GIMA
Geographical Information Management and Applications

Amsterdam and the spatial justice debate

Studying the distributional equality of urban greenery

Master Thesis

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Abstract

Green spaces are crucial for urban functioning, since they provide many indispensable benefits. Considering these benefits, urban green spaces (UGS) should be equally distributed over the population. However, this is not always the case: many scholars believe that neighbourhoods with a high socioeconomic status (SES) have more greenery than neighbourhoods with a low SES. Additionally, UGS is often treated as an uniform whole, with no distinction between public and private, even though they have different meanings to their users. The following research will consider these issues in Amsterdam. This thesis therefore has three aims: (1) to develop a method to properly distinguish between private and public vegetation; (2) to provide insight into the spatial equality of the distribution of urban green spaces in Amsterdam; and (3) to contribute to the broader societal dialogue concerning spatial justice in relation to UGS. These objectives generated the following research question: *How spatially equal is the distribution of private and public green spaces in the city of Amsterdam and how does this relate to the spatial justice debate?* In this GIS-based research, a distinction between private and public green spaces will be made and the distributions of those will be studied in relation to SES. Afterwards, the results will be validated by linking them to existing literature. The results show great disparities in the amount of green space between neighbourhoods. Residents of neighbourhoods located more in the outskirts of the city have access to more private and public UGS. Private green space is more equally distributed than public green space, but still with large differences. Additionally, high SES neighbourhoods are located in the city centre and south of the centre, whereas low SES neighbourhoods are found more towards the boundaries of the city. Visual interpretation of these patterns suggests that areas with lower SES generally provide access to slightly more total, private and public UGS than high SES neighbourhoods. Yet, these observations are largely invalidated by statistical analysis. The unequal distribution of UGS in Amsterdam therefore seems to be the result of other factors, besides neighbourhood SES. These findings for Amsterdam do therefore not correspond to the dominant spatial justice paradigm that more SES is accompanied with more UGS, but can be linked to conclusions of scholars who state that other factors should be taken into consideration when determining spatial justice and that results may vary across space.

Preface and acknowledgements

Almost every individual will agree on the fact that urban greenery delivers essential contributions to the city life. Who does not like a nice walk in a green environment, or a vegetated garden to catch some sunlight while enjoying your morning coffee? I am born and raised in Amsterdam and after the twenty-four years I have lived in this city, it still charms me. I have even developed, like a real cocky Amsterdammer, a true fascination for the functioning of the city. However, greenery is in a lot of places scarce in this city. Bearing this and my background as a Human Geographer in mind, a fruitful curiosity for this research subject was developed and with this thesis, I was able to bring my interest into practice.

The thesis that lays in front of you is part of the Geographical Information Management and Application master, commissioned by the University of Utrecht, University of Twente, University of Wageningen, and Delft University of Technology. In the beginning I was somewhat insecure whether my capabilities would be sufficient for successful fulfilment of this thesis; I had, for instance, never worked with remote sensing before. Yet, here were are: six months of hard work – especially those last weeks spending more time in the library than at home were intense – have resulted in the thesis that is now in front of you.

Now that my thesis has reached completion, a word of thanks is in place. I want to express my gratitude to those who helped me along the bumpy road that is called my thesis. Firstly, and foremost, I want to thank my first supervisor Aldo Bergsma, my second supervisor Sjerp de Vries, and the responsible professor Ron van Lammeren for guiding me through the process, sharing their expertise with me and providing extensive feedback. Additionally, I want to thank Roland van Zoest, for supporting me by providing the required aerial photographs. Without this data, this research would not have been possible.

Furthermore, my profound gratitude goes to my friends and family, who were there for me, encouraged me and who had to listen to my enthusiasm, at a certain point replaced by a constant whining. Without them, writing this thesis would have been an abhorrent process.

Last but not least, I would like to thank all other people that in some way contributed to this thesis, by investing valuable time and energy in me.

That said, I hope you enjoy reading my thesis.

Heleen Elenbaas
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List of abbreviations

AIC	Akaike Information Criteria
BAG	Basis Registration Addresses and Buildings, *Basisregistratie Adressen en Gebouwen*
BRT	Basis Registration Topography, *Basisregistratie Topografie*
CBS	Dutch Office for Statistics, *Centraal Bureau voor de Statistiek*
CIR	Colour-infrared
DKK	Digital Cadastral Map, *Digitale Kadastrale Kaart*
ESS	Ecosystem services
FGS	Formal green spaces
GI	Green infrastructure
GIS	Geographical Information System
GML	Geography Markup Language
IGS	Informal green spaces
MAUP	Modifiable area unit problem
NDVI	Normalized Difference Vegetation Index
NIR	Near-infrared
OLS	Ordinary Least Squares model
PEJ	Positive environmental justice
SAC	Spatial autocorrelation
SES	Socioeconomic status
SEM	Spatial Error Model
SLM	Spatial Lag Model
SPUGS	Small public urban green spaces
UGS	Urban green spaces
UHI	Urban heat island
WUR	Wageningen University and Research

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1. Introduction

In 2012, the World Health Organization (WHO) warned in their programme for health and sustainable development that current urbanization paces result in unhealthy living environments for urban dwellers. Examples are the speaking images of people living on dump sites, slums with large numbers of people living on very small pieces of land and dwellers lacking access to clean water using the same river for preparing food, bathing and as a toilet. These cases might be the extreme ones in developing countries, but also in Western countries does urbanization lead to unhealthy conditions. Illustrations are highways completely blocked by the amount of cars leading to poisonous smog and in addition to that industries polluting surrounding air, land and water. Development and implementation of green space is often a suitable way to deal with these problems and to improve the situation, since these spaces provide fundamental components in any urban ecosystem and provide many health-related benefits (WHO, 2012). The WHO, and with them many scholars and urban planners hence emphasize the importance of green areas in urban environments.

Although the importance of vegetation is recognized, green space in cities is scarce and the amount of green space will, as a result of urbanization, reduce even more (Zhou & Wang, 2011). Two reservoirs of urban green that are the first to be compromised are public parkland and residential tree cover (Lin et al., 2015). But those are not the only urban green spaces (UGS). UGS include any natural or human-modified areas consisting of vegetation, water or other permeable surfaces (Wendel et al., 2011). This can be for instance public parks or domestic gardens, riverbanks, railway and road corridors or green spaces surrounding historical sites (Anguluri & Naranyanan, 2017). UGS less thought of are vegetated sport pitches (Houlden et al., 2017), cemeteries, storm water ponds (Wendel et al., 2011) or overgrown abandoned industrial sites (Anguluri & Naranyanan, 2017).

1.1 Problem definition

There are many benefits that together highlight the importance of urban green spaces. First of all, UGS provides crucial ecosystem services (Aalbers & Pauleit, 2013; Whitehead, 2009; Shen et al., 2017; Zhou & Wang, 2011; Lin et al., 2015; Anguluri & Narayanan, 2017; De La Barrera et al., 2015), such as mitigation of the urban heat island effect (UHI) (Maimaitiyiming et al., 2013; Zhou & Wang, 2011; Lin et al., 2015), or recreation (Aalbers & Pauleit, 2013; Zhou & Wang, 2011). Urban green spaces as parks and waterfronts also encourage people to engage in physical activity (Sallis & Glanz, 2006), which is important because urban lifestyles are becoming increasingly sedentary (Sallis & Glanz, 2006; Prior et al., 2014) and physical activity improves health (Yu et al., 2011). Besides this, it has been proven that urban green spaces contribute to mental wellbeing and improves quality of life (Houlden et al., 2017; Sallis & Glanz, 2006; Shen et al., 2017; Hoyle et al., 2017; Van Zoest & Hopman, 2014; Yao et al., 2014). Also, sufficient greenery contributes to the liveability of a neighbourhood and greater sustainability by relieving pressure of urbanization (Aalbers & Pauleit, 2013; Birge-Liberman, 2010; Haaland & Konijnendijk van den Bosch, 2015; Coolen & Meesters, 2012). The presence of UGS can, besides all benefits listed above, enhance property values of surrounding buildings. Although this appears to be a positive outcome, it can be perceived negative as well. Wüstemann and his co-authors highlight the paradoxical aspect of urban greening: "While the creation of urban green space to address environmental justice problems make neighbourhoods healthier and more attractive, it also can increase property values and housing costs what can lead to further gentrification and social segregation" (Wüstemann et al., 2017: 130).

Because of all the benefits and also a few burdens provided by urban greenery, UGS should be distributed evenly over the urban area and its population. Yet, this is not always the case. Urban dwellers living in neighbourhoods with lower socioeconomic status (SES) often have lower accessibility to and availability of UGS then their counterparts living in areas with a higher SES (Wen et al., 2013; Wüstemann et al., 2017; You, 2016; De La Barrera et al., 2015; Shen et al., 2017). The spatial distribution of green spaces over urban environments experienced increased attention of those in various fields, such as people working in health or spatial and urban planning (Horwood, 2011). This has led to a substantial body of literature discussing this distribution and most scholars' opinion seem to fit the discourse that there is a positive correlation between UGS and neighbourhood SES resulting in an unequal distribution of UGS. Various authors refer to this as a case of spatial injustice.

However, Lin et al. (2015) not only studied the distribution of UGS in relation to SES, but the authors also differentiated between various types of UGS. They found that neighbourhoods with higher SES generally have more residential tree cover yet less public parkland. Lin et al. interpreted residential tree cover as private UGS and public parkland as public UGS. Treating private and public UGS separately is interesting since they have different meanings and the concept of UGS should therefore not be treated as a uniform whole but should be subdivided in different categories (Coolen & Meesters, 2012). Though there is an extensive body of literature available on the topic of UGS distributions, Lin et al. (2015) are among the few that distinguish between different types of UGS. It therefore seems interesting to investigate the distribution of both private and public UGS in the light of the spatial justice discourse. However, according to Lin et al. (2015), private green space comprises also residential tree cover, although this reservoir of greenery is not truly private. It thus could also be interesting to develop a more appropriate distinction between private and public green spaces. Since this has not been done for the Netherlands, the city of Amsterdam has been chosen as study area for this thesis.

1.2 Research objective and questions

Set against the background elaborated above, this thesis addresses three research objectives. The first is to develop a method to properly distinct between private and public green spaces. By doing so is aimed at providing insight in the spatial equality of the distribution of urban green spaces in Amsterdam. This way, this thesis ambitiously aims at contributing to the broader societal discussion about spatial justice in relation to UGS, which is the third research objective. These objectives are translated in the following research question:

How spatially equal is the distribution of private and public green spaces in the city of Amsterdam and how does this relate to the spatial justice debate?

Spatial equality and spatial justice as well as the spatial distribution of public and private urban green spaces are the elements that form the basis of the research. These concepts generated four sub questions:

1. How is urban green space distributed in Amsterdam?
    a) How is public green space distributed in Amsterdam?
    b) How is private green space distributed in Amsterdam?
2. How is socioeconomic status distributed in Amsterdam?
3. To what extend is there a correlation between these distributions and how spatially equal is this distribution?
4. How do these results contribute to the spatial justice debate?

1.3 Relevance

The importance of urban ecosystem services is often underexposed (Derkzen et al., 2015). Yet ecosystem services highlight the crucial role green space plays in the urban. Due to urbanization, the provision of greenery in built-up environments is under pressure causing UGS and its ecosystem services often being compromised (Zhou & Wang, 2011). Moreover, UGS might be lost very soon without any action – a major challenge in urban areas with high urbanization rates (Derkzen et al., 2017). Additionally, green spaces are important in adapting to climate change, whether they are located are in urban environments or not. Furthermore, urbanization pressuring the availability of urban greenery is a societal issue. Therefore, research to the distribution of private and public green spaces over society in relation to socioeconomic differences in urban environments is crucial to society. This underpins the societal relevance of this thesis.

Besides that this subject discusses societal issues, it is also scientific highly relevant. There have been various studies carried out to the spatial justness of the distribution of UGS and it appears from the theoretical matter on this subject that a low socioeconomic status is generally associated with a small amount of green space. However, only a few of the studies carried out to UGS took place in the Netherlands. Some examples of research to UGS in the Netherlands are the studies of Derkzen et al. (2015), who studied the ecosystem services in Rotterdam; Van Zoest and Hopman (2014), who described new funding ways for green space since Dutch municipal budgets are under pressure, and Zhang et al. (2015), who studied green space attachment in comparison to health in two neighbourhoods in Groningen. Yet, these authors did not relate their research to SES or spatial justice. An example of a study that did incorporate the relation between SES and the distribution of UGS carried out in the Netherlands is provided by Li (2015), who explores the correlation between accessibility of UGS and neighbourhood SES. However, none of the studies to the urban greenery and socioeconomic status in the Netherlands made a distinction between private and public green spaces. Lin et al. (2015) are among the few who also did this, but in Sydney. Since this has not been done for the Netherlands, and more specifically for Amsterdam, this thesis responds to a gap in scientific knowledge. Furthermore, compared to the worldwide number of studies focusing on public UGS, only few focus on private UGS (Balooni et al., 2014). For these reasons this thesis will offer a valuable contribution to the existing literature and will thus be scientific relevant.

1.4 Reading guide

In remainder of this report, the conceptual framework will be developed in chapter 2. This chapter starts with an elaboration on green spaces, followed by an explanation of the spatial justice concept and will finalize with information on socioeconomic status. In chapter 3, the study area is described and thereafter the research methodology is outlined. In chapter 4, the results of the analyses will be presented, as well as the answers on each of the sub questions. Chapter 5 concludes with answering the main research question. This is followed by the discussion, in chapter 6. Here, some limitations of this research will be discussed. Also will be reacted on the research objectives. This report is completed by the bibliography and appendices.

2. Theoretical background and conceptual framework

For this chapter, an extensive literature review was held to develop a conceptual framework. This framework will serve as proverbial handhold for the developed methodology.

2.1 Urban green spaces

2.1.1 Defining urban green spaces

Scholars have developed numerous definitions for urban green spaces (UGS). Houlden et al. (2017) use a definition that comprises all areas of grass, trees or other vegetation. Anguluri & Narayanan (2017) do not only include vegetated spaces in their definition of UGS, but also abandoned industrial sites. Wendel et al. (2011) state that cemeteries and storm water ponds also can be considered as green spaces. Thus, green spaces do not necessarily have to be 'green' of colour as they can be 'blue' (water) or 'grey' (abandoned industrial sites). Some authors also include sport parks and golf courses. In this study, UGS are defined as all areas covered with vegetation and foliage.

The variations in ways of defining UGS highlight the fact that UGS is a broad concept (Horwood, 2011). Moreover, it is of interest to people in diverse fields, for example health professionals, environmental activists and urban planners. These actors all have different goals to achieve, resulting in diverse ways of framing UGS and additionally leading to various policy approaches. Horwood (2011) argues that the concept of Green Infrastructure (GI) can be used to integrate these multiple policy approaches into one that serves various wishes and needs. GI is defined by Banzhaf and De La Barrera as "an interconnected network of natural and semi-natural areas which maintain the natural ecological processes in the urban areas to contribute to health and quality of life for human beings" (Banzhaf & De La Barrera, 2017: 1). GI considers green space thus as a multifunctional network of green spaces providing various benefits (Horwood, 2011; Banzhaf & De La Barrera, 2017). The multifunctional aspect of GI creates opportunities to integrate different interests and can consequently be used for strategic planning.

Another way of approaching UGS is offered by Rupprecht and his co-authors (2015), who distinct between formal and informal green spaces. Formal green spaces (FGS) are those predestined as green space, such as parks (Rupprecht et al., 2015). Informal green spaces (IGS) on the other hand are not necessarily meant to function as green space. One can think of vacant lots, brownfields or railway verges. Considering the growing urban populations, formal green spaces in urban environments are increasingly insufficient in fulfilling residents' needs. Therefore, according to these authors, the role of IGS for the UGS infrastructure gains importance. Yet, their ecological status is often of limited quality, because of the unintentional formation. Although from the study of Rupprecht et al. (2015), held in Brisbane, Australia and Sapporo, Japan, appears that most residents generally value informal green spaces, this relationship between residents and IGS is complex and sometimes contradictory, for instance in the case of vacancy. Vacancy can be associated positively when it is considered as potential for urban greenery, but may also be negative when associated with decrepitude. In their study, Rupprecht et al. conclude that residents prefer a medium level of human interference in this complex balance: greenery should not appear too artificial but requires a certain level of maintenance.

The definition that Houlden et al. (2017) use to describe green spaces differs those from other authors in that it also includes the purpose of the area. They state that UGS are "deliberately reserved for recreational, aesthetic or environmental purposes" (Houlden et al., 2017: 2). Considering this in the light of the distinction between FGS and IGS as shown by Rupprecht et al. (2015), it can be stated that Houlden et al. therefore define formal green spaces.

2.1.2 The value of urban green spaces

As stated in the introduction, UGS have many benefits and are thus valuable elements in the urban environment. Green spaces are essential for urban ecosystems to provide ecosystem services (ESS) (WHO, 2012). Ecosystem services are the benefits humans obtain from the workings of the natural world and can be classified in supporting, regulating, provisioning and cultural services (Fitter et al., 2010). Supporting ecosystem services provide the basis that makes all other services possible. Concerning UGS, these include soil formation, water cycling and nutrient cycling. Regulating services regulate processes that contribute to human wellbeing. Examples of such services provided by UGS are climate regulation in case of the urban heat island effect, water purification, hazard protection when vegetated areas drain water in case of heavy rainfall and pollination of flowers and crops. Provisioning services supply humans with goods obtained from nature. Regarding UGS, one can think of for instance food provision in allotment gardens. The last category, cultural services, include spiritual, religious, aesthetic, inspirational, recreational or educational services. In urban green spaces this is for instance leisure, and the restorative effect or aesthetic value UGS have.

Because of all the benefits provided, UGS is often perceived to contribute to sustainable development (Rostami et al., 2015). In 1987, the Brundtland Commission defined sustainable development as development that meets the present needs without compromising ability of next generations to meet their needs (Brundtland Commission, 1987). UGS play an important role in sustainable development in cities (Rostami et al., 2015). Moreover, UGS contributes to sustainable development in three different fields. Firstly, environmental sustainability is enhanced by developing and maintaining vegetated areas since they provide regulating ESS, for example vegetation mitigating air pollution. As elaborated in earlier sections, UGS furthermore provide multiple other ecosystem services, crucial to maintain urban ecosystems. Second, green spaces contribute to the economic sustainability of a city, because UGS reinforce the identity of a city which will increase the attractiveness of the city for living and working but also for investments and tourism (Van Leeuwen et al., 2009). Third, UGS are of distinguished importance for social cohesion, as they encourage the use of outdoor spaces, bring people together and increase interaction among for instance neighbours. In the light of current trends of climate change and pressuring urbanization, sustainable development is of great importance, which highlights again the crucial presence of UGS.

2.1.3 Private VS public UGS

Based on ownership, there is a difference between public green space and private green space (Shen et al., 2017; Balooni et al., 2014). Public green spaces are "public goods that can be accessed freely by all citizens and mainly encompass vegetated natural spaces and human modified spaces" (Shen et al., 2017: 59), such as for instance urban parks. Private urban green spaces are not accessible for all and include among others domestic gardens. Coolen & Meesters (2012) investigated the meanings people attach to those spaces and conclude that private and public greenery have different notions. Whereas domestic gardens are considered as an outdoor extension of the dwelling, public parks are part of the environment of the dwelling, and are not part of the dwelling itself (Coolen & Meesters, 2012).

Because private and public UGS have different meanings to their users (Coolen & Meesters, 2012), it is interesting to compare and study the two categories apart. One of the studies making a distinction between private and public UGS is the study by Van Leeuwen et al. (2009). These authors categorize UGS in modern cities in four classes: limited public green space enriching ecological quality of space (such as flower beds or plants); open public space that serve recreational needs of visitors (such as parks to practice sports); private gardens attached to private properties meant for private use; and private UGS belonging to organizations such as schools and hospitals to create the feeling of openness, nature and health. In these four categories, there is a clear distinction between private and public green spaces.

Public and private green spaces are both important for the functioning of a city, but in a different way. Public green spaces and public spaces in general are important determinants in the construction of the identity of a city and formed the setting for public life across history (Banzhaf & De La Barrera, 2017). Also public green spaces function as a major factor in determining the meaning people attach to the public space. For instance, since public UGS provide areas for leisure and serve as a meeting point where interaction amongst people can take place. But additionally, public green spaces can also serve as a location for celebrations, honouring of sports teams, demonstrations or other events and may shape the way people feel about their city. Also Coolen and Meesters highlight the importance of having public UGS near the home: "The most valued open areas are often the intimate and familiar ones which play a part in people's daily lives, rather than the distant parks and outstanding landscapes far from the dwelling" (Coolen & Meesters, 2012: 52). Public UGS near the home is most valued by those who do not have a garden and contributes positively to a sense of nature.

