38 Deep dive scenario 2 - Space for limited functions 2040 (Own illustration)

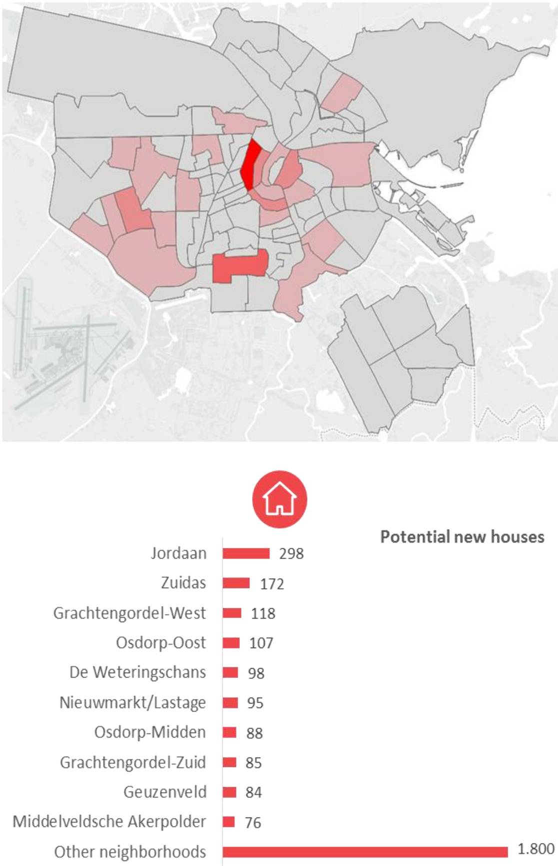

Figure 39 Deep dive scenario 2 - Potential new house 2040 (Own illustration)

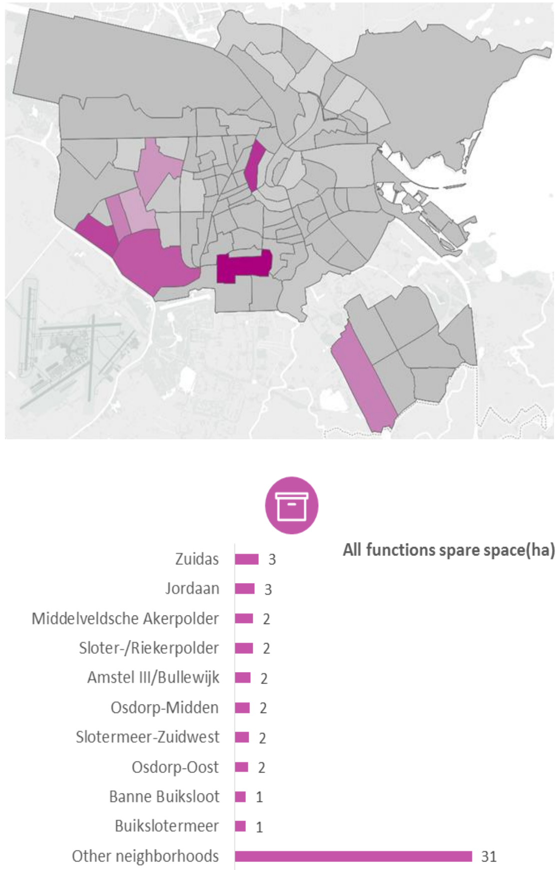

Figure 40 Deep dive scenario 2 - Spare space for all functions 2040 (Own illustration)

6.3.2 Deep dive results scenario 3

Scenario 3 has a lower output than scenario 2 for each of the variables. Figure 41 shows a total amount of 48 ha of space for all functions, divided over different neighborhoods than in scenario 2. The neighborhoods Zuidas, Overamstel and Amstel III had high outputs in scenario 2, but these are now replaced by Nieuwmarkt, Tuindorp, and Banne Buiksloot. The space for limited functions shows the same sequence as scenario 2, but with a total amount of 7 ha, this is significantly lower. In scenario 3 are 2.286 potential new homes that can be built, of which, similar to scenario 2, the largest amounts are in de Jordaan, Grachtengordel-West, and De Weteringschans. The spare space in scenario 3 is 43 ha. Although the amounts of spare space are comparable to scenario 2, the neighborhoods and sequence are slightly different, see Figure 44. The neighborhoods Zuidas, Amstel III, and Buikslotermeer have been replaced by Waterlandpleinbuurt, Tuindorp Oostzaan, and Nieuwmarkt.

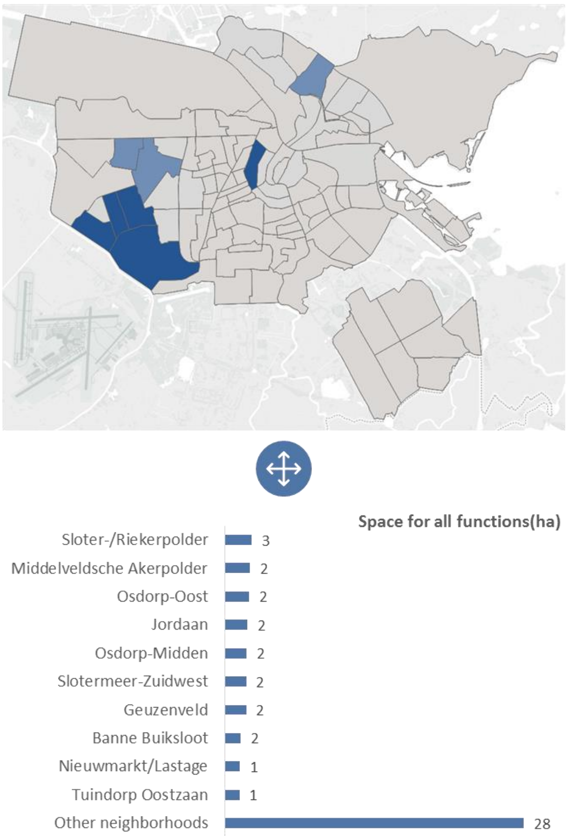

Figure 41 Deep dive scenario 3 - Space for all functions 2040 (Own illustration)

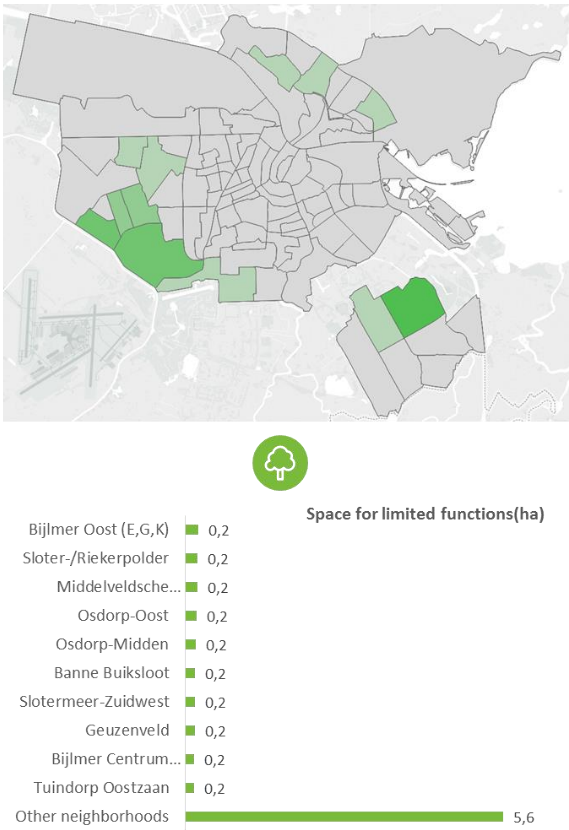

Figure 42 Deep dive scenario 3 - Space for limited functions 2040 (Own illustration)

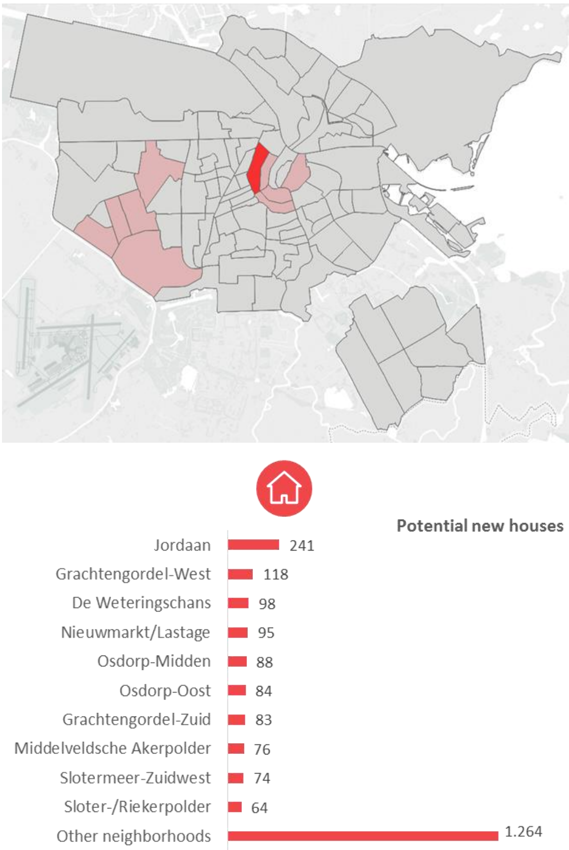

Figure 43 Deep dive scenario 3 - Potential new house 2040 (Own illustration)

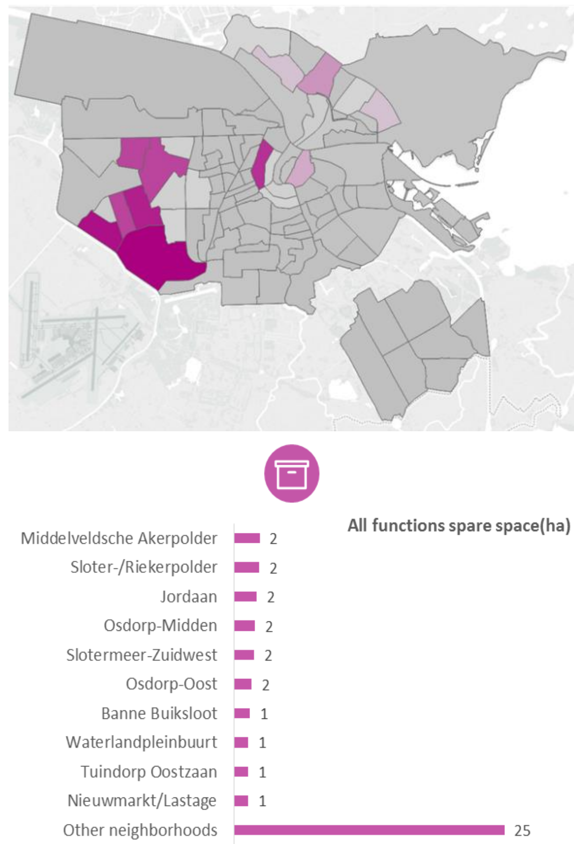

Figure 44 Deep dive scenario 3 - All functions spare space 2040 (Own illustration)

6.3.3 Deep dive results scenario 4

Scenario 4 has the highest outputs for all variables. Figure 45 shows a total amount of space for all functions of 345 ha. Compared to scenarios 2 and 3 a lot more neighborhoods are highlighted, however the top 10 is similar. The effect of the extra highlighted neighborhoods can be seen in the total amount, which is significantly higher than the other scenarios. The space for limited functions is in total 292 ha in scenario 4. Although the top 10 has a similar sequence compared to scenario 2, the amounts are significantly higher. Furthermore, Figure 46 shows that almost every neighborhood has an output, which is different than the other scenarios. The total amount of potential new houses is 3.331. Figure 47 shows a comparable division over the neighborhoods as scenario 2. The total amount of spare space is 57 ha. The spare space is divided over the same neighborhoods as in scenario 3 and 4.

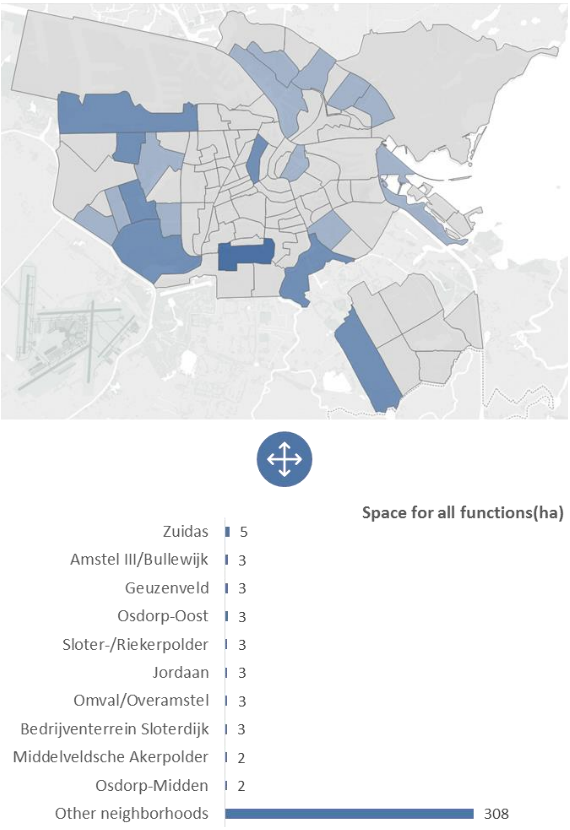

Figure 45 Deep dive scenario 4 - Space for all functions 2040 (Own illustration)

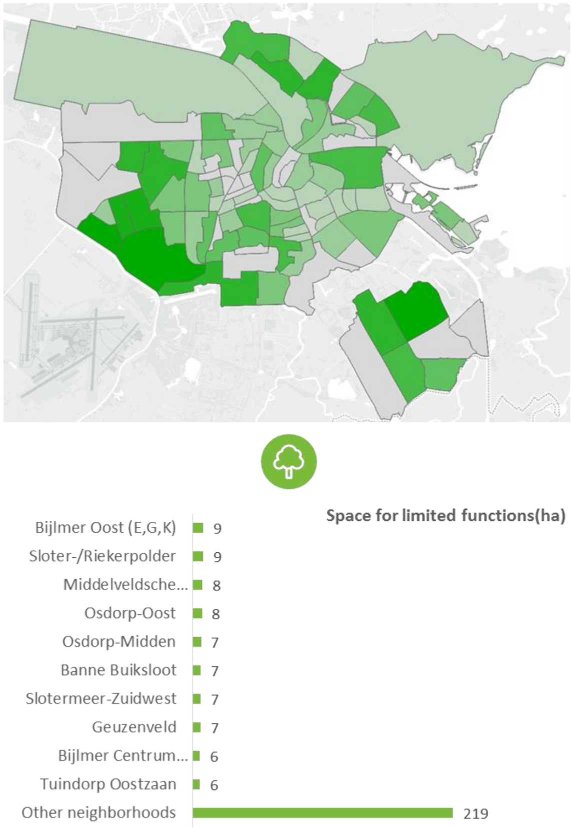

Figure 46 Deep dive scenario 4 - Space for limited functions 2040 (Own illustration)

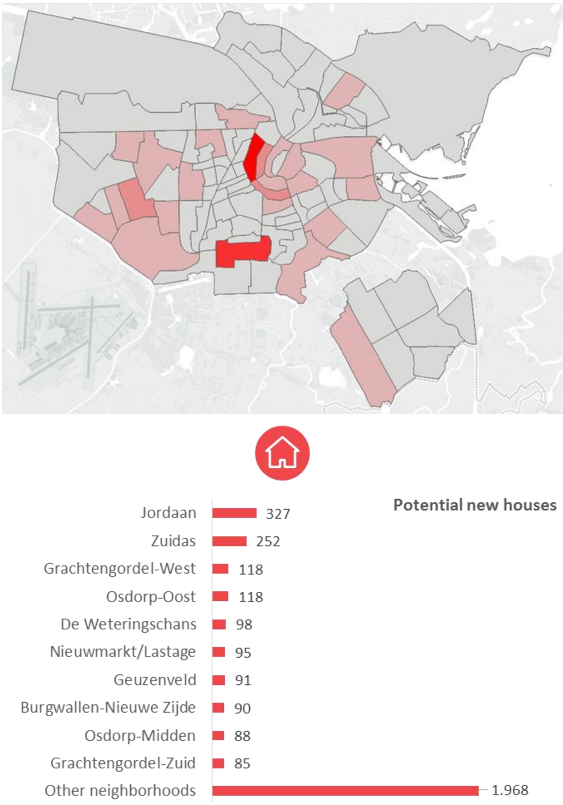

Figure 47 Deep dive scenario 4 - Potential new houses 2040 (Own illustration)

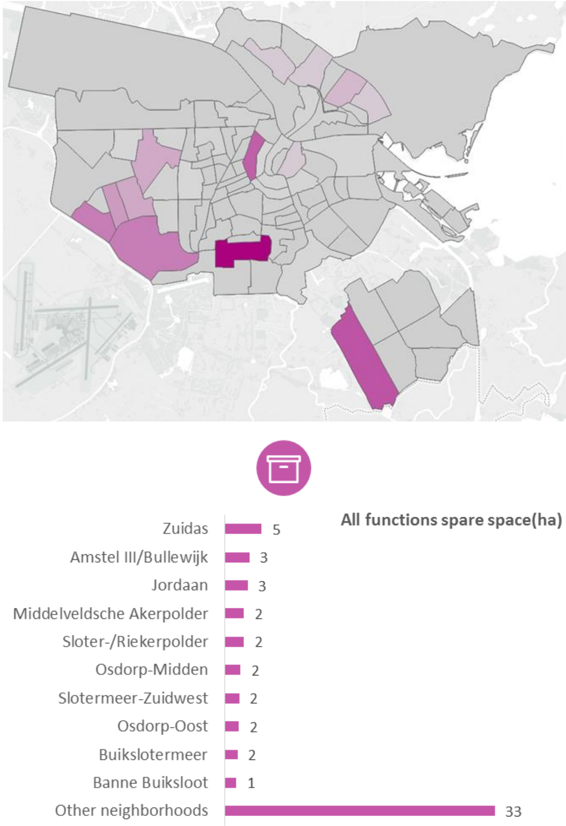

Figure 48 Deep dive scenario 4 - All functions spare space 2040 (Own illustration)

6.4 Spatial value results

In this section there will be looked at how the outputs from the previous sections affect the economic, environmental, health and social spatial value. Each will now be discussed further.

6.4.1 Economic spatial value

According to the literature on the value of blue and green in a city, see Section 3, the value of properties can increase between the ranges of 4% to 12%, depending on the type of house and the quality of the urban green, when they are located within 300 meters of public greenery (Luttik & Jókövi, 2003). If the freed up space by smart mobility is transformed into greenery, this will help to increase the real estate value in that area. In addition, smart mobility can increase economic spatial value by the potential new houses that can be built. These houses will be built on the space for all functions. The economic value of this space is thus determined by the average value of housing in that area, as the value of ground is determined by its function. This means smart mobility has a relatively larger impact on the spatial value in locations where land is expensive. The calculation of the economic value has followed the approach as discussed in Section 2.5.2. The economic effect of the attractiveness of an area and the location choice of new businesses will not be discussed. In literature (Maas, 2009) this was assumed as an important effect of extra greenery, but is hard to determine and depends on a lot of variables. Hence, this is not part of the scope of this research, but can be an interesting follow up research.

The Table below shows which total potential economic spatial value smart mobility can have for the city of Amsterdam. This is calculated following the method discussed in Chapter 2. Scenario 4 shows with 3,9 billion euro the highest output in economic spatial value, followed by scenario 2 with 3,5 billion and scenario 3 with almost 2 billion euro. It shows that for all scenarios the output increase in property value is significantly higher than the output in extra properties sold.

Table 21 Economic spatial value - Deep dive results

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Increase in property value	0	€ 2.713.893.600	€ 1.309.540.720	€ 3.031.620.200
Extra properties sold	0	€ 805.103.808	€ 645.816.079	€ 875.636.889
Total	**0**	**€ 3.518.997.408**	**€ 1.955.356.799**	**€ 3.907.257.089**

6.4.2 Social spatial value

According to literature a relation exists between public green and social cohesion. The amount of green space in an environment is associated with positive feelings of social safety. If greenery increases with 1% in the Netherlands, the social cohesion increases with 0.55% (Vreke, Slaverda, & Langers, 2010). It is important to mention that this relation is only valid for the Netherlands. In countries with a higher crime rate, public green results in a higher feeling of unsafety and in a lower cohesion level. The different scenarios result in the following increases of social coherences, see Table 22. Again scenario 4 shows the highest output with a minimum of 0%, a maximum of 5%, and an average of 2%. Scenario 2 has a bandwidth of 0%-3%, and an average of 1%. Scenario 3 has a maximum of 1%, but an average lower than 1%.

Table 22 Social spatial value

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Minimum	0	0%	0%	0%
Maximum	0	3%	1%	5%
Average	**0**	**1%**	**0%**	**2%**

6.4.3 Health spatial value

The availability of public green helps to increase the amount of exercise people do. If a sufficient availability of green exists, people start to walk, cycle and garden faster, which is beneficial for their health (Maas, 2009). Furthermore, it helps to reduce the risk of certain diseases, like depression, and reduces the use of medicines and hospitalization. Literature shows that 1% more green within a radius of 1 km results in 0,835 fewer patients per 1,000 inhabitants (Maas, 2009). On a neighborhood level, the availability of green is not known, but on a municipality level it results in the output of Table 23. It shows that smart mobility can have an indirect effect on the health of the population and that it can reduce the amount of patients up to 13.267 in scenario 4. Scenario 3 has the lowest output and results in a reduction of 2127 patients.

Table 23 Health spatial value

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Percentage green increase	0	13%	3%	19%
Reduction of patients	**0**	**8.852**	**2.127**	**13.267**

6.4.4 Environmental/ecological spatial value

The freed up space by smart mobility can also help to improve the environmental and ecological spatial value. The freed up space can help to increase the air quality, the water storage capacity, the biodiversity, the food production, and to decrease urban heat. Besides the expectation that smart mobility will result in less emissions (KiM Netherlands Institute for Transport Policy Analysis, 2015a), the air quality will be improved by the extra vegetation that is placed on the freed up space. Trees can take up 1kg of fine particles per tree, which results in a maximum total take up by smart mobility of 47803kg (Kirchholtes, 2012) in scenario 4. This amount of take up results in a maximum total cost reduction of 19 million euro, assuming €403 per kilogram fine particles (Kirchholtes, 2012).

For the decrease in urban heat a same calculation can be made. Literature shows that 1% change from red area, streets/housing etc., to green area results in a reduction in urban heat of 0,1 degree Celsius (Klok et al., 2010). The results show that smart mobility has a maximum potential of heat reduction of almost 1 degree Celsius. In scenario 4 the average reduction is almost 0,35C, followed by an average of 0,23C in scenario 2, and 0,1C in scenario 3.

Table 24 Environmental spatial value – fine particles

Fine particles	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Minimum	0 kg	0 kg	0 kg	0 kg
Maximum	0 kg	986 kg	419 kg	1.470 kg
Average	0 kg	331 kg	78 kg	493 kg
Total	**0 kg**	**32.071 kg**	**7.607 kg**	**47.803 kg**

Table 25 Environmental spatial value – Heat reduction

Heat reduction	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Minimum	0,00C	0,00C	0,00C	0,00C
Maximum	0,00C	0,59C	0,25C	0,89C
Average	0,00**C**	0,23C	0,05C	0,35C

Figure 49 Transformation into public area. Reprinted from: www.contemporist.com

7. Discussion

The results of the different scenarios have been shown in Chapter 6. These results will be interpreted in this chapter. Furthermore, this chapter will elaborate on how the results of Chapter 6 can be compared to findings of earlier work and what new and important findings can be done. The different outputs on national level and deep dive level will be discussed in Section 7.1. Section 7.2 will elaborate on how the outputs of Chapter 6 affect the spatial values. Section 7.3 discusses how the output space for limited functions can be used to meet the public ambitions. Possible applications of the findings for the municipality of Amsterdam are discussed in Section 7.4. Finally, steps for effective governance of smart mobility is discussed in Section 7.5.

7.1 Discussion of spatial results

For the variables space for all functions, space for limited functions and potential new homes, the results show that smart mobility causes the highest output in larger urban areas, such as Amsterdam, Utrecht, The Hague, and Eindhoven. This corresponds to the interview findings (Spark, 2016) (Rigo, 2017) (Romph, 2017), and is also expected as larger cities have a bigger parking capacity, which can result in a bigger amount of freed up space. However, when looked at the variables separately, the variables show significant different distributions of output for the rest of the Netherlands. Space for all functions mainly becomes available in the large urban areas, G-20 cities, and shows a high concentration of the output. This is caused by the fact that larger cities have a more dynamic housing stock, which in relation with parking requirements can be used to change the parking capacity. The results have shown that demolition plans have more effect on the potential freed up space by smart mobility than the development plans. Contrary to the space for all functions, the space for limited functions becomes available in all regions of the Netherlands. This shows that space for limited functions does not depend on the housing developments. When looked at the output potential new homes, it was expected that this output would only show high results in areas where space for all functions also showed high output. However, it shows that the housing density determines the output of potential new homes stronger than the available space for all functions. The fact that the housing dynamics and the housing density determine the extent to which the positive effects of smart mobility can be utilized, is a new and important finding. Furthermore, it showed that spare space becomes available in locations where they have a low housing demand. Especially in these regions, the freed up space by smart mobility could help to improve the area and increase the attractiveness of the region.

Similar to the results on a national level, the housing dynamics of a neighborhood show to be important. It showed that areas with a lot of development or demolition plans have more freed up space than areas with low dynamics. This means that areas with a dynamic market can benefit more from the positive effects of smart mobility. However, the type of parking shows to be important as well, more than on a national level. The output space for limited functions becomes available in almost all the neighborhoods, as street parking is present in all the neighborhoods. The output space for all functions however, only becomes available in areas with a dynamic market or with high capacities of built facility and field parking. This is an important finding in order to benefit from the effects of smart mobility. Similar to the findings on a national level, the housing density shows to be an important factor in determining the potential new housing developments on a deep dive level. Furthermore, it showed that spare space becomes available in areas with development plans only. This means that more housing on the same area than currently assumed could be developed. This would increase the housing density, benefitting the reduction of car use.

