Analysis of parking facilities in Enschede

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1. Introduction

Urban car parking is increasingly problematic in both developed and developing nations. The rapid increase in car ownership has led to a shortage of parking spaces in many cities, and this imbalance between supply and demand for parking spaces can be seen as the root cause of parking issues. This mismatch is partially caused by inadequate land use planning and incorrect estimates of the amount of space needed in the initial stages of planning. A few common parking issues include a lack of parking spaces, expensive parking fees, and traffic backups caused by people looking for parking. (Ibrahim, 2017)

Economic growth in cities is mostly based on individuals having access to commodities, services, activities and information. Cities heavily rely on automobile users since they form the backbone of modern society. The economic benefits rise with the efficiency and efficacy of this foundation due to agglomeration effects, and networking advantages. Cities with higher agglomeration levels have services closely located together and consequently have higher GDP per capita and productivity levels. Although large growing economies are beneficial for cities, the externalities caused by unplanned urban transportation contribute largely to greenhouse gases and other pollutants. Urban transportation is currently the largest single source of global transport-related carbon emissions as well as the main local source of urban air pollution, accounting for more than 60% of all miles travelled worldwide. (Rode et al., 2014) From this traffic, on average 34% of car users are cruising (looking for a parking spot). Studies have shown that the mean cruising time comes down to 8.0 minutes, meaning that valuable time is wasted and more avoidable congestion emerges. (Hampshire & Shoup, 2019) One can conclude that car usage is inevitable to support the economy. However, parking is a time-consuming and harmful phenomenon that should be resolved. Solving the cruising problem won't clear the current pollution rate within the transport section but it can eliminate unnecessary emissions and save time making transportation more efficient.

Currently, the city of Enschede is confronted with a parking challenge, because on one hand car users have difficulties in finding parking locations close to their desired activities, and on the other hand the current parking garages are underused. However, the municipality is busy with a major reconstruction of multiple parts of the city. These developments are categorized under Project 'Centrumkwadraat'. Centrumkwadraat is a large project enforced by the municipality to create a more green and spacious city whilst maintaining its urban feel. Besides this new green and spacious feeling, a large mobility shift is ongoing. Car usage these days is far less self-evident in the city. Therefore, the municipality opts to create a more bicycle and pedestrian-friendly city centre.

The remainder of this research proposal consists of the following chapters. First, more context about the study area and involved parties are drawn, in chapter 3 some studies that are conducted in the past will be analyzed to contextualize this challenge and to give more background information which can lead to strategy development for my own research. After that, the research questions will be drawn to give an insight into where the research is headed. In chapter 4, the methodology will be explained. In chapter 5, the preliminary table of contents is depicted and an indication of the project planning is given.

2. Context

In this chapter, more detail about the context of the assignment will be given, for instance, the location of the study area and the parties that are concerned with the assignment are shortly handled.

2.1 Involved parties

The company that hosts this bachelor research assignment is called Ska-pa. Ska-pa is a company that creates real estate projects whilst considering a pleasant living environment where buildings and areas are developed to make people feel at home. The team of Ska-pa has an extensive history with the municipality of Enschede and therefore, recommendations that are made by the company are often well-considered. Besides that, the municipality is the legislative organ which drives the city of Enschede and chooses what policies are executed. Besides setting up and maintaining policies, the municipality is also responsible for overseeing redesigns and constructions of public places that take place in the city. In the case of this project, the role of the municipality is quite extensive. The municipality will be closely involved with the project since the research intervenes between the policies about car usage within the city's boundaries, the prospect of the city in general and possible reconstructions of multiple areas.

The main report will serve a purpose of a proposition for the municipality in which the current parking problem is handled. In the report, extensive research using a GIS model is executed. Within the model, only constraints and restrictions imposed by the local government are taken into account. Besides the rules and constraints, Enschede's vision on the mobility and infrastructure will also be considered.

2.2 Study area

The project is mainly focused on the parking problem within the Singels of Enschede's boundaries as depicted below. Most car users struggle to find a proper parking spot and in the pursuit of a sufficient spot, traffic is most often delayed, which in turn results in large inconvenience for other road users.

Figure 1 - Study area

Besides a recommendation for new locations for parking lots, large areas within the study area of the city is due for redevelopment, as stated before. To give a little indication on the projects that Centrumkwadraat holds, figure 2 below is added. Here, the coloured parts are due for redevelopments. (Kemerink, 2016)

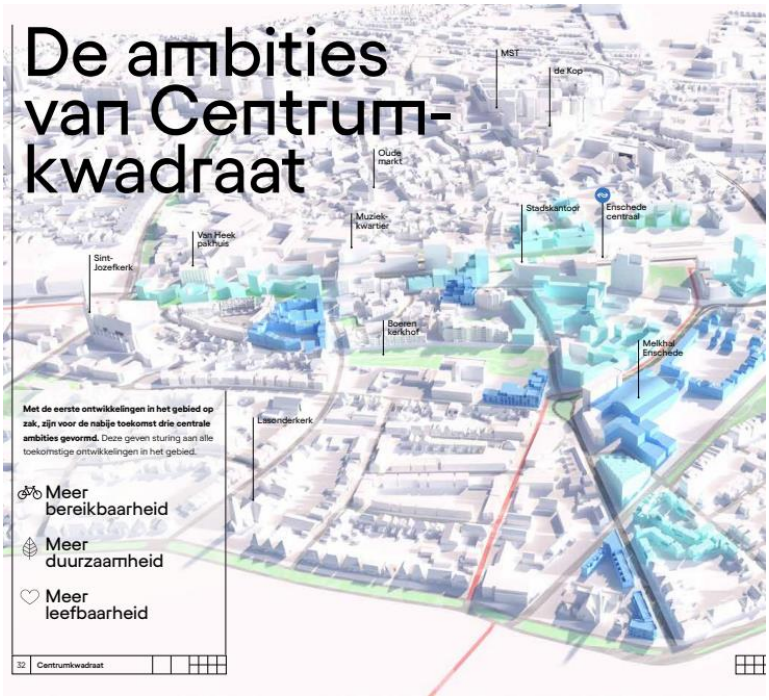


Figure 2 - Highlights for due projects

3. Studies conducted in the past

In Boroujerd County, one of the largest cities in Western Iran, car user behaviour has been studied both on-street and off-street parking. Since the city is very crowded and passages are already small, new parking locations have to be considered. The area needed to build additional parking lots was calculated using the Parking Generation Method before the site selection process. Then, it was decided on what site selection criteria to use, such as "distance from travel absorber centres," "distance from passages," "the cost of real estate," and "suitable land use for parking lots," while "unsuitable land uses for public parking spaces," like historical monuments, were acknowledged as constraining factors and were excluded from further analysis. Following that, pairwise comparisons were used to weigh the specified criteria. The Boolean Method was finally used to overlay the map layers once. The output map's selected places were not distributed evenly across the research region, therefore the overlaying was done once more using the fussy Ordered Weighted Average (OWA), and a total of four spots were identified as being appropriate for city parking lots. Aliniai et al. (2015)

In another study, one of the busiest districts of Esfahan City (Iran) is analyzed on lies in the city's centre and is one of the busiest districts. This area of the city is home to the majority of the city's historical structures, mosques, and official, commercial, and tourism centres. The procedure of choosing the best-suited parking spot was broken down into three parts for this study. First, practical parking selection criteria will be discussed, with appropriate weighting applied in multi-criteria decision-making (MCDM). Following the determination of the selection criteria, mathematical models were created utilizing the outcomes of the Pairwise Comparison model. This stage involved the selection of the Analytical Hierarchical Process (AHP) method. Second, the chosen area's GIS was combined with the mathematical models. Lastly, fuzzy logic was used to find the optimal parking space. Below is an overview of the user criteria and sub-criteria used for choosing the parking locations. Raheleh Farzanmanesh (2010)

In Tehran, finding parking spots today plays a crucial role in contemporary urban transportation systems due to the enormous technological advancements that have occurred, particularly in the sector of transportation. If we had understood the significance of the ideal distribution of parking spaces in the city centre, it would have been handled with much more care. It is evident that parking spots have a significant role in reducing the amount of static traffic on the streets. This problem indirectly results in fewer parking spaces on the street, better traffic flow, and wider roadways. A key component of traffic management is parking management. Incorrect and unconventional decisions have negative effects on the urban transportation network, the environment, and economic growth. The proper distribution of parking is also closely related to several criteria, their various values, and their significance. Finding of parking spots with traditional techniques and paper maps could not offer right and valid results in such a way that consider all important components but by utilizing GIS and AHP could obtain dependable solutions. (Massahi et al. 2012)

The following article focuses on parking issues in cities, particularly in the Netherlands. The scarcity of parking space can lead to negative environmental impacts due to emissions from cars driving around looking for spots. The author uses GIS to analyze parking dynamics and create predictive models that can estimate parking occupancy and direct drivers to available parking spots. The models are based on different variables, such as land-use, accessibility to public transport, day, and time. The author compares four different locations in Rotterdam and finds that each location has its own unique characteristics that determine parking dynamics. The thesis also emphasizes the importance of freely available parking data and technological developments for collecting both indoor and outdoor parking data. (Cooper, 2018)

Another study created an integrated model of downtown traffic congestion and curbside parking. The market for curbside parking spots is cleared by exogenously pricing curbside parking below its social opportunity cost and adjusting the stock of cruising cars, which add to traffic congestion. Downtown neighborhoods with more density have both garages and street parking. Garages are conspicuously spaced due to economies of scale in garage building. Parking garages have market power due to the friction of space. The equilibrium garage parking rate and distance between parking garages are determined by the spatial rivalry between parking garages. As well, the stock of vehicles waiting to park is adjusted to balance the complete costs of the garage and on-street parking. The components of these two models are combined in this study, creating an integrated model of curbside parking, garage parking, and traffic congestion. A numerical example using parameters typical of a medium-sized US city is used to investigate curbside parking policy in this context. The main finding is that raising the on-street parking tax seems like a very appealing strategy because it produces efficiency gains that could be multiple times as large as the additional cash received. (Arnott et al. 2009)

The last article put its focuses mainly on the environmental impact of parking garages on urban places. This study will analyze the space allocation of parking lots in a typical midwestern county in order to assess the supply of parking spots to possible demand. We also calculate the amount of ecosystem services lost in this county's parking lot area. We discovered that parking lots occupy 5.65 km2 (1 397 acres) of Tippecanoe County, Indiana, meaning that they make up 0.44% of the county's total land area. According to previous research, there are roughly 2.2 parking spaces for every registered vehicle. The total amount of parking lots account for more than 6.57% of all parking spaces of the county's total urban footprint. The area of parking lots in the city’s boundaries is three times greater than the area of parks, and runoff and pollution from parking lots are significantly higher than those from these areas before they were converted to parking lots. (Davis, 2010)

3.1 Review on literature

In the following part a comparison between the first three mentioned studies with regards the input used for the models will be given. The reason for this comparison is because they share many similarities. After that, the other literature will be reviewed.