Also private green spaces have always been important for cities, for instance in the growing of agricultural products (Van Leeuwen et al., 2009). Innovation and the development of new goods and services commonly takes place in urban areas. This also applies to innovative agriculture, generally starting on private patches in urban environments. Originating from historical periods, medieval towns already had to take care of their own food production inside the city walls and could not rely on the rural hinterland. This is less obvious nowadays since agricultural patches of land are rare within present-day city boundaries, yet other forms of urban agriculture have developed. Examples are community gardens, allotment gardens, school gardens and city farms. However, the most obvious form of private UGS is probably the garden attached to the dwelling. Private gardens are considered, amongst other things, as a place to be, a place of freedom, a place to own, to care for and to exert creativity and can contribute to a sense of escapism, identity, ownership and even relationships (Coolen & Meesters, 2012). Additionally, an important asset of residential gardens is privacy. For these reasons, back and front yards are important to inhabitants of the Netherlands, which is represented by the fact that over 80% of Dutch movers prefer having a garden over a balcony.

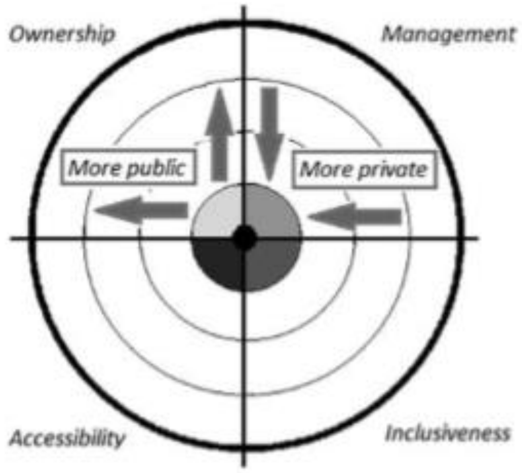
As from the sections above appears, both public and private green spaces are important for urban functioning. However, the way the distinction between private and public UGS is made in these sections is too simplistic because this distinction is in reality often ambiguous. The conceptual understanding of this difference is based on two concepts: ownership and access (Johnson & Glover, 2013). When looking at ownership, space can be publicly owned, or privately. Yet, this boundary is often fuzzy since hybrid forms of ownership emerge, such as public spaces controlled and managed by private parties or vice versa. However, ownership is often irrelevant to individual conceptions of spaces as public or private. It is therefore useful to consider how space is understood by its users because a publicly owned space does not necessarily imply unrestricted access. Therefore accessibility should be considered as well in the assessment of spaces as public or private. Johnson and Glover (2013) introduce a framework of how spaces can be classified based on these two concepts (see table 1).

Table 2.1: Access-ownership framework (Johnson & Glover, 2013).

	Easy to deny access/restricted access	**Difficult to deny access/unrestricted access**
Private ownership	Private-public space (e.g., a restaurant)	Common space (e.g., courtyard)
Public ownership	Club space (e.g., a municipal soccer stadium)	Outwardly public space (e.g., public park)

The classification of Johnson and Glover (2013) also applies to UGS. Private ownership and restricted access can be found in domestic gardens. An example of open access but private ownership is a courtyard (‘*hofje’* in Dutch). Areas with public ownership and restricted access are for instance military training grounds from the Ministry of Defence. The last category according to the taxonomy of Johnson and Glover (2013) are publicly owned spaces with unrestricted access, such as urban public parks. However, this distinction between private and public space is often perceived as simplistic since many forms of hybrid ownership and access have emerged (Johnson & Glover, 2013). Langstraat and Van Melik (2013) additionally state that an increasing number of publicly owned plazas, shopping centres but also UGS like urban parks are managed by private parties. According to these authors this leads to less government expenses and more well-maintained public spaces, in line with the discourse that it is more efficient to put production of services and goods, here public spaces, in hands of the market. Although these spaces managed by private parties may feel public for their users, they are not truly public. Langstraat and Van Melik (2013) therefore wonder whether this is 'the end of public space'. Because of the fuzzy separation between different forms of ownership and access, these authors proposed the 'OMAI model' for categorizing the publicness of spaces. The abbreviation OMAI represents the four dimensions ownership, management, accessibility and inclusiveness. In this model these dimensions are integrated into a pie chart. The larger the 'slice', the more public the space in that dimension (see figure 2.1). Considering this model is useful, since it is also applicable to UGS: ownership, management, accessibility and inclusiveness can, also regarding green spaces, vary in how public or private they are.

Figure 2.1: OMAI model (Langstraat & Van Melik, 2013).



Some scholars are worried about the increasing privatization of public space and more specifically public UGS. Yet the main concern in this 'end of public space' argument is not about the private ownership, but about the consequences this type of ownership involves (Langstraat & van Melik, 2013). Private ownership only becomes problematic when it leads to more restricted access.

It is important to understand how private and public green space is defined in this study because the results are dependent on these definitions. The distinction between private and public green spaces made will be based on accessibility and use rather than ownership. The use of the concepts of 'private' and 'public' therefore refer to respectively restricted access and unrestricted access instead of owned by private parties or owned by the state or parties related to the state. As mentioned before, Shen et al. (2017) define public UGS as green spaces that are freely accessible for all. In this thesis this definition is used as the basis of the conceptual understanding of public green spaces. All UGS that might have restricted access for some individuals, so where access can be denied, are thus not accessible to all and are therefore classified as private.

2.1.4 Future of UGS

Considering the increasing pressure of urbanization on the one hand and climate change on the other, maintaining and developing UGS is a challenge (Thierfelder & Kabisch, 2016). Additionally, cities often have tight budgets for urban planning and are dealing with an urban population with diversifying wants and needs. This results often in a decrease in the urban greenery. Many scholars therefore argue for the exploration of alternative ways of urban greening. Peschardt et al. (2012) support the concept of SPUGS: small public urban green spaces. According to these authors, the reduction of UGS leads to less contact between city residents and nature. SPUGS can be a solution to this problem. By creating multiple smaller green patches, average distance to UGS decreases, which generally leads to more frequent visits. Wang et al. (2017) focus on roof gardens as a potential for increasing urban green. These gardens are merged into the building structure and are designed for active human use. Since floor space is getting scare due to urbanization, roof planes seem a reasonable option for gardening. Additional to roof gardens, Perini et al. (2011) explore the potential of vertical gardens, which imply that vegetation is not planted on the roof of a building, but on the walls. Vertical gardens can consist of climbing plants attached to the frontage of a building whether supported by cables or trellis, called a 'green façade', or can consist of panels containing soil with vegetation installed on the façade of a building, named a 'living wall system'. Vertical gardens have a regulating and positive impact on the thermal effect of buildings and thus and account in the battle against the UHI effect. Besides UHI mitigation, vertical gardens and green roofs provide numerous other ESSs and environmental benefits.

2.2 Spatial justice

Considering the many benefits of vegetation in urban environments, many scholars argue that UGS should be evenly distributed over the city area. Yet, there is no consensus about what is considered even. Multiple authors address this issue. A concept that applies to this case is spatial justice. Spatial justice is about locational discrimination that, according to Armstrong (2012), is fundamental in the creation of persistent spatial structures of privilege and advantage. These advantages are most often based on class, race, and gender (Armstrong, 2012). In the case of the distribution of UGS, class and to a lesser extent race, are indicators that can predict access to UGS. Moreover, these characteristics are proxies for socioeconomic status (SES), which is correspondingly considered a major factor in forecasting access to UGS. Multiple authors therefore describe the relationship between SES and UGS. De La Barrera et al. focused on income as a single indicator of SES and found a positive correlation between income and the amount of public UGS and its quality (De La Barrera et al., 2015). Also Wendel et al. argue that residents with lower incomes or minority status are being disadvantaged in the distribution of green spaces and water features (Wendel et al., 2011). Wolch et al. (2014) focuses on income and ethnicity and state that white and more affluent communities are disproportionately benefitted in the distribution of UGS. The findings of Shen et al. are similar: districts with higher SES tend to have better and larger greenery than lower SES districts (Shen et al., 2017). Yet Shen and his co-authors found that household composition also seem to matter:

neighbourhoods with a large share of family households tend to have more UGS than neighbourhoods with mainly single households (Shen et al., 2017). Although the complexity of the concept 'spatial justice' has resulted in a fierce debate with sensitive opinions is, after an extensive literature review, concluded that the dominant paradigm in the spatial justice debate is that higher neighbourhood SES is generally accompanied by more UGS and that this is a spatial justice issue. However, Lin et al. discovered, in contrast to the authors mentioned above, that public UGS decreases with greater socioeconomic advantage (Lin et al., 2015). However, this is offset to the positive relationship between residential tree cover and SES. In other words: more affluent neighbourhoods have less public green space, but more private green space. This thesis will build on these findings of Lin et al. (2015) and will use their conclusions in the conceptual framework.

Back to the concept of spatial justice. The use of this concept raises several questions. What is just and what is unjust? When is a distribution even? This highlights the complexity of the concept of spatial justice. Various authors have tried to define 'justice'. For instance Kabisch & Haase (2014), who introduced three dimensions to be taken into account when addressing injustice regarding public spaces such as urban parks. Distributive justice focuses on fair distribution of resources over all social groups. Secondly, procedural justice is about fair integration of all actors into planning and decision-making. The third dimension is interactional justice, which relates to interpersonal relationships in a specific place. This thesis will focus on distributive justice. Yet a fair distribution may still have many definitions. When is a distribution considered just? This is elaborated by Lindgren (2011). She states that people's experience of justice is based on their opinion of what justice is. When the experienced reality is different than what justice means to them, people may feel treated unjustly. What people understand as just, depends on, among others, political view and social structures, contextual factors and on what is being distributed. Often, the feeling of injustice emerges when scarcity increases. When resources become scarce, a fair distribution is of greater importance. Lindgren (2011) incorporated this knowledge about justice into three general perceptions of what is just. These three principles are different ways of dealing with justice and injustice, but can all be perceived as just, depending on one's viewpoint. The first is the 'equal outcome' principle. The idea behind this principle is that different inputs are needed to reach the same output. For instance, a neglected and a properly maintained urban park have to reach the same state of preservation. To reach the same status, the neglected park requires more inputs and effort than the preserved park. This principle is considered to be just since both parks will have the same outcome. Applying this to the city-level distribution of UGS implies that all neighbourhoods should, regardless the SES of that particular neighbourhood and the required inputs, reach the same UGS maintenance level, eventually resulting in equal amounts of urban greenery. Inputs are thus defined as inputs in the provision of greenery (e.g. maintenance or development of green spaces). The second principle is called 'same inputs' and involves a constant level of inputs for all, regardless their degree of decline. In other words, neighbourhoods with a lot and well-preserved UGS receive the same input as districts with less and neglected green space. This may be perceived just since all neighbourhoods receive the same input. Yet in practice, this approach results in areas with severe deterioration having worse outcomes than others. The third principle, 'less inputs', is based on the idea that neglected UGS deserve less inputs because this decline of green space is taken as a sign that people do not care. This principle results in the largest difference in outcome between spaces with varying degrees of decline. Often, the equal outcome principle is considered as the most ideal (Lindgren, 2011). Therefore, the spatial justice definition used in this thesis is based on the principle of equal outcome. Hence, the distribution of UGS is here perceived just when all neighbourhoods have, regardless their SES, an equal amount of green spaces.

To pursue an equal provision of greenery over urban areas and to increase spatial justice, authorities on different scale levels have instituted norms and directives for the minimum amount of UGS. Berlin for instance aims at providing 6 m^2 per capita, Leipzig at 10 m^2 and in the UK the non-governmental body Natural England advised that every resident should have access to UGS of at least 2 hectares within 300 meters from home (Kabisch et al., 2016). The Dutch Ministry of Housing, Spatial Planning and Environment set their directive to provide 75 m^2 UGS per dwelling (VROM, 2006).

Moreover, since this is not only about the distribution of UGS locations, but also about the distribution of their ecosystem services, this is considered to be an environmental justice issue too (Shen et al., 2017; Wüstemann et al., 2017). Environmental justice refers to the distribution of the goods and bads of the environment over society (Walker, 2012). Every individual should be able to enjoy the environment in an equal way and should have equal access to environmental resources (Van Sparrentak, 2014). When this is not the case, scholars speak of environmental injustice. Since various social groups seem to be benefitted more in the distribution of UGS than others, green space access is increasingly recognized as an environmental justice issue (Wolch et al., 2014).

Walker (2012) defines environmental justice as the allocation of environmental benefits and burdens over society. However, environmental justice often has a negative connotation since it focuses in most of the cases on the distribution of burdens. Van Sparrentak (2014) used the concept of positive environmental justice (PEJ) to offer with this a positive lens in the environmental justice literature. Whereas 'regular' environmental justice debates focus on the distribution of environmental bads, PEJ focuses on the distribution of environmental goods. This thesis is constructed around the question how UGS is distributed. Since green spaces are generally perceived as an environmental good, a PEJ lens is also used in this thesis.

2.3 Socioeconomic status

In the previous chapter, the concept of spatial justice is elaborated. From an extensive literature research emerges that the most common way to define spatial justice in relation to UGS is by using socioeconomic status (SES). SES is a way of defining individuals', households', or community access to social, economic, or political resources (Psaki et al., 2014), which can be material goods, money, power, social networks, healthcare, education, or other resources (Oakes, 2012).

When people with similar SES characteristics spatially group together, it is called socioeconomic segregation (Bailey et al., 2017). As socioeconomic segregation increases, households with a low SES increasingly dwell in low SES neighbourhoods whereas households with a high SES increasingly live in neighbourhoods with a high SES (Quillian & Lagrange, 2016). Considering the distribution of fair opportunities over society, socioeconomic segregation is perceived negative since it contributes to further advantaging of the advantaged and disadvantaging of the disadvantaged. Furthermore, an increasing number of scholars recognizes the effect of SES of the neighbourhood on its residents, in particular children. Children dwelling in low SES neighbourhoods have lesser educational opportunities: they score lower grades, have lower chances of finishing school and entering college than their counterparts living in high SES neighbourhoods. Children who grew up in low SES environments generally earn 30% less at later age than children from high SES neighbourhoods. For adults, residence in low SES areas has been linked to worse mental and physical conditions. Additionally, low SES neighbourhoods tend to have higher crime rates and thus are more dangerous.

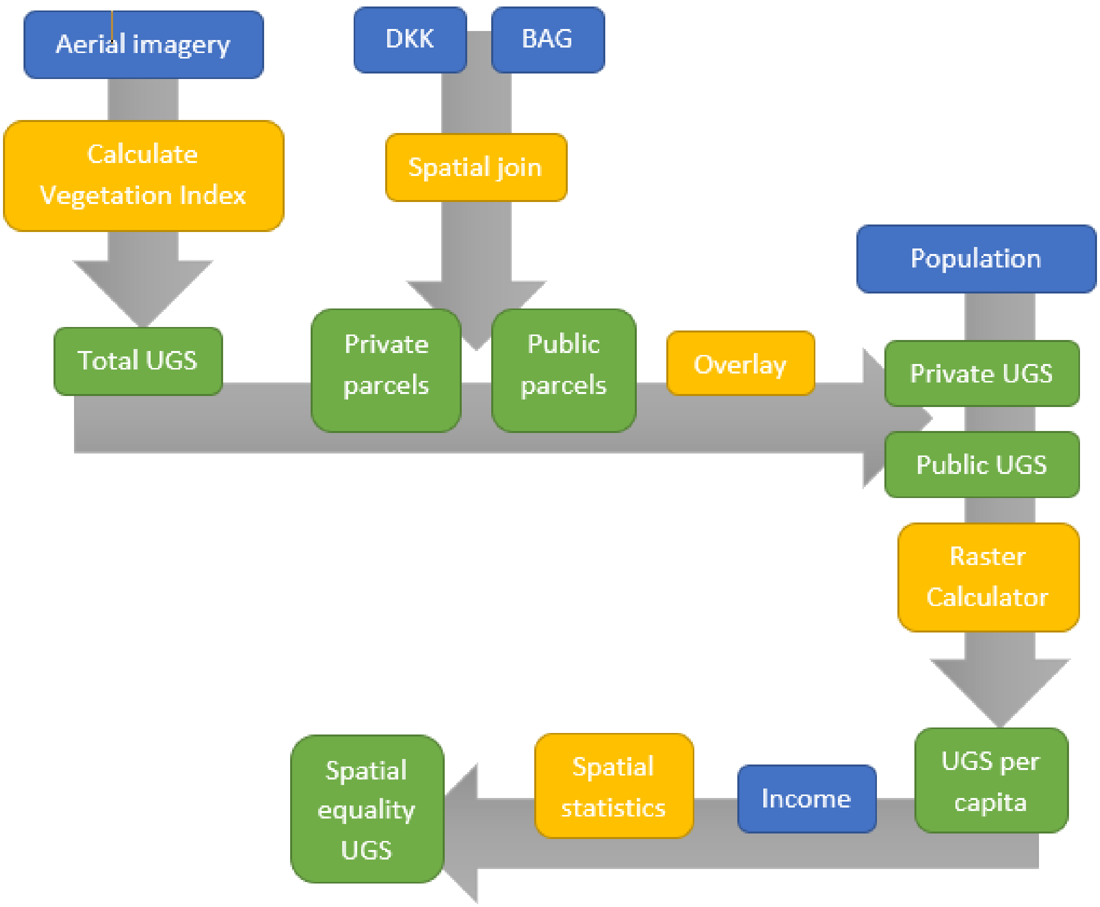
To measure socioeconomic status, multiple indicators can be used. Oakes classifies SES indicators in two categories: proxy measures and composite measures. Proxy measures are univariate indicators such as income or education. The main advantage of univariate measures is that they are simple, and easy to check and correct. On the other hand, the main disadvantage is that they don't capture the complex nature of SES. Composite measures are more suitable to shed light on this complexity, because they consist of multiple indicators that together form a singular quantity. An important weakness of composite measures is that the indicators require weighting. Composite measures are thus subject to the researcher's opinion. Moreover, these kinds of indices have been criticised because they only create a snapshot and do not provide information about change (Hincks, 2017). No matter what indicator you use for measuring SES, it will be a complex matter. Oakes captures this complexity in the following quote: "Today there are college drop-outs who are internet billionaires, poor persons with big screen televisions and expensive luggage, and increasingly large number of people who are rejecting consumerism in favour of simpler and less environmentally damaging lifestyles. In short, SES today is clearly a hyper dimensional latent variable that is difficult to pin down" (Oakes, 2012: 8). The complexity of properly determining SES is also underpinned by the large number of different variables used to measure SES, including: parents' education (Aarø et al., 2009); family household income (Johnson et al., 2011); income, unemployment, and educational attainment (Quillian & Lagrange, 2016); human, social, and material capital (Scharoun-Lee et al., 2009).

This chapter provided the theoretical background of the research topic. Based on this literature, the conceptual framing of this study was shaped. Summarizing, in this thesis the distributional justice of UGS in relation to SES will be studied, based on the equal outcome principle. UGS will be subdivided in private and public UGS, whereas private and public do not refer to ownership but to accessibility.

3. Methods

In the previous section, an extensive literature review is held to create a conceptual framework. Furthermore, this research comprises a GIS-based analysis to create insight in the fairness of the distribution. Additionally, relevant literature is also used to validate the results of the GIS-based analysis, by comparing them to conclusions of other researchers. The used literature is obtained via the online library of the University of Amsterdam and Google Scholar. The GIS software that is used to perform the analysis is ArcMap, accompanied by the spatial statistical analysis software GeoDa. In order to create overview of the methodology, a workflow diagram is constructed and presented in figure 3.1. In the bibliography section, a list of all datasets used in this study is presented. In the following sections the study area will be described as well as how UGS and SES are measured and how possible correlations between those variables is calculated.

Figure 3.1: Workflow diagram



3.1 Study area

This thesis focuses on Amsterdam. More specifically, the study area consists of the area within the municipal boundaries of the city, which is a surface of 219 km^2 (Municipality of Amsterdam, 2017). Amsterdam is, besides that it is with 844.952 inhabitants in 2017 the largest city in the Netherlands, also the capital of the country and is located in the province of Noord-Holland (figure 3.2). Additionally, Amsterdam is known as 'compact city' with high building density (Korthals-Altes & Tambach, 2008). Dense urban areas often lack sufficient green space (Haaland & Konijnendijk van Bosch, 2015) and given that this city is classified as highly urbanized (CBS, 2015), it is therefore interesting for this study. Additionally, studies to the private and public UGS distribution have never been carried out in this study area before, which highlights the importance of such research in Amsterdam.

