Inequity by proximity: analysing inequity in public green spaces caused by the 15-minute city

A case study of Utrecht

Figure 1.

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Colophon

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1. Abstract

In response to the covid-19 pandemic and climate change concerns, the *15-minute city* (FMC) concept has gained traction as an urban planning approach. However, there is a growing concern regarding potential inequity in access to public green spaces caused by the implementation of the FMC concept, driven by limitations in travel time and modes of transport. This study investigates to which extent the introduction of the 10-minute city concept in the city of Utrecht causes inequity in public green spaces. This is supported by sub-questions looking at both the inequity in the amount and type of public green spaces and the difference between the different modes of transport.

The municipality of Utrecht is chosen as a case study since it aims to introduce a variant of the FMC, the 10-minute city, by 2040. A Geographic Information System (GIS) analysis is performed on the municipality, using open-source data, considering the current distribution of public green spaces and overlaying buffers of 10 minutes by walking or cycling. The findings reveal that currently, inequity in both access to the amount of as well as the different types of public green spaces is evident. The analysis is restricted by the inability to perform a part of the analysis due to the size of the dataset. Further research needs to be performed on which causations relate to the inequity of public green spaces.

Contents

2. Introduction

2.1 Background

In 2015, the Paris Agreement was adopted at the UN Climate Change Conference in Paris. The agreement is a result of a growing concern among UN member countries for the effects global warming will have on climate, among which are "more frequent and severe droughts, heatwaves and rainfall" (UNFCCC, 2023). There is a strong scientific consensus that humans are causing global warming, mainly due to the burning of fossil fuels leading to extra greenhouse gasses like carbon dioxide being released into the atmosphere (Cook *et al.*, 2016; European Commission, 2023). In 2015, 68% of the global carbon footprint originated from urban areas (Moran *et al.*, 2018; Gurney *et al.*, 2022). By 2100, urban areas are expected to be responsible for 62,6% to 79,6% of the global carbon footprint (Gurney *et al.*, 2022). To meet the goals of the Paris Agreement in time, cities will need to significantly lower their share of the total global carbon footprint.

To mitigate global warming cities are looking at new strategies and concepts to make their cities more sustainable and resilient. The concept *15-minute city* (FMC) gained popularity within the urban planning field and among policymakers after its introduction in 2015 by urban planner Carlos Moreno (Moreno *et al.*, 2021). In a FMC, residents can access all essential services and amenities within a 15-minute walk or bicycle ride from their homes. These essential services and amenities include grocery stores, schools, parks, and healthcare facilities (Moreno *et al.*, 2021). The goal of the FMC is to develop compact neighbourhoods where people live, work, and play without long commuting times and therefore reducing car dependency and encouraging an active way of life. Furthermore, the concept leads to reduced environmental impact and improved quality of life for residents.

During and post the recent Covid-19 pandemic the FMC concept was rapidly realised for the first time in Paris by Mayor Anna Hidalgo (Moreno *et al.*, 2021; Yeung, 2021). Due to lockdowns imposed by the government to prevent the further spread of the disease, residents of the city were restricted in mobility to one kilometre from their residence making the step to a FMC smaller and kickstarting the movement (Yeung, 2021). Due to the success of the implementation in Paris, other cities around the world also started implementing the concept and adjusting the concept to easily fit different communities and cities (Moreno *et al.*, 2021; Municipality of Utrecht, 2021b). In addition, international organisations like the C40 cities and UN-Habitat started promoting the concept to raise people's quality of living in urban areas both during and post-covid (C40, 2020; UN-Habitat, 2020).

However, previous studies have provided evidence for inequality in access to public spaces, especially public green spaces (Zhou and Kim, 2013; Xu *et al.*, 2018; Luo *et al.*, 2022). Access to public green spaces "refers to residents' fair access to green space, not affected by other residents' factors" (Luo *et al.*, 2022) and is important since "green space may reduce people's exposure to air pollution by promoting carbon sequestration and oxygen production, absorbing air pollutants, and mitigating the urban heat island's effect" (Luo *et al.*, 2022). Referring to the FMC concept, there is a growing concern that within the concept the inequity in green spaces will grow between different neighbourhoods (Luo *et al.*, 2022).

To investigate this concern further this research performs a case study on the Dutch city of Utrecht. The city is expected to grow to 450.000 inhabitants by 2040, from currently just over 350.000, and is introducing the *10-minute city*, a variant of the FMC, as a strategic vision for the city by 2040 (Municipality of Utrecht, 2021b). The vision is adopted by the city council of Utrecht, but the plans have not been transformed into official plans (Municipality of Utrecht, 2021a). Green spaces are taken into consideration within the strategic vision, for example, the city aims to have green spaces for everyone within walking distance by 2040 (Municipality of Utrecht, 2021b). However, research on the current inequity of green spaces is missing. Therefore, the municipality is possibly unaware of the negative effects the introduction of the concept will cause. By looking at the current inequity of green spaces, the city of Utrecht can consider these results for the implementation of the "10-minute city" and prevent inequity, and the negative effects of this inequity, by 2040.

2.2 Research problem

As established in the introduction, limited research on the inequity of green spaces from the perspective of a FMC exists. However, there is a research gap in the geographical context of the Netherlands. This research aims to fill this research gap by performing a case study on the city of Utrecht. The city aims to introduce a *10-minute city,* a variant of the FMC, but research on the inequity in access to public green spaces this causes is lacking. Therefore, the main research question of this study is: *To what extent does the introduction of the 10-minute city concept in the city of Utrecht cause inequity in public green spaces?*

To help answer this main research question, the following sub-question have been formulated:

1. How does the possible inequity spatially differ in the amount of public green spaces?
2. How does the possible inequity spatially differ between the different types of public green spaces?
3. To what extent does the possible inequity spatially differ between walking and cycling as a mode of transport?

2.3 Structure of the bachelor project

The paper introduces the concepts and theories used throughout the study, like the FMC concept and public green spaces. After the theories and concepts are introduced, the (inter)connections between them are discussed in the conceptual model. This is followed by the hypothesis of the research by the author. In the methodology section, the datasets and data analysis scheme is explained in-depth to ensure the replicability of the analysis. After the analysis is explained the results are visualized and explained. This is followed by a discussion of the results relating to the sub-research questions. Finally, a conclusion is given to summarise the results of the thesis.

3. Theoretical framework

3.1 The 15-minute city concept

The *15-minute city* concept, or “la ville du quart d’heure” was first introduced by French urban planner Carlos Moreno in 2015 (Moreno *et al.*, 2021; Municipality of Paris, 2022). In essence, the concept aims to locate essential services and amenities within 15 minutes of walking or cycling distance from residences. While the term can be considered new, the concept itself can be traced to the ‘neighbourhood units’ from American urban planner Clarence Perry (Perry, 1929). He argued that cities should be organised into self-contained neighbourhoods with a range of services and amenities within walking distance from the residents’ homes. The main difference with the FMC is that Perry’s concept focuses more on the *community* and *social cohesion* aspects, while the FMC concept focuses more on the aspects of *sustainability* and *resilient neighbourhoods*. This shift can be attributed to the crises that urban areas are facing currently, as mentioned in the background. Walking and cycling are selected as modes of transport (MoT) since they are active MoTs, meaning they result in physical exercise for the users, and have a low carbon impact. Both factors relate positively to the aims of the FMC, like encouraging an active way of life.

After the introduction of the FMC concept by Moreno, other urban planners adjusted the concept slightly to fit into certain case studies. For example, Da Silva et al. (2019) introduced the 20-minute city in conjunction with a case study of Tempe, a city in Arizona. The travel time is adjusted to the geographical context of the case, but the overall concept remains to make essential services and amenities reachable within a certain amount of time by sustainable modes of transport (Capasso Da Silva, King and Lemar, 2019). Other examples are the “15-minute walkable neighbourhood” and the “10-minute city” (Moreno *et al.*, 2021; Municipality of Utrecht, 2021b). The concepts all share a close resemblance and thus can be labelled as the *x-minute city* concept, where the x can be replaced by a different amount of minutes.

Further building on the concept, Moreno *et al.* (2021) introduced the FMC framework, which identified four dimensions to adopt for cities to offer “an urban life that could be categorized as being of high value”(Moreno *et al.*, 2021). These dimensions reflect challenges that cities were facing during and post-covid. By following the four dimensions as a guide, the authors argue that some issues during the pandemic could have been avoided. For example, allowing people to practice activities such as exercising through walking while limiting social contact (Moreno *et al.*, 2021).

The framework (figure 2) starts with density, which means “that density ultimately allows sustainability pursuits to be achieved on the economic, social and environmental frontiers.”(Moreno *et al.*, 2021). The density of an area, therefore, depends on the economic, social, and environmental context of the area. The second dimension, proximity, consists of two major aspects. Firstly, increasing proximity reduces the commuting time for individuals. Secondly, it contributes to lower environmental impact (Moreno *et al.*, 2021). The third dimension is diversity, which also has two aspects. Firstly, the need for a mixed-use neighbourhood to make the FMC work. Secondly, the need for diversity in culture and people. Both of these make the neighbourhood more economically resilient and increase liveability (Moreno *et al.*, 2021). The last dimension, digitalization, strengthens all other dimensions by combining new technologies and draws ideas from the Smart City concept. This is further visualised by the arrows from and to *urban data* and *urban services.*

Figure 2. *'The FMC Framework'*

3.2 Public green spaces

Public green space is a broad term and is defined differently by multiple authors. For example, in his research on "passive" ecological gentrification, Broitman (2022) considers *parks*, *agricultural* and *natural land uses*. The strategic vision made by the municipality of Utrecht takes a different approach by looking at geographical scales. The first scale looks at greenery at street level while the biggest scale, the fifth, examines greenery surrounding the city area(Municipality of Utrecht, 2021b). In this thesis, both methods are considered, as well as the data available. This selection is further explored in the *variables* chapter.

Public green spaces are a key to success within the FMC concept, as argued by many urban planners discussing the topic (Moreno *et al.*, 2021; Municipality of Utrecht, 2021b; Luo *et al.*, 2022). The significance of public green spaces, as emphasized in the introduction, lies in their favourable influence on the well-being of residents. Examples are the absorption of unhealthy pollutants, diminishing the urban heat island effect and the facilitation of noise reduction (You, 2016; Luo *et al.*, 2022). Moreover, public green spaces provide residents with an area "to leisure, communicate and socially interact" (You, 2016), thereby aligning with multiple objectives of the FMC. Like the FMC concept, public green spaces became even more important during the recent covid-19 pandemic, both for physical and mental health (Broitman, 2022). This claim is further acknowledged by the fact that policymakers favoured access to public green spaces during the covid-19 pandemic over stricter lockdown measures (Broitman, 2022). In addition, the perception of public green spaces shifted during and post-covid; people show increased interest and place more value in the proximity to them.

