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Sexual violence in the city: the role of the built environment

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Summary

Violence limits freedom and citizen's access to opportunities in the city. In the Netherlands, 35% of women have experienced physical or sexual violence by a non-partner and 7% have experienced it in the previous 12 months. Such statistics place women's safety concerns as a problem still present in the twenty-first century and well worth of study.

This research's main objective is to explain the relationship between built environment's spatial features and gender-based sexual violence in public streets through the quantitative analyses of micro and macro spatial features of the streets of four neighbourhoods of Rotterdam: Cool, Nieuwe Westen, Hillesluis and Pendrecht. The micro spatial features are the function of the street, it's constitutedness, the density and inter-visibility of entrances. The macro spatial features were obtained with the use of Space Syntax: angular analyses with low and high metrical radius, local and global integration. Sexual violence reports were provided by Rotterdam's police (from 2012 to 2017).

Results indicate that neither Jane Jacobs' ideals of safety through eyes on the streets, nor Oscar Newman's defensible space can be defended separately when aiming the safety of women in the streets. Pooled Poisson regression models were created to explain the number of sexual violence reports per street and per block. The resulting models at both scales show significant positive correlation between the occurrence of sexual crimes and the amount of women in the streets, local integration and function of the street. This indicates that non-residential streets that may be safe during the day become more dangerous during the night, when natural surveillance disappears. Results also suggest that mixed use is safer when there is a higher share of residences. Both hypotheses are supported by findings of Hillier and Sahbaz (2008).

Inter-visibility of entrances is a negative correlate of crime, supporting that greater natural surveillance results in greater safety in the streets. Coefficients of to-movement could indicate that, on average, a street with higher flow of people has fewer crimes (especially in residential neighbourhoods), but the block that attracts such movement (usually a commercial one) has more crimes because of the lack of surveillance after stores close.

A second conclusion is that the amount of people in the streets and the time component of crimes are essential elements in the analysis of the spatial distribution of sexual violence in the streets. Third is the conclusion that there seems to be more than one mechanism that governs the spatial – and temporal - distribution of sexual violence in the streets.

The findings are in line with previous researches in the fields of sexual harassment in the streets, crime research, street robbery in public spaces, and gender differences in the use of streets.

As recommendations for urban policy practice, results suggest that women's safety in residential streets could benefit from a design that includes residences on both sides, with good inter-visibility between entrances. In commercial areas, land use should allow and encourage the inclusion or construction of residences, to provide mixed-use. Yet, more research is advised to confirm these ideas. Nevertheless, women's safety in the city can benefit from greater gender equality in the employment of urban practitioners, and from the inclusion of gender mainstreaming in urban design.

Keywords

Sexual violence, women's safety, built environment, micro spatial features, Space Syntax.

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Abbreviations

IHS	Institute for Housing and Urban Development

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Chapter 1: Introduction

> Space cannot change cultural patterns,
> but it can support social life
> or be an obstacle to it.
>
> Eva Kail, CEO of the city of Vienna, Austria
>
> (Trust Women 2014 - Plenary: How To Make Mega-Cities Women-Friendly? 2014)

1.1. Background

"Cities are hubs for ideas, commerce, culture, science, […] social development and much more. At their best, cities have enabled people to advance socially and economically." (UN, 2015)[1]. The opening words of United Nations' Sustainable Development Goals regarding cities and communities provide a glimpse of the importance of cities for a thriving humanity. Several authors have explained agglomeration in cities by the opportunities it provides for jobs, education, and interactions. However, increased agglomeration entails disadvantages too, such as increased violence (Scott and Storper, 2014, Bettencourt, 2013).

Streets, in their central role of public spaces, are the stage for a number of crimes: from pick pocketing to robbery to sexual assault. More than a punctual sporadic event, violence limits freedom and citizen rights on a daily basis (Falú, 2009, Valentine, 1989, Stanko, 1995). It affects the way people access opportunities by limiting times when they go outside, limiting their choice of transportation, limiting choice of routes and destinations and even resulting in the renounce of desired activities. This is specially so for women, who suffer from sexual harassment and assault in cities all over the world (World Health Organization, 2013, Sur, 2014). In other words, women and men do not access and experience the city in the same way (Beebeejaun, 2009).

Violence against women is not a new problem. Nevertheless, it remains a current and urgent one. Ample data supports the focus on this topic: in Brazil, data of São Paulo state indicates an increase of reported sexual assault by 6.7% in 2016, to nearly ten thousand cases in one year[2]. In the Netherlands, 35% of women have experienced physical or sexual violence by a non-partner since the age of 15, and 7% have experienced it in the 12 months prior to being interviewed (European Union Agency for Fundamental Rights, 2014). On a continental scale, the Violence Against Women survey report made by the EU Agency for Fundamental Rights (2014) declares that "violence against women [...] is an extensive human rights abuse that the EU cannot afford to overlook." (p. 3). The reduced number of policies and programs on the matter might be due to the lack of report and research: only 14 % of women reported to the police the most serious incident of non-partner sexual violence they suffered[3]. Such statistics

[1] Goal 11: Make cities inclusive, safe, resilient and sustainable

[2] The question of whether such increase indicates higher rate of reporting, increase of incidence or both, requires deeper study.

[3] This number results from the interview of 42,000 women in 28 Member States of the European Union. Only 30% of women reported the most serious case of non-partner sexual violence to any organization or service (police, hospital, social services, legal services, etc.), (European Union Agency for Fundamental Rights 2014, Table 3.4).

place women's safety concerns as a problem still globally present in the twenty-first century and well worth of study[4].

1.2. Problem statement

According to the UN Committee on the Elimination of Discrimination against Women (CEDAW) of 1992, gender-based violence "is a form of discrimination that seriously inhibits women's ability to enjoy rights and freedoms on a basis of equality with men". The Council of Europe Convention on preventing and combating violence against women adopted in 2011 (The Istanbul Convention) that "'violence against women' is understood as a violation of human rights and a form of discrimination against women and shall mean all acts of gender-based violence that result in, or are likely to result in, physical, sexual, psychological or economic harm or suffering to women, including threats of such acts, coercion [...], whether occurring in public or in private life;" (European Union Agency for Fundamental Rights, 2014, p.9).

Several researchers have shown how limited access to the city curtails women's economic potential in diverse ways: family and home responsibilities that have traditionally fallen on women's shoulders, such as taking kids to school and groceries shopping, limit women's time availability, eventually forcing them to take part-time jobs. Additionally, restrictions on entrance and exit times, work location that might be unsafe at night, accessibility to work that requires a car, are all factors that can prevent women from getting the best opportunities and best paying jobs available to them (Sweet and Ortiz Escalante, 2010). As Andrew (1995, p. 106) said, "Urban safety is compatible with, and indeed can be seen as part of, the economic development strategies pursued by municipal governments".

Factors associated with higher probability of sexual violence are various, but they can be grouped into three categories: social factors (such as gender inequality and sexism), economic factors (World Health Organization, 2010) and physical (spatial) factors. This research focuses on spatial factors related to gender-based sexual violence that happens in streets.

Studies regarding safety in the public realm began decades ago: in 1961, Jane Jacobs wrote about factors that contribute for safer streets, sidewalks and, therefore, cities. Based on her observations, she defended that maintaining urban safety is a fundamental function of streets, and that prosperous neighbourhoods are those that succeed in maintaining safety in spite of the majority of strangers inherent to any metropolitan city. However, a few cases of violence in a street or neighbourhood are enough for people to fear it. When people fear the street, they use it less, in a vicious cycle, making it less and less safe (Jacobs, 2011). Therefore, lively streets are safer and feel safer, and neighbourhoods with mixed uses are necessary to guarantee people use the street during various times of the day, night and weekends. Other physical aspects related to the feeling of safety in the city are lighting, the entrapment effect (blocked escape) and concealment ("a physical occlusion of space big enough to hide a potential offender", Boomsma and Steg, 2014, p. 197).

In Vienna, landscape design was proven to affect and re-balance the gender proportion of kids above the age of 9 that use a park: girls who had been previously excluded for not being able to compete with boys for the space started to use the park after it was redeveloped. This

[4] "Women can perpetrate violence, and men and boys can be victims of violence at the hands of both sexes, but the results of this survey, together with other data collection, show that violence against women is predominantly perpetrated by men. This is overwhelmingly the case when it comes to sexual violence and sexual harassment. With this in mind, the majority of violence against women can be understood as gender-based violence." (European Union Agency for Fundamental Rights, 2014, p.7)

experience clearly suggests the influence of spatial aspects in the use people make of the environment. Yet, there is a gap in the literature regarding the influence of spatial aspects in gender-based sexual violence in the city.

1.3. Research objective

The objective of this research is to explain the relationship between built environment's spatial features and gender-based sexual violence on public streets, through comparison of gender-based violence on public streets and micro and macro spatial features of the streets. As a result, the study will enable policy recommendations for cities that aim to be safer for women and, consequently, for everyone.

1.4. Research question

What is the relationship between spatial features of the built environment and women's safety from sexual violence in the streets of Rotterdam?

Sub-questions

1) How is gender-based sexual violence spatially distributed in Rotterdam's neighbourhoods?
2) What are the socioeconomic characteristics of the neighbourhoods with highest incidence of sexual violence?
3) How can the four chosen neighbourhoods be described according to the spatial features of the built environment?
4) What is the relationship between the spatial distribution of gender-based sexual violence and spatial features of neighbourhoods?
5) What are the spatial features of streets where sexual harassment takes place?

1.5. Significance of the study

Previous studies have been mostly qualitative and focused on fear. For instance, there are studies on

- the geography of fear: how fear impacts on women's use of space (Valentine, 1989, Bowman, 1993, Hanson, 2010, Sur, 2014). Recent studies focused particularly on mobility (Crane, 2007, Rapino* and Cooke, 2011);
- fear and perception of safety: what makes people feel safe or unsafe in public spaces. Studies found gender and self-assessed vulnerability as predictors of fear (Ferraro, 1996, Killias and Clerici, 2000, Fisher and Sloan III, 2003, Boomsma and Steg, 2014);
- Planning and gender: whether urban planners take gender into account in the planning process, and the impacts of doing so (Kancilia and Warner, 2015);
- Spatial factors and safety: discuss factors of the built environment that are associated with safety, such as eyes in the street, mixed uses, lighting, effect of entrapment (blocked escape) and concealment, aggregate neighborhood risk of crime (ANROC) (Jane Jacobs, 1961, Hillier and Sahbaz, 2008, Boomsma and Steg, 2014, Drawve, Thomas, et al., 2016). Only part of these have been effectively proven so far;
- Built environment and walkability: how spatial factors affect human behavior towards walking exercises. Found that higher residential density, land use mix, street connectivity, aesthetics and safety are associated with higher walkability (Saelens, Sallis, et al., 2003, Frank, Schmid, et al., 2005);

Therefore, this study aims to add quantitative analysis to the existing literature by combining factors that have seldom been studied together: the spatial features of public streets, gender and sexual violence.

Moreover, it aims to provide policy guidance for urban planners and managers that intend to build safer cities for women and, consequently, for everyone.

1.6. Scope and limitations

This research focuses in the city of Rotterdam. The main reason for this choice is the recent publication of the Seksuel straatintimidatie report about sexual harassment in the streets of Rotterdam. It found that, in 2016, from a sample of 1200 women aged 18 to 45, 84% experienced men whistling at them, shouting, insulting, asking for sex, or were followed or cornered in public spaces. As a result, 44% of interviewed women felt irritated, insulted, threatened or limited in their sense of personal freedom by sexual harassment.

Focus was given exclusively to sexual violence towards women in the public space. This selection is due to the strong correlation between sexual violence and gender, and to the fact that the public realm is directly under responsibility of urban planners and managers.

The time frame of the research limits data collection of sexual violence to secondary sources and primary data collection of spatial features to four selected neighbourhoods, as further explained in Chapter 3. The sexual violence data covers the period from 2012 to 2017, since Rotterdam's police records did not include gender before 2012.

Data availability largely limits and define analyses possibilities: police data can only be segregated to street level, not to block level. Moreover, the records have no identification of the gender of suspects or victims for a large part of the records. For this work, it was assumed that records with 'unknown' gender of victims or suspects follow the pattern of the cases in which such information is known.

Police data is assumed to be a reliable source of information of sexual violence in public spaces. However, it is estimated to account for only 14% of occurrences of sexual violence committed against women by a non-partner (European Union Agency for Fundamental Rights, 2014).

Part of the data used in this work's analysis refers to the amount of people in the streets. This information has been collected by counting people manually. This process is subjective in nature due to physical and spatial limitations such as: people are usually moving, and unforeseen changes may happen in minutes. Moreover, randomness plays an important part in any instant snapshot obtained of movement in the streets. Besides these factors, it is not possible to count every streets in the neighbourhood at the same time. Finally, the number of people per street is associated with a moment in time (one day or a few days in a month of a year), whereas the crime data are scattered across five and a half years.

The indicators *crimes per person*, and *crimes per women* can not necessarily be compared across neighbourhoods, since the people in each one were not counted on the same days. These indicators serve as a general reference.

Another input of the analysis is the density of entrances (doors) that give access from the public to private spaces. However, counting entrances may also be subjective: should two doors for the same building count as one or two? Is an entrance defined by the group of people who use it, or by the opportunity it provides to move from a (semi) public to a private space? In this work, each apartment (entrance) door was counted as one entrance.

Chapter 2: Literature Review

In the search for safety in urban environments, divergent theories have been proposed to answer the question: what characteristics should we aim for the physical space, so that it can be safer for people? On one side, Oscar Newman, in 1972 Defensible Space, proposed that spaces should be designed in a way that clearly shows who belongs there and who does not, so that rightful inhabitants would feel entitled and responsible to question visitors and intruders alike, creating an environment of natural surveillance. On the other side, Jane Jacobs, in 1961 Death and Life of Great American Cities, had previously proposed the opposite approach to natural surveillance: that spaces should invite locals as well as dwellers of other neighbourhoods to use it at all times of the day and night, as a way of keeping eyes in the street.

Transposing these divergent ideas to the issue of eliminating gender-based violence in the streets, two very different scenarios can be imagined for a city that would be free of this problem: the first, Newman-inspired, of a city that has areas for exclusive male use, and areas for exclusive female use. Shopping, entertainment, education and jobs, all clearly divided by the gender of its users. Clearly, without gender mixture in the streets, there can be no sexual violence of men towards women[5] [6]. The second scenario, Jacobs-inspired, presents a gender-mixed city, where the vivacity of streets would ensure its safety. In the latter, the seemingly-utopian goal of ending sexual gender-based violence depends on not-entirely known factors of the physical environment and its relations with human behaviour, not to mention culture, education and so many other socioeconomic aspects involved in this complex issue. The scientific, well-grounded choice for one scenario relies on the study of those who have been building knowledge on such inter-related fields.

Many scholars have contributed to answer this question. The relationship between gender and city access and opportunities is a starting point in this literature review: how gender is a socially constructed concept and norm, and how this construction relates to the way women use the city. It is argued that gender-based sexual violence have profound influence on the relationship of women with the city, beyond the realm of conscious thought. The second part of this chapter will focus on violence in public spaces: existing theories and explanations. Finally, the literature review will focus on what has been proved about spatial and physical characteristics of the built environment in relation to human behaviour, specifically focusing on crime in public spaces.

2.1. Foreword

Prior to looking into the literature review, it is important to take a step back for a reflection. Donna Haraway suggests in her theory of situated knowledge that the so-called scientific "objective" construction of knowledge has been, in fact, the knowledge that represented the perspective of the white male, without assuming this perspective as a partial one. Rather, this perspective has been repeatedly declared as a 'universal' perspective that would be valid for everyone. According to this point of view, feminine approaches to scientific knowledge are seen as 'partial' approaches, because women belong to a sub-group of the world population. What the situated knowledge theory suggests is that, in order to claim (and reach) objectivity, both approaches (feminine and previously called 'universal' or 'objective' approaches) should

[5] For the sake of argument, let us assume it would be possible for people to separate by gender everywhere from their doorsteps out.