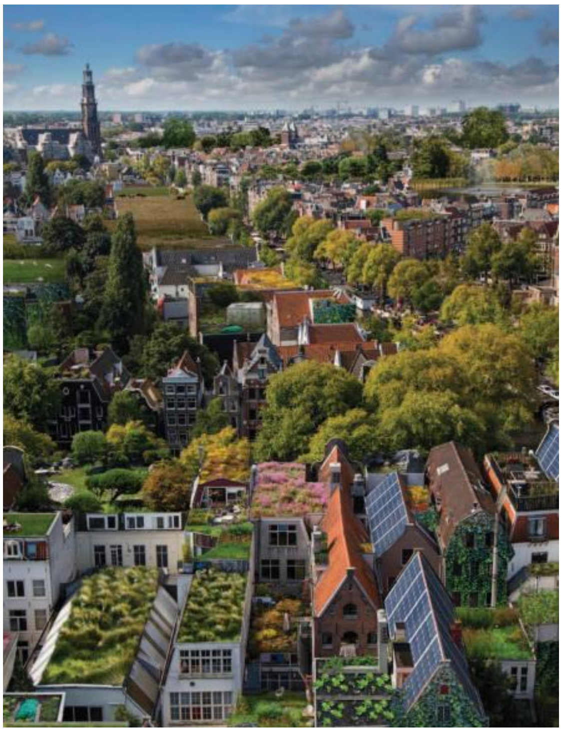
Figure 3.2: Location Amsterdam in the Netherlands

To generate a proper understanding of the distribution of UGS in Amsterdam, it is interesting to know something about the urban green policies of the municipality. The Municipality of Amsterdam drafted their urban greening policy 'Agenda Green' in 2015 (Municipality of Amsterdam, 2015). The motivation behind the strategy is that the majority of inhabitants of Amsterdam does not have a garden. Therefore, the provision of public greenery is an important issue in Amsterdam since public green spaces are considered as garden for the residents of the city. This motivation has resulted in an investment of 20 million euros in urban green space. The policy is constructed around four pillars: urban parks, climate and biodiversity, neighbourhood green space and connections and accessibility.

Because lots of Amsterdam's residents do not own a garden, urban parks are used intensively (Municipality of Amsterdam, 2015). This is illustrated by the enormous number of visitors, with the Vondelpark in leading position with 10 million visitors per year. Therefore, the Municipality of Amsterdam draws attention to the restructuring of urban parks, aiming at increasing the ability to cope with the intensive uses. To reach this objective, new facilities will be developed, such as toilets, water taps and facilities for physical exercise. Additionally, Amsterdam is built on peat bog and has, as a result, to deal with subsiding soils. This in turn leads to wet ground which is a challenge for urban parks. By taking this into consideration in the choice of plant and tree species, this problem can be mitigated.

Bearing climate change in mind, making Amsterdam climate-proof is a high priority on the municipal's list (Municipality of Amsterdam, 2015). Green spaces play a crucial role herein, for instance in draining rainwater and coping with rising temperatures (Derkzen et al., 2017). Additionally, UGS increases biodiversity. To increase the green surface in the city, the municipality aims at developing green roofs (see figure 3.3), on the one hand by exploring the potential for roof gardens on municipal property, and on the other hand by economically stimulating individuals to green their roofs. Besides green roofs, the municipality acknowledges the importance of green spaces for rainwater disposal. Where investments in urban greenery are made, attention is devoted to the water retaining capacity. Furthermore, to increase biodiversity and the climate-coping mechanisms of the city, the municipality initiated a tree policy considering the amount and species of trees in the city. In order to create space for further natural growth, bottlenecks in the ecological structure of Amsterdam will be resolved by developing wildlife crossings on land and fish crossings in water.

Figure 3.3: Municipality of Amsterdam aims for green roofs (Municipality of Amsterdam, 2015).



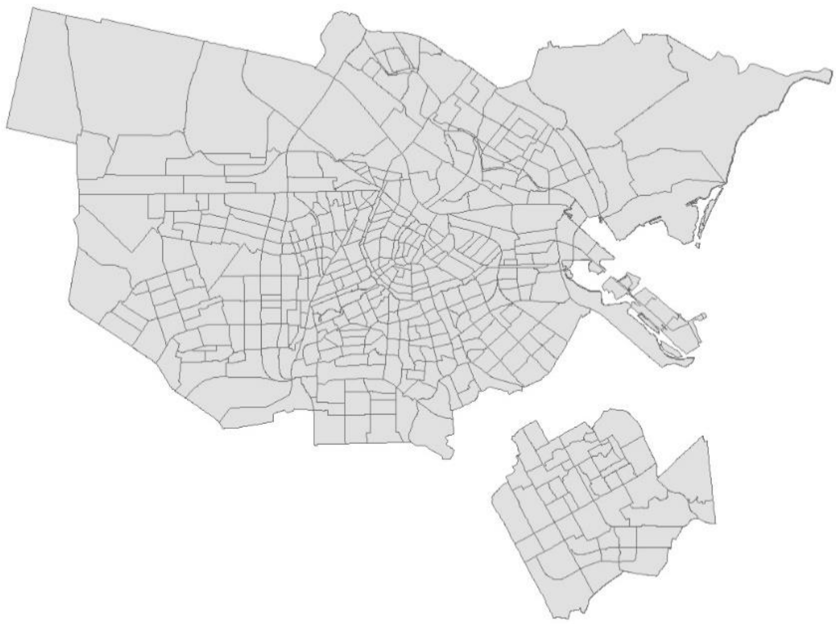
The third theme in the UGS policy of the Municipality of Amsterdam is neighbourhood green space (Municipality of Amsterdam, 2015). The municipality aims at increasing the amount of UGS in the neighbourhood by creating various small pocket parks or adding greenery to existing ones. Additionally, attention is devoted to development and greening of neighbourhood sport fields, natural play grounds and routes for walking and cycling. The surge of urban agriculture and the growing awareness of natural and healthy food are encouraged by the municipality by initiatives for vegetable, herb, and flower gardens.

The fourth pillar is related to connections between and accessibility of green spaces (Municipality of Amsterdam, 2015). The municipality states that Amsterdam has an extensive provision of urban green, but that it can be better expressed when it is more accessible and connected. Therefore, the focus lays on improvement of walking and biking routes between green areas for daily recreational use. The municipality aims at doing this by resolving bottlenecks in infrastructural connections between green spaces in and around the city and by investing in the experiential value of these routes.

These measures should result in an increase in the amount of urban greenery in Amsterdam. Some of those are already carried out, such as for instance the redecoration and replanting of the Martin Luther Kingpark or the development of a green connection between the Vondelpark and the Rembrandtpark (Municipality of Amsterdam, 2016).

As aforementioned, the study area consists of all the land within the municipal boundaries of Amsterdam. This area includes 476 neighbourhoods. A full list of those can be found in appendix A.

Figure 3.4: Neighbourhoods in study area



3.2 Measuring UGS

In order to answer the first sub question, the provision of urban greenery in the study area should be measured. Indicators of UGS can be classified in qualitative and quantitative measures. This thesis is constructed around quantitative indicators. To measure qualitative aspects of UGS, field work such as observations and interviews are required, and unfortunately, there are not enough resources and time available to conduct such data. Additionally, these kinds of measures are subjective, as for instance access to parks is different for elderly and children and middle-aged persons (Gupta et al., 2012). Therefore, the focus will be on quantitative measures. Using quantitative indicators seems a good option, according to Gupta et al. (2012): "There is a need for getting quantifiable information regarding green structures and their amount and distribution for sustainable planning" (Gupta et al., 2012: 333). According to De La Barrera et al. (2015), UGS covers three domains: quality, quantity, and spatial distribution. As far as possible within the scope, the methodology of this thesis fits the approach of De La Barrera et al. (2015), since quantity and spatial distribution will be evaluated. As discussed, quality aspects do not fit within the scope of this research.

To quantitatively measure the availability of green spaces, the spatial distribution of public, private, and the total UGS will be assessed, as well as UGS per capita for these three categories. Green space per capita is widely used and recognized as an appropriate way to assess UGS availability (Banzhaf & De La Barrera, 2017). Additionally, GIS is a suitable method to measure these green space characteristics (Van Leeuwen et al., 2009). Likewise, using remote sensing to determine whether areas have vegetation or not is a common method in green space assessment (Gupta et al., 2012; Gupta et al., 2016; Li & Liu, 2016; M'Ikiugu et al., 2012). This method is therefore applied in this study. From the Wageningen University and Research (WUR) a mosaic dataset consisting of a large number of aerial photographs was obtained. The images are false colour, with vegetation displayed in red, also known as CIR (colour-infrared, see figure 3.5). The imagery was collected in July 2016 (Beeldmateriaal Nederland, 2016). These photographs have a resolution of 25 by 25 centimetres and a tile width of 1000 meters. The mosaic dataset has three spectral bands (red, green and infrared or R, G and IR, Beeldmateriaal Nederland, 2018). The information of the red and NIR bands was used to calculate NDVI (Normalized Difference Vegetation Index). This is a common method to detect vegetation in aerial imagery (Gupta et al., 2012). ArcMap uses the following the following equation to calculate this vegetation index (ESRI, 2016):

$$NDVI = \frac{(IR - R)}{(IR + R)} \times 100 + 100$$

By enabling the option 'Scientific Output', the resulting values range between -1 and 1. Figure 3.6 gives an impression of what the results look like. This NDVI layer was reclassified in a dichotomous map with the classes vegetation (all NDVI scores above 0,1) and no vegetation (all NDVI scores up to and including 0,1) (ESRI, 2016). This map is used to visualize the total UGS availability in the case study city.

Figure 3.5: CIR photo (WUR, 2016).

Figure 3.6: NDVI

3.2.1 Separating public and private green spaces

To determine whether the detected vegetation belongs to the category private or public, data from the BAG (Basis Registration Addresses and Buildings) in combination with the digital cadastral map (DKK) is used. Both datasets are provided by the Dutch Cadastre and obtained as open data from PDOK (public services on the map) in GML format and are collected in 2016. The DKK contains all cadastral parcels, such as represented in figure 3.7. The BAG carries information about the location and function of buildings in a feature class consisting of points. Building functions are classified in residential, industrial, shopping, offices, health functions, and gathering. In the conceptual framework is elaborated that UGS is considered as public when it is accessible for everyone. When access can be denied, it is in this study treated as private. Public access does not apply to buildings with one of the aforementioned functions, since, theoretically, access to dwellings, shops, industrial buildings, etcetera, can be denied and these spaces are thus not accessible for everyone. Therefore, buildings belonging to these categories are classified as private.

This information is combined with the cadastral parcels by spatially joining the BAG and the DKK together. Parcels that contain one or more locations of buildings with such a function are classified as private parcels, and parcels without as public (see figures 3.8 and 3.9). Vegetation located on private parcels is classified as private UGS, and vegetation on public parcels is classified as public UGS.

Figure 3.7: Cadastral parcels (DKK, 2016).

Figure 3.8: Joining cadastral parcels and building functions (DKK, 2016; BAG, 2016).

Figure 3.9: Separation private (blue) and public (yellow) parcels

Yet there are some issues that lead to incorrect classification. In some cases, public parks contain for instance a shop or a museum, which results in these parks being classified as private UGS. Conversely, there are patches of land with no buildings on it that belong to private UGS but are categorized as public such as for instance allotment gardens. To correct for this type of errors, the classification made is compared to the location of public UGS in the BRT (Basis Registration Topography). The BRT consists of multiple topographic maps with varying scale levels. Here, the map with the largest scale is used. This map is called Top10NL and contains topographical data on 1:10.000 scale. The data is collected in 2016 and available in GML format. These vector maps carry information about land use and vegetated areas. The land use classes that together form public UGS (such as grassland, woodland, etcetera) are exported to a new layer resulting in a layer with only public UGS according to the Top10NL. This layer contains public parks and large green patches on streets and squares. This layer does not include small patches of streetscape greenery or trees in streets, which makes it unsuitable to account for all public UGS. Because it includes the main green features, it is nevertheless suitable to correct the classification errors. With Raster Calculator the public UGS layer derived from the Top10NL was added to the public UGS layer based on the parcel classification, to add large missing public green features. The layer derived from Top10NL was consequently subtracted from the private UGS layer, to erase large public green spaces from the private UGS layer.

3.2.2 Green space per capita

All the steps described above lead to three datasets that represents the spatial availability of the total, the private and the public UGS in Amsterdam. The following step, as represented in the flow diagram, is to calculate green space per capita.

To calculate the amount of UGS per person, knowing the total amount of green space for each neighbourhood is required. This is calculated with the Zonal Statistics tool. The Zonal Statistics tool requires a layer that serves as input for the zones, and a layer that carries the values for which the statistics should be calculated. The division of neighbourhoods is used as zonal input, and the layer with the spatial distribution of UGS as value input. The Zonal Statistics tool consequently calculates the number of cells classified as vegetation per neighbourhood. Data on the number of inhabitants is obtained via the CBS (Dutch Office for Statistics) on neighbourhood level for the year 2016. This dataset has a shapefile format and requires rasterization to support calculations. After performing Polygon to Raster operations on the inhabitants information Map Algebra was used to divide the amount of UGS of each neighbourhood by the number of inhabitants. This way, private, public and total green space per capita was calculated for each neighbourhood in the study area.

A serious constraint in calculating the amount of green space per neighbourhood is the modifiable area unit problem (MAUP). This problem occurs when variables are measured using arbitrary boundaries (Berghauser-Pont & Haupt, 2009). When point-based measures are aggregated into districts, an ecological fallacy arises because the resulting summary values are dependent upon the choice of the district boundaries. In this study, the amount of UGS per spatial unit is measured. This variable is therefore influenced by the boundaries of that particular unit, in this case neighbourhoods. To minimize the effect of the MAUP, the aggregation level is kept as low as possible. This implies that all data is used on the most detailed scale level, which is per neighbourhood.

Yet, calculating UGS per capita for each neighbourhood raises another issue. In reality, people are able to visit green spaces located outside the boundaries of their own neighbourhood but in these calculations only UGS in the own neighbourhood is counted. A potential solution to this problem is to draw buffers around the neighbourhood polygons. This results however in some UGS being counted twice, which creates an overly positive image. To resolve this type of issues, moving window analysis is useful but considering the time available for this thesis not within the scope of the research. Nevertheless, Gupta et al. (2012) give a valuable reason why measuring green spaces at neighbourhood level is a good idea: "Measuring UGS at neighbourhood level is important as neighbourhood is the working level for application of greening strategies" (Gupta et al., 2012: 325). Despite these limitations is therefore chosen to measure UGS at neighbourhood level.

3.3 Measuring SES

The second sub question is '*How is socioeconomic status distributed?*'. As discussed in section 2.3, measuring SES can be challenging. A multivariate measure has a higher ability of capturing the complex nature of SES variations than an univariate measure, yet constructing one requires among others the availability of data for various variables. Considering the resources available for this thesis, it is unfortunately not possible to gather this data and creating a multivariate index for measuring SES is therefore beyond the borders of the scope of this research. For this reason has been decided to use a univariate measure. According to Oakes (2012), when it comes to measuring SES, income is the most commonly used univariate indicator. Household income is compared to multivariate measures rather rudimentary, nevertheless it has proven to predict significant outcomes (Johnson et al., 2011). Therefore, the single measure income will be used as a proxy indicator for SES. This data is obtained via the CBS and dates from 2014. Income is measured by the gross average annual personal income per inhabitant. The average is based on the total population in private households and calculated on neighbourhood level (CBS, 2016). Personal income includes earnings from labour, own enterprises and social assistance benefits.

CBS provides also information on the share of people per neighbourhood that is classified as having a low income and having a high income. An individual has a low income when he or she belongs to the nationwide 40% with the lowest personal income. All Dutch personal incomes are ranked and the 40% of people having the bottommost incomes are classified as 'low income'. A person with a high income belongs to the national 20% with the highest incomes. Incomes are ranked the same way as the low-income category. To create more overview, the neighbourhoods of the study area are classified in high, middle and low SES neighbourhoods. Income is used as a proxy indicator for SES, and therefore is assumed that areas with lower incomes have a lower SES and areas with higher incomes have a higher SES. To categorize the neighbourhoods of the study area into low and high SES, the abovementioned taxonomy of the CBS is used, yet average neighbourhood income is used as input instead the income of individuals. In other words: the 40% neighbourhoods in the study area with the lowest average annual income is classified as low SES, the 20% neighbourhoods with the highest incomes as high SES, and all neighbourhoods in between as middle SES. Please note that this classification does not tell anything about the absolute values that fall within each category. For instance, people living in neighbourhoods that belong to the category low SES in this taxonomy do not necessarily have a 'low' income, but they do have lower average incomes than their counterparts from middle or high SES neighbourhoods. This division generates a more uncluttered overview which facilitates visual interpretation of SES patterns.

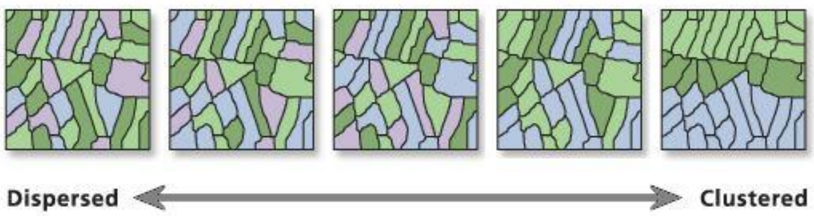
3.4 Measuring correlations between UGS and SES

As is elaborated in section 2.2, spatial justice is contested concept. Therefore, it should be defined very carefully and precisely. How spatial justice is understood in this study is elaborated in the conceptual framework, but summarized it comprises distributional justice according to the equal outcome principle.

Whether this type of justice exists in the current situation in the study area, will be examined by the third sub question. This will be analysed by comparing the spatial distribution of UGS in Amsterdam with the SES of the neighbourhoods. After visualizing the outcomes of the first and second sub question, visual interpretation will tell whether there appears to be spatial patterns or not. The findings of the visual comparison will be tested by using spatial statistics. This way will be calculated to what degree SES predicts the availability of UGS in the study area. SES is measured in average annual income per person, and UGS in square meters per person. The statistics used are global Moran's I, R^2 value, Akaike Information Criteria and the p-value.

Moran's I calculates the level of spatial autocorrelation (SAC). Spatial autocorrelation measures the degree to which the occurrence of spatial phenomena can be predicted by the values of neighbouring observations. Moran's I can be calculated locally or globally. Local Moran's I tests for clusters, whereas the global statistic looks for clustering (Anselin et al., 2006). The resulting value can range from -1 to 1, with -1 representing complete dispersal, and 1 perfect clustering (see figure 3.10). In this study the global Moran's I is calculated, based on the inverse distance principle. This implies that neighbours located close-by have a larger influence on computations than neighbours located further away. This is the most used and a suitable option (Pandit et al., 2013). R^2 is the coefficient of determination and expresses the proportion of variance in the dependent variable that is explained by the model. When no variation can be explained by the model, R^2 is 0, and when the model explains all variation, R^2 returns the value 1. The Probability value, or p-value, tells something about the possibility that found correlations are the result of chance. When the p-value is smaller than 0.05, there is a significant correlation found between the variables and the correlations are thus not the results of chance. These statistics will be calculated for three different regression models. The Akaike Information Criteria (AIC) gives information about the model fit. The lower the AIC value, the better the model fit (Anselin, 2005). The AIC values of three models will be compared to determine which model is the most suitable for the data used in this study.

Figure 3.10: Spatial autocorrelation (ESRI, 2017).