However, inequality in both access to and usage of public green spaces also became more evident during the pandemic (Broitman, 2022). As mentioned in the background, local governments imposed limitations on travel distance during the pandemic. Due to these restrictions, people living in neighbourhoods with less or no public green spaces could not, or not to the extent other neighbourhoods could use public green spaces. This inequity occurs in both the amount of public green spaces as well as the variety of public green spaces people have access to. These two factors together determine the total inequity of public green spaces. The presence of inequity in public green spaces is undesirable as it results in inequity of the positive effects associated with the proximity to these spaces.

3.3 Conceptual model

Figure 3 presents the conceptual model of this study. The model starts at the bottom with the introduction of the FMC concept, adjusted to the case of Utrecht with the 10-minute variant. Within the FMC the two fundamental aims of the concept are identified: creating a sustainable and resilient neighbourhood and having essential services and amenities within 10 minutes. These aims can only be realised when equity is realised for access to all essential services and amenities, among which are public green spaces. In the conceptual model, this positive feedback loop is visualised by a green arrow. The red dotted line visualises inequity due to a lack of access to public green spaces in certain areas. Due to the inequity, there is no feedback loop and therefore the aims of the FMC are not met. The model is limited to the travel distance imposed by the FMC for both MoTs supported in the concept.

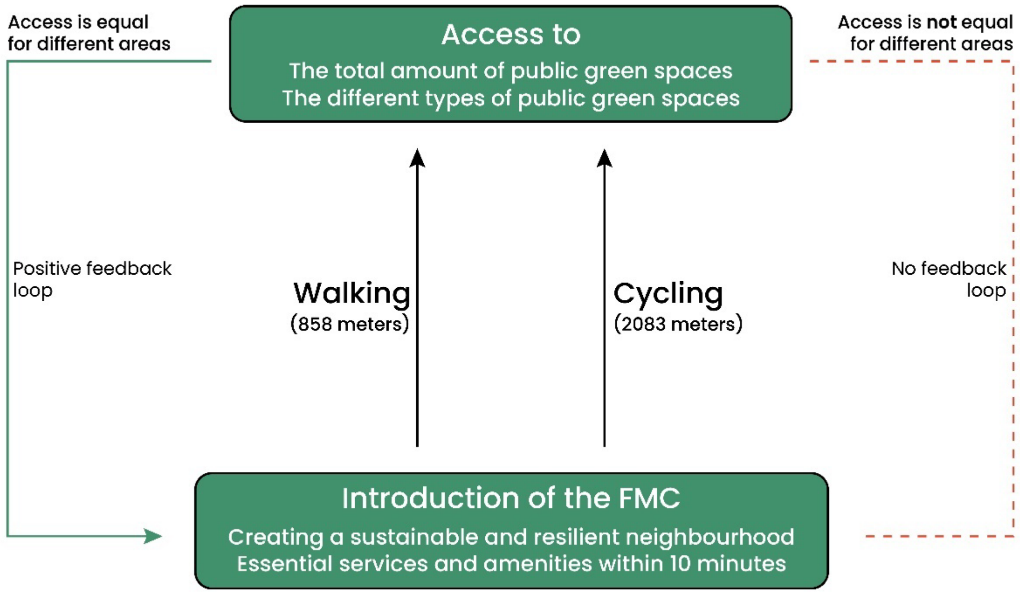

Figure 3. *'Conceptual Model'*

3.4 Hypothesis

Considering the current academic literature examined, the author has the following hypothesis for the main research question: 'The proposed introduction of the 10-minute concept in the city of Utrecht will cause inequity in green spaces.' However, since the proposed introduction is still a strategic vision, and not a policy document or concrete design, the proposed vision can still be amended to prevent the inequity of green spaces. While the proposed introduction of the 10-minute city concept might cause inequity in green spaces when not carefully considering this limitation when implementing the concept, the concept can bring major benefits to the city in terms of creating a sustainable and resilient city.

4. Methodology

4.1 Research method and data selection

To answer the research questions of the bachelor project a careful selection of a research method is necessary. While the research questions can be answered by both quantitative and qualitative research methods, a quantitative research method is preferred due to several reasons. Firstly, the research revolves around a concept which is currently not implemented in the case city of Utrecht. Therefore, qualitative methods such as questionnaires would give results on how respondents think about the concept and not the reality of the concept when implemented. When using a quantitative research method, the concept can be added without changing other variables. Secondly, there is a chance that a qualitative research method results in biased answers from the respondents. For example, respondents might give biased answers to questions about inequity in public green spaces in the hope of gaining personal advantages in the creation of new public green spaces in the future. Thirdly, individuals might have different personal values towards different public green spaces and therefore give different answers towards a value that should be factual.

The specific quantitative research method that is chosen for this research is a geo-data analysis. Multiple datasets are available and are published by different governmental and commercial institutions. By choosing a geo-data analysis, spatial patterns and perspectives can be analysed. Furthermore, the geo-data analysis makes it possible to visualize the analysis. Both factors bring the analysis to a higher level as well as make the research more accessible.

The data is analysed in a Geographical Information System (GIS), specifically ArcGIS Pro, and beautified with tools of the Adobe Creative Cloud suite. Furthermore, Excel is used for creating tables, figures and further analysing the data. To assess the inequity of public green spaces several datasets were analysed for compatibility and quality of data. For example, *the green map of the Netherlands*, published by the National Institute for Health and Environment (RIVM), and the *land use map*, published by the Central Bureau of Statistics (CBS), were considered for the analysis. While both datasets contain high-quality data on green spaces and land use throughout the Netherlands, the data is aggregated into 10-by-10-meter parcels or hectares. This makes analysis per individual public green space impossible, which is necessary to answer the sub-questions of the research. Furthermore, these datasets are not updated yearly and therefore lack recent additions to green spaces in the municipality of Utrecht. For example, in 2020 a former canal in the city centre was restored, while the latest version of the *land use map* was published in 2017 (CU2030, 2020).

A dataset that does meet the requirements is the *OSM land use* dataset from open street map (OSM) data, visualised for Utrecht in figure 4. OSM is an organization that builds freely accessible maps by using a large network of volunteers all over the world (OpenStreetMap.org, 2023a). The datasets from OSM are updated and available for download every 12 hours. The data used in this study was downloaded on the 8th of May 2023. While the data is not published by a governmental institution, the data can be considered of high quality due to the high rate of peer reviews performed by the community. In addition, large multinational companies like Strava, Snapchat and Uber rely on the datasets from OSM for the maps in their services (OpenStreetMap.org, 2023b). The *OSM land use* dataset consists of 27 different types of land use. Polygons of each individual land use can be found within the 27 different types. For example, there are 193 polygons with the land use *park* within 2083 meters of the municipality of Utrecht. Individual polygons per land use make it possible to perform analysis on individual public green spaces.

The *neighbourhood map* from the CBS is used for analysis on a neighbourhood scale. While the map is published on a national scale, the data is collected by all individual municipalities. The dataset includes key figures per neighbourhood, like socioeconomic numbers on the inhabitants of the neighbourhood. In addition, the dataset enables to limit the analysis to the selected case, Utrecht, and the individual neighbourhoods within the municipality. This is possible since the data is available as a vector file and therefore can be used within ArcGIS Pro. The latest version, published in 2022, is used for the analysis in this research. While this date does not match the exact date of the download of the *OSM land use* dataset, this does not impact the analysis. The dataset is only used to spatially divide the data per neighbourhood. Since 2022 there have not been any changes in the spatial distribution of neighbourhoods in Utrecht. In the appendix, figure 21 shows the different neighbourhoods.

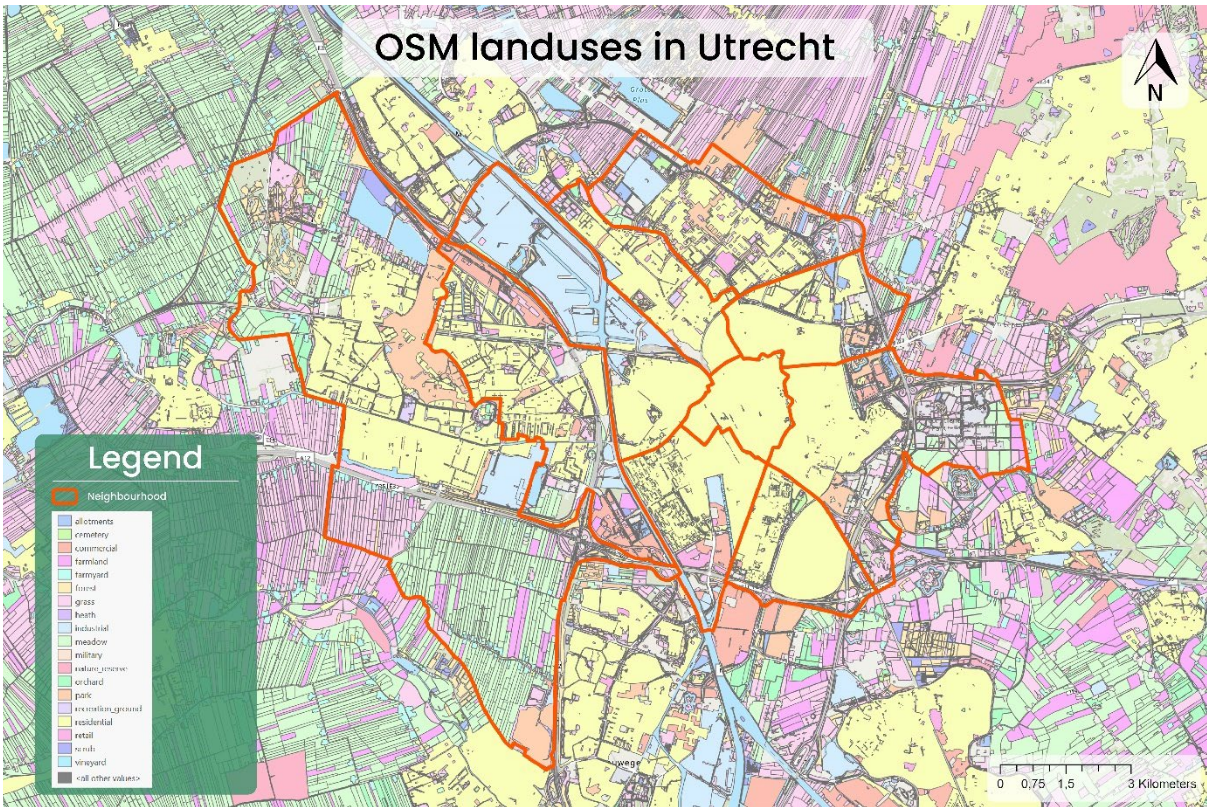

Figure 4. 'The OSM land use dataset combined with the neighbourhood map from the CBS'

4.2 Variables

The independent variable used in the analysis is the distance that can be travelled in 10 minutes by either cycling or walking from the selected public green space. The 10 minutes is chosen to assess whether a current implementation of the strategic vision by the municipality of Utrecht will cause inequity in public green spaces. The travel distances for each MoT associated with 10 minutes are in table 5. In practice, residents would be able to commute distances exceeding the 10-minute limitation to access a specific public green area. Nonetheless, to evaluate the FMC concept itself, a strict boundary of 10 minutes is established within the analysis.