[6] May the reader keep in mind that the sole focus of this research is on violence that happens in public spaces.

assume their situated, partial views of the world. In other words, they should declare themselves as views that are associated to a subject who authors them: be it men or women, in this example (Haraway, 1988). Different points of view are equally valid and important, but they must clearly specify which perspective they represent[7]. This reflection can be applied to the understanding of the city: of how each group and sub-group of citizens may view the city in a different and yet objective way, according to how he/she experiences the city.

2.2. Women, gender and sexual violence

According to the Oxford dictionary, woman is *"1. An adult human female. 1.1 [with modifier] A female person associated with a particular place, activity, or occupation. 1.2 A peremptory form of address to a woman. 1.3 A female worker or employee. 1.4 A female who is paid to clean someone's house and carry out other domestic duties. 1.5 A man's wife, girlfriend, or lover."*[8] The last two definitions show how the female gender is a social construction, embedded in time and space, and not only an innate set of characteristics genetically determined, as the sex of a person is. In this study, focus will be given to the female gender identity, regardless of biological sex: this means anybody who identifies themselves as a woman, whether or not this matches their anatomy. This gender identity is considered to be the base for understanding sexual violence on city streets.

As a localized example of the social construction mentioned, a brief overview of female roles in The Netherlands in the 1900's might make this concept more palpable: in 1924, a law was passed to prohibit women to work in the civil service[9]. Society expected them to take care of the children and husband at home. In 1947, 98% of married Dutch women between the ages of 15 and 64 were full-time housewives.

In 2006, Dutch women outnumbered the number of male students in university for the first time ever[10]. According to Afaina de Jong (2017), architecture schools start with a balance of 50/50 men to women ratio, and around 40% of graduates are women. In the job market, however, this number drops: according to the Dutch Bureau Architectenregister report of 2015, women represent only 22% of the registered architects and 32% of the registered urban planners in the Netherlands (Architectenregister, 2015). From this perspective (of men being the majority of architects and planners), it may not come as a surprise that cities do not exhibit a gender-friendly built environment. The Rijksarchief voor Nederlandse Architectuur en Stedenbouw, the largest Architecture collection in the world, has around 650 authors archives of the most important Dutch architects and urban planners of the past 130 years, but only 15 of those are women, or 2% of the total (Feminismen in de Architectuur. 2017).

The right to the city is exercised every day, in every activity a person engages in. To access such activities, people largely need to move across the city by any means they chose or have available to them. Commuting research (Rapino and Cooke, 2011) shows women's mobility in the city to be very different from that of men. Gender roles traditionally associated with women, such as taking care of kids, running errands and keeping house provision, have an impact in the way they move in the city: women walk more and use public transportation more than men do. They also do more trip-chaining (such as dropping the kids at school on the way to work,

[7] For example, this is a research made from a white woman's perspective.

[8] https://en.oxforddictionaries.com/definition/woman accessed in 15/April/2017

[9] it was abolished in 1956

[10] Source: Vrouwen van Rotterdam exposition from the Museum Rotterdam. Visited in April/2017

or stopping for groceries on the way home) then men, who usually go from home to work and back, directly. In Rotterdam, such conclusions can also be seen in the 2004-2015 report of displacements in Rotterdam - The Hague Metropolitan region and the Netherlands (*Verplaatsingen in de metropoolregio Rotterdam Den Haag en Nederland*): men do more trips to work and leisure than women, while women have higher proportion of trips for shopping purposes. Men also do more trips driving a car (31%) than women (16%). Women do more trips by public transportation (28%), bike (19%) and as a car passenger (15%) (p. 70), as can be seen in Table 1.

Table 1: Modal share per gender in Rotterdam 2010-2015. Source: *Verplaatsingen in de metropoolregio Rotterdam Den Haag en Nederland 2004-2015*, p. 70

Rotterdam modal share	Men	Women
Driving car	31%	16%
Car passenger	7%	15%
Public transportation	22%	28%
Bike	17%	19%

However, transportation and city planning as a whole have not been attentive of such differing needs. In 2014, a survey with over 400 planners in the USA indicated that, even though 94% of respondents' communities had a comprehensive plan, only 2% of these consider the needs of women, whereas 55% are concerned with specific needs of the aging population (Kancilia and Warner, 2015, p.6). Nevertheless, communities better suited for women's needs would be better suited for all, the authors conclude.

Walking is a common factor in the majority of city trips: whether it is from origin to destination, from the job to where the bicycle or car is parked, or to and from the public transit stop. Walking is the first, cheapest and most basic way for the human being to move and experience the city. It is also one of the modes of transportation that leaves an individual more vulnerable to approaches in public spaces.

Women's perception of safety is deeply affected by their lack of control over who they interact with: "unlike men, women find that when in public space their personal space is frequently invaded by whistles, comments or actual physical assault from strange men" (Valentine, G. 1989, p. 386). Adding to this, Cintia Bowman (1993) proposed the "open category" theory to explain how men often seem to feel entitled to impose interaction with unknown women in the street[11]. She observes that men invade women's privacy in the public sphere to reinforce that women (unlike men) belong to the private sphere. In Rotterdam, Fischer and Sprado found that 50% of women attributed street sexual harassment to a desire by men to exercise power (2017).

Tamar Fisher and Natascha Sprado conducted a research on street sexual harassment with 1200 women aged 18 to 45 which showed that, over a period of one year, 84% had experienced sexual harassment in the form of men whistling at them, shouting, insulting, asking for sex, following or cornering them in public spaces. Results revealed that 44% of respondents felt irritated, insulted, threatened, or limited in their sense of personal freedom by such undesired approaches. They explained that reporting sexual harassment took too much time and energy and produced too little result (Fischer and Sprado, 2017). A research in Brazil showed that 81% of women respondents said they had given up going somewhere, passing by construction work, going out by foot, or something else, out of fear of harassment, and 90% of respondents admitted to have changed clothes thinking about the place where they were going, because they

[11] It is an analogy with how people tend to feel comfortable to approach unknown people on the street who are accompanied by "someone or something in an 'open' category, such as dogs or children" (Bowman, 1993, p. 526).

were afraid of being harassed. Finally, 73% said they do not respond to street harassment, the majority of which because of fear (Hueck, K., 2013).

Fear of crime, for women, is mostly a fear of men (Stanko, 1995). A reason for this is that "the behaviour of any stranger encountered is potentially unpredictable and uncontrollable" in the public space (Valentine, 1989, p. 386). Interestingly, Valentine's research suggests that women perceive only men as 'strangers' in the public space. What some authors call 'paradox' lies on the fact that women's greatest fear of sexual assault derives from strangers in the public space, even though data reports show that victimization is much higher at home with partners or other acquaintances (European Union Agency for Fundamental Rights, 2014). The fear of public spaces is partly due to government's policies advising women to avoid places and times perceived as more 'dangerous', and also due to societal tendency to place on victims the blame for being in 'the wrong place at the wrong time' or for wearing 'inappropriate clothes' when they were attacked (Stanko, 1995, Valentine, 1989). Such institutional and social behaviour has long placed on women responsibility to avoid such attacks, rather than focusing on building societies and cities less favourable to such crime.

Ferraro (1996, p. 686) suggests that "whenever face-to-face confrontation is likely, most women fear rape", which is known as the *shadow of sexual assault* theory (Fisher and Sloan III, 2003). This fear results of the imagined horror of a sexual assault (regardless of personal experiences) and likely results of the stigmatizing character of this crime, he concludes. This theory is an important step in the acknowledgement of the meaning of safety for women in cities.

2.3. Sexual violence in public spaces

Gender and city access studies explored in the previous section explain sexual harassment as a demonstration of the power of men, and a reminder of ownership of public spaces displayed by men towards women.

Sexual violence is defined by the World Health Organization as "any sexual act, attempt to obtain a sexual act, unwanted sexual comments or advances, […] or otherwise directed against a person's sexuality using coercion, by any person regardless of their relationship to the victim, in any setting including but not limited to home and work." (World Health Organization, 2010, p. 102). This definition clearly includes sexual harassment ("unwanted sexual comments or advances") as 'sexual violence', but it does not provide a complete definition of sexual harassment. Based on Bowman (1993, p. 524), this work adopts the definition by which sexual harassment occurs when strange man/men address one or more women in a public space and, "through looks, words, or gestures the man asserts his right to intrude on the woman's attention, defining her as a sexual object, and forcing her to interact with him." The importance of addressing at the same time sexual harassment and violence is because harassment is seen by women as a reminder and a threat of their vulnerability to sexual violence. This is evidenced by the common pattern of escalation of street harassment previously described in the literature "in which the target's failure to respond [to a man's approach] results in escalation and a superficially friendly interaction is transformed into one that is transparently hostile" (Bowman, 1993, p. 525). The definition adopted in this work for sexual violence is thus presented in Figure 1.

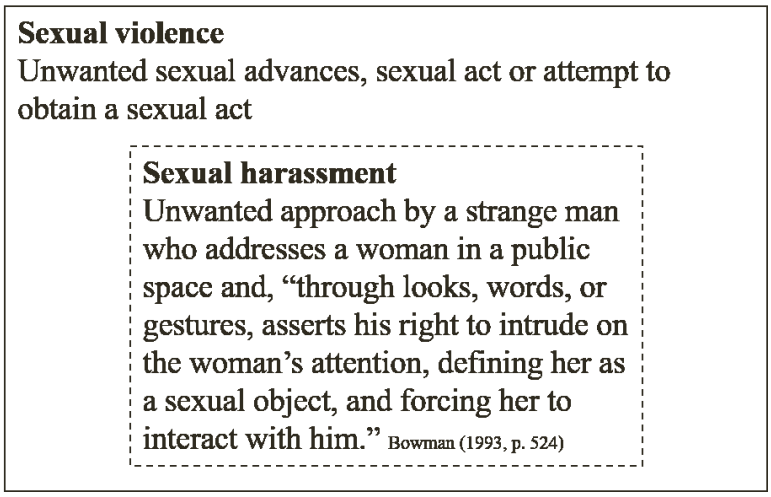


Figure 1: Working concept of sexual violence

2.3.1. Why does it happen?

While no significant studies were found explaining why most serious cases of sexual violence in the public space happen, there are studies that examined the motivations behind sexual harassment in streets, which are presented hereafter.

Back in 1984, Benard and Schlaffer asked men who were harassing women in the street why they did that. Most of them answered it was a result of boredom and of a "feeling of youthful camaraderie" they felt when discussing women with other men, while only 15% admitted doing so "to anger or humiliate their victims" (p. 397). The latter also employed graphic sexual commentary and threats. For some migrants and construction workers, insults were mostly aimed at the privileged class that women symbolized to them. A minority of men reported believing that women enjoyed such attention. Overall, most men were surprised by the idea that not only women disliked the attention but also felt limited in their sense of freedom in the public space. The interviewed men reported having never given it any thought. Fischer and Sprado report similar findings from the literature: that perpetrators of sexual harassment report to find it 'fun', not harmful, that they did not think it could be demeaning, that it could limit women's freedom nor that women might not like it (Fischer and Sprado, 2017).

Benard and Schlaffer found that 20% of men only engaged in such behaviour when accompanied by other male friends, while Fischer and Sprado's research in Rotterdam showed that 47% of women were often or always harassed by perpetrators who were in a group. The authors cite Hakkert & Smulders, 1998, emphasizing that being in a group provides anonymity and a diminished sense of individual responsibility to the street sexual harassers, reducing their fear of personal consequences (Fischer and Sprado, 2017).

When analysing perpetrator's lifestyles, the authors found that young people involved in street sexual harassment usually have little reason to stay at home, know little structural leisure, and likely have no responsibilities, resulting in boredom and a lot of time spent in the streets, providing opportunities for harassing behaviour.

Benard and Shlaffer were surprised to find that harassment diminished during the night. The conclusion was that, at such times, women would be more than just bothered or irritated with the approach, but outright alarmed, so the possibility was much higher that she would "have an 'extreme' response (such as calling for help) that the good [male] citizen would not like to have to explain". The same 'good citizen' did not run such risk during the day.

The occurrence of sexual harassment did not significantly vary with factors like country of origin, whether the women were completely covered (in Egypt) or less so (in Rome or Vienna),

nor with the education, income or age of the men (Benard and Schlaffer, 1984). The only exempt areas were villages where everybody knows each other and residential suburban areas, the authors concluded. The study from Rotterdam, on the other hand, showed different results: that sexual harassment is more common in places with a culture of entertainment in the streets and in late night shopping in the city centre. However, the scariest forms happened in residential areas or on women's way to residential areas. Finally, the Dutch research showed that large social distance (language, age, education and ethnicity) between victim and perpetrator was one of the factors that made the experience more intimidating. An unkempt appearance of the perpetrator or the fact that it was a group of harassers were other aggravating factors.

Drawve et al (2016) provide a good review of theories to explain crime in general. They focus on 5 theories of why/where crimes happen. The first is the *Social disorganization* theory, that focuses on neighbourhood level social indicators: racial and cultural heterogeneity, residential instability and poverty. The *Systemic model* developed from Social disorganization theory goes further in explaining how the residential instability prevents the formation of strong social bonds in the neighbourhood. Next, the *Routine activities* theory is based on the idea that the more an individual moves across space, the more opportunities a criminal has to victimize him/her. Crime is thus the result of "an increase in the relative prevalence of individuals motivated to offend in conjunction with an increase in potential victims who lack capable guardianship", which "is likely to result in more criminal opportunities that are acted upon". (p. 22).

Fourth, the *Crime Generators and Attractors* theory (CGA) is also grounded on the idea that more opportunities for crime will result in higher victimization, but it goes beyond to explain that some land uses are more attractive to offenders. Lands uses where victims are less capable of defending themselves, (such as after drinking too much alcohol) or have more money on them (such as banks or pawn shops). Finally, the *Risky places* theory supports that risk is variable across space, that vulnerability is greater where risk is greater (where more than one criminogenic feature overlap), and that the "effect risky places have on crime is a function of variation in both vulnerability and exposure across the physical landscape" (Drawve, Thomas, et al., 2016, p. 23).

The extent to which sexual violence corresponds to a crime depends on the laws of each country: "rape is a crime in all EU Member States although there are differences in the definition of what constitutes rape" (European Union Agency for Fundamental Rights, 2014, p. 11). In the Netherlands, sexual violence can be identified as a crime of sexual assault (aanranding), when someone through violence or through another act of threat of violence or other acts compels another to commit or tolerate indecent acts. Or it can be a crime of rape (verkrachting), when it also involves penetration of the body. By law, street sexual harassment is not a crime. It is seen as 'too subjective'. Nevertheless, fines, penalties and facilitated reporting are seen by politicians as a possible way of reducing cases, even if it has a more symbolic value. Moreover, awareness and improved education are seen by politicians, victims and experts as more promising solutions.

On the matter of what generates sexual violence, moral values and experiences (such as childhood physical or sexual abuse) are argued to be at the root of sexual violence in both private and public spaces (Jespersen, Lalumière, et al., 2009). The focus on public spaces in this work is due to its being the setting for most sexual harassment and violence perpetrated by

strangers[12]. Thus, 'better' public spaces could be argued to inhibit the occurrence of such violence (if only it was known what it means for the space to be 'better'). The public space is also the realm undeniably under government's responsibility, as this is a matter of public safety (Sweet and Ortiz Escalante, 2010). Figure 2 shows a simplified model of how a set of moral values and experiences may produce individuals who are predisposed to sexual violence or not. The encounter of such predisposed individuals with conducive ("favourable") conditions to sexual violence may then lead to the occurrence of crimes.