The first model is the non-spatial Ordinary Least Squares approach (OLS). OLS calculates the parameters of a linear function by minimizing the sum of the differences between the observed and the expected value. This model is not suitable in case of SAC of one of the variables, because it is non-spatial. If one of the variables returns a high Moran's I value, the Spatial Lag Model (SLM) or Spatial Error Model (SEM) are a better option. Those two models both correct for spatial dependencies. Spatial dependencies can occur in two forms (Anselin & Rey, 1991). In one form, it affects the error terms only, and in this case using a SEM will be the best option. In the other form, the dependent variable is affected by spatial dependencies. In this case, the SLM is the most suitable option.
Attention should be devoted to the different neighbourhood classifications used in 2014 and in 2016. The number of neighbourhoods in 2016 is larger than the number of neighbourhoods used in 2014: 476 versus 95. Because the neighbourhoods of 2014 are split up in smaller spatial entities, the number of neighbourhoods has increased. UGS is measured according to the new neighbourhood boundaries but income was only available for 2014, according the old neighbourhood polygons. To be able to compare UGS and SES, conversion from one of the neighbourhood divisions to the other is required. Because the neighbourhoods from 2014 were all split up in smaller spatial units, it is possible to disaggregate the SES data. The SES value of the larger neighbourhood was assigned to all smaller neighbourhoods falling in that larger neighbourhood. As discussed earlier, MAUP occurs when data is aggregated into arbitrary boundaries. To minimize this effect, the aggregation level should be as low as possible. Therefore, the disaggregation of SES data seems a better option than aggregating the UGS data.

For 30 of these smaller neighbourhoods, income data is not available. Usually, spatial units get -999999 as no data score. However, including neighbourhoods with an average annual income of -999999 in the analysis will affect the results. Therefore, neighbourhoods with unknown income are excluded in the statistical analysis. The statistics are thus applied to 446 of the 476 neighbourhoods in Amsterdam.

4. Results

This chapter discusses the results of the research per sub question. Each section in this chapter therefore answers one of the four sub questions.

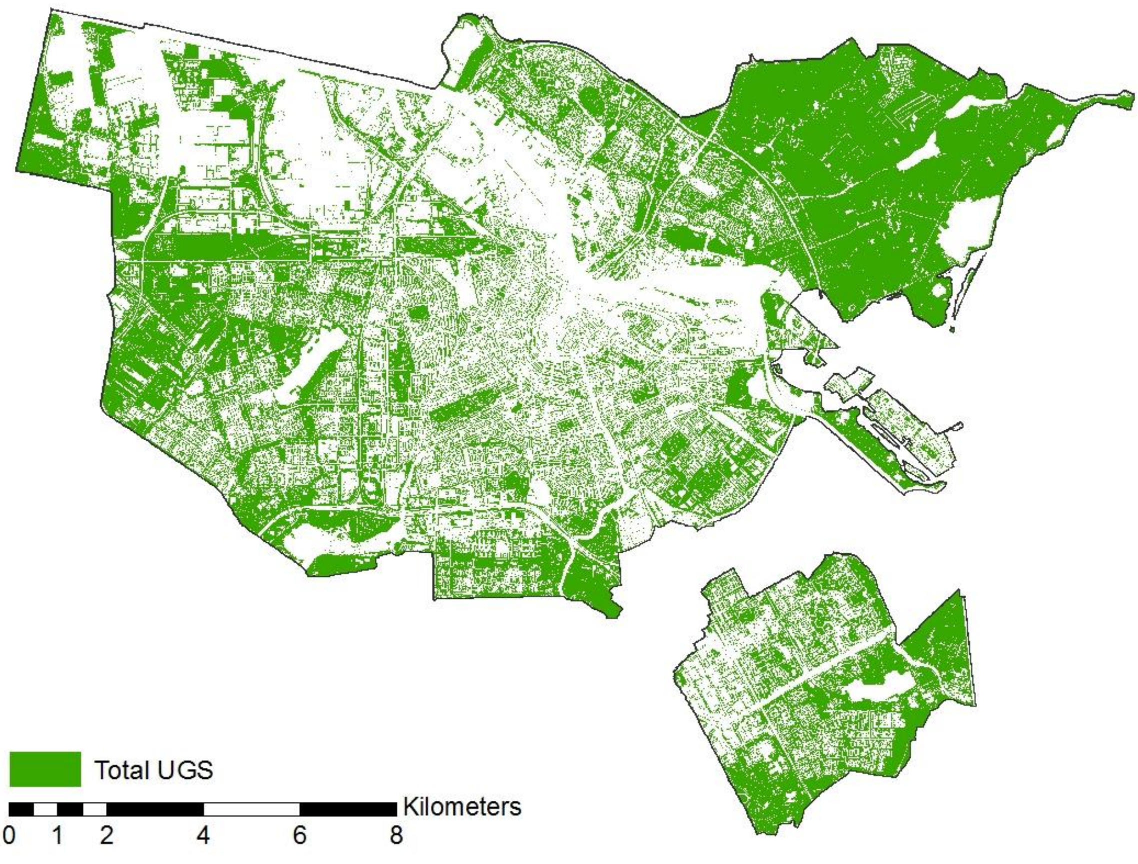
4.1 UGS in Amsterdam

The distribution of UGS forms the basis of the spatial justice debate. This therefore elementary component will be discussed in this chapter. First, the spatial distribution of UGS in Amsterdam will be discussed, followed by the distribution per capita.

4.1.1 Spatial distribution

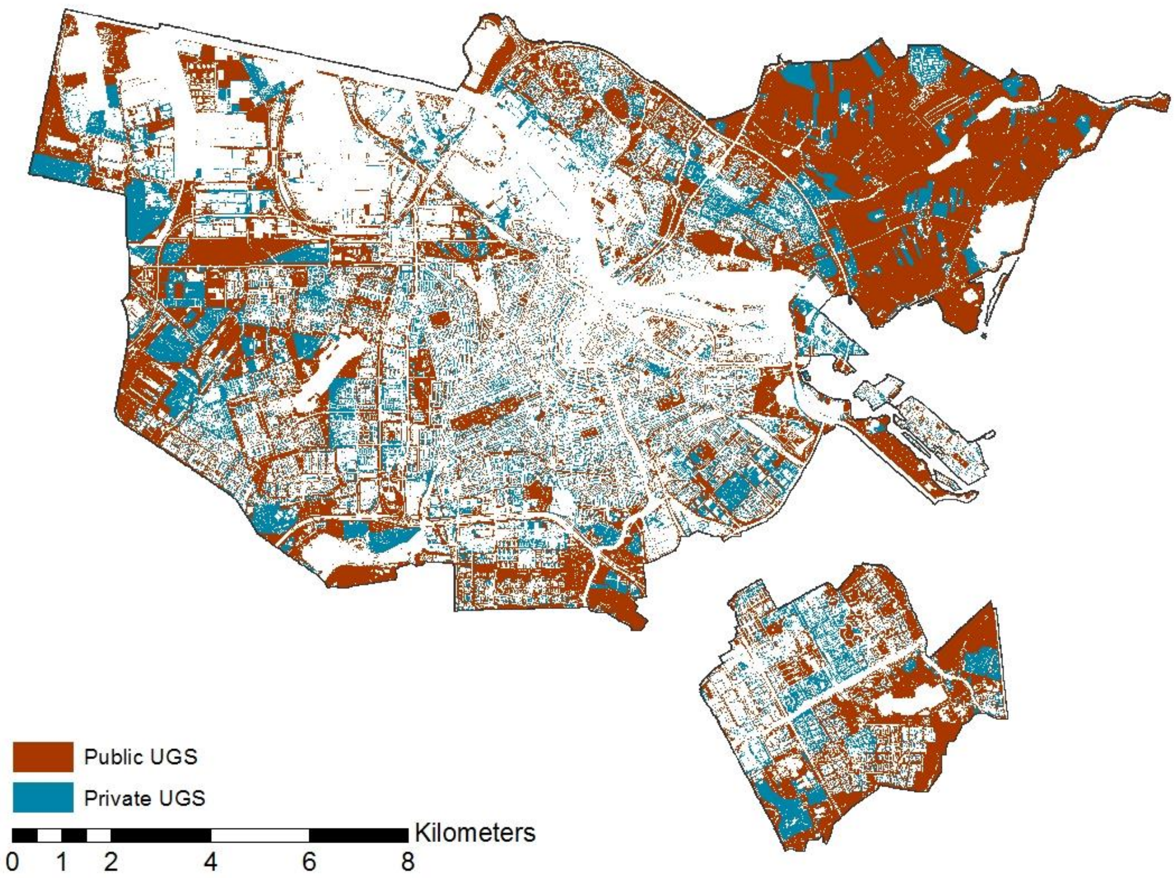
The spatial distribution of all the UGS in Amsterdam is represented in the figure 4.1. Clearly visible is that neighbourhoods located in the city centre have few UGS. Neighbourhoods surrounding the inner city have a larger portion of UGS and districts located in the outskirts of the city are amongst the greenest of Amsterdam, especially the large patch of UGS in the north-eastern part of the city. Additionally, the south-eastern part of the homonymous neighbourhood (also called Bijlmer) has a lot of vegetation. Furthermore, urban parks are clearly distinguishable as well as lakes and the rivers IJ and Amstel. In Amsterdam, 48,7% of the pixels is classified as vegetation.

Figure 4.1: Total UGS Amsterdam



In figure 4.2, the total UGS is subdivided in the categories public and private. The majority of UGS is classified as public. 42,2% of the surface of Amsterdam is public UGS whereas private UGS account for 4,1% of the land use in the city. The public UGS category contains more larger patches of vegetation (e.g. parks), and private UGS consists of more smaller green spaces (e.g. backyards). Additionally, it appears that most public green spaces can be found outside the city centre whereas private green spaces are more evenly distributed over the city surface. Figures 4.3 and 4.4 represent the separate categories public and private UGS.

Figure 4.2: Private and public UGS



The inner city of Amsterdam has very limited public green space. The largest green spaces accessible for all are located closer to the city's boundaries. Districts that have a large amount of publicly accessible UGS are the southern part of IJburg, New-West and the Bijlmer in the south-eastern part of the city. The north-eastern parts also have lots of public UGS. Additionally, urban parks such as the Vondelpark are also on this map clearly visible.

The private green spaces in Amsterdam are shown in figure 4.4. Although private UGS is more equally distributed over the urban area than public green spaces, there are still districts with less private UGS than others. The most central part of the city has, as with total and public UGS as well, the least private vegetation. Additionally, the north-western parts have relatively few private green spaces, which is likely caused by the fact that this is the industrial part of Amsterdam. The north-eastern part appears to have very few private UGS as well, which can be explained by the large amount of public UGS in this area.

Figure 4.3: Public UGS

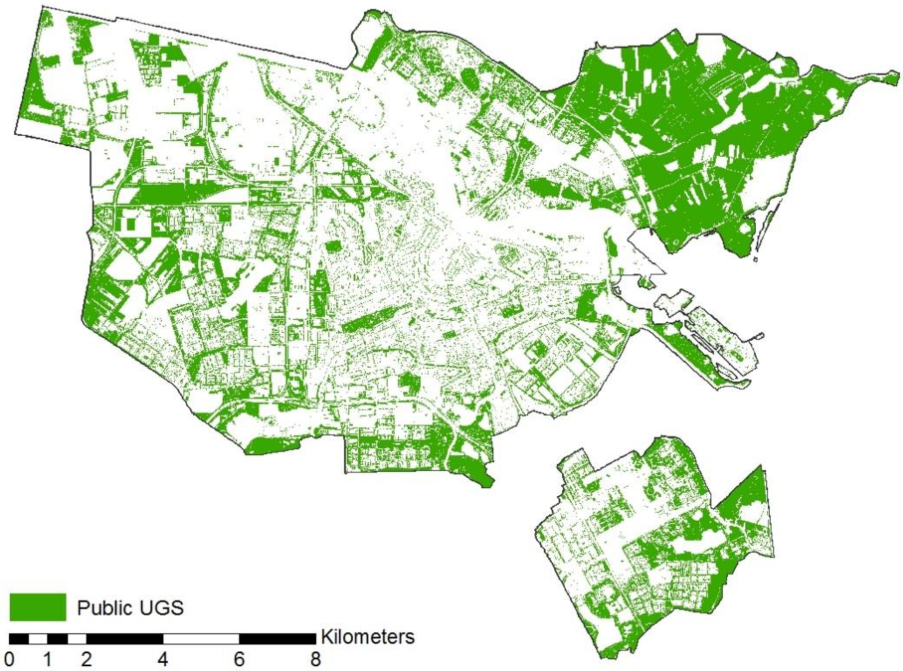
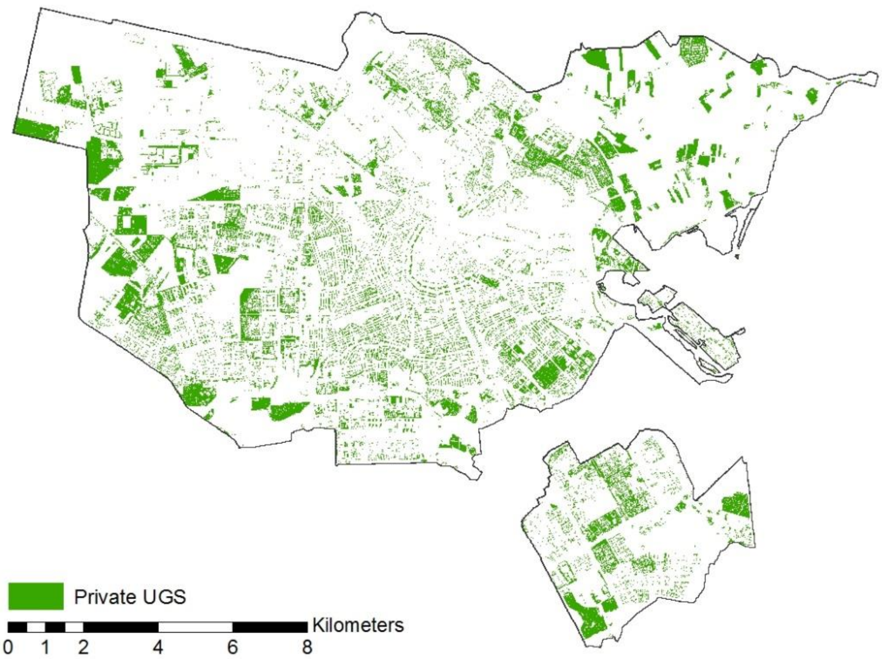


Figure 4.4: Private UGS



4.1.2 UGS per capita

Figure 4.5: Population density

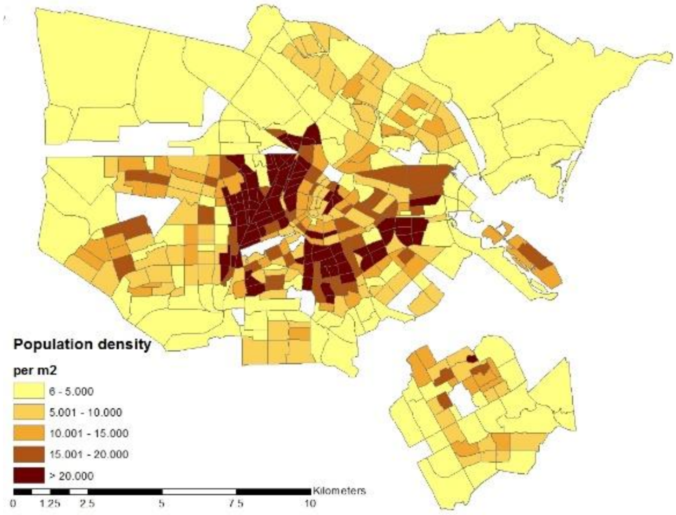


Figure 4.5 shows the population density in Amsterdam. The most crowded neighbourhoods are located around the city centre and in the most central part of the city. The neighbourhoods appearing white in the map have no inhabitants at all or the number of inhabitants is unknown. The population density and the spatial distribution of UGS are used as input to calculate green space per capita. Total, private and public UGS per capita is visualized in respectively figures 4.6, 4.7 and 4.8. Some neighbourhoods appear white or grey which implies that there is no data available for these areas. This is because these quarters have no inhabitants.

Figure 4.6: Total UGS per capita

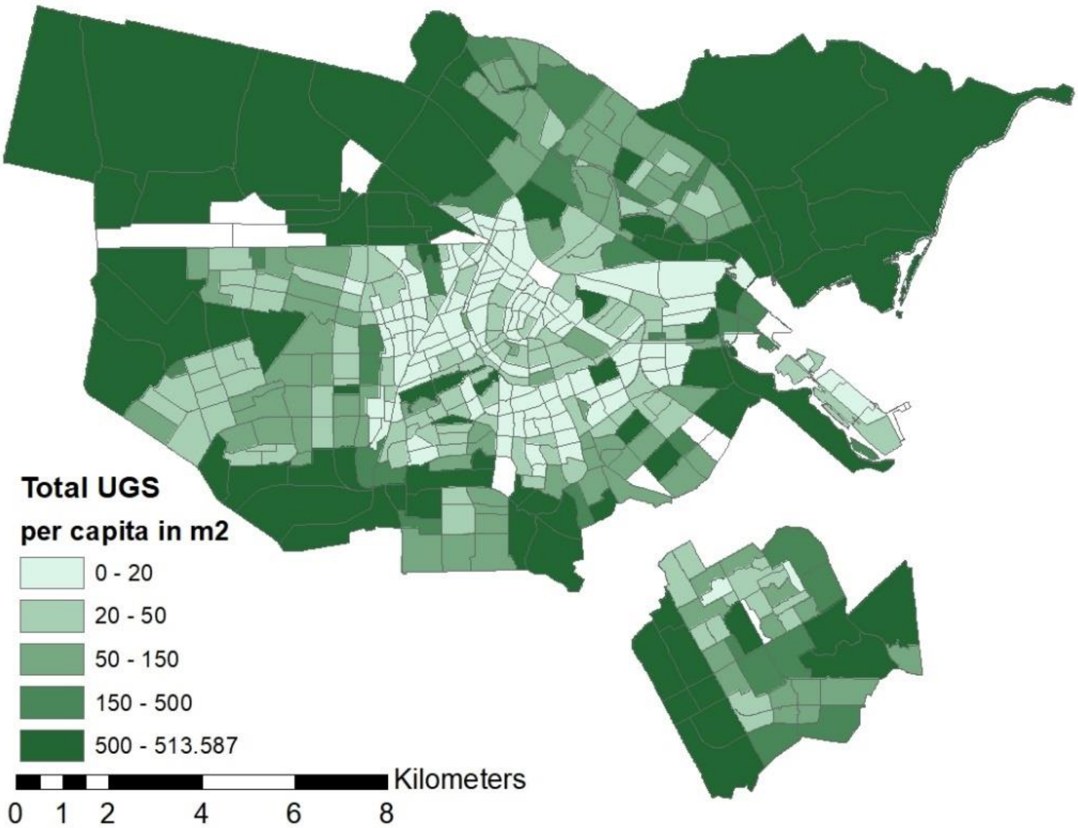
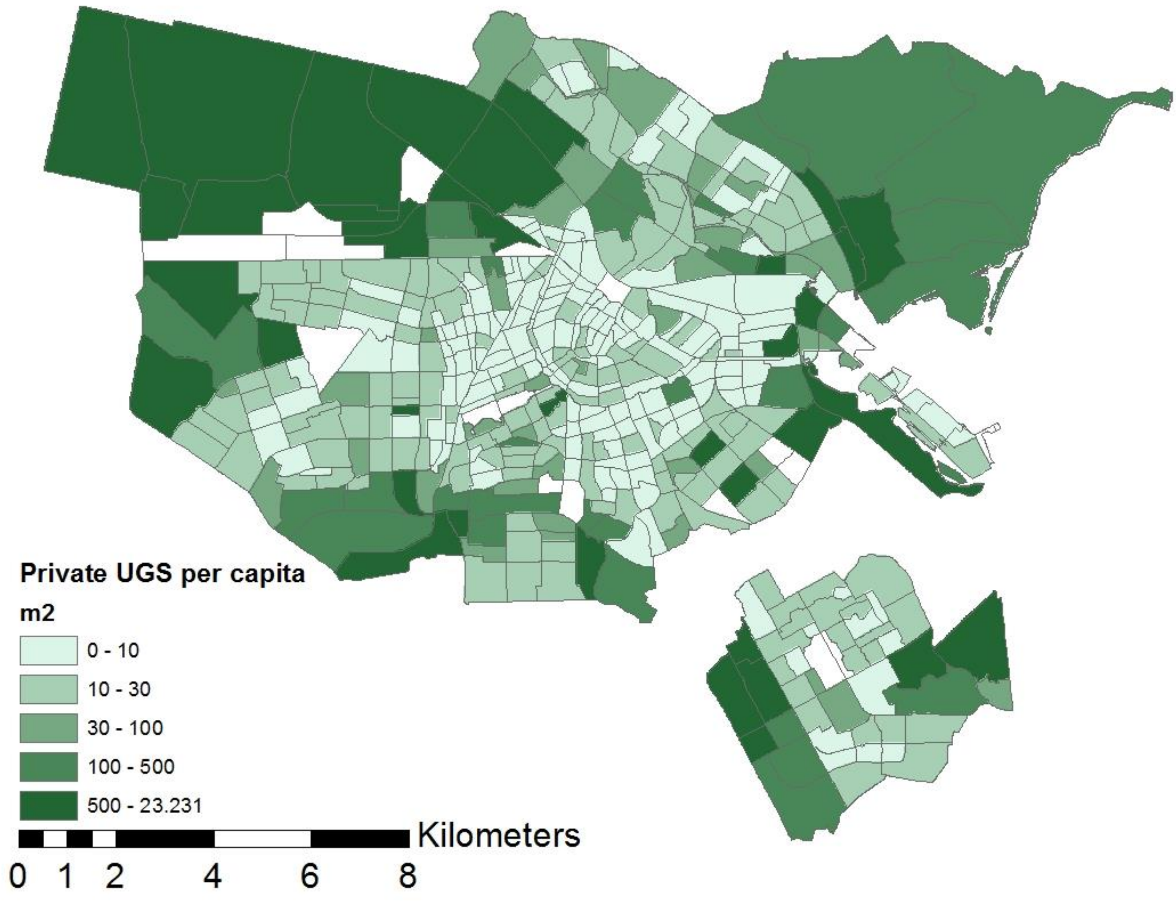


Figure 4.6 shows that people living in centrally located quarters have generally less total UGS per capita. This seems logical: these districts are less spacious and have a higher population density than areas located more towards the boundaries of the city. There are some exceptional neighbourhoods:

the P.C. Hooftbuurt, the Oosterparkbuurt and the Marineterrein all have a high amount of total UGS per capita and are located in or around the city centre, as well as the Vondelpark.