All first three paragraphs discuss studies conducted in Iranian cities to determine optimal locations for parking spots. The first article focuses on Boroujerd County and the use of the Parking Generation Method to calculate the area needed for additional parking lots. The study then used site selection criteria, such as proximity to travel absorber centres and passages, as well as cost and land use suitability, all of which can be found in figure 3 below. Pairwise comparisons were used to weigh these criteria, and the Boolean and fuzzy Ordered Weighted Average methods were used to identify four suitable spots for city parking lots.

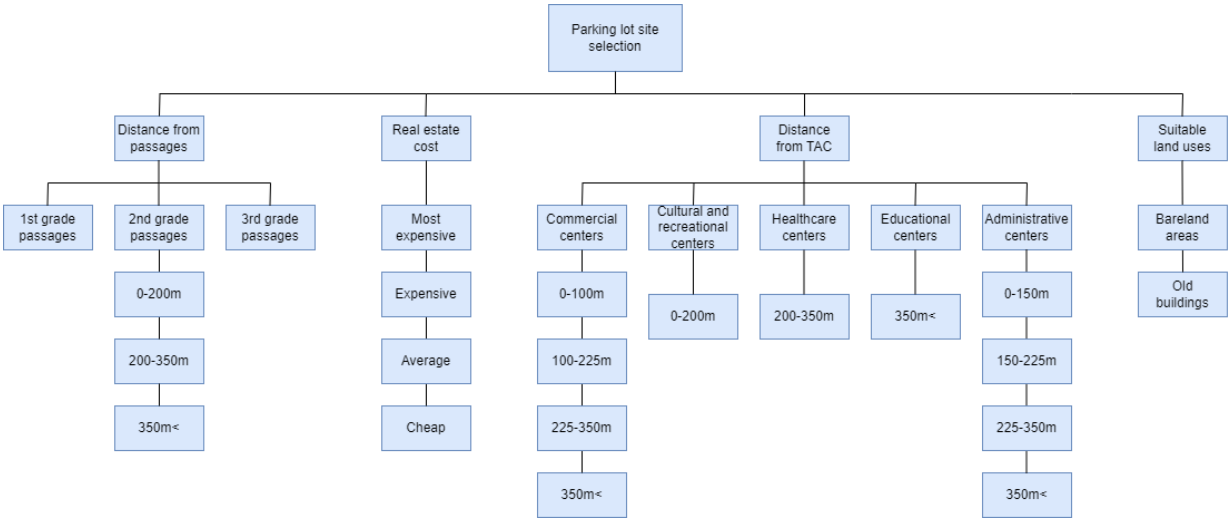


Figure 3 - Decision tree of public parking lot site selection in Boroujerd City. This figure is a replica of 'Parking Lot Site Selection: An Opening Gate Towards Sustainable GIS-based Urban Traffic Management' by Aliniai, K. et al., (2015).

The second article discusses a study conducted in one of the busiest districts of Esfahan city, which is home to many historical structures, commercial centres, and tourist attractions. The study used multi-criteria decision-making and mathematical models to determine the best-suited parking spot. The criteria used for the allocation is depicted in the table below. The chosen area's GIS was combined with the mathematical models, and fuzzy logic was used to find the optimal parking space. The article provides an overview of the user criteria and sub-criteria used for choosing the parking locations.

Table 1 - Efficient criteria in parking site selection in Esfahan city. From 'Parking site selection management using Fuzzy logic and Multi Criteria Decision Making' by Raheleh Farzanmanesh, A. G. N., Ahmad Makmom Abdullah (2010).

Criteria	Sub-criteria
Distance from absorbing excursion space	Trade, official centres, servicing, recreative, tourist, parks, educationl buildings and hospital
Attainment of major streets	Pedestrian and streets crossing, streets width
Construction	Premises value
Population	Population density
Efficient landuse for parking places	Ruined buildings, comprehensive parking, garages, comprehensive schools, stadium and green spaces, existing green spaces
Inappropriate usage	**Major trade and official centres, 50 meters hospitals buffer, historical centres and mosques.**

The third article discusses the importance of finding parking spots in Tehran, particularly in contemporary urban transportation systems, a more detailed overview can be seen below in figure 4. The article emphasizes the significance of the proper distribution of parking spots to reduce static traffic, improve traffic flow, and provide wider roadways. The article highlights the role of parking management in traffic management and discusses how traditional techniques and paper maps may not offer valid results. Instead, GIS and the Analytical Hierarchical Process (AHP) method can provide dependable solutions.

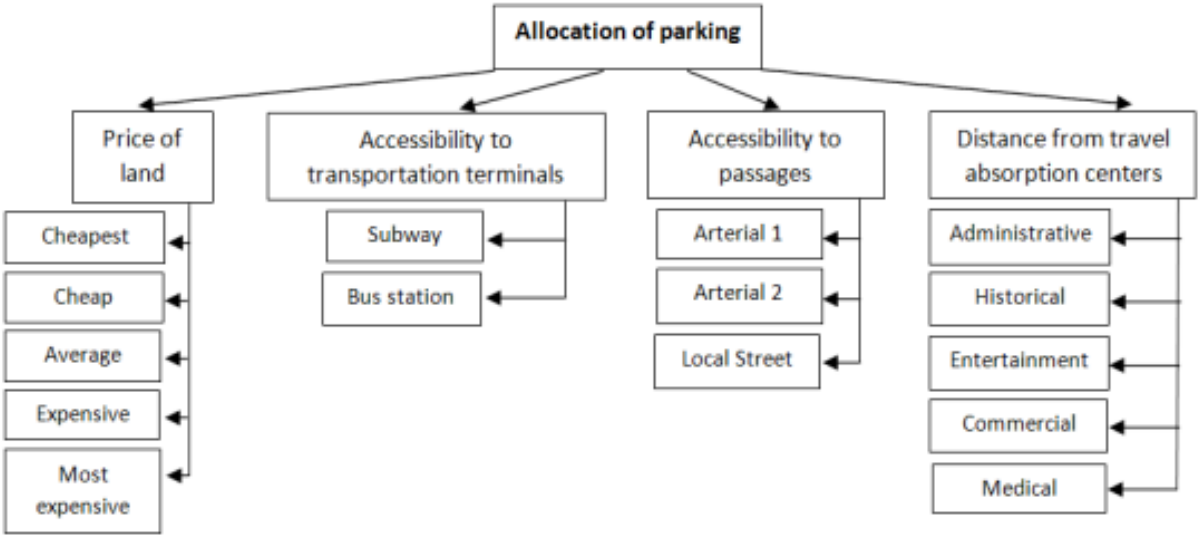


Figure 4 – Structural hierarchy process of allocating parking spots in Tehran. From 'Developing Optimal Zones for Urban Parking Spaces by Arc GIS and AHP' by Hosseinlou, M. H. (2012).

In summary, all three articles discuss studies conducted to find optimal parking spots in Iranian cities. Each study utilized different methods such as the Parking Generation Method, multi-criteria decision-making, mathematical models, Boolean and fuzzy Ordered Weighted Average methods, and GIS and AHP methods. The studies considered various site selection criteria such as proximity to travel absorber centres and passages, cost and land use suitability, and user criteria and sub-criteria. The articles emphasize the importance of proper parking management in traffic management, reducing static traffic, improving traffic flow, and providing wider roadways.

The first three use interesting social factors which should be considered, for instance the distance people are willing to walk from the parking of their car to their destination. Besides that, the landuse will play a big role within the model building as some of the overlaying inputs will be used within this multi criteria decision tree. For instance, the distance from medical facilities, economical centres and to schools.

The fourth study mentions a way of smart parking that could be integrated within Enschede but will be very hard to incorporate within this study as it is too complex and broad for the duration of this research model. However, it could be adopted in another study regards parking within the parameters of the Singel.

The fifth article, a solution is presented for the parking problem by raising the cost for the car user when they choose for curbside parking rather than parking at a parking garage. Currently the municipality already is already testing this hypothesis by implementing this rule. Whether it is effective is not yet decided but the plan is to experiment with that a lot more. Although this article is interesting and could solve a big part of the problem, it might be hard to implement this within the GIS-model that will be constructed. Therefore, it will most likely not be adopted within further research.

The last article focuses mainly on the environmental impact of parking garages and their large carbon footprint alongside with the spatial waste that comes with the construction of parking garages. This article suits this research rather well since it incorporates ideas of minimizing space for a rather simple task of 'storing cars'. Besides that does the article include having green spaces throughout cities which is in line with the mobility vision and zero emission zone policy of the municipality.

4. Research problem and objectives

Currently, parking within the boundaries of the Singels in Enschede is problematic since too many people use on-street parking while parking garages are under-occupied. This statement came clear during an interview with Timo Kemerink (senior projectmanager at the municipality of Enschede). Besides the parking problem, the reconstructions entail that many recreational sites are constructed which will most likely involve more mobility in the city and in addition to that will the parking demand in the city grow expectatly. At the same time, the municipality envisions a mobility shift from car usage to a more bicycle and pedestrian friendly surrounding, this creates a challenge.

Besides the first challenge, project Centrumkwadraat still wants to maintain and even improve the accessibility of the city. The latter creates an extra challenge since the current situation already requires extensive analysis, adding more input for the problem results in a large challenge. Determining suitable places for parking lots is a challenging topic as one should consider many constraints and criteria implemented by the local municipality. The municipality of Enschede already stated that cars should be able to easily access the economical hub of the city. At the moment, the parallel parking spots are almost always in use, while the parking garages are often under-utilized. Therefore, an assessment on the locations of the current parking garages situated within the parameters of the Singel will be conducted.

The objective of this research is therefore to assess the current parking occupancy rates and determine suitable locations for parking, considering the sustainable mobility vision of the municipality of Enschede. The corresponding research objectives are:

1. *Assess the current location and occupation rates of the parking garages within the areas of the Singels in Enschede*

An assessment of the current situation regarding occupation rates of the parking garages will be performed. Besides this assessment, information on constraints and regulations on the land use and the municipality's (sustainable) mobility plans will be considered. Besides that, project Centrumkwadraat is expected to impact the parking behaviour of residents and visitors. Therefore, the focus of the assessment will lie on these developments within project Centrumkwadraat. Based on the analysis on the current situation and the model, the following question flows naturally:

2. *Identify the most suitable location of parking facilities with regards to the city's developments and other criteria*

Since the large multi-annual plan Centrumkwadraat in Enschede is considered, where multiple residences and other common areas such as a shopping mall are constructed, whereas other green hubs are envisioned, not every area is suitable for the construction of parking garages. These areas are therefore excluded from the model. After this assessment is done, a conclusion can be drawn from the output of GIS models and a conclusion can be drawn from these outputs. This conclusion will hold a thorough plan for the future of the parking facilities in Enschede.