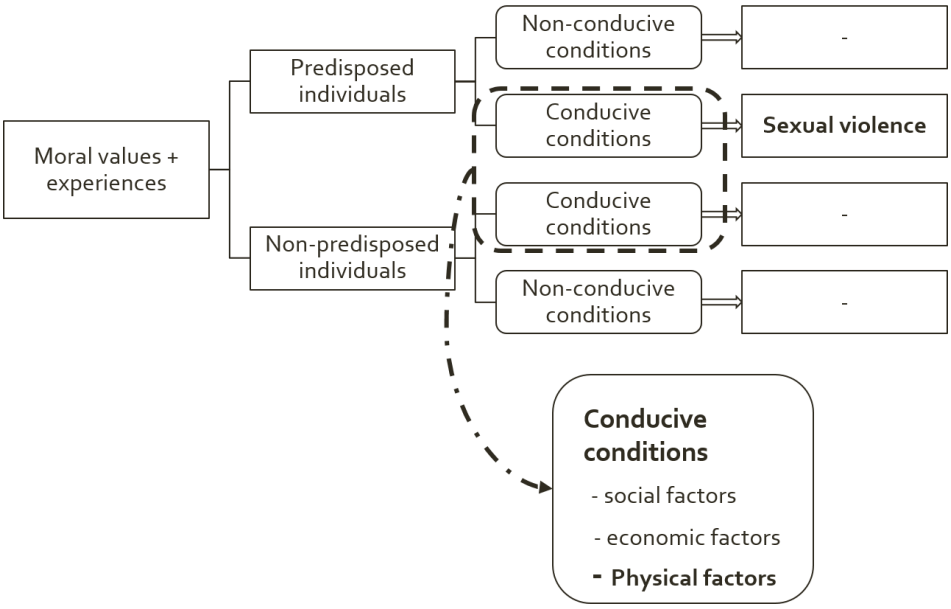


Figure 2: Conceptual framework for sexual violence in public spaces

It remains, therefore, to study what these physical factors or spatial features are, which will be explored in the following section.

2.4. Spatial features of the urban built environment

To delineate what is meant with 'urban spatial features of the built environment', some definitions are brought forward:

- "Urban = (1) of, relating to, or located in a city" (Garner, 2016);
- "Urban space is mostly linear. It consists mostly in streets, roads, boulevards, highways" (Van Nes, 2007, p. 35);
- "Built environment is a physical environment designed, built, and maintained by people" (Castree, Rogers, et al., 2013).

Therefore, 'spatial features of the urban built environment' refer to the characteristics of the space between buildings and to the location of buildings, their doors and windows, in relation to the street. It also includes the positioning of the street in relation to the greater city network.

Cities are the stage for the largest part of human face-to-face interaction. As much as people shape cities, cities also shape people's behaviours and interactions (Van Nes, 2007, Van Nes and De Rooij, 2015, Montgomery, 2015). Although Jane Jacobs eloquently described her

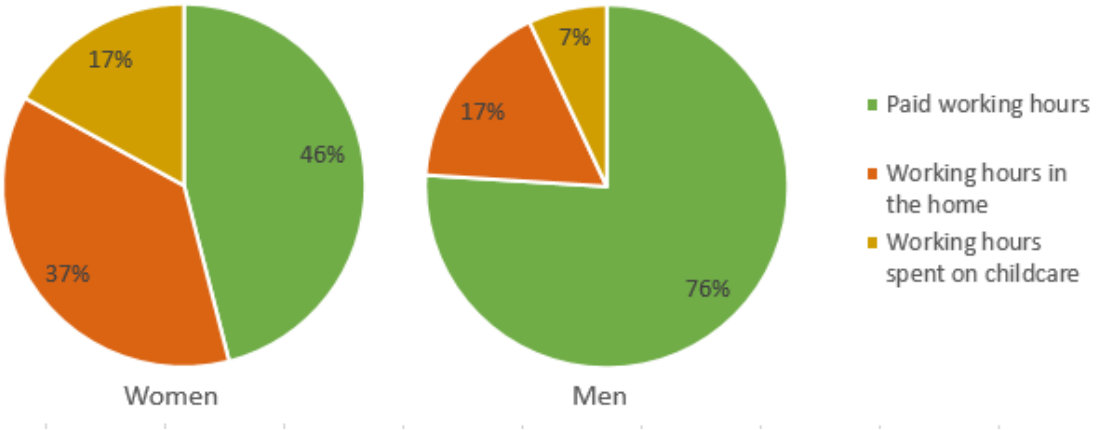
[12] On the other hand, cases perpetrated by (ex) partners, family members and acquaintances, happen mostly in private spaces (European Union Agency for Fundamental Rights, 2014).

observations of life in the city and its relation to the physical environment, she did not present a scientific research *per se*. Scholars throughout the decades have been working to test both Jacobs's and Newman's diverging theories. There is, nevertheless, still a long way to go due to the intricacy of the issue: human behaviour is extremely complex, and explaining it depends on the understanding of multiple areas of knowledge. While urban physical configuration might not be the only, nor the most important one, it is still a significant part of why people behave differently in different places.

Based on literature review, Boomsma and Steg (2014) concluded that the most important physical space factors for the perception of safety are lighting, effect of entrapment (blocked escape) and concealment, besides gender. To control over other variables, the authors studied these factors in a virtual environment. They found that women felt more afraid than men did in the same settings, and that people felt less safe in situations with lower lighting and higher entrapment. Other studies have registered experiences with physical modifications of space to increase its safety. Beebeejaun (2009) terms them 'technical fixes' (as opposed to social ones) that have focused on improving visibility in landscaping, lighting and the implementation of Closed Circuit TV (CCTV). Although these are important, she highlights the insufficient gender understanding (by professionals involved in these urban regeneration programs) as an obstacle to better results of the interventions. In her opinion, technical fixes must "challenge gender relations, rather than perpetuate them" (Beebeejaun, 2009, p. 226). Lastly, she draws attention to the fact that CCTV is not fit to monitor verbal and other less explicit forms of sexual violence.

According to Beebeejaun, "urban planning's contribution to livable safe cities has not been innocent in reinforcing gender divisions" (2009, p. 220). Based on observations of the different uses each gender makes of urban public spaces, Vienna and other cities have adopted gender-sensitive planning, also known as gender mainstreaming. According to the Gender Mainstreaming in Urban Planning and Urban Development manual by the city of Vienna (Damyanovic, Reinwald, et al., 2013), this concept refers to planning with a focus on gender differences and specificities, as a way to guarantee quality of the planning process, and it is relevant and effective in all planning levels and phases. It aims at creating spaces that support users of all ages, genders and backgrounds, since their life condition, and thus needs, might differ regarding mobility situation, place of work and time budget, among other aspects. In other words, "gender mainstreaming aims to change the frameworks and structures that create inequalities" (Damyanovic, Reinwald, et al., 2013, p. 17)[13]. Graph 1 presents an example of how daily routines can be different across genders in Austria, relative to gender roles in family and society.

[13] Vienna's gender mainstreaming manual also mentions that this approach has been included in the European context through the Treaty of Amsterdam of 1997, which took effect in 1999 (Damyanovic, Reinwald, et al., 2013).



Graph 1: Differences in women's and men's paid and unpaid work share. Source: Women's Department of the City of Vienna, 2005, p. 88, own graph.

In order to understand the built environment and its relationship with human behaviour, scholars need tools to measure the spatial characteristics of a city or neighbourhood. Objective measures make it possible to assign attributes and numeric values to streets, thus enabling the comparison of streets with one another, within and across cities. Additionally, it facilitates the comparison of streets' assigned values of certain parameters with socioeconomic data, such as crime, pedestrian flows, and other phenomena associated with geographic locations. Such comparisons and correlations are the basis that support the creation or confirmation of theories about the interrelationship between the built environment and (anti-)social behaviours in the city.

Space Syntax is a family of tools that allow researchers to measure physical space objectively. The robustness of this method lies on its independency of context, since it does not depend on culture, society or political structures (van Nes, 2008). Space Syntax consists of three sets of tools: metric, topological and geometric measures. With these, it enables the identification of a city's main streets for pedestrians, main streets for cars and economic centres, all through spatial analysis alone (Van Nes, 2007). Although it is still being tested in research, the results have been shown to correlate well with reality, with exceptions in places with strong political forces (such as communism) or a planning system that influence the way in which people would naturally occupy and use space (Hillier, Turner, et al., , 2007).

Through these sets of tools, Space Syntax allows scholars to create theories about how urban space networks in general relate to the social, economic and cognitive factors, which shape urban networks and are affected by them. This is done through the measure of accessibility (to-movement) of a street segment, and measure of through-movement (people who have origin and destination elsewhere and are passing by). Both are measures of potential movement, but they can be expected to show a 60% to 80% correlation with observed movement in the streets (Hillier and Sahbaz, 2008).

Highlighting some conclusions of space networks' studies, it was found that highly locally integrated streets can attract or support economic activity and pedestrians, in what is known as the *theory of natural movement* (Hillier, Penn, et al., 1993). In other words, shops attract pedestrians, while pedestrian flows also attract more shops to a street, in a mutually reinforcing process. This theory shows that shops (also called 'movement attractors') and the movement of pedestrians influence each other, but they do not influence the street grid. In contrast, the street grid seems to influence both movement and the location of attractors, as shown in Figure 3.

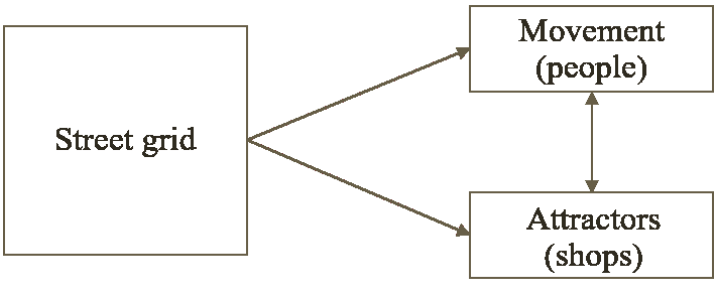


Figure 3: Theory of natural movement. Source: the author, based on (Hillier, Penn, et al., 1993, Van Nes, 2007).

High local integration means that the street is metrically accessible (is in close reach), and is in a topologically shallow area (few direction changes are necessary to reach it from a number of different origins) in a local scale (neighbourhood scale, as opposed to the city scale). In other words, local integration points to vital local centres. *High global integration*, on the other hand, refers to a street's integration on the city scale. It was found to be associated with stores clustered in shopping centres (as opposed to linearly spread along a shopping street), and high traffic flows (Van Nes, 2007).

Comparing space syntax results with street functions, Van Nes and De Rooij (2015) found that, although commercial functions usually locate on better connected streets, the opposite is not necessarily truth: not all well connected streets have functions. Van Nes and Aghabeik (2015) propose that the lack of visibility (of doors and windows to the street and to each other) can be an explanation for this: in their study, they found that wide streets with low visibility were also poor in functions, despite being well connected.

On the realm of criminality, macro scale studies show the impact of the street network on the geographic and temporal distribution of crime (Hillier and Sahbaz, 2008). Studies concluded that different types of crime require different types of space: while pickpocketing typically happens in busy streets with high pedestrian flows, burglary happens mostly in locally segregated streets, with low levels of pedestrian flow and, thus, low natural surveillance (López and Nes, 2007, Hillier and Sahbaz, 2008, Adel, Salheen, et al., 2016).

Another line of research explores the use of Space Syntax for analysis in the urban micro scale. This is the scale of the street, which can be analysed through a number of indicators:

- the density of entrances;
- the degree of constitutedness of the street: whether houses and buildings have their entrance in the street (constituting the street) or on the side or back façade (not constituting the street);
- how inter-visible entrances are: whether neighbours can naturally see each other's Figure 1houses' entrances, based on the spatial configuration of the built environment;
- how topologically deep entrances are: whether the house door is in the street (topologically shallow entrance), guarded by a small garden, on the side façade after a garden, or on the fifth floor, after a hallway, an elevator and a ground hallway (topologically deep entrance), for example. The higher the number of 'steps' (direction changes) between the public and private space, the higher the topological depth.

López and Nes (2007) showed that these micro scale spatial characteristics impact on urban street life and safety, as Jane Jacobs predicted. When micro scale attributes were compared with crime occurrence data, burglary was mostly associated with unconstituted streets (without entrances directly in the street), with low inter-visibility from neighbours, with high topological depth both in relation to the street (far from neighbours' and pedestrians' sight) and to the city

(far from main streets). They concluded that the micro scale factors are interrelated to the macro scale ones.

Another study confirmed that neighbourhoods with poor connection between buildings and streets (low degree of inter-visibility of entrances) and with low spatial integration generate social segregation among ethnicities, gender and age of users (Van Nes and Aghabeik, 2015). It also found that women were more frequently seen walking in vibrant, integrated streets, and very rarely in the most segregated streets. The latter was only used by men. Van Nes and De Rooij (2015) added to this that vibrant streets were perceived to be safer, and that the street network and micro scale relationship between streets and buildings played a role in making such streets lively. As expected, the opposite was also true: neighbourhoods that lacked the street connection and inter-visibility made people feel unsafe in the streets.

Van Nes and De Rooij (2015) developed a method of urban analysis for consolidated areas based on the use of layers proposed by Heeling (2002). The revised layers, presented in Figure 4: The four layers of urban analysis proposed by Van Nes and de Rooij (2015) based on Heeling (2002). Source: Van Nes and de Rooij (2015), are:

1. Spatial structure: how streets are connected to each other (analysed through Space Syntax);
2. Relation between public space (the streets) and private space (the buildings): measured through the density of entrances and the inter-visibility between doors and windows on the ground floor;
3. Program: the function of each building (residential, commercial, etc.);
4. Use: how people use the space between buildings and who are these people (men, women);

The first layer provides information on the expected use of streets, identifying to-movement (routes more locally accessible), with angular analysis with low metrical radius, and through-movement, with angular analysis with high metrical radius. The authors cite Van Nes and Stolk (2012) in saying that the most vital local shopping centres are found where to-movement and through-movement routes coincide. The underlying idea is that through-travellers mostly take the simplest (even if a bit longer) paths, while locals usually make more direction changes to take the shortest path. Consequently, the spatial layout largely determines which streets will have larger flows of people and traffic, which in turn influences the location of shops (Van Nes and De Rooij, 2015, Hillier et al 1998).

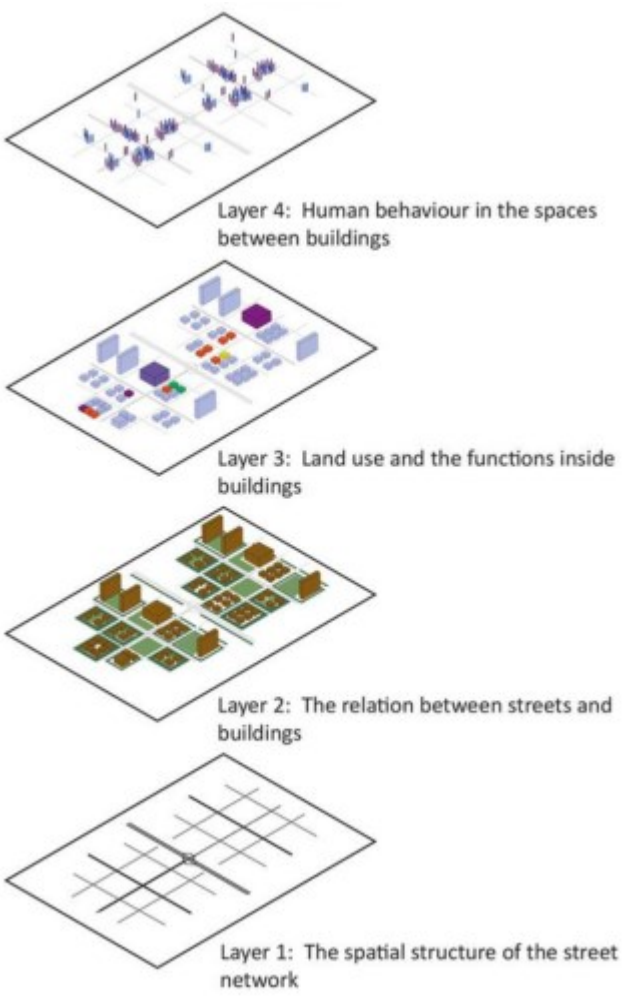


Figure 4: The four layers of urban analysis proposed by Van Nes and de Rooij (2015) based on Heeling (2002). Source: Van Nes and de Rooij (2015)

The second layer offers an insight on the social control, eyes on the streets and to the streets. The higher the density of entrances and the inter-visibility of doors and windows to the street, the higher the perception of safety, resulting in more people using the street and consequent higher social control (Van Nes and De Rooij, 2015).