Chapter 6 has shown the potential output that smart mobility can have, depending on the scenario. Section 7.1 has indicated what the most important factors are that determine how and where the effects of smart mobility can be used. Therefore, Chapter 6 and Section 7.1 together form the answer to the first sub research question: *"How does autonomous and shared mobility affect the current used space within the existing building area, taking into account the different mobility future scenarios?"*. Although, for the answer of this sub research question there has only been focused on the effects of smart mobility on the parking reduction, it is expected that smart mobility will also affect the current road network footprint. Depending on the scenario, much more space can become available. The potential freed up space that smart mobility can realize, might be significantly higher. It is recommended that this will be researched in the future.

7.2 Discussion of the effects on spatial values

This section will discuss the findings on the second sub-research question: *"How does autonomous and shared mobility affect the spatial value, taking into account the different mobility future scenarios?"*. The results on economic spatial value show that smart mobility has an indirect positive effect on the property values in a neighborhood, in which the increase in value by extra greenery has more effect than the value of the extra properties sold. The degree of the effect is however relative, as the positive effect depends on the existing value in a neighborhood. Amsterdam has the highest property values in the Netherlands, so it can be expected that the results of Section 6.4.1 are significantly lower if a different city in the Netherlands is chosen. The fact that value increase has a stronger economic spatial value than extra properties sold is to the best of the author's knowledge a new finding on smart mobility. Besides the effect on value, smart mobility has another indirect effect. As already mentioned in Chapter 3, a reduction in parking requirements, and a reduction in costs, could affect the affordability of housing and could increase the feasibility of new housing developments. In addition, the results of Chapter 6 have shown that a significant amount of spare space is available. On these areas more housing can be developed. This indicates that smart mobility could increase the accessibility of housing for lower to mid-class incomes, and could increase the possible housing density. If the housing density is increased in areas near rails infrastructure, this will help to reduce car use even more (Oudendijk, 2017). How effective smart mobility will be on both aspects, has not been researched due to a time constrain. It is recommended that this will be done in future research.

The results of Section 6.4.2 indicate that smart mobility can increase the social coherence up to 5% in Amsterdam. This means that 5% of the residents of a neighborhood feels better integrated, participated and identified with the neighborhood itself (Vreke et al., 2010). This is to the best of the author's knowledge a new finding on smart mobility.

The results furthermore showed that the possible increase in greenery can have a health spatial value. Literature already showed that smart mobility, especially by electric vehicles, could improve the air quality and the health of the population. But the indirect effect of a reduction in patients had not yet been mentioned.

The final spatial value that is discussed in Section 6.4 is the environmental/ecological spatial value. Only results on CO2 take up and urban heat reduction are given, as for the remaining three environmental and ecological variables; biodiversity, food production and water storage capacity, no literature exists on what effect extra space will generate. However, it can be expected that more greenery gives the possibility for more species of flora and fauna to develop, which improves the biodiversity and the food production. A higher area of greenery also results in more ground in which rainwater can infiltrate, which increases the water storage capacity of a city. The beneficial environmental effects of smart mobility were already mentioned in several researches. This research thus confirms that smart mobility can have a positive effect on the environment.

7.3 Possible new functions on freed up space

To what extent the spatial values of Section 7.2 will be achieved, depend on how municipalities will use the space and how they will pursue their smart mobility policies. The third sub-research question was: *"How can the potential affected space be utilized and help to achieve the public ambitions of a municipality, taking into account the different mobility future scenarios?"* This section will discuss the possible functions a municipality could place on the freed up space. Section 7.4 will discuss the policy related answer.

7.3.1 Possible new functions

For which functions the affected space can be used depends if the space is suitable for all functions or only for limited functions. The major difference between these two options is that the space for all functions is big enough to develop buildings on it, while the space for limited functions are often smaller size and odd size plots, which makes it unsuitable for buildings. If the space for all functions is used for housing, depends on the housing demand in a region. On a national level, not every region has sufficient demand, so in these regions the space can be used for other functions. Many functions can be thought of, e.g. an improvement of the public space, development of a park, development of a school etc. However, because the chosen function strongly depends on the ambitions of a municipality, this will not be further specified on a national level. On a municipality level, Amsterdam, a region with a high scarcity of housing, it is expected that the ground suitable for housing will be used for housing.

The space for limited functions will mainly be used to improve the public space. A futureproof, sustainable and green public area are often mentioned as important ambitions (Wolch, Byrne, & Newell, 2014). To meet these ambitions, an overview has been created of potential functions into which the space for limited functions could be transformed. An important source has been the report by Arup on the effects of different green functions within a city (Arup Deutschland GmbH, 2016). Section 3.7 showed that the municipality of Amsterdam aims to improve greenery, the attractiveness of the city, adaptations regarding the climate, and mobility. Mainly options that could add to these goals are included. Table 26 shows an overview of the different functions that were identified.

Table 26 Optional functions for freed up space

Option	***Function***	***Option***	***Function***
Urban Farm	*Food production/green*	Wind turbines	*Energy*
Greenhouses	*Food production/green*	Urban gym	*Facility*
Beehives and highways	*Biodiversity*	Sport area (pedal)	*Facility*
Wildlife corridors	*Biodiversity*	Modular plant walls	*Green*
Integrated habitat creation	*Biodiversity*	Playground	*Facility*
Flood residence	*Water*	Commercial area	*Facility*
Water storage	*Water*	Cycle lanes	*Facility*
Sustainable urban dranage	*Water*	Creative meet areas	*Facility*
Bioreactive facade	*Biodiversity*	Bike storage	*Facility*
Urban vegetation	*Green*	Drop off lanes	*Facility*
City gardens	*Green*		

Several functions can be expected at any location, but others, like wind turbines, will not be placed throughout the whole city. A division needed to be made where a certain function can be expected. Because the freed up space is mainly located next to a street, it has been chosen to divide the functions using different street types. In general, five different street types can be divided; a city street, visitors street, local street, thoroughfare street and an arterial road (Wouter van der Veur, 2013), see Figure 50. By logical reasoning, a division has been made which functions can be expected at the different types of streets. Wind turbines are for example not expected in local streets, while urban vegetation can be expected in all types of streets. The division is shown in Table 27.

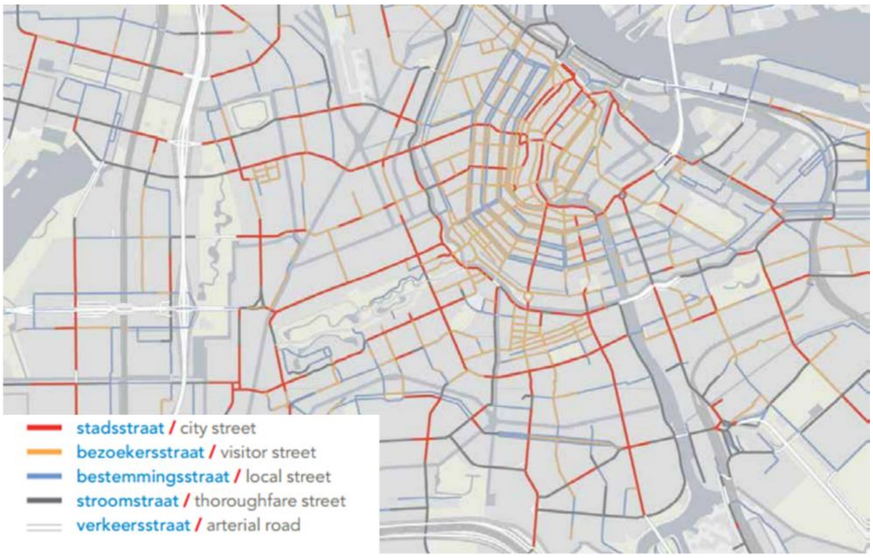

Figure 50 Type of streets in Amsterdam. Reprinted from planAmsterdam 2013.

Table 27 Possible functions per type of street

Function	**Goal**	**Citystreet**	**Visitorstreet**	**Local street**	**Thoroughfare street**	**Arterial road**
Urban Farm	Food production/green		1	1		
Greenhouses	Food production/green		1	1		
Beehives and highways	Biodiversity	1			1	1
Wildlife corridors	Biodiversity	1	1	1		
Integrated habitat creation	Biodiversity	1	1	1	1	1
Flood residence	Water	1			1	
Water storage	Water	1	1		1	
Sustainable urban dranage	Water	1	1	1	1	
Bioreactive facade	Biodiversity	1			1	1
Urban vegetation	Green	1	1	1	1	
City gardens	Green		1	1		
Wind turbines	Energy				1	1

Urban gym	facility	1	1	1	1	
Sport area (pedal)	facility	1	1	1	1	
Modular plant walls	Green	1	1		1	1
Playground	facility		1	1		
Commercial area	facility	1	1		1	
Cycle lanes	facility	1	1		1	
Creative meet areas	facility	1	1		1	
Bike storage	facility	1	1		1	
Drop off lanes	facility	1	1	1	1	

7.3.2 Impression of transformation possibilities

Amsterdam finds it important to improve the greenery and attractiveness of the city, adaptations regarding the climate, and mobility. It is recommended that the functions doing so, will be implemented in all areas of Amsterdam. This means that everywhere in Amsterdam extra functions like urban gardens, water storage, vegetation, green houses, cycle lanes, bike storages, and drop off lanes will be placed on the freed up space. These functions will help the municipality in the ambitions regarding health, ecology, climate, and social quality. The following figures can give an impression of how the streets before can be transformed to streets after the effect of smart mobility becomes visible. An impression has been made for each of the street types, showing the possible functions and the possible benefits.

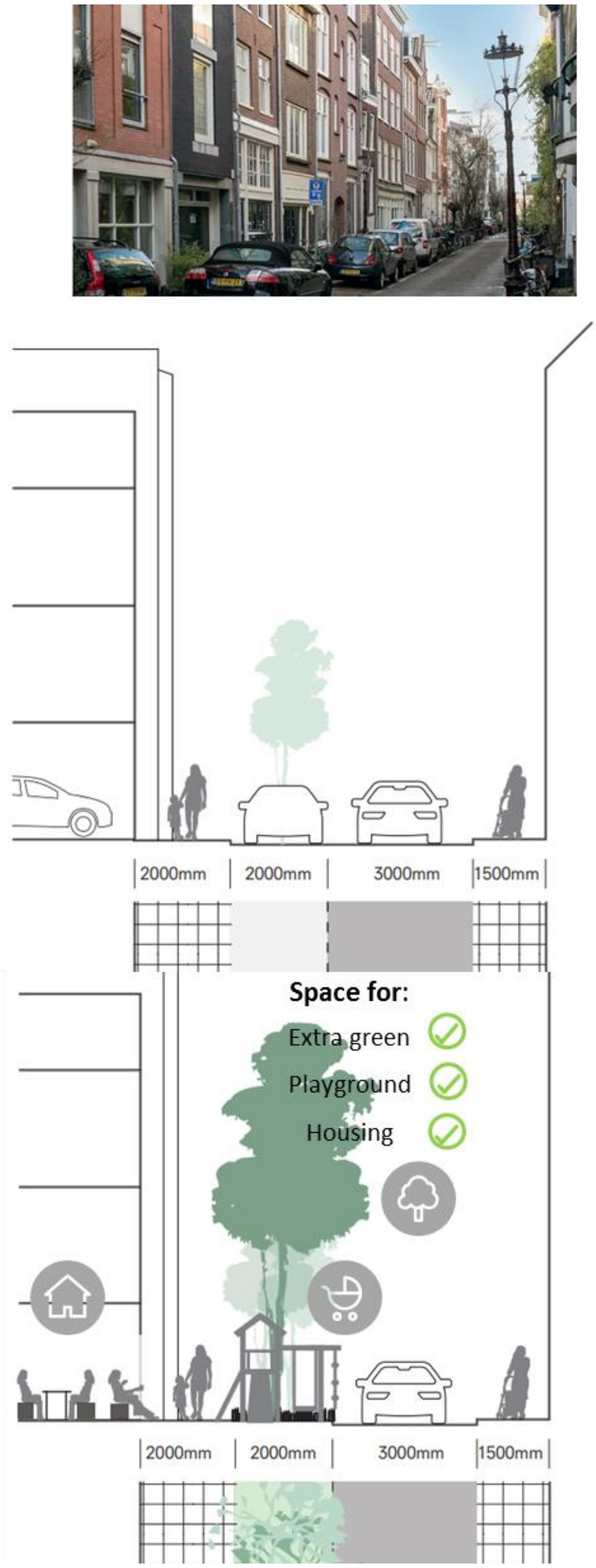

Figure 51 Localstreet transformation potential - Utrechtsedwarsstraat, Amsterdam (Own illustration)

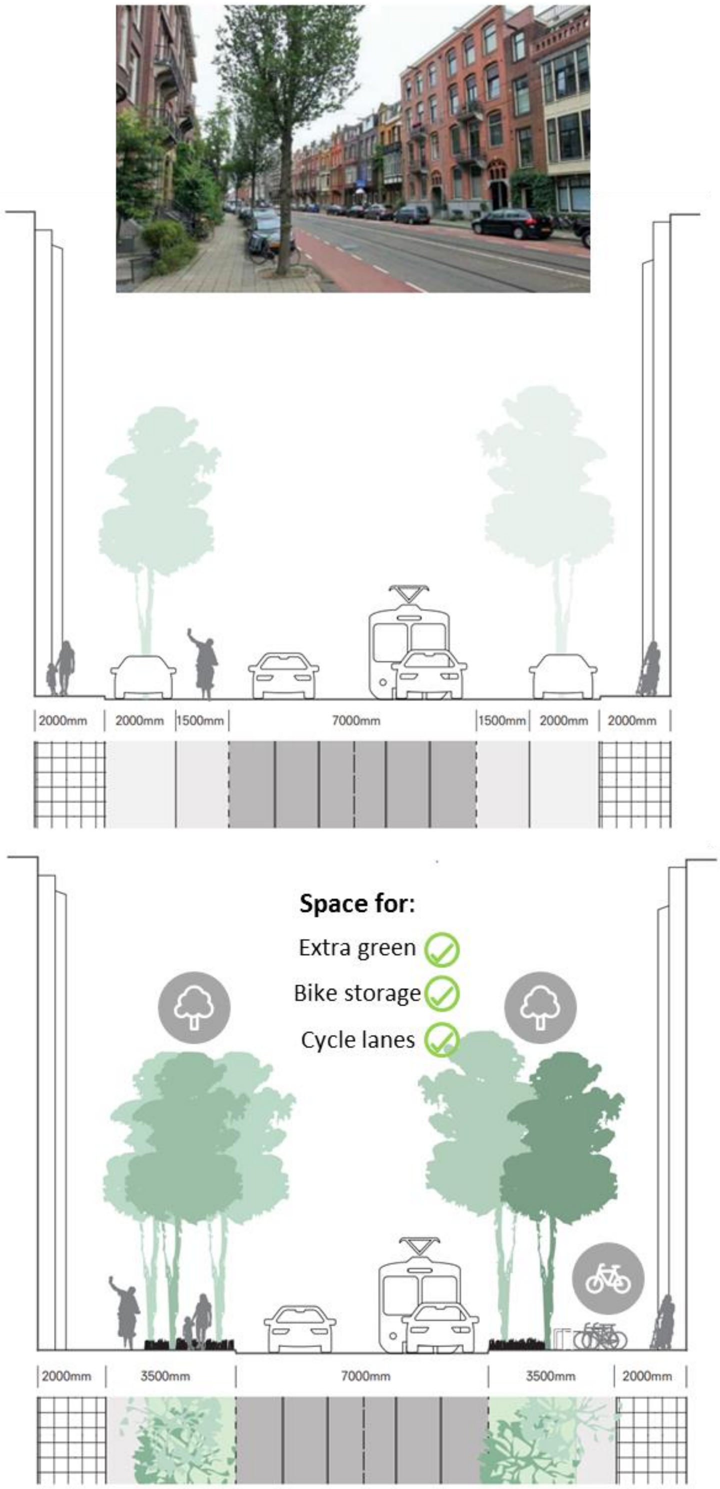

Figure 52 Citystreet transformation potential - Koninginngeweg, Amsterdam (Own illustration)

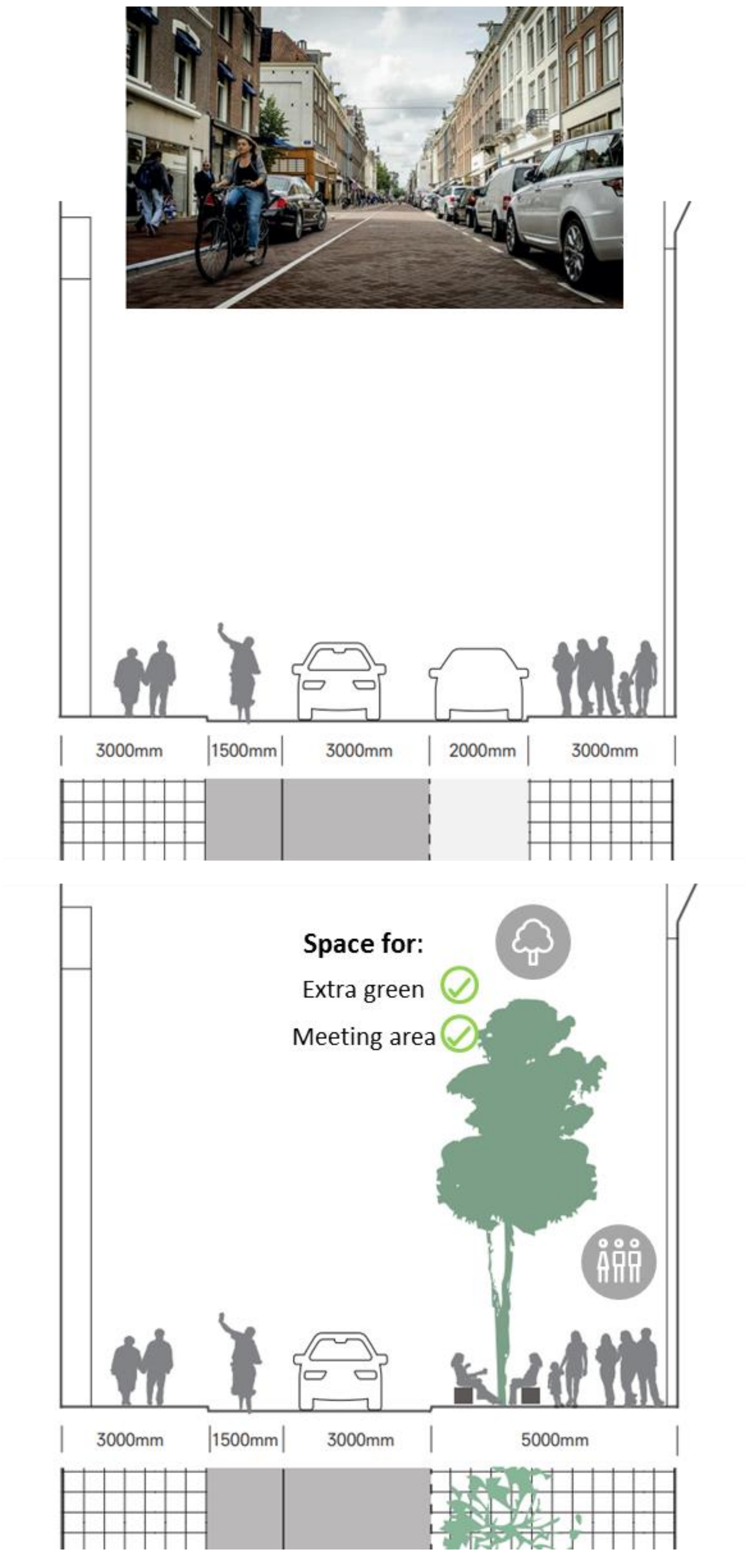

Figure 53 Visitorsstreet transformation potential - PC Hooftstraat, Amsterdam (Own illustration)

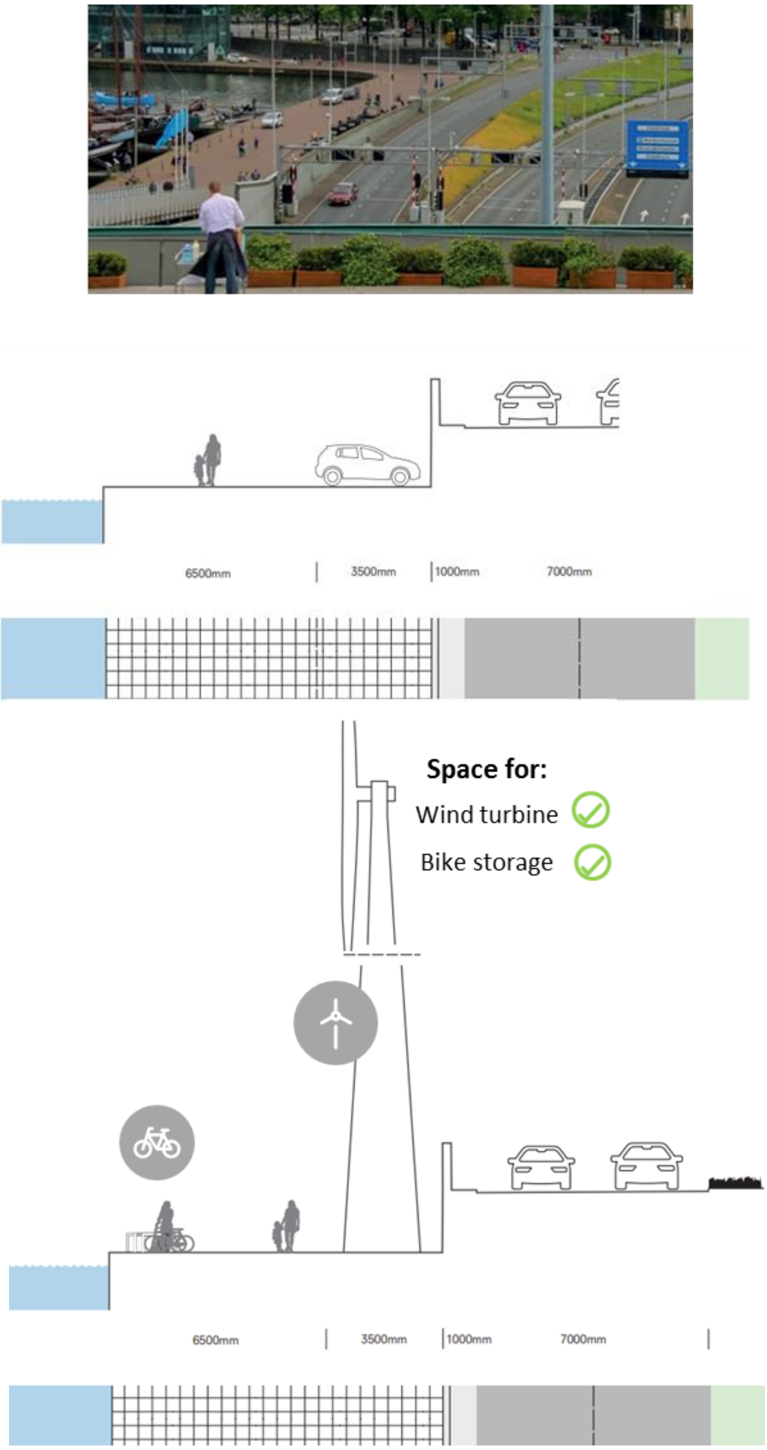

Figure 54 Arterial road transformation potential - Ijtunnel, Amsterdam (Own illustration)

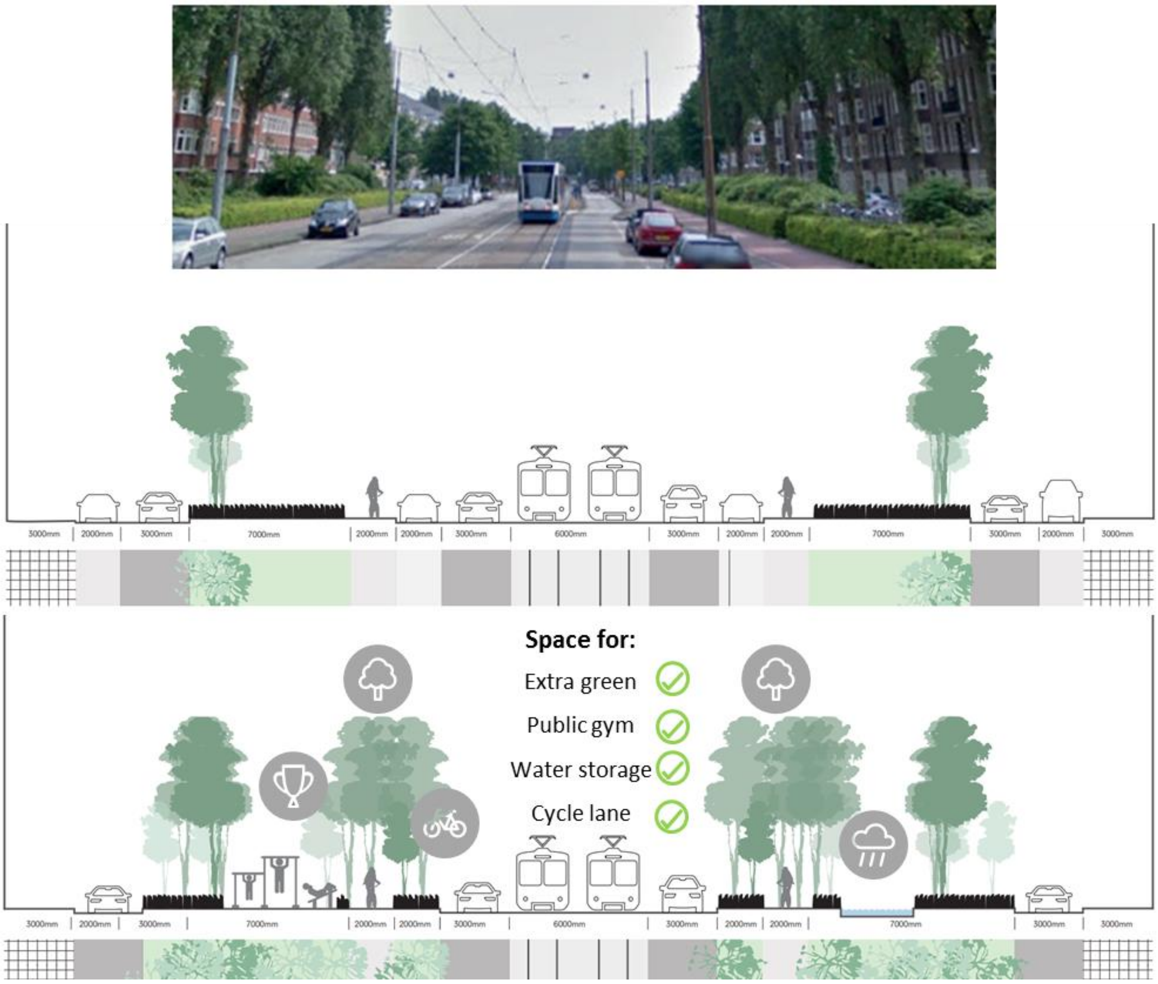

Figure 55 Thoroughfare street transformation potential - Rooseveltlaan, Amsterdam (Own illustration)

7.4 Governance of smart mobility

This research has worked with scenarios in order to determine the effects. Depending on the policy and the effectiveness of the governance of both the national and local governments, these scenarios will become reality. This section will briefly elaborate what kind of policy should be applied in order to realize the maximum effect, scenario 4.

