Characteristics of urban green space (UGS) to promote the diversity of users in a compact urban development

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JULY 2022

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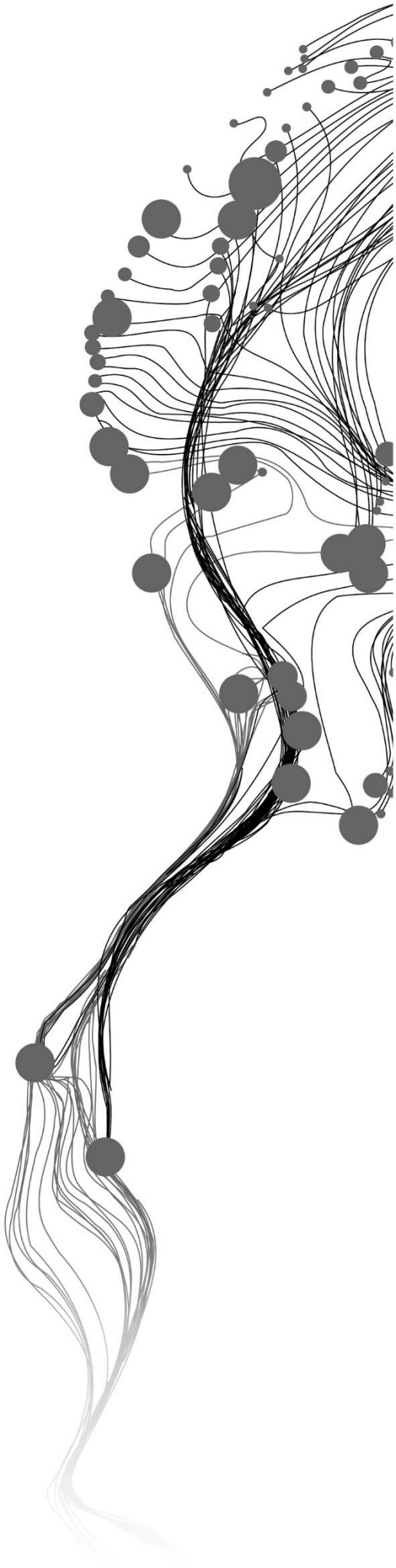

Characteristics of urban green space to promote the diversity of users in a compact urban development

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ABSTRACT

Urban green spaces, namely public urban parks, provide a range of physical and psychological well-being benefits for urban residents but often remain unused or under-used by a portion of the population. Especially in a compact urban development where land is scarce and developing new urban green space can be challenging, diverse users must use the valuable allocated land to urban parks to its fullest potential. This thesis aims to identify the characteristics of urban green space in a compact urban form and its surrounding neighborhood that promote diversity of users. The socio-ecological model(Schipperijn, 2010) was applied to conceptualize the factors of urban parks and surrounding neighborhoods influencing urban park use. The fifth dimension of neighborhood environment with function-mix, active travel, and public transportation was added to the model to adapt the model to this thesis. The study applies structured observation in two urban parks in Amsterdam's compact neighborhoods, and the diversity of the users was defined as users of different genders and ages. The result revealed that multifunctional areas in the parks attract more diverse users. Multifunctionality can be promoted by: a) placing a range of functions simultaneously within the same area or by b) spatial segregation of functions in one zone. Also, the findings indicate the synergy between the arrangement of activities in the park and the surrounding neighborhood's land use and transportation offered unique activity chances. The active park use was promoted by better access to public transportation and walking/ cycling infrastructure in Oosterpark, and sports fields and broad walking pathways supported the possibility of active park use. The framework developed in this study provides a holistic overview of factors influencing the use of urban parks in compact development, and the findings provide an empirical understanding of such factors. This study highlights the need for collaboration between different disciplines, including urban planning, landscape design, and related fields, to pursue a common goal of appreciating the fullest potential of urban parks by promoting the diversity of users.

Keywords: Urban green space, urban park, diversity of users, age, gender

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UGS = Urban Green Space

1. INTRODUCTION

1.1. Background and justification

The accelerated urbanization and rapid worldwide population growth expose many people to urban environments. Worldwide, the percentage of urban residents will reach 70% by 2050 (United Nations, 2014). The considerable migration to the cities, expansion, and densification highlight the urgent need for sustainable urban development. To achieve that aim, the United Nation's sustainable development goal 11 sets the broad ambition to "Make cities and human settlements inclusive, safe, resilient and sustainable." However, because of the multidimensionality of sustainable development, each dimension may move forward individually, developing friction and contradictions with other dimensions (Bibri et al., 2020). One of the unclear areas is the interaction between the goals of the compact city and the green city (Giezen et al., 2018), which is known as the "compact city paradox" (de Roo, 2000; Neuman, 2005).

Compact urban development is one of the most promising sustainable urbanism paradigms (Bibri, 2020). It limits urban development from sprawl and encourages densification, mixed land use, public transportation, and active travel. Compact development encourages reducing travel time and car dependency, mitigating air pollution by promoting active travel and public transportation, lowering building material use, facilitating the provision of various service facilities, and diversity of land use and social contact (Jabareen, 2006; Næss et al., 2011; Neutens et al., 2013a) However, some drawbacks are associated with dense, compact urban development; namely, congestion, air pollution, overuse of infrastructure, small-space dwellings, and unaffordable housing (Burton, 2000; Burton et al., 2003; Wolff & Haase, 2019). One of the essential criticisms of compact urban development is lacking or removing urban green areas during the compacting process (Artmann et al., 2019; Næss et al., 2020). At the same time, urban green space is one of the cities' essential sustainability elements.

Urban green spaces (UGS), as Taylor & Hochuli (2017,page32) defined, are "urban parks, including public parks, street verges, cemeteries, and sports grounds." The benefits of UGS for human well-being are well documented; there is a general agreement that urban green positively influences the quality of life (Andersson et al., 2014; Artmann et al., 2017; Niemelä, 2014) and provides various ecosystem services for urban residents. Ecosystem services refer to humans' benefits from the ecosystem (Bolund & Hunhammar, 1999). UGS has various physical and mental health benefits for urban residents. It contributes to physical health by boosting "green exercise" such as walking and physical activity (Pretty et al., 2003), lowering the mortality rate (Takano et al., 2002), and increasing the survival of the elderly (Hu et al., 2008). Also, access to UGS positively influences self-reported stress and anxiety (Space, 2005; Stigsdotter et al., 2010; Van den Berg et al., 2010), improving feeling and safety (Kuo et al., 1998; Mouratidis, 2019), and happiness (White et al., 2013). Additionally, UGS contributes to health and well-being by reducing or mitigating environmental pollution (Markevych et al., 2017). Areas around UGS have fewer air pollutants (Hirabayashi & Nowak, 2016; McDonald et al., 2016). UGS reduces noise pollution's acoustic and psychological harm by physically reducing noise exposure and mitigating the stress of noise (Van Renterghem et al., 2015). Recently, Covid 19 pandemic highlighted the potential of UGS in boosting urban residents' mental health. Xie et al. (2020) and Ugolini et al. (2020) indicated that UGS was found to be significant during the Covid-19 pandemic to mitigate the negative implication for health and well-being. Urban residents used UGS extensively because of less infection risk for leisure and physical activities. Finnsson (2020) has noted that the pandemics revealed the importance of access to urban green space, and it should be considered in future planning, design, and development of UGS.

UGS also fosters social cohesion, which refers to a positive connection between members of a society and feeling accepted in a group (de Vries et al., 2013; Forrest & Kearns, 2001). In a study in The Netherlands, urban parks were a valuable tool for stimulating interaction between different ethnic groups (Peters et al., 2010). In a study in Baltimore, the United States, Holtan, et al. (2015) found that tree canopy and social capital are positively related in neighborhoods. The reason derives from the increased use of sidewalks and outdoor spaces with trees. Also, higher levels of tree canopy fostered a sense of mystery that encourages walkers around the corner of the next block to meet their neighbors (Holtan et al., 2015).

Considering the essential benefits of urban green space for urban residents' including health, well-being, and social cohesion, and the significant contribution of UGS to spatial sustainability, it is worthy of addressing the provision of UGS in compact urban development.

1.2. Research problem

Despite the enormous amount of money governments invest in park management and the apparent well-designed spaces, many parks are under-utilized or used by a minority of the population (Azmi & Karim, 2012; Moulay et al., 2017; Neutens et al., 2013b, 2013a; Peters et al., 2010; Van Riper & Kyle, 2014; Zanon et al., 2013). One of the significant sustainability goals set by SDG11, Target 11.7, is "to provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities"(UN-Habitat, 2020, page 45). Thus, under-utilized UGS or used by only specific groups of users means that parks will not be appreciated to their fullest potential. This issue is even more critical in a compact development because of the scarcity and value of the land.

In the compact urban form, all urban elements such as buildings, infrastructure, green areas, and mixed-land uses are close and compete for limited land (Burton et al., 2003). Moreover, the imperviousness ratio is higher because of the artificial material and buildings (Arnold & Gibbons, 1996). The limited space left for vegetation growth is exposed to environmental pollution due to urbanization (Tian et al., 2012a). Hence, the inevitable scarcity of land in compact, dense development can put pressure on UGS and may result in loss of green space or a decline in its provision (Haaland & van den Bosch, 2015; Neuman, 2005). Changes in UGS through the compact process reveal a massive decrease in the quantity of UGS in Asian and Australian cities, and to a lesser degree, in Europe and North American cities (Haaland & van den Bosch, 2015). The densification in Amsterdam and Brussels placed pressure on UGS, resulting in reduced quality, connectivity, and size of urban green areas in both cities. However, in an analysis of green space in European cities between 1990 and 2006, the Western European cities showed an increase in UGS while Eastern cities decreased UGS, and overall compact cities maintained less green space per capita (Kabisch & Haase, 2013).

The limited quantity of UGS in compact development can be compensated for by using it by all possible users. As Beer, Delshammar, and Schildwacht suggest, in the context of compact, dense development, the needs of all the users of UGS should be considered (2003). UGS not being used means that some health and social cohesion benefits will not be obtained. In UN-Habitat's New Urban Agenda, attention to all user's needs and inclusive urban green space has also been pointed out. It emphasizes "safe, inclusive, accessible, green and quality public spaces" (UN-Habitat, 2017, page 5, 15). It encourages creating societies" where the needs of all inhabitants are met, recognizing the specific needs of those in vulnerable situations" (UN-Habitat, 2017,page5). Also, section 37 encourages the promotion of public spaces such as inclusive parks that enable "dialogue among a wide diversity of people and cultures" (UN-Habitat, 2017,page15). The WHO stresses "universal access" to urban green space for all population groups and users, and the design of UGS, which "facilitates activities by all population groups" (WHO Regional Office for Europe, 2017, page 11). Considering the significant potential of UGS, access and use of UGS become an essential measure of equity for a diverse group of urban residents (Mehta & Mahato, 2020). Therefore, examining UGS, especially in compact urban developments, can provide insights into the use of urban parks by different user groups and potentially facilitate the access of more users to the health and social benefits of UGS.

The use of green space is influenced by individual factors such as age, ethnicity and education, and physical ability (e.g., Galloway, 2002; Payne et al., 2002; Roovers et al., 2002) and environmental and physical factors such as distance, size, facilities, and possibilities for activities and social and cultural conditions (e.g., Coles & Bussey, 2000; Kaczynski et al., 2008; Van Herzele & Wiedemann, 2003). Despite significant research on the use of UGS and factors influencing the use of UGS (Pinto et al., 2021; Schipperijn, 2010; Schipperijn, Ekholm, et al., 2010a), less research has been focused on the uses of the diversity of users of UGS (Mehta & Mahato, 2020b; Taylor et al., 2020). At the same time, several studies indicated that UGS mostly fails to foster the use and need of diverse user groups. (Byrne, 2012; Forsyth & Musacchio, 2005; Loukaitou-Sideris, 1995). Accordingly, this study aims to understand the characteristics of UGS and surrounding neighborhoods in a compact urban development that optimizes the diversity of users that use a UGS.

1.3. Research objectives

1.3.1. General objective

The main aim of this thesis is to understand the characteristics of UGS and surrounding neighborhoods in a compact urban development that optimize the diversity of users.

1.3.2. Specific objectives

1) Understanding the interaction between the concepts of urban green space and compact urban development.

1. What is urban green space?
2. What is a compact urban development?
3. How do UGS and compact urban development interact?

2) Conceptualizing the use and users of urban green space in the context of compact urban development.

1. What factors affect the use of UGS?
2. What factors in the surrounding neighborhood of UGS affect the use of UGS?
3. How does compact development affect the use and users of UGS?

3) Explain the characteristics of urban green spaces that promote the diversity of users.

1. Who are the users of urban green space?
2. How do the users use urban green space?
3. How do the characteristics of urban green space and the surrounding neighborhood promote the diversity of its users?

1.4. Thesis structure

The structure of the thesis is as explained below:

Chapter 1, the introduction, provides the background, justification, the research problem, objectives, and research questions.

Chapter 2, the literature review, defines the concepts of UGS and compact development. Also, relevant literature about the use of UGS and compact urban development is reviewed.

Chapter 3, methodology, presents the overall methodology and study area, introducing the two urban parks as case studies, database and data collection methods, and data analysis methods.

Chapter 4, results, and discussion, includes the results, discussion of the results, and interpretations.

Chapter 5, conclusion and recommendation, discusses the study's contributions and limitations and provides recommendations for further research.

2. LITERATURE REVIEW

This section first defines urban green space and compact urban development. Also, the relevant research on the use of urban green space and contributing factors are reviewed.

2.1. Urban green space

Urban green space (UGS) refers to surfaces of the urban environment with vegetation such as grass, trees, shrubs, etc. (Vargas-Hernández et al., 2020). Santos et al. (2021) refer to the areas within the urban fabric with vegetation as urban green space, such as urban parks, lawns, street trees, private or public gardens, cemeteries, sports fields, and green walls and roofs. Hence, UGS is a broad concept encompassing all areas with vegetation in the urban fabric, but this thesis will solely focus on urban public parks. Urban public parks are open to the public, located in urban or suburban communities, with the purpose of civic benefit to users from the general public (Public Park | The Cultural Landscape Foundation, 2020).

2.2. Compact urban development

The compact urban development appeared to react to the urban sprawl in the suburbs after the second world war (Tong, 2018). The environmental, social, and economic problems associated with urban sprawl (United Nations, 2018) have made compact urban development a sustainable model for future urban development (Cortinovis et al., 2019). The compact urban development is characterized by high density, mixed land use, public transportation, walking, and cycling (Rogatka and Ribeiro, 2015). Mixed land use and high density bring high accessibility to housing, jobs, public spaces, service, and facilities. Also, a compact urban development provides efficient use of public transportation and active travel (walking and cycling), reduces travel time by shorter distances, and overall reduces car dependency (Jabareen, 2006; Næss et al., 2020; Rogatka & Ribeiro, 2015).

2.3. Urban green space in a compact urban development

Literature on urban green space in a compact urban development has several themes. Several attempts have been made to formulate the challenges of providing urban green space under compact development (e.g., Haaland & van den Bosch, 2015; Madureira & Monteiro, 2021; Russo & Cirella, 2018; Tian et al., 2012). Other studies focused on strategies and policy developments to overcome such challenges (e.g., Madureira & Monteiro, 2021). Other literature delved into understanding the use of UGS and dimensions associated with compact development (e.g., Crawford et al., 2008; Kaczynski et al., 2010; Liu et al., 2017; McCormack et al., 2010; Parra et al., 2010; Peschardt et al., 2012; Schipperijn, Ekholm, et al., 2010; Schipperijn, Stigsdotter, et al., 2010; Sundevall & Jansson, 2020). The flowing sections detail the studies mentioned above.

2.3.1. Challenges and Strategies of going green and compact

The main two groups of UGS strategies in compact urban development address: a) developing new UG sites and b) preserving and improving the existing ones (Jim, 2004). In developing a new urban green area, Jim (2013) suggests thinking out of the box and embracing novel approaches. A diverse number of alternative vegetation strategies have been proposed for compact cities, including vegetation attached to or integrated with buildings, including garden balconies, green roofs, vegetation on the wire above streets, green facades, and edible green walls (Delshammar, 2014; Russo et al., 2017; Whittinghill & Rowe, 2012). In preserving and improving the existing green space, several strategies are also proposed, such as optimizing

the geometry and connectivity of green space patches, improving the biodiversity of UGS (Jim, 2013), enhancing the multifunctionality of UGS in terms of the capacity of UGS in the provision of various ecosystems services and functions (Hansen et al., 2019a). It has been noted(Balikçi et al., 2021) that densification and compact development reduce UGS quantity and degrade the quality. Hence, one of the crucial strategies for existing green spaces is enhancing UGS quality to compensate for the limited quantity. Also, in terms of the capacity of UGS in the provision of various ecosystem services and functions, multifunction UGS was proposed as one way of high-quality UGS in densified cities (Beer et al., 2003; Haaland & van den Bosch, 2015; Hansen et al., 2019a).

2.3.2. Factors affecting the use of UGS in the context of compact city

Studies on UGS and factors affecting the use of UGS focus on two broad groups of variables; variables related to users as individual characteristics and physical and environmental variables related to UGS and surrounding neighbourhoods which is not exclusively to the context of the compact urban development but relate to elements that associate with it.