3. *Provide recommendations regarding the location of parking garages*

In order to have a higher occupation rate of the parking garages, a possible recommendation on reallocation of parking garage(s) is necessary.

5. Research methods

In this section, the methods that will be used for the bachelor thesis are drawn to show how the research questions will be answered. Each question will be assessed individually in later sections. To start, a clear overview of actions that have to be undertaken is described below.

Based on the studies that are conducted in the past, the main focus will lie on making an extensive model within ArcGIS software. This software is capable of handling geographical information and calculating the most suitable options for certain polygons which can be selected within the map.

5.1. Assess the current location and occupation rates of the parking garages within the areas of the Singels in Enschede

In order to assess the study area in its current form on the occupation rates within the parking garages, much data is required. Since this data is not publicly available, close cooperation with the municipality is of utmost importance. With discrete agreements alongside with the municipality, this data will be shared with me because the municipality will – hopefully – benefit from this research as well since this is a topical challenge which is not yet resolved.

A thorough examination will be done in different sections of the city. Therefore, the study area is split up into different compartments, for a clear overview of the different segments, see figure 5. Since it is interesting to know how many cars are owned per household, a demography map will be linked to each zone which will be linked to the average car possession.

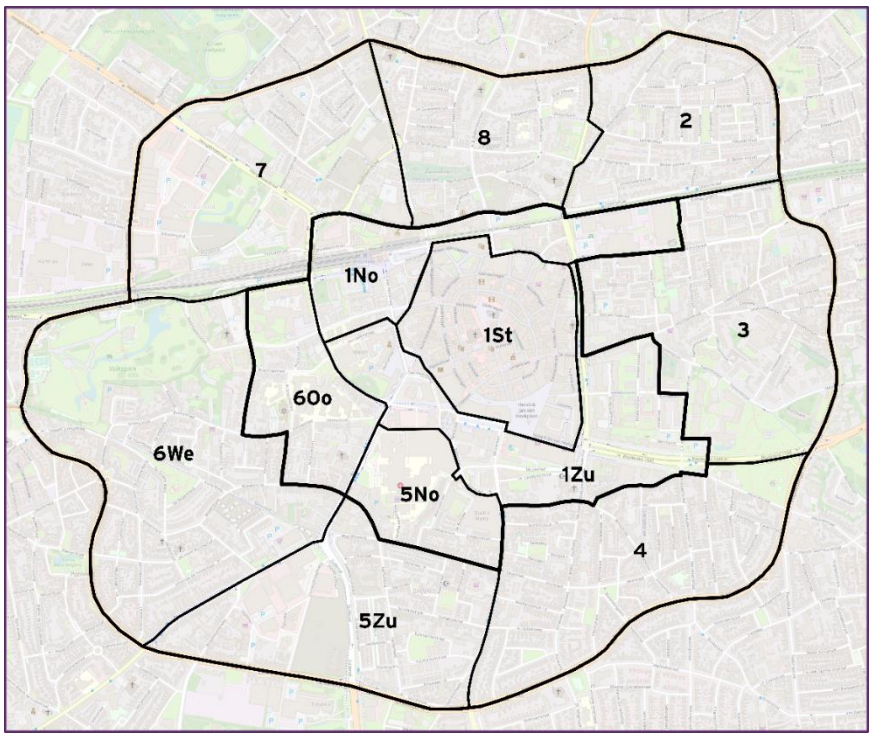


Figure 5 - Schematic overview of the segmented study area

Then, the data on occupation rates will be collected from Ivo Hulsebos (assistant manager at the local parking department) who assets the data count on parking garages within the city's parameters. The data regards the countings of the occupation rates are given in averages from each day part (morning, afternoon and evening). With this data the peak intensities will be used as a reference point. The reference point serves as starting point for the implementation of the model where the highest occupation point will be used to determine whether additional parking garages are required.

After the data is collected, it will be processed and will be translated to spreadsheets in Excel to give an insight in the occupation rates from both parking garages and on-street parking. Within the spreadsheets each parking garage will be handled individually which on its turn will be processed to a graph which then can be compared to check whether patterns in the peak moments of each parking facility within the study area can be found. Reading these trends could impact the construction of the model.

Based on this data, an accurate GIS-model can be built with accurate numbers derived from the spreadsheets and data from the municipality. After the occupation rates have been assessed and compared, a closer look into the suitable locations for new parking garages will be assessed.

5.2. Identify the most suitable location of parking facilities with regards to the city's developments and other criteria

In this part, the GIS model will play a big role where most of the conclusions and research will be based off. This research applies both extensive literature research as spatial analysis which will be supported by criteria that is found for existing methods in earlier executed similar research. Besides the software that will be used, spatial data from the municipality about occupation rates will be used, as well as goals which are set will be met.

Setting up the model comes with some challenges since all models are a simplified representative of the real-life world to target specific problems. Therefore, multiple factors have to be eliminated before constructing the model.

In order to pick the best location(s) for parking garages, geographical information software will be used to evaluate the most suitable locations. Within the construction of the model, the spatial parking index is used to test every possible area. These criteria will be combined into a Spatial Parking Index so each criterion will be taken into account. The criteria is based on literature research from other studies that encountered the same challenge.

New data from project Centrumkwadraat will be gathered including the new expected demography of the projects within Centrumkadraat. With this information, a rough indication can be made on how many additional cars have to be stored and how these changes affect the traffic flows as well.

With this new data, the follow-up model can be constructed in which a multicriteria analysis will be done. The input for this analysis is yet to be decided and its input will be made in compliance with the municipality. Although, there are a few key factors that should be included namely, the distance from medical health centres, schools, green hubs and to economical hubs as these are important factors for Enschede and have a major impact on the allocation of parking garages.

For the population density, maps of the demographics regards the study area from CBS and ESRI Nederland will be used to get an insight in the population density.

Data regards environmental impact and future development plans have already been gathered from the municipality and will be directly implemented in the model.

5.3 Provide recommendations regarding the location of parking garages

Within this last part, mostly a recommendation to the municipality will be given. Here the GIS-model will be given which shows the output map where the most suitable location(s) for parking garages will be presented.

6. Methodology

In this part, the methods for the research are layerd out. This part mainly consists of three parts namely, assessing suitable locations, setting up the Spatial Parking Index and testing the suitable locations using a ranking system.

6.1 Setting up the spatial parking index

To come up with a solution to the problem, the research is split into different parts. Firstly, indicators have to be determined to set up criteria on which possible locations for parking garages could be tested on. For valid input, the indicators used in this paper are based off of literature research. Using these indicators, the criteria for suitable locations should be assigned a score to verify which of the locations should be considered for the construction of a parking garage.

Each article used multiple indicators to determine the allocation of parking garages. Reading these articles gives a good insight for constructing a viable parking index for this research. Below, an overview of each indicator is depicted with their reference(s) and is shown whether this data is available for the research for this paper. Based on the availability and the number of shared indicators from the references, the final indicators are setup.

Table 2 - Indicators found in articles

Indicator	References	Available
Distance important centers	Aliniai et al. (2015) | (Massahi et al. 2012) | Raheleh Farzanmanesh (2010)	✓
Distant from passages	Aliniai et al. (2015) | (Massahi et al. 2012) | Raheleh Farzanmanesh (2010)	✓
Suitability of landuse; development plans	Aliniai et al. (2015) | (Davis, 2010)	
Population	Raheleh Farzanmanesh (2010)	✓
Attainment of major streets	Raheleh Farzanmanesh (2010) | Aliniai et al. (2015)	✓
Environmental impact; green spaces	(Cooper, 2018) | (Davis, 2010)	✓
Cost of real estate/land	Aliniai et al. (2015) | (Massahi et al. 2012) | Raheleh Farzanmanesh (2010)	

Now that the indicators with each availability is present, the spatial parking index with its criteria can be made. This index is gives a reliable set of criteria to set up the GIS-model. Each of the available indicators will be used to create the model except for the 'distant from passages' indicator since this criteria would require a lot more research which is beyond the scope of this assignment and will therefore not be included.

The Spatial Parking Index is drawn below in figure 5 for a clear overview. Here, the measurements are stated, which are implemented in the model.

Figure 6 - Spatial Parking Index Indicators

With the set, the maximum allowable distance from each facility to the parked car must be assigned. Almost all facilities have a maximum acceptable distance people are willing to walk to these facilities. Hence, an overview is depicted in the table below that showcase these distances, all of the acceptable distances are derived from literature review.

The picked facilities are a set of combined parameters that have been researched by CROW and CBS, both parties work narrowly with the government.

Table 3Table with acceptable walking distances derived from two sources:(CBS, 2017-2023; CROW, 2015)

From parked car to	Acceptable walking distance (m)
Supermarket	400
Inner city/shopping area	600
Work space	500
School	400
Catering sector (pubs, restaurants)	500
Healthcare institutions	250
Hospital	150
Cinema/theater	600
Sporting facilities	300
Other	400

Now that the maximum distances from parking garages have been determined, the spatial index for each indicator can be determined. The table below is used as main input to set up the GIS-model on which latter research is based.

Table 4 - Spatial Parking Index based on literature review

Criteria	Indicators	Measurement	Units	weight
Future Development Plans	Areas that are subdue to major developments requiring additional parking spots	Centrumkwadraat	Distance in meter (<400m)	0.5
		Other major developments	Distance in meter (<400m)	0.5
Environmental Impact	Climate change adapters	Green hubs	Distance in meter (<600m)	0.5
		EV-charging spots	Distance in meter (<400m)	0.5
Demography	Residents information	Population density	Scale 1 to 9	0.5
		Car per household	Scale 1 to 9	0.5
Connectivity	Acceptable walking distance for different facilities	Supermarket	Distance in meter (<400m)	0.125
		Inner city/shopping area	Distance in meter (<600m)	0.125
		Work space	Distance in meter (<500m)	0.125
		School	Distance in meter (<400m)	0.125
		Catering sector (pubs, restaurants)	Distance in meter (<500m)	0.125
		Healthcare institutions	Distance in meter (<250m)	0.125
		Hospital	Distance in meter (<150m)	0.125
		Cinema/theater	Distance in meter (<600m)	0.125
		Sporting facilities	Distance in meter (<300m)	0.125
		Other	Distance in meter (<400m)	0.125

The weights of the Measurements are assumed to be equal. This is mainly due to the fact that the municipality was not certain on the assignment of the importance to these criteria.