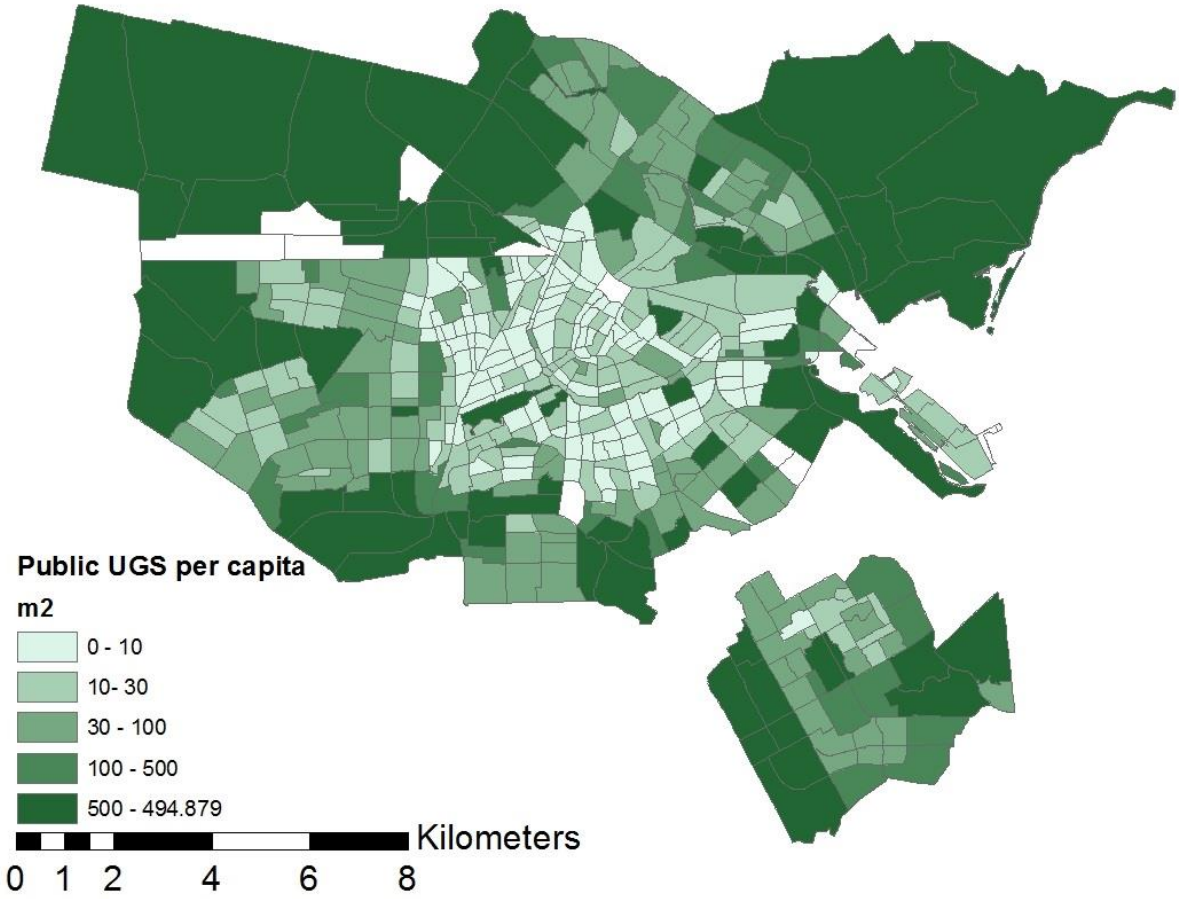
Private UGS per capita is high in neighbourhoods further away from the city centre, for example the areas in the north-western and north-eastern parts of Amsterdam. Additionally, residents of the southern districts enjoy relatively much private UGS per person, as well as people living in some areas in the Bijlmer and near IJburg in the east. Neighbourhoods that show the less private UGS per capita are located in and around the city centre. These quarters often deal with high population density which partly explains the low UGS per capita scores.

Figure 4.7: Private UGS per capita



People dwelling in more outwardly located districts generally have access to more public green space per person than those living in central quarters, except for people living in the Museumplein area, the Oosterpark, the Marineterrein and the Vondelpark. Additionally, the northern and western parts of Amsterdam high amount of public green space per capita.

Figure 4.8: Public UGS per capita



Based on the green space per capita maps, comparison of the categories public and private is complicated because the maps do not show the large differences between these categories. For this reason, the spatial distribution of UGS locations and the green space per capita are combined (figures 4.9 - 4.11). In these figures, the amount of green space per capita is represented by colour gradient, but also by the absolute amount of green space in the neighbourhood. Visualizing UGS per capita this way exposes the differences in amount for public and private. In central neighbourhoods, the differences between the amount of public and private UGS are not that large. But, when focusing on neighbourhoods located more in the outer city, there is an obvious difference between the amount of private and public green space per person. Because of the low population density, these neighbourhoods fall within the highest classes of UGS per capita in both categories, yet this visualization reveals the large differences between the amount of public and private UGS.

Figure 4.9: Total UGS per capita and spatial distribution

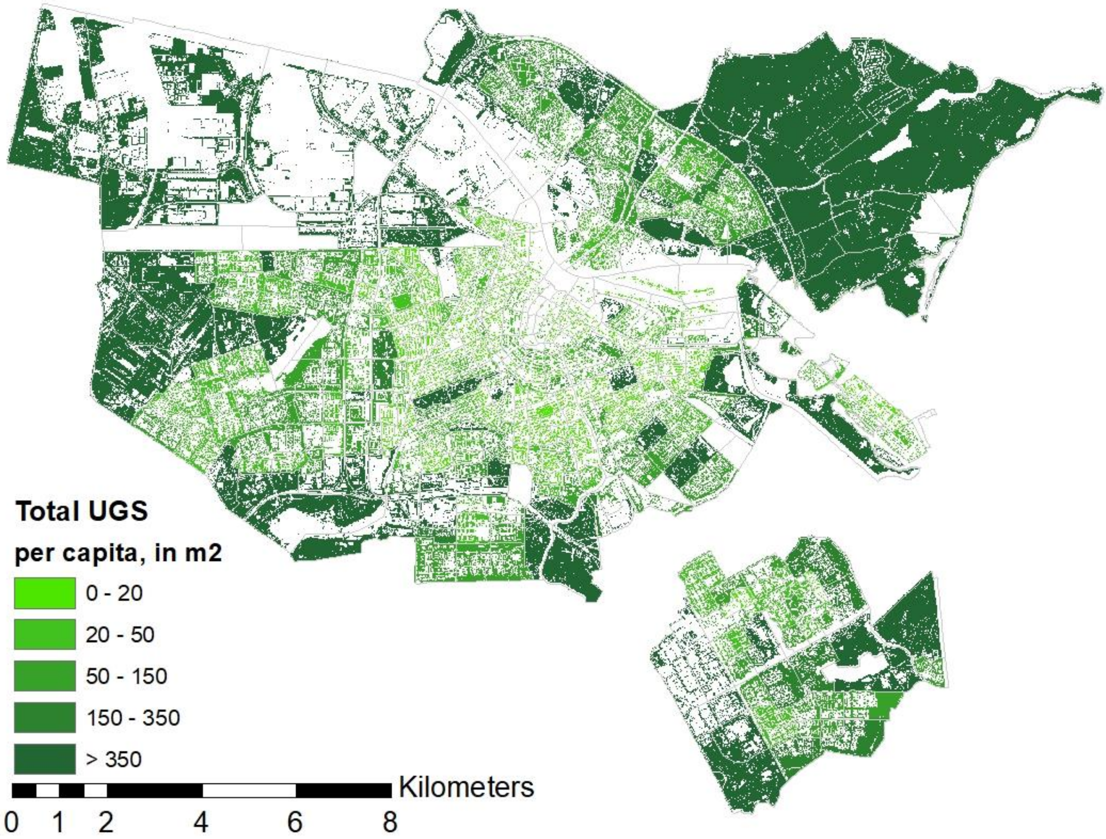


Figure 4.10: Public UGS per capita and spatial distribution

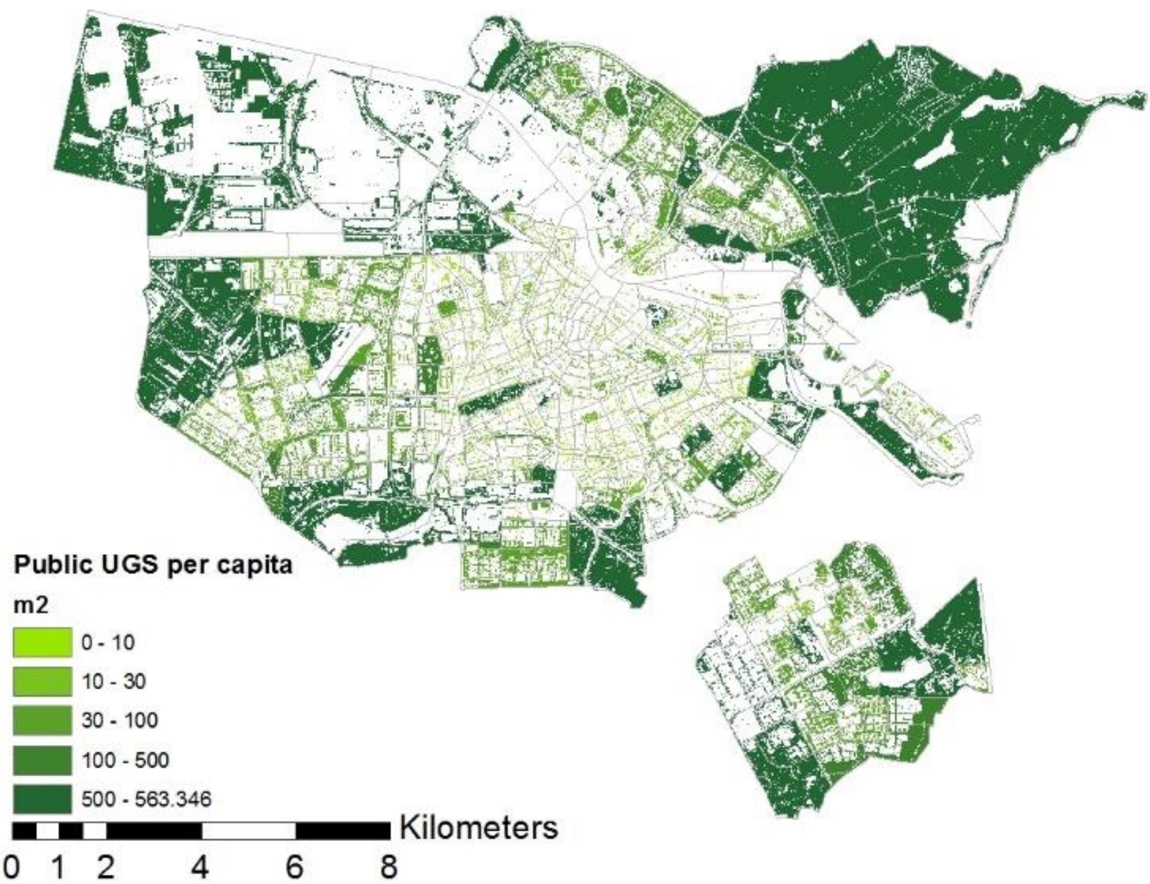
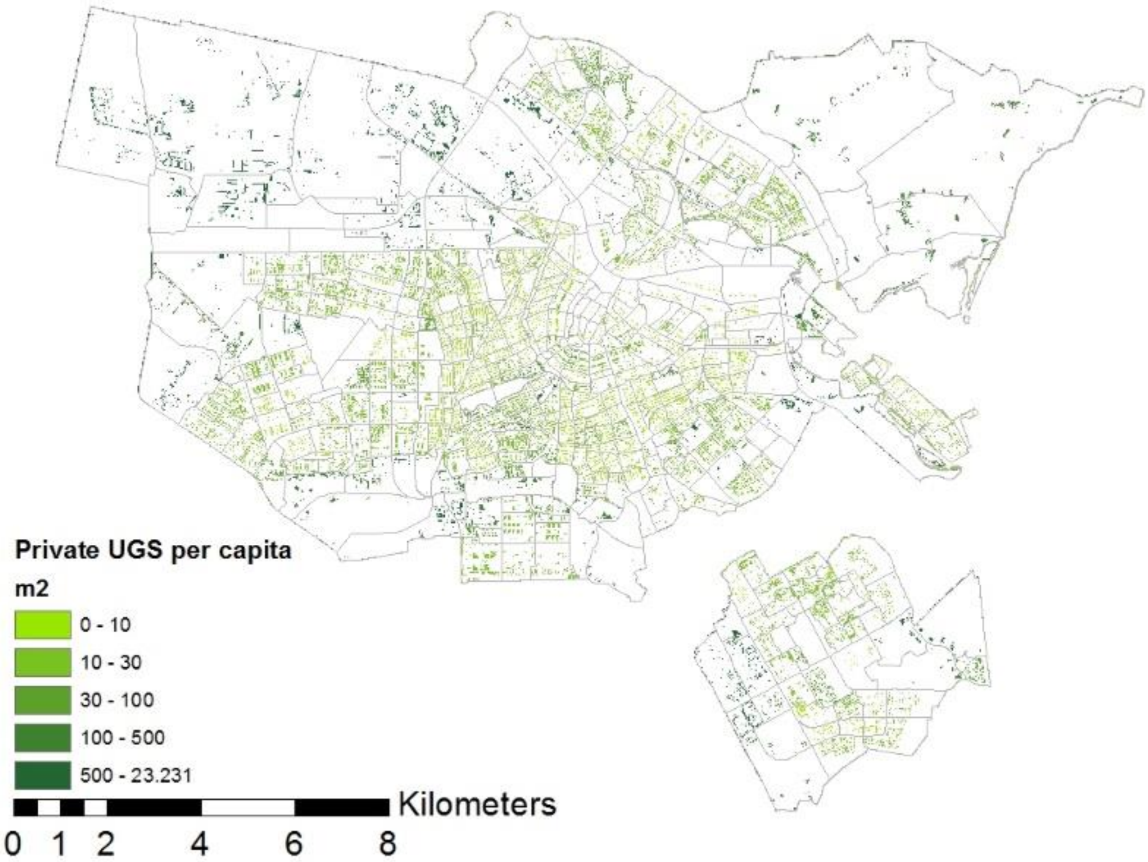


Figure 4.11: Private UGS per capita and spatial distribution



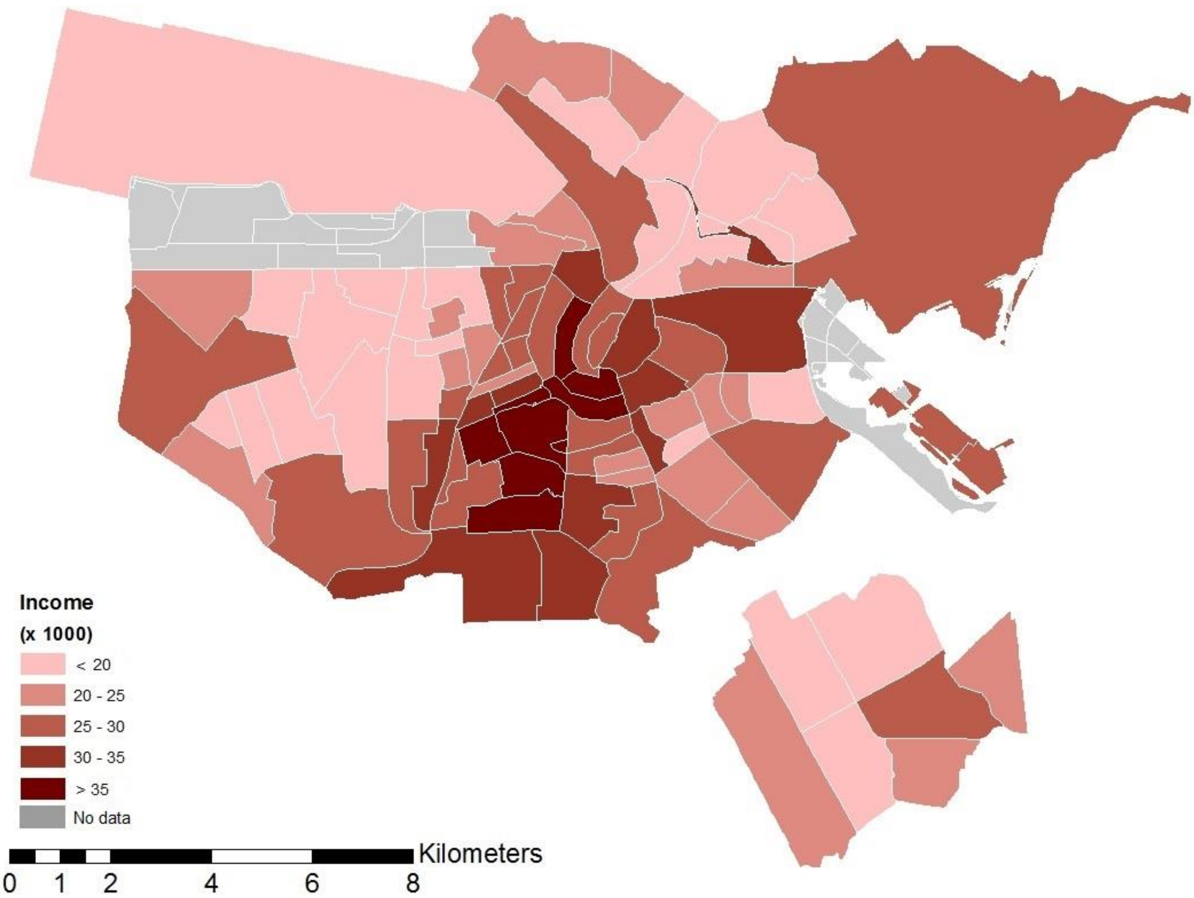
The first sub question was ‘How is UGS distributed in Amsterdam?’ After the analysis done in this chapter, this question can be answered for the total UGS provision, as well for private and public UGS. Summarizing, most UGS can be found at the city’s boundaries whereas green space in the centre is scarce. From all UGS, the majority is classified as public. This category is characterized by large patches of green, most of them located near the municipal boundaries, and smaller UGS such as streetscape greenery. The UGS classified as private is more evenly spread out over the city and contains less large patches than the public UGS provision. Yet, whereas public UGS increases towards the boundaries of the study area does private UGS decrease. However, the amount of private UGS per capita still increases, because of the low population density in these more outwardly located neighbourhoods.

4.2 SES in Amsterdam

In order to draw conclusions about the equality of the distribution of green spaces in relation to SES, knowledge about the distributional characteristics of SES in Amsterdam is required. Therefore, in this chapter the question 'How is socioeconomic status distributed in Amsterdam?' will be answered. As elaborated in the methodology section, income is used as indicator for SES.