The physical and environmental variables contributing to the use of urban parks can be put into different themes. One theme of the study focuses on the perceived environment of the urban parks, such as accessibility to urban parks, quality of urban parks, attractiveness, and safety. Accessibility to an urban park indicates the level of services each park offers regarding its spatial distribution (Lee & Hong, 2013). Accessibility to the park is a multidimensional concept that can relate to the distance and proximity of residents' houses to the park and the quantity and quality of the park's amenities (Chang et al., 2019a; Wang et al., 2021). Distance to a park has been noted as one of the fundamental factors affecting its use; when traveling distance increases, the park use decreases (Liu et al., 2017; Schipperijn, Stigsdotter, et al., 2010; Tu et al., 2020). Also, the quality of urban parks regarding landscape, facilities, and vegetation affects their use (Mao et al., 2022). It's been noted that all users appreciate high-quality parks regarding cleanliness, lack of litter, and sense of maintenance (Shams & Barker, 2019).

The other theme of the literature focuses on the elements of the parks' surrounding neighborhood in relation to park use. Elements include walking, cycling, active travel (Liang et al., 2017), and public transportation (Chen & Chang, 2015; Liang & Zhang, 2018; Lu et al., 2014). In a recent study in Hong Kong, Chang et al. (2019b) measured urban park accessibility for every housing state with different transportation modes (walking, bus, mass transit railways). They found that public transportation shortened the travel time to urban parks for all residents and increased its use.

Land use mix has also been associated with park use. The contribution of a study in Boston, Cincinnati is that access to various land uses in the walkable distance from home to the park increases the park use of the children and their physical activity (Rosenberg et al., 2009). This is supported by another study in Bogotá that found that land-use diversity in the surrounding neighborhood of a park promotes the active park use of older adults (Parra et al., 2010). Also, (Huang et al., 2020) found a positive link between land use mix and children's park use and park-based physical activity in New York City. The result of another study indicates an association between built-environment density and park use (Fry et al., 2021).

The second research group focuses on the users and their individual features in park use. User's age has been noted as an essential factor affecting park use (Galloway, 2002b; Laatikainen et al., 2017; Liu et al., 2017; Ode Sang et al., 2016; Payne et al., 2002a; Schipperijn, Stigsdotter, et al., 2010).

Several studies have investigated the ability of UGS to provide suitable environments for specific age groups, such as children (Jansson et al., 2016) and the elderly (Parra et al., 2010; Zhang, 2017). However, we know little about park use considering different user groups, the differences and similarities between their use pattern, and how UGS can afford various user groups (Jansson et al., 2016). Only one recent study in a park in central Landskrona, Sweden, by Sundevall & Jansson (2020) has investigated the environmental affordances of an inclusive urban park for different age groups. This study approaches the age-inclusive parks with the concept of multifunctionality and environmental affordances (possibilities for actions). The

results indicate that social multifunctionality for various age groups is obtainable since different users enjoy having people around them because of liveliness and safety. Also, the study indicates the importance of developing various environmental features to offer various affordances, such as lively and quiet places (Sundevall & Jansson, 2020). However, the study and study area are not in the context of a compact city and overlook some elements that have been found significant by other studies for affecting the use of urban parks, such as gender, dominating male participants in the study.

User's gender has also been noted as a contributing factor influencing urban parks' use (Derose et al., 2018; Ode Sang et al., 2016). In a study in low-income neighborhoods in Los Angles, women reported fewer and shorter durations of park visits (Derose et al., 2018). Moreover, gender has been linked to the perception of safety in urban parks in a study in Poland by Polko & Kimic (2022). The authors indicate a considerable difference between male and female respondents who felt less safe than male respondents in the same urban park. Also, they highlight the need for more gender-inclusive urban parks (Polko & Kimic, 2022b).

2.4. Summary

This chapter reviews relevant concepts regarding UGS, compact urban development, and UGS use. The primary identified components related to the use of UGS and factors affecting it are accessibility, quality of facilities, safety as characteristics related to the perceived environment, land-use mix, walking, cycling, and public transportation as characteristics of the surrounding neighborhood, individual features of the users such as age, gender, ethnicity.

3. METHODOLOGY

3.1. Overall methodology

This study aims to provide insights into characteristics of urban green space, namely urban parks in compact developments, which promote diversity of users. Cross-sectional research was applied. A cross-sectional research design collects data on more than one case study at a specific time. Two urban parks were chosen for this thesis, and the quantitative and qualitative data were collected and analyzed to answer the research questions. The cross-sectional research design (Bryman, 2012b; Yin, 2009) allows us to empirically analyze the characteristics of urban parks and the surrounding environment that allow the diverse population to use the park. Figure 1 shows the overall methodology flowchart.

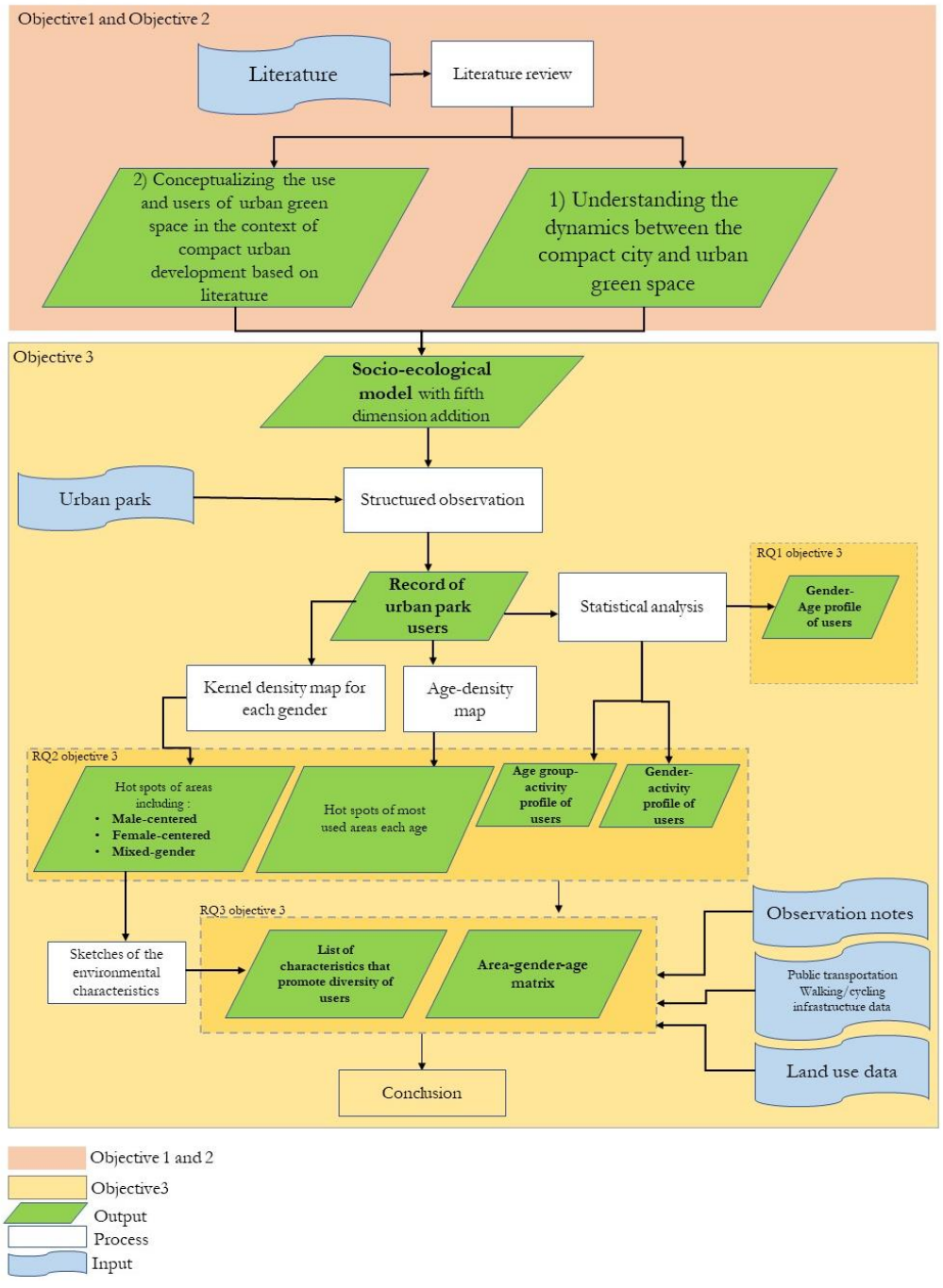


Figure 1: Methodology flowchart

3.2. Study area

According to the aim of the study, the study area should contain an urban park in a compact neighborhood. Amsterdam in the Netherlands (as shown in figure 2) was selected because it has a long compact city planning experience (Westerink et al., 2013). According to Gemeente of Amsterdam's Structural vision Amsterdam 2040 (Dienst Ruimtelijke Ordening, 2011), Amsterdammers love greenery and water, and the figures of visitors to green spaces in the city have doubled over the past ten years. A large-scale survey into the green wishes of Amsterdammers showed that for half of them, the greenery in the neighborhood is an essential condition when choosing a place to live or establish a business. Also, "parks to study or work in" have grown in Amsterdammer's online search history (Dienst Ruimtelijke Ordening, 2011).

Another section of structural vision Amsterdam 2040 noted that Amsterdammers want greenery in their street, a well-usable park within walking distance of the house, and a large green area within cycling distance of the house. Each green element must meet high-quality requirements and offer users many possibilities. With the further densification of the city, the pressure on the use of the parks will increase; hence, the investment in parks' quality and attracting a diverse population becomes more important (Dienst Ruimtelijke Ordening, 2011).

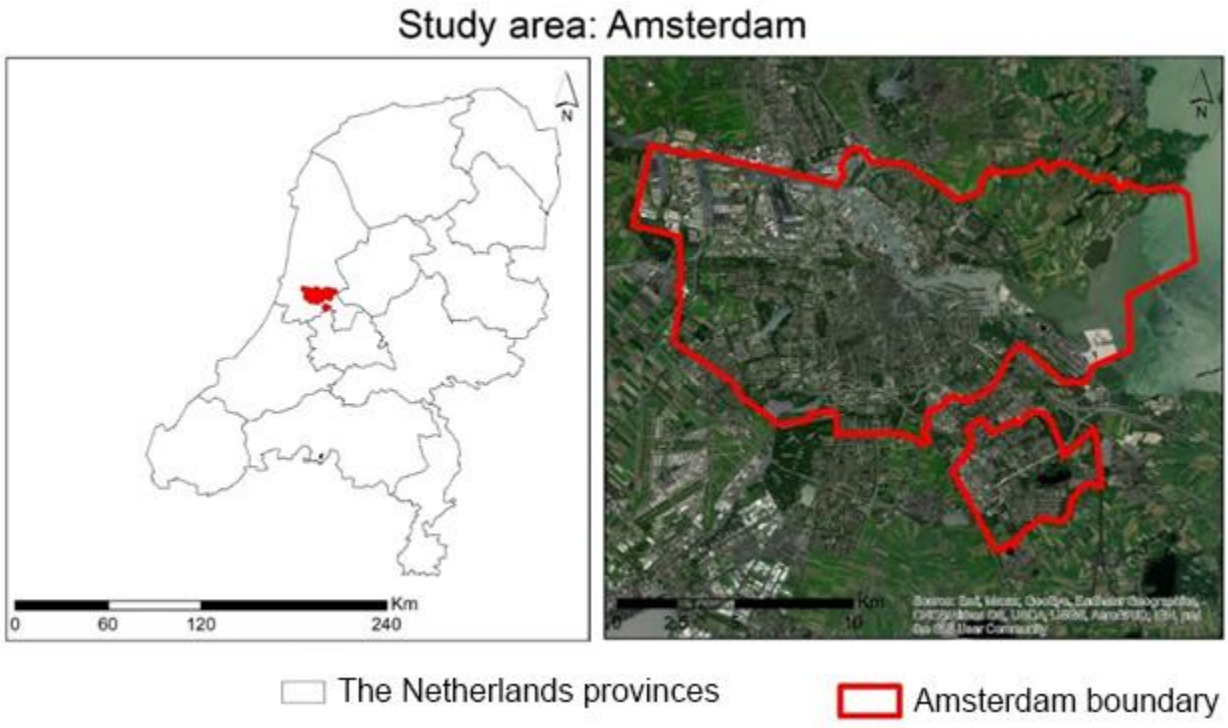


Figure 2:Amsterdam as the study area

3.2.1. Park selection

The criteria for urban park selection are ownership, size, and surrounding neighborhood characteristics. Private UGSs such as private backyards and gardens, roof gardens, courtyards, and balconies, were excluded because they do not welcome a broad group of users. This study will focus on public-owned urban parks. Another aspect is the size of the urban park. Public parks vary according to size and their facilities; mini-parks with an area size of less than 2 ha, neighborhood parks with an area size between 2 to 8 ha, community parks (8 to 40 ha), and larger parks, including district parks, regional or metropolitan parks, and natural parks (Forsyth and Musacchio, 2005, Han et al., 2013). This study will focus on neighborhood parks because developing a small park in a compact development is less challenging than finding space for a larger one. Also, mini-parks often have limited possibilities for activity and facilities, so neighborhood parks are ideal candidates for this thesis.

After carefully examining Amsterdam's parks based on their size and compact neighborhood, Erasmuspark and Oosterpark were selected. Figure 3 shows their location within Amsterdam.

Figure 3: three candidates parks for case studies, from which Erasmuspark and Oosterpark were studied.

3.2.1.1. Erasmuspark

Erasmuspark is in the west of Amsterdam in "Bos en Lommer" neighborhood, on "Jan van Galenstraat", between "Admiralengracht" and "Hooftweg" as shown in figure 5. Egbert Mos in 1957 designed the park with inspiration from Mondrian paintings (Carey, 2013). The park has an area of 9-hectare, designed with straight lines, rectangular beds, and rows of trees. The park has five entrances shown in fig.4; entrances number 1 and 5 are the main entrances, number 2 and 4 lead to a walking path along the water bodies surrounding the park, and entrance number three leads to a bridge over the "Erasmusgeracht" channel and into the park.

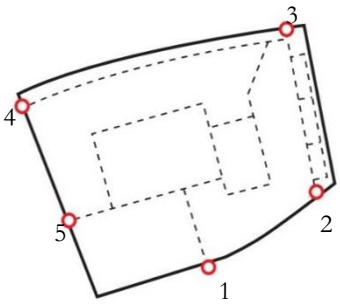


Figure 4: Erasmus park entrances.
Source: Atlas Stadsparken Amsterdam(van de Haagen et al., 2013)

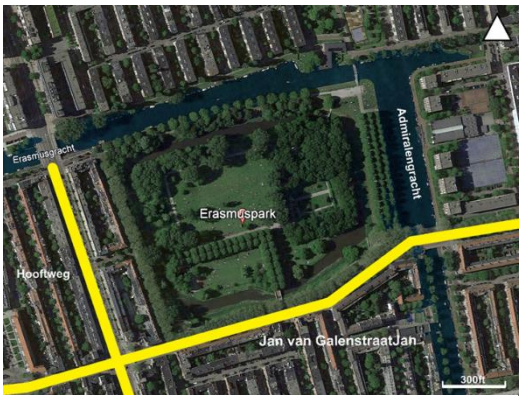


Figure 5: Erasmuspark surrounded by two water canals and two streets
source: https://earth.google.com/

The park has one open lawn and a smaller one with dog restrictions, a forest-like vegetation area, a "Miracle Garden", a kiosk café called "Terrasmus," sports equipment, a playground, and walking paths (See fig.6).

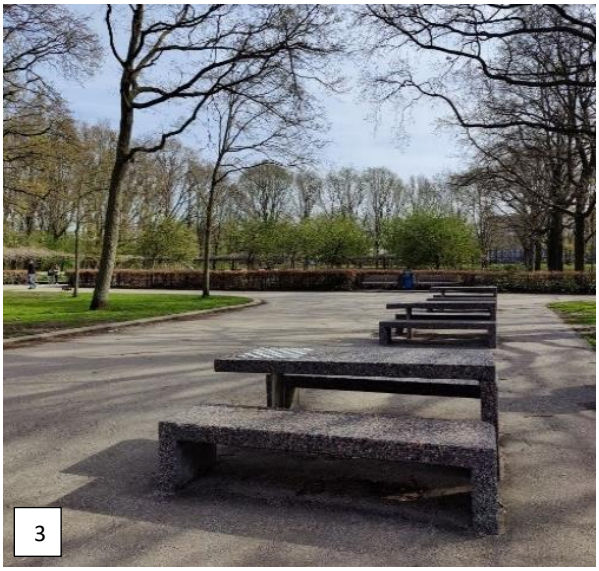


Figure 6: parts of Erasmuspark. 1: layout, 2: lawn, 3: seating areas, 4: Terrasmus café , 5: playground , 6: pathaways, 7: Miracle garden

Erasmuspark is an island surrounded by water bodies and has an open character. The park is accessible by bicycle from two entrances. Also, there are two tram and bus stations within 5- and 7-minutes of walking to the park (See fig. 7).