With these input values, the suitability of parking garages can be determined, which is the first step to allocating suitable locations for parking facilities.

6.2 Calculating the indicators

In this part, the Indicators' establishment will be constructed. These calculations will come back at the end of this report and will then be assessed. Before the calculations can be run, the determination of the allocation of the parking garages must be made. But first, the formulas for the Spatial Parking Index are given below.

Future Development Plans

For the future Development Plans, the formula below is setup. This equation indulges the weight that is assigned to them in table 4. In the first fraction, the distance from the parking garage to projects of CentrumKwadraat is over the number of projects that lie within the parameter. This applies as well to the second fraction, although now it subjects to other large projects.

$$FDP = n_{centrum^2} \sum (0.5\ (400 - length_{centrum^2})) + n_{Projects} \sum 0.5\ (400 - length_{Projects})$$

Environmental Impact

Below the formula to determine the score for the Environmental Impact is given. Here, the same principle from the equations above apply here as well. Only now the subjects are for the distance from the parking garage to green hubs and EV.

$$Demography = n_{Green\ Hubs} \sum (0.5\ (600 - length_{Green\ Hubs})) + n_{EV} \sum (0.5\ (400 - length_{EV}))$$

Demography

The Demography works a little differently than the other indicators as this criterium will be assigned to certain districts within the city's parameters. These districts will be derived from CBS who have their own database with multiple demographical information sources. Each district will be ranked from 10 to 90 where 10 indicates that that district benefits the most from a parking garage and 90 the least.

Demography is split into two parts, namely the population density and the car ownership per household. Each of the criteria will be ranked and will get a certain score, since the weights of these indicators is equal, the average of these scores will be combined to come up with the final score for this indicator.

$$Environmental\ Impact = 0.5 \cdot Score_{Population\ density} + 0.5 \cdot Score_{car/household}$$

Connectivity

For the connectivity, a few major attractions of the city have been selected, which are based on literature review and are listed in table 3. Each facility is assigned to a certain maximum allowable walking distance which can be computed in the formula. When multiple facilities lie in the overlapping buffer zones, the denominator will get higher, resulting in a lower and thus better score.

$$Connectivity = 0.125 \cdot n_{Facility} \sum (Length_{MaxAcceptable} - length_{Facility})$$

Spatial Parking Index

The Spatial Parking Index is then calculated by the average scores of the measuerments they are tested by. Resulting in an average score that provides for a final score which indicates the suitability of the parking garage. The formula for this score is given below.

$$SPI = (FDP \cdot 0.25) + (Environmental\ Impact \cdot 0.25) + (Demography \cdot 0.25) + (Connectivity \cdot 0.25)$$

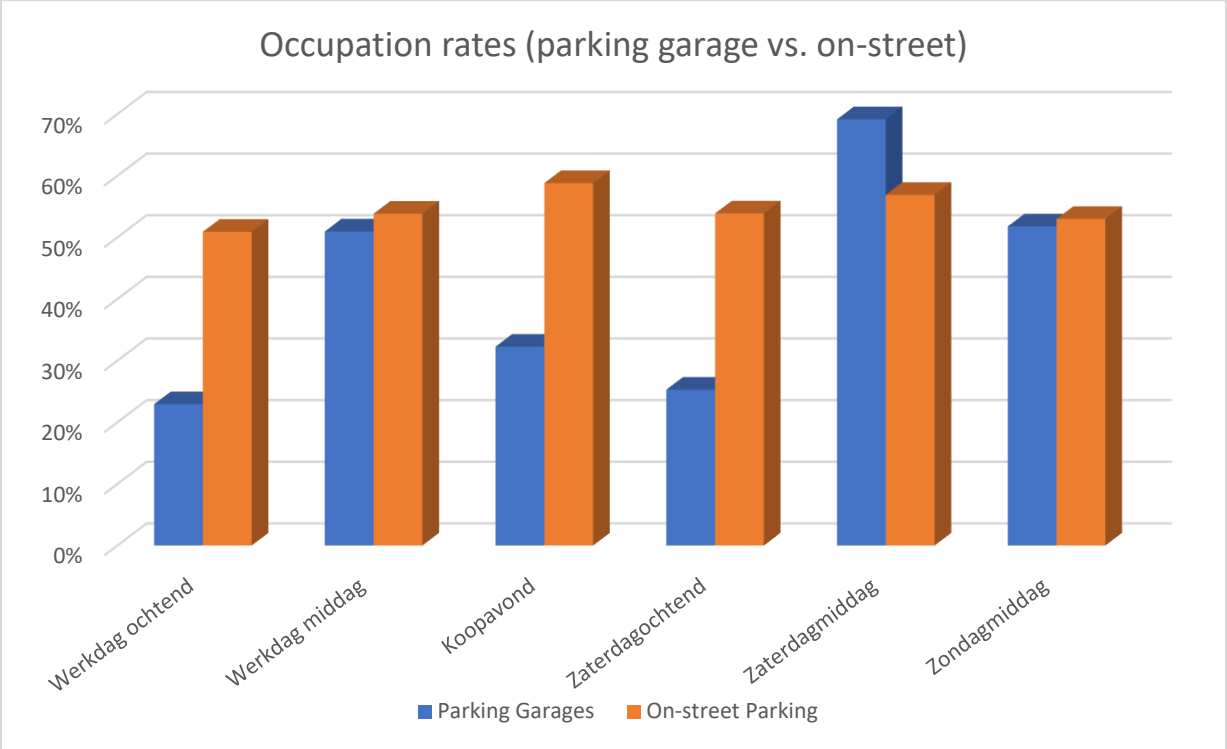
7. Research and results

In this part the research questions which are constructed in the previous part will be handled and discussed. Besides that an answer will come out of this play.

7.1. Assessment on the current situation regards parking

First the numbers regards the occupation rates will be depicted in a graph below to give an insight in the occupation rates of the parking spots. Not only the on-street parking is depicted, an overview of all parking garages located within the study area are shown as well.

In the retrieved data there is an distinguished number between so-called 'free parking' and 'regulated parking'. Where free parking means that the car user can use the parking spot free of charge whereas the regulated parking is regulated for car users who are allowed to park in a designated area.



Graph 1 - Occupation rates within the study area (parking garages versus on-street parking)

In the graph above, an overview off the comparison between on-street parking and parking in parking garages is depicted. Here, occupation rates are shown for main day parts (morning, afternoon and evening). The bars showcase the percentage occupation of the total amount parking spots, for example, on Saturday morning 24% of all parking spots within all of the parking laying in the study area, are occupied.

7.2. Model

For the construction of the model, geographical information software is used in order to determine the most suitable location(s) for parking garage(s) within the study area.

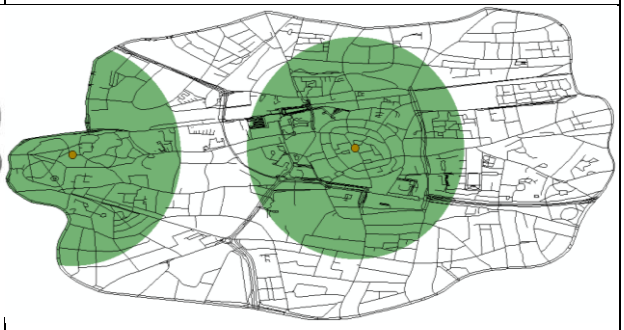
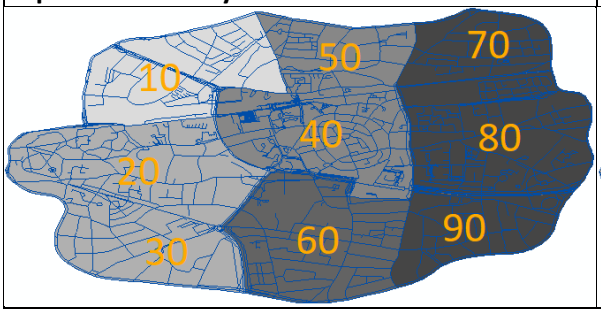
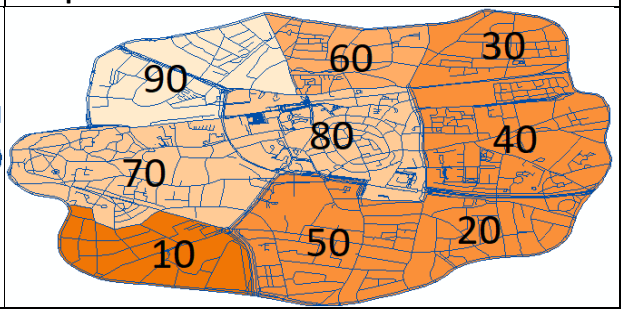
7.2.1. Setup of the model

Below a picture of the basemaps including each criterion of the model is depicted. The locations of each polygon is based on updated google streetview images which were loaded in before the construction of the model with all of its polygons. Thus giving the model both an accurate location and geological reference to the right location. Since all maps have the same orientation, the north arrow is only included in the first picture.

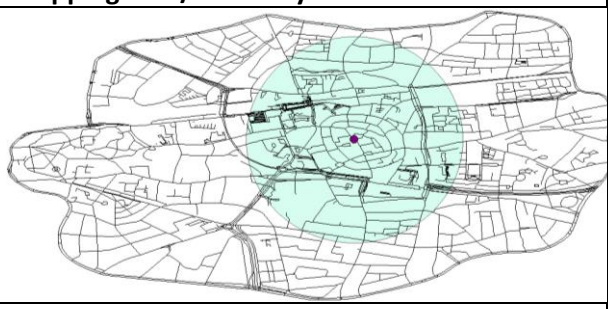
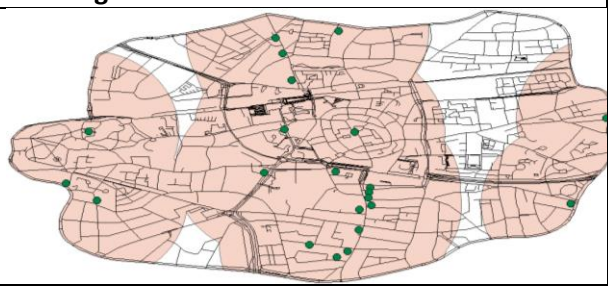
While constructing the base map, a simplification regards the 'shopping area' polygon has been made. This can be seen in the figure below and is due to a simplification since the shopping area is not quite defined. Given this vague information summed up to assigning this area to the center of the inner city. Besides that are the shopping centres highly concentrated in this vicinity.

For the demography overlay, accurate numbers from CBS has been used. Unfortunately, the population density could not be depicted on a more detailed manner due to the absence of this information. The map has been divided into a total of 9 subdivisions, indicating all different neighbourhoods from CBS.