The third layer adds the land use. Mixed land uses were said by Jane Jacobs to be necessary to create vital urban spaces, because different uses generate flows of people in the streets at different times of the day. Conversely, mixed uses have also been associated with higher incidence of street robbery when the share of residences is low (Hillier and Sahbaz, 2008).

Finally, the fourth layer provides an estimation of the real use people make of the streets. It is an estimation because it is based on static snapshots: various counts throughout the day of how many people are in the street, which can include performed activity (walking, standing, sitting, playing), gender and age (child, youngster, adult, elderly). The combination of the various snapshots offer an indication of which streets have higher and lower flows of people, and if different people use streets differently.

In a rare mention to sexual violence and public space in literature, a study about crime in relation to urban design found a "positive and significant correlation between person crimes and the percentage of informal districts' housing due to the increase of rape incidents within those areas" (Adel, Salheen, et al., 2016, p. 935). This study, however, does not explores the relationship between sexual violence and space further.

The relationship between concepts explored in this chapter can be visualized in the conceptual framework proposed in Figure 5: in the search for the city's opportunities, women are exposed to the risk of sexual violence victimization, which, in turn, depends on a set of factors, namely spatial, social and economic.

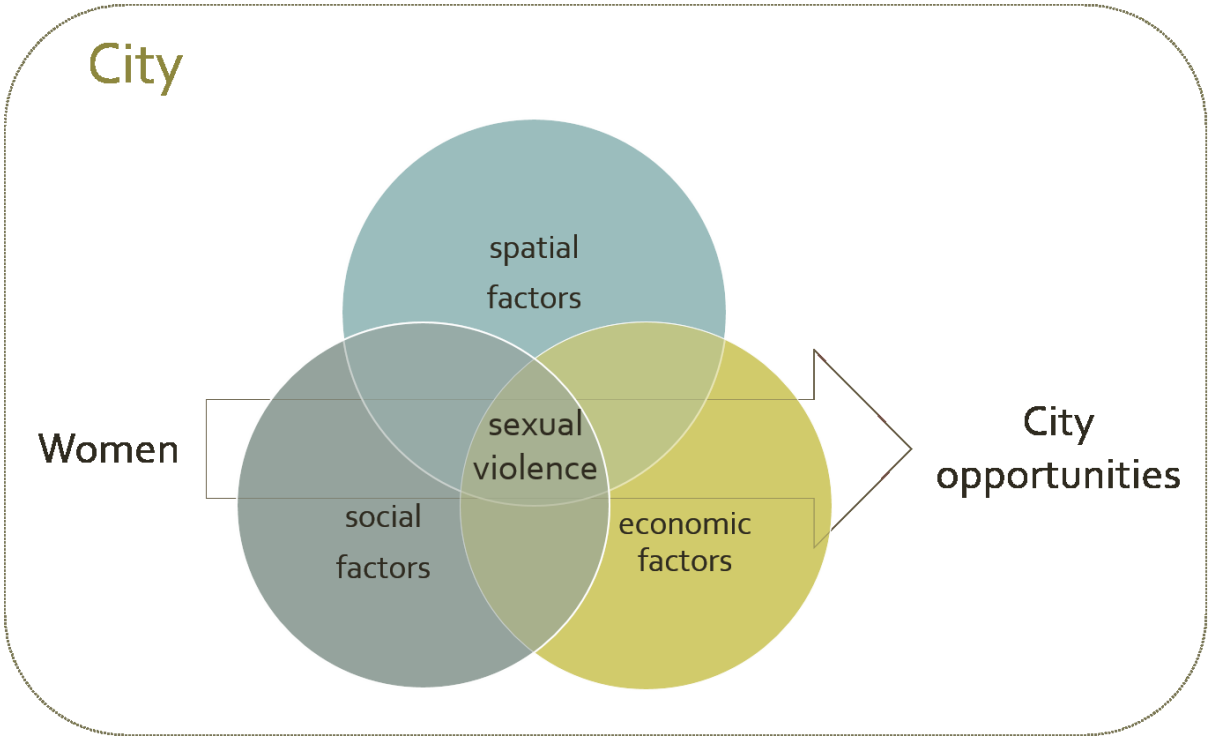


Figure 5: Conceptual framework

The literature review presented in this chapter shows two facets: firstly, strong indication that there is indeed a relationship between urban spatial features of the built environment and sexual violence. Secondly, the need for further research in this area, due to the lack of systematic knowledge on the relationship between urban spatial features of the built environment and sexual violence victimization. The search for municipality data on sexual violence suffered by women in public streets in Rotterdam showed that, although the police possesses records on sexual violence divided by gender, location (public or private spaces) and type of sexual crime (indecent exposure, sexual assault, rape, other sex crimes, etc.), the municipality does not seem to use such information in its planning process. The aim of the present study is to improve understanding of the relationship between spatial features of the built environment and women's safety against sexual violence in the streets of Rotterdam, to enable policy recommendations for cities that aim to be safer for women and, consequently, for everyone.

Chapter 3: Research Design and Methods

To answer the question of which scenario is more likely to provide safety for women (the Newman-inspired, or the Jacobs-inspired scenario), and to reach the objective of this research of explaining the relationship between built environment's spatial features and gender-based sexual violence in public streets, it is necessary to compare data on gender-based sexual violence in public streets and the micro and macro spatial features of those streets.

As shown in Chapter 1, the research is structured into the following question and sub-questions:

What is the relationship between spatial features of the built environment and women's safety to sexual violence in the streets of Rotterdam?

Sub-questions

1) How is gender-based sexual violence spatially distributed in Rotterdam's neighbourhoods?
2) What are the socioeconomic characteristics of the neighbourhoods with highest incidence of sexual violence?
3) How can the four chosen neighbourhoods be described according to the spatial features of the built environment?
4) What is the relationship between the spatial distribution of gender-based sexual violence and spatial features of neighbourhoods?
5) What are the spatial features of streets where sexual harassment takes place?

3.1. Operationalization

Table 2 shows the operationalization of the concepts included in the research questions and defined in the theoretical review. It includes indicators, source of the information and scale of measurement for each variable.

Table 2: Operationalization

Concepts	Variables	Indicators	Scale of measurement	Source
Gender-based sexual violence	Police reports	Distribution in space of reported cases of sexual violence against women in public spaces	Number of reported crimes against women in public spaces per street per year	Rotterdam Police
		Sexual violence in a neighbourhood/street	% of women in a neighbourhood who reported to have been victim of sexual violence	
		Distribution of occurrences in time (daytime/night time)	% of women in a neighbourhood who reported to have been victims of sexual violence per time of the day	
	Self-reported victimization	Sexual harassment in own neighbourhood	% of women who reported to have been victims of sexual harassment in their own neighbourhood	Fischer and Sprado (2017)
		Neighbourhoods with sexual harassment	% of women who indicated a neighbourhood in the top 3 where they experienced most sexual harassment in recent years	
Spatial features of the built environment	Micro scale	Amount of people in the streets	Number of women, men and young men per street block per time of the day	Own data collection & Van Nes and De Rooij (2015)
		Density of entrances	Number of entrances per street length	
		Constituted streets	Degree to which streets are constituted by entrances (none, low, medium, high)	
		Inter-visibility of doors and windows in the ground floor (plinth)	Degree of inter-visible doors and windows on each street (none, low, medium, high)	
		Function	Main function of the ground floor of street's buildings	
	Macro scale	Metrical analysis	Local and global integration (Space syntax street network configuration	Own analysis
		Angular analysis	Local and global analysis (Space syntax)	
Socioeconomic characteristics	Social characteristics	Social network	% Neighbours who know each other	Roterdam Wijkprofiel (2014, 2016)
		Social integration	Residents who say having trouble reading Dutch	
		Education	% School drop-outs (18 to 22 years old) without starting qualification	
	Economic characteristics	Economic situation	Income	
			% Residents with low household income	
			% Households with high income	

3.2. Research strategy

Considering the explanatory purpose of the research's main question, the research strategy is based on the use of primary quantitative data collection, to be analysed in conjunction with secondary data. The urban analysis method proposed by Van Nes and de Rooij (2015) will be used for the investigation of the spatial features of the built environment. The following sources of information will be used for an analysis of sexual violence and socioeconomic conditions in the city:

- Rotterdam's police department's records of sexual violence against women provides data of reported sexual violence in each street of each neighbourhood of the city;
- The report about street sexual harassment in Rotterdam, which shows neighbourhoods that have been most appointed by women as one of the top 3 where they have suffered more street sexual harassment in the previous year, and also which of the respondents'

own neighbourhoods are reported by more women as places where they have been harassed[14];

- Socioeconomic data on neighbourhoods from the Wijkprofiel.

These analyses of secondary data will provide an overview of the socioeconomic and sexual crime distribution in the city, as well as the answer for sub-questions 1) and 2). It will show the background against which the spatial features of streets may or may not have further influence on the occurrence of sexual violence in the streets. This investigation is important because socioeconomic conditions may overrule spatial characteristics of the environment in the explanation of crime (López and van Nes, 2007).

The analysis of Police records and the report on sexual harassment in Rotterdam provides triangulation of data for sub-question one, since the first has primary data about sexual violence, and the second has quantitative and also qualitative research on the complementary topic of sexual harassment in public spaces.

Rotterdam has approximately 635.000 inhabitants[15], 71 neighbourhoods grouped in 14 districts. Four neighbourhoods have been selected for the following step: the data collection of micro spatial characteristics on the relationship between public and private spaces. The choice of four objects of analysis is aligned with the human resources and time constraints of this research. At the same time, it is a large enough sample to allow for the study of different spatial functions and architectural types.

The neighbourhoods were chosen with the aim of providing a comprehensive view of residential neighbourhoods as well as of centralities, both from post-war and pre-war construction periods[16], as shown in Table 3. They also represent the North (Centre and Nieuwe Westen) and South (Hillesluis and Pendrecht) areas of Rotterdam, and four different districts: Stadscentrum (the city center – Cool), Delfshaven (Nieuwe Westen), Charlois (Pendrecht) and Feijenoord (Hillesluis). Figures 6 and 7 show the chosen neighbourhoods, Rotterdam's central districts and neighbourhoods.

Table 3: The chosen neighbourhoods

Type of neighbourhood	Construction period	
	Pre-war	**Post war**
Centre	Hillesluis	Centre
Residential	Nieuwe Westen	Pendrecht

[14] The first category indicates where there are more women in the streets, because of the opportunities to work, go shopping, etc., while the second indicates areas where the problem is more common for residents themselves;

[15] Statline, June, 2017. Accessed in August, 2017. Available at: http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=37230ned&D1=0,17&D2=443&D3=182-193,195-200&VW=T

[16] which are associated with more car-centred or people-centred construction visions, respectively.

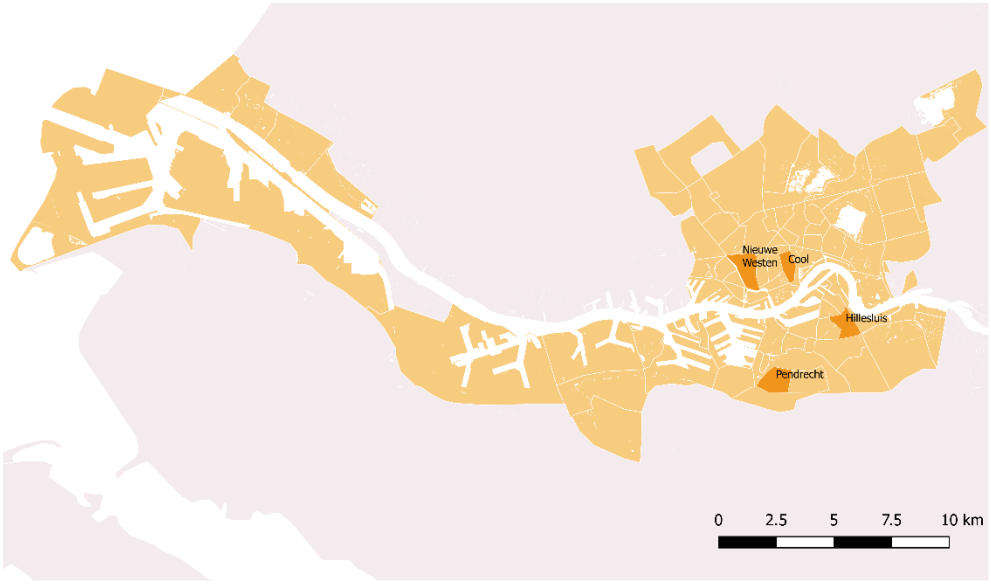


Figure 6: Location of the chosen neighbourhoods

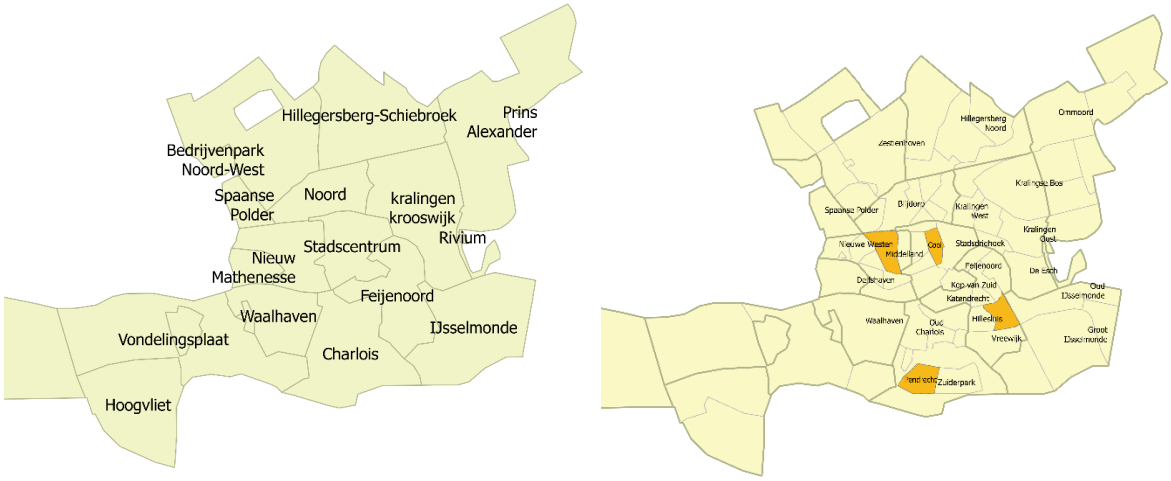


Figure 7: Rotterdam's central districts and neighbourhoods

In these areas, information about the spatial characteristics of the neighbourhoods has been collected following the urban analysis method's layers of Van Nes and De Rooij (2015) with slight alterations. The layers in this study are: the spatial structure (axial and angular analysis of Rotterdam's street network through Space Syntax analysis), the relation between streets and buildings (constitutedness, density of entrances and inter-visibility of doors and windows), functions of buildings (residential, commercial or mixed – usually buildings with commercial use on the ground floor and residences on the upper floors) and human use of spaces between buildings (static snapshots differentiating between men, women and groups of men potentially threatening). Here, the amount of people in the streets has an additional purpose: to allow the calculation of the risk of victimization, which results from the division of the numbers of reported cases of sexual violence per street by the number of women in the respective streets.