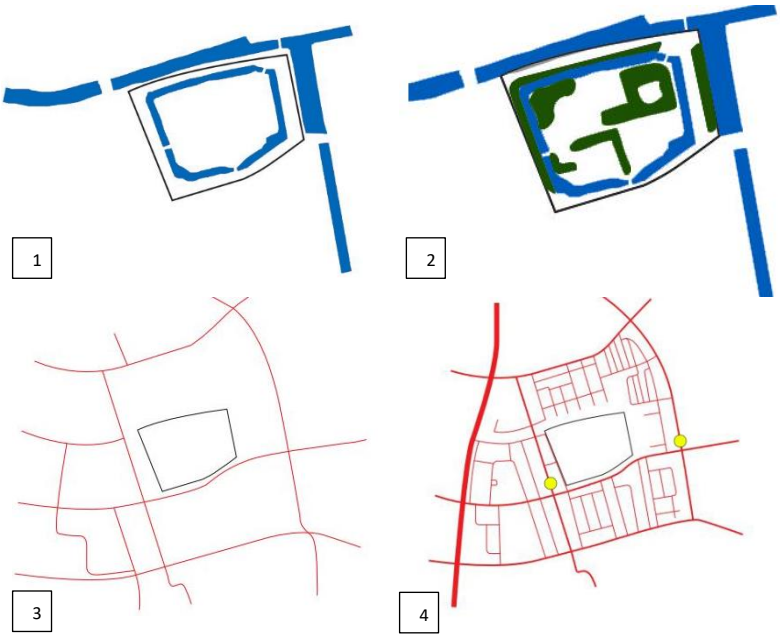


Figure 7: Erasmuspark waterbodies, character, accessibility. 1:the park is an island surrounded by water (color blue is waterbodies), 2: the park has an open character (the color dark green is dense vegetation and color blue is water bodies) 3:connection of the park to cycling infrastructure 4: connection of the park to street network and the closest public transportation stops (yellow dots are bus and tram stops).Source: Atlas Stadsparken Amsterdam (van de Haagen et al., 2013)

3.2.1.2. Oosterpark

Oosterpark is located east of Amsterdam in the neighborhood called "Oosterparkbuurt," with a 23 hectares area. It has direct access from "Linnaeusstraat" and "Oosterparkstraat," "'s-Gravesandestraat," as shown in figure 8. The park has ten entrances from which entrance numbers 5, 6, and 7, visible in fig. 9, were added in a recent renovation. It was designed by landscape architect Leonard Anthony Springer and constructed in 1891(van de Haagen et al., 2013).

Figure 8: Oosterpark and surrounding streets
Source: httpt://earth.google.com/

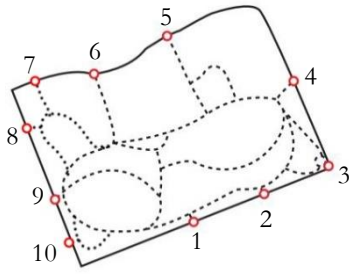


Figure 9: Oosterpark entrances ,Source: Atlas Stadsparken Amsterdam(van de Haagen et al., 2013)

The Oosterpark consists of a large lawn, sports field, playgrounds, multiple plazas, and etc. (see fig10)

Figure 10: Oosterpark. 1: Layout of the park, 2: performing area, 3:water plaza, 4: Hotel Plaza, 5: pathway, 6: lawn, 7:playgroud

Oosterpark has a central water body and an open character. The park is accessible by bicycle from all the entrances. Also, three tram and bus stations are in the park's immediate vicinity (See figure 11).

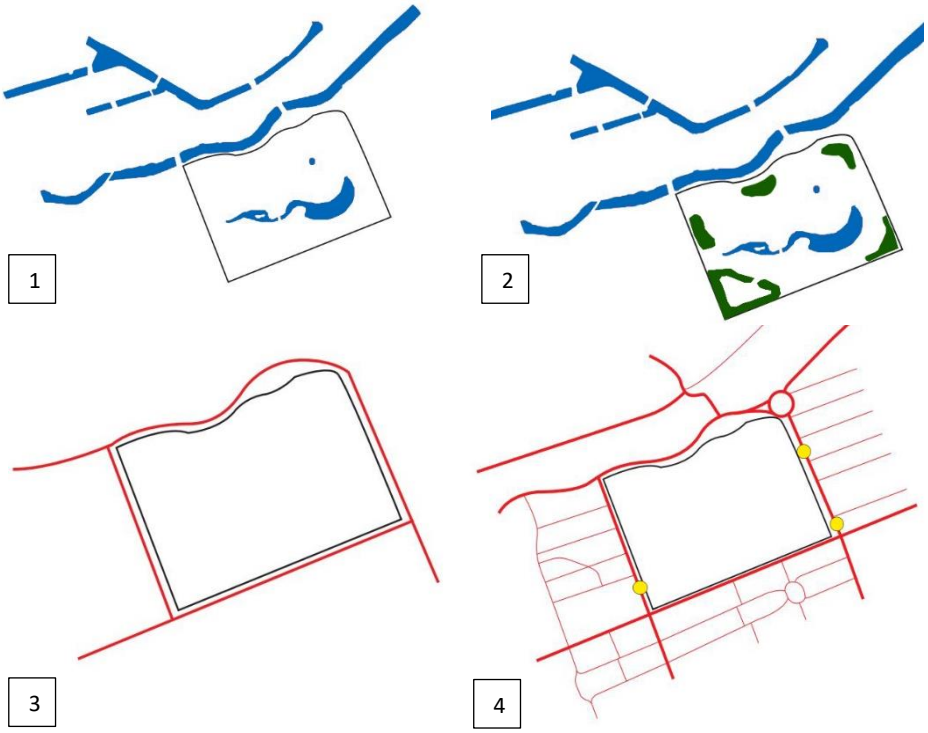


Figure 11: Oosterpark waterbodies, character, accessibility. 1: the proportion of waterbody to the whole park, 2: the park has an open character, dark green are areas with dense vegetation , 3) connection of the park to cycling infrastructure 4: connection of the park to street network and the closest public transportation stops(yellow dots are bus and tram stops). Source: Atlas Stadsparken Amsterdam(van de Haagen et al., 2013)

3.3. Methodology framework

To achieve objective 2 of this thesis, namely "Conceptualizing the use and users of urban green space in the context of compact urban development based on literature," several pieces of literature were reviewed. This section summarizes the findings in the literature review and provides a model to explain the use and users of urban green space in the context of compact development and support the data collection and analysis. I found the socio-ecological model helpful in understanding the use of urban parks. This model has been used vastly to estimate human behavior in related fields such as leisure research (Raymore, 2017) and active living research (Sallis et al., 2006), and physical activity research (Owen et al., 2004). Also, in the field of urban green space, Schipperijn (2010) applied the model in a Danish context. Due to the environmental and social similarities between the Dutch and Danish contexts, this model was applied for this thesis. This model explains the use of UGS with four dimensions, as shown in figure 12; individual factors, perceived environment, behavior, and physical environment.

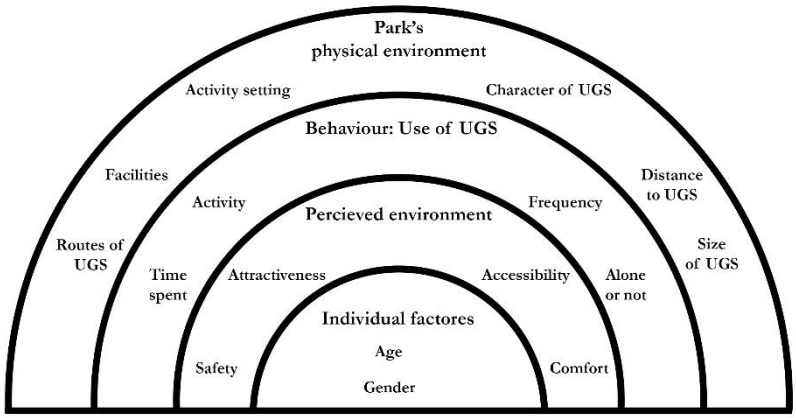


Figure 12: Socio-ecological model to understand factors influencing use of urban park. Adopted from (Schipperijn, 2010)

Individual factors refer to features related to the users. Several studies have found that the use of urban green space is affected by the age of the users (Galloway, 2002b; Laatikainen et al., 2017; Liu et al., 2017; Ode Sang et al., 2016; Payne et al., 2002a; Schipperijn, Stigsdotter, et al., 2010), gender (Derose et al., 2018; Ode Sang et al., 2016), health in terms of disabilities(Perry et al., 2021; Wojnowska-Heciak et al., 2022), ethnicity (Mohamad Muslim et al., 2018), and education (Jan, 2010; Van Riper & Kyle, 2014). In this thesis, diversity of users means users with different individual features, as mentioned above. Since the scope of the thesis cannot cover all the individual factors in the socio-ecological model, age and gender will be considered.

Perceived environment means factors such as quality of urban green space, quality of facilities, the sense of safety, accessibility of urban green space, and comfort of use (Schipperijn, 2010). The importance of accessibility to parks for encouraging park use is regardless of age, gender, or ethnicity (McCormack et al., 2010).

The behavior dimension implies how users use the urban green space. Aspects such as the activity users perform, the duration of the park visit, the frequency, and whether the users are in groups or alone are essential (Schipperijn, 2010). But, in this thesis, only the activity users perform will be considered.

The physical environment entails two dimensions; the park and the surrounding environment. In the park's physical environment, factors such as size, distance to the park, the character of the park in terms of close or open character, routes and pathways, and type of facilities and possibilities of activities are essential.

Since this thesis aims to study urban parks in compact urban development, the neighborhood factors will also be added to the socio-ecological model, mixed land use, public transportation, density, and active travel. Hence, the adopted model is customized, and colors will be added to differentiate the various dimensions of the model visually; Figure 13 presents the new model for this study.

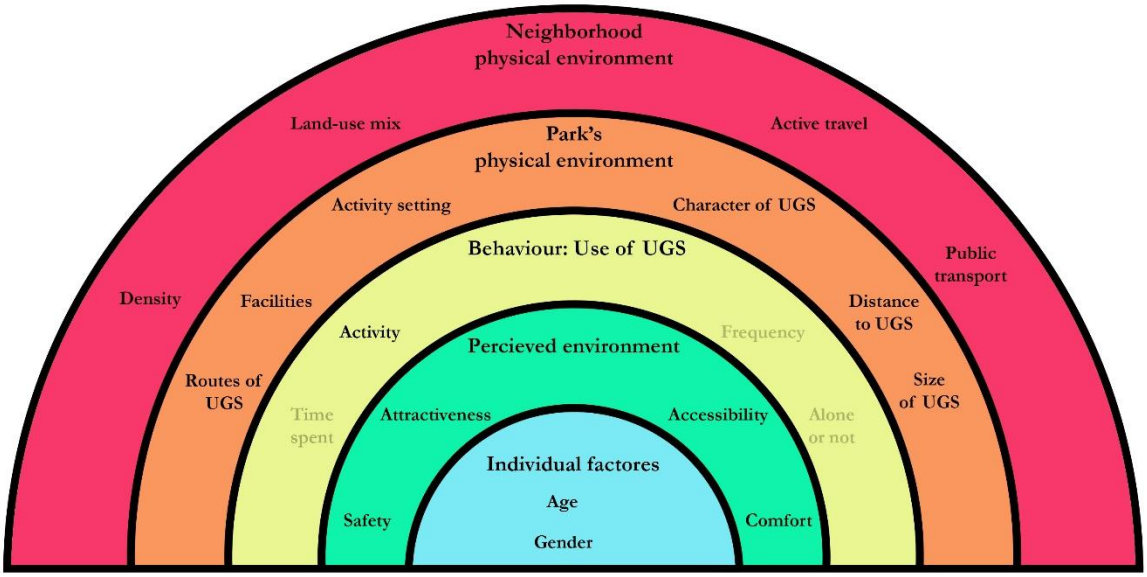


Figure 13: Socio-ecological model to understand factors influencing use of urban green space. Adapted from (Schipperijn, 2010)

3.4. Data and data collection

This thesis used primary and secondary data to carry out the research. The secondary data were mainly obtained from Amsterdam's data portal [1] belonging to the Municipality of Amsterdam. Primary data was obtained through structured observation in April 2022. The database and its resources are explained in table 1. Also, the open street map was used for two purposes: as a base map for results and analysis and to understand better the park and the surrounding neighborhood.

Table 1:Source and details of database

Data type	source	Type of file	Year	Description
Function mix data of Amsterdam	https://data.amsterdam.nl/ Municipality of Amsterdam department of Spatial planning and sustainability	Shapefile	April 2022	Polygon data of building blocks. Each building is labeled based on the land uses for residential, service, and offices, and the combination of them
Cycling and walking network	https://data.amsterdam.nl/ Municipality of Amsterdam department of Spatial planning and sustainability	Shapefile	2022 January	Line layer of walking/ cycling routes of Amsterdam
Public transportation lines and stops	https://data.amsterdam.nl/ Municipality of Amsterdam department of Spatial planning and sustainability	Shapefile	2022 January	Line and point layer of tram/bus lines in Amsterdam
Open street map	https://www.openstreetmap.org/	-	-	The open street map was used to get familiar with the case studies and surrounding areas
Users of Erasmuspark and Oosterpark	Fieldwork observation	Shapefile	2022 April	Point layer of users observed with attributes including gender, age, activity, Static or Mobile, Group or Alone

3.5. Data collection: structured observation

The observation technique was applied to study the spatial relationship between park characteristics and park-use behavior. "Structured observation is a method for systematically observing the behavior of individuals in terms of a schedule of categories" (Bryman, 2012a, page 270). One of the main advantages of direct observation against similar social methods such as surveys is accuracy; there are several potentials for gathering inaccurate data in the survey. The problem of communication and interpretation between interviewer and respondent, the issue of memory when respondents misremember some aspects of their behavior, the gap between respondents' reported behavior and their actual behavior, etc., make the survey research problematic for behavior research (Bryman, 2012b). Behavior mapping is one of the observational tools that record in-situ users' behavior and the environment setting of the behavior. This tool allows to objectively capture the use of an urban park and how the setting supports the behavior (Loebach et al.,

[1] https://data.amsterdam.nl/

2020). This technique is valuable for this study because interviews and questionnaires are ineffective for diverse users such as children or youth who may have problems explaining their behavior and environment. The following aspects were considered in the observations of the park.

1) User

- What is the estimated age and gender of users of the urban park?

For this question, different categories of age and gender were pre-defined. Age groups in this thesis are children, teenagers, adults, and the elderly. Also, gender groups are considered male and female. It should be noted that estimation of gender and age is subjective and based on facial or body features. Such features are wrinkles, mobility ability, height, and clothing.

- Where are the users located?

The approximate location of the users was recorded using the GIS and Mergin plugin app.

- What activity are they doing?

Up to three activities were recorded for some users. For instance, if a user was walking and talking with friends, walking was recorded as activity 1 (main activity) and talking as activity 2.

2) Park facilities and characteristics

- What are the characteristics of the environment or setting where activity is carried out??

This item

Sun exposure (Yes/No/Partial)Shade (Yes/No/Partial)
Setting type (bench, open grass, picnic tables)
Facilities and different activity settings (water, plaza, lawn, body training equipment, sports fields)
Where the area is in relation to the park's routes (located along the main routes/ located along the secondary routes)
How are the areas visually accessible for users in and from outside of the area? (It is open; users see and can be seen / it offers partial visual accessibility; there are visual barriers such as vegetation, and users can partially see and be seen while having some privacy/ the area is totally secluded and visually inaccessible from outside and inside)

3) Park's surrounding neighborhood

The park's entrance, the surrounding public transport stations, and land use around the park. Although such information was obtained from primary data, in-situ knowledge and pictures deepened the neighborhood's understanding.

There are four critical steps to carrying out observation research: 1) preparing a base map of the urban park, 2) deciding on the data collection tools in the fieldwork, 3) deciding on the data variables that need to be recorded, 4) setting up a systematic protocol for data collection including the observation zones 5) setting up a strategy for data analysis (Loebach et al., 2020).

There are three possible approaches for carrying out the research in behavior mapping: paper-based and digital-based methods using GIS as ArcGIS or QGIS and a hybrid method. In the paper-based method, the base map is printed on the paper with proper scale, and users' characteristics, behavior, and environmental setting will be recorded on the paper. Later, the recorded data can be digitalized in ArcGIS or QGIS for data analysis. This method will develop codes to mark the users' age, gender, and activities. As shown in fig.14 (Mehta & Mahato, 2021) used such a method to observe users' behavior in two parks in Cincinnati, Ohio; figure 14 shows an example of an observation sheet of their study.