Table 5 - Basemaps including all criteria and their corresponding buffer zones

CentrumKwadraat & Major Developments	**Green Hubs**
	
Population density	**Cars per Household**
	

People/km²	Cars/Household
<2470	<0.32
2471 - 5277	0.32-0.50
5278 - 6593	0.50-0.65
6594 - 7380	0.65-0.80
>7381	>1.0

Supermarkets	Shopping area/Inner city
	
Schools	**Catering sector**
	

Now that the indicators are depicted, the determination of the most suitable locations can be established. This is done by overlaying the indicators with their buffers.
Before this step is executed, it is useful to get an insight in the locations of the current parking garages. In figure 7, the locations of the parking garages are marked with a black circle and includes a buffer zone surrounding these points.

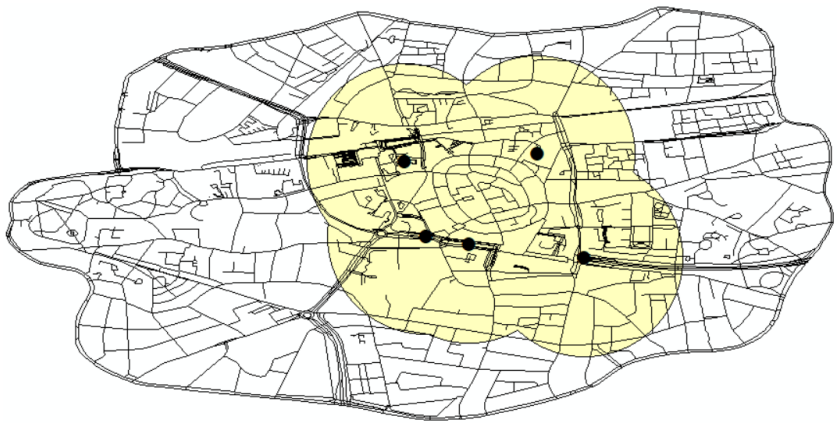


Figure 7 - Map showcasing all current parking garages

For the output map in which the most suitable locations will be depicted, the buffer zone from figure 7 will be cut out and will be left out for the consideration of constructing a new parking garage. The buffer zone is set to 400 meters as this is assumed to be a respectable distance people are willing to drive. Besides that, was this decision made due to the fact that the vision of Enschede is to have a car free city centre, besides that does the no additional parking garages are necessary in the vicinity.

The output map for suitability of parking garages is depicted below, showing the greener parts are more suitable for fitting a parking garage. This is due to the fact that these areas have overlays with multiple other acceptable distances.

then transferred to single parts using the mutlipart to singlepart tool. This creates a feature class that contains singlepart features from the multipart implemented input. After this step the single feature class was put through the spatial join analysis tool to create an image that could show overlapping polygons. Creating an output map that depicts the amount of overlapping polygons between the buffer zones gives an insight in suitability for parking garages. Because these areas share the optimum walkable distances on the map.

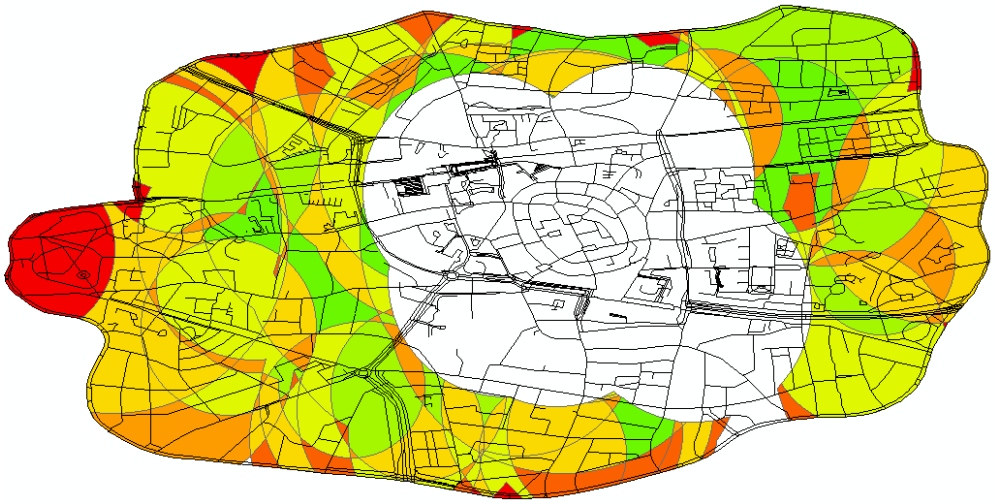


Figure 8 – Output map showing overlapping buffer zones of each criterion

In this map, the suitability of each polygon is depicted by its colour, whereas the greener a polygon is, the more it is suitable for a parking garage. The more red a polygon is, the less suitable this area is.

From the attribute table, the zones that showed the most overlap have been selected. From each zone, the centre is chosen as a reference point to measure the lengths from each facility. The list from possible parking garage to facility can be found in the appendix.

Figure 9 - Candidate locations for parking garages

7.2.2. Testing the candidate parking garages

Now that the most suitable locations have been determined, the scores from parking index can be calculated. Below, the map that show the most suitability is shown.

Figure 10 – Scores from each potential parking garage calculated by the score index

Again, the suitability is depicted with a gradient, where red is the least suitability and green shows the best suitability. The scores for each candidate parking garage is shown in the table below.

Table 6 - Scores for each individual potential parking garage

Parking garage	Score
6	182
5	330
4	499
3	543
2	555
1	2622

7.2.3. Recommendation

Combining the results of the research, I would recommend the municipality to construct three parking garages in the study area which are marked with labels 1 to 3 in figure 10. These parking garages will operate next to the already existing parking garages since the new ones are spread further out to the Singels and show good potential with regards to accessibility towards other facilities.

8. Conclusion

The main goal of this report was to determine the most suitable locations for parking garages within the Singels in Enschede. The cause for this is that Enschede momentarily is faced with a large shift to a more environmental friendly environment.

Firstly, the hypothesis regards a parking problem had to be tested. In the research clearly came forward that on-street parking is far more used than parking in parking lots. Which is not in line with the vision the municipality of Enschede entails. In their future plans clearly is stated that the city centre should be emission free. Hence giving the next problem which had to be solved: finding suitable places for parking garages where cars can be parked outside of the inner city.

This problem was handled using spatial research with GIS software. Here, the input for the model was based on several several indicators derived from literature research and was tested by a scoring system.

The scoring system operated largely on the distance people are willing to walk to certain facilities. Next to these facilities, demography regards population density and cars per household were used.

The paper did not go into detail about traffic flows and traffic intensity which could be included in future research. Besides that, the results of this paper were not tested in the real world which would most likely give different results. Although, this paper could function as a start for further research regards this topic.

9. Discussion

In this part the skeptical points and questionable things are handled to acknowledge that certain parts could be improved in order to give a more accurate result.

The point of this paper is to allocate the most optimal locations for parking garages. The determination of the most suitable location geographical software is used. Although this software is perfectly capable of handling problems like this, some decision making by me could have been better. This is mainly because I have never built such a model with such a scope and size.

Although the output data came out fine, there are a few things that could not go unnoticed. First of all is the lack of traffic that is not loaded into the model. The research was primarily focused on the spatial analysis without taking main roads and such into consideration. By taking traffic flows into account, a more accurate model can be constructed. Although this might be interesting for further research, it was beyond the scope of this assignment since only 10 weeks were assigned.

Though the intention was to include traffic flows, I was not able to find any specific data and the municipality would not hand me the counting records due to safety regulations.

Besides traffic flows, the study area should be enlarged to not merely the output map which was depicted in the results but to a larger area beyond the 'Singelgebied'. This way, facilities that lie just outside the study area could also be considered in the SPI which could impact the output map drastically. Since multiple facilities outside of the study area were present which all could have contributed to the amount of polygons and bufferzones.
Not only could the feature classes influence the output map by extending the boarders, traffic flows could also be considered. Since Enschede gets multiple visitors from outside the city, it is interesting to analyze where they are coming from and where they are heading. Including an extensive OD-matrix (origin-destination matrix) is not a superfluous luxury. By assessing the OD-matrix, one could assess main arteries and use it to the advantage.

Although the data which was acquired by the municipality was quite extensive, some major details were unfortunately left out. This was seen in one of the diagrams where no data on certain countings were given. This data could have been significant for the research. Besides the left out information, the data used for the research were based on other research of 2019 which could have been more updated. Although, the countings were quite accurate since they stem from the time before COVID-19.

Lastly, the maps look flattened but everything was done to try and solve this issue, unfortunately to no avail. The correct coordination set is used making the georefencing reliable.

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11. Appendix

In this part all the data that was used from the municipality in order to make the model is shown. This data was used to give the results and build the model. In this part all the data that was used from the municipality in order to make the model is shown.

Parkeervoorzieningen	Regiem bezetting	Capaciteit Voor	Mutatie 2019	Na	Bezetting werkdag-ochtend	werkdag-middag	werkdag-avond	Koop-avond	werkdag-nacht	zaterdag-ochtend	zaterdag-middag	zaterdag-avond	zondag-middag
Gebied 1 Stadserf	Vrijparkeren	0	0	-	-	-		-			-		-
	Gereguleerd	60	0	60	27	22		20			34		24
Irenegarage	Garage	525	0	525	46	141		222			396		288
HJ van Heekgarage	Garage	1741	0	1.741	250	767		842			1.649		1.271
Q-park	Garage	460	0	460	172	386		310			420		287
Nieuwe garage	Garage	0	0	-	-	-		-			-		-
extra bezetting ivm groei bezoek					-	-		-			-		-
extra bezetting ivm groei auto					-	-		-			-		-
Totaal huidig		2.786	-	2.786	495	1.316		1.394			2.499		1.870
Parkeerbehoefte voorgaande jaren totaal													
Parkeerbehoefte voorgaande jaren totaal bezoek													
Parkeerbehoefte voorgaande jaren % eigen terrein													
Parkeerbehoefte totaal					-	-	-	-	-	-	-	-	-
Parkeerbehoefte bezoekers					-	-		-			-		-
Parkeerbehoefte % op eigen terrein					-	-		-			-		-
Nieuwe bezeting # totaal					495	1.316	-	1.394	-	-	2.499	-	1.870
Nieuwe bezeting % totaal					18%	47%	0%	50%	0%	0%	90%	0%	67%
Saldo t.o.v. clasificatie tekort %				2.647	2.152	1.331	2.647	1.253	2.647	2.647	148	2.647	777
Nieuwe bezeting # bewoners eigen terrein					495	1.316	-	1.394	-	-	2.499	-	1.870
Nieuwe bezeting % bewoners eigen terrein					18%	47%	0%	50%	0%	0%	90%	0%	67%
Saldo t.o.v. clasificatie tekort %					2.152	1.331	2.647	1.253	2.647	2.647	148	2.647	777
Nieuwe bezeting # (% op eigen terrein)					495	1.316	-	1.394	-	-	2.499	-	1.870
Nieuwe bezeting % (% op eigen terrein)					18%	47%	0%	50%	0%	0%	90%	0%	67%
Saldo t.o.v. clasificatie tekort %					2.152	1.331	2.647	1.253	2.647	2.647	148	2.647	777