Figure 4.12 represents the average annual income per inhabitant. People earning relatively much are more likely to live in neighbourhoods in the city centre such as the Canal Ring and south of the centre such as the Willemsparkbuurt, Apollobuurt and Museumkwartier. Residents with lower incomes are concentrated in the western and northern districts of Amsterdam, and in the Bijlmer in the southeast. To invigorate this argument, also the distributions of people with high incomes and low incomes are discussed in this chapter.

Figure 4.12: Average annual income per inhabitant



Figures 4.13 and 4.14 represent respectively the share of people with a high and low income. The district Oud-Zuid, consisting of the neighbourhoods Willemspark, Museumkwartier, Apollobuurt and around the business area surrounding the World Trade Centre in the south of Amsterdam form a large area with relatively high percentages of people belonging to the highest income groups. Additionally, the western zone of the Canal Ring and Nieuwendammerdijk in the north also account for a large proportion of high income inhabitants. Low shares of high income people can be found in the central part of the north of Amsterdam (Volewijck and Vogelbuurt), around the industrial areas in the west called Sloterdijk, on Zeeburg and southwest IJburg in the east and the central Bijlmer neighbourhood in the southeast of the city.

Figure 4.14: Proportion of people having a high income

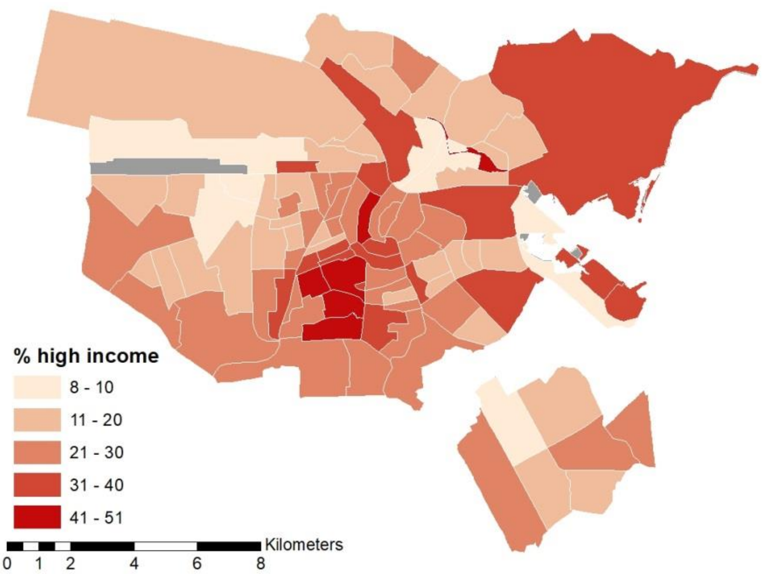
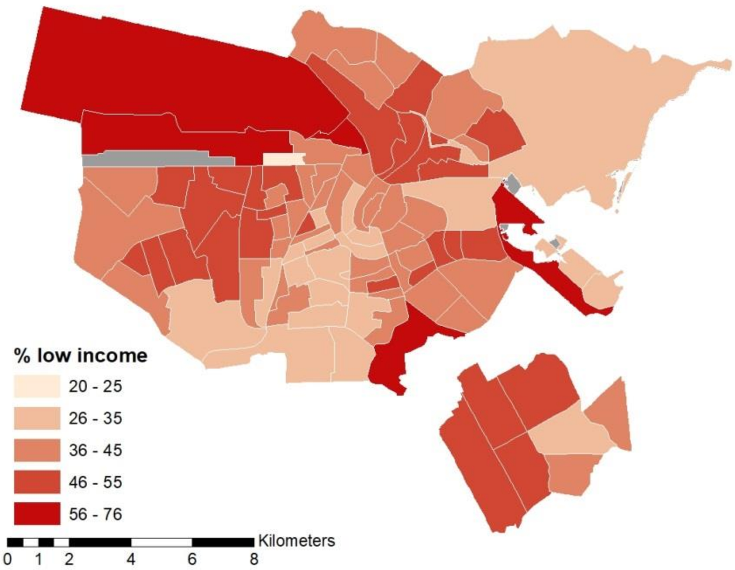


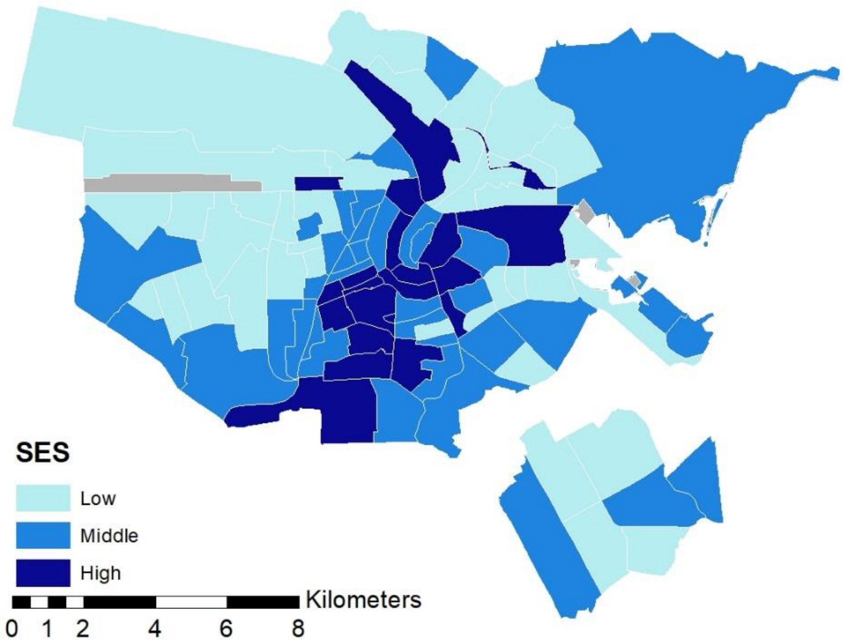
Figure 4.13: Proportion of people having a l income



Neighbourhoods with a large share of low incomes are located in the northwest of Amsterdam, which is the industrial port area, the east and the south. Additionally, districts located in the north (Tuindorp and Volewijck), the west (Kolenkitbuurt, Slotervaart, Slotermeer), the east (Transvaalbuurt and Indische Buurt) and the southeast (Bijlmer) have also relatively large shares of people with low incomes. Areas with a small share of people with low incomes are located in the south, the Canal Ring and the northeast of Amsterdam. Furthermore, the neighbourhoods that have a large share of high income people generally have a small proportion of low income people and the other way around.

Because income is used as indicator for SES, it can be stated that those neighbourhoods with high incomes have a high SES and neighbourhoods with low incomes have a low SES. This knowledge is used to categorize the neighbourhoods of Amsterdam based on the annual average income into different classes of SES (figure 4.15). The taxonomy of the CBS is used to define the classes of high and low SES, i.e. 40% neighbourhoods with the lowest average income are classified as low SES, the 20% neighbourhoods with the highest income as high SES and all neighbourhoods in between as middle SES. The class boundaries are therefore as follows: all annual incomes below 23 thousand euros are classified as low SES, incomes between 23 and 31,5 thousand as middle SES and incomes above 31,5 thousand as high SES.

Figure 4.15: Neighbourhoods with low, middle and high SES



In conclusion and to answer the second sub question: people with high SES generally live in quarters in the city centre (e.g. the Canal Ring), or south of the city centre. Neighbourhoods with residents with lower SES are located in the north, west, southeast and partly in the east.

4.3 Spatial equality of green space in Amsterdam

The results from the previous two sub questions will be compared in order to draw conclusions about the spatial justice of UGS in Amsterdam. As defined in the conceptual framework, spatial justice is here defined as distributional justice according to the equal outcome principle. Applied to UGS, this implies that UGS should be distributed evenly over the urban area, regardless the SES of the neighbourhood.

Figures 4.16, 4.17 and 4.18 show respectively the total, public and private UGS per capita and SES. The total UGS map shows that residents in high SES neighbourhoods tend to have access to more UGS per person than residents from the surrounding middle SES neighbourhoods. Additionally, low SES neighbourhoods, especially those located in the western districts of the study area, seem to have the most green space per capita. However, this observation is, of course, rather simplistic. People dwelling in middle SES neighbourhoods in the south, southeast and north of the city seem to enjoy a lot of green space per person, whereas residents living in low SES neighbourhoods positioned in the southeast or centrally northern areas have access to less UGS per capita.

Considering public UGS, residents living in neighbourhoods with low or middle SES, seem to have access to more publicly available green spaces, than their counterparts living in high SES neighbourhoods, especially in quarters in the west, north and southeast of the study area. Nevertheless, this does not apply to the city centre and its adjacent neighbourhoods, since high SES neighbourhoods seem to have slightly more public UGS than the surroundings middle SES areas. Regarding private green space per capita, figure 4.18 suggests that people dwelling in high SES neighbourhoods tend to have access to slightly more green space per person than the residents living in the surrounding middle SES neighbourhoods, except for the high and middle SES areas in the south of the city. Furthermore, the people residing in the low SES districts in the far west and northeast have substantially more green space per person than their counterparts in low SES areas in the mid-west and southeast.

Figure 4.16: Total UGGS per capita and SES

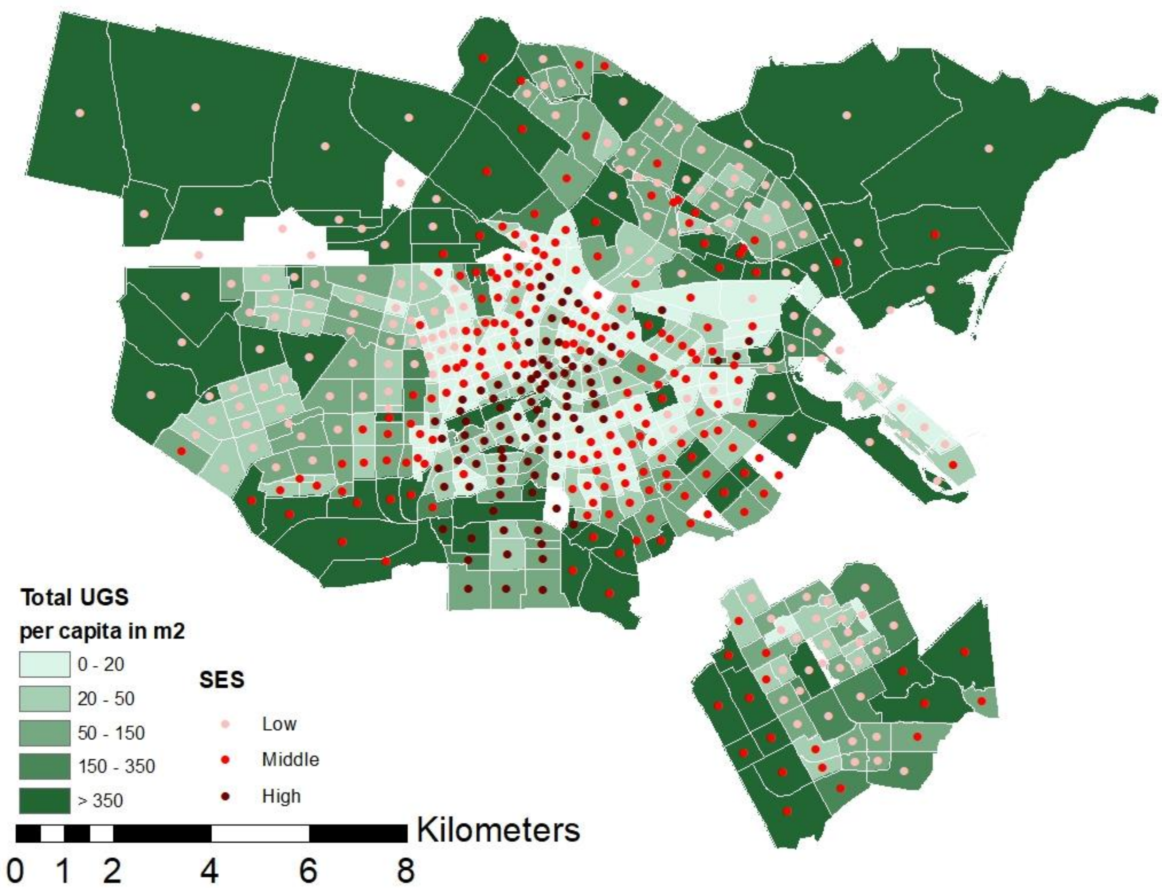


Figure 4.17: Public UGS per capita and SES

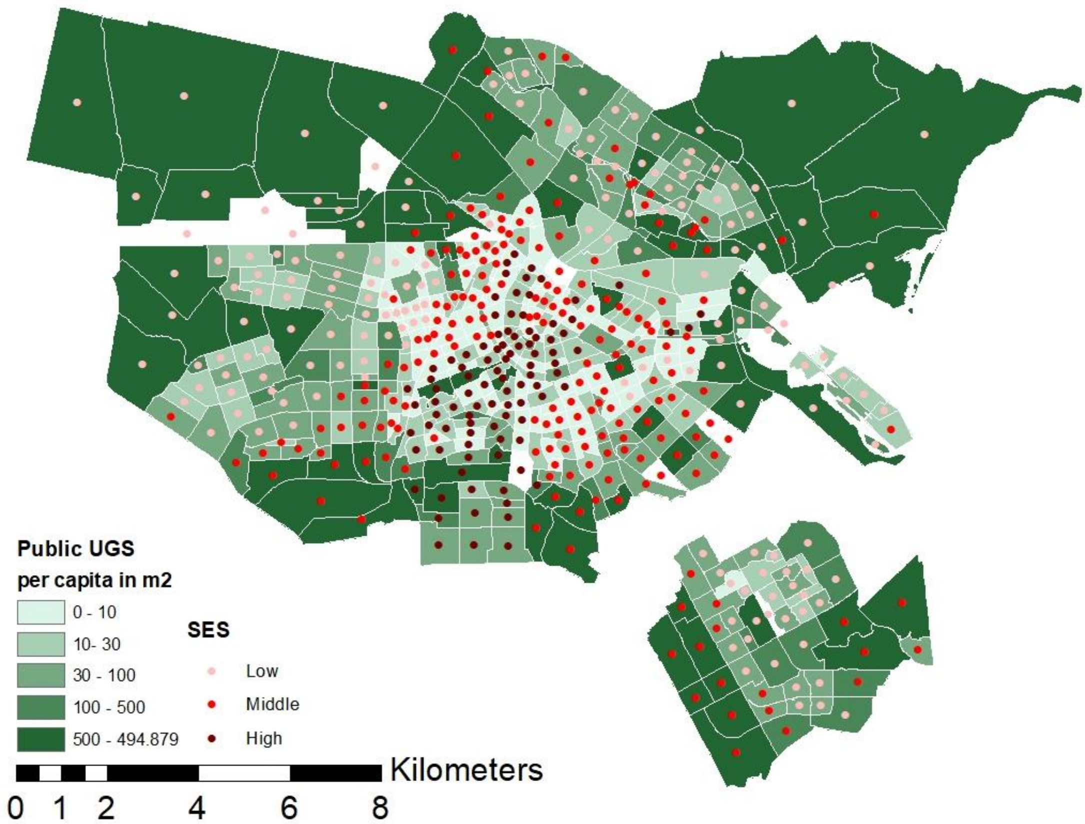
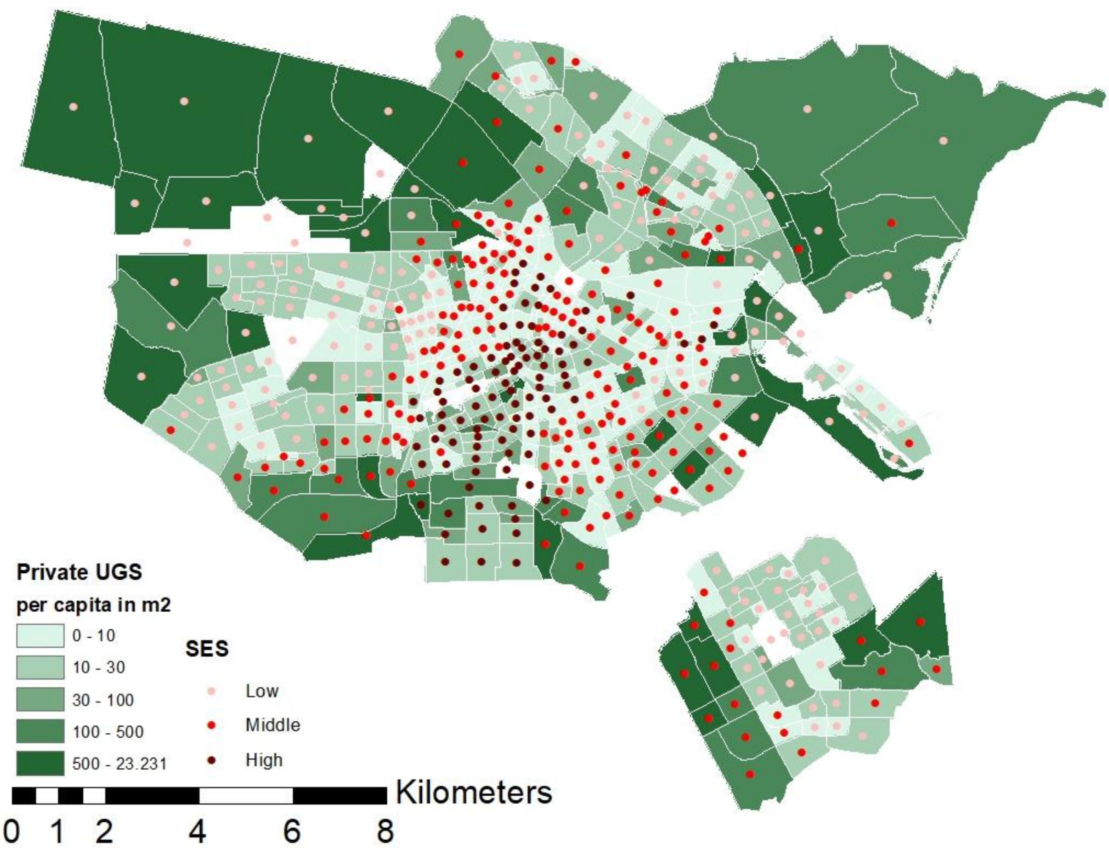


Figure 4.18: Private UGS per capita and SES



To check whether these patterns observed visually do actually exist, spatial statistics are applied. First, the global Moran's I is calculated for the average annual income, the total UGS, public UGS and private UGS. These statistics are presented in table 4.1. There is strong positive spatial autocorrelation for average annual income, which implies that neighbourhoods with high SES are likely to be surrounded by neighbourhoods with high SES and neighbourhoods and vice versa. In other terms, neighbourhoods with similar SES tend to spatially group together. This Moran's I value has a p-value of 0,000000 indicating a significant outcome that is not the result of chance. The Moran's I of total UGS is very small and not significant. The distribution of private UGS is characterized by very small positive SAC, with a possibility of 3% that it is the outcome of chance. Also, the distribution of public UGS is marked by a very small, significant SAC.

Table 4.1: Moran's I

	Moran's I	**P-value**
Income	0,728652	0,000000
Total UGS	0,006279	0,260775
Private UGS	0,013506	0,035547
Public UGS	0,014916	0,000788

The high Moran's I statistic for income suggests that usage of the OLS model is not suitable, because correction for SAC of SES is required. According to the AIC of all the three UGS categories (see table 4.2), the model performs best as a Spatial Error Model (SEM). The results are presented in table 4.3. The complete outputs are attached in appendix B. With a significance level of 5%, no relation between income and the three dependent variables under review can be found. However, with a 10% significance level, the level of income seems to have a negative relationship with private UGS and public UGS. This means that, regarding private and public green spaces, the higher the SES, the lower the amount of green space. With the aforementioned level of significance of 10%, still no relation between income and total UGS can be found. For all three tested models, the R^2, which denotes the level of variance in the dependent variable that is explained by the model, is very low. For private UGS, the R^2-value indicates that 1,7% of the variation in the distribution of private UGS per capita can be explained by the spatial distribution of SES. Regarding public UGS per capita, 3,3% of the variation in the distribution is explained by SES. The coefficient suggests that this variation consists of a negative correlation between SES and public UGS. These low values signify that there are more factors of importance on the level of UGS that are not included in this model.