Mode of Transport	Average speed	Travel distance
Walking	1,43 m/s (Bosina and Weidmann, 2017)	858 meters
Cycling	3,47 m/s (Ministerie van Infrastructuur en Waterstaat, 2018)	2083 meters

Table 5. 'Travel distance per MoT'

Only a few of the land use layers within the *OSM land use* dataset can be considered a public green space. These layers were selected based on both similar studies, like the paper on *passive ecological gentrification* by Broitman (2022) and personal judgement from the author. Furthermore, only types of public green spaces were selected that are present in or close to the municipality of Utrecht. In the original dataset, the water layer was split into a few different layers. Since the dataset does not differ in other categories, like for example different parks in different layers, the water layers were merged into one layer. In table 6 a summary of the selected layers can be found.

#	Types of public green space	Description
1	Water	Bodies of water like lakes and rivers
2	Park	A park
3	Meadow	A meadow, possibly used for grazing cattle
4	Nature reserve	A nature reserve
5	Recreation ground	An open green space for general recreation
6	Orchard	An area used for growing fruit-bearing trees
7	Grass	An area where grass grows
8	Forest	A forest or woodland

Table 6. 'Types of public green spaces'

4.3 Data analysis scheme

In this section, the processing of data and the analysis is further explained. As mentioned before, the analysis itself was performed in the GIS programme ArcGIS Pro. Since the *OSM land use* dataset is an open dataset made by volunteers, it is important to first assess the quality of the dataset. Individual public green spaces were selected at random and compared to both satellite imagery and observations made within the city of Utrecht by the author. Overall, the dataset proved to be highly accurate. Only a single polygon in the layer *nature reserve* was removed from the analysis since the location was not an actual nature reserve. However, due to the large number of polygons within the dataset, it is impossible to examine all polygons. Therefore, it is important to account for possible minor inaccuracies in the results due to wrongly coded land uses.

Before the start of the analysis all polygons further away than 2083 meters from the municipality borders of Utrecht were removed since they would not influence the analysis. The analysis starts by separating all types of public green spaces into individual layers (figure 8). For each of the eight layers, a buffer analysis is performed based on the polygons inside the layers. The size of the buffer is set to 858 meters, the distance a person can walk in 10 minutes (figure 9). This step is repeated with a buffer size of 2083 meters, the distance a person can cycle in 10 minutes. This results in 18 layers with buffers. By creating these buffers around the individual polygons, it is possible to visualize the reach of each public green space. The analysis scheme for all the different steps is visualised in figure 7.

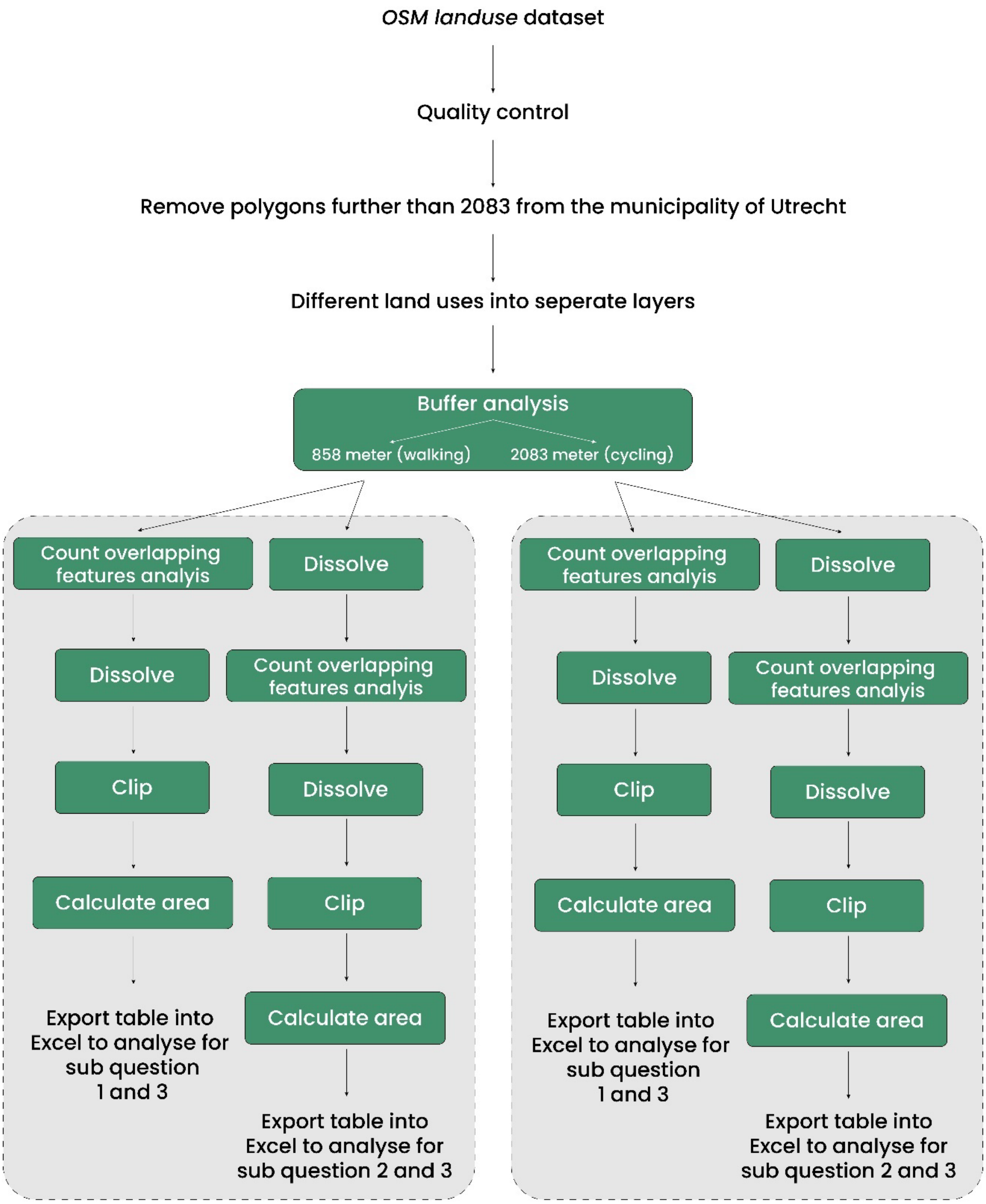

Figure 7. 'Data analysis scheme'

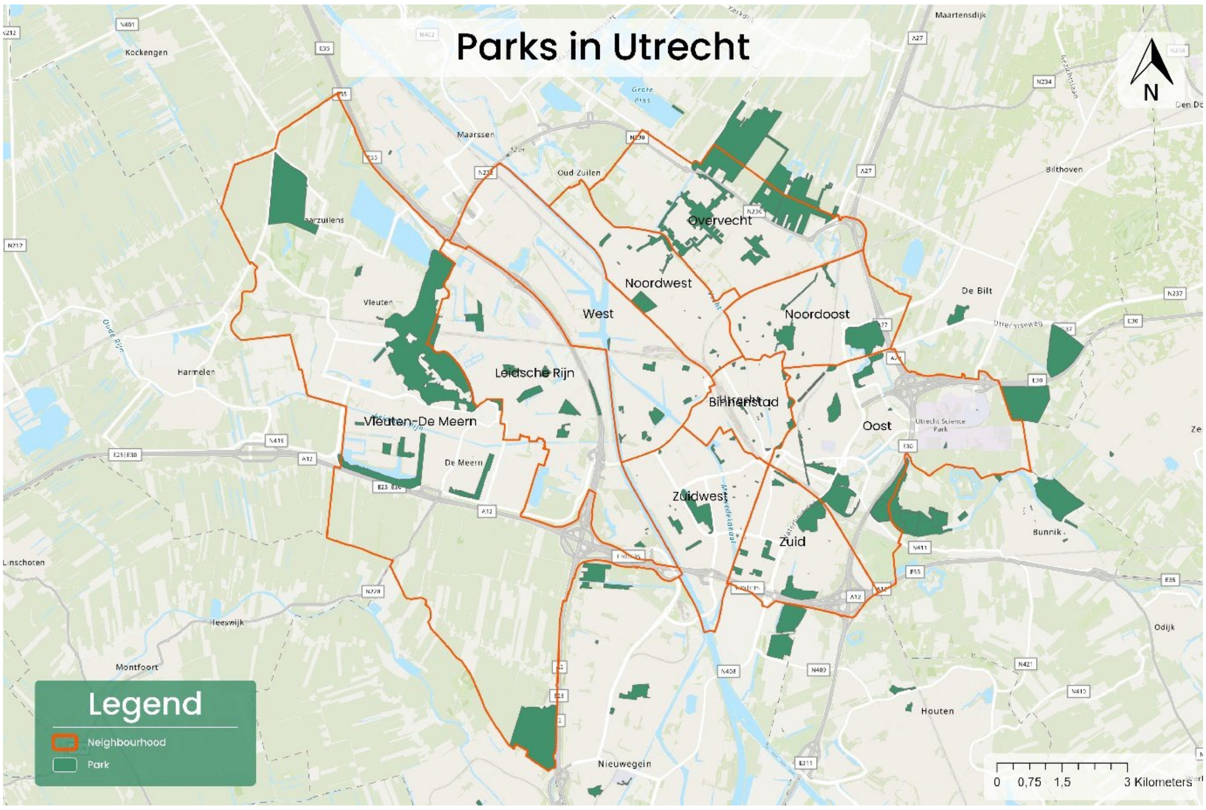

Figure 8. 'Individual parks in Utrecht'