The previous policy on parking has led to a large amount of underpriced parking in the Netherlands. This was mainly caused by the auto-centric land use planning and the idea that parking was an important source of income. Therefore, the policy on parking needs to be changed drastically. The new policy should be bold, aiming to decrease the capacity and increase the price, as parking demand has shown to be elastic (Groote et al., 2016). It can be concluded that a change in parking pricing affects trip frequency, route, mode, destination, scheduling, vehicle type, parking location, type of service selected, and location decision (Litman, 2017). This is an important conclusion for the feasibility of the scenarios and the results. Besides an effective policy on parking, the government should also act as a facilitator of the smart mobility transition. They should focus on several important elements. Firstly, the government should regulate the legal liability and insurance issues that hinder the use of car sharing (Rigo, 2017) (Oudendijk, 2017). Secondly, the social preference factor should be met. People are naturally afraid of new techniques. The government should make it compulsory to get familiar with it in driving lessons. This will help to build up trust in the new techniques, which will increase the social preference towards smart mobility (Oudendijk, 2017). Thirdly, the government should act as an arbiter, director, and co-provider in data sharing (Docherty et al., 2017). Finally, the government should facilitate and enable innovation, while acting as a venture client for new mobility providers (Docherty et al., 2017).

7.5 Potential applications of results

This study has showed that smart mobility has a substantial potential for the restructuring and transformation of the public space. It will give municipalities the option to free up scarce ground, to change its function and to increase the spatial value. This section will show how the potential effects of smart mobility could be used to improve the public space of the municipality of Amsterdam in a targeted and effective manner. An area analysis report of the municipality of Amsterdam is used to determine which areas need extra care. The area analysis report includes important data, key figures and indicators of the different neighborhoods in Amsterdam (Gemeente Amsterdam, 2015). For this research the following indicators were used: *grade of own neighborhood, grade of public green, grade of cleanliness street, % of people with overweight, % of people that meet daily exercise requirements, % of non-Western inhabitants* , *% of couples with children*, and *amount of stores per 1000 inhabitants*. These indicators can be used to determine if a neighborhood need an extra investment in public space, in facilities, or in greenery. It also shows if facilities like exercise areas, playgrounds and meeting areas are needed. Table 28 shows how the different neighborhoods in Amsterdam score on the different indicators.

Table 28 Indicator results of different neighborhoods

	Grade own neighborhood	**Grade of public green**	**Grade of cleanliness street**	**% people with overweight**	**% people that meet exc. Req.**	**% non western**	**% couples with child**	**Stores per 1000 inhabitants**	**Specific function aim**
Amsterdam	7,4	6,8	6,4	40	67	34,8	16,3	6,8	
Centrum West	8,1	6,7	6,9	28	78	13	8,2	32	Commercial
Centrum Oost	8,1	7	7	29	78	16,2	10,2	11,3	Commercial
Westerpark	7,8	6,9	6,5	34	70	25,6	11,7	3,4	Sport, meet areas
Bos en Lommer	6,8	6,6	6,2	44	64	48,9	17,4	3,4	Sport, green
Oud-West/ De Baarsjes	7,6	6,8	6,4	36	72	25,6	11,7	8,1	

Slotermeer/ Geuzenveld	6,4	6,5	5,6	50	59	61,4	24,3	3,2	Sport, green, meet areas, playground
Osdorp	6,7	6,8	6,1	50	54	52,9	21,1	5,5	Sport, green, meet areas, playground
De Aker/ Nieuw Sloten	7,4	7	6,7	55	51	32,8	33,9	1,1	Sport, playground , meet area
Slotervaart	6,7	6,6	5,8	43	63	49,9	20,3	2,1	Sport, green, meet areas, playground
Zuid-Noord	8,1	7,1	6,6	32	74	13,1	16,6	9,6	Commercial
Buitenveldert /Zuidas	8	7,4	7,2	35	64	20,1	13,4	5,2	
De Pijp/ Rivierenbuurt	7,9	6,8	6,3	34	73	18,9	11	9,5	Commercial
Oud-Oost	7,3	6,6	6,3	38	65	37,4	13,4	6,4	Meet area
Indische Buurt/ Oost. Havengebied	7,5	6,9	6,5	37	67	37,7	19	3,2	Meet area
Watergraafsmeer	7,7	7,1	7	33	75	18	16	3,3	
IJburg/ Eiland Zeeburg	7,3	7,1	6,6	29	55	35,9	34,7	2,4	Meet area, playground
Noord-West	7	6,4	5,7	56	61	34	25	1,6	Sport, green, meet areas, playground
Oud-Noord	7,1	6,3	5,8	46	63	33,2	17,1	4,7	Sport, green, meet areas, playground
Noord-Oost	6,9	6,7	5,7	51	58	46,9	21,5	4,5	Sport, green, meet areas, playground
Bijlmer Centrum	6,8	6,8	6,2	41	64	74,2	12,5	7,7	Sport, green, meet areas, playground
Bijlmer Oost	7,2	7	6,4	52	59	69,8	16,5	1,6	Sport, green, meet areas, playground
Gaasperdam/ Driemond	7,2	6,9	6,5	49	62	52,9	17,7	1,5	Sport, green, meet areas, playground

Several neighborhoods score significantly below the average grade of a neighborhood. It shows that the areas Bos en Lommer, Slotermeer, Geuzenveld, Osdorp, Slotervaart, Oud-Oost, Noord-West, Oud-Noord, Noord-Oost, and Bijlmer Centrum all score low on the scores for public green and the cleanliness of the area. In addition, these areas score high on the percentage of overweight, non-Western and people with children. As shown in Section 6.3, these are also the areas that show a significant freed up space potential, and have a good opportunity to increase the health, environmental, economic and social values. It is recommended that the freed up space in these areas, besides the general improvements in ecology, environment and mobility, will be used for the functions urban gym and sport area, playground and meeting place. This will help to increase the quality and livability significantly in the area. Several areas which score relatively good on the general neighborhood score, could be improved even further. Certain areas show to have high economic/commercial activities. Especially in the areas centrum, Zuid-Noord, and de Pijp/Rivierenbuurt the freed up parking space could be used for small stores and kiosks. This will help to increase the areas mixed functions of work, live and play. The areas Oud-Oost, Indische Buurt/Oost. Havengebied, and IJburg/Zeeburg have relatively a lot of parents with children and a non-Western inhabitants. In these areas it is recommended that the functions playgrounds and meet areas are implemented. Playgrounds will increase the attractiveness of the area, and will reduce the amount of movers, while meet areas will help to bring different cultures together and increase the social coherence.

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Figure 56 Transformation into meeting area. Reprinted from: www.contemporist.com

8. Conclusion

Shared and autonomous vehicles provide municipalities with a strategic solution in urban development. Smart mobility can be a game changer in realizing the ambitions of a safe, livable, sustainable, and attractive city. Former policies on mobility however have resulted in long term undesirable effects. This increases the urgency to consider the spatial implications of smart mobility in an early phase of its development. A lot of research on the effects of smart mobility has been carried out already, but these focus only on first order local effects. This study aimed to identify if the effects of smart mobility can be used for restructuring and transformation challenges, where it can be used, and how it can contribute to the ambitions of a municipality. The main question of this research is:

"To what extent can autonomous and shared mobility contribute to the restructuring and transformation of the public space and help to achieve a region's public ambitions, taking into account the different mobility future scenarios?"

Although there is still a high level of uncertainty, significant implications can be expected. This research has shown that smart mobility could result in a significant reduction of the current parking capacity. Depending on the scenario, between 0% and 88% of the parking capacity can be reduced in the future. The bandwidth depends on the market share of shared and autonomous mobility, as well as on how important variables as the total driven kilometers, the replacement ratio by shared mobility, and the reduction of the parking footprint will change. In a maximum scenario, the reduction of 88% of the parking capacity results in over 10.000 ha of freed up parking space on a national level, and in over 637 ha of space for the municipality of Amsterdam. On the national freed up space over 50.000 new homes and 7.974 ha of extra public space could be developed. On the space within the municipality of Amsterdam 3.331 homes and 292 ha of extra public space could be realized. This shows that smart mobility can result in influential changes of the current public space. Where and to what extent smart mobility can contribute to restructuring challenges depends on three factors. Firstly, housing dynamics determine if the potentially freed up street parking can be transformed into all functions. It showed that a higher housing dynamic results in more freed up space suitable for all functions. Secondly, the housing density in an area determines how many homes could be developed on the freed up space. Thirdly, which is mainly important on a neighborhood level, the type of parking determines whether space is suitable to transform to all functions or to limited functions. Neighborhoods with high capacities of built facility and field parking show to have a potentially high amount of space suitable for all functions. On the contrary, it showed that space suitable for limited functions does not depend on these factors, and becomes available in every municipality and neighborhood. The freed up parking spaces for limited functions could be restructured and transformed to functions that could help to improve greenery, the attractiveness of the city, the climate adaptation infrastructure, and mobility. Additionally, this research showed that smart mobility can positively contribute to the depopulation challenges in certain Dutch municipalities, and that it could increase housing densities on a municipality scale. Smart mobility therefore shows to result in a positive indirect economic, social, environmental, ecological and health effect. It will strongly depend on the governance of the national and local government how the benefits of smart mobility can be used. In order to realize the maximum effect, it should dare to significantly change its parking policies, while acting as a facilitator for smart mobility, in which it solves legal and trust issues, enables innovation and acts as partner in new mobility businesses.

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Figure 57 Transformation into playground. Reprinted from www.taringa.net

9. Limitations and recommendations

The limitations of this research will be discussed to take them into account and to avoid misjudgments and over-generalizations of the results. This will be done in Section 9.1. In Section 9.2 the recommendations for further research will be given.

9.1 The limitations of the findings

This research has several limitations that need to be addressed. These limitations regard the scope, the method and the model. The limitations of the scope come from the fact that this research has only focused on public parking and the municipality of Amsterdam. If private parking would be included as well, this could result in different results. Every city has its own characteristics, which determine the potential of smart mobility in a city. If a different city was chosen, different results would be generated. A possible important limitation of the method has been the expert interviews. This research has tried to use a wide selection of experts, however it can be concluded that most of the experts were relatively positive towards smart mobility. If more critics were interviewed, this could have resulted in different results.

As already mentioned in Section 5.5, the model of this research includes several limitations. The first limitation regards the determination of the scenarios. For the determination several important affecting factors were used, and those were combined with the percentage market shares of each mobility type to develop a transition scenario. The sensitivity analysis showed that the affecting factors replacement ratio and extra travelled kilometers have a strong effect on the transition rate. An important limitation is the uncertainty that exists on these factors. The effect of these factors could be counterproductive in the long run, as innovations and future events may turn out differently than first intended. The percentage market shares is the second method limitation. Although these percentages were determined using current forecasts on when the different technologies and mobility types are expected, unexpected events or developments can occur that affect these forecasts. The final limitation of this model are the assumptions that had to be made. In total, nine assumptions were made. These assumptions were validated during the different expert interviews, but could turn out differently if other experts were interviewed.

9.2 Recommendations

Several topics were encountered during this research that are recommended to perform further studies on. This research has focused only on the effects of smart mobility on parking spaces, and particularly on public parking. It is expected that smart mobility will also affect other public space, like road design (Litman, 2014). Literature indicates that road capacities can be increased by autonomous vehicles, thus smaller roads can facilitate the same mobility demand (Litman, 2014). At the same time, drop off lanes are needed to let people get in and out of the car. It is recommended that future research will look at what the effects of smart parking will be on road footprints and how that can be used with restructuring and transformation challenges. Furthermore, it is recommended that there will be looked at the spatial potential that exists with private parking spaces. These are currently not included in the research, but could, especially by the increase of current parking initiatives, result in an even higher potential for the improvement of the public space.

Furthermore, the sensitivity analysis of this research showed that several factors have a strong effect on the transition rate. Although research has been conducted on these subjects already, still a lot of uncertainty exists, for example on the extra kilometers traveled. On these topics extra research needs to be carried out in order to reduce the uncertainty. The final recommendation for further research regards the effects on spatial value. These have been discussed in this research, but especially the effect on economic spatial value will be much more complicated in real life. In this research the economic value has been determined by the value increase and the extra properties sold. However, several assumptions were made in order to do this value calculation. It is recommended that a more extensive study is done on these effects. Furthermore, literature showed that also an effect exists on the attractiveness to settle for businesses. This was not included in this research, thus further research is needed. This research showed that a significant amount of spare space can become available. It is recommended that on a national level an exploration is done on how this space can be used to increase the attractiveness of the region. On a municipality level, it is recommended to research to what extent the housing density can be increased and what the effects would be for the area.

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Figure 58 Transformation possibility playground/waterstorage. Reprintedfrom www.behance.net

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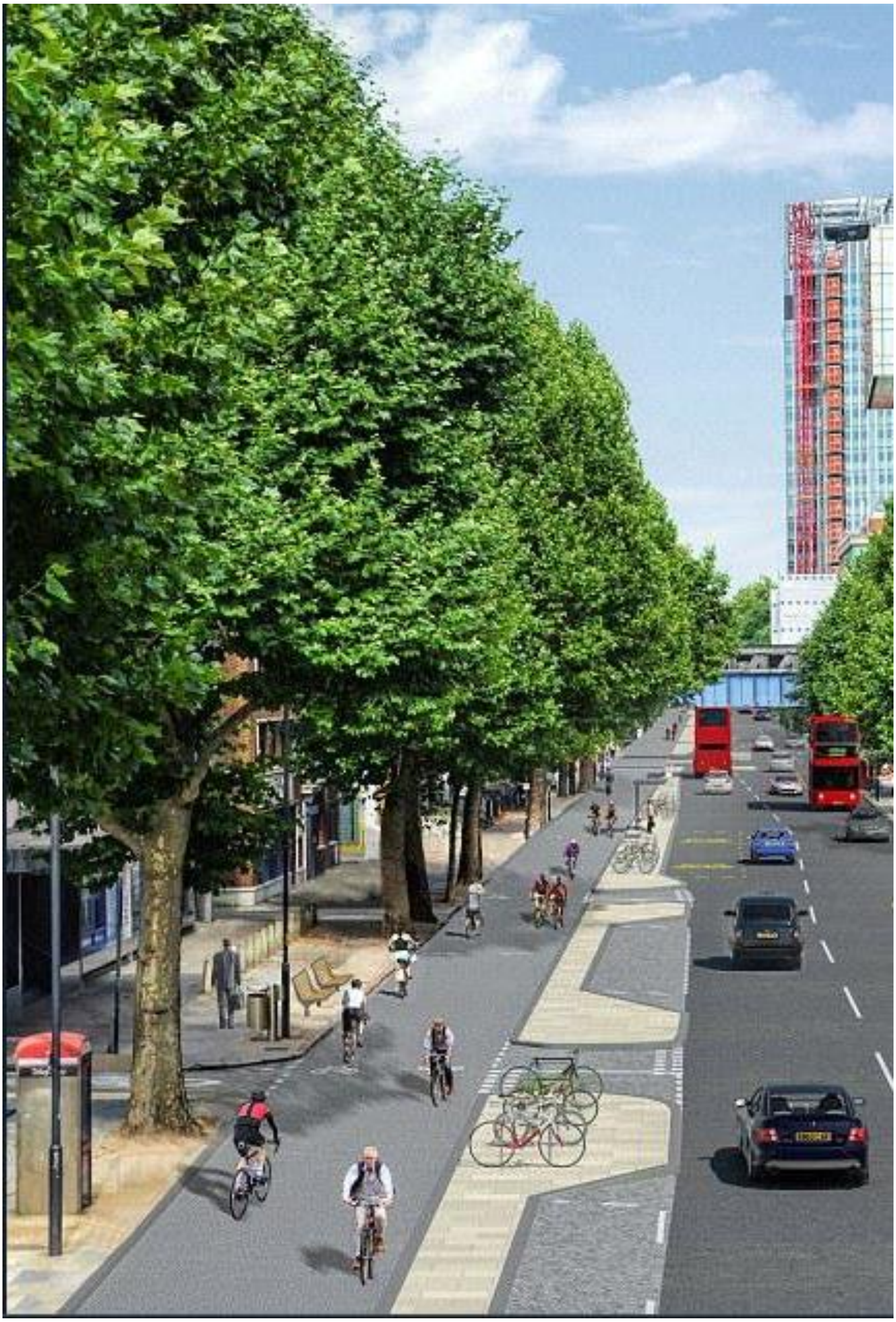

Figure 59 Transformation into cycle lane. Reprinted from www.thinkingcities.com

Appendix I - Search methodology

Search carried out in Google scholar, scopus, TU Delft library, research gate. Period of search was between 10/08/17 – 23/10/17. Searches have been carried out in Dutch and English. In the table below, only the English term is shown. Furthermore, the internal database of Deloitte has been used.

Number	Search term
1	Car sharing
2	Car sharing market, market for car sharing
3	Effect of car sharing
4	Impact car sharing
5	Forecast car sharing
6	Future of car sharing
7	Car sharing scenarios
8	Car sharing public space
9	Car sharing policy
10	Car sharing environment
11	Car sharing spatial impact
12	Car sharing demand
13	Autonomous vehicles
14	Self-driving vehicles/cars
15	Future of autonomous vehicles
16	Market for autonomous vehicles
17	Impact of autonomous vehicles
18	Effect of autonomous vehicles
19	Benefits of autonomous vehicles
20	Forecast autonomous vehicles
21	Autonomous vehicles scenarios
22	Autonomous vehicles policy
23	Autonomous vehicles environment
24	Autonomous vehicles spatial impact
25	Autonomous vehicles demand
26	Autonomous vehicles public space
27	Autonomous vehicles parking space
28	Car sharing parking space
29	Potential of car sharing
30	Potential of Autonomous vehicles
31	Parking policies, dutch parking policies
32	Autonomous vehicles infrastructure
33	Autonomous vehicles transport
34	Green value
35	Blue vs green value
36	Electric cars

37	Parking requirements
38	Parking requirements impact
39	Parking and housing affordability
40	Car sharing trends
41	Future of mobility
42	Car ownership in future mobility
43	Smart mobility
44	Effects of smart mobility
45	Restructuring possibilities smart mobility
46	Free space car sharing
47	Governance of smart mobility
48	Parking policy Amsterdam

Appendix II - Flow chart transition rate

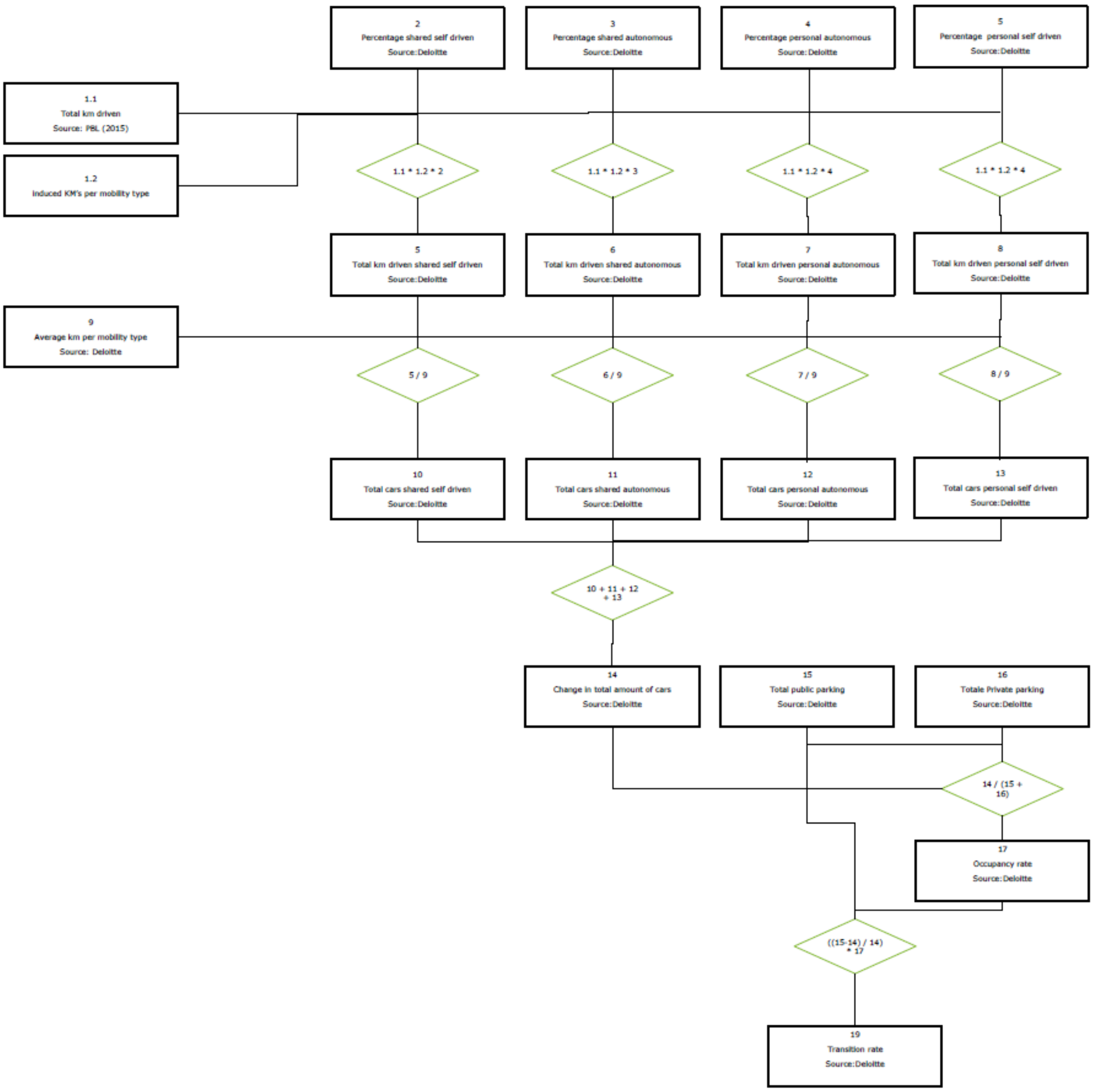

Figure 60 Flow chart transitoin rate

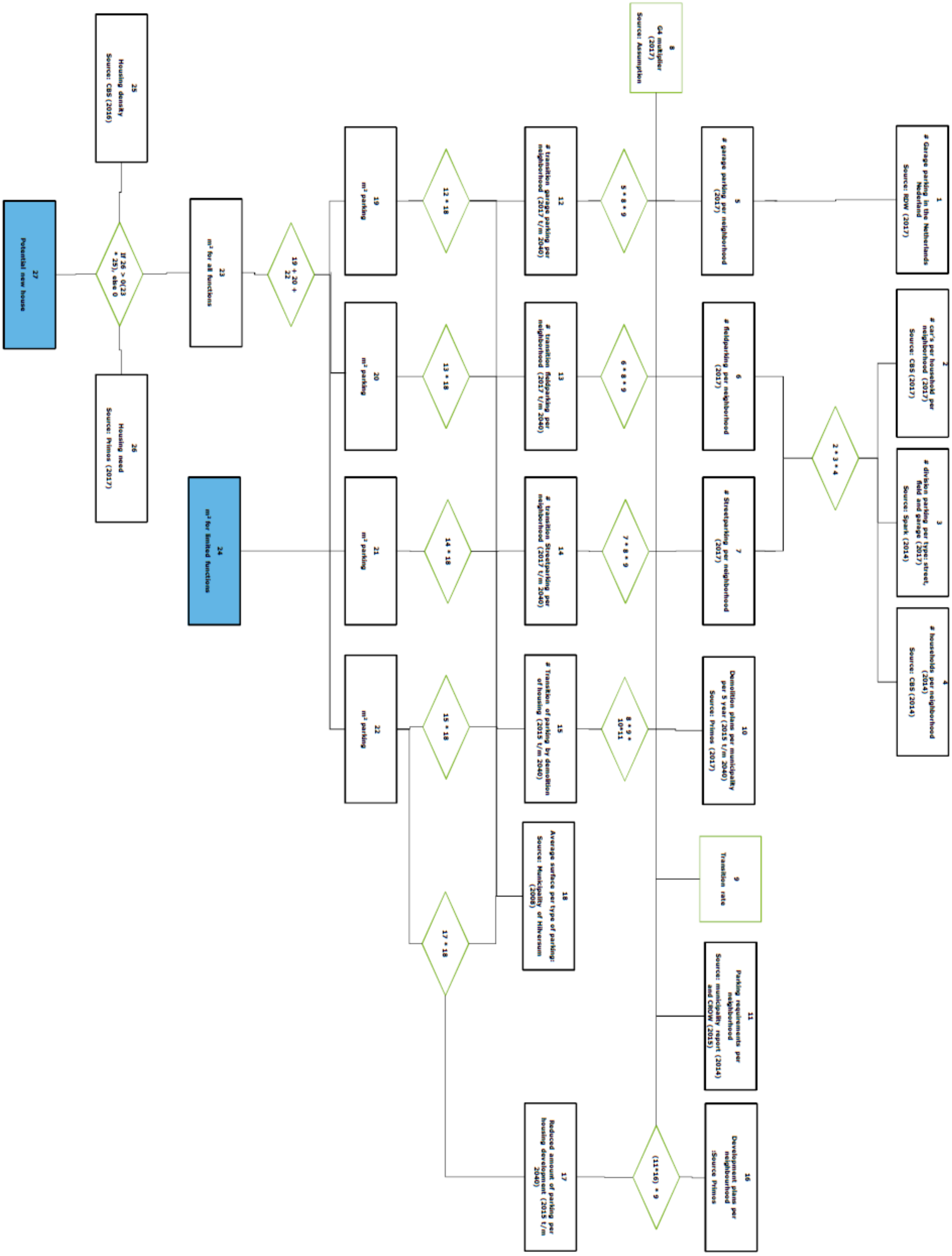

Figure 61 Flow Chart Python model

Appendix IV – Interview reports

Conversation report Kees Oudendijk
RDW
06/12/17

Conversation report:

- Kees was responsible for the NVO portfolio at RDW. He has only been focusing on sustainable mobility since a year ago.
- He is concerned with mobility as a service. He is currently working on a mobility platform, with which he hopes to be able to fill in the collective question.
- Currently, the different transport modes do not match well enough. The challenge now is to combine demographic issues with the different types of mobility.