Table 4.2: AIC scores

	Ordinary Least Squares (OLS)	**Spatial Lag Model (SLM)**	**Spatial Error Model (SEM)**
Total UGS	10776	10775	10773
Private UGS	8358	8357	8355
Public UGS	9970	9976	9962

Table 4.3: Results SEM

	R^2	**Coefficient SES**	**P-value**
Private UGS	0,017798	-39,17	0,0573880
Public UGS	0,033364	-240,85	0,0730659
Total UGS	0,008810	-209,67	0,4984184

After comparing the spatial distributions of average annual income and UGS per capita the conclusion can be drawn that with a significance level of 5%, none of the correlations are significant. However, when we would be using a significance level of 10%, some other conclusions can be drawn. Firstly, average annual income and thus SES predicts 1,7% of the spatial distribution of private green spaces per capita, which is expressed in a negative relationship. A higher SES of the neighbourhood accordingly corresponds to a lower amount of private green space per capita. Secondly, SES is able to forecast 3,3% of public UGS per capita, also with a negative relationship. This suggests that a higher SES is accompanied with a lower amount of public UGS. Thirdly, also with a significance level of 10%, there is no significant correlation between the spatial distributions of total UGS and SES.

The question that should be answered in this section is 'to what extend is there a correlation between these distributions and how spatially equal is this distribution?' After visualizing SES and UGS and performing the statistical analysis, this question can be answered. High SES neighbourhoods seem to have slightly more green space than the surrounding middle SES neighbourhoods. Low SES areas towards the municipal boundaries have the most UGS per person. This applies to private, public and total UGS, but the differences within and between these categories vary. Even though it seems that those are observable patterns, this is largely invalidated by the results of the statistical analysis. The low percentages of SES explaining UGS per capita show that there is almost no correlation between the variables income and UGS or, depending on the significance level, there is no correlation at all. Therefore, in the case of this study area, SES does not necessarily predict UGS availability. Because of the large differences in private, public and total green space availability between neighbourhoods, it can be stated that the spatial distribution of UGS in Amsterdam is not equal, but not as a result of SES. UGS availability is likely to be predicted by other variables too.

4.4 Contribution to the spatial justice debate

The fourth sub question is '*How do these results contribute in the spatial justice debate?*'. The objective of this question is to validate the results found in the previous sections by linking it to existing literature. By investigating whether the results correspond to the findings of other scholars is aimed at fitting the results in the contemporary spatial justice debate.

There is an ongoing debate about the spatial justness of the distribution of UGS. Recalling this debate completely is out of scope, but there is an extensive body of literature, written by scholars who believe that the provision of greenery is not distributed evenly over the urban environment (Hashem, 2015; Wendel et al., 2011). Frequently, SES is seen as a predictor of UGS access: high SES is associated with more UGS than low SES (Wen et al., 2013; Wüstemann et al., 2017; You, 2016; De La Barrera et al., 2015; Shen et al., 2017). This is, by many scholars, perceived as a spatial justice issue (Shen et al., 2017). Being aware that this is an oversimplification of the actual debate – a proper elaboration on spatial justice would be more extensive than this whole thesis – it should be taken into account that there is even no consensus what spatial justice means and how it should be defined, which can make the use of the concept 'spatial justice' tricky. This highlights the complexity of the spatial justice discussion.

As mentioned above, the dominant paradigm in the spatial justice debate is that a higher neighbourhood SES is accompanied by more access to UGS. Nevertheless, the results found in this study do not correspond to this perception of spatial justice. In the introduction, the conclusions of Lin et al. (2015) were mentioned. These authors found that high SES is generally associated with less public green space but more private green space. The results of this study partly agree to those of Lin et al. In study area Amsterdam, after visual comparison, the distributions of SES and public UGS seem to suggest that high SES is accompanied by low amount of public green spaces. Statistical analysis indicates nevertheless that SES only accounts for 3,3% of the variations in the distribution of public green spaces when using the relatively high significance level of 10%. Lin et al. also argue that neighbourhoods with high SES generally provide their residents with a more extensive private greenery provision than low SES neighbourhoods. Visual interpretation of the private UGS distribution indicates that this does not apply to the study area of Amsterdam. Private green space is relatively evenly spread spatially over the urban environment and barely, or, depending on the significance level, not at all influenced by SES.

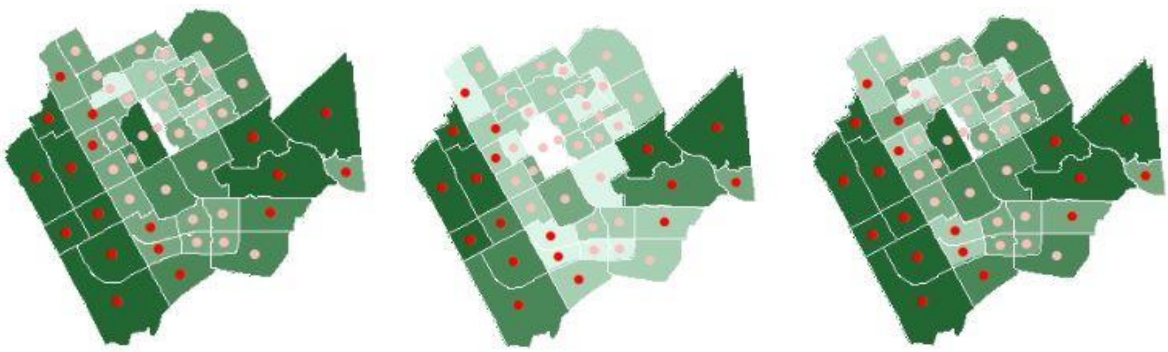
Besides the patterns observed by Lin et al. (2015), also the conclusions of Li and Liu (2016) are interesting in relation to the results found in Amsterdam. Li and Liu found, paralleling the findings of Lin et al., that public green space provision in Shanghai tend to be lower in neighbourhoods with high SES residents. However, these authors put this in perspective by arguing that this conclusion does not apply to all neighbourhoods and state that their findings outline that other physical conditions should also be kept in mind for better understanding of the relationships between public UGS and neighbourhood SES (Li & Liu, 2016). Because the found results in some neighbourhoods in the study of Li and Liu are different than other neighbourhoods, the conclusion of Wen et al. (2013) is interesting to consider. Wen et al. (2013) state that SES indicators are important predictors of spatial access to parks and green spaces, but correlations vary across space and urbanization level. This argument is interesting to bear in mind in relation to the findings of study area Amsterdam, because there are similar patterns observable in Amsterdam that do not apply to the study area as a whole. For instance, when comparing SES and UGS in the Bijlmer district, it seems that residents in higher

SES neighbourhoods have access to more total, private and public green space than their counterparts in lower SES areas (figure 4.19). This corresponds with the theory of Lin et al. (2015), that high SES neighbourhoods generally have more private green space, but also to the dominant discourse that high SES is associated with more UGS than low SES. Nonetheless, when applying statistical analysis to these observations in this area to see whether these patterns are statistically significant, only for public UGS in the Bijlmer a correlation with SES was found. The model output (see table 4.4, complete regression report attached in appendix B) indicates the existence of a significant, positive correlation implying that a higher SES of a neighbourhood corresponds to more public green space in that neighbourhood. The R^2 suggests that 24,4% of the variation in the amount of public green space can be explained by SES. The significance level used was 5%. This clearly corresponds to the dominant spatial justice paradigm, that a higher SES is accompanied by more UGS.

Table 4.4: Results SEM Bijlmer

	R^2	Coefficient SES	p-value
Public UGS	0,244246	449,9156	0,0234449

Figure 4.19: Total, private and public UGS and SES in the Bijlmer



To answer the fourth sub question, the study to the distribution of SES and UGS for the study area of Amsterdam as a whole did not yield clear relationships. Drawing conclusions about the spatial justness of the distribution of UGS in Amsterdam is therefore not possible. The results of this thesis thus do not fit the dominant paradigm that a higher SES goes along with more and better spatial access to urban greenery. Yet, there are scholars that took a slightly different point of view in the spatial justice debate, amongst them are Lin et al. (2015); Li and Liu (2016) and Wen et al. (2013). Those researchers drew conclusions that, in the light of the spatial justice debate, also apply to Amsterdam. Because there is no clear correlation between SES and UGS in this study area, especially the statement of Li and Liu that other factors should be considered too in the assessment of green space availability make sense considering Amsterdam. Additionally, what will be found varies along with the scale level (Wen et al., 2013).

5. Conclusion

The main research question posed in this report is: '*How spatially equal is the distribution of private and public green spaces in the city of Amsterdam and how does this relate to the spatial justice debate?'*. Based on the results of the four sub questions, this question can be answered.

In the previous section, the distribution of green space in Amsterdam was studied. Based on the results was concluded that areas with the most UGS can be found in the outer city, whereas areas with UGS scarcity are found within the inner city. Furthermore, the provision of public UGS is substantially larger than the provision of private UGS, but private green space is spread more evenly over the urban area. Incorporating the population in green space distributions shows that people dwelling in neighbourhoods located more outwardly have access to more green space than residents of more centrally located neighbourhoods. This applies to private, public as well as total green space, yet differences between these categories are large, especially between private and public UGS per capita.

Besides the provision of UGS, also the distribution of SES is studied. The findings show that high SES neighbourhoods are located in the city centre and south of the centre. Low SES districts can be found in the northern, western and south-eastern parts of Amsterdam. Middle SES neighbourhoods mostly surround the city centre and are thus positioned between the high and low SES areas.

The findings about UGS and SES are thereafter used as input to detect possible patterns and correlations between these variables. Although visual interpretation seems to suggest that high SES neighbourhoods generally provide their residents with more UGS per capita than middle SES neighbourhoods whereas residents of low SES neighbourhoods tend to have access to the most UGS per capita, statistical analysis invalidates most of these observations. There is no significant evidence for a correlation between neighbourhood SES and total green space per resident. Depending on the significance level used, a correlation for private and public green space and neighbourhoods SES can be found, yet the explained variance is very small. This implies, for all three UGS categories, that other factors play a role in the distribution. As seen in the first sub question, the distribution of total, public and private green space is not spatially equal, but judging from the results of the statistical analysis, this unequal distribution is not caused by SES.

These outcomes can be validated by linking it to findings of other scholars. The most common paradigm in the spatial justice debate – that high SES neighbourhoods have more UGS than low SES neighbourhoods – does not apply to the results of this thesis. But the ambiguous results of the third sub question make it interesting to consider spatial justice in Amsterdam from a perspective similar to those of Wen et al. (2013) and Li and Liu (2016), because the spatial equality of the UGS distribution is affected by more than just SES, and varies across space.

In conclusion, the distribution of green space in Amsterdam is not spatially equal. This distribution shows great disparities in the amount of green space between neighbourhoods. Private green space is more equally distributed than public green space, but still with large differences between central neighbourhoods and neighbourhoods located more in the outskirts of the city. The spatial justice debate considers to what extend neighbourhood SES can predict UGS availability, but in Amsterdam, SES does hardly or not at all play a role in the distribution of urban greenery. Because no clear relationship between neighbourhood SES and the availability of green spaces was found, it is hard to link it to the spatial justice debate. Yet, the findings of this thesis correspond to the discourse that, besides neighbourhood SES, other factors should be considered too, and that these factors vary across space. This also applies to Amsterdam.

6. Discussion and reflection

While working on this research, some issues were identified. This chapter discusses these, followed by a reflection on the research objectives.

6.1 Discussion

In the methodology section was justified why UGS is measured following the neighbourhood boundaries. The results of this method do not completely represent the way how green space is used by the residents of Amsterdam, since people can visit UGS positioned in adjacent neighbourhoods. For proper analysis, creating a model as close to reality as possible, but also as simple as possible, is key. Being aware that measuring UGS per neighbourhood is not completely realistic, it should be noted that no approach is perfect. Bearing the scope of this thesis in mind, the method applied in this thesis was the best compromise in developing a realistic, but simple model.

Another issue arose in relation to the vegetation index. The amount of surface classified as vegetation is probably more than reality. This is due to the fact that trees account for a larger vegetated surface in this classification than in reality, because the photos were taken from above. Since trees are on ground level smaller than they appear in aerial imagery, these results in a rather large surface classified as UGS. However, from an ESS perspective, green appearance is perceived more important than land use, and therefore the effect this over-classification has on the results is negligible.

Attention should also be devoted to the fact that presence of UGS does not tell anything about accessibility. In the methodology section is explained that this thesis focuses on the spatial location of urban greenery. Nothing is concluded however about the accessibility of these spaces. Presence of UGS does not guarantee access. One can have a large park very nearby, but it might still feel inaccessible because of safety issues such as traffic or drug trafficking, social exclusion or simply lack of entrances. Therefore, this difference should be considered in interpreting the conclusions of this report.

Maybe one of the most important issues of this report is the definition of spatial justice. This is a sensitive concept, hence it should be used carefully. Additionally, the results depend on the way spatial justice is defined. One of the outcomes of this research is that no conclusions about spatial justice in Amsterdam can be drawn, since no explanatory correlations between neighbourhood SES and UGS are found. If, however, spatial justice was defined differently, this would have affected the results and other conclusions would have been drawn.

The variable income was, as indicated by the Moran's I value, positively spatial auto-correlated. For this SAC is a logical explanation. Income data was available for the year 2014, when the neighbourhood division with 95 quarters was used. This data was thereafter disaggregated to the level of the 476 smaller neighbourhoods. This has resulted in lots of neighbourhoods getting the same income value as surroundings neighbourhoods. To reduce the subsequent high level of SAC, instead of disaggregating income, UGS incomes could have been aggregated to the larger neighbourhoods. This increases however the effect of the MAUP. Additionally, a spatial regression model (SEM) was used, which is able to cope with SAC. Therefore is chosen to disaggregate income data instead of aggregating UGS data.

When using a significance level of 10%, negative correlations can be found between neighbourhood SES and public UGS and neighbourhood SES and private UGS, however rather weak. The expectations therefore were to also find a negative correlation between the total UGS and neighbourhood SES. Yet, this correlation does not exist. It is likely that this issue has affected the results, however, with current knowledge, a possible explanation is not available. This is something to bear in mind when interpreting the conclusions.

6.2 Reflection on research objectives

As stated in the introduction, this study had three research objectives: (1) to develop a method to properly distinct between private and public vegetation; (2) to provide insight in the spatial equality of the distribution of urban green spaces in Amsterdam; and (3) to contribute to the broader societal dialogue about spatial justice in relation to UGS.

In this thesis, a way of separating private and public UGS is developed, according to the definitions of public and private green spaces used in this report. Whether other individuals consider this as a suitable classification method depends on various factors and is, for now, unknown. Nevertheless, considering the way public and private UGS is defined and the available resources for this thesis (i.e. time, software, data and competences), the first objective is considered as achieved.

Additionally, this report drew an image of the distribution of private, public and all the green spaces in Amsterdam. This yielded awareness about the inequality of the city's greenery. Considering the fact that similar research, especially in combination with neighbourhood SES, was not conducted before in Amsterdam, it can be stated that this report provided insight in the spatial distribution of UGS. This implies that also the second research objective is achieved.

The third and last objective is quite ambitious. The number of studies to urban greenery in combination with SES is abundant and contributing to this extensive body of literature is therefore challenging. With this study is proved that in Amsterdam not only SES matters, but mostly other factors account for UGS variations. Therefore, knowledge is contributed to the subject of spatial justice. This may not be ground-breaking and revolutionary information, but that does not make it less valuable. Therefore is concluded that also the third objective of this research is achieved.

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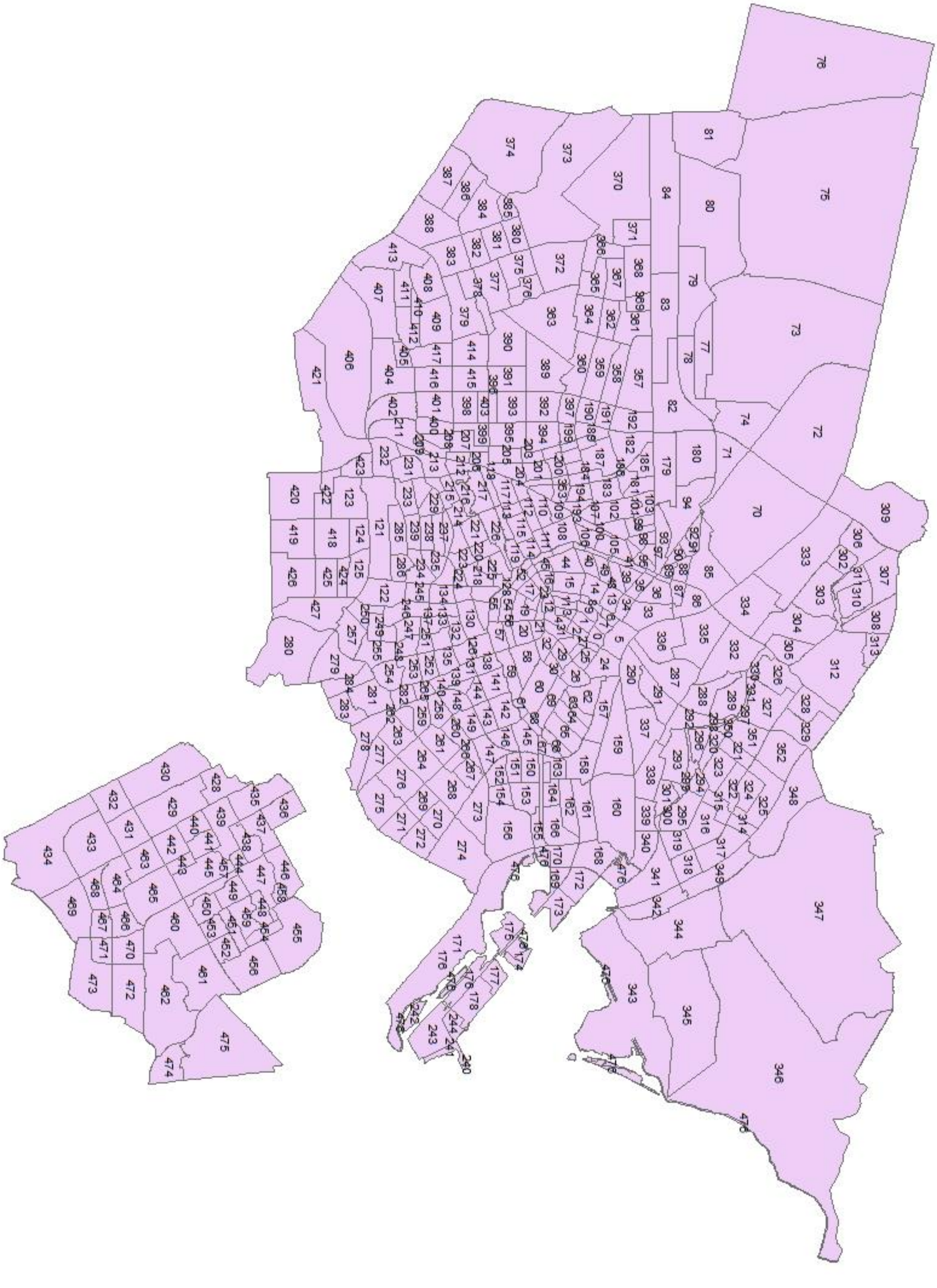
Appendix A: Neighbourhoods in the study area