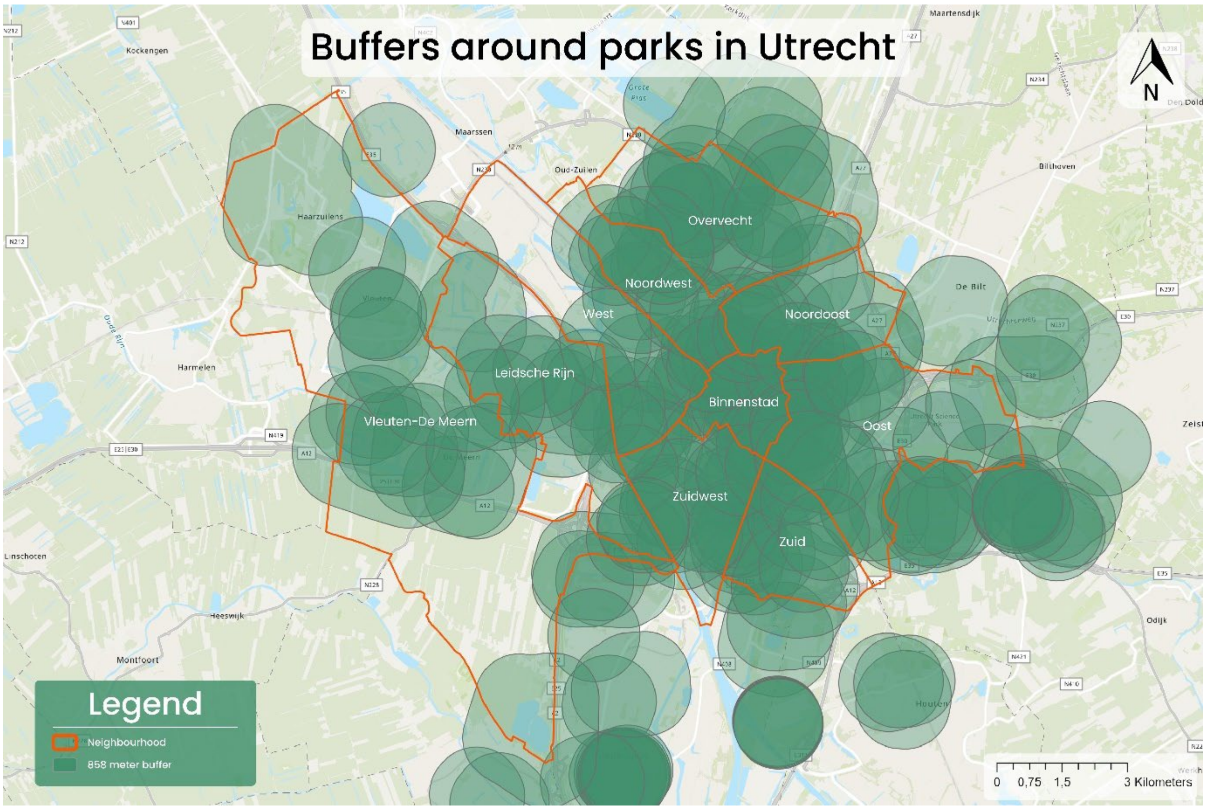

Figure 9. 'Buffers around each park for walking distance'

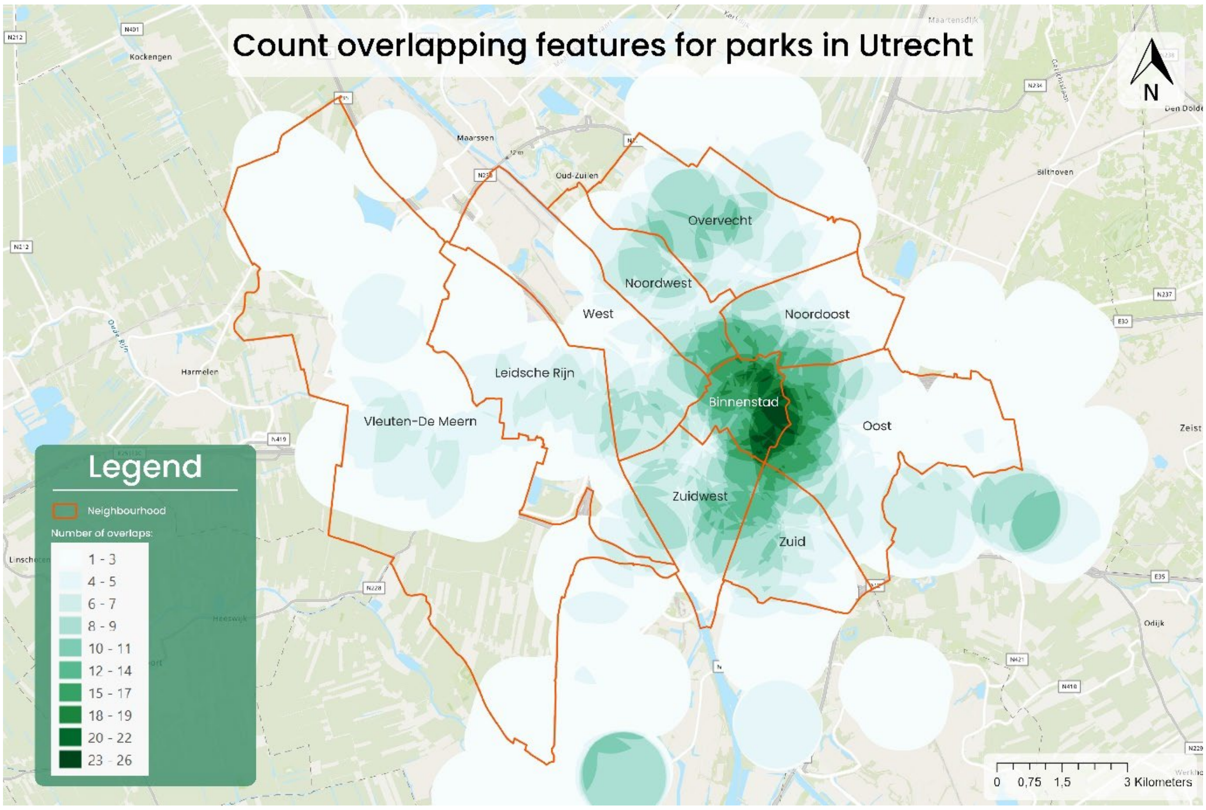

Figure 10. 'Count overlapping features analysis on park buffers for walking distance'

To answer sub-question one, a count overlapping features analysis was performed. The input for the tool was all eight buffer layers from either walking or cycling. By performing this analysis, two maps were created visualizing how many public green spaces were within reach by each MoT for the whole area of the municipality of Utrecht (figure 11). To analyse the data further, the two maps were dissolved per *count_overlapping_features* and clipped per neighbourhood. For each neighbourhood, the area in square meters per *count_overlapping_features* was calculated and exported into Excel. The *count_overlapping_features* column equals the number of buffers that are overlapping each other. In other words, the amount of public green spaces a person living in this spatial area has access to within 10 minutes. The export to Excel makes it possible to calculate averages and percentages of areas with a certain *count_overlapping_features* per neighbourhood. This step is necessary to answer sub-question three.

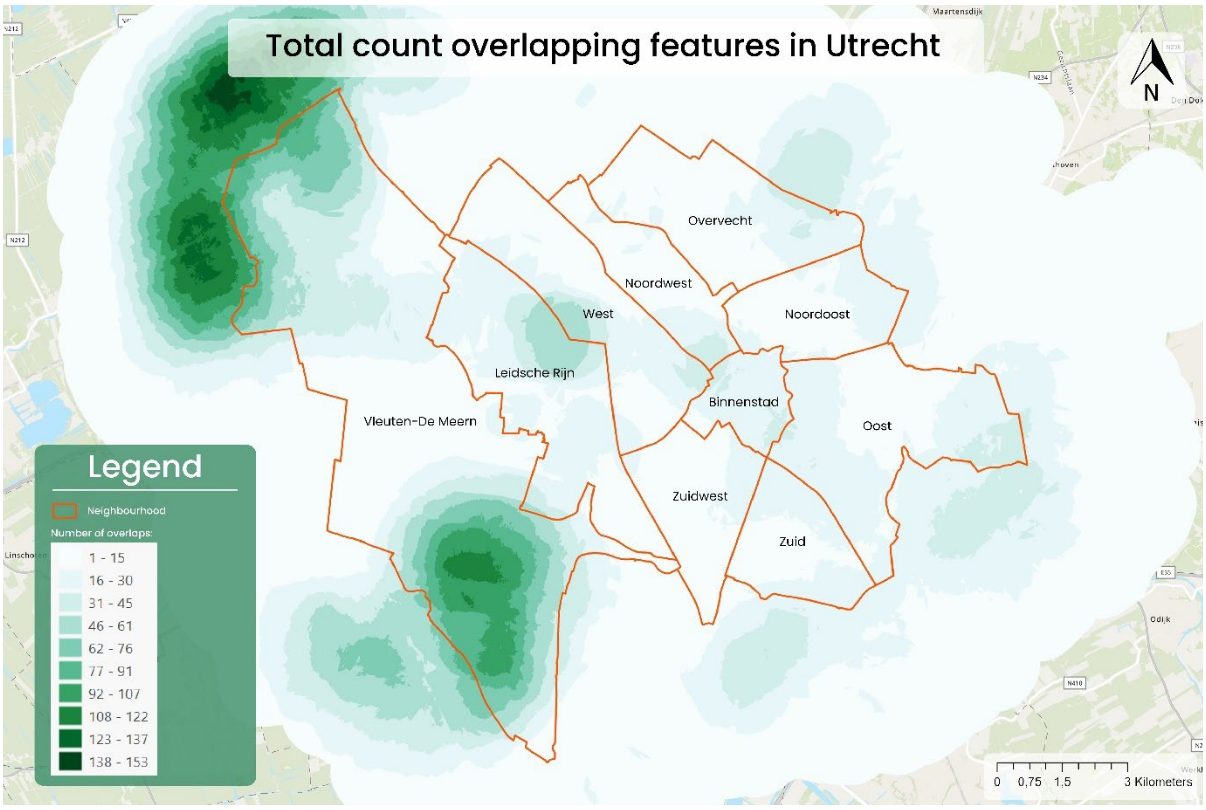

Figure 11. 'Total count overlapping features for the total amount for walking distance'

To answer sub-question two, the eight layers per mode of transport with buffers were dissolved based on the buffers inside each layer. The result of the dissolve is that a map is created per layer with all the area that has at least one buffer overlapping the area in a polygon (figure 12). Per mode of transport, a count overlapping features analysis was performed. This analysis counts for the two modes of transport to how many of the eight types of public green space each area has access to. Like the analysis scheme to answer sub-question one, these two maps were dissolved per *count_overlapping_features* and clipped per neighbourhood. The area of each *count_overlapping_features* was calculated and exported into Excel to support.