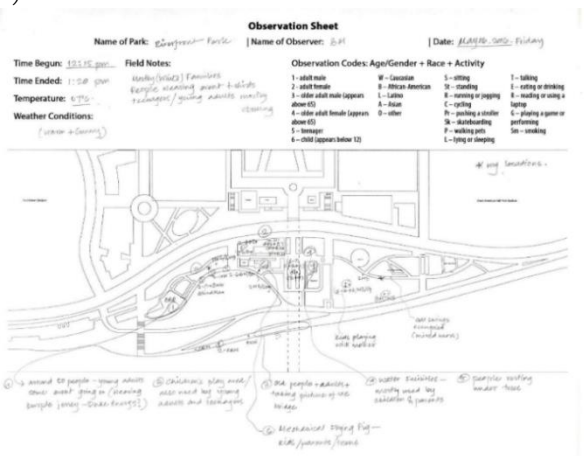


Figure 14: paper-based observation sheet using by(Mehta & Mahato, 2021)

3.5.1. Pilot observations and the actual observations

Three pilot studies were carried out to test the data collection method. The main objectives of pilot studies were to decide on a paper-based or digital-based data collection approach. The first pilot study happened on the 7th of February with a completely digital-based approach. The case study was Volspark in Enschede. The start time of the observation was 16:46, and the duration was 22 minutes. The weather was sunny with a temperature of 14 Celsius. A total number of 32 users were recorded. The "Input" app and Merging Plugin on QGIS was used to record users' features. Input is a free mobile app developed by Lutra Consulting for using and collecting QGIS. Data collected by Input will be synchronized to the desktop QGIS using the Mergin plugin (Using Input/Mergin and QGIS for Field Data Collection — Community Health Maps, 2019). Features that needed to be recorded, such as age group and gender and whether the users are alone or in a group, were chosen by a drop-down option in the app when the user's location was specified.

The pilot study was repeated under different locations, dates, and data collection approaches. The second pilot study was conducted in the Wooldrikspark in Enschede on the 29th of March 2022. The paper-based approach was adopted for this round of pilot study. Figure 15 presents the observation sheet used to record the user's features with corresponding codes. The duration of observation was one hour and repeated thrice between 10-11 a.m., 1-2 p.m., and 4-5 p.m.

The third pilot study was conducted on the 7th of April before fieldwork in the Saphartipark in Amsterdam. A paper-based approach was applied. Although only some parts of the park were open, the paper-based data collection was ineffective because of the high number of users. So, the digital-based approach with some alteration was applied.

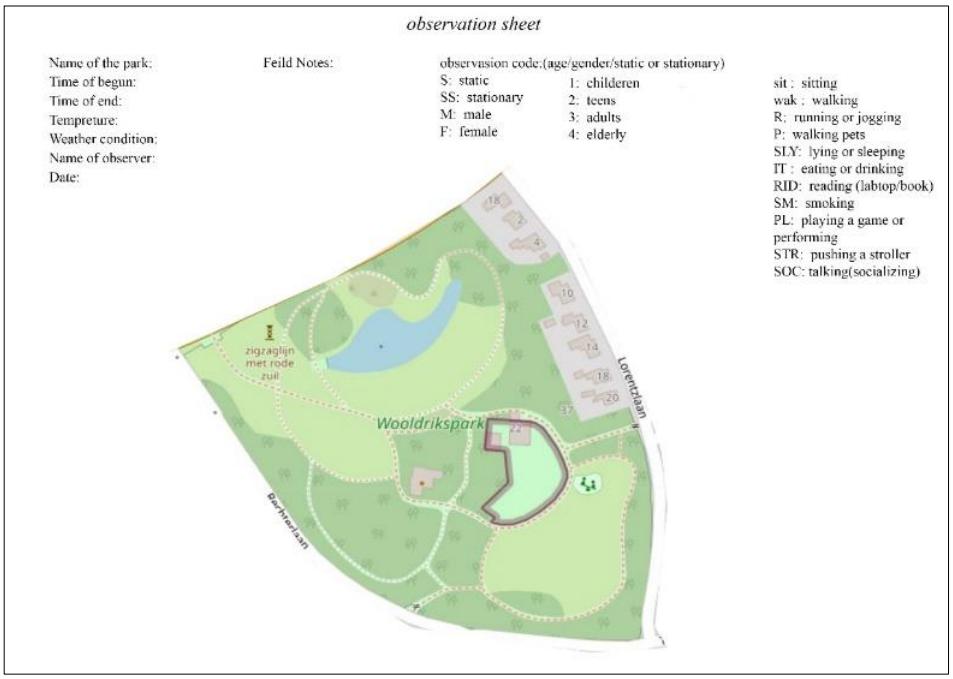


Figure 15:observasion sheet in paper-based observation pilot study

To sum up the experience of pilot studies, there are some considerations for choosing paper-based or digital-based approaches; The time of transporting data from the field to the GIS platform in this thesis QGIS and the efficiency of work in the data-gathering phase. The Mergin plugin advantages fast data transformation. Despite the user-friendly platform of the Mergin App, it was not convenient to gather the data on various features of the users via the drop-down menu. On the other hand, the coding system in the paper-based approach fits better to record various desired features of the users. Hence, a hybrid approach was applied using the Mergin plugin and coding system to record some features.

The actual structured observation was carried out from nine to 12 of April in three time slots: 10-11 a.m., 13-14 a.m., and 16-17 a.m. On the 9th and 11th of April, Oosterpark and 10th and 12th of April, Erasmuspark was observed. In total, 1673 users were recorded.

3.6. Data analysis

The analysis process used a combination of quantitative and qualitative methods. This section details the used methods.

3.6.1. Descriptive statistics

Descriptive statistics, namely, the percentage, was used to summarize the data gathered in observation. The individual factors, including gender, age, and activity users were performing, were considered, and presented by Sankey diagrams. Sankey diagrams are a visualization tool to show flows or resources. In this thesis, age or gender, several entities are presented by the text. The entities are linked by flows, which are proportional to the quantity represented (Stafford, 2019). To that aim, Flourish studio[3], an online web-based visualization tool, was applied. The data in the form of a .xlx file was uploaded to the website, and the desired Sankey diagram was obtained. This information will be used in capture 4 to answer r.q.1 of objective 3.

3.6.2. Kernel density analysis

To find the hot spots of female-centered, male-centered, and gender-mixed areas, kernel density analysis was carried out using QGIS 3.20.3. kernel density map was used to answer research r.q.2 objectives 3 in chapter 4. the process of kernel density analysis is detailed in several steps:

- Step one: Two vector shape layers containing female and male users were prepared.
- Step two: The heat map option was selected in the layer styling tab.
- Step three: Using vector to raster conversion, two heat map layers were converted to raster layers.
- Step four: Two male and female raster layers were normalized to 0-1 and -1 to 0, respectively, with the Equation one:

$$\text{Equation 1: normalization formula: } x' = (x - x_{min}) / (x_{max} - x_{min})$$

- Step five: Using the "Fill No Data" command, the no data cells were filled with zero for both layers.
- Step six: Using a field calculator, female and male raster layers were summed up, making a new raster layer.
- Step seven: The raster layer generated in step three was converted to a vector layer using the Raster to vector conversion command.
- Step eight: The outcome of step six was clipped using Raster>extraction> Clip raster by Mask Layer. The outcome of step seven was used as the mask layer.
- Step nine: The outcome from the previous step was changed in Symbology>Render type> Single-band pseudoscalar. Blue was assigned to the lowest value presenting female concentration and red to the highest value presenting male concentration. The value in between was showing the gender-mixed areas.

3.6.3. Qualitative analysis of environmental characteristics

Sketch drawings were used to visualize the environmental characteristics recorded in the observation. Figure 16 presents an example of the sketches used to present the environmental characteristics. Figure 17 presents each element of the sketches and its corresponding meaning. After identifying the hot spots via kernel density analysis, each highlighted area was sketched, and environmental characteristics were visualized. Hence, the similarities and differences of different highlighted areas were identified.

[3] https://flourish.studio/

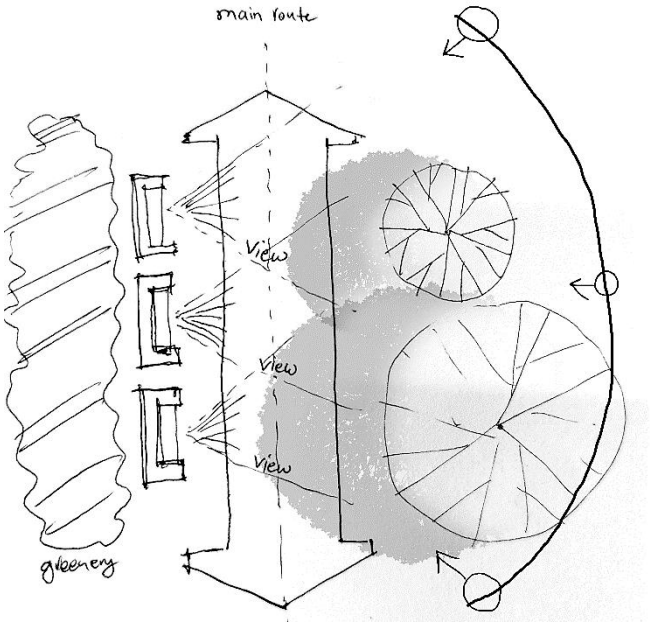


Figure 17: one example of sketches drawn in the analysis for one of the areas that was highlighted

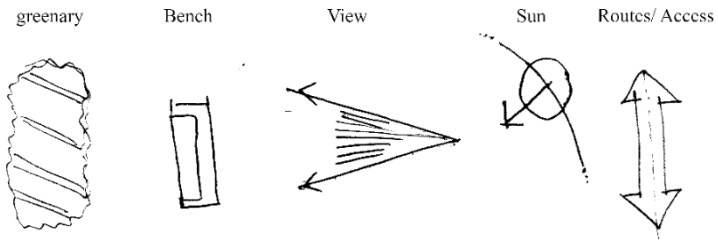


Figure 16: elements used in the sketch and corresponding meaning

3.7. Summary

In this section, methods to carry out the research were presented. Two urban parks in Amsterdam were selected: Erasmuspark and Oosterpark. Primary data using Amsterdam. The Amsterdam data portal provided the primary data such as land use data, walking and cycling network, and public transportation network. The Secondary data concerning users of urban parks through structured observations were collected. Data is analyzed through mixed qualitative and quantitative methods. For qualitative data, descriptive statistics using the Sankey diagram were applied. Also, concerning the location of users, Kernal destiny maps were created. The observation notes and features of the built environment were extracted using the theoretical framework, sketches, and literature review.

4. RESULTS AND DISCUSSION

This section presents the result of the analysis to address research objective 3, namely" explain the characteristics of urban green spaces that promote the diversity of users."
The literature review and methodology section targeted research objectives 1 and 2; "Understanding the interaction between the concepts of urban green space and compact urban development" and "Conceptualizing the use and users of urban green space in the context of compact urban development." The result was summed in the form of a theoretical framework. The following subsections detail the outcomes of the statistical and spatial analysis for the third objective.

4.1. Users of urban green space

This section answers research question 1 of objective 3, "Who are the users of urban green space?". The Sankey diagrams in Figures 16 and 17, called "age-gender group profile," show the population percentage according to the individual features of age and gender. The wider the arrows in the Sankey diagram, the bigger the proportion. The results shown in Fig. 16 and Fig. 17 indicate that adults share the largest population of park users. Erasmuspark shows a higher percentage of female users than male users and only a small percentage of teenagers. Also, Oosterpark attracted more male users and more teenagers in total.

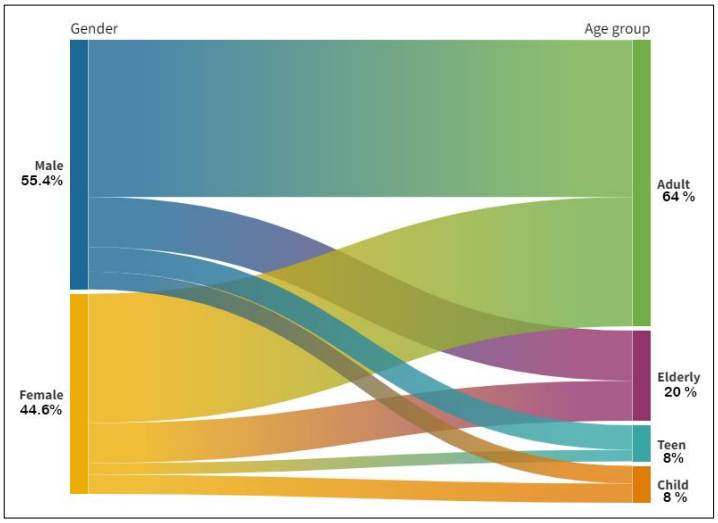


Figure 16: Gender-age group profile of Oosterpark users

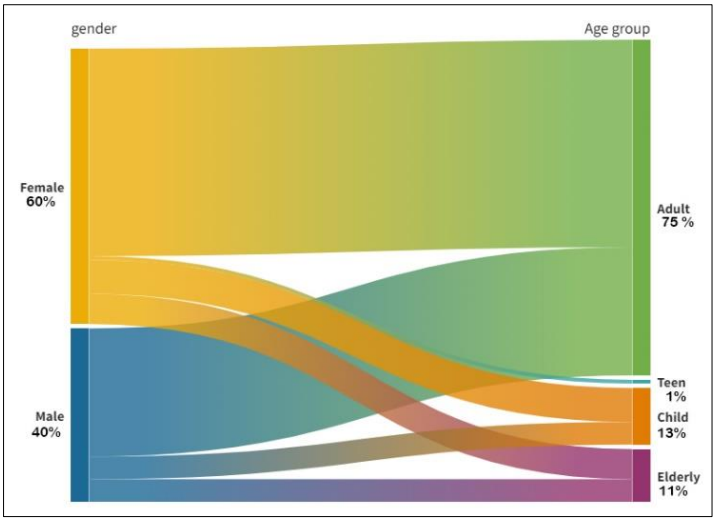


Figure 17: Gender-age group profile of Erasmuspark users

The different share of user's gender and the share of teenagers in two parks can be explained by the land uses surrounding the two parks. The result of the function-mix evaluation in figure 18 indicates that Erasmuspark, with a higher share of female users, is surrounded mainly by residential land use in the 800 meters or 10 minutes walking distance buffer zone. Oosterpark, with a higher share of male users, is surrounded by higher land-use diversity, as illustrated in figure 18. These findings validate the result of a recent study that found more residential land use around the urban park fosters a higher female presence than in parks surrounded by other land-use functions (Mushkani & Ono, 2021). This association between the gender of users and land uses of the surrounding neighborhood reflects the different gender roles; Closeness to residential areas attracts more women because women look after the household and children more than men, and men have more access to the labour market (Holland Alumni Network, 2016). The presence of several schools and educational institutions around Oosterpark explains the presence of more teenagers in the Oosterpark, especially on the weekdays.

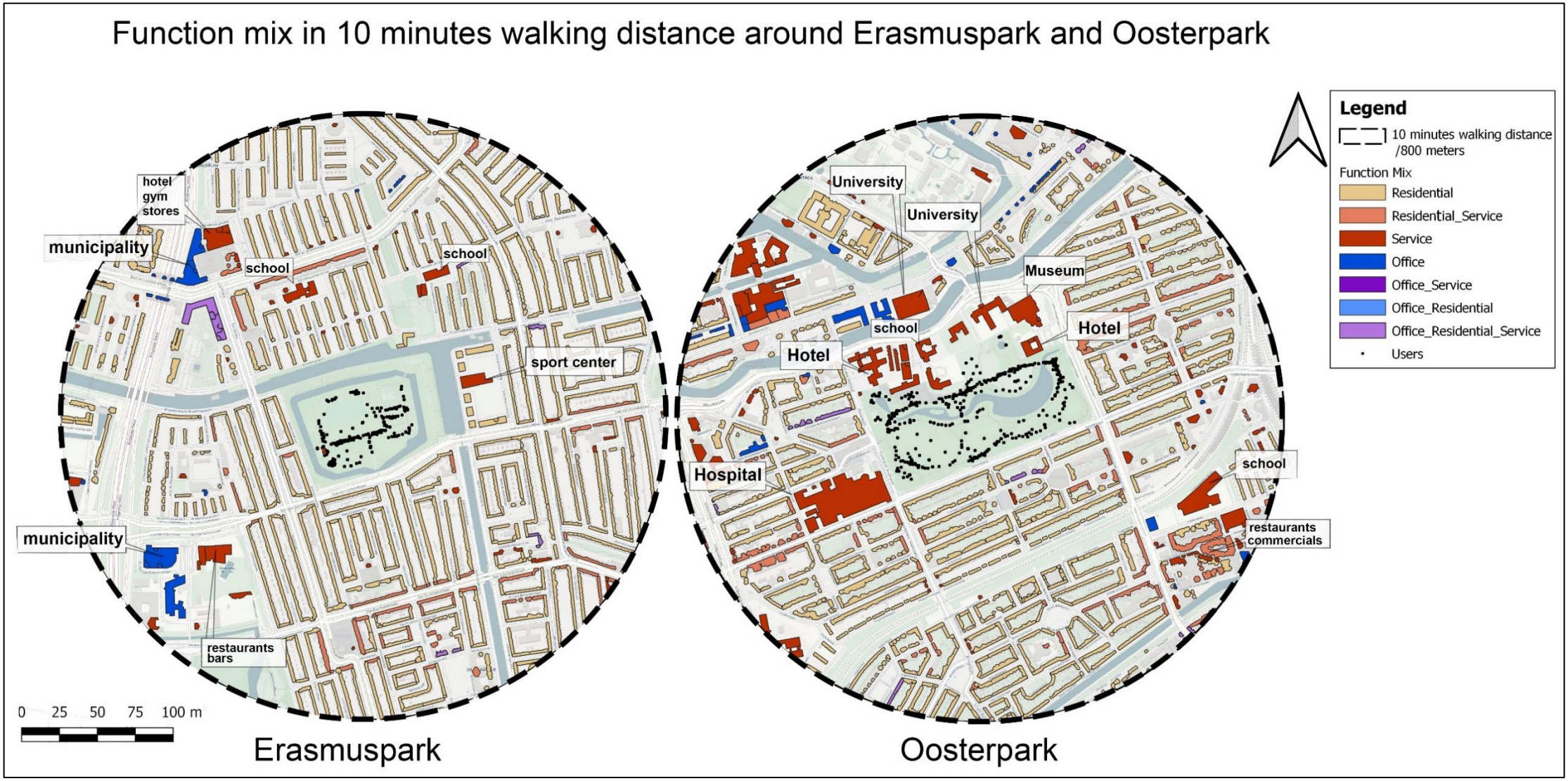


Figure 18: Function mix in 10-minute walking distance around the two parks
Source: https://data.amsterdam.nl/

4.2. Use of the urban park

This section presents the result of descriptive statistical analysis and kernel density spatial analysis to answer the second research question of objective three: "How do the users use urban green space?" To that aim, the analysis targeted the activities observed in the parks, the users' location, age and gender, and environmental characteristics in which users were observed performing activities.