Gebied 1 Noord	Vrijparkeren	0	0	-	-	376		467			464		407
	Gereguleerd	457	0	457	237	-		-			-		-
Stationsgarage	Garage	344	0	344	172	232		272			252		221
Nieuwe garage	Garage	0	0	-	-	-		-			-		-
extra bezetting ivm groei bezoek					-	-		-			-		-
extra bezetting ivm groei auto					-	-		-			-		-
Totaal huidig		801	-	801	409	608		739			716		628
Parkeerbehoefte voorgaande jaren totaal													
Parkeerbehoefte voorgaande jaren totaal bezoek													
Parkeerbehoefte voorgaande jaren % eigen terrein													
Parkeerbehoefte totaal					-	-	-	-	-	-	-	-	-
Parkeerbehoefte bezoekers					-	-		-			-		-
Parkeerbehoefte % op eigen terrein					-	-		-			-		-
Nieuwe bezeting # totaal					409	608	-	739	-	-	716	-	628
Nieuwe bezeting % totaal					51%	76%	0%	92%	0%	0%	89%	0%	78%
Saldo t.o.v. clasificatie tekort %				761	352	153	761	22	761	761	45	761	133
Nieuwe bezeting # bewoners eigen terrein					409	608	-	739	-	-	716	-	628
Nieuwe bezeting % bewoners eigen terrein					51%	76%	0%	92%	0%	0%	89%	0%	78%
Saldo t.o.v. clasificatie tekort %					352	153	761	22	761	761	45	761	133
Nieuwe bezeting # (% op eigen terrein)					409	608	-	739	-	-	716	-	628
Nieuwe bezeting % (% op eigen terrein)					51%	76%	0%	92%	0%	0%	89%	0%	78%
Saldo t.o.v. clasificatie tekort %					352	153	761	22	761	761	45	761	133

Gebied 1 Zuid	Vrijparkeren	0	0	-	-	-		-			-		-
	Gereguleerd	1038	0	1.038	520	490		566			601		518
Mooienhof 1	Garage	45	0	45	16	16		20			18		18
Mooienhof 2	Garage	100	0	100	81	87		25			52		25
Hermandad	Garage	293	0	293	-	-		37			90		46
Nieuwe garage	Garage	0	0	-	-	-		-			-		-
extra bezetting ivm groei bezoek					-	-		-			-		-
extra bezetting ivm groei auto					-	-		-			-		-
Totaal huidig		1.476	-	1.476	617	593		648			761		607
Parkeerbehoefte voorgaande jaren totaal													
Parkeerbehoefte voorgaande jaren totaal bezoek													
Parkeerbehoefte voorgaande jaren % eigen terrein													
Parkeerbehoefte totaal					-	-	-	-	-	-	-	-	-
Parkeerbehoefte bezoekers					-	-		-			-		-
Parkeerbehoefte % op eigen terrein					-	-		-			-		-
Nieuwe bezeting # totaal					617	593	-	648	-	-	761	-	607
Nieuwe bezeting % totaal					52%	50%		44%			52%		41%
Saldo t.o.v. clasificatie tekort %				1.402	785	809	1.402	754	1.402	1.402	641	1.402	795
Nieuwe bezeting # bewoners eigen terrein					617	593	-	648	-	-	761	-	607
Nieuwe bezeting % bewoners eigen terrein					52%	50%		44%			52%		41%
Saldo t.o.v. clasificatie tekort %					785	809	1.402	754	1.402	1.402	641	1.402	795
Nieuwe bezeting # (% op eigen terrein)					617	593	-	648	-	-	761	-	607
Nieuwe bezeting % (% op eigen terrein)					52%	50%		44%			52%		41%
Saldo t.o.v. clasificatie tekort %					785	809	1.402	754	1.402	1.402	641	1.402	795

Gebied 2	Vrijparkeren	834	0	834	451	507		572			516		503
	Gereguleerd	1	0	1	-	-		-			-		-
Nieuwe garage	Garage	0	0	-									
extra bezetting ivm groei bezoek					-	-		-			-		-
extra bezetting ivm groei auto					-	-		-			-		-
Totaal huidig		835	-	835	451	507		572			516		503
Parkeerbehoefte voorgaande jaren totaal													
Parkeerbehoefte voorgaande jaren totaal bezoek													
Parkeerbehoefte voorgaande jaren % eigen terrein													
Parkeerbehoefte totaal					-	-	-	-	-	-	-	-	-
Parkeerbehoefte bezoekers					-	-		-			-		-
Parkeerbehoefte % op eigen terrein					-	-		-			-		-
Nieuwe bezeting # totaal					451	507	-	572	-	-	516	-	503
Nieuwe bezeting % totaal					54%	61%	0%	69%	0%	0%	62%	0%	60%
Saldo t.o.v. clasificatie tekort %				793	342	286	793	221	793	793	277	793	290
Nieuwe bezeting # bewoners eigen terrein					451	507	-	572	-	-	516	-	503
Nieuwe bezeting % bewoners eigen terrein					54%	61%	0%	69%	0%	0%	62%	0%	60%
Saldo t.o.v. clasificatie tekort %					342	286	793	221	793	793	277	793	290
Nieuwe bezeting # (% op eigen terrein)					451	507	-	572	-	-	516	-	503
Nieuwe bezeting % (% op eigen terrein)					54%	61%	0%	69%	0%	0%	62%	0%	60%
Saldo t.o.v. clasificatie tekort %					342	286	793	221	793	793	277	793	290

Gebied 3	Vrijparkeren	608	0	608	432	450		496			474		466
	Gereguleerd	727	0	727	334	376		467			464		407
Nieuwe garage	Garage	0	0	-									
extra bezetting ivm groei bezoek					-	-		-			-		-
extra bezetting ivm groei auto					-	-		-			-		-
Totaal huidig		1.335	-	1.335	766	826		963			938		873
Parkeerbehoefte voorgaande jaren totaal													
Parkeerbehoefte voorgaande jaren totaal bezoek													
Parkeerbehoefte voorgaande jaren % eigen terrein													
Parkeerbehoefte totaal					-	-	-	-	-	-	-	-	-
Parkeerbehoefte bezoekers					-	-		-			-		-
Parkeerbehoefte % op eigen terrein					-	-		-			-		-
Nieuwe bezeting # totaal					766	826	-	963	-	-	938	-	873
Nieuwe bezeting % totaal					57%	62%	0%	72%	0%	0%	70%	0%	65%
Saldo t.o.v. clasificatie tekort %				1.268	502	442	1.268	305	1.268	1.268	330	1.268	395
Nieuwe bezeting # bewoners eigen terrein					766	826	-	963	-	-	938	-	873
Nieuwe bezeting % bewoners eigen terrein					57%	62%	0%	72%	0%	0%	70%	0%	65%
Saldo t.o.v. clasificatie tekort %					502	442	1.268	305	1.268	1.268	330	1.268	395
Nieuwe bezeting # (% op eigen terrein)					766	826	-	963	-	-	938	-	873
Nieuwe bezeting % (% op eigen terrein)					57%	62%	0%	72%	0%	0%	70%	0%	65%
Saldo t.o.v. clasificatie tekort %					502	442	1.268	305	1.268	1.268	330	1.268	395

Gebied 4	Vrijparkeren	195	0	195	146	131		133			140		127
	Gereguleerd	1429	0	1.429	647	744		881			769		765
Nieuwe garage	Garage	0	0	-									
extra bezetting ivm groei bezoek					-	-		-			-		-
extra bezetting ivm groei auto					-	-		-			-		-
Totaal huidig		1.624	-	1.624	793	875		1.014			909		892
Parkeerbehoefte voorgaande jaren totaal													
Parkeerbehoefte voorgaande jaren totaal bezoek													
Parkeerbehoefte voorgaande jaren % eigen terrein													
Parkeerbehoefte totaal					-	-	-	-	-	-	-	-	-
Parkeerbehoefte bezoekers					-	-	-	-	-	-	-	-	-
Parkeerbehoefte % op eigen terrein					-	-	-	-	-	-	-	-	-
Nieuwe bezeting # totaal					793	875	-	1.014	-	-	909	-	892
Nieuwe bezeting % totaal					49%	54%	0%	62%	0%	0%	56%	0%	55%
Saldo t.o.v. clasificatie tekort %				1.543	750	668	1.543	529	1.543	1.543	634	1.543	651
Nieuwe bezeting # bewoners eigen terrein					793	875	-	1.014	-	-	909	-	892
Nieuwe bezeting % bewoners eigen terrein					49%	54%	0%	62%	0%	0%	56%	0%	55%
Saldo t.o.v. clasificatie tekort %					750	668	1.543	529	1.543	1.543	634	1.543	651
Nieuwe bezeting # (% op eigen terrein)					793	875	-	1.014	-	-	909	-	892
Nieuwe bezeting % (% op eigen terrein)					49%	54%	0%	62%	0%	0%	56%	0%	55%
Saldo t.o.v. clasificatie tekort %					750	668	1.543	529	1.543	1.543	634	1.543	651

Gebied 5 Noord	Vrijparkeren	0	0	-	-	-		-			-		-
	Gereguleerd	272	0	272	132	127		142			121		132
MST	Garage	900	0	900	-	-		-			239		225
Nieuwe garage	Garage	0	0	-									
extra bezetting ivm groei bezoek					-	-		-			-		-
extra bezetting ivm groei auto					-	-		-			-		-
Totaal huidig		1.172	-	1.172	132	127		142			360		357
Parkeerbehoefte voorgaande jaren totaal													
Parkeerbehoefte voorgaande jaren totaal bezoek													
Parkeerbehoefte voorgaande jaren % eigen terrein													
Parkeerbehoefte totaal					-	-	-	-	-	-	-	-	-
Parkeerbehoefte bezoekers					-	-		-			-		-
Parkeerbehoefte % op eigen terrein					-	-		-			-		-
Nieuwe bezeting # totaal					132	127	-	142	-	-	360	-	357
Nieuwe bezeting % totaal					49%	47%	0%	52%	0%	0%	31%	0%	30%
Saldo t.o.v. clasificatie tekort %				1.113	981	986	1.113	971	1.113	1.113	753	1.113	756
Nieuwe bezeting # bewoners eigen terrein					132	127	-	142	-	-	360	-	357
Nieuwe bezeting % bewoners eigen terrein					49%	47%	0%	52%	0%	0%	31%	0%	30%
Saldo t.o.v. clasificatie tekort %					981	986	1.113	971	1.113	1.113	753	1.113	756
Nieuwe bezeting # (% op eigen terrein)					132	127	-	142	-	-	360	-	357
Nieuwe bezeting % (% op eigen terrein)					49%	47%	0%	52%	0%	0%	31%	0%	30%
Saldo t.o.v. clasificatie tekort %					981	986	1.113	971	1.113	1.113	753	1.113	756