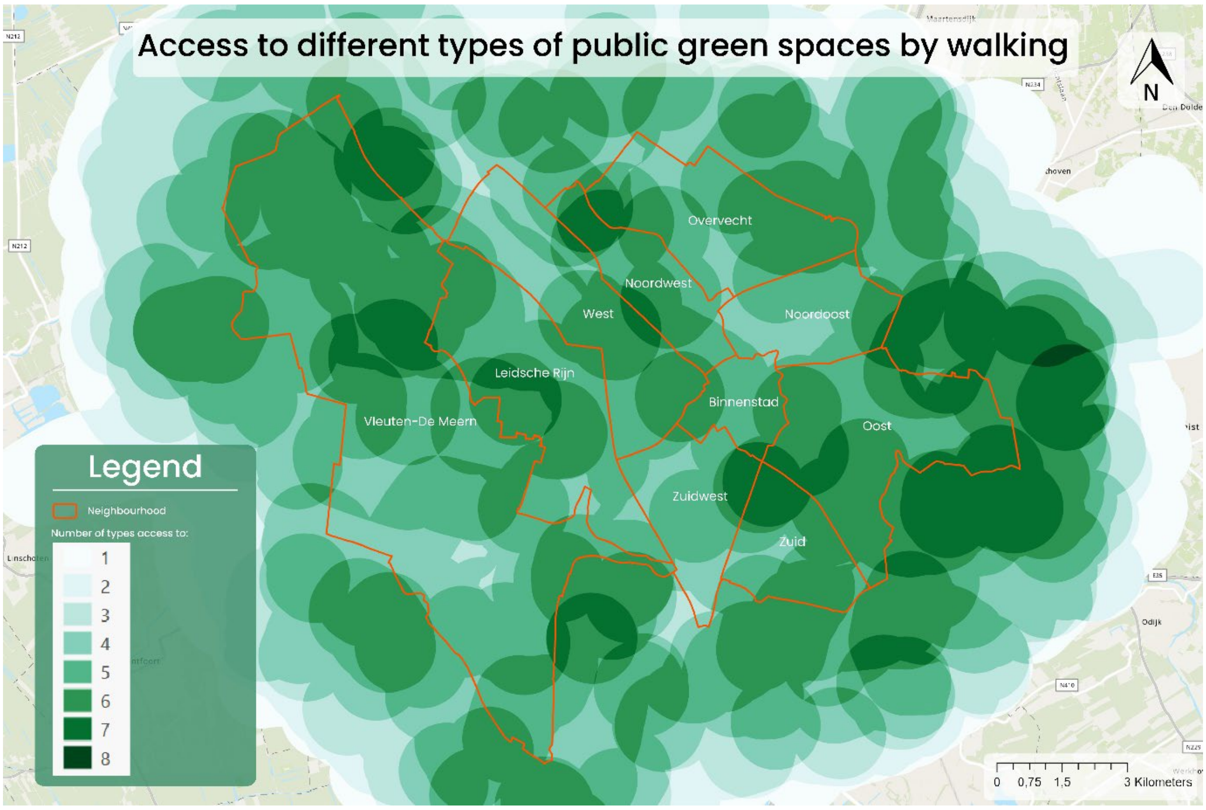

Figure 12. 'Count overlapping features for different types for walking distance'

5. Results

In this paragraph, the results of the analysis stated in chapter four are described. The results are visualised both on maps exported from ArcGIS Pro and bar charts exported from Excel. Furthermore, interesting numbers, like the deviation from an average, are extracted from Excel and listed in the description.

5.1 Spatial distribution of inequity in the amount of public green spaces

Before reviewing the results of subchapter 5.1, it is important to note that the analysis performed for this subchapter is incomplete. Due to the size of both the *grass* and *forest* layers, ArcGIS Pro was not able to calculate the number of overlaps for these layers. This limitation is further discussed in chapter 6.1. Therefore, the results discussed in this subchapter are only based on the first six public green spaces in table 6.

Figure 13 visualises the distribution of the total amount of public green spaces when walking. Large dark green spots can be found in the southern and northern parts of the neighbourhood *Vleuten-De Meern*, where areas can be found with access to up to 153 public green spaces. This is in stark contrast with the other neighbourhoods, where no dark green areas are evident and most neighbourhoods seem to have a similar colour palette. This trend can also be seen in figure 14, where the average access to the number of public green spaces per neighbourhood is shown. The neighbourhood *Vleuten-De Meern* has more than double the access to the number of public green spaces when compared to the average of all neighbourhoods. It is important to note that this is an average and that *Vleuten-De Meern* also has parts with access to fewer amounts of public green spaces. The large difference between the neighbourhoods mainly occurs due to the large amount of smaller public green spaces just outside the neighbourhood, and not just the size of the neighbourhood itself. In both figures 13 and 14, it is evident that the average in the other neighbourhoods is lower. Only the *Binnenstad* and *Leidsche Rijn* neighbourhoods scored slightly higher than the overall average, with scores of 24,59 and 22,58.

When looking at the same visualisations with the cycling MoT, figure 15 and 16, a similar trend can be seen. While more neighbourhoods are closer to the average, the neighbourhood *Vleuten-De Meern* has access on average to almost twice the amount of public green spaces than the overall average, with the average being 100,64 compared to 197,80 for *Vleuten-De Meern*. This is caused by the same areas in the north and south of the neighbourhood which again appear as dark green areas in figure 15.

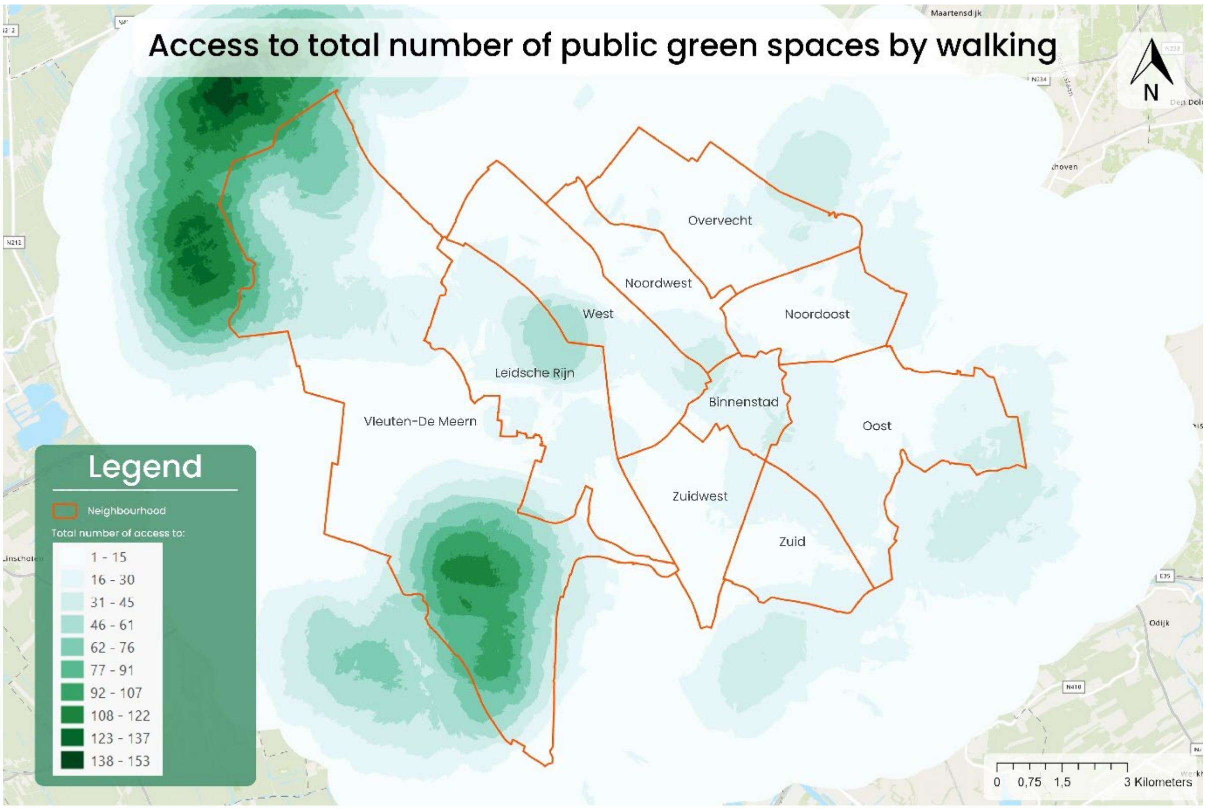

Figure 13. 'Access to the total number of public green spaces by walking'

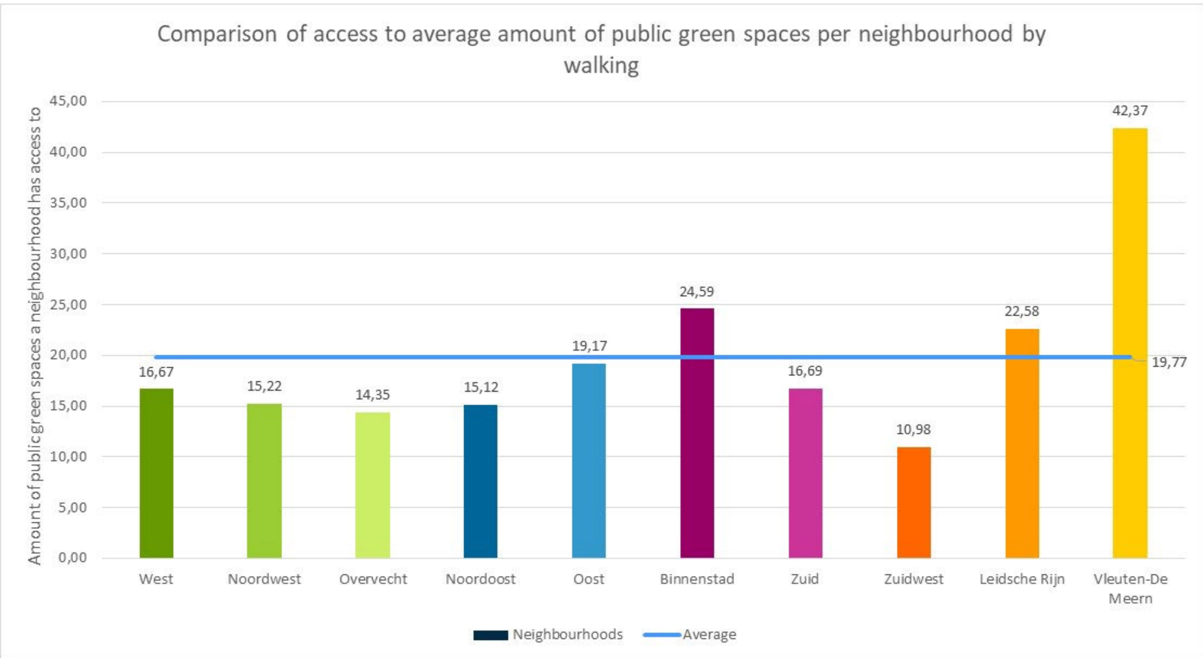

Figure 14. 'Comparison of access to the average amount of public green spaces per neighbourhood by walking'