To understand how users were using the urban park, I investigated gender and the main activity that users were engaged in at the moment of observation. The gender-activity profile in Figure 19 illustrates the proportion of female and male users and their main activity observed in Oosterpark.

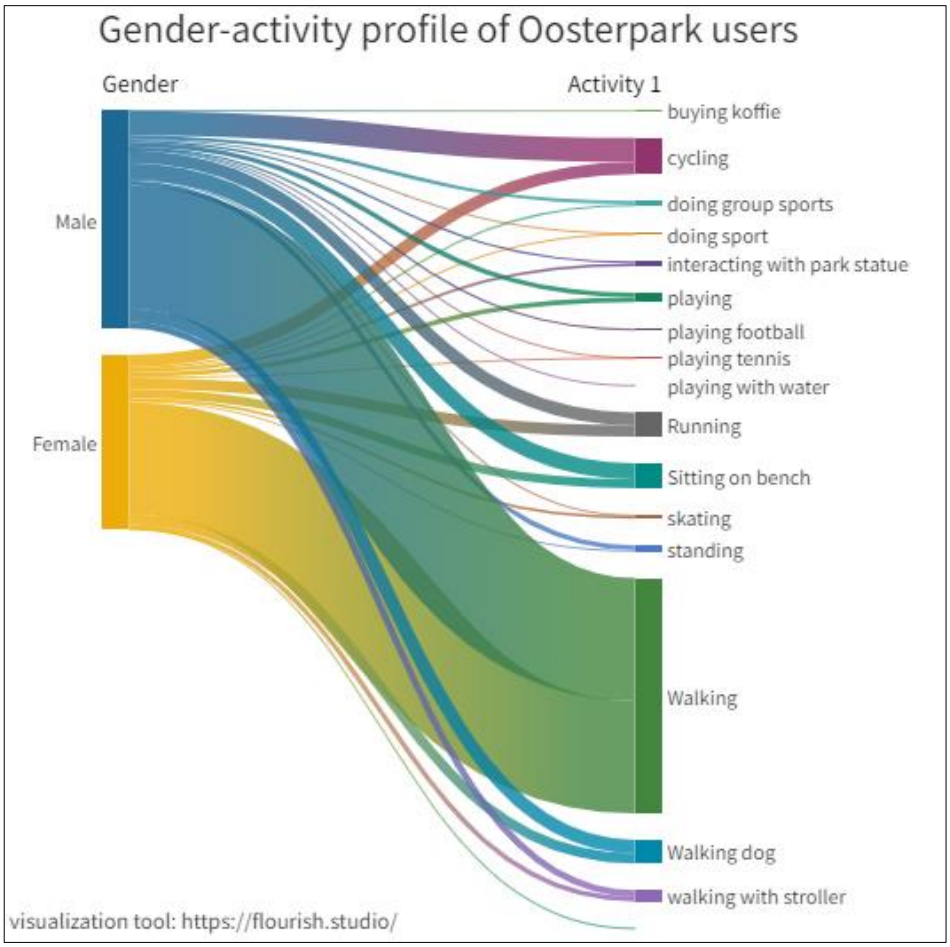


Figure 19:Gender-activity profile of Oosterpark users

The most observed activities in Oosterpark were walking-related (walking but also walking the dog, and walking with the stroller (pushing the stroller). Next, users were observed cycling, running, and sitting on benches. Fewer users did other active activities such as skating, playing, and doing sports. Notably, physically active behavior such as walking, various sports, and running was more performed than sedentary behavior such as sitting on the bench or grass.

There was no significant difference between the two genders and observed activities; females and males engaged in the same activities, except for cycling; more men were observed cycling in the park.

From figure 20, it's evident that the most frequent activity done in Erasmuspark is sitting on the bench, followed by walking, sitting on the grass, walking the dog, walking with a stroller, and sitting at the café. Noteworthy, there is a relatively even distribution between different activities. In addition, sedentary behavior such as sitting on the bench, at the café, and on grass has a higher proportion than active activities. The share of female and male users engaged in such activities remains the same, with female users more than male users.

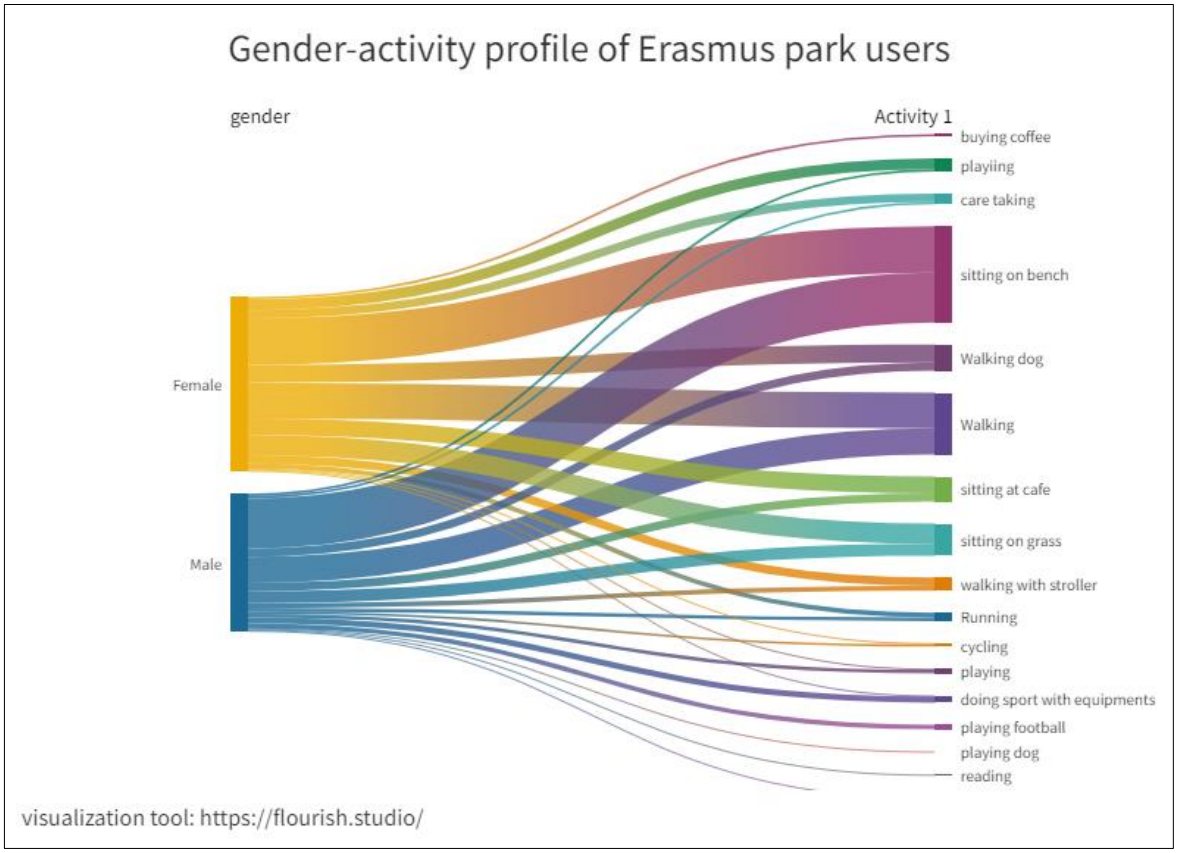


Figure 20: Gender-activity profile of Erasmuspark users

A comparison of age-activity profiles of the two parks reveals that the users of Oosterpark were more physically active than those in Erasmuspark. The difference between the two parks regarding active behavior can be seen in the neighborhood's walking, cycling, and public transport accessibility and the park's pathways and sports facilities. Several studies indicate that better access to walking and cycling infrastructure and public transport will promote physically active use of the park (Barreno et al., 2021; Sallis et al., 2016). Figure 21 on the next page shows that Oosterpark has immediate access to bus/tram stops around the entrances, and the density of the walking routes in the park is higher than in Erasmuspark. Also, the pathways in Oosterpark are wider, allowing users to walk and cycle with each other. The widest pathway in the Oosterpark with the higher number of cyclists connects one cycle lane in the east of the park to another cycle lane in the west(see figure 21). Such a good connection with transportation infrastructure leads some users to use the park for transit. For example, if the users cycled through the park to reach some shops or their homes. Using the park as transit was one of the reasons for park visits in a study done in Australia (Taylor et al., 2020).

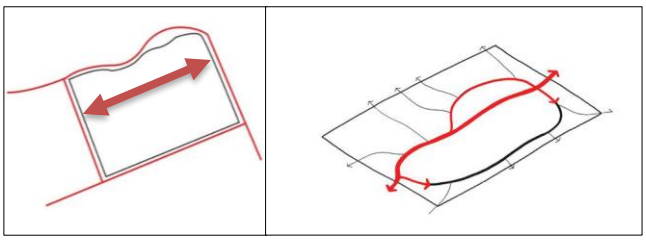


Figure 21: the main path of the Oosterpark and it's connection to the cycling infrastructure

Also, men cycled more than women. Several other studies also confirmed that male users are more physically active than female users in urban parks (Cohen et al., 2014, 2021; Floyd et al., 2008b, 2008a). These findings also relate to a qualitative review study (McCormack et al., 2010b) investigating characteristics of urban parks associated with park use, indicating that women consider urban parks a safe place to meet and socialize and consider parks as a setting for performing physical activity.

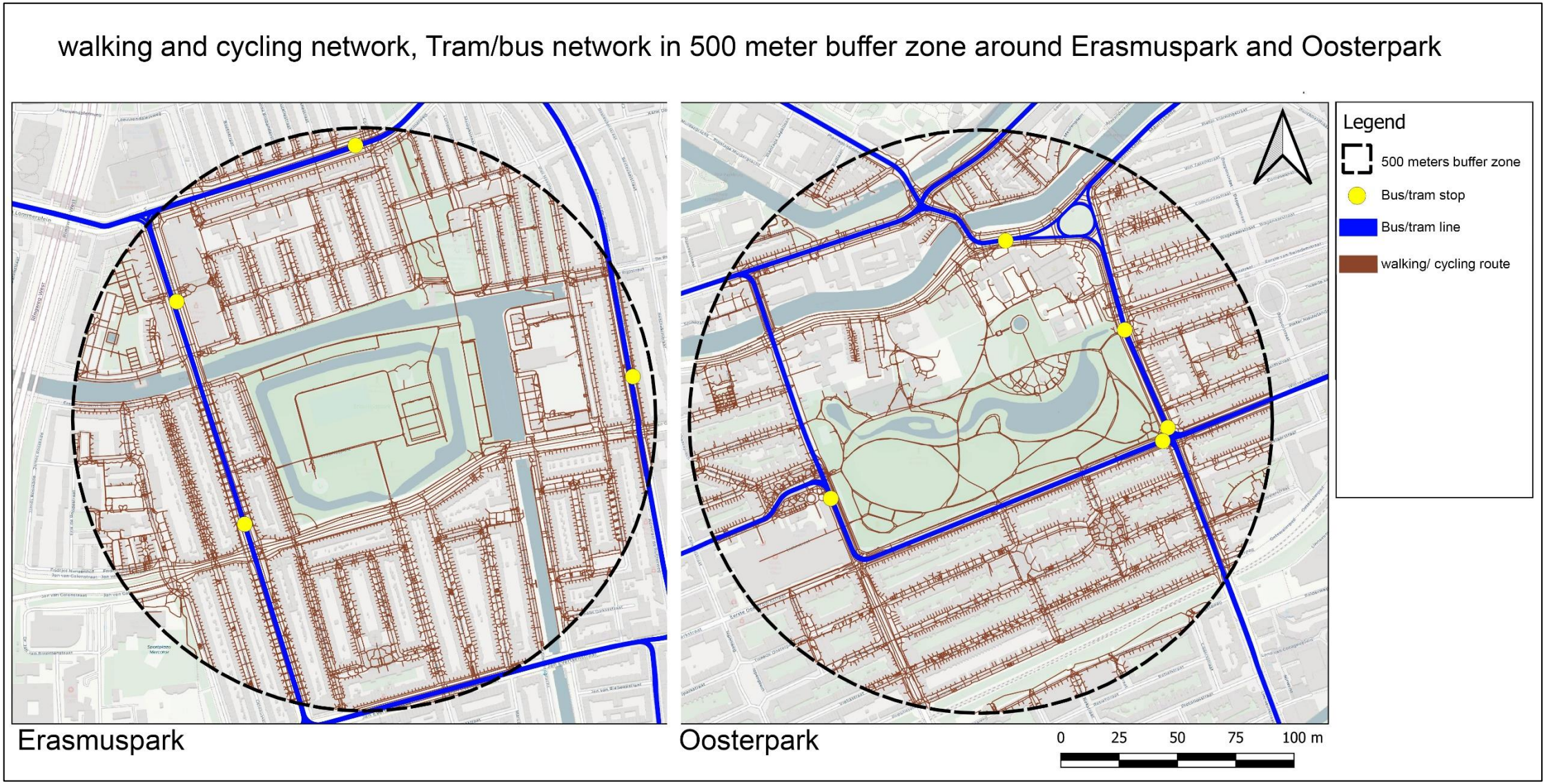


Figure 22: walking/cycling network, tram/bus network in 500 meters buffer zones around the parks,
Source: https://data.amsterdam.nl/

The two factors of main activity (as activity 1 in fig.23) and age were considered for further analysis. The age-activity profile of the two parks in this section reveals the distribution of activities between different age groups. Figure 23 summarizes the statistical analysis of age and activities in Oosterpark, called the age-activity profile. This figure is quite revealing in several ways.

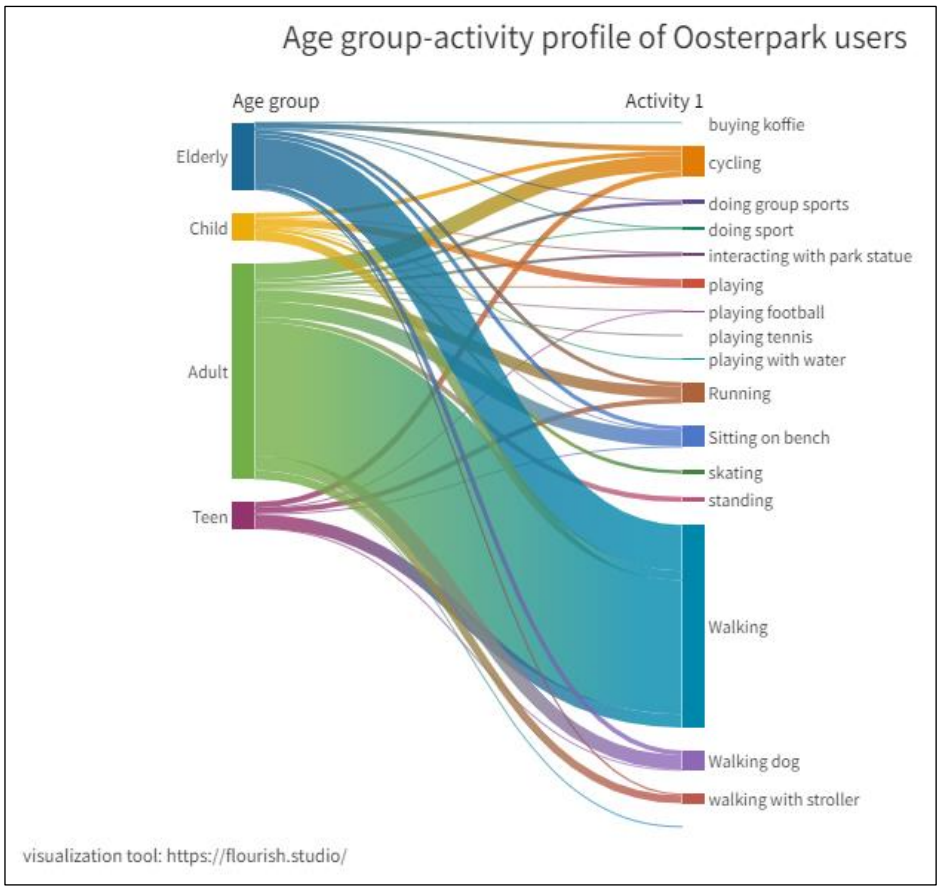


Figure 23:Age group-activity profile of Oosterpark users

The elderly were observed often walking. The second most frequent activities they were doing were sitting on a bench, walking a dog, and cycling. They were also seen walking with a stroller, doing exercise and group sports such as Tai chi, and buying coffee.