Gebied 5 Zuid	Vrijparkeren	627	0	627	403	396		363			387		307
	Gereguleerd	347	0	347	134	185		179			134		175
Nieuwe garage	Garage	0	0	-									
extra bezetting ivm groei bezoek					-	-		-			-		-
extra bezetting ivm groei auto					-	-		-			-		-
Totaal huidig		974	-	974	537	581		542			521		482
Parkeerbehoefte voorgaande jaren totaal													
Parkeerbehoefte voorgaande jaren totaal bezoek													
Parkeerbehoefte voorgaande jaren % eigen terrein													
Parkeerbehoefte totaal					-	-	-	-	-	-	-	-	-
Parkeerbehoefte bezoekers					-	-		-			-		-
Parkeerbehoefte % op eigen terrein					-	-		-			-		-
Nieuwe bezeting # totaal					537	581	-	542	-	-	521	-	482
Nieuwe bezeting % totaal					55%	60%	0%	56%	0%	0%	53%	0%	49%
Saldo t.o.v. clasificatie tekort %				925	388	344	925	383	925	925	404	925	443
Nieuwe bezeting # bewoners eigen terrein					537	581	-	542	-	-	521	-	482
Nieuwe bezeting % bewoners eigen terrein					55%	60%	0%	56%	0%	0%	53%	0%	49%
Saldo t.o.v. clasificatie tekort %					388	344	925	383	925	925	404	925	443
Nieuwe bezeting # (% op eigen terrein)					537	581	-	542	-	-	521	-	482
Nieuwe bezeting % (% op eigen terrein)					55%	60%	0%	56%	0%	0%	53%	0%	49%
Saldo t.o.v. clasificatie tekort %					388	344	925	383	925	925	404	925	443

Gebied 6 West	Vrijparkeren	1217	0	1.217	754	758		813			758		745
	Gereguleerd	166	0	166	65	75		87			55		88
Nieuwe garage	Garage	0	0	-									
extra bezetting ivm groei bezoek					-	-		-			-		-
extra bezetting ivm groei auto					-	-		-			-		-
Totaal huidig		1.383	-	1.383	819	833		900			813		833
Parkeerbehoefte voorgaande jaren totaal													
Parkeerbehoefte voorgaande jaren totaal bezoek													
Parkeerbehoefte voorgaande jaren % eigen terrein													
Parkeerbehoefte totaal					-	-	-	-	-	-	-	-	-
Parkeerbehoefte bezoekers					-	-		-			-		-
Parkeerbehoefte % op eigen terrein					-	-		-			-		-
Nieuwe bezeting # totaal					819	833	-	900	-	-	813	-	833
Nieuwe bezeting % totaal					59%	60%	0%	65%	0%	0%	59%	0%	60%
Saldo t.o.v. clasificatie tekort %				1.314	495	481	1.314	414	1.314	1.314	501	1.314	481
Nieuwe bezeting # bewoners eigen terrein					819	833	-	900	-	-	813	-	833
Nieuwe bezeting % bewoners eigen terrein					59%	60%	0%	65%	0%	0%	59%	0%	60%
Saldo t.o.v. clasificatie tekort %					495	481	1.314	414	1.314	1.314	501	1.314	481
Nieuwe bezeting # (% op eigen terrein)					819	833	-	900	-	-	813	-	833
Nieuwe bezeting % (% op eigen terrein)					59%	60%	0%	65%	0%	0%	59%	0%	60%
Saldo t.o.v. clasificatie tekort %					495	481	1.314	414	1.314	1.314	501	1.314	481

Gebied 6 Oost	Vrijparkeren	0	0	-	-	-		-			-		-
	Gereguleerd	335	0	335	148	135		129			164		119
Nieuwe garage	Garage	0	0	-									
extra bezetting ivm groei bezoek					-	-		-			-		-
extra bezetting ivm groei auto					-	-		-			-		-
Totaal huidig		335	-	335	148	135		129			164		119
Parkeerbehoefte voorgaande jaren totaal													
Parkeerbehoefte voorgaande jaren totaal bezoek													
Parkeerbehoefte voorgaande jaren % eigen terrein													
Parkeerbehoefte totaal					-	-	-	-	-	-	-	-	-
Parkeerbehoefte bezoekers					-	-		-			-		-
Parkeerbehoefte % op eigen terrein					-	-		-			-		-
Nieuwe bezeting # totaal					148	135	-	129	-	-	164	-	119
Nieuwe bezeting % totaal					44%	40%	0%	39%	0%	0%	49%	0%	36%
Saldo t.o.v. clasificatie tekort %				318	170	183	318	189	318	318	154	318	199
Nieuwe bezeting # bewoners eigen terrein					148	135	-	129	-	-	164	-	119
Nieuwe bezeting % bewoners eigen terrein					44%	40%	0%	39%	0%	0%	49%	0%	36%
Saldo t.o.v. clasificatie tekort %					170	183	318	189	318	318	154	318	199
Nieuwe bezeting # (% op eigen terrein)					148	135	-	129	-	-	164	-	119
Nieuwe bezeting % (% op eigen terrein)					44%	40%	0%	39%	0%	0%	49%	0%	36%
Saldo t.o.v. clasificatie tekort %					170	183	318	189	318	318	154	318	199

Gebied 7	Vrijparkeren	178	0	178	101	118		98			84		95
	Gereguleerd	855	0	855	283	310		306			413		319
Nieuwe garage	Garage	0	0	-									
extra bezetting ivm groei bezoek					-	-		-			-		-
extra bezetting ivm groei auto					-	-		-			-		-
Totaal huidig		1.033	-	1.033	384	428		404			497		414
Parkeerbehoefte voorgaande jaren totaal													
Parkeerbehoefte voorgaande jaren totaal bezoek													
Parkeerbehoefte voorgaande jaren % eigen terrein													
Parkeerbehoefte totaal					-	-	-	-	-	-	-	-	-
Parkeerbehoefte bezoekers					-	-		-			-		-
Parkeerbehoefte % op eigen terrein					-	-		-			-		-
Nieuwe bezeting # totaal					384	428	-	404	-	-	497	-	414
Nieuwe bezeting % totaal					37%	41%	0%	39%	0%	0%	48%	0%	40%
Saldo t.o.v. clasificatie tekort %				981	597	553	981	577	981	981	484	981	567
Nieuwe bezeting # bewoners eigen terrein					384	428	-	404	-	-	497	-	414
Nieuwe bezeting % bewoners eigen terrein					37%	41%	0%	39%	0%	0%	48%	0%	40%
Saldo t.o.v. clasificatie tekort %					597	553	981	577	981	981	484	981	567
Nieuwe bezeting # (% op eigen terrein)					384	428	-	404	-	-	497	-	414
Nieuwe bezeting % (% op eigen terrein)					37%	41%	0%	39%	0%	0%	48%	0%	40%
Saldo t.o.v. clasificatie tekort %					597	553	981	577	981	981	484	981	567