The figures of Hillesluis, Pendrecht and Nieuwe Westen had been previously collected by Van Nes and De Rooij (2015)(Van Nes and De Rooij, 2015)(Van Nes and De Rooij, 2015), while the present study involves the collection of primary data in the city centre (Cool) and the preparation of a single database with the information of the four neighbourhoods. The four areas combined result in 708 street segments (blocks), 247 streets and about 84.8 kilometres of streets.

Finally, the data results from the spatial data gathering were compared in order to answer the research question about the relationship between spatial features of the built environment and sexual violence.

3.3. Data collection methods

This research uses secondary and primary data. The secondary data was obtained from Rotterdam's police (5 and a half years of sexual assault and rape with gender information), from the municipality of Rotterdam (Wijkprofiel of 2014 and 2016), from the report of Fischer and Sprado (2017) and from (Van Nes and De Rooij, 2015). The primary data was collected at block level through personal observation and stored in a database.

- Amount of people in the streets:
  - Number of people in each street block of the neighbourhood;
  - Categories of people: men/women/threatening groups of men[17], walking/standing/sitting;
  - Collection days:
    - Thursday/Friday: 6, 7 and 13/July/2017;
    - Monday/Tuesday: 10 and 11/July/2017;
- Density of entrances:
  - Number of house, store, building entrances per 10 meters of street. Includes both sides of the street;
  - Each apartment door was counted as one entrance (when turned to the street and located at- or close to- ground level);
  - Back doors (from stores and restaurants) were included;
- Constituted streets:
  - whether entrances are in the street (constituting the street) or on the side or back façade (not constituting the street);
  - Back doors of stores and restaurants do not count for street constitution;
- Inter-visibility of doors and windows in the ground floor (plinth):
  - whether neighbours can naturally see each other's houses' entrances, measured in no/low/medium/high visibility (see Figure 8);
- Function
  - Commercial, residential or mixed, with separation between the ones that function during the day and the ones that remain open during the evening and night.

[17] Groups perceived as threatening in some way, or that should be avoided. Composed entirely or mainly by young men. Any group that can be perceived as unpredictable and potentially unpleasant source of interaction.

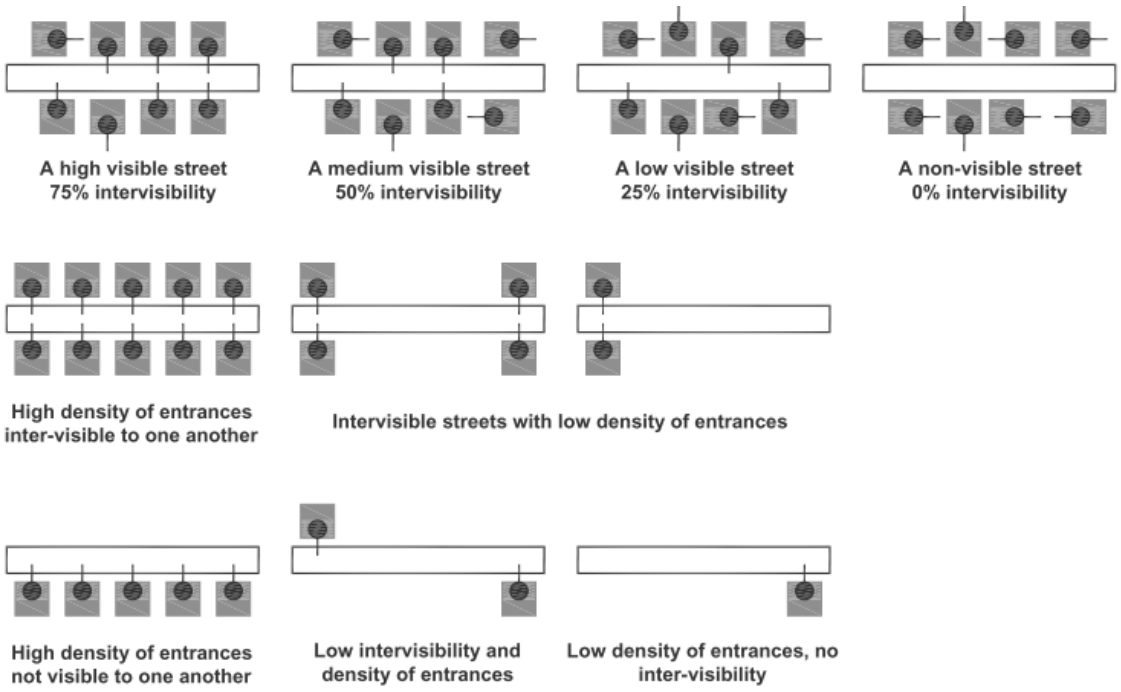


Figure 8: Guide for the measure of inter-visibility. Source: López and Nes, 2007, p. 08.

The choice of a quantitative method is preferred in this case because this research aims for statistical analysis and external validity, to enable the results to be generalized for the city. Quantitative data also facilitates the analysis process, given the objective to compare spatial features of the built environment with the occurrence of crime.

Lub and de Leeuw (2016) make a case for how a qualitative study can complement the quantitative results of the wijkprofiel. However, the subject of analysis in the present research lies on the under-explored area between women's safety (which has been greatly studied in qualitative fashion) and urban built environment's spatial features (which is usually investigated in quantitative ways, such as Space Syntax). Therefore, a quantitative data collection is ideal to enable comparisons between data from these two fields of knowledge.

3.4. Data analysis methods

The secondary information was analysed through Excel spreadsheet tool (for numeric, chart analysis), and through QGIS geographic information software (for spatial analysis). The results were also described and analysed with statistical program STATA.

The data collected about spatial features of the built environment, were stored in both QGIS (as attributes of the road network of Rotterdam) and Excel spreadsheet (as a database) and analysed with these softwares. The macro spatial analysis was carried out with the Multi-Platform Spatial Network Analysis Softare DepthmapX, which enables the examination of each street in the local and global street network context. Finally, results about crime and built environment features will be spatially compared in QGIS, statistically analysed in Stata, and conclusions will be drawn.

The statistical analysis was conducted using a pooled Poisson model. It is pooled because the 5 and a half years of sexual violence records were combined to provide a larger sample per block and street, instead of analysing each year separately as panel data (similar approach was used in Hillier and Sahbaz, 2008). The choice of a Poisson model over an Ordinary Least Squares (OLS) regression is because it is better suited for a count dependent variable (number

of sexual crimes). OLS would be better suited for a continuous dependent variable or a log-transformed count variable, but this would create issues due to the large amount of zeros in the dependent variable. Another option for count data is the Negative Binomial Regression if data was over-dispersed, but since this was not the case (the variance is much smaller than the standard deviation for this data), a Poisson model showed good fit to the data[18].

Spatial features of the built environment are expected to vary greatly according to the architectural style of each neighbourhood, with higher density of entrances and constituted streets in pre-war neighbourhoods, and lower density of entrances and unconstituted streets in post-war neighbourhoods, for example.

Some additional details about the data analysis process are:

- Spatial distribution of sexual harassment and violence:
    - Crimes per neighbourhood: police data;
    - Comparing sexual violence and sexual harassment: aggregate crimes per district, since the sexual harassment data is at district level;
    - Rotterdam street map obtained from OpenSourceMaps;
        - Manual preparation/verification: 1 link per street block;
    - Crimes per street:
        - Observation for border streets of Cool neighbourhood (Coolsingel, Weena, Kruisplein): adopted half the street's amount of crimes, because only one side of the street was considered inside the neighbourhood (for people counting), and because there is a large distance between both sidewalks of these streets;
        - The crimes per street were divided into crimes per block proportionately to the length of each block in the street, since the police data obtained is at street level.

3.5. Reflection on validity and reliability

As Van Thiel (2014) explains, both reliability and validity are central concerns to any research. Reliability relates to accuracy and consistency (repeatability) of research. Validity subdivides in internal and external validity: internal validity refers to whether the evaluated effect corresponds to what the researcher aimed to study, which translates to whether the theory has been adequately operationalized, and whether the supposed relationship between independent and dependent variables really exists. Complementarily, external validity relates to whether the conclusions obtained can be generalized to diverse populations, settings and so on.

With this is mind, the presented research strategy has been designed to reach reliability and validity: the use of secondary data allows for meaningful, representative results that fit into the time and human resource constraints. Police data is the most reliable currently available, and the triangulation with Fischer and Sprado (2017) provides consistency. The spatial observation brings new information in quantitative form, allowing for statistical, geographical analysis and comparison with the sexual violence data. The statistical analysis allows results to be generalized for the city (thus providing external validity). The expected results are in the lines of "streets with higher local integration, as well as higher integration between public and private spaces are correlated with smaller occurrence of sexual violence".

[18] Poisson modelling: https://stats.idre.ucla.edu/stata/dae/poisson-regression/

The choice of quantitative data collection through observation provides internal validity, answering the question about the relationship between spatial features of the built environment and sexual violence in greater detail than the existing data allows. The presented research strategy also allows for analysis of the relationship between variables, which is one of the aspects of internal validity.

Some of the main challenges include assessing the amount of people in the streets, which is a subjective process, since people will not stop moving to be counted (which would go against the purpose of representing natural movement). Unforeseen changes may happen in minutes, such as rain, public events or happenings. Moreover, randomness plays an important part in any instant snapshot obtained of movement in the streets. Besides these factors, it is not possible to count every street in the neighbourhood at the same time. Another aspect is that the number of people per street is associated with a moment in time (one day or a few days in a month of a year), whereas the crime data are scattered across five and a half years. For all these reasons, the amount of people in the street serves as a reference, and not a definite number. Finally, the indicators *crimes per person*, and *crimes per women* can not necessarily be compared across neighbourhoods, since the people in each one were not counted on the same days, besides the considerations above. These indicators also serve as a general reference.

Another challenge regards the fact that police data has no identification of the gender of suspects or victims for a large part of the records. For this work, it was assumed that records with 'unknown' gender of victims or suspects follow the pattern of the cases in which such information is known. Additionally, police data is assumed to be a reliable source of information of sexual violence in public spaces, and yet, it is estimated to account for only 14% of occurrences of sexual violence committed against women by a non-partner (European Union Agency for Fundamental Rights, 2014). For the time being, this fact can merely point to the importance of the present research, since for every reported case of sexual violence, it can be estimated that 7 other cases happened and were not reported.

Chapter 4: Research Findings

After the bombing in the Second World War, Rotterdam was reconstructed following modernist urban planning ideals. In the search for a well-ordered separation between work, shopping and home, the city accomplished also a gender separation in space, according to the Dutch sociologist Marguerite van den Berg (2012). Although it might not be the Newman-inspired scenario suggested in Chapter 2, this path may have accidentally reached a similar result. Seventy years later, the modernist model might not fit current society, but it continues to influence the way in which men and women use space in Rotterdam. As police data shows, it does not seem to work when it comes to ensuring women's safety.

This chapter contains data analysis and research findings organized in five parts. The first seeks to reveal patterns in Rotterdam police's records of sexual violence (sexual assault and rape) in the streets of Rotterdam, examining the spatial distribution of cases as well as their distribution in time (day, week and year), and comparing with results from Fischer and Sprado (2017) of sexual harassment research in Rotterdam.

The second section presents the socioeconomic characteristics of Rotterdam's neighbourhoods and searches for similarities among the areas with most sexual violence records. The third part concentrates on the micro-scale spatial characteristics of the four neighbourhoods that are focused on this research: Cool, Nieuwe Westen, Hillesluis and Pendrecht. It includes the functions of streets, density and inter-visibility of entrances, space syntax analysis and use of the streets.

The fourth section contains the graphs and statistical models created based on the sexual violence records analysed on the first part, and on the spatial characteristics of the four areas examined in the third part. These models aim to answer this research's question of what is the relationship between spatial features of the urban built environment and the spatial distribution of sexual violence in the streets of Rotterdam.

Concluding, the fifth part searches for patterns among the streets or blocks with higher incidence of sexual violence. Attention is given to each neighbourhood and, lastly, blocks and streets are grouped by rate of crimes per street length.

4.1. Spatial distribution of gender-based sexual violence

4.1.1. Rotterdam's police sexual violence data

The data provided by the police includes sexual assault and rape cases registered from January 2012 until (and including) June 2017. It contains information of when it happened (day, time), where (street, neighbourhood and district) and who was involved (victim, suspect, witnesses, sometimes with the gender of each one).

Out of 1087 reported cases of rape and assault, only 29% (320) have identified suspects, of which 98,4% are male, 1,3% are both male and female[19], and 0,3% are female, as can be seen in Chart 1. These findings are in line with earlier publications about sexual violence: that although there may be cases committed by women or with the participation of women, these constitute the absolute minority.

[19] Of the cases with identified suspects, 81% have a single suspect, and 19% have 2 or more suspects.

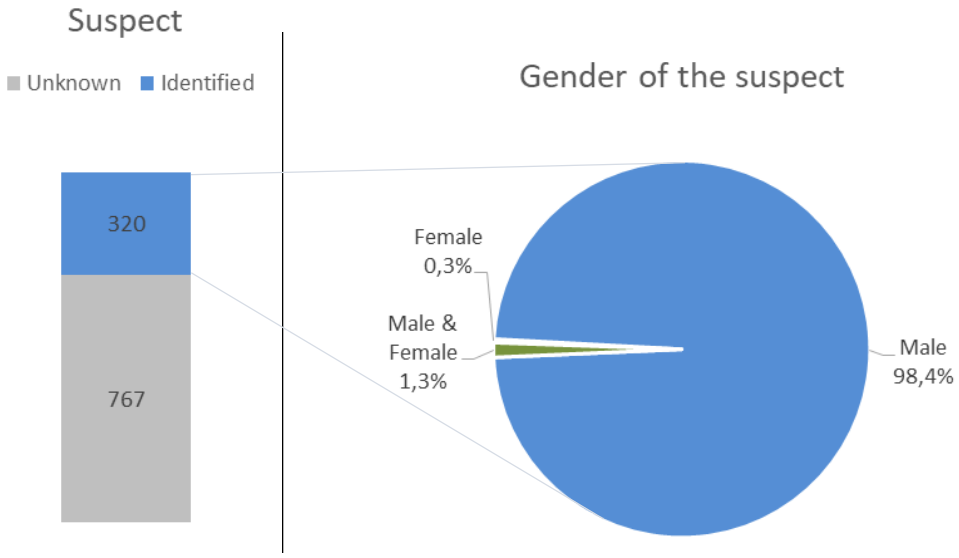


Chart 1: Gender distribution of suspects. Source: Rotterdam police, own graph

The gender of the victim was identified in 55% of the reported cases of rape and sexual assault. Of these, 96% of cases had female victims, 3,7% had male victims, and 0,3% had both, as shown in Chart 2. The results are essentially the same when assault and rape are analysed separately.