1. Kop Zeedijk
2. Oude Kerk e.o.
3. Burgwallen Oost
4. Nes e.o.
5. BG-terrein e.o.
6. Stationsplein e.o.
7. Hemelrijk
8. Nieuwendijk Noord
9. Spuistraat Noord
10. Nieuwe Kerk e.o.
11. Spuistraat Zuid
12. Begijnhofbuurt
13. Kalverdriehoek
14. Langestraat e.o.
15. Leliegracht e.o.
16. Felix Meritisbuurt
17. Leidsegracht Noord
18. Spiegelbuurt
19. Gouden Bocht
20. Van Loonbuurt
21. Amstelveldbuurt
22. Rembrandtpleinbuurt
23. Reguliersbuurt
24. Leidsegracht Zuid
25. Oosterdokseiland
26. Scheepvaarthuisbuurt
27. Rapenburg
28. Lastage
29. Nieuwmarkt
30. Uilenburg
31. Valkenburg
32. Zuiderkerkbuurt
33. Waterloopleinbuurt
34. Westerdokseiland
35. Haarlemmerbuurt Oost
36. Haarlemmerbuurt West
37. Westelijke eilanden
38. Planciusbuurt Noord
39. Planciusbuurt Zuid
40. Driehoekbuurt
41. Bloemgrachtbuurt
42. Marnixbuurt Noord
43. Zaagpoortbuurt
44. Marnixbuurt Midden
45. Elandsgrachtbuurt
46. Passeerdersgrachtbuurt
47. Groenmarktkadebuurt
48. Marnixbuurt Zuid
49. Anjeliersbuurt Noord
50. Anjeliersbuurt Zuid
51. Leidsebuurt Noordwest
52. Leidsebuurt Zuidwest
53. Leidsebuurt Noordoost
54. Leidsebuurt Zuidoost
55. Weteringbuurt
56. Den Texbuurt
57. Utrechtsebuurt Zuid
58. Frederikspleinbuurt
59. Weesperbuurt
60. Sarphatistrook
61. Plantage
62. Alexanderplein e.o.
63. Marine-Etablissement
64. Kattenburg
65. Wittenburg
66. Oostenburg
67. Czaar Peterbuurt
68. Het Funen
69. Kazernebuurt
70. Kadijken
71. Coenhaven/Mercuriushaven
72. Alfa-driehoek
73. Petroleumhaven
74. Westhaven Noord
75. Vervoerscentrum
76. Amerikahaven
77. Afrikahaven
78. Westhaven Zuid
79. Sloterdijk II
80. Sloterdijk III Oost
81. Sloterdijk III West
82. De Heining
83. Teleport
84. Bretten Oost
85. Bretten West
86. Houthavens West
87. Houthavens Oost
88. Zeeheldenbuurt
89. Spaarndammerbuurt Noordoost
90. Spaarndammerbuurt Zuidoost
91. Spaarndammerbuurt Zuidwest
92. Spaarndammerbuurt Midden
93. Spaarndammerbuurt Noordwest
94. Westergasfabriek
95. Overbraker Binnenpolder
96. De Wittenbuurt Noord
97. De Wittenbuurt Zuid
98. Staatsliedenbuurt Noordoost
99. Fannius Scholtenbuurt
100. Westerstaatsman
101. Buyskade e.o.
102. Ecowijk
103. Markthallen
104. Bedrijvencentrum Westerkwartier
105. Marcanti
106. Frederik Hendrikbuurt Noord
107. Frederik Hendrikbuurt Zuidoost
108. Frederik Hendrikbuurt Zuidwest
109. Da Costabuurt Noord
110. Bellamybuurt Noord
111. Bellamybuurt Zuid
112. Da Costabuurt Zuid
113. Borgerbuurt
114. Lootsbuurt
115. Helmersbuurt Oost
116. WG-terrein
117. Cremerbuurt Oost
118. Cremerbuurt West
119. Vondelparkbuurt West
120. Vondelparkbuurt Oost
121. Vondelparkbuurt Midden
122. Zuidas Noord
123. RAI
124. VU-kwartier
125. Zuidas Zuid
126. Vivaldi
127. Hemonybuurt
128. Gerard Doubuurt
129. Frans Halsbuurt
130. Hercules Seghersbuurt
131. Sarphatiparkbuurt
132. Willibrordusbuurt
133. Van der Helstpleinbuurt
134. Lizzy Ansinghbuurt
135. Cornelis Troostbuurt
136. Diamantbuurt
137. Burgemeester Tellegenbuurt Oost
138. Burgemeester Tellegenbuurt West

139. Swammerdambuurt
140. Weesperzijde Midden/Zuid
141. Parooldriehoek
142. Oosterparkbuurt Noordwest
143. Oosterpark
144. Oosterparkbuurt Zuidoost
145. Oosterparkbuurt Zuidwest
146. Dapperbuurt Noord
147. Dapperbuurt Zuid
148. Oostpoort
149. Transvaalbuurt West
150. Transvaalbuurt Oost
151. Noordwestkwadrant Indische buurt Noord
152. Noordwestkwadrant Indische buurt Zuid
153. Zuidwestkwadrant Indische buurt
154. Noordoostkwadrant Indische buurt
155. Zuidoostkwadrant Indische buurt
156. Zeeburgerdijk Oost
157. Flevopark
158. Oostelijke Handelskade
159. Rietlanden
160. Java-eiland
161. KNSM-eiland
162. Sporenburg
163. Borneo
164. Entrepot-Noordwest
165. Architectenbuurt
166. Bedrijvengebied Veelaan
167. Bedrijvengebied Cruquiusweg
168. Bedrijvengebied Zeeburgerkade
169. Zeeburgereiland Noordwest
170. Zeeburgereiland Zuidoost
171. Zeeburgereiland Zuidwest
172. Nieuwe Diep/Diemerpark
173. RI Oost terrein
174. Zeeburgereiland Noordoost
175. Steigereiland Noord
176. Steigereiland Zuid
177. Haveneiland Zuidwest/Rieteiland West
178. Haveneiland Noordwest
179. Haveneiland Noordoost
180. Woon- en Groengebied Sloterdijk
181. Bedrijventerrein Sloterdijk I
182. Bedrijventerrein Landlust
183. Bosleeuw
184. Landlust Zuid
185. Erasmusparkbuurt Oost
186. Gibraltarbuurt
187. Landlust Noord
188. Erasmusparkbuurt West
189. Robert Scottbuurt Oost
190. Robert Scottbuurt West
191. Laan van Spartaan
192. Kolenkitbuurt Zuid
193. Kolenkitbuurt Noord
194. Geuzenhofbuurt
195. Trompbuurt
196. Pieter van der Doesbuurt
197. John Franklinbuurt
198. Jan Maijenbuurt
199. Orteliusbuurt Noord
200. Mercatorpark
201. Balboaplein e.o.
202. Columbusplein e.o.
203. Orteliusbuurt Midden
204. Orteliusbuurt Zuid
205. Paramariboplein e.o.
206. Postjeskade e.o.
207. Surinamepleinbuurt
208. Westlandgrachtbuurt
209. Aalsmeerwegbuurt West
210. Aalsmeerwegbuurt Oost
211. Legmeerpleinbuurt
212. Bedrijventerrein Schinkel
213. Schinkelbuurt Noord
214. Schinkelbuurt Zuid
215. Valeriusbuurt Oost
216. Valeriusbuurt West
217. Willemsparkbuurt Noord
218. Vondelpark West
219. Johannnes Vermeerbuurt
220. P.C. Hooftbuurt
221. Concertgebouwbuurt
222. Cornelis Schuytbuurt
223. Banpleinbuurt
224. Hondecoeterbuurt
225. Harmoniehofbuurt
226. Museumplein
227. Vondelpark Oost
228. Duivelseiland
229. Bertelmanpleinbuurt
230. Marathonbuurt Oost
231. Marathonbuurt West
232. Olympisch Stadion e.o.
233. IJsbaanpad e.o.
234. Van Tuyllbuurt
235. Diepenbrockbuurt
236. Beethovenbuurt
237. Hiltonbuurt
238. Minervabuurt Noord
239. Minervabuurt Midden
240. Minervabuurt Zuid
241. Middeneiland Zuidwest
242. Centrumeiland
243. Rieteiland Oost
244. Haveneiland Oost
245. Haveneiland Noord
246. Wielingenbuurt
247. Scheldebuurt West
248. Scheldebuurt Midden
249. Scheldebuurt Oost
250. Veluwebuurt
251. Kop Zuidas
252. IJselbuurt West
253. IJselbuurt Oost
254. Kromme Mijdrechtbuurt
255. Rijnbuurt Oost
256. Rijnbuurt Midden
257. Rijnbuurt West
258. Zorgvlied
259. De Eenhoorn
260. Julianapark
261. Don Bosco
262. Frankendael
263. Tuindorp Amstelstation
264. De Wetbuurt
265. Tuindorp Frankendael
266. Van der Kunbuurt
267. Linnaeusparkbuurt
268. Middenmeer Noord
269. Middenmeer Zuid
270. Sportpark Middenmeer Zuid
271. Sportpark Middenmeer Noord
272. Park de Meer
273. Sportpark Voorland
274. Science Park Noord
275. Science Park Zuid
276. Betondorp

277. Nieuwe Oosterbegraafplaats
278. Drieburg
279. Weespertrekvaart
280. Amstelglorie
281. Overamstel
282. Amstelkwartier Noord
283. De Omval
284. Amstelkwartier Zuid
285. Amstelkwartier West
286. Prinses Irenebuurt
287. Beatrixpark
288. Van der Pekbuurt
289. Bloemenbuurt Zuid
290. Bloemenbuurt Noord
291. IJplein e.o.
292. Vogelbuurt Zuid
293. Vogelbuurt Noord
294. Vliegenbos
295. Tuindorp Nieuwendam West
296. Tuindorp Nieuwendam Oost
297. Blauwe Zand
298. Buiksloterdijk West
299. Buiksloterdijk Oost
300. Nieuwendammmerdijk West
301. Nieuwendammerdijk Oost
302. Nieuwendammerdijk Zuid
303. Tuindorp Oostzaan West
304. Tuindorp Oostzaan Oost
305. Terrasdorp
306. De Bongerd
307. Oostzanerdijk
308. Walvisbuurt
309. Twiske West
310. Noorder IJplas
311. Molenwijk
312. Circus/Kermisbuurt
313. Kadoelen
314. Twiske Oost
315. Baanakkerspark Noord
316. Baanakkerspark Zuid
317. Werengouw Midden
318. Markengouw Midden
319. Markengouw Zuid
320. Werengouw Zuid
321. Rode Kruisbuurt
322. Loenermark
323. Buikslotermeerplein
324. Plan van Gool
325. De Kleine Wereld
326. Buikslotermeer Noord
327. Banne Zuidwest
328. Banne Zuidoost
329. Banne Noordwest
330. Banne Noordoost
331. Buiksloterbreek
332. Marjoleinterrein
333. Papaverweg e.o.
334. Cornelis Douwesterrein
335. NDSM terrein
336. Buiksloterham
337. Overhoeks
338. Bedrijventerrein Hamerstraat
339. Zamenhofstraat e.o.
340. Bedrijventerrein Nieuwendammerdijk
341. Schellingwoude West
342. Schellingwoude Oost
343. Schellingwoude Noord
344. Durgerdam
345. Zwarte Gouw
346. Ransdorp
347. Holysloot
348. Zunderdorp
349. Noorderstrook West
350. Noorderstrook Oost
351. Nintemanterrein
352. Elzenhagen Zuid
353. Elzenhagen Noord
354. Kortenaerkwartier
355. Filips van Almondekwartier
356. De Wester Quartier
357. Van Brakelkwartier
358. Buurt 3
359. Buurt 2
360. Slotermeer Zuid
361. Noordoever Sloterplas
362. Buurt 4 Oost
363. Buurt 5 Noord
364. Sloterpark
365. Buurt 5 Zuid
366. Buurt 6
367. Buurt 7
368. Buurt 8
369. Buurt 9
370. Eendrachtspark
371. Osdorper Binnenpolder
372. Buurt 10
373. Ookmeer
374. Osdorper Bovenpolder
375. Bedrijvenpark Lutkemeer
376. Wildeman
377. Meer en Oever
378. Osdorpplein e.o.
379. Calandlaan/Lelylaan
380. Osdorp Zuidoost
381. Osdorp Midden Noord
382. Osdorp Midden Zuid
383. Zuidwestkwadrant Osdorp Noord
384. Zuidwestkwadrant Osdorp Zuid
385. De Punt
386. Bedrijvencentrum Osdorp
387. Middelveldsche Akerpolder
388. De Aker West
389. De Aker Oost
390. Oostoever Sloterplas
391. Emanuel van Meterenbuurt
392. Jacob Geelbuurt
393. Overtoomse Veld Noord
394. Overtoomse Veld Zuid
395. Rembrandtpark Noord
396. Rembrandtpark Zuid
397. Johan Jongkindbuurt
398. Lucas/Andreasziekenhuis e.o.
399. Koningin Wilhelminaplein
400. Andreasterrein
401. Delflandpleinbuurt Oost
402. Delflandpleinbuurt West
403. Riekerhaven
404. Schipluidenbuurt
405. Riekerpolder
406. Park Haagseweg
407. Nieuwe Meer
408. Sloterweg e.o.
409. Nieuw Sloten Noordwest
410. Nieuw Sloten Noordoost
411. Belgi├½plein e.o.
412. Nieuw Sloten Zuidwest
413. Nieuw Sloten Zuidoost
414. Dorp Sloten

415. Louis Crispijnbuurt
416. Jacques Veldmanbuurt
417. Staalmanbuurt
418. Medisch Centrum Slotervaart
419. Gelderlandpleinbuurt
420. Buitenveldert Midden Zuid
421. Buitenveldert Zuidwest
422. Amsterdamse Bos
423. Buitenveldert West Midden
424. Zuiderhof
425. De Klenckebuurt
426. Buitenveldert Oost Midden
427. Buitenveldert Zuidoost
428. Amstelpark
429. Hoofdcentrum Zuidoost
430. Amstel III deel A/B Noord
431. Amstel III deel C/D Noord
432. Amstel III deel A/B Zuid
433. Amstel III deel C/D Zuid
434. AMC
435. Hoge Dijk
436. Venserpolder West
437. Venserpolder Oost
438. D-buurt
439. F-buurt
440. Amsterdamse Poort
441. Hoptille
442. Rechte H-buurt
443. Hakfort/Huigenbos
444. Huntum
445. Vogeltjeswei
446. Nelson Mandelapark
447. E-buurt
448. G-buurt West
449. Bijlmermuseum Noord
450. Kortvoort
451. Kelbergen
452. K-buurt Midden
453. K-buurt Zuidoost
454. K-buurt Zuidwest
455. Grunder/Koningshoef
456. G-buurt Oost
457. Kantershof
458. Gooisekant
459. G-buurt Noord
460. Bijlmermuseum Zuid
461. L-buurt
462. Gaasperpark
463. Gaasperplas
464. Holendrecht West
465. Reigersbos Noord
466. Holendrecht Oost
467. Gaasperdam Noord
468. Gaasperdam Zuid
469. Reigersbos Midden
470. Reigersbos Zuid
471. Gein Noordwest
472. Gein Zuidwest
473. Gein Noordoost
474. Gein Zuidoost
475. Dorp Driemond
476. Landelijk gebied Driemond

Appendix B: SEM outputs

Private UGS

```
SUMMARY OF OUTPUT: SPATIAL ERROR MODEL - MAXIMUM LIKELIHOOD ESTIMATION
Data set              : Correlatieonderzoek
Spatial Weight        : Weights.gal
Dependent Variable    :     PRIVPP_1  Number of Observations:  446
Mean dependent var    :   437,414798  Number of Variables   :    2
S.D. dependent var    :  2841,098685  Degrees of Freedom    :  444
Lag coeff. (Lambda)   :     0,108404

R-squared             :     0,017798  R-squared (BUSE)      : -
Sq. Correlation       : -             Log likelihood        :-4175,883296
Sigma-square          :7,92818e+006   Akaike info criterion :     8355,77
S.E of regression     :       2815,7  Schwarz criterion     :     8363,97

-----------------------------------------------------------------------
    Variable    Coefficient      Std.Error       z-value    Probability
-----------------------------------------------------------------------
    CONSTANT      1490,784        576,1914       2,587306     0,0096730
  AVG_INK_IN     -39,17054        20,61236      -1,900343     0,0573880
      LAMBDA     0,1084044      0,07475619       1,450106     0,1470289
-----------------------------------------------------------------------

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                                     DF      VALUE           PROB
Breusch-Pagan test                       1        157,7194       0,0000000

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL ERROR DEPENDENCE FOR WEIGHT MATRIX : Weights.gal
TEST                                     DF        VALUE         PROB
Likelihood Ratio Test                    1        2,245152       0,1340337

COEFFICIENTS VARIANCE MATRIX
   CONSTANT  AVG_INK_IN      LAMBDA
 331996,505903  -11470,432060    0,000000
 -11470,432060  424,869265    0,000000
   0,000000    0,000000    0,005588

========================= END OF REPORT==============================
```

Public UGS

```
SUMMARY OF OUTPUT: SPATIAL ERROR MODEL - MAXIMUM LIKELIHOOD ESTIMATION
Data set              : Correlatieonderzoek
Spatial Weight        : Weights.gal
Dependent Variable    :  PUBLICUGSC  Number of Observations:  446
Mean dependent var    : 2455,401345  Number of Variables   :    2
S.D. dependent var    :17318,275251  Degrees of Freedom    :  444
Lag coeff. (Lambda)   :    0,183901

R-squared             :    0,033364  R-squared (BUSE)      : -
Sq. Correlation       : -            Log likelihood        :-4979,415434
Sigma-square          :2,89916e+008  Akaike info criterion :     9962,83
S.E of regression     :     17026,9  Schwarz criterion     :     9971,03

-----------------------------------------------------------------------
    Variable    Coefficient     Std.Error       z-value    Probability
-----------------------------------------------------------------------
    CONSTANT      8995,479       3759,191       2,392929     0,0167144
  AVG_INK_IN     -240,8501       134,3716      -1,792418     0,0730659
      LAMBDA     0,1839011      0,0721558       2,548666     0,0108136
-----------------------------------------------------------------------

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                                        DF      VALUE          PROB
Breusch-Pagan test                          1        206,0562      0,0000000

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL ERROR DEPENDENCE FOR WEIGHT MATRIX : Weights.gal
TEST                                        DF       VALUE         PROB
Likelihood Ratio Test                       1        7,637532      0,0057166

COEFFICIENTS VARIANCE MATRIX
   CONSTANT  AVG_INK_IN      LAMBDA
 14131520,238758  -487433,689588    0,000000
 -487433,689588  18055,724071    0,000000
   0,000000     0,000000     0,005206

========================= END OF REPORT==============================
```

Total UGS

```
SUMMARY OF OUTPUT: SPATIAL ERROR MODEL - MAXIMUM LIKELIHOOD ESTIMATION
Data set              : Correlatieonderzoek
Spatial Weight        : Weights.gal
Dependent Variable    :         PP_1  Number of Observations:  446
Mean dependent var    : 6854,816143  Number of Variables   :    2
S.D. dependent var    :42541,179071  Degrees of Freedom    :  444
Lag coeff. (Lambda)   :    0,107286

R-squared             :    0,008810  R-squared (BUSE)      : -
Sq. Correlation       : -            Log likelihood        :-5384,906469
Sigma-square          :1,79381e+009  Akaike info criterion :     10773,8
S.E of regression     :     42353,4  Schwarz criterion     :       10782

-----------------------------------------------------------------------
    Variable    Coefficient     Std.Error        z-value   Probability
-----------------------------------------------------------------------
    CONSTANT      12486,73       8657,565       1,442291     0,1492203
  AVG_INK_IN     -209,6704       309,7143     -0,6769802     0,4984184
      LAMBDA     0,1072855     0,07479178       1,434456     0,1514423
-----------------------------------------------------------------------

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                                      DF      VALUE          PROB
Breusch-Pagan test                        1        57,06132      0,0000000

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL ERROR DEPENDENCE FOR WEIGHT MATRIX : Weights.gal
TEST                                      DF       VALUE         PROB
Likelihood Ratio Test                     1        2,254053      0,1332649

COEFFICIENTS VARIANCE MATRIX
   CONSTANT  AVG_INK_IN      LAMBDA
 74953425,839102  -2589686,705755     0,000000
 -2589686,705755  95922,937478    0,000000
   0,000000     0,000000     0,005594

========================= END OF REPORT==============================
```

Public UGS in the 'Bijlmer'

```
SUMMARY OF OUTPUT: SPATIAL ERROR MODEL - MAXIMUM LIKELIHOOD ESTIMATION
Data set              : BijlmerrCorrelatie
Spatial Weight        : BijlmerrCorrelatie.gal
Dependent Variable    :  PUBLICUGSC  Number of Observations:   48
Mean dependent var    : 2033,729167  Number of Variables   :    2
S.D. dependent var    :| 5458,890286  Degrees of Freedom    :   46
Lag coeff. (Lambda)   :    0,342426

R-squared             :    0,244246  R-squared (BUSE)      : -
Sq. Correlation       : -            Log likelihood        : -475,022656
Sigma-square          :2,25211e+007  Akaike info criterion :    954,045
S.E of regression     :     4745,64  Schwarz criterion     :    957,788

-----------------------------------------------------------------------
    Variable    Coefficient     Std.Error       z-value   Probability
-----------------------------------------------------------------------
    CONSTANT     -7853,314       4480,366     -1,752829     0,0796313
  AVG_INK_IN      449,9156       198,5414      2,266105     0,0234449
      LAMBDA     0,3424259      0,1899541      1,802677     0,0714388
-----------------------------------------------------------------------

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                                        DF      VALUE         PROB
Breusch-Pagan test                          1        10,52473     0,0011779

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL ERROR DEPENDENCE FOR WEIGHT MATRIX : BijlmerrCorrelatie.gal
TEST                                        DF       VALUE        PROB
Likelihood Ratio Test                       1        3,942973     0,0470675
========================= END OF REPORT==============================
```