Car sharing:

- Scientific literature claims that less cars are required, but he does not agree. In rural areas, car demand is lower, so the total demand for mobility is strongly depended of where new housing will be developed. If you develop new buildings in the vicinity of rail infrastructure facilities, you will need less cars.
- He expects car sharing to happen in cities, but will depend on how well the platforms will be developed.
- Car sharing concepts like snappcar could work. But then problems like legal liability should be regulated.
- The level of education also determines how much a car is used.

Public transport:

- Bus transport is not an incentive to reduce cars. Especially rails, e.g. trams, trains etc., reduce car use.
- Mobility remains an individual question and very demographically bound. You stay until an age of 30 in the city, during which you use public transport and you do not need a car. Between 30 and 55 people have children for which they move to neighborhoods just outside the city (center) with less public transport. In this age the need for a car is more apparent. After an age of 55, (with children grown up) one says goodbye to the car again. If urban planning responds well to this, then the need for a car will be much less.

Autonomous:

- Before self-driving cars are mainstream, society will be a generation further. I think this will be (almost) 20 years. Research proves that even if cars are equipped with

ADAS features much drivers lare reluctant using these systems. . People do not dare to trust it, autonomous functions in current cars are now being turned off. Only when people learn to trust AV in training etc. they dare to use it. Even now, software is not yet developed enough, but this is developing in a fast pace.
- Technically it could all be possible, but people themselves will be a limiting factor.
- RDW is leading in Europe with the approval of test pilots and aims to stay.

Future:

- Starting from 2020, trucks will first do platooning.
- From 2020-2025 cars can park in the parking garage themselves.
- The current youth generation is much more used to dealing with technology. If this generation will start driving, so around 2030, that can be a game changer. Young people see cars as a means of transport, not because they like to drive.
- Car sharing will take off in particular in urban areas. Paris is already further in its policies than Amsterdam, which is further than Rotterdam. Rotterdam has a higher level of blue collar working class, and foreigners, which are much more used to use the car as a transport mode.
- From 2040 it is feasible that there will be 30% less car use. The life cycle of a car is appr. 20 years. Cars on the current market will be removed in about 20 years time. So a survey of current sales will give some indication about the future state of automoblity.

Policy:

- Kees advises to implement autonomous aspects in the driving lessons. Involve early. CBR is about Human factor.
- Also important to pay attention to the older generation, who are much less used to technology or the use of public transport.
- Perhaps the combination of kilometer pricing and information is a way to make them aware of how they are traveling. This group does not know how to reach mobility platforms.
- Pricing of KM will give a lot of effect.
- Car use helps to keep infrastructure up-to-date, due to costs. Investments must be used out of public transport, so you have to be careful that it does not come into a negative spiral.
- Platform, demography, private and public transport are the four components that determine the use of smart mobility.

Conversation report Jos van Ommeren
VU
22/11/2017

Car-use:

- His estimate is that car use will decrease in cities. Government is going to implement such a policy that that happens. Finesses are important.
- Cities will not accommodate extra traffic.
- He thinks that pricing for driving will be introduced very quickly.
- Huge effect of people changing from public transport to car sharing. He thinks that literature exists of a lot of wishful thinking.

Future:

- Jos indicates that nobody knows exactly how future mobility will develop.
- 100,000 places in Amsterdam for permit holders. What are municipalities going to do with space? Offering it for cheap?
- It could become busier between cities, but in his opinion this will be of small influence. Other effect is less accidents on the road. Within the cities, he thinks we are doing well and little will change.
- Many garages are still there in 20 years. They can be exploited. Self-driving cars will therefore be parked there. In the long term, parking capacity in cities will be completely gone.
- Greenwheels will only significantly increase when it becomes autonomous, as little or no effect until cars become autonomous. Greenwheels does not have a strongly diminishing effect on the total fleet in his opinion.

Location of parking:

- Wherever parking is expensive, Jos expects parking spaces to disappear first. Expensive garages will still be used for the next 30 years. But he expects that street parking will become no longer accepted very quickly.
- This will not happen in villages.
- 40,000 parking spaces at Schiphol. So there you can park all self-driving vehicles.
- He thinks that private property will be taken away. The government will abolish parking permits for street parking in cities.

Occupancy rate:

- The occupancy rate of parking can have a higher efficiency. Jos indicates that no scientific literature is available on how efficiency can be achieved, but he indicates that efficiency alone can be already achieved by the fact that self-driving cars can park closer to another car. Where now a meter of space must be, can become an inch. Garages can have just 3 times more capacity.

Conversation report Walter Dresscher
De natuurlijke stad
24/11/2017

DE NATUURLIJKE STAD

General notes:

- Walter indicates that the potential offered by car sharing is enormous.
- He emphasizes that this potential is only visible if policy is designed to stimulate car sharing.
- He has already read a lot of reports and research, but so far there is little result because municipalities lack the resources to get a good overview of all this knowledge.
- The question is how they will respond.
- Predicting the future is a dangerous activity for you will get what you predict, and not what you WANT.

Solutions:

- A solution would be to link the shared cars with parking permits, and remove the parking spaces for every permit that is being hand in.
- People living in the same street should be able to discuss the way they want to use their public space. This way people can be presented with alternatives for the ownership of a car and rethink their use of public space.
- Important that hard measures are taken. If you do not want cars to drive, you have to close the road.
- Dutch municipalities do not dare to change. Other cities like Paris and London do dare to take measures. This is due to the political system in the Netherlands that is based on consensus (polderen).

Converstation report Erik de Romph
TNO
15/11/2017

General notes:

- Erik indicates that it is important to clearly indicate whether you are looking at ride- or car sharing. Both have a significantly different effect on the demand of mobility. Ride sharing will decrease the amount of cars needed, you can't predict that with certainty for car sharing
- At the moment, vehicle kilometers and person kilometers are calculated with an average occupancy per vehicle. However, this can change significantly in the future, especially through ride sharing.
- Erik thinks it's a good approach to work with scenarios. Give a maximum scenario and a current scenario.

Car sharing/ Mobility as a service:

- The extent to which MAAS is going to be successful depends on the quality level. If it can be tailored to your personal needs and it will provide mobility flawless, this will result in more demand.
- In the G4 cities is already a shortage of parking places. It is therefore logical that car sharing is already higher in those regions. In addition, the costs in the G4 for parking are also the highest. This is an extra driver to switch to car sharing.

Conversation report Auke Hoekstra
TU Eindhoven
15/11/2017

General notes:

- Distinguish in future forecast the share of selfdriving and car-sharing. Both have different effects.

Future:

- Auke expects that the space required for parking will be reduced. Mostly because of less cars when sharing. Partly because his expectation is that the more you share, the smaller the vehicles will become. Also this parking will be furhter away from where we live.
- Although he does expect AV to promote driving more, he also expects that VR will reduce how much we travel. On average he expects less km travelled but this is a prediction with a high uncertainty.
- Auke expects far fewer cars when sharing takes off. Every shared car will replace at least non-shared cars. This also implies increased mileage per shared car although he does not know any studies on this. E.g. it could be that shared cars are disproportionally used for short trips which would make their increase in number of kilometers much less then five times.

Conversation report Marco van Burgsteden
CROW
27/11/2017

Future:

- If you look at current trends, you do not really see a reason to reduce parking places.
- If a shared car is very cheap and it rains, will more car use be expected at the expense of bicycle and public transport?
- What kind of shared cars do you look at?
    - Snappcar
    - Peer-to-peer
    - Community car sharing
    - Car2go
    - All facilitate completely different markets
- No car- but ride sharing !!
    - Synchronize with agenda, high possibility of efficiency
    - You will receive a certain time slot or more flexibility via business subscription.
    - Congestion reduces because you know everything in advance.

Trends/developments:

- The trends and developments are very specific and differ per region.
- Marco also indicates that public transport in the Netherlands is regulated differently than in the US. This complicates comparing the forecast of mobility market shares, done by Deloitte US, with the Dutch market.

Parking spaces:

- Provide transformation possibilities for built-up parking facilities. E.g. pay attention to the space needed if you no longer have doors that open.
- Improving the efficiency of parking spaces is only possible if you share data with each other, so if government plays a directing role.

Points of attention:

- How do you include regulations/policy in your scenario?
- How does public transport change?
- What does it mean for the road authority?
- Car sharing can add a social effect. Look at Netterden in the municipality Oude Ijsselstreek, is a neighborhood car with volunteers around to pick people up.
    - For hospital visits
    - Older generation

- Neighborhood car - you pay nicely for it - People can subscribe - very successful
- Think about what role you want to play as a government
    - Arrange a top 3 of scenarios. If this happens, then I want that to happen

Conversation report Sacha Oerlemans

Qpark

04/12/17

Forecast:

- If Sacha looks at the population growth and urbanization needs, no other conclusion can be drawn than that the number of parking places will grow. How much the capacity will grow, she does not know.
- She emphasizes that built parking facilities will grow, but street parking will start to decrease. Q park does not include that street parking will disappear in its policy.
- Q park uses the EPA 2013 sources and various BCG reports to develop forecasts. Many opportunistic reports exists, but BCG is in Sacha's opinion well clarified.

Carsharing/AV:

- Sacha thinks that car sharing has little impact on Qpark's business.
- Sacha agrees that the parking capacity can be utilized more efficiently. She thinks that, given the large parking supply, is still a lot to be gained. Especially at offices. Sat-Sunday proposition. She emphasizes that in those cases you are talking about very dense cities, in which this efficiency can be achieved.
- She indicates that that municipalities do not want to have car sharing everywhere. Car sharing propositions are therefore difficult.
- She believes that AV will affect train / public transport and will affect existing infrastructure.

Conversation report Robert Bosman
Car2Go
15/12/2017

- What is your expectation regarding the rise of shared mobility?
What percentage of the fleet will be shared cars between now and 2040?

Car sharing will, in relation to owning a car, have an increasingly larger position in the areas where the concept of car sharing has potential. These are currently only large cities such as Amsterdam. On an European level, on average, one conventional car disappears for every 11 users of car sharing. The total number of car sharing users (worldwide and all providers) was 5.7 million in 2015 and is expected to be 20.1 million in 2021.

- What is your expectation regarding self-driving cars? How will this develop between now and 2040? What will the AV affect most?

Car sharing currently sets the foundation for the self-driving car. The techniques and information from the use of car sharing are important for the development of autonomous vehicles. At the moment, some of our techniques are already used within the development autonomous vehicles of Daimler (Mercedes-Benz), which are expected to be on the road within five years.

- How do you expect that both types of mobility will affect parking?

30% of the traffic in a city is caused by motorists looking for a parking space. With an increase in car sharing (read: fewer car owners) this will have a positive effect on parking. People will find a parking spot more quickly, parking spaces will be released earlier (Own cars in cities are parked three times longer than in neighboring municipalities) and ultimately less parking space is needed. With self-driving cars, cars can be parked outside the street or neighborhood on special parking lots (coming ahead yourself) and the streets will be used less.

- Is this parking impact different for street, field or garage parking places?

Yes, street parking is often used by residents. With car sharing and self-driving cars, the number of own cars and therefore the demand decreases. Parking garages (public) will always be used by visitors from outside the city.

- Will technological developments such as the Internet of things affect this?

I do not know the effect on parking itself. car2go can now be used with Amazon's Alexa. This allows you to search and reserve a car in the neighborhood. In a few years it can probably drive towards your home.

Conversation report Evelien van der Molen
Municipality of Amsterdam
10-01-2018

What is your expectation of the rise of the shared mobility? What percentage of the fleet will be shared cars between now and 2040? To what extent does the municipality see a role to facilitate this? Which initiatives does the municipality consider?

In the political arena, car sharing is often seen as a 'holy grail'. It is expected to solve all accessibility problems. However, we currently see only a percentage of less than 2% in Amsterdam. We also see modest growth in classic shared cars. There can, of course, be a change, such as a certain technological development, which results that many people suddenly switch to car sharing concepts.
Car sharing is also used as a generic term, while many differences car sharing concepts exists. Among users of classic car sharing, you see reduced car ownership. At Car2Go you see that effect less; this free-floating form of car sharing mainly concerns additional inner city trips. At peer2peer the supply is large, but the use is still very low. More research data is desired.

- What is your expectation in relation to the self-driving car? How and when do you expect the introduction of it? On what will the AV have the most impact on? To what extent does the municipality see a role to facilitate this? Which initiatives does the municipality consider?

It will take a long time before the self-driving car will be introduced. Level 5 AV in a busy urban environment is still far away. The impact is also difficult to predict, because the effect depends on how much of the AV will be shared. Only shared mobility can contribute to an improved mobility of Amsterdam.

The municipality is monitoring and testing the developments, but we do not yet have a grip on the near future. For example, sites that are now in use as a P + R location could, in the long run, be given a different function in the context of parked self-driving vehicles.

- How do you expect that both types of mobility will affect parking?
The higher the percentage of car sharing, the fewer parking spaces are needed. For self-driving vehicles are also fewer places available in the center, given that these vehicles can park in a different location.

- Is this parking impact different for street, field or garage parking spaces?
Yes, because the municipality will steer on less parked cars on the street. .
For example, the municipality hires parking spaces at garages for permit holders.

- How do you expect the occupancy rate of parking spaces to change in the future? Will technological developments such as the Internet of things affect this?
At this moment the municipality is working together with Tom Tom to see if it is possible to link data with smartphones. This means that people are better informed, because information provision is very important; one must be informed which places are full, so that a different location must be used.

- **To what extent does the municipality see a role to invest in making the reduction of street parking possible? Is offering parking permits to residents (in privately managed garages) one of these policy proposals?**
The municipality already makes public investments, such as the Albert Cuyp garage. Recently, the Nota Parking Standards Auto was adopted by the city council. Residents of new buildings will no longer receive a parking permit for parking on the street, regardless of the availability of parking spaces on their own grounds. The new residents must therefore take into account the availability of parking in their choice for a home. Developers are positive towards car sharing. Developers who implement a future-proof car sharing concept can receive a reduction on the minimum parking requirement.
The national government has set up the Green Deal Car Sharing, but the government does not intervene with the municipal policy. Trials are being conducted from the government and the ministry on self-driving transport, but no policy dictation is being implemented.

Gespreksverslag Aron Rigo
Snappcar
17/11/2017

General:

- Snappcar does not make own carsharing forecasts. They use what is online available. Every procent increase in use is currently enough.
- They do analysis on users of snappcar. They see a higher use in dense areas. Rural might not be feasible.
- In general, people want a car within 5 mins travel time.

Carsharing drivers:

- Interest in leasing term is new. Leasing facilities for sharing are becoming more and more popular.
- Insurance is currently a bottleneck in matching demand and supply.

Conversation report Ronald de Jong
ANWB
24/11/2017

General notes:

Previous project experience:

- "Beter benutten"
- "Talking traffic"
- "Verkeersonderneming"
- "TU delft"

Car sharing:

- Knowledge of car sharing is very limited
- In addition, the speed of technology adoption is very difficult to predict, see mobile phone.
- Earlier other analyzes show:
  - o Trend car use -> KiM - no decline in car ownership among young people - only later in terms of age
  - o Price is decisive! If price interesting enough + coupled with sufficient reliability, this could decrease car use.
- Ronald expects a Service Economy - on demand transport services, but no sharing economy
- Eventually, a few large parties will remain
  - o The shared car providers
  - o Last mile solutions
  - o The government itself can mean a lot: stimulating car sharing
  - o Take Antwerp as an exmaple- 2020 - 2025 policy
  - o Very clear perspective
  - o Then people can make a plan
  - o Then you force people to think
  - o Make the policy behind parking permit clear - how expensive it will be in the coming years. Inform people already. That causes less resistance.

Mobility as a Service:

- Ronald expects a change to private lease and MAAS.
- Change and awareness take time.
- Amber - substantially different average mileage than normal cars, because they make far more kilometers per year

- Partly, EV is going to solve that - less maintenance-sensitive
- Schiphol taxis - much lower detoriation - 2% of the battery deterioration - electric cars can last longer!
- On demand transport services will become potentially cheap in the city, but not necessarily in rural areas.
  - When you need demand transport from Nootdorp – then you need to go far away or pay substantially more
  - Or own car ownership

AV:

- Ronald expects autonomous cars to be introduced much later than DUpress predicts
- Especially in inner city!

Environmental policy:

- Compelling in environmental zones
- Trend: liveability, clean air and space. In addition, there is a generation of people who can and want to pay for it.

Netherlands:

- The need for mobility only grows towards 2040
- Short-term increase in car mobility
- On the other hand a decrease - by sharing concepts
- Only after 2020 2025 -> a decrease!
- Is very affordable now - a car!
- Private lease can slowly cause a change here

Conversation report Ed van Savooyen
Spark
24-11-2017

Total amount of cars:

- The change of the fleet is twofold:
- 1) It becomes either a chain - multiple mobilities to arrive at destination
- 2) The public transport - evaporates by self-driving vehicles
- Regardless of what kind of cars will be parked, public parking garages will appear.
- Therefore, increasingly critical of underground parking.
- Up to 10 years ago the urban planner focused on the undergrounding of garages.
- Large overcapacity parking garages in many municipalities

Autonomous cars and car sharing:

- Sharing has now been accepted.
- Autonomous driving is still debaTable. We have little knowledge of it.
- New reality created -> new housing development - a kind of opportunism arose
- Developers embrace that - fly on it! But have little knowledge about it
- Dare to apply replacement ratio 1 to 4, so:
    - 0.91 car per car
    - Of reduction: 55% is 1st car, the rest is 2nd or 3rd car.

Policy:

- Let's keep in mind - that it could go towards all directions!
- We must be able to fall back - for municipalities important to think about setback options.

Appendix V – Calculation economic spatial value 1

Scenario 2	Average value(WOZ)		Potential new houses	Total value	
Burgwallen-Oude Zijde	€	290.000	28,5	€	8.253.351
Burgwallen-Nieuwe Zijde	€	296.000	73,1	€	21.637.142
Grachtengordel-West	€	560.000	118,4	€	66.281.379
Grachtengordel-Zuid	€	533.000	84,7	€	45.127.981
Nieuwmarkt/Lastage	€	340.000	94,6	€	32.162.683
Haarlemmerbuurt	€	345.000	21,1	€	7.285.127
Jordaan	€	308.000	297,7	€	91.697.442
De Weteringschans	€	400.000	98,0	€	39.202.236
Weesperbuurt/Plantage	€	354.000	43,4	€	15.370.949
Oostelijke Eilanden/Kadijken	€	275.000	25,2	€	6.923.356
Westelijk havengebied	€	-	11,4	€	-
Bedrijventerrein Sloterdijk	€	-	14,2	€	-
Houthavens	€	159.000	0,0	€	-
Spaarndammer- en Zeeheldenbuurt	€	222.000	42,0	€	9.326.157
Staatsliedenbuurt	€	242.000	20,6	€	4.976.400
Centrale Markt	€	292.000	3,3	€	956.605
Frederik Hendrikbuurt	€	248.000	15,8	€	3.923.434
Da Costabuurt	€	297.000	9,0	€	2.678.392
Kinkerbuurt	€	248.000	12,0	€	2.971.790
Van Lennepbuurt	€	235.000	12,5	€	2.945.484
Helmersbuurt	€	346.000	16,0	€	5.544.244
Overtoomse Sluis	€	299.000	11,9	€	3.564.839
Vondelbuurt	€	642.000	4,7	€	3.028.627
Sloterdijk	€	297.000	1,4	€	423.593
Landlust	€	189.000	49,8	€	9.404.092
Erasmuspark	€	195.000	9,1	€	1.778.005
De Kolenkit	€	180.000	20,8	€	3.740.352
Chassébuurt	€	241.000	12,0	€	2.899.326
Van Galenbuurt	€	197.000	8,9	€	1.759.795
Hoofdweg e.o.	€	194.000	19,6	€	3.804.614
Westindische buurt	€	248.000	12,7	€	3.145.610
Bedrijventerrein Sloterdijk	€	-	14,2	€	-
Slotermeer-Noordoost	€	136.000	36,1	€	4.912.324
Slotermeer-Zuidwest	€	144.000	74,9	€	10.792.544
Geuzenveld	€	171.000	83,7	€	14.319.493
Eendracht	€	240.000	7,2	€	1.736.585
Lutkemeer/Ookmeer	€	389.000	2,1	€	820.998
Osdorp-Oost	€	167.000	107,4	€	17.935.873
Osdorp-Midden	€	183.000	87,9	€	16.090.908
De Punt	€	158.000	30,7	€	4.854.377
Middelveldsche Akerpolder	€	279.000	76,4	€	21.323.254
Slotervaart Noord	€	191.000	34,3	€	6.549.145
Overtoomse Veld	€	163.000	54,9	€	8.946.909
Westlandgracht	€	207.000	19,3	€	3.992.794
Sloter-/Riekerpolder	€	267.000	67,8	€	18.107.541
Oude Pijp	€	278.000	44,5	€	12.381.998
Nieuwe Pijp	€	262.000	22,4	€	5.855.953
Zuid Pijp	€	263.000	12,3	€	3.234.059
Hoofddorppleinbuurt	€	263.000	16,0	€	4.215.022
Schinkelbuurt	€	259.000	5,7	€	1.468.613
Willemspark	€	669.000	12,3	€	8.199.381
Museumkwartier	€	625.000	25,4	€	15.893.506
Stadionbuurt	€	298.000	21,4	€	6.377.125
Apollobuurt	€	729.000	14,4	€	10.480.856
Museumkwartier	€	625.000	25,4	€	15.893.506
Scheldebuurt	€	334.000	28,7	€	9.585.354
IJselbuurt	€	261.000	10,0	€	2.609.164
Rijnbuurt	€	253.000	9,9	€	2.497.471
Zuidas	€	267.000	172,4	€	46.033.777
Buitenveldert-West	€	257.000	33,2	€	8.525.634

Buitenveldert-Oost	€	235.000	7,0	€	1.647.777
Weesperzijde	€	306.000	11,5	€	3.518.592
Oosterparkbuurt	€	238.000	18,1	€	4.306.360
Dapperbuurt	€	244.000	15,2	€	3.720.023
Transvaalbuurt	€	233.000	16,8	€	3.906.182
Indische Buurt West	€	200.000	19,0	€	3.793.727
Indische Buurt Oost	€	213.000	33,4	€	7.121.532
Oostelijk Havengebied	€	341.000	41,1	€	13.998.454
Zeeburgereiland/Nieuwe Diep	€	136.000	10,8	€	1.468.376
IJburg West	€	331.000	6,1	€	2.017.776
IJburg Zuid	€	301.000	2,7	€	802.765
Frankendael	€	224.000	47,6	€	10.663.979
Middenmeer	€	296.000	21,2	€	6.263.324
Betondorp	€	190.000	5,6	€	1.070.064
Omval/Overamstel	€	154.000	44,5	€	6.855.692
IJburg Oost	€	-	0,2	€	-
Volewijck	€	159.000	24,8	€	3.936.366
Ijplein/Vogelbuurt	€	170.000	17,9	€	3.040.017
Tuindorp Nieuwendam	€	185.000	14,3	€	2.641.123
Tuindorp Buiksloot	€	175.000	6,0	€	1.058.263
Nieuwendammerdijk/Buiksloterdijk	€	395.000	5,5	€	2.160.788
Tuindorp Oostzaan	€	179.000	29,2	€	5.223.319
Oostzanerwerf	€	195.000	22,4	€	4.360.778
Kadoelen	€	275.000	7,9	€	2.159.166
Tuindorp Nieuwendam	€	185.000	14,3	€	2.641.123
Buikslotermeer	€	156.000	40,7	€	6.344.512
Banne Buiksloot	€	177.000	35,5	€	6.282.697
Nieuwendammerdijk/Buiksloterdijk	€	395.000	5,5	€	2.160.788
Tuindorp Buiksloot	€	175.000	6,0	€	1.058.263
Waterland	€	442.000	0,8	€	349.205
Amstel III/Bullewijk	€	-	35,9	€	-
Bijlmer Centrum (D,F,H)	€	123.000	9,8	€	1.211.525
Bijlmer Oost (E,G,K)	€	148.000	18,7	€	2.764.454
Nellestein	€	135.000	0,9	€	117.975
Holendrecht/Reigersbos	€	148.000	12,5	€	1.857.140
Gein	€	165.000	0,8	€	127.047
Driemond	€	235.000	0,0	€	7.468