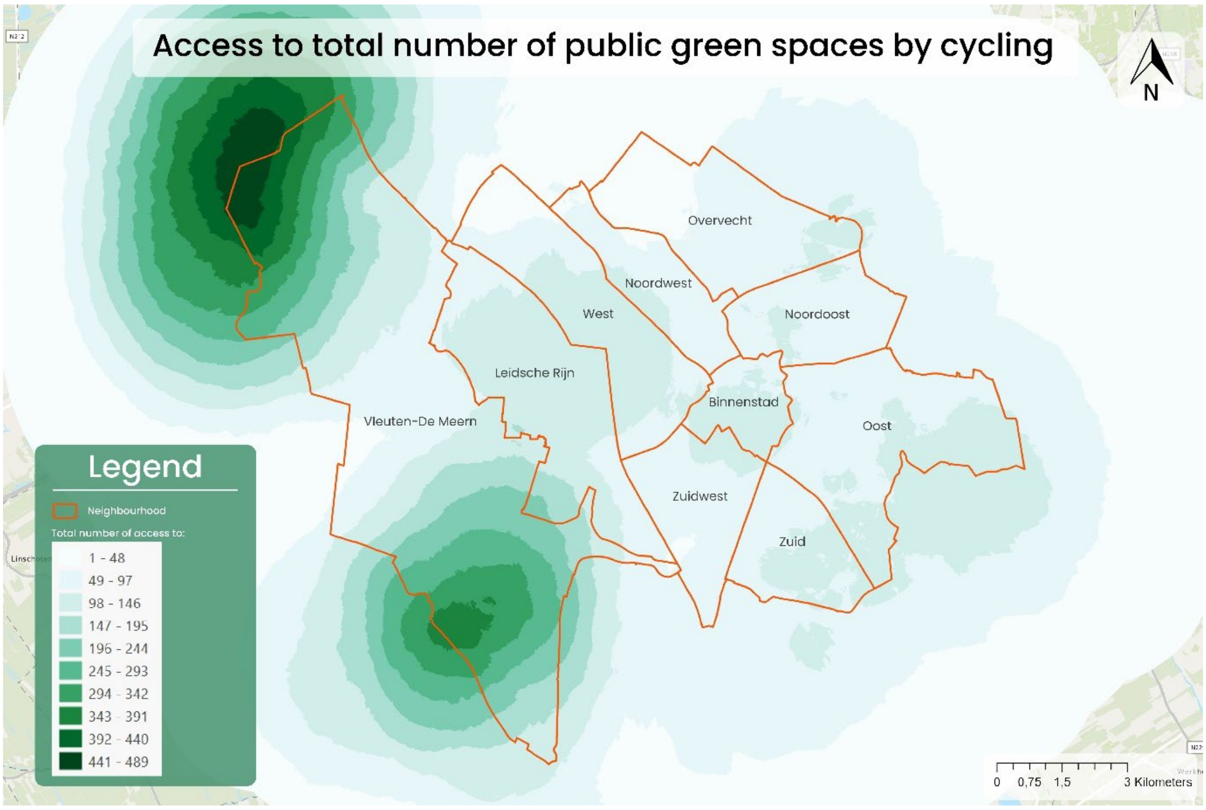

Figure 15. 'Access to the total number of public green spaces by cycling'

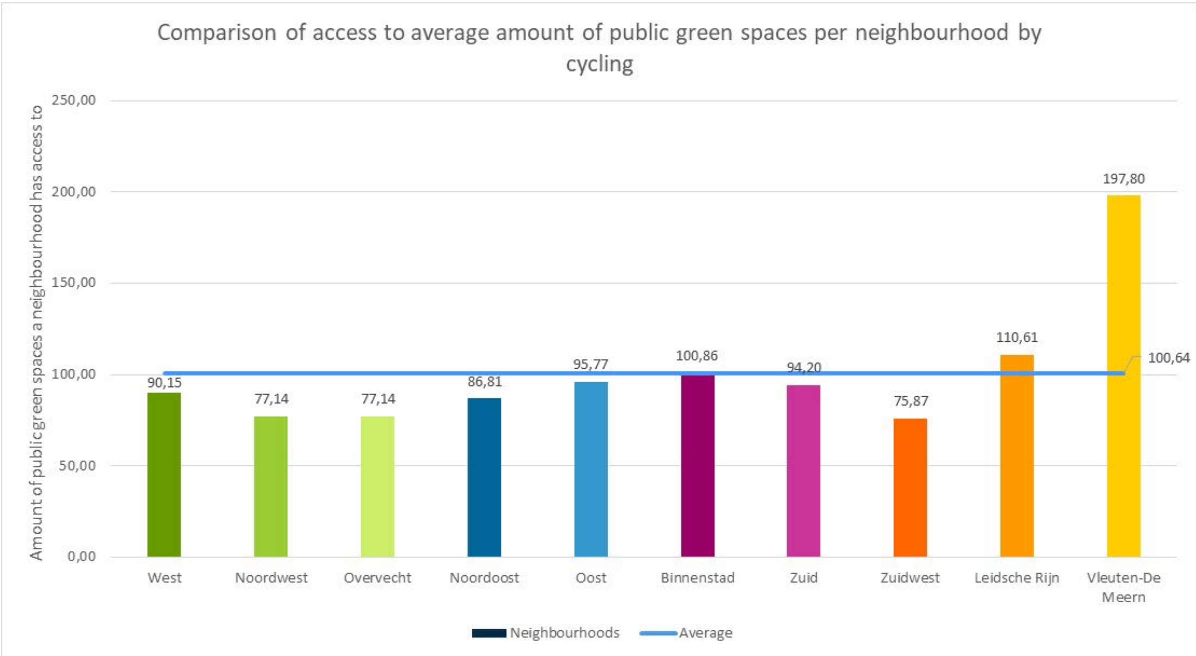

Figure 16. 'Comparison of access to the average amount of public green spaces per neighbourhood by cycling'

5.2 Spatial distribution of inequity in the different types of public green spaces

In figure 17, the inequity in average access to the different types of public green spaces by walking is visualized. All different neighbourhoods are close to the average, with a maximum deviation of 0,59. This is consistent with figure 18, where a palette of light to dark green circles is evident throughout the city. There are no areas with access to all the different types of public green spaces. In the neighbourhoods *West*, *Zuidwest* and *Vleuten-De Meern* areas exist with access to three different public green spaces, the lowest rating throughout the municipality.

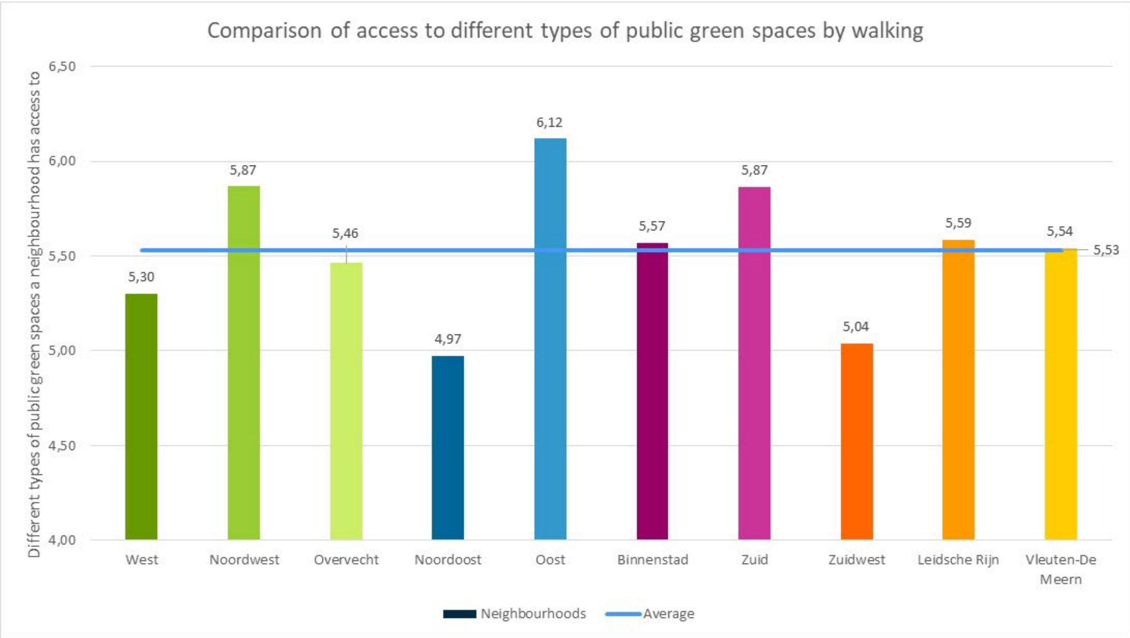

Figure 17. 'Comparison of access to different types of public green spaces by walking'

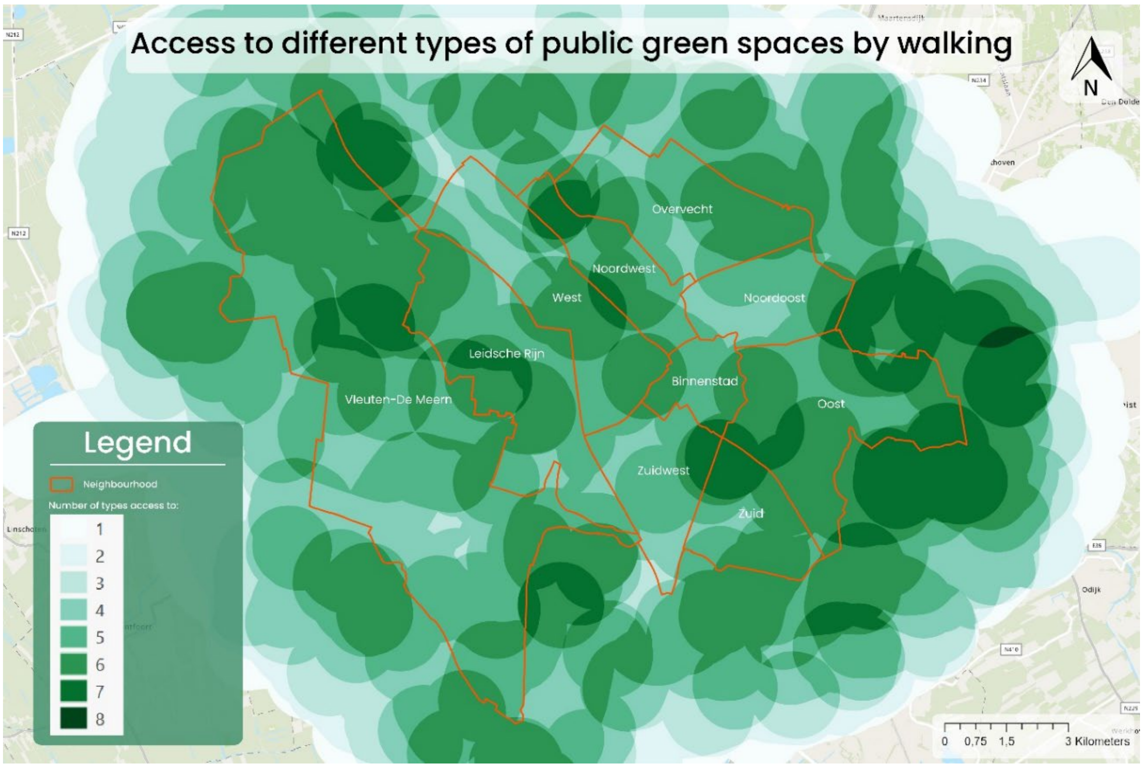

Figure 18. 'Map of access to different types of public green by walking'

In the same figure for the cycling mode of transport (figure 19), the different neighbourhoods are overall closer to the average. However, the maximum deviation for cycling is larger than for walking. The *Oost* neighbourhood deviates 0,72 from the average. This is caused by 73,9% of the neighbourhood having access to all different types of public green spaces. The whole municipality has no areas with access to five or fewer different types of public green spaces by cycling, while several parts of the municipality have access to all types of public green spaces. This is visualized by the dark green areas in figure 20.