Adults were also observed often walking. The second most frequent activities were cycling, walking the dog, walking with a stroller, running, and sitting on the bench. The adults are involved in a broader range of activities than other age groups. Activities such as playing football and tennis, playing with children in the playground, interacting with parks' statues (including looking at them, going around them, taking a picture with them, or climbing and sitting on them), and standing and watching the kids play, and doing group and individual exercises.

The teenagers were also observed significantly walking, followed by cycling and running. Overall, they were observed engaging in a narrower range of activities; besides those mentioned above, they played football and sat on the bench.

The children mainly were either walking or playing. They are also involved in a narrower range of activities; besides those mentioned above, they cycle, interact with park statues, skate, play with water and sit on the bench.

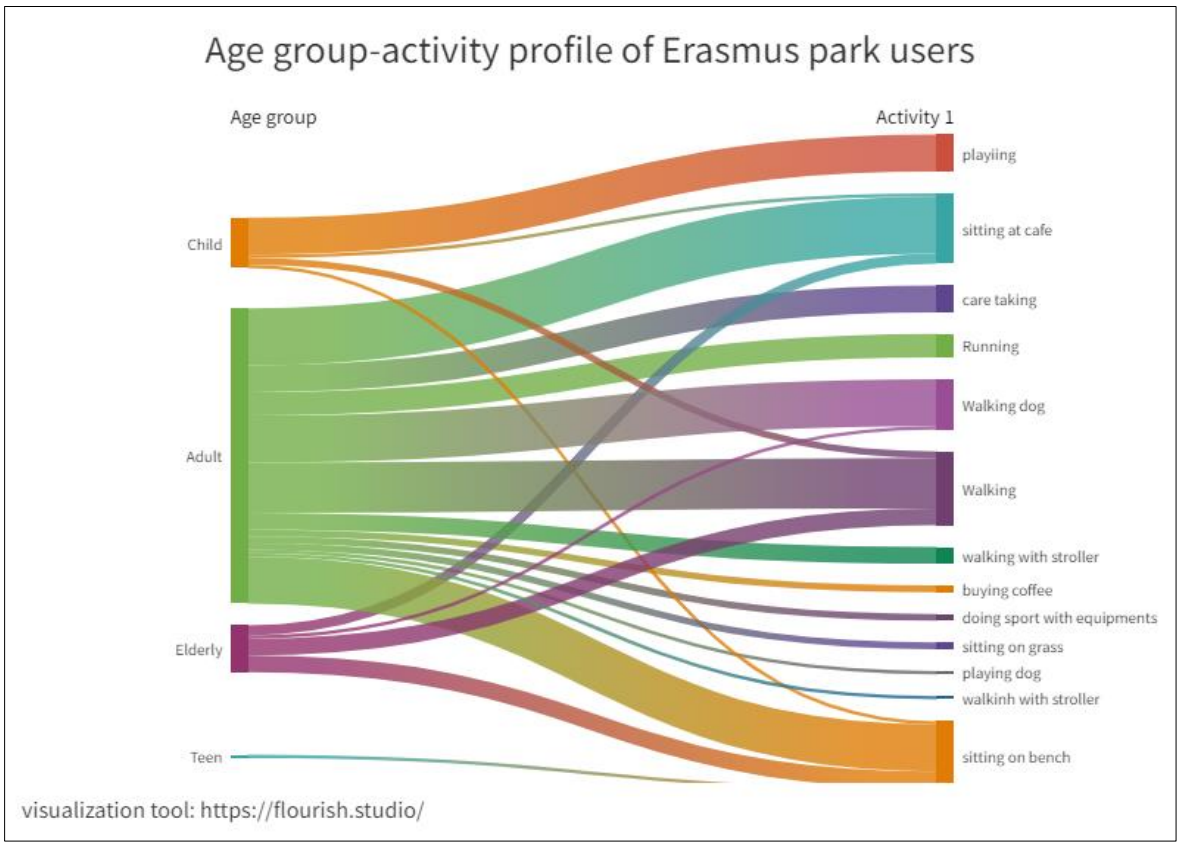


Figure 24: Age group-activity profile of Erasmuspark users

Figure 24 provides the age-activity profile of Erasmuspark users. The elderly were observed significantly walking and sitting on a bench. The other activities with slightly less frequency were sitting at the café and walking a dog. The Adults were observed doing four activities with the same frequency; walking, sitting at the café, walking a dog, and sitting on a bench. The other activities with less frequency were walking with a stroller, standing while taking care of children, running, buying coffee, and doing sports with exercise equipment. The teenagers were only observed sitting on the bench. The children were mainly playing or sitting at the café with their caregivers. Moreover, they were observed walking and sitting on the bench.

4.2.1. Spatial analysis of the use of urban parks

In this section, I present the results of kernel density analysis for male and female users of the parks. The kernel density analysis identified the hot spots of both parks' male-dominated, female-dominated, and gender-mixed areas (see appendix 1 to 4). The theoretical framework, relevant literature, and sketches explain the environmental characteristics of the three areas mentioned above.

Table 2 illustrates some examples of male-dominated areas in Erasmuspark and Oosterpark. It seems that all male-dominated areas offer the possibility to watch others and be seen since mainly they are located close to crowded routes with open, visually accessible spatial arrangements. Based on the theoretical framework, one factor can explain it: activity in the behavior dimension. Watching the others use the park can be an activity for some users, especially male users. Previous studies confirm that the presence of other users who engage in expected and acceptable ways of using the space and participate in typical activities such as walking, sitting on a bench, talking, watching other people, having fun together, etc., are received significantly positively (Mehta & Mahato, 2021; van Aalst & Brands, 2021).

Table 3 shows some examples of female-dominated areas in Erasmuspark and Oosterpark. It seems that for female users, having quietness and being separated from busy, crowded park routes and close connection with vegetation is essential. Table 4 presents some examples of gender-mixed areas in Erasmuspark and Oosterpark. It appears multifunctionality, sunlight exposure and half-shadow exposure, defined physical boundaries with entrance and exit, and the presence of children promote gender-mixed areas.

Table 2: Environmental characteristics of male-dominated areas in two parks

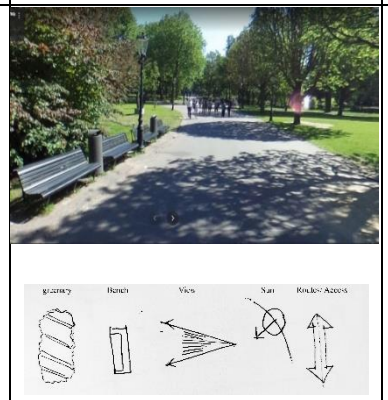
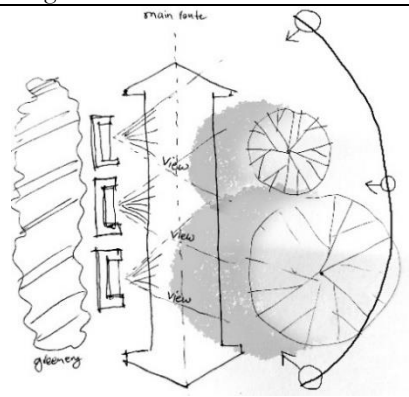
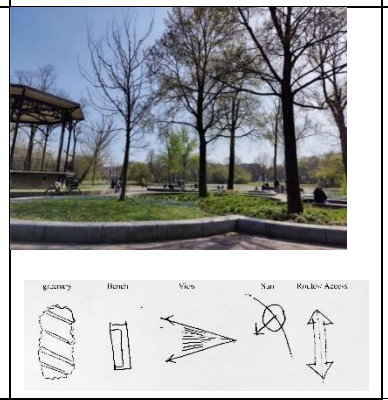
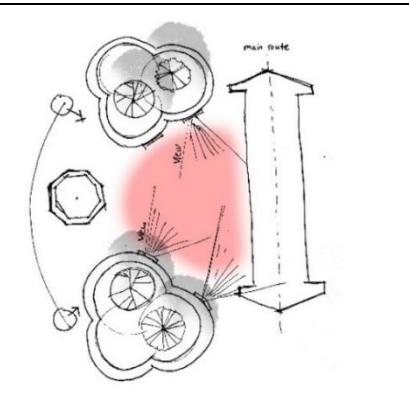
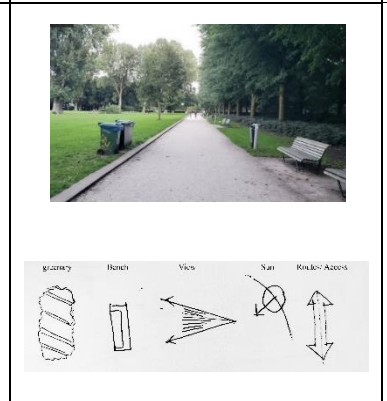
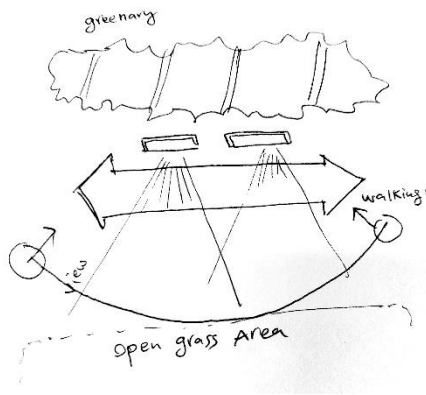
Three examples of male-dominated areas in Erasmuspark and Oosterpark					
Number	Picture	Diagram	Characteristic	Framework	Description
1 figure11			possibility to watch others and be seen	Behavior> Activity	Areas with male users' concentration seem to offer the possibility of watching other users and being seen by others because they are mainly located on crowded main routes with a wide view. However, it seems to be related to activity and attraction rather than perceived safety. This is confirmed by previous studies that the presence of other users who engage in expected and acceptable ways of using the space and participate in typical activities such as walking, sitting on a bench, talking, watching other people, having fun together, etc., are received significantly positively (Mehta & Mahato, 2021; van Aalst & Brands, 2021).
4 figure11					
1 figure13			sunlight exposure half-shadow exposure	Perceived environment > Comfort	All female-dominated areas offered seating areas and benches with sunlight exposure throughout the day without dense vegetation that blocks sunlight.

Table 3:Environmental characteristics of female-dominated areas in two parks

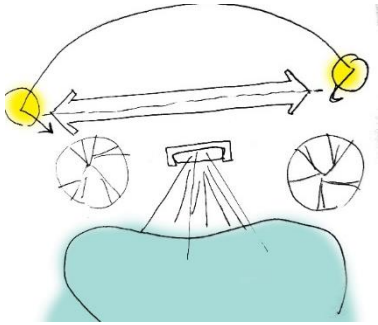
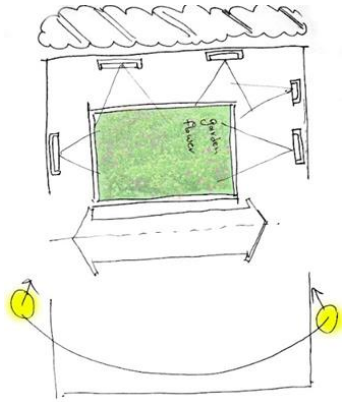
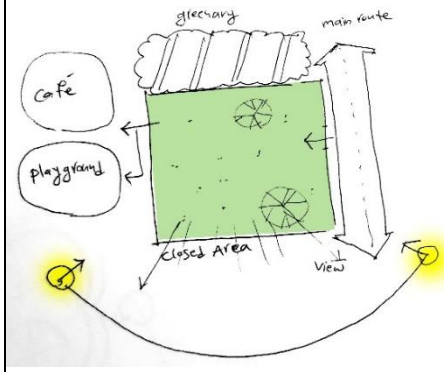
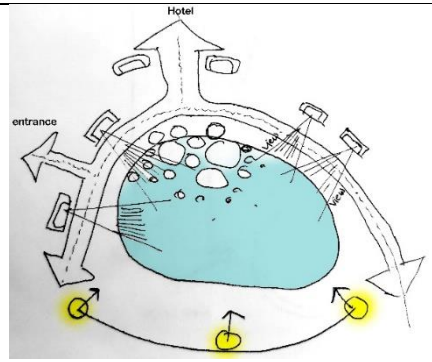
Three examples of female-dominated areas in Erasmuspark and Oosterpark					
Number	Picture	Diagram	Characteristic	Framework	Description
8 figure11			sunlight exposure half-shadow exposure	Perceived environment> Comfort	All female-dominated areas offered seating areas and benches with sunlight exposure throughout the day without dense vegetation that blocks sunlight.
			Close contact or view of the vegetation	- Perceived environment> - Comfort - Attractiveness park physical environment> -Facilities -activity setting	Women were found concentrating in places where they could have closer interaction with nature and vegetation. These intersections include taking pictures, looking at the view, walking through the garden, and smelling the flowers in the Miracle garden.
7 figure13	 		-Located along with one of the secondary routes - Quiet and less-crowded areas of the park (inner layers)	Perceived environment> Perceived safety park physical environment> activity setting	Although the presence of other users and visibility have been noted by previous studies as an essential element of improving perceived safety, especially for women(Polko & Kimic, 2022a), less crowded and inner parts of the parks were in this thesis found female-centered areas. The character of the parks can play an essential role in the visibility and perceived safety as both parks have an open character and most areas are not visually isolated. Women seem to consider privacy as well as safety. This finding can be explained by a previous study where it was found that there is a fine line between feeling safe and feeling crowded(Lis & Iwankowski, 2021).To put it another way, park users, notably women, feel safe and well in situations when they see other people in the area and are not separated from them by a visual obstruction, as long as these people are located some distance away. That is why it is worth creating spaces for relaxation away from crowded spaces but where the active people are visible.

Table 4:environmental characteristics of gender-mixed areas in two parks

Two examples of gender-mixed areas in Erasmuspark and Oosterpark					
Number	Picture	Diagram	Characteristic	Framework	Description
5 figure17			Defined physical boundaries (presence of fence) with defined entrance and exit	Perceived environment > Perceived safety	Defined physical boundaries can help restrict some activities, such as a walking dog, which is popular in both case studies. The presence of dogs and feces can cause conflict for other users. (Derges et al., 2012; Instone & Sweeney, 2014) Defined physical boundaries can help restrict animals from entering and increase some users' safety and sense of security.
			Presence of children		The presence of children or closeness to the playground has been confirmed as a positive element for perceived safety for both genders, especially women (Polko & Kimic, 2022a). Areas around playgrounds and areas that engage children and offer the possibility to play bring a sense of safety for other users.
4 figure16			sunlight exposure half-shadow exposure	Perceived environment > Comfort	All gender-mixed areas offered seating areas and benches with sunlight exposure throughout the day without dense vegetation that blocks sunlight.
			Multifunctionality	park physical environment > -Facilities -Activity setting	Multifunctional spaces offer different activity possibilities to both genders and different ages (Sundevall & Jansson, 2020); Places where children can play, teenagers can hang out, and parents and elderly can sit, walk, or socialize while enjoying other users' presence can promote the use of both genders.
			Locating along the secondary routes of the park	park physical environment > -Activity setting	Quiet and less-crowded areas provide a pleasant experience and comfort to perform activities such as relaxing, eating, reading, and talking.

4.2.1.1. Age-density analysis and activity-density analysis

Figure 25 and figure 26 depict different ages and locations of users in Oosterpark and Erasmuspark. Based on the figures and theoretical framework, there are some important points to mention.

Children were mainly located in playgrounds. Observing the playgrounds based on the theoretical framework highlights two factors: facilities and perceived safety. Play facilities in both parks offered the children the possibilities of physical activities such as climbing, running, and suspending; in Oosterpark, several adults were also seen playing with their children using the play facilities. Considering perceived safety, locating the playground in Erasmuspark close to Terrasmus café gives the playground a sense of social control. The fact that the presence of other users increases the perceived safety is in line with previous studies (Shams & Barker, 2019). However, children users were not only confined to playgrounds; other areas offered children the possibility of play and usage; areas that invited them to interact physically, including running, climbing, close contact with vegetation, and being observed by other users. Using the empirical evidence, two areas of Miracle garden (figure 26 area D) and Hotel Plaza (figure 25 area B) have significant examples. In the Miracle garden, children could enter and play with the various vegetation while the adults and other users sat on the benches and observed them. Also, in the Hotel Plaza, the huge stones in the waterbody engage children to climb and play while other users sat on the bench and observed them. Previous studies also found that areas with playfulness while providing a safe environment can engage children (Sundevall & Jansson, 2020).

Adults and the elderly were found using all the areas in both parks. As confirmed by other studies, teenagers sharing the lowest population of users were primarily seen in secluded areas such as sports fields and quiet seating areas with other users. A recent study in Utrecht (van Aalst & Brands, 2021) indicates that teenagers prefer to visit parks with their group apart from others. They also appreciate the presence of other users as long as it does not affect their group privacy (van Aalst & Brands, 2021). Another study indicates they prefer to have their group privacy and not get disturbed by other users, especially children (Sundevall & Jansson, 2020).