Scenario 3	Average value(WOZ)		Potential new houses	Total value	
Burgwallen-Oude Zijde	€	290.000	28,5	€	8.253.351
Burgwallen-Nieuwe Zijde	€	296.000	39,1	€	11.561.949
Grachtengordel-West	€	560.000	118,4	€	66.281.379
Grachtengordel-Zuid	€	533.000	83,2	€	44.371.258
Nieuwmarkt/Lastage	€	340.000	94,6	€	32.162.683
Haarlemmerbuurt	€	345.000	16,4	€	5.645.502
Jordaan	€	308.000	241,1	€	74.245.578
De Weteringschans	€	400.000	98,0	€	39.202.236
Weesperbuurt/Plantage	€	354.000	13,3	€	4.703.679
Oostelijke Eilanden/Kadijken	€	275.000	19,7	€	5.428.098
Westelijk havengebied	€	-	0,5	€	-
Bedrijventerrein Sloterdijk	€	-	0,7	€	-
Houthavens	€	159.000	0,0	€	-
Spaarndammer- en Zeeheldenbuurt	€	222.000	11,9	€	2.650.601
Staatsliedenbuurt	€	242.000	20,6	€	4.976.400
Centrale Markt	€	292.000	3,3	€	956.605
Frederik Hendrikbuurt	€	248.000	15,8	€	3.923.434
Da Costabuurt	€	297.000	9,0	€	2.678.392
Kinkerbuurt	€	248.000	11,5	€	2.857.174
Van Lennepbuurt	€	235.000	12,5	€	2.945.484
Helmersbuurt	€	346.000	15,8	€	5.466.887
Overtoomse Sluis	€	299.000	11,9	€	3.564.839

Vondelbuurt	€	642.000	4,7	€	3.028.627
Sloterdijk	€	297.000	0,1	€	20.309
Landlust	€	189.000	23,4	€	4.424.377
Erasmuspark	€	195.000	9,1	€	1.778.005
De Kolenkit	€	180.000	10,5	€	1.891.275
Chassébuurt	€	241.000	12,0	€	2.899.326
Van Galenbuurt	€	197.000	8,9	€	1.759.795
Hoofdweg e.o.	€	194.000	19,6	€	3.804.614
Westindische buurt	€	248.000	12,7	€	3.145.610
Bedrijventerrein Sloterdijk	€	-	0,7	€	-
Slotermeer-Noordoost	€	136.000	36,1	€	4.912.324
Slotermeer-Zuidwest	€	144.000	73,9	€	10.639.817
Geuzenveld	€	171.000	58,7	€	10.029.925
Eendracht	€	240.000	7,2	€	1.736.585
Lutkemeer/Ookmeer	€	389.000	2,1	€	820.998
Osdorp-Oost	€	167.000	84,5	€	14.104.698
Osdorp-Midden	€	183.000	87,9	€	16.090.908
De Punt	€	158.000	29,6	€	4.670.102
Middelveldsche Akerpolder	€	279.000	76,4	€	21.323.254
Slotervaart Noord	€	191.000	33,3	€	6.363.916
Overtoomse Veld	€	163.000	54,9	€	8.946.909
Westlandgracht	€	207.000	9,5	€	1.975.088
Sloter-/Riekerpolder	€	267.000	64,0	€	17.099.075
Oude Pijp	€	278.000	25,5	€	7.097.928
Nieuwe Pijp	€	262.000	22,4	€	5.855.953
Zuid Pijp	€	263.000	12,3	€	3.234.059
Hoofddorppleinbuurt	€	263.000	16,0	€	4.197.710
Schinkelbuurt	€	259.000	5,4	€	1.389.981
Willemspark	€	669.000	12,3	€	8.199.381
Museumkwartier	€	625.000	25,4	€	15.893.506
Stadionbuurt	€	298.000	13,4	€	3.980.733
Apollobuurt	€	729.000	14,4	€	10.480.856
Museumkwartier	€	625.000	25,4	€	15.893.506
Scheldebuurt	€	334.000	23,2	€	7.761.248
IJselbuurt	€	261.000	10,0	€	2.609.164
Rijnbuurt	€	253.000	9,9	€	2.497.471
Zuidas	€	267.000	7,5	€	2.005.843
Buitenveldert-West	€	257.000	12,9	€	3.321.239
Buitenveldert-Oost	€	235.000	7,0	€	1.647.777
Weesperzijde	€	306.000	11,5	€	3.505.609
Oosterparkbuurt	€	238.000	17,8	€	4.239.684
Dapperbuurt	€	244.000	15,2	€	3.720.023
Transvaalbuurt	€	233.000	12,2	€	2.832.400
Indische Buurt West	€	200.000	19,0	€	3.793.727
Indische Buurt Oost	€	213.000	14,7	€	3.120.750
Oostelijk Havengebied	€	341.000	22,8	€	7.779.015
Zeeburgereiland/Nieuwe Diep	€	136.000	0,7	€	100.527
IJburg West	€	331.000	6,1	€	2.015.155
IJburg Zuid	€	301.000	2,7	€	802.765
Frankendael	€	224.000	16,1	€	3.603.834
Middenmeer	€	296.000	21,2	€	6.263.324
Betondorp	€	190.000	2,8	€	526.803
Omval/Overamstel	€	154.000	7,3	€	1.123.778
IJburg Oost	€	-	0,0	€	-
Volewijck	€	159.000	24,8	€	3.936.366
Ijplein/Vogelbuurt	€	170.000	17,9	€	3.040.017
Tuindorp Nieuwendam	€	185.000	14,3	€	2.641.123
Tuindorp Buiksloot	€	175.000	6,0	€	1.058.263
Nieuwendammerdijk/Buiksloterdijk	€	395.000	5,5	€	2.160.788
Tuindorp Oostzaan	€	179.000	29,2	€	5.223.319
Oostzanerwerf	€	195.000	22,4	€	4.360.778
Kadoelen	€	275.000	7,9	€	2.159.166
Tuindorp Nieuwendam	€	185.000	14,3	€	2.641.123

Buikslotermeer	€	156.000	30,4	€	4.737.031
Banne Buiksloot	€	177.000	35,5	€	6.282.697
Nieuwendammerdijk/Buiksloterdijk	€	395.000	5,5	€	2.160.788
Tuindorp Buiksloot	€	175.000	6,0	€	1.058.263
Waterland	€	442.000	0,8	€	349.205
Amstel III/Bullewijk	€	-	1,5	€	-
Bijlmer Centrum (D,F,H)	€	123.000	2,0	€	247.955
Bijlmer Oost (E,G,K)	€	148.000	3,2	€	479.033
Nellestein	€	135.000	0,3	€	34.940
Holendrecht/Reigersbos	€	148.000	1,9	€	275.899
Gein	€	165.000	0,8	€	127.047
Driemond	€	235.000	0,0	€	7.468

Scenario 4	Average value(WOZ)		Potential new houses	Total value	
Burgwallen-Oude Zijde	€	290.000	28,5	€	8.253.351
Burgwallen-Nieuwe Zijde	€	296.000	90,5	€	26.773.516
Grachtengordel-West	€	560.000	118,4	€	66.281.379
Grachtengordel-Zuid	€	533.000	85,4	€	45.513.761
Nieuwmarkt/Lastage	€	340.000	94,6	€	32.162.683
Haarlemmerbuurt	€	345.000	23,5	€	8.111.380
Jordaan	€	308.000	326,6	€	100.594.471
De Weteringschans	€	400.000	98,0	€	39.202.236
Weesperbuurt/Plantage	€	354.000	58,8	€	20.809.166
Oostelijke Eilanden/Kadijken	€	275.000	24,3	€	6.677.703
Westelijk havengebied	€	-	14,8	€	-
Bedrijventerrein Sloterdijk	€	-	18,3	€	-
Houthavens	€	159.000	0,0	€	-
Spaarndammer- en Zeeheldenbuurt	€	222.000	57,3	€	12.725.132
Staatsliedenbuurt	€	242.000	20,6	€	4.976.400
Centrale Markt	€	292.000	3,3	€	956.605
Frederik Hendrikbuurt	€	248.000	15,8	€	3.923.434
Da Costabuurt	€	297.000	9,0	€	2.678.392
Kinkerbuurt	€	248.000	12,1	€	3.003.883
Van Lennepbuurt	€	235.000	12,5	€	2.945.484
Helmersbuurt	€	346.000	16,1	€	5.568.174
Overtoomse Sluis	€	299.000	11,9	€	3.564.839
Vondelbuurt	€	642.000	4,7	€	3.028.627
Sloterdijk	€	297.000	1,8	€	548.349
Landlust	€	189.000	63,2	€	11.942.771
Erasmuspark	€	195.000	9,1	€	1.778.005
De Kolenkit	€	180.000	23,9	€	4.308.786
Chassébuurt	€	241.000	12,0	€	2.899.326
Van Galenbuurt	€	197.000	8,9	€	1.759.795
Hoofdweg e.o.	€	194.000	19,6	€	3.804.614
Westindische buurt	€	248.000	12,7	€	3.145.610
Bedrijventerrein Sloterdijk	€	-	18,3	€	-
Slotermeer-Noordoost	€	136.000	36,1	€	4.912.324
Slotermeer-Zuidwest	€	144.000	74,8	€	10.767.089
Geuzenveld	€	171.000	91,5	€	15.645.757
Eendracht	€	240.000	7,2	€	1.736.585
Lutkemeer/Ookmeer	€	389.000	2,1	€	820.998
Osdorp-Oost	€	167.000	118,1	€	19.730.745
Osdorp-Midden	€	183.000	87,9	€	16.090.908
De Punt	€	158.000	31,1	€	4.911.382
Middelveldsche Akerpolder	€	279.000	76,4	€	21.323.254
Slotervaart Noord	€	191.000	34,6	€	6.606.446
Overtoomse Veld	€	163.000	54,9	€	8.946.909
Westlandgracht	€	207.000	22,3	€	4.616.977
Sloter-/Riekerpolder	€	267.000	68,8	€	18.360.975
Oude Pijp	€	278.000	54,2	€	15.075.838
Nieuwe Pijp	€	262.000	22,4	€	5.855.953

Zuid Pijp	€	263.000	12,3	€	3.234.059
Hoofddorppleinbuurt	€	263.000	16,0	€	4.220.377
Schinkelbuurt	€	259.000	5,8	€	1.492.939
Willemspark	€	669.000	12,3	€	8.199.381
Museumkwartier	€	625.000	25,4	€	15.893.506
Stadionbuurt	€	298.000	23,9	€	7.118.455
Apollobuurt	€	729.000	14,4	€	10.480.856
Museumkwartier	€	625.000	25,4	€	15.893.506
Scheldebuurt	€	334.000	30,4	€	10.149.646
IJselbuurt	€	261.000	10,0	€	2.609.164
Rijnbuurt	€	253.000	9,9	€	2.497.471
Zuidas	€	267.000	251,9	€	67.261.274
Buitenveldert-West	€	257.000	39,4	€	10.135.626
Buitenveldert-Oost	€	235.000	7,0	€	1.647.777
Weesperzijde	€	306.000	11,5	€	3.522.608
Oosterparkbuurt	€	238.000	18,2	€	4.326.987
Dapperbuurt	€	244.000	15,2	€	3.720.023
Transvaalbuurt	€	233.000	19,1	€	4.453.601
Indische Buurt West	€	200.000	19,0	€	3.793.727
Indische Buurt Oost	€	213.000	43,0	€	9.161.146
Oostelijk Havengebied	€	341.000	50,3	€	17.169.149
Zeeburgereiland/Nieuwe Diep	€	136.000	13,5	€	1.839.825
IJburg West	€	331.000	6,1	€	2.018.587
IJburg Zuid	€	301.000	2,7	€	802.765
Frankendael	€	224.000	57,2	€	12.820.683
Middenmeer	€	296.000	21,2	€	6.263.324
Betondorp	€	190.000	6,5	€	1.238.124
Omval/Overamstel	€	154.000	55,0	€	8.471.060
IJburg Oost	€	-	0,2	€	-
Volewijck	€	159.000	24,8	€	3.936.366
Ijplein/Vogelbuurt	€	170.000	17,9	€	3.040.017
Tuindorp Nieuwendam	€	185.000	14,3	€	2.641.123
Tuindorp Buiksloot	€	175.000	6,0	€	1.058.263
Nieuwendammerdijk/Buiksloterdijk	€	395.000	5,5	€	2.160.788
Tuindorp Oostzaan	€	179.000	29,2	€	5.223.319
Oostzanerwerf	€	195.000	22,4	€	4.360.778
Kadoelen	€	275.000	7,9	€	2.159.166
Tuindorp Nieuwendam	€	185.000	14,3	€	2.641.123
Buikslotermeer	€	156.000	45,9	€	7.164.012
Banne Buiksloot	€	177.000	35,5	€	6.282.697
Nieuwendammerdijk/Buiksloterdijk	€	395.000	5,5	€	2.160.788
Tuindorp Buiksloot	€	175.000	6,0	€	1.058.263
Waterland	€	442.000	0,8	€	349.205
Amstel III/Bullewijk	€	-	53,5	€	-
Bijlmer Centrum (D,F,H)	€	123.000	12,4	€	1.529.392
Bijlmer Oost (E,G,K)	€	148.000	23,5	€	3.471.455
Nellestein	€	135.000	1,1	€	143.662
Holendrecht/Reigersbos	€	148.000	15,9	€	2.346.301
Gein	€	165.000	0,8	€	127.047
Driemond	€	235.000	0,0	€	7.468

Appendix VI – Calculation economic spatial value 2

Scenario 2	Distance to public green	Amount of houses	Average value	Space(ha)	New parks	New distance	Value increase
Burgwallen-Oude Zijde	1,3	2867	€ 290.000	5460	0,61	1,24	€ 0
Burgwallen-Nieuwe Zijde	1,3	2791	€ 296.000	5935	0,66	1,23	€ 0
Grachtengordel-West	1	4321	€ 560.000	16581	1,84	0,82	€ 0
Grachtengordel-Zuid	0,5	3347	€ 533.000	13502	1,50	0,35	€ 0
Nieuwmarkt/Lastage	0,8	6112	€ 340.000	21178	2,35	0,56	€ 0
Haarlemmerbuurt	0,8	5610	€ 345.000	17645	1,96	0,60	€ 0
Jordaan	0,6	12973	€ 308.000	31361	3,48	0,25	€ 159.827.360
De Weteringschans	0,3	4569	€ 400.000	15295	1,70	0,13	€ 73.104.000
Weesperbuurt/Plantage	0,5	4377	€ 354.000	10372	1,15	0,38	€ 0
Oostelijke Eilanden/Kadijken	0,8	7280	€ 275.000	20318	2,26	0,57	€ 0
Westelijk havengebied	0,6	47	€ -	11342	1,26	0,47	€ 0
Bedrijventerrein Sloterdijk	0,5	42	€ -	0	0,00	0,50	€ 0
Houthavens	1	1199	€ 159.000	17808	1,98	0,80	€ 0
Spaarndammer- en Zeeheldenbuurt	0,5	6017	€ 222.000	17071	1,90	0,31	€ 0
Staatsliedenbuurt	0,4	7838	€ 242.000	18888	2,10	0,19	€ 75.871.840
Centrale Markt	0,6	1197	€ 292.000	2939	0,33	0,57	€ 0
Frederik Hendrikbuurt	0,4	5078	€ 248.000	11392	1,27	0,27	€ 50.373.760
Da Costabuurt	0,8	2649	€ 297.000	6363	0,71	0,73	€ 0
Kinkerbuurt	0,9	3601	€ 248.000	8042	0,89	0,81	€ 0
Van Lennepbuurt	0,7	4455	€ 235.000	9688	1,08	0,59	€ 0
Helmersbuurt	0,4	4220	€ 346.000	12974	1,44	0,26	€ 58.404.800
Overtoomse Sluis	0,5	4465	€ 299.000	10899	1,21	0,38	€ 0
Vondelbuurt	0,2	908	€ 642.000	4129	0,46	0,15	€ 0
Sloterdijk	0,2	233	€ 297.000	29150	3,24	-0,12	€ 0
Landlust	0,5	9550	€ 189.000	27688	3,08	0,19	€ 72.198.000
Erasmuspark	0,3	3056	€ 195.000	9589	1,07	0,19	€ 23.836.800
De Kolenkit	0,2	4559	€ 180.000	14182	1,58	0,04	€ 0
Chassébuurt	0,6	2950	€ 241.000	8633	0,96	0,50	€ 0

Van Galenbuurt	0,2	3213	€ 197.000	8049	0,89	0,11	€ 0
Hoofdweg e.o.	0,4	5705	€ 194.000	16296	1,81	0,22	€ 44.270.800
Westindische buurt	0,4	3613	€ 248.000	11685	1,30	0,27	€ 35.840.960
Bedrijventerrein Sloterdijk	0	42	€ -	0	0,00	0,00	€ 0
Slotermeer-Noordoost	0,2	4214	€ 136.000	22823	2,54	-0,05	€ 0
Slotermeer-Zuidwest	0,3	7789	€ 144.000	45892	5,10	-0,21	€ 44.864.640
Geuzenveld	0,3	6038	€ 171.000	44911	4,99	-0,20	€ 41.299.920
Eendracht	0,2	933	€ 240.000	9615	1,07	0,09	€ 0
Lutkemeer/Ookmeer	0,7	307	€ 389.000	4718	0,52	0,65	€ 0
Osdorp-Oost	0,4	8214	€ 167.000	51627	5,74	-0,17	€ 54.869.520
Osdorp-Midden	0,2	6614	€ 183.000	46991	5,22	-0,32	€ 0
De Punt	0,3	2590	€ 158.000	17666	1,96	0,10	€ 16.368.800
Middelveldsche Akerpolder	0,4	5383	€ 279.000	54699	6,08	-0,21	€ 60.074.280
Slotervaart Noord	0,3	3355	€ 191.000	22425	2,49	0,05	€ 25.632.200
Overtoomse Veld	0,4	4904	€ 163.000	25604	2,84	0,12	€ 31.974.080
Westlandgracht	0,6	4012	€ 207.000	19819	2,20	0,38	€ 0
Sloter-/Riekerpolder	0,2	5637	€ 267.000	57148	6,35	-0,43	€ 0
Oude Pijp	0,3	9215	€ 278.000	27660	3,07	-0,01	€ 102.470.800
Nieuwe Pijp	0,4	7489	€ 262.000	24136	2,68	0,13	€ 78.484.720
Zuid Pijp	0,6	4570	€ 263.000	13560	1,51	0,45	€ 0
Hoofddorppleinbuurt	0,5	6470	€ 263.000	30317	3,37	0,16	€ 68.064.400
Schinkelbuurt	0,5	2273	€ 259.000	8247	0,92	0,41	€ 0
Willemspark	0,4	2609	€ 669.000	18680	2,08	0,19	€ 69.816.840
Museumkwartier	0,3	6785	€ 625.000	38683	4,30	-0,13	€ 169.625.000
Stadionbuurt	0,6	6437	€ 298.000	29463	3,27	0,27	€ 76.729.040
Apollobuurt	0,4	3869	€ 729.000	30409	3,38	0,06	€ 112.820.040
Museumkwartier	0,5	6785	€ 625.000	38683	4,30	0,07	€ 169.625.000
Scheldebuurt	0,3	7404	€ 334.000	36820	4,09	-0,11	€ 98.917.440
IJselbuurt	0,3	2985	€ 261.000	12416	1,38	0,16	€ 31.163.400

Rijnbuurt	0,5	5229	€ 253.000	20211	2,25	0,28	€ 52.917.480
Zuidas	0,6	1430	€ 267.000	4843	0,54	0,55	€ 0
Buitenveldert-West	0,4	7443	€ 257.000	40750	4,53	-0,05	€ 76.514.040
Buitenveldert-Oost	0,4	4505	€ 235.000	25243	2,80	0,12	€ 42.347.000
Weesperzijde	0,8	2729	€ 306.000	7951	0,88	0,71	€ 0
Oosterparkbuurt	0,3	6191	€ 238.000	14018	1,56	0,14	€ 58.938.320
Dapperbuurt	0,4	4958	€ 244.000	11597	1,29	0,27	€ 48.390.080
Transvaalbuurt	0,6	4677	€ 233.000	10162	1,13	0,49	€ 0
Indische Buurt West	0,6	6682	€ 200.000	15217	1,69	0,43	€ 0
Indische Buurt Oost	0,5	4983	€ 213.000	14461	1,61	0,34	€ 0
Oostelijk Havengebied	0,7	8597	€ 341.000	34648	3,85	0,32	€ 0
Zeeburgereiland/Nieuwe Diep	1	627	€ 136.000	2988	0,33	0,97	€ 0
IJburg West	0,8	5480	€ 331.000	25599	2,84	0,52	€ 0
IJburg Zuid	0,3	2653	€ 301.000	12692	1,41	0,16	€ 31.942.120
Frankendael	0,3	5845	€ 224.000	18343	2,04	0,10	€ 52.371.200
Middenmeer	0,3	7348	€ 296.000	27306	3,03	0,00	€ 87.000.320
Betondorp	0,3	1949	€ 190.000	6487	0,72	0,23	€ 14.812.400
Omval/Overamstel	0,9	2937	€ 154.000	8328	0,93	0,81	€ 0
IJburg Oost	0	0	€ -	0	0,00	0,00	€ 0
Volewijck	0,3	4837	€ 159.000	26744	2,97	0,00	€ 30.763.320
Ijplein/Vogelbuurt	0,5	4071	€ 170.000	20041	2,23	0,28	€ 27.682.800
Tuindorp Nieuwendam	0,3	1844	€ 185.000	15193	1,69	0,13	€ 13.645.600
Tuindorp Buiksloot	0,3	912	€ 175.000	7390	0,82	0,22	€ 6.384.000
Nieuwendammerdijk/Buiksloterdijk	0,2	626	€ 395.000	6703	0,74	0,13	€ 0
Tuindorp Oostzaan	0,4	5069	€ 179.000	41506	4,61	-0,06	€ 36.294.040
Oostzanerwerf	0,4	3688	€ 195.000	35440	3,94	0,01	€ 28.766.400
Kadoelen	0,3	1220	€ 275.000	13835	1,54	0,15	€ 13.420.000
Tuindorp Nieuwendam	0,3	1844	€ 185.000	15193	1,69	0,13	€ 13.645.600
Buikslotermeer	0,5	5579	€ 156.000	33206	3,69	0,13	€ 34.812.960
Banne Buiksloot	0,3	5923	€ 177.000	45975	5,11	-0,21	€ 41.934.840
Nieuwendammerdijk/Buiksloterdijk	0,7	626	€ 395.000	6703	0,74	0,63	€ 0

Tuindorp Buiksloot	0,5	912	€ 175.000	7390	0,82	0,42	€ 0
Waterland	1	834	€ 442.000	11126	1,24	0,88	€ 0
Amstel III/Bullewijk	0,4	188	€ -	5019	0,56	0,34	€ 0
Bijlmer Centrum (D,F,H)	0,2	11781	€ 123.000	41591	4,62	-0,26	€ 0
Bijlmer Oost (E,G,K)	0,3	12084	€ 148.000	59159	6,57	-0,36	€ 71.537.280
Nellestein	0,2	1680	€ 135.000	8495	0,94	0,11	€ 0
Holendrecht/Reigersbos	0,4	8338	€ 148.000	39700	4,41	-0,04	€ 49.360.960
Gein	0,3	5134	€ 165.000	29926	3,33	-0,03	€ 33.884.400
Driemond	0,8	625	€ 235.000	5585	0,62	0,74	€ 0

Scenario 3	**Distance to public green**	**Amount of houses**	**Average value**	**Space(ha)**	**New parks**	**New distance**	**Value increase**
Burgwallen-Oude Zijde	1,3	2867	€ 290.000	3697,5	0,4	1,3	€ -
Burgwallen-Nieuwe Zijde	1,3	2791	€ 296.000	4159,7	0,5	1,3	€ -
Grachtengordel-West	1	4321	€ 560.000	11228,9	1,2	0,9	€ -
Grachtengordel-Zuid	0,5	3347	€ 533.000	9149,9	1,0	0,4	€ -
Nieuwmarkt/Lastage	0,8	6112	€ 340.000	14342,4	1,6	0,6	€ -
Haarlemmerbuurt	0,8	5610	€ 345.000	2129,7	0,2	0,8	€ -
Jordaan	0,6	12973	€ 308.000	21439,6	2,4	0,4	€ -
De Weteringschans	0,3	4569	€ 400.000	10358,4	1,2	0,2	€ 73.104.000
Weesperbuurt/Plantage	0,5	4377	€ 354.000	1768,9	0,2	0,5	€ -
Oostelijke Eilanden/Kadijken	0,8	7280	€ 275.000	3127,4	0,3	0,8	€ -
Westelijk havengebied	0,6	47	€ -	350,0	0,0	0,6	€ -
Bedrijventerrein Sloterdijk	0,5	42	€ -	958,6	0,1	0,5	€ -
Houthavens	1	1199	€ 159.000	0,0	0,0	1,0	€ -
Spaarndammer- en Zeeheldenbuurt	0,5	6017	€ 222.000	2191,1	0,2	0,5	€ -
Staatsliedenbuurt	0,4	7838	€ 242.000	2248,7	0,2	0,4	€ -
Centrale Markt	0,6	1197	€ 292.000	349,9	0,0	0,6	€ -
Frederik Hendrikbuurt	0,4	5078	€ 248.000	1356,2	0,2	0,4	€ -
Da Costabuurt	0,8	2649	€ 297.000	757,6	0,1	0,8	€ -
Kinkerbuurt	0,9	3601	€ 248.000	959,2	0,1	0,9	€ -