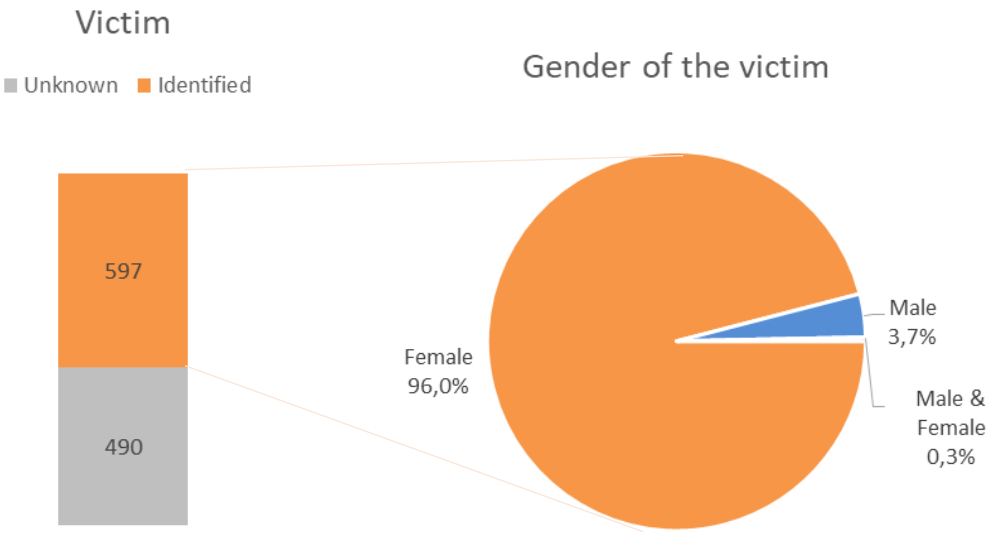
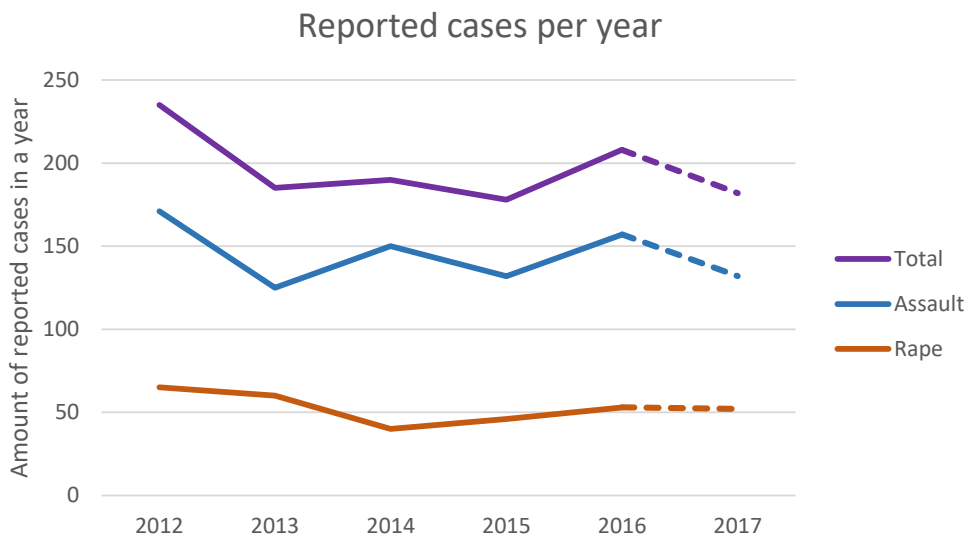


Chart 2: Gender distribution of the victims. Source: Rotterdam police, own graph

From this point on, the cases with male victims and female suspects are discarded, and the remainder 1059 are used for the analysis.

Examining the type of crime, Graph 2 shows that sexual assault is about three times more frequent than rape in Rotterdam's police records. In the 5,5 years of data, there have been 780 cases of sexual assault (an average of 143 cases per year) and 279 cases of rape (an average of 51 cases per year[20]).

[20] Considering 2017 as half a year (Jan-June).



Graph 2: Number of reported cases of assault and rape in public streets per year in Rotterdam (Jan/2012 - Jun/2017). Source: Rotterdam police and author's prediction of 2017's total. Own graph.

In the sequence, Figure 9 presents the number of cases per neighbourhood for the period of 2012-2017 for all neighbourhoods included in the police records. It can be seen that the city centre holds the highest amount of cases, in Cool, Stadsdriehoek, and CS-kwartier, followed by Groot Ijsselmonde, Kralingen-West, Zuiderpark and Vreewijk.

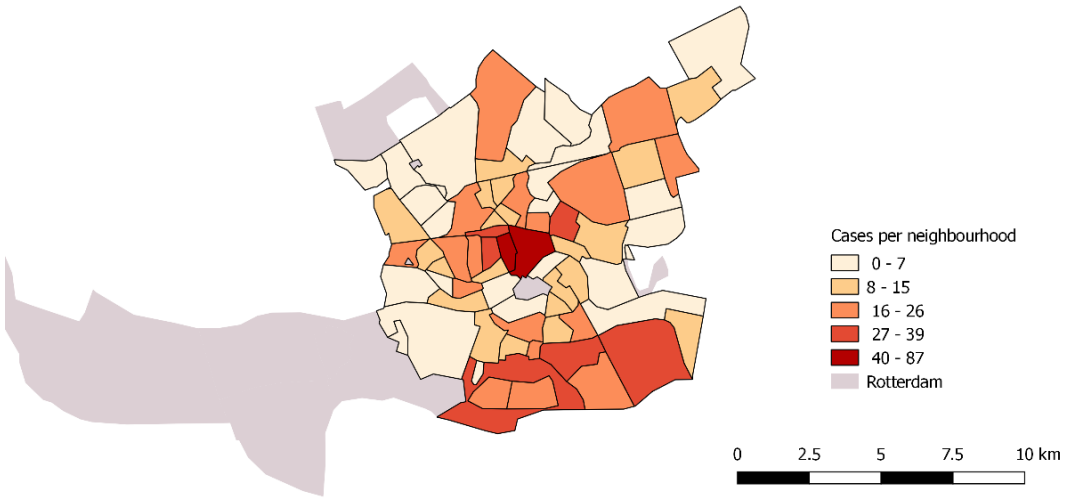


Figure 9: Neighbourhoods with most reported cases of sexual assault and rape in the streets. Source: Rotterdam police, Jan/2012 - Jun/2017. Own map

To allow for comparison between different sources of data, Figure 10 shows Rotterdam police's reported cases of sexual assault and rape aggregated per district (on the left), and sexual harassment cases on the right (Fischer and Sprado, 2017). The maps show that the spatial distribution is similar: the city centre concentrates the majority of cases of both sexual harassment and violence.

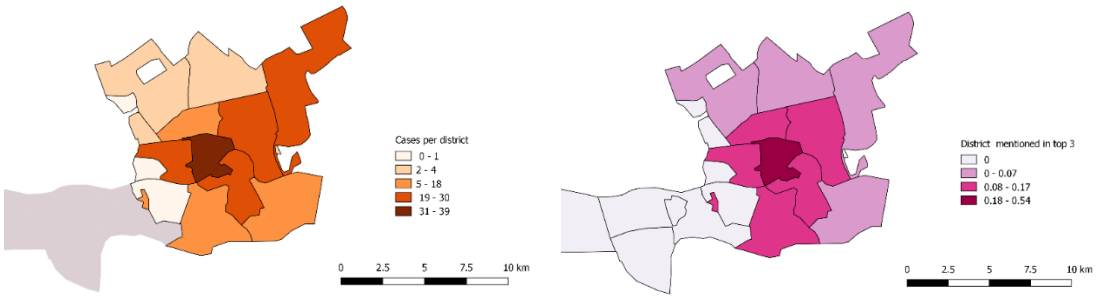


Figure 10: Districts with most reported cases of sexual assault and rape in the streets in 2016 (left) and districts most cited in the top 3 where women suffered most sexual harassment in the streets in 2016 (right). Source: Rotterdam police (2017) (left) and Fischer & Sprado (2017) (right). Own map

Next, Figure 11 shows in which districts inhabitant women suffered sexual harassment in the street three or more times in 2016 (Fischer and Sprado, 2017). The difference between this and the map on the right in Figure 10 can be explained by the fact that one shows where harassment happened the most, while the other shows where the problem is more common for residents themselves.

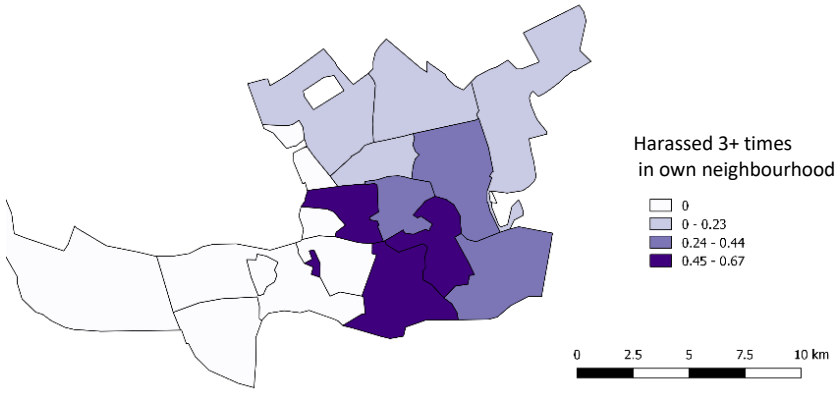


Figure 11: Districts where inhabitant women suffered most sexual harassment in the streets in 2016. Source: Fischer & Sprado (2017). Own map

The distribution of sexual violence cases in Rotterdam's neighbourhoods is shown in Graph 3 for the 25 neighbourhoods with most reported cases in the period of 2012-2017. It can be seen that the four chosen neighbourhoods of study (Cool, Nieuwe Westen, Pendrecht and Hillesluis) rank 1^{rst}, 9th, 19th and 25th, respectively, providing a range of occurrence rates for analysis.

The time of the day in which cases happened is included in the graph, considering 'morning' the period from 6h to 12h, 'afternoon' from 12h to 18pm, 'evening' from 18h to 24h and 'night' from 24h until 6h. The importance of also examining the time when cases happened, and not only the place, is related to how spaces and their use may change according to the time of the day (daytime, night time), of the week (weekday, weekend) or the year (the different seasons).

Graph 3 contradicts expectations: Nieuwe Westen, Pendrecht and Hillesluis have all been listed as 'problem neighbourhoods' in the Netherlands, and yet, it is Cool that shows higher incidence of gender-based sexual violence. Furthermore, there is a common feeling in Rotterdam that southern neighbourhoods are more dangerous but, at least in concern to sexual violence, the city centre and Nieuwe Westen (the two neighbourhoods under study, north of the river Maas)

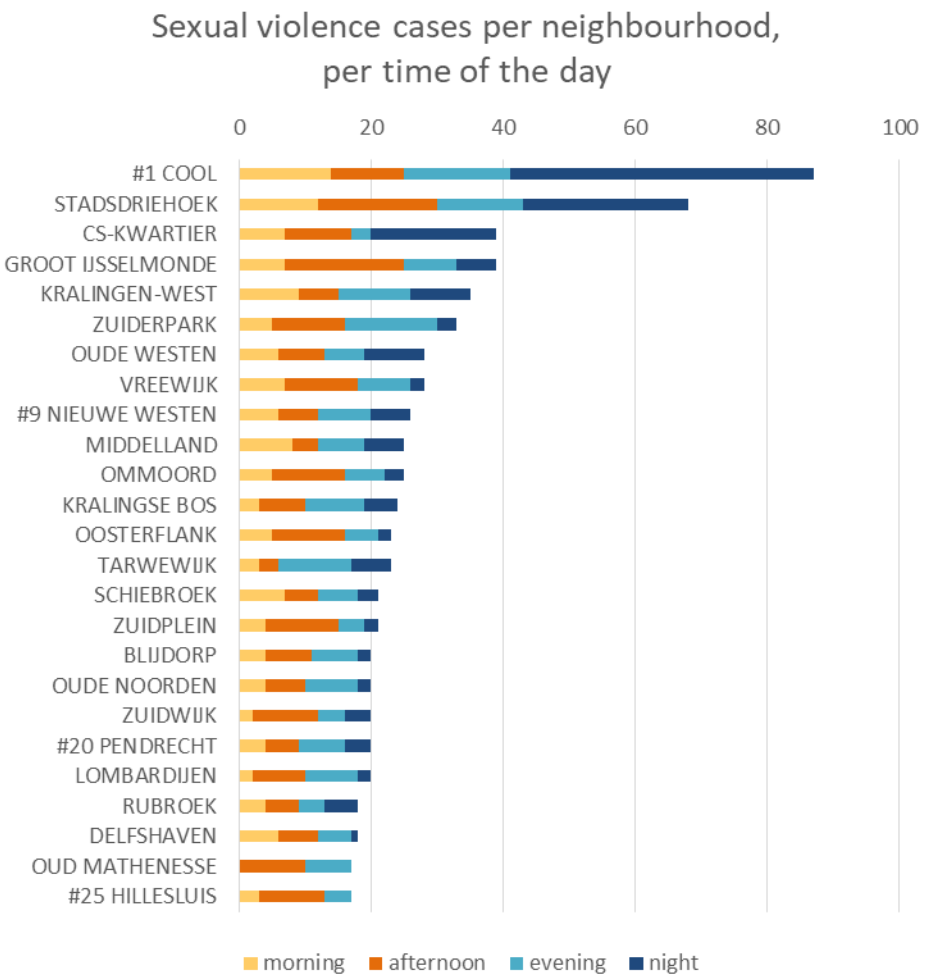
are more dangerous than the two in the south[21]. Table 4 adds to this analysis: while Cool may have the highest incidence of sexual violence reports per resident, it shows the lowest rate of incidence when considering the total amount of people who walk in the neighbour during a week day.

Table 4: Crimes per population, per people on the streets in a weekday and per total street lenght in each area.

Neighbourhood	Crimes (2012-2017)	Pop. 2016	People/ day	Metres of streets	Crimes/ pop	Crimes/ people/day	Crimes/ block (100m)
Cool	87	5086	9611	13161	0,017	0,009	0,066
Nieuwe Westen	26	19224	2090	26303	0,0014	0,012	0,010
Pendrecht	20	11655	1292	26013	0,0017	0,015	0,008
Hillesluis	17	11863	1526	19306	0,0014	0,011	0,009

Another point raised by Graph 3 is that the three neighbourhoods with most cases are in the city centre district (Cool, Stadsdrihoek and CS-kwartier), and have most of their cases happening at night (between midnight and 6 am). There could be a correlation with the amount of nightlife (bars and clubs) in these neighbourhoods, in line with what Fischer and Sprado (2017) found about sexual harassment: that it is more common in places with a culture of entertainment in the streets and of late night shopping in the city centre of Rotterdam.

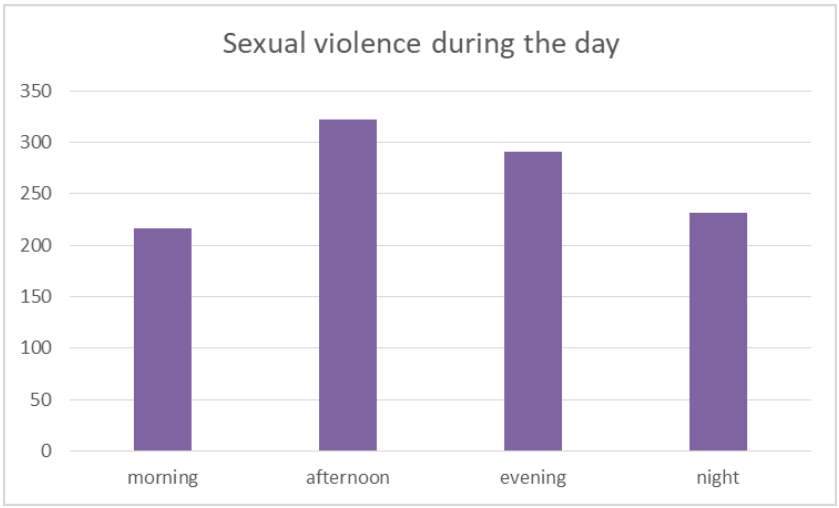
[21] Supposing that the police data is representative of all cases that happen (but are not necessarily reported) in Rotterdam.