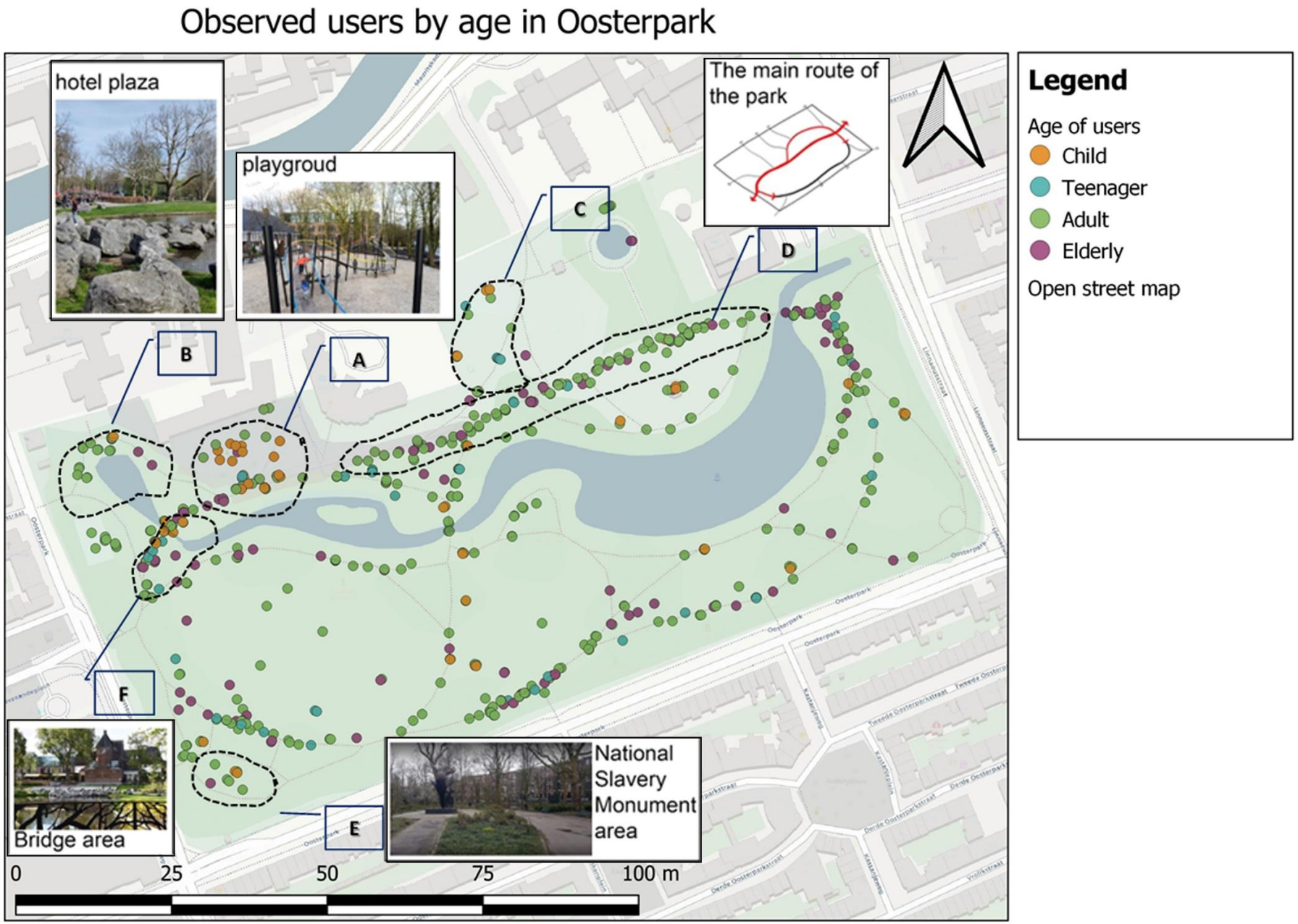


Figure 25:observed users by age in Oosterpark

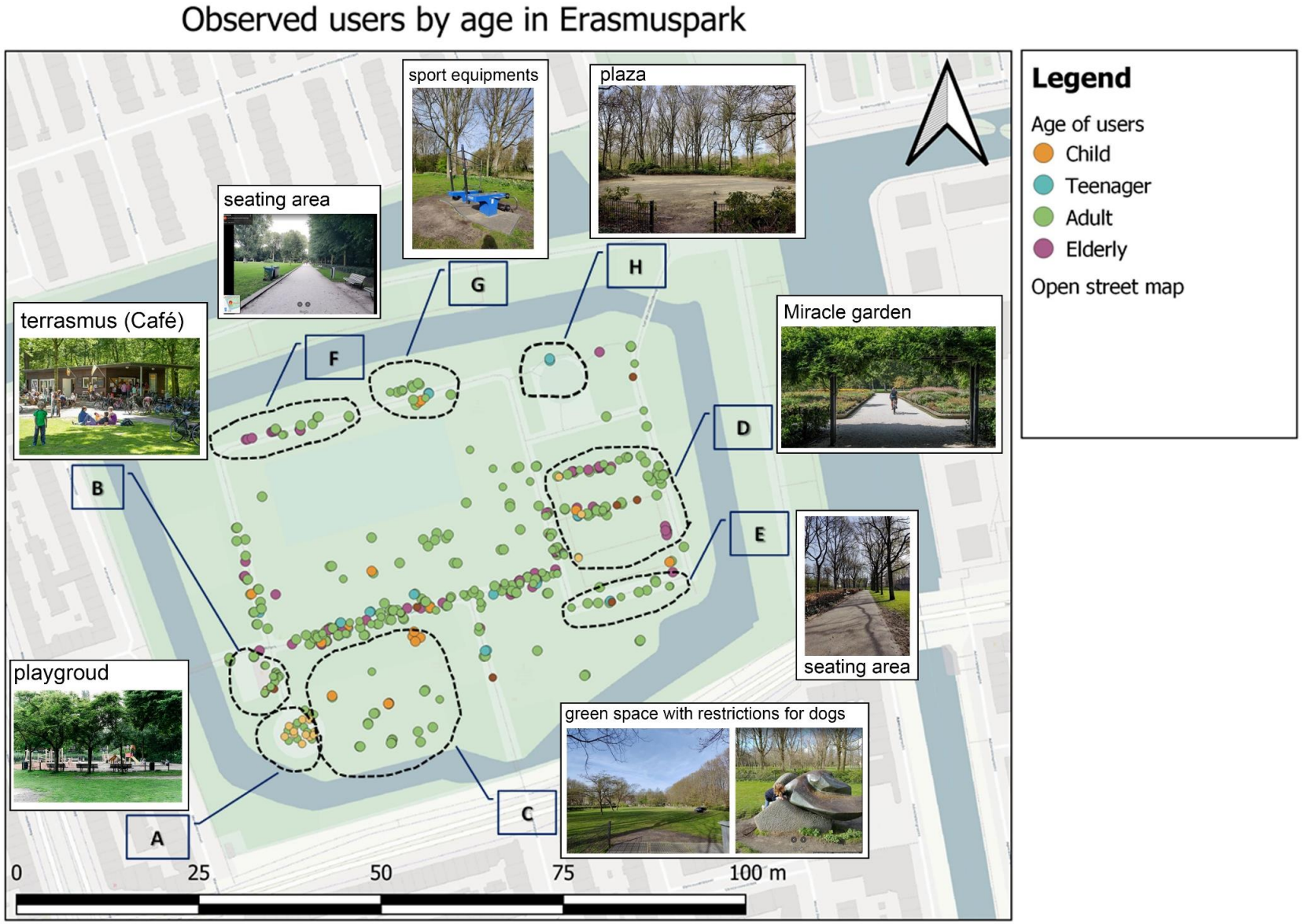


Figure 26:Observed users by age in Erasmuspark

4.3. Users diversity by age and gender in urban parks

In this section, I address the question, "How do the characteristics of urban green space and surrounding environment promote diversity of its users." To that aim, the outcome of the previous section's analysis was scrutinized from the angle of the diversity of users, and an **"area-gender-age"** matrix of all the highlighted areas from the analysis was created. In this matrix, routes and pathways were excluded, and only areas with distinct boundaries offering static activity possibilities were included, such as playgrounds, plazas, etc.

In table 5, the Area-gender-age matrix of Erasmuspark, areas are colored based on a comparison between the age-gender profile of the area and the whole park, which means the closer two profiles together, the area was more successful in accommodating all the possible users. The Miracle garden, with the higher position in the matrix (Table 5), has environmental characteristics that allow a wider range of users to use it. In the kernel density analysis, the Miracle Garden was found with defined physical boundaries, defined exit and entrance, the possibility of close contact with vegetation, the possibility of play for children, and multifunctionality.

The lower we go on the table, the more mono function the areas become. The playgrounds, which only are used by children and adult caregivers, should be accompanied by other areas at close distance to afford higher diversity of users collectively. As in the Erasmuspark case study, the playground, Terrasmus café, and small lawn (with dog restrictions) were located close to each other and created a hub for diverse users. When children were playing in the playground, many adults, as their caregivers, were standing or waiting for them. The adults could appreciate the café while caregiving for their children in the playground; the close distance allowed the adults to enjoy coffee and a conversation while their children were playing.

To sum up, multiple separate multifunctional areas or a group of areas with monofunctional areas and collectively multifunction can promote the diversity of users. Such an approach to multifunctionality is close to what (Hansen et al., 2019b; Sundevall & Jansson, 2020) proposed as a "tessellated approach," "total multifunctionality." The tessellated approach to multifunctionality refers to the spatial segregation of functions within one zone, i.e., the playground, café, and lawn in Erasmuspark. "Total multifunctionality" is when all the functions are balanced simultaneously and in the same location, i.e., Miracle Garden.

The synergy between land-uses surrounding the park and activities and functions of the park increases the park's potential to accommodate the use of diverse users. Land uses surrounding the Oosterpark are more diverse and contain art galleries, museums, hotels, catering, and education centers. So, people come to the neighborhood for various reasons and may end up using the park. For example, in Oosterpark, several users were observed carrying a suitcase or sitting on the bench with a suitcase related to the hotels around the park. Such users cross the park to reach the hotels or use a waiting area with their luggage. As the second example, Erasmuspark is surrounded by residential land use, lacking catering land uses; establishing a catering land use, Terrasmus café in the park answered its demand. Hence, It is essential to consider the unique potential of the surrounding neighborhood and consider them an opportunity to accommodate such users.

Table 5:area-gender-age matrix of Erasmuspark

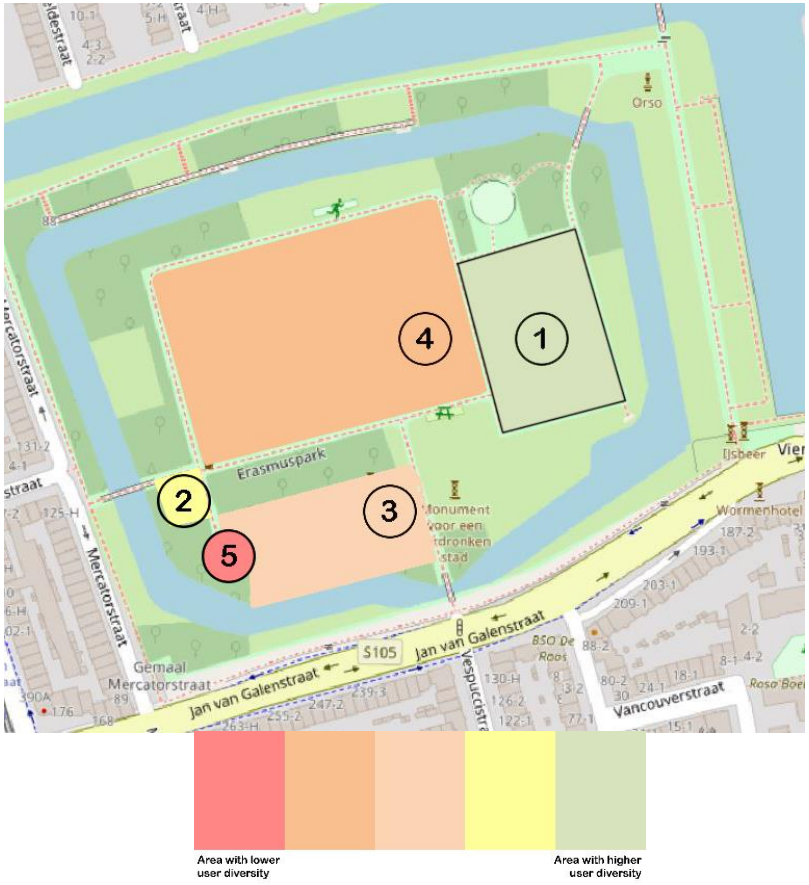
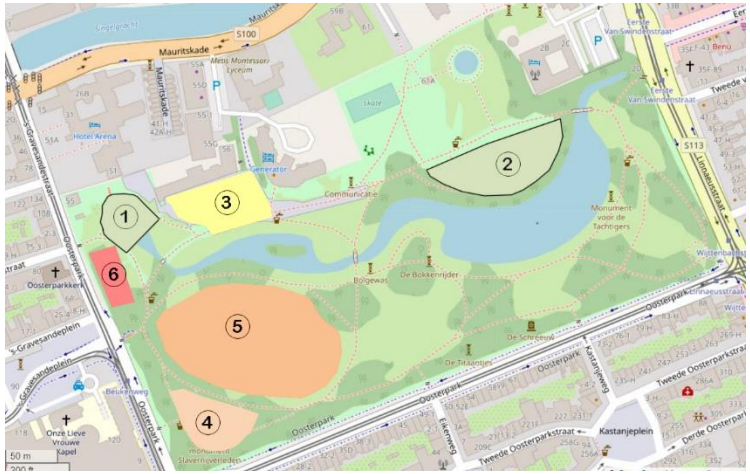
Location in the park	Number Of area	Name of the area	Female %	Male %	Child %	Teens %	Adults %	Elderly %	Activities affordances
		The whole park	60	40	11	1	75	13	
	1	**Miracle garden**	54	46	7	4	57	31	sitting on the bench/ playing in the garden/reading on the bench/taking pictures of flowers/ care taking/ interactive with nature/ socializing in group
	2	**Terrasmus**	66	34	18	2	70	10	sitting at terrace/ drinking/ socializing /eating/ waiting for children to play (care giving)
	3	**Open area with dog restrictions**	56	44	26	0	70	4	sitting on grass/ reading book
	4	**Open green area**	50	50	3	3	93	0	playing with dog/sitting on the grass/playing football
	5	**Playground**	74	26	54	0	38	8	playing /care giving/sitting on the bench /talking

Table 6:area-gender-age matrix of Oosterpark

Location in the park	Number Of area	Name of the area	Female%	Male%	Child %	Teens %	Adults %	Elderly %	Activities affordances
		The whole park	44	56	8	8	64	20	
	1	**Hotel plaza**	**38**	**62**	**21**	**3**	**62**	**14**	Sitting on the benches, sitting on stairs, wooden pieces, sitting on rocks/ climbing on rocks, playing with water fountain/ reading book
	2	**Performing plaza**	**66**	**34**	**18**	**2**	**70**	**10**	Sitting on the benches, performing arts, watching performing arts, skating, dancing, working out,
	3	**Children's playground**	**52**	**48**	**32**	**2**	**27**	**3**	Playing / sitting
	4	**Slavery monument plaza**	**38**	**63**	**25**	**0**	**63**	**13**	Slavery monument plaza
	5	**Open grass area**	**47**	**53**	**0**	**17**	**56**	**28**	Dog walking/ playing with the dog, sitting on the grass, lying on the grass
	6	**Tennis sports fields**	**22**	**78**	**0**	**0**	**100**	**0**	Playing tennis, sitting on benches, watching people playing tennis

5. CONCLUSION AND RECOMMENDATION

5.1. Reflection on research objectives and questions

This thesis aimed to explain the characteristics of UGS, namely, urban public parks in a compact urban development that promote diversity of users regarding age and gender. Three research objectives and related research questions were developed to achieve the thesis's aim. Based on the findings of the study based on the two case studies of Oosterpark and Erasmuspark, the answers are elaborated below.

Objective 1: Understanding the key concepts of urban green space, compact urban development, and their interaction

In this thesis, urban green space (UGS) refers to any surface of the urban environment with vegetation. UGS is a broad concept encompassing all areas with vegetation in the urban fabric. Still, this thesis solely focused on public urban parks in compact urban development characterized by function-mix, high density, dense and compact development that promotes public transportation and active travel. In compact urban development, all urban elements such as buildings, infrastructure, green areas, and mixed-land uses are close and compete for limited land (Burton, Jenks, and Williams 2003). Moreover, the imperviousness ratio is higher because of the artificial material and buildings (Arnold and Gibbons 1996). The limited space left for vegetation growth is exposed to environmental pollution due to urbanization (Tian, Jim, and Tao 2012a). Hence, the inevitable scarcity of land in compact, dense development can put pressure on UGS and may result in a loss of green space or a decline in its provision (Harland and van den Bosch, 2015; Neuman, 2005). Despite the pressure that compact urban development puts on urban public parks, it creates some potential for use and users of urban public parks. In this thesis, better access to public transportation, cycling, and walking infrastructure in Oosterpark was found to promote park-based physical activity.