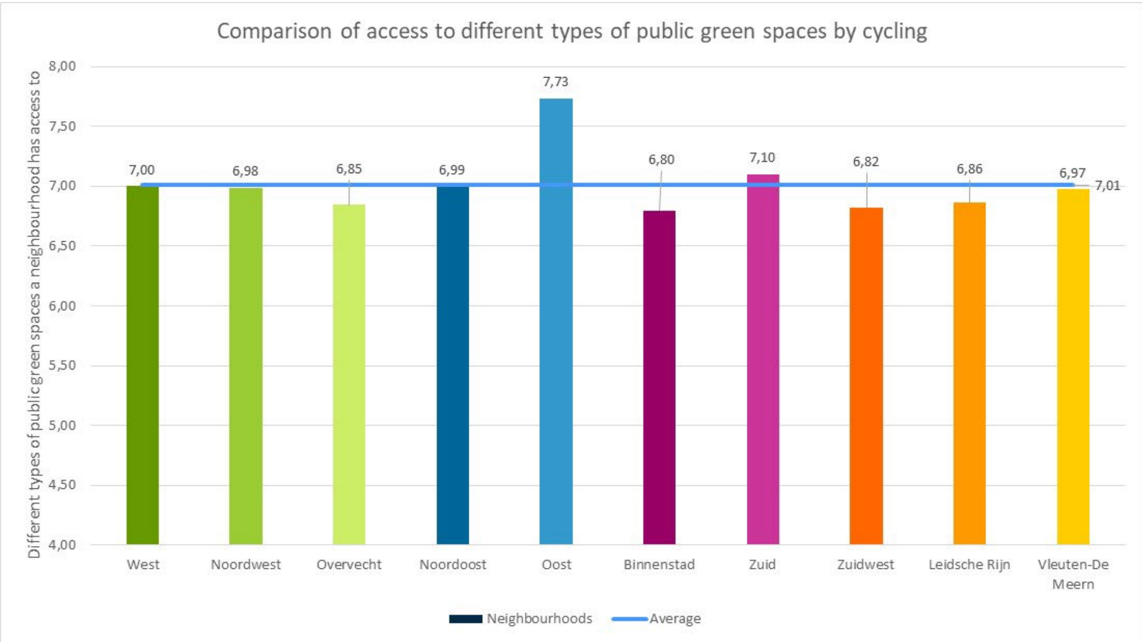

Figure 19. 'Comparison of access to different types of public green spaces by cycling'

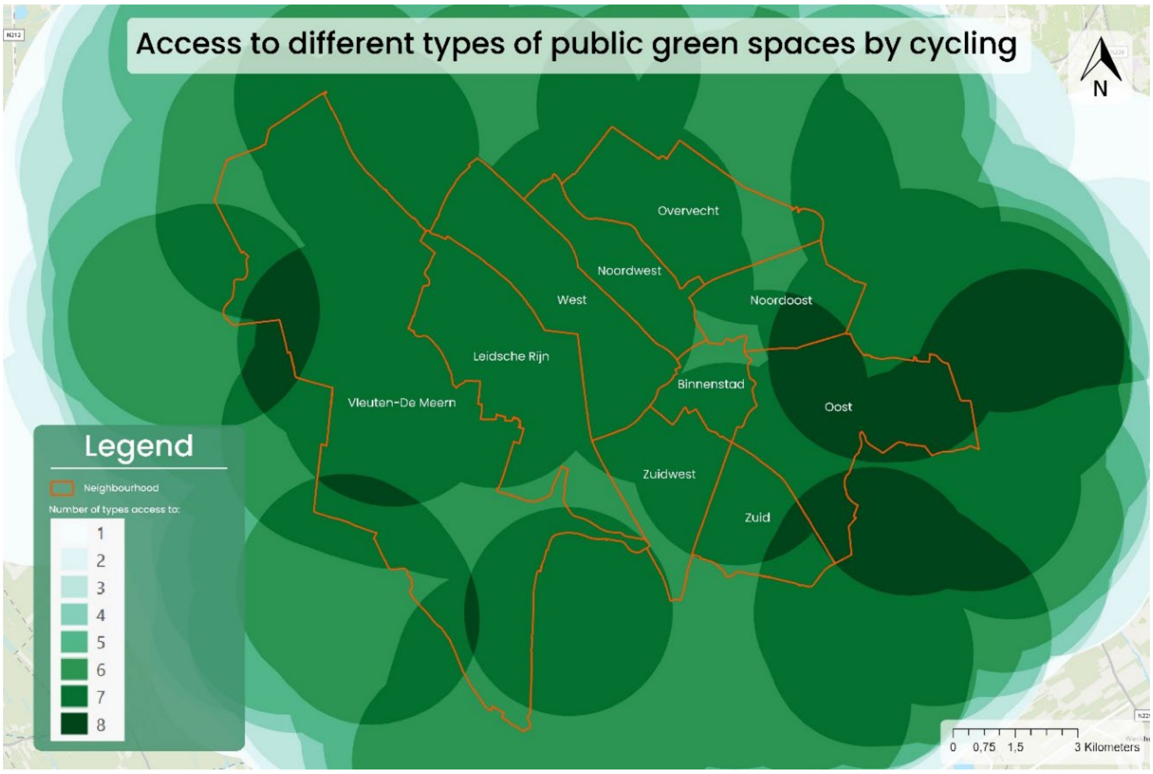

Figure 20. 'Map of access to different types of public green by cycling'

5.3 Spatial difference in inequity between walking and cycling

Starting with the analysis of access to the total amount of public green spaces, the largest difference between walking and cycling is the total number of public green spaces areas have access to. With the larger travel distance associated with cycling, the average increases from 19,77 to 100,64, an increase of more than 408%. The maximum increases even further from 123 to 486 public green spaces. The whole municipality has access to at least 30 public green spaces when cycling, while for walking areas exist which have access to as little as one public green space. Additionally, due to the longer travel distance, the different neighbourhoods move closer to the average compared to walking, with the exclusion of *Vleuten-De Meern*. Similarities are also evident, like the neighbourhood *Zuid* scoring lowest for both walking and cycling.

Within the analysis of access to different types of public green spaces, there are differences to be noted between the two modes of transport. First, there are larger differences between the neighbourhoods in the walking analysis. The maximum difference in average per neighbourhood when walking equals 1,14, while this is only 0,93 for cycling. Furthermore, the analysis for walking results in values between 3 and 7, a total of 5 different values, while the analysis for cycling only results in values between 6 and 8, a total of 3 different values. Second, the analysis shows that the results for cycling are higher on average than cycling.

However, there are also similarities between the two modes of transport. Neighbourhoods that score lower on average when walking also score lower on average when cycling. For example, the *Zuidoost* neighbourhood scores lower than average on both modes of transport. The opposite is also true; neighbourhoods scoring higher than average when walking also score higher than average when cycling. A clear example of this is the *Oost* neighbourhood.

6. Discussion

Following previous literature, which suggested that the FMC might cause inequity in access to public green spaces (Zhou and Kim, 2013; Xu *et al.*, 2018; Luo *et al.*, 2022), the results of this study indicate that by introducing the 10-minute city in Utrecht neighbourhoods have different equities in access to public green spaces. The first sub-research question is answered by figures 14 and 15, which show that throughout the city the access to the amount of public green spaces differs. For example, *Vleuten-De Meern* has more than double the access than *Zuidwest*, showing the large difference in equity. Furthermore, from figures 13 and 15 can be concluded that the average amount of public green spaces neighbourhoods have access to differ majorly. In addition, there appears to be a trend that areas that score low based on walking also score low on cycling.

Figures 18 and 20 illustrate the answer to sub-research question two. While the differences between neighbourhoods are lower than with the first sub-research question, there still are deviations from the average. However, especially for cycling as a mode of transport, all areas within the municipality have access to at least six of the eight types of public green spaces. As described in the conceptual model, it is important to have equal access to different types of public green spaces to be able to attain the positive feedback loop and therefore achieve the aims of the FMC.

For the third sub-research question it follows that there are major differences between the two modes of transport. When examining the average access to the different types of public green spaces, walking (5,53) scores significantly lower than cycling (7,01) out of a maximum score of eight. The differences in access to the total amount of public green spaces are even larger, differing by several hundred. These results are in line with the hypothesis of the author. While a difference between MoTs might not cause more inequity in the same space, it can cause inequity between groups of people who are not able to use one of the MoTs, and therefore the results need to be considered.

As is explained by the conceptual model, this has effects on the aims of the FMC concept, or in the case of Utrecht the implementation of the 10-minute city. If the municipality would introduce the concept without changing the currently available public green spaces, the inequity would cause the aims of the FMC less likely to be realised. These aims are to create a sustainable and resilient neighbourhood and have essential services and amenities within 15 minutes, both can only be realised by creating equity in the access to public green spaces. The results for the three different sub-questions differ too largely to conclude specific neighbourhoods, since a neighbourhood might score high on one account of inequity, but low on another account.

6.1 Reflection on incomplete analysis

As briefly discussed in paragraph 5.1, the analysis for sub-question one is incomplete. Specifically, the *grass* and *forest* layers are too large to perform a *count overlapping features* analysis tool in ArcGIS Pro. Due to the large number of polygons in these layers, the tool needed to calculate the number of overlapping features for several million individual parts. Attempts were made by the author to perform the calculation in different GIS programmes or via the High-Performance Computing cluster from the Rijksuniversiteit Groningen. Unfortunately, the author was unable to complete these steps due to time constraints. Therefore, it is important to consider when reviewing the results and conclusion that part of the analysis is incomplete and that inequity in access to the total amount of public green spaces might be higher or lower than currently visualised in figures 13 to 16.