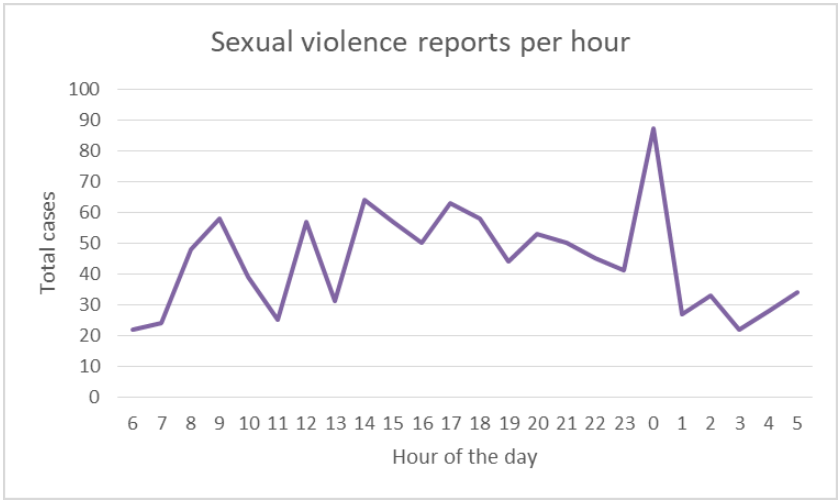
Graph 3: Total amount of assault and rape cases in the 25 neighbourhoods with most cases, in the 5,5 year period.[22] Source: Rotterdam police, own graph.

In contrast, in the remaining areas, most cases of sexual violence happened in the afternoon or evening, supporting the information in Graph 4, which shows that most cases in the city happened at such periods. These results contradict expectations, since part of the afternoon cases have happened in daylight. A hint of how Graph 3 and Graph 4 can be part of the same story may be seen in Graph 5: a look at the hourly distribution of cases in Rotterdam shows that most occurrences happened between midnight and 1 a.m., while the remainder of cases are more or less evenly distributed over the day from 8h to 20h.

[22] Considering only the assault and rape cases in which victims are women or unidentified, and suspects are men or unidentified (97,4% of the total for the 5,5 years period).

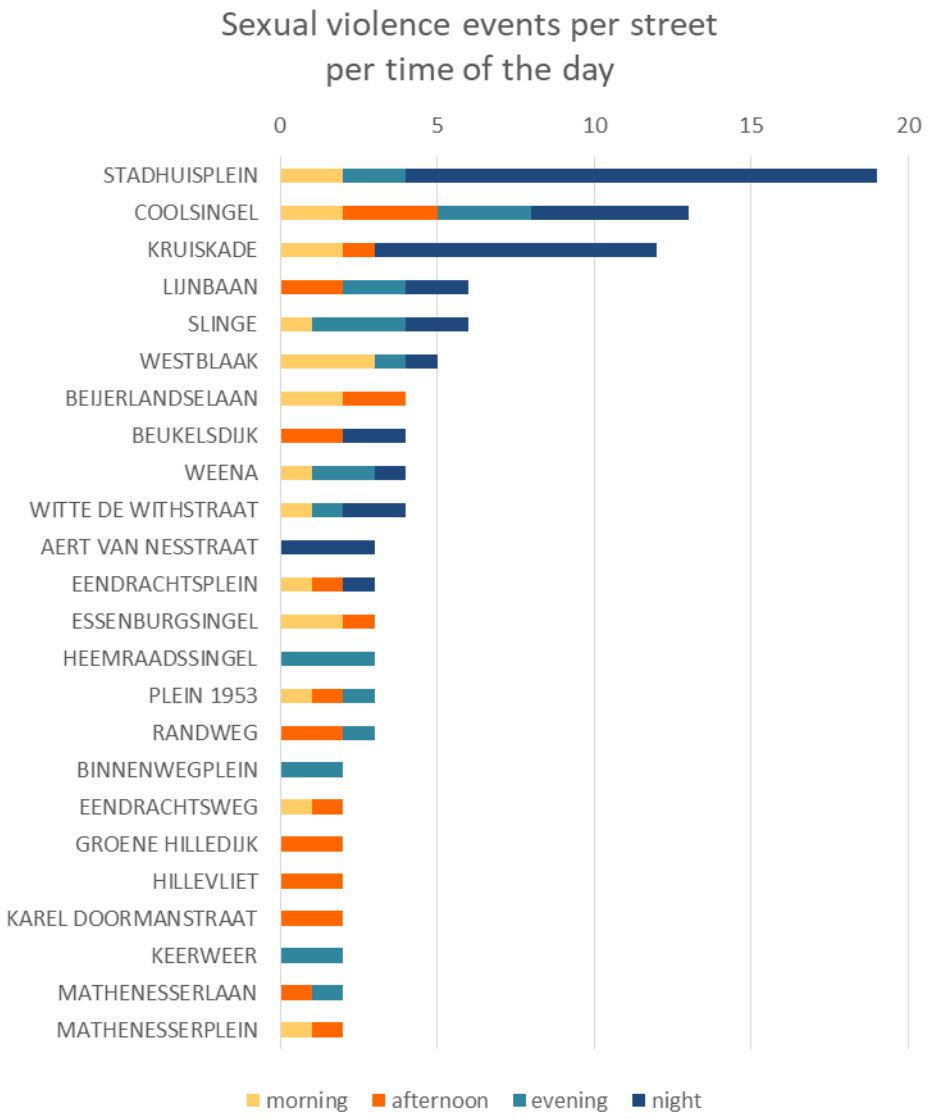


Graph 4: Total number of cases of sexual violence per period of the day (Jan/2012 - Jun/2017). Source: Rotterdam police, own graph.



Graph 5: Sexual violence per hour of the day (Jan/2012 - Jun/2017). Source: Rotterdam police, own graph.

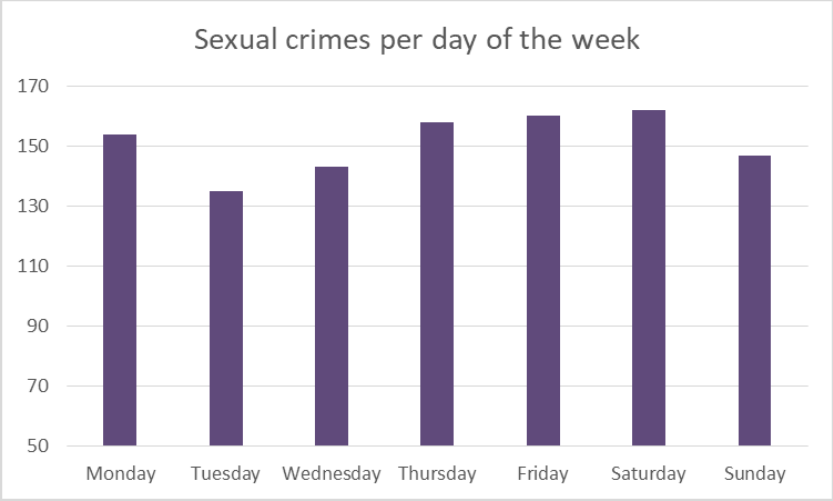
Another view on this subject is provided by Graph 6, which presents the analysis of the 25 streets with most incidents and the time when they happened. It shows that nearly all streets with sexual violence cases at night (from midnight to 6 am) are nightlife spots or are close to them. It should be considered, however, that this can also result from the fact that there is (likely to be) smaller movement in the streets at such hours in other parts of the city.



Graph 6: Sexual assault and rape cases per street per time of the day, in the 5,5 year period.[23] Source: Rotterdam police, own graph.

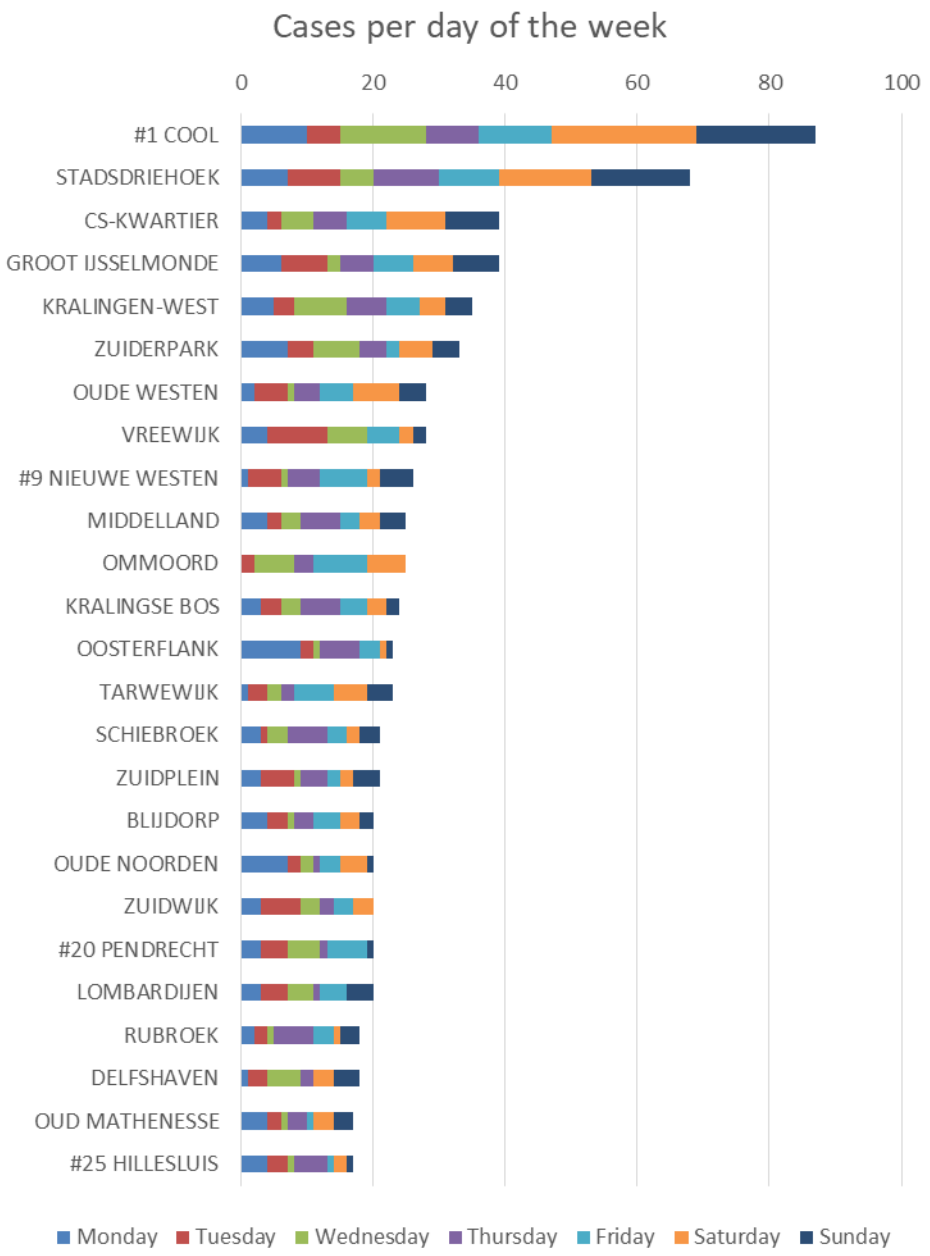
Next, Graph 7 presents the distribution of sexual violence in Rotterdam per day of the week. It shows that most cases happen on Thursday, Friday and Saturday, followed by Monday. The difference between days of the week is more subtle than could be expected: Saturdays have only 20% more cases than Tuesdays, the least 'dangerous' days according to the reports.

[23] This graph includes the absolute number of cases per street. Since Coolsingel and Weena are at the borders of Cool neighbourhood and are very wide streets, half the cases of each of them were considered in the study area, for the statistical analysis.



Graph 7: Sexual violence per day of the week (Jan/2012 - Jun/2017). Source: Rotterdam police, own graph.

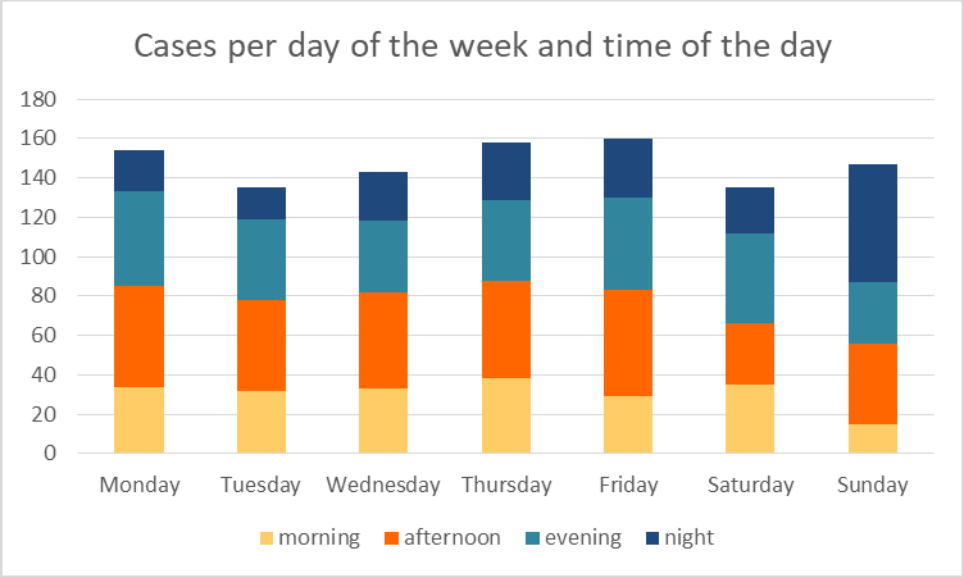
In the sequence, Graph 8 offers a more detailed insight into the weekly distribution of cases in Rotterdam's neighbourhoods. As expected, the city centre (Cool, Stadsdriehoek and CS-Kwartier), that concentrates much of the city's nightlife, has most of its cases on Saturdays and Sundays. In the remaining areas, no clear pattern appears.



Graph 8: Total amount of assault and rape cases per day of the week in the neighbourhoods with most cases, in the 5,5 year period.[24] Source: Rotterdam police, own graph.

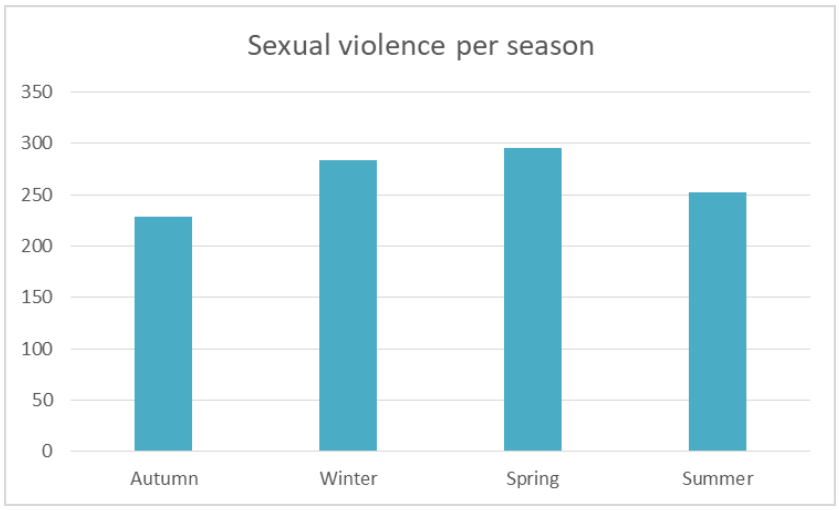
Graph 9 presents the distribution of cases in the periods of the day in the week: it shows that Sunday night - the period from Saturday at midnight until 6 am on Sunday - is the time with most cases (60), followed by Friday afternoon (54) and Monday afternoon (51).

[24] Considering only the assault and rape cases in which victims are women or unidentified, and suspects are men or unidentified (97,4% of the total for the 5,5 years period).