Van Lennepbuurt	0,7	4455	€ 235.000	1153,4	0,1	0,7	€ -
Helmersbuurt	0,4	4220	€ 346.000	1545,8	0,2	0,4	€ -
Overtoomse Sluis	0,5	4465	€ 299.000	1297,6	0,1	0,5	€ -
Vondelbuurt	0,2	908	€ 642.000	491,6	0,1	0,2	€ -
Sloterdijk	0,2	233	€ 297.000	65,6	0,0	0,2	€ -
Landlust	0,5	9550	€ 189.000	3425,9	0,4	0,5	€ -
Erasmuspark	0,3	3056	€ 195.000	1141,6	0,1	0,3	€ 23.836.800
De Kolenkit	0,2	4559	€ 180.000	1786,9	0,2	0,2	€ -
Chassébuurt	0,6	2950	€ 241.000	1027,8	0,1	0,6	€ -
Van Galenbuurt	0,2	3213	€ 197.000	958,2	0,1	0,2	€ -
Hoofdweg e.o.	0,4	5705	€ 194.000	1940,1	0,2	0,4	€ -
Westindische buurt	0,4	3613	€ 248.000	1391,2	0,2	0,4	€ -
Bedrijventerrein Sloterdijk	0	42	€ -	958,6	0,1	0,0	€ -
Slotermeer-Noordoost	0,2	4214	€ 136.000	9980,1	1,1	0,1	€ -
Slotermeer-Zuidwest	0,3	7789	€ 144.000	20067,6	2,2	0,1	€ 44.864.640
Geuzenveld	0,3	6038	€ 171.000	20032,4	2,2	0,1	€ 41.299.920
Eendracht	0,2	933	€ 240.000	4204,4	0,5	0,2	€ -
Lutkemeer/Ookmeer	0,7	307	€ 389.000	2063,1	0,2	0,7	€ -
Osdorp-Oost	0,4	8214	€ 167.000	22787,2	2,5	0,1	€ 54.869.520
Osdorp-Midden	0,2	6614	€ 183.000	20548,1	2,3	0,0	€ -
De Punt	0,3	2590	€ 158.000	7746,7	0,9	0,2	€ 16.368.800
Middelveldsche Akerpolder	0,4	5383	€ 279.000	23918,8	2,7	0,1	€ 60.074.280
Slotervaart Noord	0,3	3355	€ 191.000	9818,9	1,1	0,2	€ 25.632.200
Overtoomse Veld	0,4	4904	€ 163.000	11196,1	1,2	0,3	€ 31.974.080
Westlandgracht	0,6	4012	€ 207.000	1976,9	0,2	0,6	€ -
Sloter-/Riekerpolder	0,2	5637	€ 267.000	25153,5	2,8	-0,1	€ -
Oude Pijp	0,3	9215	€ 278.000	2466,4	0,3	0,3	€ 102.470.800
Nieuwe Pijp	0,4	7489	€ 262.000	2087,9	0,2	0,4	€ -
Zuid Pijp	0,6	4570	€ 263.000	1173,0	0,1	0,6	€ -
Hoofddorppleinbuurt	0,5	6470	€ 263.000	2622,9	0,3	0,5	€ -

Schinkelbuurt	0,5	2273	€ 259.000	715,3	0,1	0,5	€ -
Willemspark	0,4	2609	€ 669.000	1615,9	0,2	0,4	€ -
Museumkwartier	0,3	6785	€ 625.000	3346,2	0,4	0,3	€ 169.625.000
Stadionbuurt	0,6	6437	€ 298.000	2745,5	0,3	0,6	€ -
Apollobuurt	0,4	3869	€ 729.000	2630,5	0,3	0,4	€ -
Museumkwartier	0,5	6785	€ 625.000	3346,2	0,4	0,5	€ -
Scheldebuurt	0,3	7404	€ 334.000	3250,7	0,4	0,3	€ 98.917.440
IJselbuurt	0,3	2985	€ 261.000	1074,0	0,1	0,3	€ 31.163.400
Rijnbuurt	0,5	5229	€ 253.000	1748,3	0,2	0,5	€ -
Zuidas	0,6	1430	€ 267.000	1709,1	0,2	0,6	€ -
Buitenveldert-West	0,4	7443	€ 257.000	3787,5	0,4	0,4	€ -
Buitenveldert-Oost	0,4	4505	€ 235.000	2183,6	0,2	0,4	€ -
Weesperzijde	0,8	2729	€ 306.000	1224,0	0,1	0,8	€ -
Oosterparkbuurt	0,3	6191	€ 238.000	2159,3	0,2	0,3	€ 58.938.320
Dapperbuurt	0,4	4958	€ 244.000	1784,9	0,2	0,4	€ -
Transvaalbuurt	0,6	4677	€ 233.000	1587,1	0,2	0,6	€ -
Indische Buurt West	0,6	6682	€ 200.000	2342,1	0,3	0,6	€ -
Indische Buurt Oost	0,5	4983	€ 213.000	2340,8	0,3	0,5	€ -
Oostelijk Havengebied	0,7	8597	€ 341.000	5476,6	0,6	0,6	€ -
Zeeburgereiland/Nieuwe Diep	1	627	€ 136.000	998,5	0,1	1,0	€ -
IJburg West	0,8	5480	€ 331.000	3940,2	0,4	0,8	€ -
IJburg Zuid	0,3	2653	€ 301.000	1953,3	0,2	0,3	€ 31.942.120
Frankendael	0,3	5845	€ 224.000	3159,9	0,4	0,3	€ 52.371.200
Middenmeer	0,3	7348	€ 296.000	4202,6	0,5	0,3	€ 87.000.320
Betondorp	0,3	1949	€ 190.000	1053,0	0,1	0,3	€ 14.812.400
Omval/Overamstel	0,9	2937	€ 154.000	2047,5	0,2	0,9	€ -
IJburg Oost	0	0	€ -	5,7	0,0	0,0	€ -
Volewijck	0,3	4837	€ 159.000	8814,0	1,0	0,2	€ 30.763.320
Ijplein/Vogelbuurt	0,5	4071	€ 170.000	6605,0	0,7	0,4	€ -
Tuindorp Nieuwendam	0,3	1844	€ 185.000	5007,1	0,6	0,2	€ 13.645.600

Tuindorp Buiksloot	0,3	912	€ 175.000	2435,4	0,3	0,3	€ 6.384.000
Nieuwendammerdijk/Buiksloterdijk	0,2	626	€ 395.000	2209,0	0,2	0,2	€ -
Tuindorp Oostzaan	0,4	5069	€ 179.000	13679,4	1,5	0,2	€ 36.294.040
Oostzanerwerf	0,4	3688	€ 195.000	11680,2	1,3	0,3	€ 28.766.400
Kadoelen	0,3	1220	€ 275.000	4559,8	0,5	0,2	€ 13.420.000
Tuindorp Nieuwendam	0,3	1844	€ 185.000	5007,1	0,6	0,2	€ 13.645.600
Buikslotermeer	0,5	5579	€ 156.000	11073,5	1,2	0,4	€ -
Banne Buiksloot	0,3	5923	€ 177.000	15152,1	1,7	0,1	€ 41.934.840
Nieuwendammerdijk/Buiksloterdijk	0,7	626	€ 395.000	2209,0	0,2	0,7	€ -
Tuindorp Buiksloot	0,5	912	€ 175.000	2435,4	0,3	0,5	€ -
Waterland	1	834	€ 442.000	3667,0	0,4	1,0	€ -
Amstel III/Bullewijk	0,4	188	€ -	849,1	0,1	0,4	€ -
Bijlmer Centrum (D,F,H)	0,2	11781	€ 123.000	642,0	0,1	0,2	€ -
Bijlmer Oost (E,G,K)	0,3	12084	€ 148.000	1003,5	0,1	0,3	€ 71.537.280
Nellestein	0,2	1680	€ 135.000	200,2	0,0	0,2	€ -
Holendrecht/Reigersbos	0,4	8338	€ 148.000	710,4	0,1	0,4	€ -
Gein	0,3	5134	€ 165.000	397,0	0,0	0,3	€ 33.884.400
Driemond	0,8	625	€ 235.000	74,1	0,0	0,8	€ -

Scenario 4	**Distance to public green**	**Amount of houses**	**Average value**	**Space(ha)**	**New parks**	**New distance**	**Value increase**
Burgwallen-Oude Zijde	1,3	2867	€ 290.000	8138,2	0,9	1,2	€ -
Burgwallen-Nieuwe Zijde	1,3	2791	€ 296.000	8846,9	1,0	1,2	€ -
Grachtengordel-West	1	4321	€ 560.000	24714,8	2,7	0,7	€ -
Grachtengordel-Zuid	0,5	3347	€ 533.000	20126,2	2,2	0,3	€ 71.358.040
Nieuwmarkt/Lastage	0,8	6112	€ 340.000	31567,7	3,5	0,4	€ -
Haarlemmerbuurt	0,8	5610	€ 345.000	26301,2	2,9	0,5	€ -
Jordaan	0,6	12973	€ 308.000	46744,9	5,2	0,1	€ 159.827.360
De Weteringschans	0,3	4569	€ 400.000	22798,9	2,5	0,0	€ 73.104.000
Weesperbuurt/Plantage	0,5	4377	€ 354.000	15460,3	1,7	0,3	€ -

Oostelijke Eilanden/Kadijken	0,8	7280	€ 275.000	30285,7	3,4	0,5	€ -
Westelijk havengebied	0,6	47	€ -	16905,5	1,9	0,4	€ -
Bedrijventerrein Sloterdijk	0,5	42	€ -	0,0	0,0	0,5	€ -
Houthavens	1	1199	€ 159.000	26544,5	2,9	0,7	€ -
Spaarndammer- en Zeeheldenbuurt	0,5	6017	€ 222.000	25446,1	2,8	0,2	€ 53.430.960
Staatsliedenbuurt	0,4	7838	€ 242.000	28153,8	3,1	0,1	€ 75.871.840
Centrale Markt	0,6	1197	€ 292.000	4380,9	0,5	0,6	€ -
Frederik Hendrikbuurt	0,4	5078	€ 248.000	16979,9	1,9	0,2	€ 50.373.760
Da Costabuurt	0,8	2649	€ 297.000	9484,9	1,1	0,7	€ -
Kinkerbuurt	0,9	3601	€ 248.000	11986,8	1,3	0,8	€ -
Van Lennepbuurt	0,7	4455	€ 235.000	14441,1	1,6	0,5	€ -
Helmersbuurt	0,4	4220	€ 346.000	19339,3	2,1	0,2	€ 58.404.800
Overtoomse Sluis	0,5	4465	€ 299.000	16246,2	1,8	0,3	€ -
Vondelbuurt	0,2	908	€ 642.000	6154,4	0,7	0,1	€ -
Sloterdijk	0,2	233	€ 297.000	43450,0	4,8	-0,3	€ -
Landlust	0,5	9550	€ 189.000	41270,1	4,6	0,0	€ 72.198.000
Erasmuspark	0,3	3056	€ 195.000	14293,3	1,6	0,1	€ 23.836.800
De Kolenkit	0,2	4559	€ 180.000	21139,1	2,3	0,0	€ -
Chassébuurt	0,6	2950	€ 241.000	12868,2	1,4	0,5	€ -
Van Galenbuurt	0,2	3213	€ 197.000	11997,3	1,3	0,1	€ -
Hoofdweg e.o.	0,4	5705	€ 194.000	24290,2	2,7	0,1	€ 44.270.800
Westindische buurt	0,4	3613	€ 248.000	17418,0	1,9	0,2	€ 35.840.960
Bedrijventerrein Sloterdijk	0	42	€ -	0,0	0,0	0,0	€ -
Slotermeer-Noordoost	0,2	4214	€ 136.000	34019,6	3,8	-0,2	€ -
Slotermeer-Zuidwest	0,3	7789	€ 144.000	68405,0	7,6	-0,5	€ 44.864.640
Geuzenveld	0,3	6038	€ 171.000	66942,1	7,4	-0,4	€ 41.299.920
Eendracht	0,2	933	€ 240.000	14331,7	1,6	0,0	€ -
Lutkemeer/Ookmeer	0,7	307	€ 389.000	7032,5	0,8	0,6	€ -
Osdorp-Oost	0,4	8214	€ 167.000	76953,7	8,6	-0,5	€ 54.869.520
Osdorp-Midden	0,2	6614	€ 183.000	70043,1	7,8	-0,6	€ -
De Punt	0,3	2590	€ 158.000	26331,9	2,9	0,0	€ 16.368.800

Middelveldsche Akerpolder	0,4	5383	€ 279.000	81532,9	9,1	-0,5	€ 60.074.280
Slotervaart Noord	0,3	3355	€ 191.000	33425,4	3,7	-0,1	€ 25.632.200
Overtoomse Veld	0,4	4904	€ 163.000	38164,5	4,2	0,0	€ 31.974.080
Westlandgracht	0,6	4012	€ 207.000	29541,5	3,3	0,3	€ 33.219.360
Sloter-/Riekerpolder	0,2	5637	€ 267.000	85182,5	9,5	-0,7	€ -
Oude Pijp	0,3	9215	€ 278.000	41228,9	4,6	-0,2	€ 102.470.800
Nieuwe Pijp	0,4	7489	€ 262.000	35976,4	4,0	0,0	€ 78.484.720
Zuid Pijp	0,6	4570	€ 263.000	20212,3	2,2	0,4	€ -
Hoofddorppleinbuurt	0,5	6470	€ 263.000	45188,8	5,0	0,0	€ 68.064.400
Schinkelbuurt	0,5	2273	€ 259.000	12292,4	1,4	0,4	€ -
Willemspark	0,4	2609	€ 669.000	27843,4	3,1	0,1	€ 69.816.840
Museumkwartier	0,3	6785	€ 625.000	57659,9	6,4	-0,3	€ 169.625.000
Stadionbuurt	0,6	6437	€ 298.000	43917,0	4,9	0,1	€ 76.729.040
Apollobuurt	0,4	3869	€ 729.000	45326,3	5,0	-0,1	€ 112.820.040
Museumkwartier	0,5	6785	€ 625.000	57659,9	6,4	-0,1	€ 169.625.000
Scheldebuurt	0,3	7404	€ 334.000	54882,5	6,1	-0,3	€ 98.917.440
IJselbuurt	0,3	2985	€ 261.000	18507,3	2,1	0,1	€ 31.163.400
Rijnbuurt	0,5	5229	€ 253.000	30125,9	3,3	0,2	€ 52.917.480
Zuidas	0,6	1430	€ 267.000	7218,7	0,8	0,5	€ -
Buitenveldert-West	0,4	7443	€ 257.000	60739,9	6,7	-0,3	€ 76.514.040
Buitenveldert-Oost	0,4	4505	€ 235.000	37626,4	4,2	0,0	€ 42.347.000
Weesperzijde	0,8	2729	€ 306.000	11851,6	1,3	0,7	€ -
Oosterparkbuurt	0,3	6191	€ 238.000	20895,3	2,3	0,1	€ 58.938.320
Dapperbuurt	0,4	4958	€ 244.000	17286,6	1,9	0,2	€ 48.390.080
Transvaalbuurt	0,6	4677	€ 233.000	15147,7	1,7	0,4	€ -
Indische Buurt West	0,6	6682	€ 200.000	22682,6	2,5	0,3	€ -
Indische Buurt Oost	0,5	4983	€ 213.000	21554,5	2,4	0,3	€ 42.455.160
Oostelijk Havengebied	0,7	8597	€ 341.000	51644,9	5,7	0,1	€ 117.263.080

Zeeburgereiland/Nieuwe Diep	1	627	€ 136.000	4453,5	0,5	1,0	€ -
IJburg West	0,8	5480	€ 331.000	38157,5	4,2	0,4	€ -
IJburg Zuid	0,3	2653	€ 301.000	18917,6	2,1	0,1	€ 31.942.120
Frankendael	0,3	5845	€ 224.000	27341,1	3,0	0,0	€ 52.371.200
Middenmeer	0,3	7348	€ 296.000	40701,6	4,5	-0,2	€ 87.000.320
Betondorp	0,3	1949	€ 190.000	9668,8	1,1	0,2	€ 14.812.400
Omval/Overamstel	0,9	2937	€ 154.000	12413,1	1,4	0,8	€ -
IJburg Oost	0	0	€ -	0,0	0,0	0,0	€ -
Volewijck	0,3	4837	€ 159.000	39863,2	4,4	-0,1	€ 30.763.320
Ijplein/Vogelbuurt	0,5	4071	€ 170.000	29872,4	3,3	0,2	€ 27.682.800
Tuindorp Nieuwendam	0,3	1844	€ 185.000	22645,7	2,5	0,0	€ 13.645.600
Tuindorp Buiksloot	0,3	912	€ 175.000	11014,8	1,2	0,2	€ 6.384.000
Nieuwendammerdijk/Buiksloterdijk	0,2	626	€ 395.000	9990,8	1,1	0,1	€ -
Tuindorp Oostzaan	0,4	5069	€ 179.000	61867,8	6,9	-0,3	€ 36.294.040
Oostzanerwerf	0,4	3688	€ 195.000	52826,2	5,9	-0,2	€ 28.766.400
Kadoelen	0,3	1220	€ 275.000	20622,6	2,3	0,1	€ 13.420.000
Tuindorp Nieuwendam	0,3	1844	€ 185.000	22645,7	2,5	0,0	€ 13.645.600
Buikslotermeer	0,5	5579	€ 156.000	49495,9	5,5	0,0	€ 34.812.960
Banne Buiksloot	0,3	5923	€ 177.000	68528,3	7,6	-0,5	€ 41.934.840
Nieuwendammerdijk/Buiksloterdijk	0,7	626	€ 395.000	9990,8	1,1	0,6	€ -
Tuindorp Buiksloot	0,5	912	€ 175.000	11014,8	1,2	0,4	€ -
Waterland	1	834	€ 442.000	16584,7	1,8	0,8	€ -
Amstel III/Bullewijk	0,4	188	€ -	7481,6	0,8	0,3	€ -
Bijlmer Centrum (D,F,H)	0,2	11781	€ 123.000	61994,1	6,9	-0,5	€ -
Bijlmer Oost (E,G,K)	0,3	12084	€ 148.000	88179,8	9,8	-0,7	€ 71.537.280
Nellestein	0,2	1680	€ 135.000	12662,1	1,4	0,1	€ -
Holendrecht/Reigersbos	0,4	8338	€ 148.000	59176,2	6,6	-0,3	€ 49.360.960
Gein	0,3	5134	€ 165.000	44606,7	5,0	-0,2	€ 33.884.400
Driemond	0,8	625	€ 235.000	8324,5	0,9	0,7	€ -

Appendix VII – Calculation environmental spatial value

Scenario 2	Space for limited functions(ha)	PM10 reduction(kg)	Heat reduction (C)
Burgwallen-Oude Zijde	5.460	91	0,16
Burgwallen-Nieuwe Zijde	5.935	99	0,10
Grachtengordel-West	16.581	276	0,37
Grachtengordel-Zuid	13.502	225	0,26
Nieuwmarkt/Lastage	21.178	353	0,29
Haarlemmerbuurt	17.645	294	0,32
Jordaan	31.361	523	0,38
De Weteringschans	15.295	255	0,27
Weesperbuurt/Plantage	10.372	173	0,13
Oostelijke Eilanden/Kadijken	20.318	339	0,21
Westelijk havengebied	11.342	189	0,01
Bedrijventerrein Sloterdijk	0	0	0,00
Houthavens	17.808	297	0,59
Spaarndammer- en Zeeheldenbuurt	17.071	285	0,12
Staatsliedenbuurt	18.888	315	0,40
Centrale Markt	2.939	49	0,06
Frederik Hendrikbuurt	11.392	190	0,32
Da Costabuurt	6.363	106	0,29
Kinkerbuurt	8.042	134	0,32
Van Lennepbuurt	9.688	161	0,39
Helmersbuurt	12.974	216	0,38
Overtoomse Sluis	10.899	182	0,36
Vondelbuurt	4.129	69	0,19
Sloterdijk	29.150	486	0,24
Landlust	27.688	461	0,27
Erasmuspark	9.589	160	0,27
De Kolenkit	14.182	236	0,20
Chassébuurt	8.633	144	0,35
Van Galenbuurt	8.049	134	0,28
Hoofdweg e.o.	16.296	272	0,41
Westindische buurt	11.685	195	0,37
Bedrijventerrein Sloterdijk	0	0	0,00
Slotermeer-Noordoost	22.823	380	0,24
Slotermeer-Zuidwest	45.892	765	0,20
Geuzenveld	44.911	749	0,34
Eendracht	9.615	160	0,04
Lutkemeer/Ookmeer	4.718	79	0,01
Osdorp-Oost	51.627	860	0,33
Osdorp-Midden	46.991	783	0,46
De Punt	17.666	294	0,29
Middelveldsche Akerpolder	54.699	912	0,36
Slotervaart Noord	22.425	374	0,20

Overtoomse Veld	25.604	427	0,18
Westlandgracht	19.819	330	0,14
Sloter-/Riekerpolder	57.148	952	0,12
Oude Pijp	27.660	461	0,44
Nieuwe Pijp	24.136	402	0,47
Zuid Pijp	13.560	226	0,39
Hoofddorppleinbuurt	30.317	505	0,36
Schinkelbuurt	8.247	137	0,28
Willemspark	18.680	311	0,29
Museumkwartier	38.683	645	0,30
Stadionbuurt	29.463	491	0,31
Apollobuurt	30.409	507	0,35
Museumkwartier	38.683	645	0,30
Scheldebuurt	36.820	614	0,37
IJselbuurt	12.416	207	0,48
Rijnbuurt	20.211	337	0,21
Zuidas	4.843	81	0,02
Buitenveldert-West	40.750	679	0,14
Buitenveldert-Oost	25.243	421	0,16
Weesperzijde	7.951	133	0,21
Oosterparkbuurt	14.018	234	0,19
Dapperbuurt	11.597	193	0,20
Transvaalbuurt	10.162	169	0,27
Indische Buurt West	15.217	254	0,32
Indische Buurt Oost	14.461	241	0,15
Oostelijk Havengebied	34.648	577	0,22
Zeeburgereiland/Nieuwe Diep	2.988	50	0,01
IJburg West	25.599	427	0,23
IJburg Zuid	12.692	212	0,19
Frankendael	18.343	306	0,12
Middenmeer	27.306	455	0,10
Betondorp	6.487	108	0,06
Omval/Overamstel	8.328	139	0,03
IJburg Oost	0	0	0,00
Volewijck	26.744	446	0,22
Ijplein/Vogelbuurt	20.041	334	0,17
Tuindorp Nieuwendam	15.193	253	0,35
Tuindorp Buiksloot	7.390	123	0,43
Nieuwendammerdijk/Buiksloterdijk	6.703	112	0,19
Tuindorp Oostzaan	41.506	692	0,26
Oostzanerwerf	35.440	591	0,14
Kadoelen	13.835	231	0,10
Tuindorp Nieuwendam	15.193	253	0,35
Buikslotermeer	33.206	553	0,22
Banne Buiksloot	45.975	766	0,28

Nieuwendammerdijk/Buiksloterdijk	6.703	112	0,19
Tuindorp Buiksloot	7.390	123	0,43
Waterland	11.126	185	0,00
Amstel III/Bullewijk	5.019	84	0,01
Bijlmer Centrum (D,F,H)	41.591	693	0,14
Bijlmer Oost (E,G,K)	59.159	986	0,16
Nellestein	8.495	142	0,04
Holendrecht/Reigersbos	39.700	662	0,15
Gein	29.926	499	0,16
Driemond	5.585	93	0,03

Scenario 3	Space for limited functions(ha)	PM10 reduction(kg)	Heat reduction (C)
Burgwallen-Oude Zijde	3697	62	0,11
Burgwallen-Nieuwe Zijde	4160	69	0,07
Grachtengordel-West	11229	187	0,25
Grachtengordel-Zuid	9150	152	0,18
Nieuwmarkt/Lastage	14342	239	0,20
Haarlemmerbuurt	2130	35	0,04
Jordaan	21440	357	0,26
De Weteringschans	10358	173	0,18
Weesperbuurt/Plantage	1769	29	0,02
Oostelijke Eilanden/Kadijken	3127	52	0,03
Westelijk havengebied	350	6	0,00
Bedrijventerrein Sloterdijk	959	16	0,00
Houthavens	0	0	0,00
Spaarndammer- en Zeeheldenbuurt	2191	37	0,02
Staatsliedenbuurt	2249	37	0,05
Centrale Markt	350	6	0,01
Frederik Hendrikbuurt	1356	23	0,04
Da Costabuurt	758	13	0,03
Kinkerbuurt	959	16	0,04
Van Lennepbuurt	1153	19	0,05
Helmersbuurt	1546	26	0,05
Overtoomse Sluis	1298	22	0,04
Vondelbuurt	492	8	0,02
Sloterdijk	66	1	0,00
Landlust	3426	57	0,03
Erasmuspark	1142	19	0,03
De Kolenkit	1787	30	0,02
Chassébuurt	1028	17	0,04
Van Galenbuurt	958	16	0,03
Hoofdweg e.o.	1940	32	0,05
Westindische buurt	1391	23	0,04
Bedrijventerrein Sloterdijk	959	16	0,00

Slotermeer-Noordoost	9980	166	0,10
Slotermeer-Zuidwest	20068	334	0,09
Geuzenveld	20032	334	0,15
Eendracht	4204	70	0,02
Lutkemeer/Ookmeer	2063	34	0,00
Osdorp-Oost	22787	380	0,14
Osdorp-Midden	20548	342	0,20
De Punt	7747	129	0,13
Middelveldsche Akerpolder	23919	399	0,16
Slotervaart Noord	9819	164	0,09
Overtoomse Veld	11196	187	0,08
Westlandgracht	1977	33	0,01
Sloter-/Riekerpolder	25154	419	0,05
Oude Pijp	2466	41	0,04
Nieuwe Pijp	2088	35	0,04
Zuid Pijp	1173	20	0,03
Hoofddorppleinbuurt	2623	44	0,03
Schinkelbuurt	715	12	0,02
Willemspark	1616	27	0,03
Museumkwartier	3346	56	0,03
Stadionbuurt	2746	46	0,03
Apollobuurt	2630	44	0,03
Museumkwartier	3346	56	0,03
Scheldebuurt	3251	54	0,03
IJselbuurt	1074	18	0,04
Rijnbuurt	1748	29	0,02
Zuidas	1709	28	0,01
Buitenveldert-West	3787	63	0,01
Buitenveldert-Oost	2184	36	0,01
Weesperzijde	1224	20	0,03
Oosterparkbuurt	2159	36	0,03
Dapperbuurt	1785	30	0,03
Transvaalbuurt	1587	26	0,04
Indische Buurt West	2342	39	0,05
Indische Buurt Oost	2341	39	0,02
Oostelijk Havengebied	5477	91	0,04
Zeeburgereiland/Nieuwe Diep	999	17	0,00
IJburg West	3940	66	0,04
IJburg Zuid	1953	33	0,03
Frankendael	3160	53	0,02
Middenmeer	4203	70	0,01
Betondorp	1053	18	0,01
Omval/Overamstel	2048	34	0,01
IJburg Oost	6	0	0,00
Volewijck	8814	147	0,07