7. Conclusion

In conclusion, the study finds that there currently seems to be an inequity in the access to public green spaces in the municipality of Utrecht when implementing the 10-minute city concept. This inequity is evident in the amount of public green spaces neighbourhoods have access to, as well as the different types of public green spaces. Between the two common modes of transportation in the FMC, walking and cycling, there are large differences. This is because by cycling a person can reach further distances in 10 minutes and thus able to reach more public green spaces. However, especially for the cycling mode of transport, inequity is less evident than for walking. This relates to the concern that the introduction of the FMC concept can cause further inequity in access to public green spaces.

The strengths of the thesis, and especially the analysis, are the use of big data in a GIS analysis to result in high qualitative results. Furthermore, the data used is publicly available and updated every 12 hours, making it possible to track the inequity in the future. A large weakness of the study is the inability to perform a part of the analysis due to the size of the data. This caused issues in the tools used to analyse the data and therefore parts of the results in sub-question one are incomplete. Another weakness is the lack of statistics to compare the inequity of public green spaces. This limitation is caused by the unavailability of studies with similar analyses.

A recommendation for future research is to investigate the possible link of inequity with socio-economic factors, like housing prices, or immigration backgrounds of the inhabitants. Currently, the study only compares the different neighbourhoods. It would be both academically and societally relevant to investigate whether certain groups of people experience more inequity than others.

8. Appendix

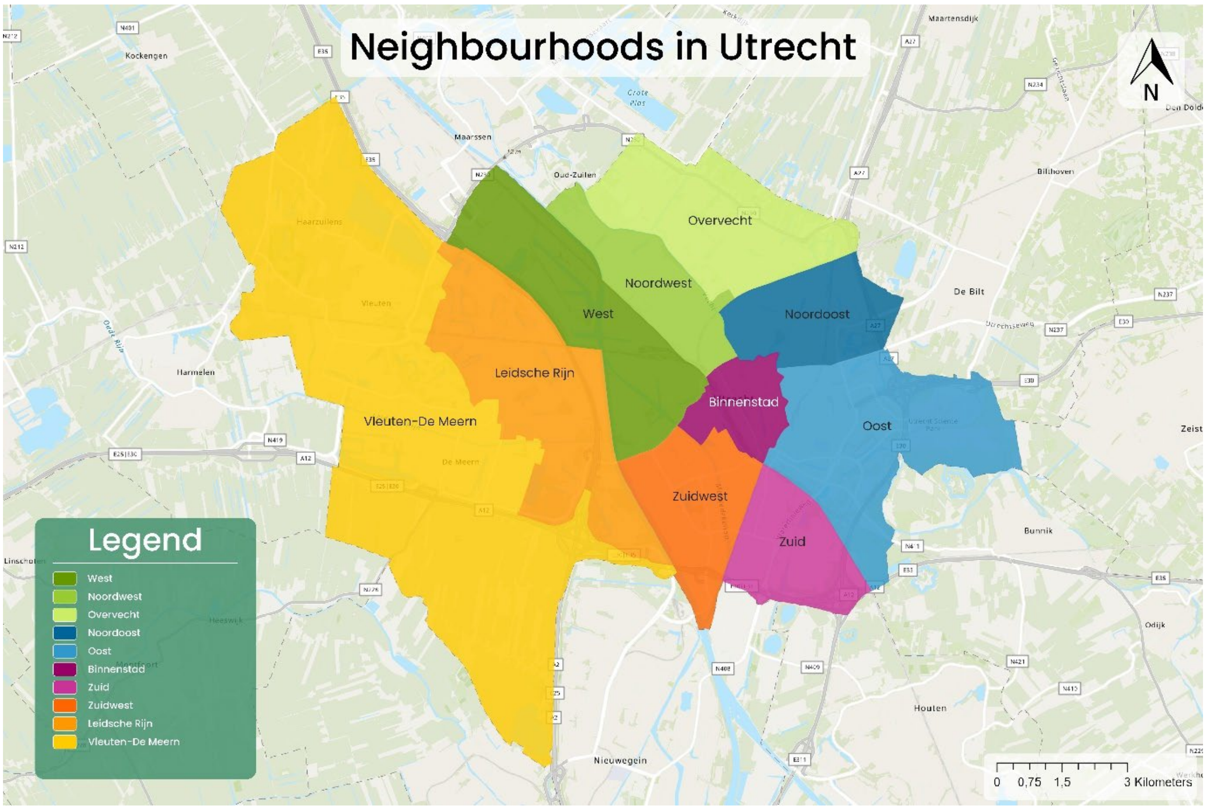

Figure 21. 'Neighbourhoods in Utrecht'

9. References

Below all references for the bachelor project are listed. Underneath the reference per figure and table are listed.

Bosina, E. and Weidmann, U. (2017) 'Estimating pedestrian speed using aggregated literature data', *Physica A: Statistical Mechanics and its Applications*, 468, pp. 1–29. Available at: https://doi.org/10.1016/j.physa.2016.09.044.

Broitman, D. (2022) '"Passive" Ecological Gentrification Triggered by the Covid-19 Pandemic', *Urban Planning*, 8(1). Available at: https://doi.org/10.17645/up.v8i1.6015.

C40 (2020) *How to build back better with a 15-minute city*. Available at: https://www.c40knowledgehub.org/s/article/How-to-build-back-better-with-a-15-minute-city?language=en_US&laguage=en_US#:~%7B%7D:text=In%20a%20\T1\textquoteright%2015-minute%20city\T1\textquoteright%20%2C%20all%20citizens%20are,and%20sustainable%20way%20of%20life (Accessed: 19 March 2023).

Capasso Da Silva, D., King, D.A. and Lemar, S. (2019) 'Accessibility in Practice: 20-Minute City as a Sustainability Planning Goal', *Sustainability*, 12(1), p. 129. Available at: https://doi.org/10.3390/su12010129.

Cook, J. *et al.* (2016) 'Consensus on consensus: a synthesis of consensus estimates on human-caused global warming', *Environmental Research Letters*, 11(4), p. 048002. Available at: https://doi.org/10.1088/1748-9326/11/4/048002.

CU2030 (2020) *Singel - CU2030*. Available at: https://cu2030.nl/project/singel (Accessed: 3 June 2023).

European Commission (2023) *Causes of climate change*. Available at: https://climate.ec.europa.eu/climate-change/causes-climate-change_en (Accessed: 19 March 2023).

Gurney, K.R. *et al.* (2022) 'Greenhouse gas emissions from global cities under SSP/RCP scenarios, 1990 to 2100', *Global Environmental Change*, 73, p. 102478. Available at: https://doi.org/10.1016/j.gloenvcha.2022.102478.

Luo, J. *et al.* (2022) 'Assessing Inequity in Green Space Exposure toward a "15-Minute City" in Zhengzhou, China: Using Deep Learning and Urban Big Data', *International Journal of Environmental Research and Public Health*, 19(10), p. 5798. Available at: https://doi.org/10.3390/ijerph19105798.

Ministerie van Infrastructuur en Waterstaat (2018) 'Cycling facts'. Netherlands Institute for Transport Policy Analysis.

Moran, D. *et al.* (2018) 'Carbon footprints of 13 000 cities', *Environmental Research Letters*, 13(6), p. 064041. Available at: https://doi.org/10.1088/1748-9326/aac72a.

Moreno, C. *et al.* (2021) 'Introducing the "15-Minute City": Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities', *Smart Cities*, 4(1), pp. 93–111. Available at: https://doi.org/10.3390/smartcities4010006.

Municipality of Paris (2022) *Paris ville du quart d'heure, ou le pari de la proximité*. Available at: https://www.paris.fr/dossiers/paris-ville-du-quart-d-heure-ou-le-pari-de-la-proximite-37 (Accessed: 19 March 2023).

Municipality of Utrecht (2021a) *Document Utrecht - Utrecht Dichtbij de tienminutenstad; Ruimtelijke Strategie Utrecht 2040 (na verwerking amendementen).pdf - iBabs RIS*. Available at: https://utrecht.bestuurlijkeinformatie.nl/Agenda/Document/dedcc939-ae80-46dc-a5b4-c980f12c082b?documentId=4362ead0-fb95-4aa5-a3fe-05bea0682fcb&agendaItemId=07474971-31c5-490a-b44b-21a50f2a0ebe (Accessed: 26 March 2023).

Municipality of Utrecht (2021b) 'Utrecht dichtbij: de tien-minutenstad. Ruimtelijke Strategie Utrecht 2040', p. 217.

OKRA (2020) *MERWEDEKANAAL, ZONE 5*. Available at: https://www.okra.nl/en/projects/merwedekanaalzone-deelgebied-5-utrecht/.

OpenStreetMap.org (2023a) *About OpenStreetMap*. Available at: https://wiki.openstreetmap.org/wiki/About_OpenStreetMap (Accessed: 3 June 2023).

OpenStreetMap.org (2023b) *Major OpenStreetMap consumers*. Available at: https://wiki.openstreetmap.org/wiki/Major_OpenStreetMap_consumers (Accessed: 3 June 2023).

Perry, C.A. (1929) 'The Neighbourhood unit', in *Regional New York and Its Environs*. New York. Available at: https://onlinelibrary.wiley.com/doi/10.1002/ncr.4110181012.

UNFCCC (2023) *The Paris Agreement | UNFCCC*. Available at: https://unfccc.int/process-and-meetings/the-paris-agreement (Accessed: 19 March 2023).

UN-Habitat (2020) 'UN-Habitat key message on COVID-19 and public space'.

Xu, C. *et al.* (2018) 'Spatial variation of green space equity and its relation with urban dynamics: A case study in the region of Munich', *Ecological Indicators*, 93, pp. 512–523. Available at: https://doi.org/10.1016/j.ecolind.2018.05.024.

Yeung, P. (2021) *How '15-minute cities' will change the way we socialise*, *BBC*. Available at: https://www.bbc.com/worklife/article/20201214-how-15-minute-cities-will-change-the-way-we-socialise (Accessed: 19 March 2023).

You, H. (2016) 'Characterizing the inequalities in urban public green space provision in Shenzhen, China', *Habitat International*, 56, pp. 176–180. Available at: https://doi.org/10.1016/j.habitatint.2016.05.006.

Zhou, X. and Kim, J. (2013) 'Social disparities in tree canopy and park accessibility: A case study of six cities in Illinois using GIS and remote sensing', *Urban Forestry & Urban Greening*, 12(1), pp. 88–97. Available at: https://doi.org/10.1016/j.ufug.2012.11.004.

10. Figures and tables

Figure 1. (OKRA, 2020)

Figure 2. (Moreno *et al.*, 2021)

Figure/table 3 to 21. Own work