Objective 2: Conceptualizing the use and users of urban green space in the context of compact urban development based on literature**.**

The second objective of this thesis aimed to conceptualize the use and users of UGS, namely, urban parks, by summarizing the contributing factors; Several factors affect the use of urban parks. Some factors related to the urban park's physical environment include amenities and facilities, routes, size of the park, and functions. The other factors relate to the park's perceived environments, including accessibility, attractiveness, quality of facilities and landscape, and perceived safety. There are other groups of factors that refer to users' individual features, including age, gender, health, and ethnicity. From the surrounding neighborhood, factors related to accessibility, land-uses, walking and cycling infrastructure, and public transportation affect the use of urban green space. Compact urban development by promoting function-mix, use of public transportation, active travel (walking -cycling), and high density can influence the use of urban parks. The socio-ecological model(Schipperijn, 2010) was applied to conceptualize the factors of urban parks and surrounding neighborhoods influencing urban park use. Based on this model, four dimensions of individual factors, perceived environment, behavior, and park's physical environment, explain the use of urban parks. To adapt the model to this thesis, the fifth dimension of neighborhood environment with factors of function-mix, active travel, and public transportation was added to the model.

Objective 3: Explain the characteristics of urban green spaces that promote the diversity of users

Concerning the design of urban parks, areas in the park that promote diversity of users in terms of different ages and gender were found with specific environmental characteristics: multifunctional in terms of providing different activity possibilities, perceived as safe with defined physical boundaries, entrance/exit, providing the comfort of use by sun/half-shadow exposure.

In the two case studies, the synergy between the arrangement of activities in the park and the surrounding neighborhood's land use and transportation provided unique activity opportunities. In the Oosterpark case study, better access to public transportation and walking/cycling infrastructure induced more active park use. Several sports fields and broad walking pathways also pursued the possibility of active park use. Also, the Terrasmus café in the Erasmuspark case study attracted a considerable number of park users by offering a catering service which lacked in the surrounding neighborhood. Grouping the café with the children's playground and lawn attracted diverse users.

5.2. Academic and social contributions

This thesis aimed to explain the characteristics of UGS, namely, urban public parks in a compact urban development that promote diversity of the users regarding age and gender. The socio-ecological model (Schipperijn, 2010) was adapted to conceptualize the factors of urban parks influencing their use. This thesis contributed to the research of urban parks in compact development by adding the fifth dimension of neighborhood physical environment to the socio-ecological model. Elements of the land-use mix, public transport, and active travel were considered in the use of two urban parks. The methodological framework developed in this thesis gives a holistic overview of factors influencing the use of urban parks. It contributes to the research development by laying the foundation for more comprehensive future research on urban park use. This model can help plan better urban parks in compact urban development since it informs the planners of more contributing factors related to the use of urban parks. Also, it encourages multi-disciplinary planning of urban parks in compact urban development by highlighting the neighborhood's physical environment and the park's physical environment.

Based on the findings of this study, successful urban parks in a compact development are multifunctional. Previous studies proposed multifunctionality in all spatial levels for UGS in compact development (Hansen et al., 2019b; Sundevall & Jansson, 2020). This thesis adds to the existing literature by providing empirical knowledge about multifunctionality on the design scale and arrangement of the park's activities (detailed in section 4.3). Also, due to the added fifth dimension to the socio-ecological model (Schipperijn, 2010), it was revealed that synergy between surrounding land use, public transportation, and walking/cycling infrastructure and the park's facilities and activities could induce certain activities. Based on the findings, I arrived at two major recommendations for urban planners, landscape designers, and related disciplines to promote diversity of the users in urban public parks in compact urban development;

1) Sensitivity and responsiveness to the land use surrounding the park; by providing the activities missing from the surroundings (e.g., catering) or understanding the park users according to the surrounding land uses and considering their needs in the activity arrangements. For example, the majority of users of Erasmuspark, surrounded by residential land use, were women.
2) Multifunctionality in the design and arrangement of the park's facilities. There are two approaches regarding multifunctional areas in the park; developing several multifunction areas such as Miracle garden(figure 26 area D) and Hotel Plaza (figure 25 area B), or developing a hub of monofunctional areas such as the café, the playground, and lawn in Erasmuspark (Areas A, B, and C in figure 26).

5.3. Limitations

One of the limitations of this study was defining the scope of diversity of the users. The diversity of users can consider all the individual features, including ethnicity, physical ability, etc. However, for the feasibility of the research, only two individual features were selected. Considering more individual features can deepen the understanding of the use of urban public parks. Although the on-site observational approach gave an empirical understanding of users' behavior, the user's opinion also can be coupled with the observation and add another layer of understanding to the use of urban public parks.

One of the methodological limitations of the study was regarding the data collection. Although structural observation and recording of the data using the QGIS and Mergin plugin [4] made it possible to document the user's location and individual features and activities, it was impossible to record each user in time series. Users may use different facilities in one visit to the park and spend different times in each area and facility. Recording the sequence and time spent on each facility can provide meaningful insights into the park's facilities' importance for each user group.

5.4. Recommendations for future studies

The methodological framework developed in this study can be used for future studies on urban public parks in compact urban development, focusing more on the fifth dimension, the neighborhood's physical environment. It is worth quantifying the influence of each of the compact neighborhood elements(e.g., land use-mix, accessibility of public transportation) on the use of the diversity of the users.

Another future research can investigate the diverse user's opinions and preferences on a compact neighborhood's physical, social, and economic environment. Users' preferences and opinions on the park's design and facilities have been investigated in prior research, but users' preferences and opinions regarding the surrounding neighborhood especially considering a compact urban development, are unclear.

The other interesting area of research can be identifying the non-users of the urban public park. This thesis based the research on the existing users in the park, while another study can focus on the potential users who are not present at the park. Comparing the user's profile of the park with the population profile in the surrounding neighborhood can reveal the non-users' population of the park. Future research can investigate the non-users of an urban public park and explore the barriers and reasons od non-use phenomena.

[4] More information at page 23

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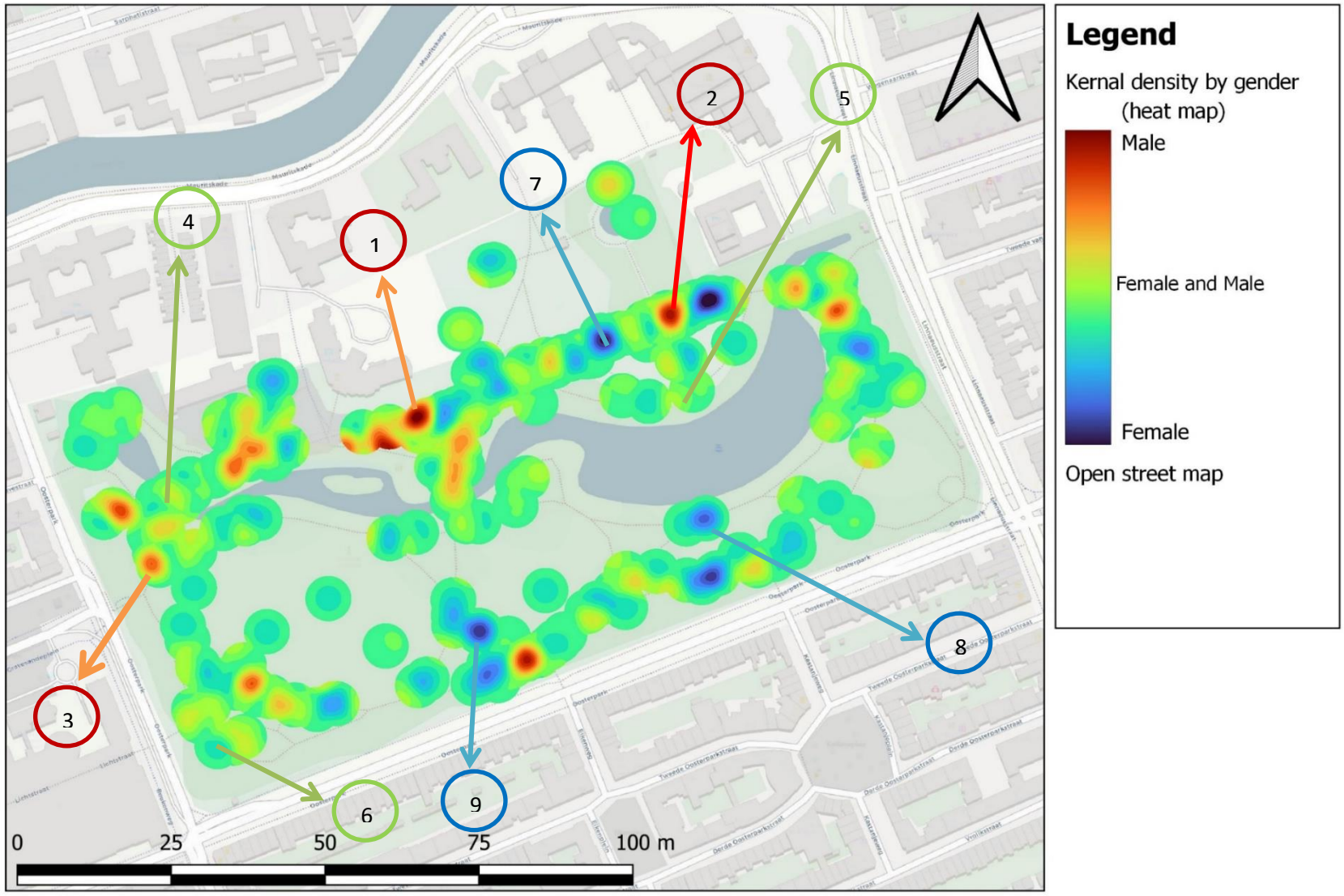
APPENDIX

Appendix 1

Kernal density map by gender in Oosterpark



Male centered spots

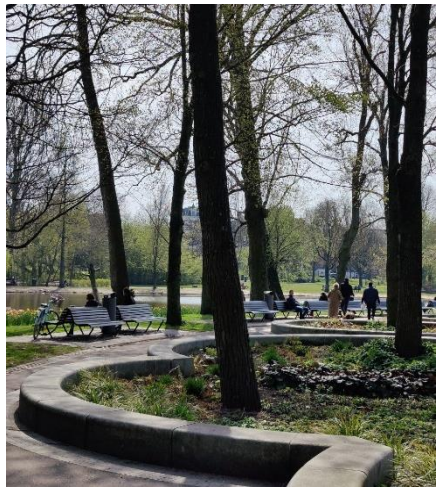
1

2

3

Neutral spots

4

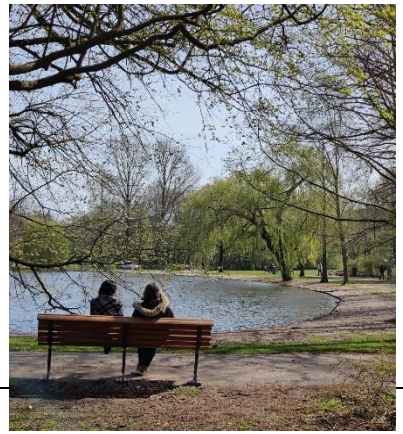


5

6

Female centered spots

7



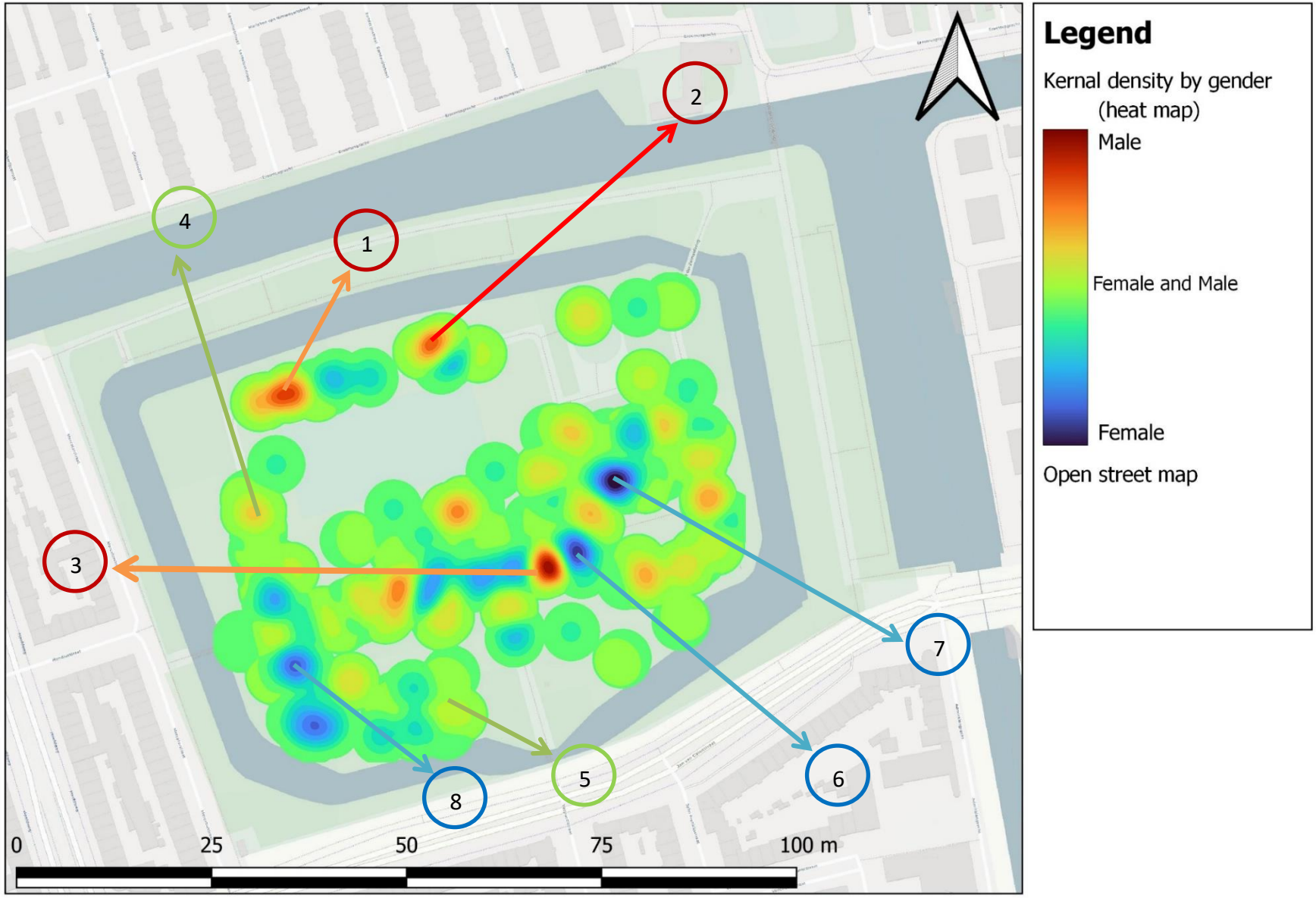
8

9

Appendix 2

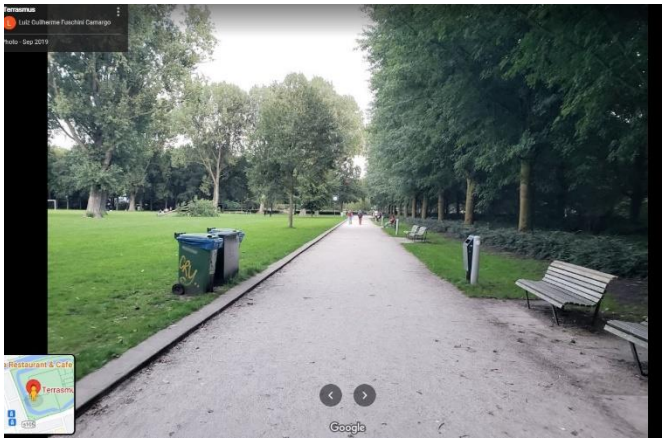
Appendix 3

Kernal density map by gender in Erasmuspark



Appendix 4

Male centered spots



1

2

3

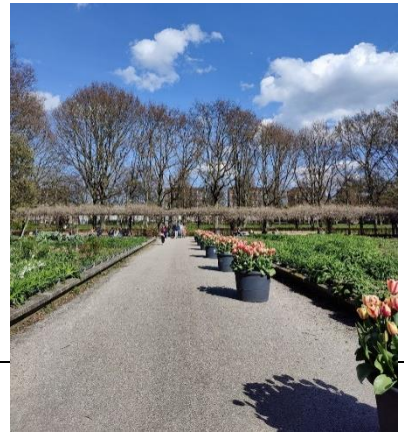
Mixed-gender spots

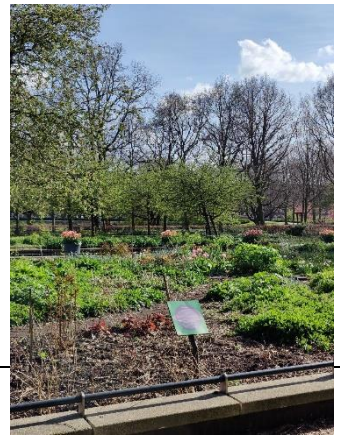
4

5

6

Female centered spots





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