Ijplein/Vogelbuurt	6605	110	0,06
Tuindorp Nieuwendam	5007	83	0,12
Tuindorp Buiksloot	2435	41	0,14
Nieuwendammerdijk/Buiksloterdijk	2209	37	0,06
Tuindorp Oostzaan	13679	228	0,09
Oostzanerwerf	11680	195	0,05
Kadoelen	4560	76	0,03
Tuindorp Nieuwendam	5007	83	0,12
Buikslotermeer	11073	185	0,07
Banne Buiksloot	15152	253	0,09
Nieuwendammerdijk/Buiksloterdijk	2209	37	0,06
Tuindorp Buiksloot	2435	41	0,14
Waterland	3667	61	0,00
Amstel III/Bullewijk	849	14	0,00
Bijlmer Centrum (D,F,H)	642	11	0,00
Bijlmer Oost (E,G,K)	1003	17	0,00
Nellestein	200	3	0,00
Holendrecht/Reigersbos	710	12	0,00
Gein	397	7	0,00
Driemond	74	1	0,00

Scenario 4	**Space for limited functions(ha)**	**PM10 reduction(kg)**	**Heat reduction (C)**
Burgwallen-Oude Zijde	8138	136	0,23
Burgwallen-Nieuwe Zijde	8847	147	0,16
Grachtengordel-West	24715	412	0,55
Grachtengordel-Zuid	20126	335	0,39
Nieuwmarkt/Lastage	31568	526	0,44
Haarlemmerbuurt	26301	438	0,48
Jordaan	46745	779	0,56
De Weteringschans	22799	380	0,41
Weesperbuurt/Plantage	15460	258	0,20
Oostelijke Eilanden/Kadijken	30286	505	0,31
Westelijk havengebied	16905	282	0,01
Bedrijventerrein Sloterdijk	0	0	0,00
Houthavens	26545	442	0,88
Spaarndammer- en Zeeheldenbuurt	25446	424	0,19
Staatsliedenbuurt	28154	469	0,60
Centrale Markt	4381	73	0,08
Frederik Hendrikbuurt	16980	283	0,47
Da Costabuurt	9485	158	0,43
Kinkerbuurt	11987	200	0,48
Van Lennepbuurt	14441	241	0,58

Helmersbuurt	19339	322	0,57
Overtoomse Sluis	16246	271	0,54
Vondelbuurt	6154	103	0,28
Sloterdijk	43450	724	0,36
Landlust	41270	688	0,40
Erasmuspark	14293	238	0,40
De Kolenkit	21139	352	0,29
Chassébuurt	12868	214	0,51
Van Galenbuurt	11997	200	0,41
Hoofdweg e.o.	24290	405	0,61
Westindische buurt	17418	290	0,54
Bedrijventerrein Sloterdijk	0	0	0,00
Slotermeer-Noordoost	34020	567	0,35
Slotermeer-Zuidwest	68405	1140	0,30
Geuzenveld	66942	1116	0,51
Eendracht	14332	239	0,06
Lutkemeer/Ookmeer	7033	117	0,01
Osdorp-Oost	76954	1283	0,49
Osdorp-Midden	70043	1167	0,68
De Punt	26332	439	0,44
Middelveldsche Akerpolder	81533	1359	0,54
Slotervaart Noord	33425	557	0,30
Overtoomse Veld	38164	636	0,26
Westlandgracht	29542	492	0,21
Sloter-/Riekerpolder	85182	1420	0,18
Oude Pijp	41229	687	0,65
Nieuwe Pijp	35976	600	0,71
Zuid Pijp	20212	337	0,58
Hoofddorppleinbuurt	45189	753	0,53
Schinkelbuurt	12292	205	0,42
Willemspark	27843	464	0,44
Museumkwartier	57660	961	0,44
Stadionbuurt	43917	732	0,46
Apollobuurt	45326	755	0,52
Museumkwartier	57660	961	0,44
Scheldebuurt	54882	915	0,55
IJselbuurt	18507	308	0,71
Rijnbuurt	30126	502	0,31
Zuidas	7219	120	0,03
Buitenveldert-West	60740	1012	0,21
Buitenveldert-Oost	37626	627	0,25
Weesperzijde	11852	198	0,32
Oosterparkbuurt	20895	348	0,29
Dapperbuurt	17287	288	0,29
Transvaalbuurt	15148	252	0,41

Indische Buurt West	22683	378	0,48
Indische Buurt Oost	21555	359	0,23
Oostelijk Havengebied	51645	861	0,34
Zeeburgereiland/Nieuwe Diep	4453	74	0,02
IJburg West	38157	636	0,34
IJburg Zuid	18918	315	0,29
Frankendael	27341	456	0,17
Middenmeer	40702	678	0,14
Betondorp	9669	161	0,09
Omval/Overamstel	12413	207	0,04
IJburg Oost	0	0	0,00
Volewijck	39863	664	0,33
Ijplein/Vogelbuurt	29872	498	0,25
Tuindorp Nieuwendam	22646	377	0,53
Tuindorp Buiksloot	11015	184	0,65
Nieuwendammerdijk/Buiksloterdijk	9991	167	0,28
Tuindorp Oostzaan	61868	1031	0,39
Oostzanerwerf	52826	880	0,21
Kadoelen	20623	344	0,15
Tuindorp Nieuwendam	22646	377	0,53
Buikslotermeer	49496	825	0,33
Banne Buiksloot	68528	1142	0,41
Nieuwendammerdijk/Buiksloterdijk	9991	167	0,28
Tuindorp Buiksloot	11015	184	0,65
Waterland	16585	276	0,01
Amstel III/Bullewijk	7482	125	0,02
Bijlmer Centrum (D,F,H)	61994	1033	0,20
Bijlmer Oost (E,G,K)	88180	1470	0,24
Nellestein	12662	211	0,06
Holendrecht/Reigersbos	59176	986	0,23
Gein	44607	743	0,24
Driemond	8325	139	0,05

Appendix VIII – Calculation social spatial value

Scenario 2	Space for limited functions(ha)	Greenery increase(%)	Social cohesion increase(%)
Burgwallen-Oude Zijde	5.460	2%	1%
Burgwallen-Nieuwe Zijde	5.935	1%	1%
Grachtengordel-West	16.581	4%	2%
Grachtengordel-Zuid	13.502	3%	1%
Nieuwmarkt/Lastage	21.178	3%	2%
Haarlemmerbuurt	17.645	3%	2%
Jordaan	31.361	4%	2%
De Weteringschans	15.295	3%	2%
Weesperbuurt/Plantage	10.372	1%	1%
Oostelijke Eilanden/Kadijken	20.318	2%	1%
Westelijk havengebied	11.342	0%	0%
Bedrijventerrein Sloterdijk	0	0%	0%
Houthavens	17.808	6%	3%
Spaarndammer- en Zeeheldenbuurt	17.071	1%	1%
Staatsliedenbuurt	18.888	4%	2%
Centrale Markt	2.939	1%	0%
Frederik Hendrikbuurt	11.392	3%	2%
Da Costabuurt	6.363	3%	2%
Kinkerbuurt	8.042	3%	2%
Van Lennepbuurt	9.688	4%	2%
Helmersbuurt	12.974	4%	2%
Overtoomse Sluis	10.899	4%	2%
Vondelbuurt	4.129	2%	1%
Sloterdijk	29.150	2%	1%
Landlust	27.688	3%	1%
Erasmuspark	9.589	3%	1%
De Kolenkit	14.182	2%	1%
Chassébuurt	8.633	3%	2%
Van Galenbuurt	8.049	3%	2%
Hoofdweg e.o.	16.296	4%	2%
Westindische buurt	11.685	4%	2%
Bedrijventerrein Sloterdijk	0	0%	0%
Slotermeer-Noordoost	22.823	2%	1%
Slotermeer-Zuidwest	45.892	2%	1%
Geuzenveld	44.911	3%	2%
Eendracht	9.615	0%	0%
Lutkemeer/Ookmeer	4.718	0%	0%
Osdorp-Oost	51.627	3%	2%
Osdorp-Midden	46.991	5%	3%
De Punt	17.666	3%	2%
Middelveldsche Akerpolder	54.699	4%	2%
Slotervaart Noord	22.425	2%	1%

Overtoomse Veld	25.604	2%	1%
Westlandgracht	19.819	1%	1%
Sloter-/Riekerpolder	57.148	1%	1%
Oude Pijp	27.660	4%	2%
Nieuwe Pijp	24.136	5%	3%
Zuid Pijp	13.560	4%	2%
Hoofddorppleinbuurt	30.317	4%	2%
Schinkelbuurt	8.247	3%	2%
Willemspark	18.680	3%	2%
Museumkwartier	38.683	3%	2%
Stadionbuurt	29.463	3%	2%
Apollobuurt	30.409	3%	2%
Museumkwartier	38.683	3%	2%
Scheldebuurt	36.820	4%	2%
IJselbuurt	12.416	5%	3%
Rijnbuurt	20.211	2%	1%
Zuidas	4.843	0%	0%
Buitenveldert-West	40.750	1%	1%
Buitenveldert-Oost	25.243	2%	1%
Weesperzijde	7.951	2%	1%
Oosterparkbuurt	14.018	2%	1%
Dapperbuurt	11.597	2%	1%
Transvaalbuurt	10.162	3%	2%
Indische Buurt West	15.217	3%	2%
Indische Buurt Oost	14.461	2%	1%
Oostelijk Havengebied	34.648	2%	1%
Zeeburgereiland/Nieuwe Diep	2.988	0%	0%
IJburg West	25.599	2%	1%
IJburg Zuid	12.692	2%	1%
Frankendael	18.343	1%	1%
Middenmeer	27.306	1%	1%
Betondorp	6.487	1%	0%
Omval/Overamstel	8.328	0%	0%
IJburg Oost	0	0%	0%
Volewijck	26.744	2%	1%
Ijplein/Vogelbuurt	20.041	2%	1%
Tuindorp Nieuwendam	15.193	4%	2%
Tuindorp Buiksloot	7.390	4%	2%
Nieuwendammerdijk/Buiksloterdijk	6.703	2%	1%
Tuindorp Oostzaan	41.506	3%	1%
Oostzanerwerf	35.440	1%	1%
Kadoelen	13.835	1%	1%
Tuindorp Nieuwendam	15.193	4%	2%
Buikslotermeer	33.206	2%	1%
Banne Buiksloot	45.975	3%	2%

Nieuwendammerdijk/Buiksloterdijk	6.703	2%	1%
Tuindorp Buiksloot	7.390	4%	2%
Waterland	11.126	0%	0%
Amstel III/Bullewijk	5.019	0%	0%
Bijlmer Centrum (D,F,H)	41.591	1%	1%
Bijlmer Oost (E,G,K)	59.159	2%	1%
Nellestein	8.495	0%	0%
Holendrecht/Reigersbos	39.700	2%	1%
Gein	29.926	2%	1%
Driemond	5.585	0%	0%

Scenario 3	Space for limited functions(ha)	Greenery increase(%)	Social cohesion increase(%)
Burgwallen-Oude Zijde	3.697	1%	1%
Burgwallen-Nieuwe Zijde	4.160	1%	0%
Grachtengordel-West	11.229	2%	1%
Grachtengordel-Zuid	9.150	2%	1%
Nieuwmarkt/Lastage	14.342	2%	1%
Haarlemmerbuurt	2.130	0%	0%
Jordaan	21.440	3%	1%
De Weteringschans	10.358	2%	1%
Weesperbuurt/Plantage	1.769	0%	0%
Oostelijke Eilanden/Kadijken	3.127	0%	0%
Westelijk havengebied	350	0%	0%
Bedrijventerrein Sloterdijk	959	0%	0%
Houthavens	0	0%	0%
Spaarndammer- en Zeeheldenbuurt	2.191	0%	0%
Staatsliedenbuurt	2.249	0%	0%
Centrale Markt	350	0%	0%
Frederik Hendrikbuurt	1.356	0%	0%
Da Costabuurt	758	0%	0%
Kinkerbuurt	959	0%	0%
Van Lennepbuurt	1.153	0%	0%
Helmersbuurt	1.546	0%	0%
Overtoomse Sluis	1.298	0%	0%
Vondelbuurt	492	0%	0%
Sloterdijk	66	0%	0%
Landlust	3.426	0%	0%
Erasmuspark	1.142	0%	0%
De Kolenkit	1.787	0%	0%
Chassébuurt	1.028	0%	0%
Van Galenbuurt	958	0%	0%
Hoofdweg e.o.	1.940	0%	0%
Westindische buurt	1.391	0%	0%
Bedrijventerrein Sloterdijk	959	0%	0%
Slotermeer-Noordoost	9.980	1%	1%
Slotermeer-Zuidwest	20.068	1%	0%
Geuzenveld	20.032	2%	1%
Eendracht	4.204	0%	0%
Lutkemeer/Ookmeer	2.063	0%	0%
Osdorp-Oost	22.787	1%	1%
Osdorp-Midden	20.548	2%	1%
De Punt	7.747	1%	1%
Middelveldsche Akerpolder	23.919	2%	1%
Slotervaart Noord	9.819	1%	0%
Overtoomse Veld	11.196	1%	0%
Westlandgracht	1.977	0%	0%

Sloter-/Riekerpolder	25.154	1%	0%
Oude Pijp	2.466	0%	0%
Nieuwe Pijp	2.088	0%	0%
Zuid Pijp	1.173	0%	0%
Hoofddorppleinbuurt	2.623	0%	0%
Schinkelbuurt	715	0%	0%
Willemspark	1.616	0%	0%
Museumkwartier	3.346	0%	0%
Stadionbuurt	2.746	0%	0%
Apollobuurt	2.630	0%	0%
Museumkwartier	3.346	0%	0%
Scheldebuurt	3.251	0%	0%
IJselbuurt	1.074	0%	0%
Rijnbuurt	1.748	0%	0%
Zuidas	1.709	0%	0%
Buitenveldert-West	3.787	0%	0%
Buitenveldert-Oost	2.184	0%	0%
Weesperzijde	1.224	0%	0%
Oosterparkbuurt	2.159	0%	0%
Dapperbuurt	1.785	0%	0%
Transvaalbuurt	1.587	0%	0%
Indische Buurt West	2.342	0%	0%
Indische Buurt Oost	2.341	0%	0%
Oostelijk Havengebied	5.477	0%	0%
Zeeburgereiland/Nieuwe Diep	999	0%	0%
IJburg West	3.940	0%	0%
IJburg Zuid	1.953	0%	0%
Frankendael	3.160	0%	0%
Middenmeer	4.203	0%	0%
Betondorp	1.053	0%	0%
Omval/Overamstel	2.048	0%	0%
IJburg Oost	6	0%	0%
Volewijck	8.814	1%	0%
Ijplein/Vogelbuurt	6.605	1%	0%
Tuindorp Nieuwendam	5.007	1%	1%
Tuindorp Buiksloot	2.435	1%	1%
Nieuwendammerdijk/Buiksloterdijk	2.209	1%	0%
Tuindorp Oostzaan	13.679	1%	0%
Oostzanerwerf	11.680	0%	0%
Kadoelen	4.560	0%	0%
Tuindorp Nieuwendam	5.007	1%	1%
Buikslotermeer	11.073	1%	0%
Banne Buiksloot	15.152	1%	1%
Nieuwendammerdijk/Buiksloterdijk	2.209	1%	0%
Tuindorp Buiksloot	2.435	1%	1%

Waterland	3.667	0%	0%
Amstel III/Bullewijk	849	0%	0%
Bijlmer Centrum (D,F,H)	642	0%	0%
Bijlmer Oost (E,G,K)	1.003	0%	0%
Nellestein	200	0%	0%
Holendrecht/Reigersbos	710	0%	0%
Gein	397	0%	0%
Driemond	74	0%	0%

Scenario 4	Space for limited functions(ha)	Greenery increase(%)	Social cohesion increase(%)
Burgwallen-Oude Zijde	8.138	2%	1%
Burgwallen-Nieuwe Zijde	8.847	2%	1%
Grachtengordel-West	24.715	5%	3%
Grachtengordel-Zuid	20.126	4%	2%
Nieuwmarkt/Lastage	31.568	4%	2%
Haarlemmerbuurt	26.301	5%	3%
Jordaan	46.745	6%	3%
De Weteringschans	22.799	4%	2%
Weesperbuurt/Plantage	15.460	2%	1%
Oostelijke Eilanden/Kadijken	30.286	3%	2%
Westelijk havengebied	16.905	0%	0%
Bedrijventerrein Sloterdijk	0	0%	0%
Houthavens	26.545	9%	5%
Spaarndammer- en Zeeheldenbuurt	25.446	2%	1%
Staatsliedenbuurt	28.154	6%	3%
Centrale Markt	4.381	1%	0%
Frederik Hendrikbuurt	16.980	5%	3%
Da Costabuurt	9.485	4%	2%
Kinkerbuurt	11.987	5%	3%
Van Lennepbuurt	14.441	6%	3%
Helmersbuurt	19.339	6%	3%
Overtoomse Sluis	16.246	5%	3%
Vondelbuurt	6.154	3%	2%
Sloterdijk	43.450	4%	2%
Landlust	41.270	4%	2%
Erasmuspark	14.293	4%	2%
De Kolenkit	21.139	3%	2%
Chassébuurt	12.868	5%	3%
Van Galenbuurt	11.997	4%	2%
Hoofdweg e.o.	24.290	6%	3%
Westindische buurt	17.418	5%	3%
Bedrijventerrein Sloterdijk	0	0%	0%
Slotermeer-Noordoost	34.020	4%	2%
Slotermeer-Zuidwest	68.405	3%	2%
Geuzenveld	66.942	5%	3%
Eendracht	14.332	1%	0%
Lutkemeer/Ookmeer	7.033	0%	0%
Osdorp-Oost	76.954	5%	3%
Osdorp-Midden	70.043	7%	4%
De Punt	26.332	4%	2%
Middelveldsche Akerpolder	81.533	5%	3%
Slotervaart Noord	33.425	3%	2%
Overtoomse Veld	38.164	3%	1%
Westlandgracht	29.542	2%	1%

Sloter-/Riekerpolder	85.182	2%	1%
Oude Pijp	41.229	7%	4%
Nieuwe Pijp	35.976	7%	4%
Zuid Pijp	20.212	6%	3%
Hoofddorppleinbuurt	45.189	5%	3%
Schinkelbuurt	12.292	4%	2%
Willemspark	27.843	4%	2%
Museumkwartier	57.660	4%	2%
Stadionbuurt	43.917	5%	3%
Apollobuurt	45.326	5%	3%
Museumkwartier	57.660	4%	2%
Scheldebuurt	54.882	6%	3%
IJselbuurt	18.507	7%	4%
Rijnbuurt	30.126	3%	2%
Zuidas	7.219	0%	0%
Buitenveldert-West	60.740	2%	1%
Buitenveldert-Oost	37.626	2%	1%
Weesperzijde	11.852	3%	2%
Oosterparkbuurt	20.895	3%	2%
Dapperbuurt	17.287	3%	2%
Transvaalbuurt	15.148	4%	2%
Indische Buurt West	22.683	5%	3%
Indische Buurt Oost	21.555	2%	1%
Oostelijk Havengebied	51.645	3%	2%
Zeeburgereiland/Nieuwe Diep	4.453	0%	0%
IJburg West	38.157	3%	2%
IJburg Zuid	18.918	3%	2%
Frankendael	27.341	2%	1%
Middenmeer	40.702	1%	1%
Betondorp	9.669	1%	0%
Omval/Overamstel	12.413	0%	0%
IJburg Oost	0	0%	0%
Volewijck	39.863	3%	2%
Ijplein/Vogelbuurt	29.872	3%	1%
Tuindorp Nieuwendam	22.646	5%	3%
Tuindorp Buiksloot	11.015	6%	4%
Nieuwendammerdijk/Buiksloterdijk	9.991	3%	2%
Tuindorp Oostzaan	61.868	4%	2%
Oostzanerwerf	52.826	2%	1%
Kadoelen	20.623	2%	1%
Tuindorp Nieuwendam	22.646	5%	3%
Buikslotermeer	49.496	3%	2%
Banne Buiksloot	68.528	4%	2%
Nieuwendammerdijk/Buiksloterdijk	9.991	3%	2%
Tuindorp Buiksloot	11.015	6%	4%

Waterland	16.585	0%	0%
Amstel III/Bullewijk	7.482	0%	0%
Bijlmer Centrum (D,F,H)	61.994	2%	1%
Bijlmer Oost (E,G,K)	88.180	2%	1%
Nellestein	12.662	1%	0%
Holendrecht/Reigersbos	59.176	2%	1%
Gein	44.607	2%	1%
Driemond	8.325	0%	0%

Appendix IX – Python output national level

Scenario 1	Space for all functions	Potential new homes	Space for limited functions
2020	0	0	0
2025	0	0	0
2030	0	0	0
2035	0	0	0
2040	0	0	0

Scenario 2	Space for all functions	Potential new homes	Space for limited functions
2020	680.753	1.581	0
2025	2.674.661	4.962	6.056.167
2030	3.776.500	6.816	9.084.251
2035	6.424.465	11.285	18.168.502
2040	7.169.130	12.767	20.187.225

Scenario 3	Space for all functions	Potential new homes	Space for limited functions
2020	680.753	1.581	0
2025	840.995	2.012	0
2030	887.395	2.031	0
2035	1.143.174	2.494	1.009.361
2040	1.153.000	2.521	1.009.361

Scenario 4	Space for all functions	Potential new homes	Space for limited functions
2020	680.753	1.581	0
2025	2.369.050	4.470	5.046.806
2030	3.212.435	5.973	7.065.529
2035	15.493.510	26.120	50.468.062
2040	6.904.496	12.576	17.159.141

Appendix X – Python output deep dive scenario 2

Scenario 2	Spare space(ha)	Space for all functions(ha)	Space for limited functions(ha)	Potential new homes
Amstel III/Bullewijk	20803	20803	5019	36
Apollobuurt	2630	2630	30409	14
Banne Buiksloot	14463	15152	45975	35
Bedrijventerrein Sloterdijk	0	20291	0	14
Betondorp	399	2139	6487	6
Bijlmer Centrum (D,F,H)	2039	3153	41591	10
Bijlmer Oost (E,G,K)	774	5347	59159	19
Buikslotermeer	14378	14378	33206	41
Buitenveldert-Oost	2184	2184	25243	7
Buitenveldert-West	2877	9000	40750	33
Burgwallen-Nieuwe Zijde	7736	7736	5935	73
Burgwallen-Oude Zijde	3589	3697	5460	28
Centrale Markt	350	350	2939	3
Chassébuurt	1028	1028	8633	12
Da Costabuurt	758	758	6363	9
Dapperbuurt	1785	1785	11597	15
De Kolenkit	1009	3747	14182	21
De Punt	5987	8181	17666	31
De Weteringschans	10358	10358	15295	98
Driemond	59	74	5585	0
Eendracht	4204	4204	9615	7
Elzenhagen	2395	2993	9082	6
Erasmuspark	1142	1142	9589	9
Frankendael	2398	10008	18343	48
Frederik Hendrikbuurt	1356	1356	11392	16
Gein	397	397	29926	1
Geuzenbuurt	1162	1162	9759	13
Geuzenveld	11771	27859	44911	84
Grachtengordel-West	10601	11229	16581	118
Grachtengordel-Zuid	9297	9297	13502	85
Haarlemmerbuurt	2617	2872	17645	21
Helmersbuurt	1221	1567	12974	16
Holendrecht/Reigersbos	438	4359	39700	13
Hoofddorppleinbuurt	2384	2632	30317	16
Hoofdweg e.o.	1940	1940	16296	20
Houthavens	0	0	17808	0
IJburg Oost	0	142	0	0
IJburg West	3232	3945	25599	6
IJburg Zuid	1953	1953	12692	3
IJplein/Vogelbuurt	6605	6605	20041	18
IJselbuurt	1074	1074	12416	10
Indische Buurt Oost	4989	5278	14461	33