Normen 2009		Gebieden					
Functie	Eenheid	Centrum gebied *1	Schil/ binnensingelgebied	Rest bebouwde kom	Buiten bebouwde kom	Marge +/-	Aandeel bezoekers *2
Wonen							
> 120 m²	woning	1,30	1,50	1,70	2,00		0,3
tussen >80 m² en 120 m²	woning	1,20	1,40	1,60	1,80		0,3
tussen >60 m² en < 80 m²	woning	1,10	1,20	1,40	1,50		0,3
< 60 m²	woning	0,60	0,60	0,80	0,80		0,3
Serviceflat/aanleunwoning	woning	0,60	0,80	1,00	1,00		0,3
Niet zelfstandige kamerverhuur	kamer	0,20	0,20	0,30	0,30		0,2
Zelfstandige wooneenheden tot 40 m2 bvo	woning	0,30	0,35	0,45	0,45		0,3
Zelfstandige wooneenheden tussen 40 en 60 m2 bvo	woning	0,40	0,50	0,60	0,60		0,3
Winkelen							
Binnenstad of hoofdwinkel (stads)centrum	100 m2 bvo	3,90				0,50	92%
Buurt- of dorpscentrum	100 m2 bvo		3,10	3,70		1,00	72%
Wijkcentrum (klein)	100 m2 bvo		3,70	4,50		1,00	76%
Wijkcentrum (gemiddeld)	100 m2 bvo		4,30	5,10		1,00	79%
Wijkcentrum (groot)	100 m2 bvo		4,80	5,70		1,00	81%
Stadsdeelcentrum	100 m2 bvo		5,20	6,30		1,00	85%
Kleinschalige winkel buiten centrum	100 m2 bvo		3,00	4,00		1,00	85%
Weekmarkt (per m1 kraam)	100 m2 bvo	0,20	0,20	0,20		0,05	85%
Bruin- en witgoedzaken	100 m2 bvo	3,65	5,55	7,35	9,25	0,75	92%
Woonwarenhuis/woonwinkel	100 m2 bvo	1,15	1,55	1,65	1,95	0,25	91%
Woonwarenhuis (zeer groot) Gebaseerd op ca. 25.000 m2	100 m2 bvo			4,75	5,15	0,75	95%
Meubelboulevard/woonboulevard	100 m2 bvo		1,85	2,25		0,25	93%
Winkelboulevard	100 m2 bvo		3,45	3,95		0,25	94%
Outletcenter	100 m2 bvo		8,80	9,60	10,40	1,00	94%
Bouwmarkt	100 m2 bvo		1,75	2,25	2,45	0,25	87%
Tuincentrum/Groencentrum	100 m2 bvo		2,25	2,55	2,85	0,25	89%
Kringloopwinkel	100 m2 bvo		1,15	1,65	2,25	0,25	89%
Buurtsupermarkt	100 m2 bvo	1,90	2,70	3,40		1,00	89%
Discountsupermarkt	100 m2 bvo	3,30	4,90	6,50		1,00	96%
Fullservice supermarkt (laag/middellaag prijssegment)	100 m2 bvo	3,10	4,60	5,40		1,00	93%
Fullservice supermarkt (middelhoog/hoog prijssegment)	100 m2 bvo	3,50	4,00	4,90		1,00	93%
Grote supermarkt	100 m2 bvo	5,90	6,80	7,70		1,00	84%
Groothandel in levensmiddelen	100 m2 bvo		6,40	6,40		1,00	80%
Werken							
Commerciële dienstverlening (kantoor met baliefunctie)	100 m2 bvo	1,55	1,85	2,25	3,55	0,25	20%
Kantoor (zonder baliefunctie)	100 m2 bvo	1,15	1,55	1,65	2,55	0,25	5%
Bedrijf arbeidsextensief en bezoekers extensief (loods, opslag, transportbedrijf)	100 m2 bvo	0,65	0,75	0,95	1,05	0,25	5%
Bedrijf arbeidsintensief en bezoeker extensief (industrie, laboratorium, werkplaats)	100 m2 bvo	1,35	1,75	2,15	2,35	0,25	5%
Lifescience bedrijven, categorie 1 (bedrijfsmatig)	100 m2 bvo	0,80	1,00	1,00	1,00		5%
Lifescience bedrijven, categorie 2 (kantoorachtig)	100 m2 bvo	1,10	1,30	1,30	1,30		20%
Lifescience bedrijven, categorie 3 (kantoor)	100 m2 bvo	1,50	1,70	1,70	1,70		20%
Bedrijfsverzamelgebouw	100 m2 bvo	1,05	1,35	1,55	1,95	0,25	5%
Horeca							
Café, bar,cafetaria	100 m2 bvo	5,00	5,00	6,00	6,00	1,00	90%
Restaurant	100 m2 bvo	9,00	9,00	13,00	13,00	1,00	80%
Afhaal restaurants *3	100 m2 bvo	6,50	6,50	6,50	6,50	3,50	
Hotel 1*	10 kamers	0,40	0,80	2,30	4,50	0,10	77%
Hotel 2*	10 kamers	1,35	2,15	3,95	6,25	0,25	80%
Hotel 3*	10 kamers	2,00	3,10	4,70	6,80	0,50	77%
Hotel 4*	10 kamers	3,20	4,90	6,80	9,00	0,50	73%
Hotel 5*	10 kamers	5,00	7,75	10,10	12,80	0,80	65%
Pension, B&B	kamer	0,50	1,00	1,00	1,00		
Discotheek	100 m2 bvo	6,10	12,30	18,40	20,80	1,00	99%
Gezondheidszorg							
Huisartsenpraktijk(centrum)	behandelkamer	2,15	2,45	2,95	3,25	0,25	57%
Fysiotherapiepraktijk (-centrum)	behandelkamer	1,25	1,45	1,75	1,95	0,25	57%
Consultatiebureau	behandelkamer	1,25	1,55	1,85	2,15	0,25	50%
Gezondheidscentr.	behandelkamer	1,55	1,85	2,15	2,45	0,25	55%
Consultatiebureauvoor ouderen	behandelkamer	1,30	1,60	1,90	2,20	0,10	38%
Tandartsenpraktijk (-centrum)	behandelkamer	1,55	1,95	2,35	2,65	0,25	47%
Ziekenhuis	bed	1,60					29%
Verpleeg- ofverzorgingshuis	wooneenheid	0,60	0,60	0,60		0,25	60%
Apotheek	per apotheek	2,55	2,75	3,15		0,25	45%
Penitentiaireinstelling	10 cellen	1,65	2,15	3,25	3,65	0,10	37%
Onderwijs							
Kinderdagverblijf(crèche)	100 m2 bvo	0,80	1,00	1,10	1,50	0,10	0%
Basisschool	leslokaal	0,75	0,75	0,75	0,75	0,25	0%
Middelbare school	100 leerlingen	3,30	4,00	4,30	4,90	1,00	11%
ROC	100 leerlingen	4,20	4,80	5,20	5,90	1,00	7%
Hogeschool	100 studenten	8,30	8,90	9,50	10,90	2,00	72%
Universiteit	100 studenten	11,70	13,50	14,70	16,80	2,00	48%
Avondonderwijs	10 studenten	4,00	5,00	6,00	10,50	1,00	95%
Sport							
Gymnastieklokaal (bijscholen)	100 m2 bvo	1,80	2,00	2,30	2,30		
Fitness studio/sportschool	100 m2 bvo	1,40	3,40	4,80	6,50	0,50	87%
Fitnesscentrum	100 m2 bvo	1,70	4,40	6,20	7,40	0,50	90%
Sporthal	100 m2 bvo	1,45	2,05	2,65	3,45	0,25	96%
Sportzaal	100 m2 bvo	1,05	1,85	2,65	3,55	0,25	94%
Wellnesscentrum(thermen, kuurcentrum,beautycentrum)	100 m2 bvo			9,30	10,30	0,50	99%
Sauna, hammam	100 m2 bvo	2,50	4,60	6,60	7,30	0,50	99%
Kunstijsbaan (400 meter)	100 m2 bvo		2,05	2,35	2,75	0,25	98%
Stadion	Zitplaats	0,12	0,12	0,12	0,12	0,08	
Golfbaan	18 holes			95,60	118,30	10,00	
Golfoefencentrum	100 m2 bvo			50,70	56,20	2,00	
Sportveld	ha terrein	20,00	20,00	20,00	20,00	7,00	
Dansstudio	100 m2 bvo	1,50	3,80	5,40	7,40	0,50	93%
Tennishal	100 m2 bvo	0,30	0,40	0,50	0,50	0,10	87%
Squash hal	100 m2 bvo	1,60	2,40	2,70	3,20	0,10	84%
Bowlingcentrum	100 m2 bvo	1,60	2,20	2,80	2,80	0,50	89%
Biljartcentrum	100 m2 bvo	0,85	1,05	1,35	1,75	0,25	87%
Indoorspeeltuin(gemiddeld en kleiner)	100 m2 bvo	2,90	3,70	4,40	5,10	2,50	97%
Indoorspeeltuin (groot)	100 m2 bvo	3,50	4,30	5,30	6,10	2,50	98%
Indoorspeeltuin (zeergroot)	100 m2 bvo	3,70	4,60	5,50	6,40	1,50	98%
Zwembad overdekt	m2 bassinopp		10,70	11,50	13,30	1,00	
Zwembad openlucht	m2 bassinopp		10,10	12,90	15,80	1,00	
Manege	box				0,40	0,10	
Kinderboerderij	100 m2 bvo			1,00	1,00		
Kartbaan, klimhal,indoorski, etc.	100 m2 bvo	6,00	6,00	6,00	6,00		
Overige functies							
Evenementenhal, beursgebouw, congresgebouw *4	100 m2 bvo	4,00	5,50	7,50	7,50	1,50	99%
Attractie- en pretpark	ha terrein	8,00	8,00	8,00	8,00	4,00	99%
Dierenpark	ha terrein	8,00	8,00	8,00	8,00	4,00	99%
Volkstuin	100 m2 bvo		1,25	1,35	1,45	0,15	100%
Religiegebouw	zitplaats	0,15	0,15	0,15	0,15	0,05	
Crematorium	gelijktijdige plechtigheid			30,10	30,10	5,00	99%
Begraafplaats	gelijktijdige plechtigheid			31,60	31,60	5,00	97%
Jachthaven	ligplaats	0,60	0,60	0,60	0,60	0,10	
Camping(kampeerterrein)	standplaats				1,20	0,10	90%
Bungalowpark(huisjescomplex)	huisje			1,60	2,10	0,10	91%
Museum	100 m2 bvo	0,40	0,60	1,00	1,00	0,10	95%
Bibliotheek	100 m2 bvo	0,45	0,75	1,05	1,35	0,25	97%
Bioscoop	100 m2 bvo	3,20	7,90	11,00	13,70	1,00	94%
Filmtheater/filmhuis	100 m2 bvo	2,60	5,20	7,70	9,90	1,00	97%
Theater/schouwburg	100 m2 bvo	7,30	7,90	9,80	12,00	1,50	87%
Musicaltheater	100 m2 bvo	2,90	3,40	3,90	5,10	0,50	86%
Casino	100 m2 bvo	5,70	6,10	6,50	8,00	0,50	86%
Sociaal cultureelcentrum/ wijk/verenigingsgebouw	100 m2 bvo	1,00	2,00	2,00	2,00		

Verplaatsing	Acceptabele loopafstand (in meters)
vanaf geparkeerde auto naar supermarkt	100-250[1]
vanaf geparkeerde auto naar stadscentrum/winkelgebied	200-600[2]
vanaf geparkeerde auto naar werklocatie	200-800[2]
vanaf geparkeerde auto naar schoollocatie	100-300[2]
vanaf geparkeerde auto naar horeca	100-500[2]
vanaf geparkeerde auto naar huisarts/fysio/ apotheek	100-250[1]
vanaf geparkeerde auto naar ziekenhuis	100-350[1]
vanaf geparkeerde auto naar bioscoop/theater	100-600[2]
vanaf geparkeerde auto naar sportlocatie binnen	100-300[2]
vanaf geparkeerde auto naar sportlocatie buiten	100-300[2]

Bijlage 6: Redelijke loopafstanden

	Centrumgebied	Schil/overloopgebied & Rest bebouwde kom
Woningen	400 meter	100 meter
Winkelen en boodschappen	600 meter	400 meter
Werkgelegenheid	750 meter	500 meter
Onderwijsvoorzieningen	400 meter	100 meter
Zorginstellingen	150 meter	100 meter
Horeca	600 meter	250 meter
Sociaal culturele voorzieningen	600 meter	400 meter
Sportvoorzieningen	600 meter	250 meter
Overige voorzieningen	600 meter	400 meter

Parking garage	n	Sport	n	Theatre	n	Hospital	n	Health	n	Catering	n	Schools	n	Shopping	n	Supermark	n	Centrum2	n	Green	n	EV	PopDensity	Car/Household	Score
1	1	85	0	0	0	0	0	0	0	0	2	88 375	0	0	0	0	0	0	0	0	1	295	20	40	182
2	0	0	0	0	0	0	4	221 142 23 125	2	485 323	3	260 137 289	0	0	0	0	0	0	0	0	4	284 258 191 380	80	70	543
3	1	160	1	532	0	0	0	0	8	290 356 246 316 294 343 371 396	1	177	0	0	1	297	0	0	0	0	0	0	40	50	330
4	0	0	4	420 447 495 533	0	0	0	0	1	189	4	229 225 135 294	0	0	0	0	3	338 253 287	0	0	1	328	50	60	499
5	0	0	0	0	0	0	2	216 244	1	409	1	220	0	0	0	0	0	0	1	489	3	81 212 283	80	70	555
6	0	0		489 578 532 583 555	0	0	1	103	4	256 191 171 348	2	273 353	0	0	1	165	20	138 323 142 369 55 229 165 116 119 162 51 217 50 321 120 345 238 262 276 283	0	0	4	262 339 308 289	90	90	2622