Indische Buurt West	2342	2342	15217	19
Jordaan	25958	26580	31361	298
Kadoelen	4560	4560	13835	8
Kinkerbuurt	308	997	8042	12
Landlust	6731	6731	27688	50
Lutkemeer/Ookmeer	2063	2063	4718	2
Middelveldsche Akerpolder	23919	23919	54699	76
Middenmeer	3878	4203	27306	21
Museumkwartier	3346	3346	38683	25
Nellestein	113	1938	8495	1
Nieuwe Pijp	2088	2088	24136	22
Nieuwendammerdijk/Buiksloterdijk	2209	2209	6703	5
Nieuwmarkt/Lastage	13177	14342	21178	95
Noordelijke IJ-oevers Oost	0	0	0	0
Noordelijke IJ-oevers West	2362	12608	13796	25
Omval/Overamstel	7966	21591	8328	45
Oostelijk Havengebied	9149	9149	34648	41
Oostelijke Eilanden/Kadijken	2361	4351	20318	25
Oosterparkbuurt	1716	2194	14018	18
Oostzanerwerf	11680	11680	35440	22
Osdorp-Midden	19800	20548	46991	88
Osdorp-Oost	17249	27888	51627	107
Oude Pijp	4346	4346	27660	45
Overtoomse Sluis	1298	1298	10899	12
Overtoomse Veld	11196	11196	25604	55
Prinses Irenebuurt e.o.	431	431	4981	2
Rijnbuurt	1748	1748	20211	10
Scheldebuurt	3087	4554	36820	29
Schinkelbuurt	379	754	8247	6
Sloter-/Riekerpolder	23711	28636	57148	68
Sloterdijk	0	1369	29150	1
Slotermeer-Noordoost	9980	9980	22823	36
Slotermeer-Zuidwest	18410	20360	45892	75
Slotervaart Noord	7079	10080	22425	34
Slotervaart Zuid	8324	14289	25844	53
Spaarndammer- en Zeeheldenbuurt	5951	6233	17071	42
Staatsliedenbuurt	2132	2249	18888	21
Stadionbuurt	2470	6655	29463	21
Transvaalbuurt	2004	2175	10162	17
Tuindorp Buiksloot	2435	2435	7390	6
Tuindorp Nieuwendam	4686	5007	15193	14
Tuindorp Oostzaan	13201	13679	41506	29
Van Galenbuurt	958	958	8049	9
Van Lennepbuurt	1153	1153	9688	13
Volewijck	8814	8814	26744	25

Vondelbuurt	492	492	4129	5
Waterland	3437	3667	11126	1
Waterlandpleinbuurt	13385	13385	40613	34
Weesperbuurt/Plantage	6168	6168	10372	43
Weesperzijde	856	1228	7951	11
Westelijk Havengebied	0	7300	11342	11
Westindische Buurt	1391	1391	11685	13
Westlandgracht	1654	7189	19819	19
Willemspark	1528	1616	18680	12
Zeeburgereiland/Nieuwe Diep	3218	13546	2988	11
Zuid Pijp	1092	1173	13560	12
Zuidas	30711	36505	4843	172

Appendix XI – Python output deep dive scenario 3

Scenario 3	Spare space(ha)	Space for all functions(ha)	Space for limited functions(ha)	Potential new homes
Amstel III/Bullewijk	849	849	189	1
Apollobuurt	2630	2630	1148	14
Banne Buiksloot	14463	15152	1735	35
Bedrijventerrein Sloterdijk	0	959	0	1
Betondorp	399	1053	245	3
Bijlmer Centrum (D,F,H)	534	642	1569	2
Bijlmer Oost (E,G,K)	774	1003	2232	3
Buikslotermeer	11073	11073	1253	30
Buitenveldert-Oost	2184	2184	953	7
Buitenveldert-West	2877	3787	1538	13
Burgwallen-Nieuwe Zijde	4160	4160	224	39
Burgwallen-Oude Zijde	3589	3697	206	28
Centrale Markt	350	350	111	3
Chassébuurt	1028	1028	326	12
Da Costabuurt	758	758	240	9
Dapperbuurt	1785	1785	438	15
De Kolenkit	1009	1787	535	11
De Punt	5987	7747	667	30
De Weteringschans	10358	10358	577	98
Driemond	59	74	211	0
Eendracht	4204	4204	363	7
Elzenhagen	2395	2993	343	6
Erasmuspark	1142	1142	362	9
Frankendael	2177	3160	692	16
Frederik Hendrikbuurt	1356	1356	430	16
Gein	397	397	1129	1
Geuzenbuurt	1162	1162	368	13
Geuzenveld	11771	20032	1695	59
Grachtengordel-West	10601	11229	626	118
Grachtengordel-Zuid	9150	9150	510	83
Haarlemmerbuurt	1883	2130	666	16
Helmersbuurt	1221	1546	490	16
Holendrecht/Reigersbos	438	710	1498	2
Hoofddorppleinbuurt	2384	2623	1144	16
Hoofdweg e.o.	1940	1940	615	20
Houthavens	0	0	672	0
IJburg Oost	0	6	0	0
IJburg West	3232	3940	966	6
IJburg Zuid	1953	1953	479	3
IJplein/Vogelbuurt	6605	6605	756	18
IJselbuurt	1074	1074	469	10
Indische Buurt Oost	2051	2341	546	15

Indische Buurt West	2342	2342	574	19
Jordaan	20817	21440	1183	241
Kadoelen	4560	4560	522	8
Kinkerbuurt	308	959	303	12
Landlust	3426	3426	1045	23
Lutkemeer/Ookmeer	2063	2063	178	2
Middelveldsche Akerpolder	23919	23919	2064	76
Middenmeer	3878	4203	1030	21
Museumkwartier	3346	3346	1460	25
Nellestein	113	200	321	0
Nieuwe Pijp	2088	2088	911	22
Nieuwendammerdijk/Buiksloterdijk	2209	2209	253	5
Nieuwmarkt/Lastage	13177	14342	799	95
Noordelijke IJ-oevers Oost	0	0	0	0
Noordelijke IJ-oevers West	2051	4829	521	12
Omval/Overamstel	989	2048	314	7
Oostelijk Havengebied	5477	5477	1307	23
Oostelijke Eilanden/Kadijken	2361	3127	767	20
Oosterparkbuurt	1716	2159	529	18
Oostzanerwerf	11680	11680	1337	22
Osdorp-Midden	19800	20548	1773	88
Osdorp-Oost	16111	22787	1948	84
Oude Pijp	2466	2466	1044	26
Overtoomse Sluis	1298	1298	411	12
Overtoomse Veld	11196	11196	966	55
Prinses Irenebuurt e.o.	431	431	188	2
Rijnbuurt	1748	1748	763	10
Scheldebuurt	3087	3251	1389	23
Schinkelbuurt	379	715	311	5
Sloter-/Riekerpolder	23711	25154	2157	64
Sloterdijk	0	66	1100	0
Slotermeer-Noordoost	9980	9980	861	36
Slotermeer-Zuidwest	18410	20068	1732	74
Slotervaart Noord	7079	9819	846	33
Slotervaart Zuid	8324	11427	975	42
Spaarndammer- en Zeeheldenbuurt	1927	2191	644	12
Staatsliedenbuurt	2132	2249	713	21
Stadionbuurt	2470	2746	1112	13
Transvaalbuurt	1416	1587	383	12
Tuindorp Buiksloot	2435	2435	279	6
Tuindorp Nieuwendam	4686	5007	573	14
Tuindorp Oostzaan	13201	13679	1566	29
Van Galenbuurt	958	958	304	9
Van Lennepbuurt	1153	1153	366	13
Volewijck	8814	8814	1009	25

Vondelbuurt	492	492	156	5
Waterland	3437	3667	420	1
Waterlandpleinbuurt	13385	13385	1533	34
Weesperbuurt/Plantage	1769	1769	391	13
Weesperzijde	856	1224	300	11
Westelijk Havengebied	0	350	428	1
Westindische Buurt	1391	1391	441	13
Westlandgracht	1654	1977	748	10
Willemspark	1528	1616	705	12
Zeeburgereiland/Nieuwe Diep	281	999	113	1
Zuid Pijp	1092	1173	512	12
Zuidas	1335	1709	183	8

Appendix XII – Python output deep dive scenario 4

Scenario 4	Spare space(ha)	Space for all functions(ha)	Space for limited functions(ha)	Potential new homes
Amstel III/Bullewijk	30975	30975	7482	54
Apollobuurt	2630	2630	45326	14
Banne Buiksloot	14463	15152	68528	35
Bedrijventerrein Sloterdijk	0	26129	0	18
Betondorp	399	2475	9669	7
Bijlmer Centrum (D,F,H)	2807	4048	61994	12
Bijlmer Oost (E,G,K)	774	6691	88180	23
Buikslotermeer	16063	16063	49496	46
Buitenveldert-Oost	2184	2184	37626	7
Buitenveldert-West	2877	10612	60740	39
Burgwallen-Nieuwe Zijde	9560	9560	8847	90
Burgwallen-Oude Zijde	3589	3697	8138	28
Centrale Markt	350	350	4381	3
Chassébuurt	1028	1028	12868	12
Da Costabuurt	758	758	9485	9
Dapperbuurt	1785	1785	17287	15
De Kolenkit	1009	4351	21139	24
De Punt	5987	8315	26332	31
De Weteringschans	10358	10358	22799	98
Driemond	59	74	8325	0
Eendracht	4204	4204	14332	7
Elzenhagen	2395	2993	13537	6
Erasmuspark	1142	1142	14293	9
Frankendael	2510	12118	27341	57
Frederik Hendrikbuurt	1356	1356	16980	16
Gein	397	397	44607	1
Geuzenbuurt	1162	1162	14547	13
Geuzenveld	11771	30279	66942	91
Grachtengordel-West	10601	11229	24715	118
Grachtengordel-Zuid	9372	9372	20126	85
Haarlemmerbuurt	2992	3247	26301	24
Helmersbuurt	1221	1574	19339	16
Holendrecht/Reigersbos	438	5488	59176	16
Hoofddorppleinbuurt	2384	2634	45189	16
Hoofdweg e.o.	1940	1940	24290	20
Houthavens	0	0	26545	0
IJburg Oost	0	173	0	0
IJburg West	3232	3946	38157	6
IJburg Zuid	1953	1953	18918	3
IJplein/Vogelbuurt	6605	6605	29872	18
IJselbuurt	1074	1074	18507	10
Indische Buurt Oost	6486	6776	21555	43

Indische Buurt West	2342	2342	22683	19
Jordaan	28579	29201	46745	327
Kadoelen	4560	4560	20623	8
Kinkerbuurt	308	1008	11987	12
Landlust	8416	8416	41270	63
Lutkemeer/Ookmeer	2063	2063	7033	2
Middelveldsche Akerpolder	23919	23919	81533	76
Middenmeer	3878	4203	40702	21
Museumkwartier	3346	3346	57660	25
Nellestein	113	2475	12662	1
Nieuwe Pijp	2088	2088	35976	22
Nieuwendammerdijk/Buiksloterdijk	2209	2209	9991	5
Nieuwmarkt/Lastage	13177	14342	31568	95
Noordelijke IJ-oevers Oost	0	0	0	0
Noordelijke IJ-oevers West	2549	14083	20564	27
Omval/Overamstel	11522	27706	12413	55
Oostelijk Havengebied	11021	11021	51645	50
Oostelijke Eilanden/Kadijken	2361	4149	30286	24
Oosterparkbuurt	1716	2205	20895	18
Oostzanerwerf	11680	11680	52826	22
Osdorp-Midden	19800	20548	70043	88
Osdorp-Oost	17566	30278	76954	118
Oude Pijp	5305	5305	41229	54
Overtoomse Sluis	1298	1298	16246	12
Overtoomse Veld	11196	11196	38164	55
Prinses Irenebuurt e.o.	431	431	7425	2
Rijnbuurt	1748	1748	30126	10
Scheldebuurt	3087	4957	54882	30
Schinkelbuurt	379	767	12292	6
Sloter-/Riekerpolder	23711	29607	85182	69
Sloterdijk	0	1772	43450	2
Slotermeer-Noordoost	9980	9980	34020	36
Slotermeer-Zuidwest	18410	20311	68405	75
Slotervaart Noord	7079	10160	33425	35
Slotervaart Zuid	8324	15003	38523	56
Spaarndammer- en Zeeheldenbuurt	8003	8290	25446	57
Staatsliedenbuurt	2132	2249	28154	21
Stadionbuurt	2470	7864	43917	24
Transvaalbuurt	2303	2474	15148	19
Tuindorp Buiksloot	2435	2435	11015	6
Tuindorp Nieuwendam	4686	5007	22646	14
Tuindorp Oostzaan	13201	13679	61868	29
Van Galenbuurt	958	958	11997	9
Van Lennepbuurt	1153	1153	14441	13
Volewijck	8814	8814	39863	25

Vondelbuurt	492	492	6154	5
Waterland	3437	3667	16585	1
Waterlandpleinbuurt	13385	13385	60536	34
Weesperbuurt/Plantage	8411	8411	15460	59
Weesperzijde	856	1230	11852	12
Westelijk Havengebied	0	9450	16905	15
Westindische Buurt	1391	1391	17418	13
Westlandgracht	1654	8802	29542	22
Willemspark	1528	1616	27843	12
Zeeburgereiland/Nieuwe Diep	4716	17445	4453	14
Zuid Pijp	1092	1173	20212	12
Zuidas	45687	52812	7219	252

Appendix XIII – Transition rate calculation excel

Scenario 1

Kilometers per type

		2015	2020	2025	2030	2035	2040
Total driven KM's	Personally owned driver-driven	99.230.135.000	103.359.237.300	107.384.876.900	107.864.567.600	106.103.350.275	105.132.211.750
	Personally owned autonomous	0	0	0	0	0	0
	Shared driver-driven	0	1.044.032.700	2.191.528.100	5.737.477.000	10.729.552.275	14.842.194.600
	Shared autonomous	0	0	0	1.147.495.400	2.384.344.950	3.710.548.650

Amount of cars per type

		2015	2020	2025	2030	2035	2040
	Personally owned driver-driven	7.580.027	7.895.442	8.202.954	8.239.597	8.105.061	8.030.877
	Personally owned autonomous	0	0	0	0	0	0
	Shared driver-driven	0	39.876	83.704	219.138	409.806	566.885
	Shared autonomous	0	0	0	43.828	91.068	141.721

		2015	2020	2025	2030	2035	2040
Total amount of cars	Total	7.580.027	7.935.318	8.286.658	8.502.563	8.605.935	8.739.484

Changes in parking capacity

		2015	2020	2025	2030	2035	2040
Changes in amount of cars	Change in total amount of cars	0	355291	706631	922536	1025908	1159457

		2015	2020	2025	2030	2035	2040
Changes in parking by reduction of cars	Private parking	4.000.000	4.000.000	4.000.000	4.000.000	4.000.000	4.000.000
	Public parking	10.000.000	10.355.291	10.706.631	10.922.536	11.025.908	11.159.457
	Total parking	14.000.000	14.355.291	14.706.631	14.922.536	15.025.908	15.159.457

		2015	2020	2025	2030	2035	2040
Percentage change in parking capacity	Changes in public parking	0%	4%	7%	9%	10%	12%
	Changes in total parking	0%	3%	5%	7%	7%	8%
	Reduction in percentage	0%	0%	0%	0%	0%	0%

Changes in parking capacity with constant occupancy rate

		2015	2020	2025	2030	2035	2040
Occupancy rate parking	Occupancy rate	0,5414305	0,55278003	0,563464062	0,569780033	0,572739772	0,576503759

		2015	2020	2025	2030	2035	2040
Parking demand with constant occupancy rate	Total amount of parking	14.000.000	14.656.209	15.305.119	15.703.887	15.894.811	16.141.469
	Public parking	10.000.000	10.656.209	11.305.119	11.703.887	11.894.811	12.141.469
	Change in cars needed	0%	7%	13%	17%	19%	21%
	% Reduction	0%	0%	0%	0%	0%	0%

Changes in parking size

		2015	2020	2025	2030	2035	2040
Smaller parking plots	Share self-driving	0%	0%	0%	1%	1%	2%
	Amount of parking for self-driving	0%	0%	0%	1%	2%	3%
	Parking demand for self driving	0%	0%	0%	0%	0%	0%
	Reduction in demand	0%	0%	0%	0%	0%	0%

Transitionrate

		2015	2020	2025	2030	2035	2040
	Reduction by less cars	0%	0%	0%	0%	0%	0%
	Reduction by constant occupancy rate	0%	0%	0%	0%	0%	0%
Transition rate	Reduction by smaller parking plots	0%	0%	0%	0%	0%	0%
	Total reduction	0%	0%	0%	0%	0%	0%

Scenario 2

Kilometers per type

		2015	2020	2025	2030	2035	2040
Total driven KM's	Personally owned driver-driven	99.230.135.000	99.183.106.500	93.139.944.250	84.914.659.600	69.146.003.550	51.947.681.100
	Personally owned autonomous	0	0	0	0	0	0
	Shared driver-driven	0	2.923.291.560	9.204.418.020	16.064.935.600	26.704.663.440	38.094.966.140
	Shared autonomous	0	0	0	1.147.495.400	2.384.344.950	3.710.548.650

Amount of cars per type

		2015	2020	2025	2030	2035	2040
	Personally owned driver-driven	7.580.027	7.576.435	7.114.807	6.486.491	5.281.950	3.968.198
	Personally owned autonomous	0	0	0	0	0	0
	Shared driver-driven	0	44.661	140.622	245.435	407.985	582.002
	Shared autonomous	0	0	0	5.844	12.142	18.896
		2015	2020	2025	2030	2035	2040
Total amount of cars	Total	7.580.027	7.621.096	7.255.430	6.737.770	5.702.077	4.569.097

Changes in parking capacity

		2015	2020	2025	2030	2035	2040
Changes in amount of cars	Change in total amount of cars	0	41069	-324598	-842257	-1877950	-3010930
		2015	2020	2025	2030	2035	2040
Changes in parking by reduction of cars	Private parking	4.000.000	4.000.000	4.000.000	4.000.000	4.000.000	4.000.000
	Public parking	10.000.000	10.041.069	9.675.402	9.157.743	8.122.050	6.989.070
	Total parking	14.000.000	14.041.069	13.675.402	13.157.743	12.122.050	10.989.070
		2015	2020	2025	2030	2035	2040
Percentage change in parking capacity	Changes in public parking	0%	0%	-3%	-8%	-19%	-30%
	Changes in total parking	0%	0%	-2%	-6%	-13%	-22%
	Reduction in percentage	0%	0%	-3%	-8%	-19%	-30%

Changes in parking capacity with constant occupancy rate

		2015	2020	2025	2030	2035	2040
Occupancy rate parking	Occupancy rate	0,541430508	0,542771776	0,530545962	0,512076428	0,47038885	0,41578558
		2015	2020	2025	2030	2035	2040
Parking demand with constant occupancy rate	Total amount of parking	14.000.000	14.075.852	13.400.482	12.444.385	10.531.503	8.438.935
	Public parking	10.000.000	10.075.852	9.400.482	8.444.385	6.531.503	4.438.935
	Reduction in cars needed	0%	1%	-6%	-16%	-35%	-56%
	% Reduction	0%	0%	-6%	-16%	-35%	-56%

Changes in parking size

			2015	2020	2025	2030	2035	2040
Smaller parking plots		Share self-driving	0%	0%	0%	0%	0%	0%
	0%	Amount of parking for self-driving	0%	0%	0%	0%	0%	0%
		Parking demand for self driving	0%	0%	0%	0%	0%	0%
		Reduction in demand						

Transitionrate

		2015	2020	2025	2030	2035	2040
	Reduction by less cars	0%	0%	-3%	-8%	-19%	-30%
	Reduction by constant occupancy rate	0%	0%	-6%	-16%	-35%	-56%
Transition rate	Reduction by smaller parking plots	0%	0%	0%	0%	0%	0%
	Total reduction	0%	0%	-6%	-16%	-35%	-56%

Scenario 3

Kilometers per type

		2015	2020	2025	2030	2035	2040
Total driven KM's	Personally owned driver-driven	99.230.135.000	99.183.106.500	104.097.584.750	97.537.109.000	85.836.418.200	55.658.229.750
	Personally owned autonomous	0	0	1.314.916.860	13.769.944.800	28.612.139.400	62.337.217.320
	Shared driver-driven	0	1.044.032.700	2.191.528.100	3.442.486.200	4.768.689.900	6.184.247.750
	Shared autonomous	0	0	1.095.764.050	2.294.990.800	4.768.689.900	9.894.796.400

Amount of cars per type

		2015	2020	2025	2030	2035	2040
	Personally owned driver-driven	7.580.027	7.576.435	7.951.844	7.450.700	6.556.903	4.251.641
	Personally owned autonomous	0	0	100.444	1.051.863	2.185.634	4.761.838
	Shared driver-driven	0	15.950	33.481	52.593	72.854	94.481
	Shared autonomous	0	0	5.580	11.687	24.285	50.390

		2015	2020	2025	2030	2035	2040
Total amount of cars	Total	7.580.027	7.592.385	8.091.350	8.566.844	8.839.677	9.158.349

Changes in parking capacity

		2015	2020	2025	2030	2035	2040
Changes in amount of cars	Change in total amount of cars	0	12358	511323	986817	1259650	1578322

		2015	2020	2025	2030	2035	2040
Changes in parking by reduction of cars	Private parking	4.000.000	4.000.000	4.000.000	4.000.000	4.000.000	4.000.000
	Public parking	10.000.000	10.012.358	10.511.323	10.986.817	11.259.650	11.578.322
	Total parking	14.000.000	14.012.358	14.511.323	14.986.817	15.259.650	15.578.322

		2015	2020	2025	2030	2035	2040
Percentage change in parking capacity	Changes in public parking	0%	0%	5%	10%	13%	16%
	Changes in total parking	0%	0%	4%	7%	9%	11%
	Reduction in percentage	0%	0%	0%	0%	0%	0%

Changes in parking capacity with constant occupancy rate

		2015	2020	2025	2030	2035	2040
Occupancy rate parking	Occupancy rate	0,541430508	0,541834936	0,557588712	0,571625311	0,579284385	0,587890606

		2015	2020	2025	2030	2035	2040
Parking demand with constant occupancy rate	Total amount of parking	14.000.000	14.022.825	14.944.392	15.822.610	16.326.521	16.915.096
	Public parking	10.000.000	10.022.825	10.944.392	11.822.610	12.326.521	12.915.096
	Reduction in cars needed	0%	0%	9%	18%	23%	29%
	% Reduction	0%	0%	0%	0%	0%	0%

Changes in parking size

			2015	2020	2025	2030	2035	2040
Smaller parking plots		Share self-driving	0%	0%	1%	12%	25%	53%
	25%	Amount of parking for self-driving	0,00	0,00	26206,90	248294,68	500000,00	1050894,09
		Parking demand for self driving	0,00	0,00	20965,52	198635,74	400000,00	840715,27
		Reduction in demand	0,00	0,00	5241,38	49658,94	100000,00	210178,82
		Percentage reduction of total capacity	0%	0%	0%	0%	1%	2%

Transitionrate

		2015	2020	2025	2030	2035	2040
Transition rate	Reduction by less cars	0%	0%	0%	0%	0%	0%
	Reduction by constant occupancy rate	0%	0%	0%	0%	0%	0%
	Reduction by smaller parking plots	0%	0%	0%	0%	1%	2%
	Total reduction	0%	0%	0%	0%	-1%	-2%

Scenario 4

Kilometers per type

		2015	2020	2025	2030	2035	2040
Total driven KM's	Personally owned driver-driven	99.230.135.000	99.183.106.500	90.948.416.150	74.587.201.000	29.804.311.875	12.368.495.500
	Personally owned autonomous	0	0	1.095.764.050	11.474.954.000	17.882.587.125	24.736.991.000
	Shared driver-driven	0	5.220.163.500	16.436.460.750	17.212.431.000	23.843.449.500	12.368.495.500
	Shared autonomous	0	0	1.205.340.455	25.244.898.800	52.455.588.900	81.632.070.300

Amount of cars per type

		2015	2020	2025	2030	2035	2040
	Personally owned driver-driven	7.580.027	7.576.435	6.947.400	5.697.594	2.276.702	944.809
	Personally owned autonomous	0	0	83.704	876.553	1.366.021	1.889.618
	Shared driver-driven	0	79.752	251.111	262.966	364.272	188.962
	Shared autonomous	0	0	6.138	128.561	267.133	415.716

		2015	2020	2025	2030	2035	2040
Total amount of cars	Total	7.580.027	7.656.187	7.288.353	6.965.674	4.274.129	3.439.105

Changes in parking capacity

		2015	2020	2025	2030	2035	2040
Changes in amount of cars	Change in total amount of cars	0	76160	-291674	-614353	-3305898	-4140922

		2015	2020	2025	2030	2035	2040
Changes in parking by reduction of cars	Private parking	4.000.000	4.000.000	4.000.000	4.000.000	4.000.000	4.000.000
	Public parking	10.000.000	10.076.160	9.708.326	9.385.647	6.694.102	5.859.078
	Total parking	14.000.000	14.076.160	13.708.326	13.385.647	10.694.102	9.859.078

		2015	2020	2025	2030	2035	2040
Percentage change in parking capacity	Changes in public parking	0%	1%	-3%	-6%	-33%	-41%
	Changes in total parking	0%	1%	-2%	-4%	-24%	-30%
	Reduction in percentage	0%	0%	-3%	-6%	-33%	-41%

Changes in parking capacity with constant occupancy rate

		2015	2020	2025	2030	2035	2040
Occupancy rate parking	Occupancy rate	0,541430508	0,543911613	0,531673454	0,520383805	0,399671641	0,348826233

		2015	2020	2025	2030	2035	2040
Parking demand with constant occupancy rate	Total amount of parking	14.000.000	14.140.664	13.461.290	12.865.314	7.894.142	6.351.886
	Public parking	10.000.000	10.140.664	9.461.290	8.865.314	3.894.142	2.351.886
	Reduction in cars needed	0%	1%	-5%	-11%	-61%	-76%
	% Reduction	0%	0%	-5%	-11%	-61%	-76%

Changes in parking size

		2015	2020	2025	2030	2035	2040
Smaller parking plots	Share self-driving	0%	0%	1%	14%	38%	67%
	Amount of parking for self-driving	0,00	0,00	24653,55	288590,60	764204,55	1340659,34
	Parking demand for self driving	0,00	0,00	15408,47	180369,13	477627,84	837912,09
	Reduction in demand	0,00	0,00	9245,08	108221,48	286576,70	502747,25
	Percentage reduction of total capacity	0%	0%	0%	1%	3%	5%

Transitionrate

		2015	2020	2025	2030	2035	2040
Transition rate	Reduction by less cars	0%	0%	-3%	-6%	-33%	-41%
	Reduction by constant occupancy rate	0%	0%	-5%	-11%	-61%	-76%
	Reduction by smaller parking plots	0%	0%	0%	-1%	-3%	-5%
	Total reduction	0%	0%	-5%	-12%	-64%	-82%

Appendix XIV – Python code national level

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Appendix XV – Python code deepdive level

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