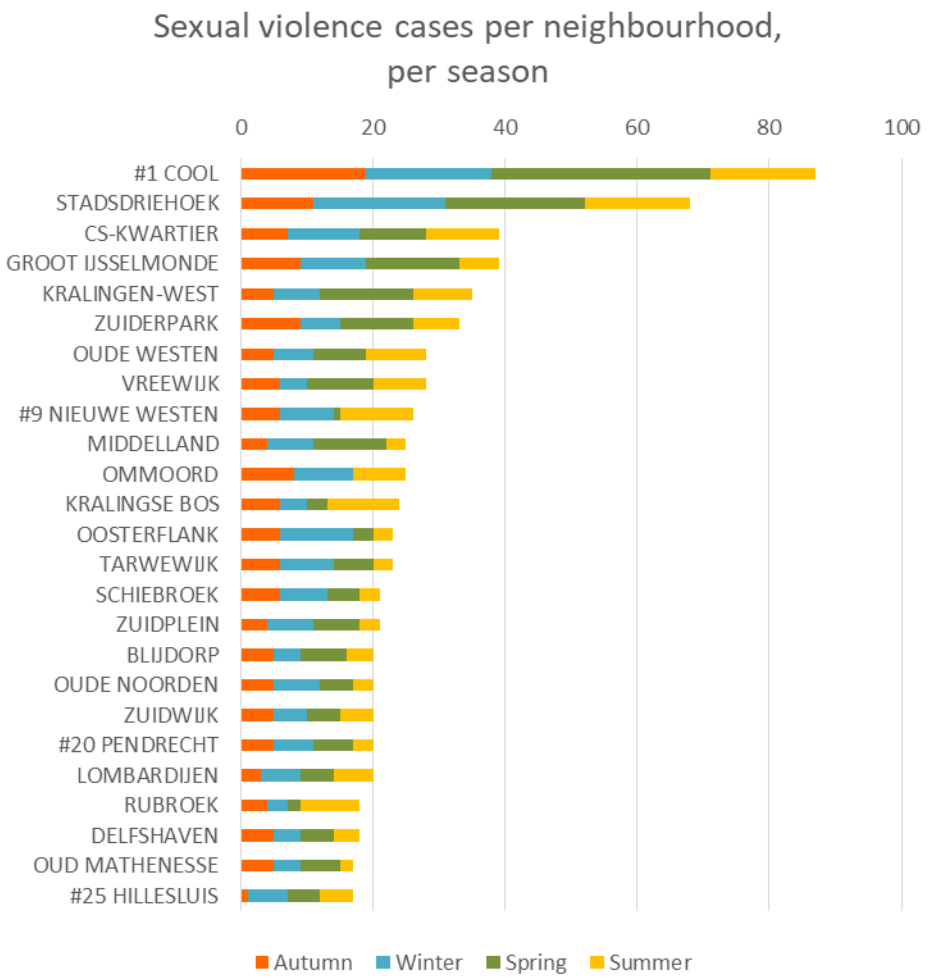
Graph 9: Distribution of sexual violence cases per time of the day in each day of the week, in the 5,5 year period. Source: Rotterdam police, own graph.

Finally, Graph 10 shows the seasons with most sexual violence cases, according to police records, to be spring or winter, similar to what is presented in Graph 11, which shows the distribution of cases per season per neighbourhood.



Graph 10: Total number of reported cases of sexual violence per season (Jan/2012 - Jun/2017). Source: Rotterdam police, own graph.

When comparing neighbourhoods, most cases of sexual violence occurred in spring, followed by winter and summer tied in second place:



Graph 11: Sexual violence cases per neighbourhood, per season. Source: Rotterdam police, own graph.

4.2. Socioeconomic characteristics of Rotterdam's neighbourhoods

Previous studies have shown that socioeconomic aspects play an important role in the occurrence of crimes and sexual violence in the streets. Factors such as social disorganization (racial and cultural heterogeneity, residential instability and poverty), lack of responsibilities at home and lack of structural leisure, resulting on boredom and young men spending a lot of time in the streets.

Consequently, understanding sexual violence in the streets of Rotterdam requires understanding socioeconomic characteristics of the city. Figure 12 to Figure 14 show some main factors: average income, portion of households with high and low income, share of residents who have trouble reading Dutch, share of residents who dropped-out of school and who know their neighbours.

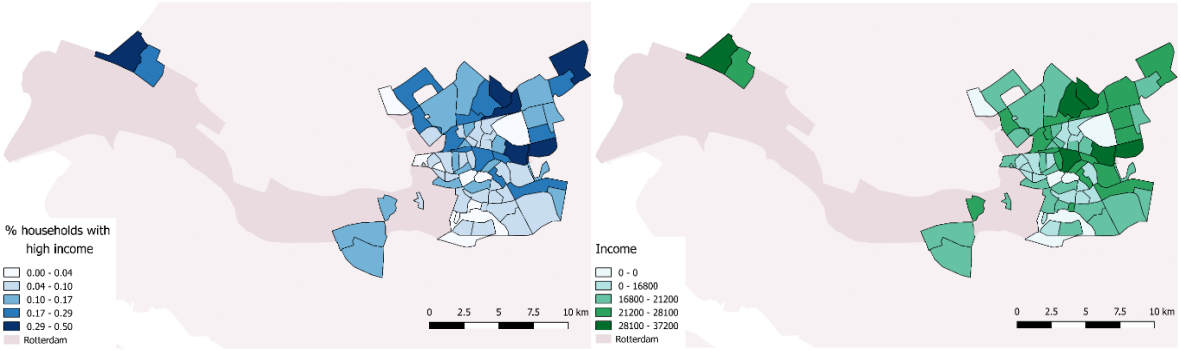


Figure 12: Percentage of households with high income (left) and average neighbourhood income. Source: Rotterdam wijkprofiel (2014), own maps.

Figure 13: Percentage of residents who have trouble reading Dutch (left) and with low household income (right). Source: Rotterdam wijkprofiel (2016), own maps.

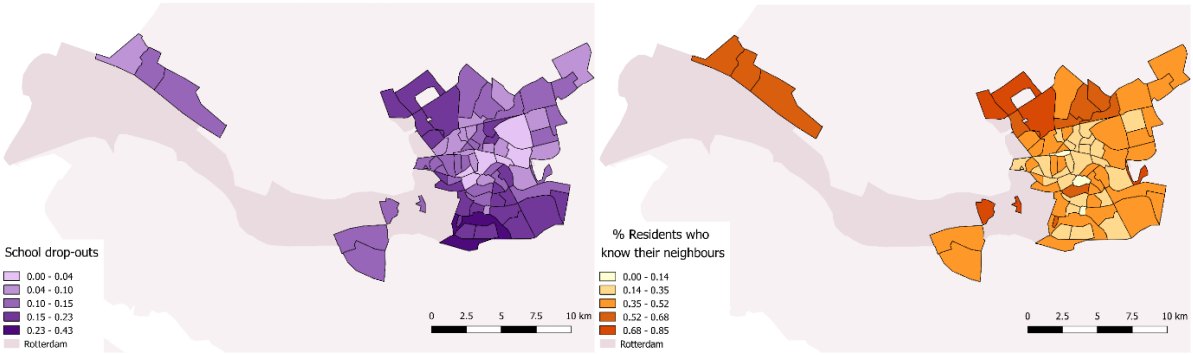


Figure 14: Percentage of residents aged 18-22 who dropped-out of school without starting qualification (left) and percentage residents who know their neighbours (right). Source: Rotterdam wijkprofiel (2016), own maps.

As expected, neighbourhoods with high average income also have high percentage of households with high income (Figure 12) and low share of residents with low household income. Cool can be said to be an average-income neighbourhood, Nieuwe Westen and Pendrecht have a higher share of low income households, and Hillesluis has about 40% residents with low household income.

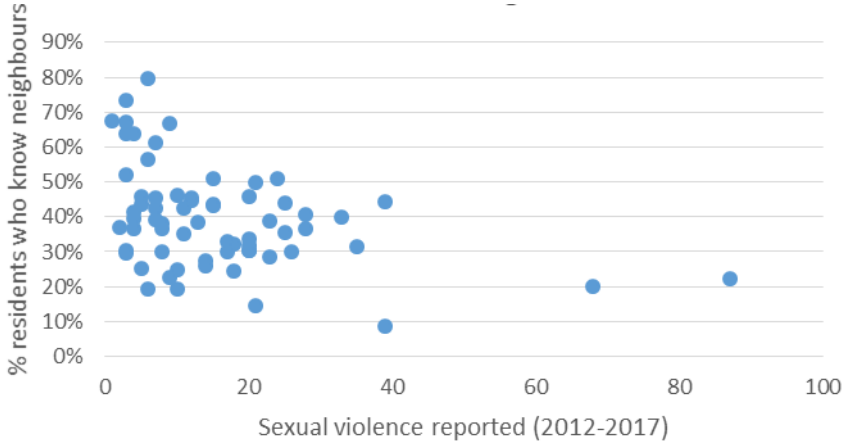
It is noteworthy that there seems to be no clear association between the share of residents who have trouble reading Dutch, the share of school drop-outs and the share of residents with low household income.

Finally, the percentage of inhabitants who know their neighbours is not associated with neither high nor low household incomes. But it is remarkable that all four neighbourhoods under study have low share of residents who know their neighbours, between 14 and 35%. The specific values of each area's characteristics are presented in Table 5.

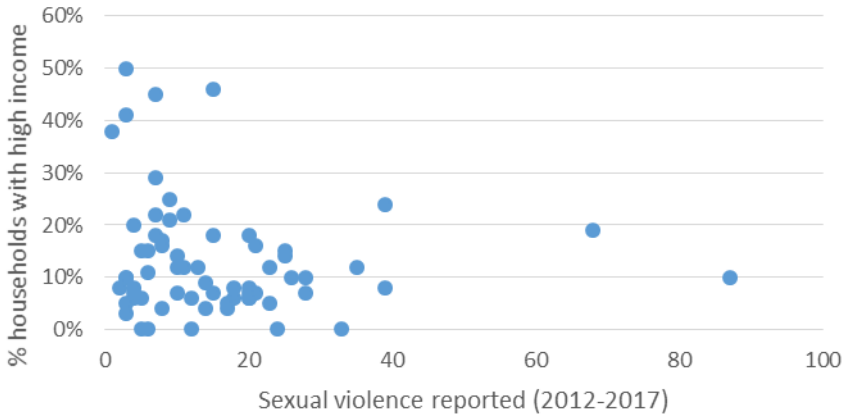
Table 5: Socioeconomic characteristics of the 25 neighbourhoods with most sexual violence cases in the period of 2012-2017. Sources: Rotterdam police (2017), wijkprofiel (2014,2016). Own table.

Neighbourhood	Sexual violence crimes 2012 - 2017	% Neighbour-hood residents who know each other	% School drop-outs (18 to 22 years) without starting qualification	% Residents who say having trouble reading Dutch	Average income	% Residents with low household income	% Households with high income
Cool	87	0.22	0.10	0.13	22700	0.12	0.10
Stadsdriehoek	68	0.20	0.04	0.16	29700	0.10	0.19
C.S. kwartier	39	0.09	0.07	0.24	25800	0.05	0.24
Groot-IJsselmonde	39	0.44	0.18	0.12	18300	0.28	0.08
Kralingen-West	35	0.32	0.06	0.25	19000	0.24	0.12
Zuiderpark	33	0.40	0.43	0.06		0.13	0.00
Oude Westen	28	0.37	0.13	0.23	16800	0.39	0.10
Vreewijk	28	0.41	0.18	0.12	17900	0.36	0.07
Nieuwe Westen	26	0.30	0.11	0.23	15800	0.26	0.10
Middelland	25	0.36	0.15	0.18	18300	0.23	0.14
Ommoord	25	0.44	0.13	0.09	22000	0.17	0.15
Kralingse Bos	24	0.51	0.02	0.12		0.08	0.00
Oosterflank	23	0.39	0.14	0.09	20700	0.25	0.12
Tarwewijk	23	0.29	0.15	0.22	14900	0.32	0.05
Schiebroek	21	0.50	0.14	0.09	20900	0.15	0.16
Zuidplein	21	0.14	0.09	0.10	24800	0.18	0.07
Blijdorp	20	0.46	0.10	0.11	28100	0.08	0.18
Lombardijen	20	0.30	0.18	0.12	17600	0.25	0.08
Pendrecht	20	0.31	0.18	0.19	16500	0.23	0.06
Oude Noorden	20	0.32	0.14	0.15	16100	0.37	0.07
Zuidwijk	20	0.34	0.20	0.13	17700	0.30	0.06
Delfshaven	18	0.32	0.11	0.19	16400	0.29	0.06
Rubroek	18	0.25	0.10	0.16	19300	0.29	0.08
Oud-Mathenesse	17	0.30	0.13	0.18	17700	0.24	0.04
Hillesluis	17	0.33	0.17	0.24	13300	0.43	0.05

A closer examination of these variables against sexual violence does not show clear patterns. Nevertheless, Graph 12 indicates that neighbourhoods where a higher share of residents know their neighbours tend to have lower amount of reports of sexual violence. Graph 13, in turn, shows that neighbourhoods with higher share of households with high income tend to have less sexual violence, but it is not a determinant factor. Reasons for this could range from such neighbourhoods being mostly in suburban areas, with low pedestrian flows, to better safety measures, and many more.



Graph 12: Percentage of residents who know their neighbours *versus* reported sexual violence in the neighbourhood. Source: Rotterdam police, own graph



Graph 13: Percentage of households with high income *versus* reported sexual violence in the neighbourhood. Source: Rotterdam police, own graph

4.3. The four neighbourhoods: spatial features, movement and incidence of sexual violence

This section is structured in four parts: Cool, Nieuwe Westen, Pendrecht and Hillesluis (Figure 15). Each one is examined in detail concerning their spatial features: the local and global integration, to- and through-movement (as analyzed with Space Syntax), the functions of buildings, the density of entrances and inter-visibility of doors at ground level. The flows of people who use public space in the four neighbourhoods are mapped.

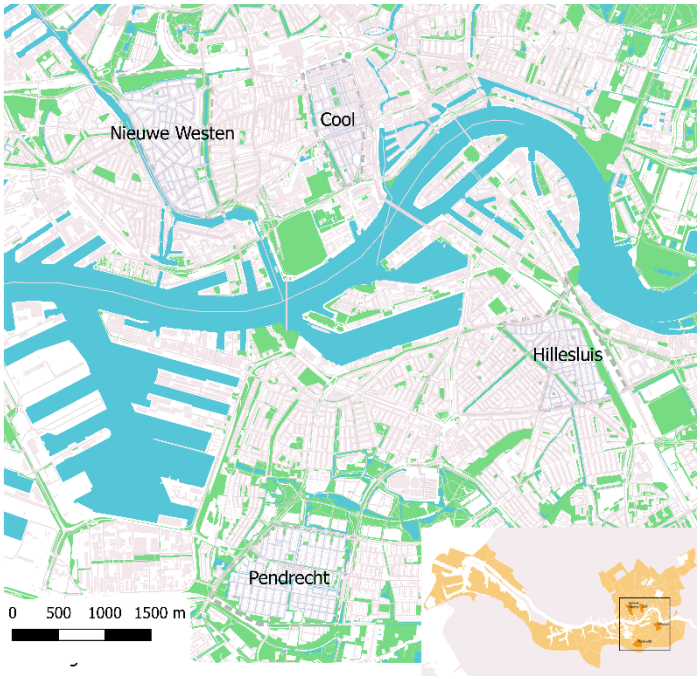


Figure 15: Location of the four areas in Rotterdam. Own map.

4.3.1. Cool

Figure 16 (left) shows the main streets in the neighbourhood. Cool is the city centre, located between the city hall (on the East, in Coolsingel) and Rotterdam's Central Station (on the North, in Weena), the main entrance of the city for those who come by train or bus. The area has 5.086 inhabitants[25] and is composed of three very different areas: the region above Westblaak street, where the main open shopping centre of Rotterdam (Photograph 1) is located; Witte de Withstraat (left on Photograph 2), a famous, lively bar and restaurant street, and the remaining residential area below Westblaak street. The map with Cool's land use can be seen in Figure 16. Besides grouping functions into commercial, residential and mixed (commercial on the ground floor and residential on top), uses are also separated into 'commercial' for businesses that run in the normal 9h to 17h hours and 'commercial day & night' for restaurants, bars and others that run until later evening or night.

[25] http://wijkprofiel.rotterdam.nl/nl/2016/rotterdam//rotterdam-centrum/cool/

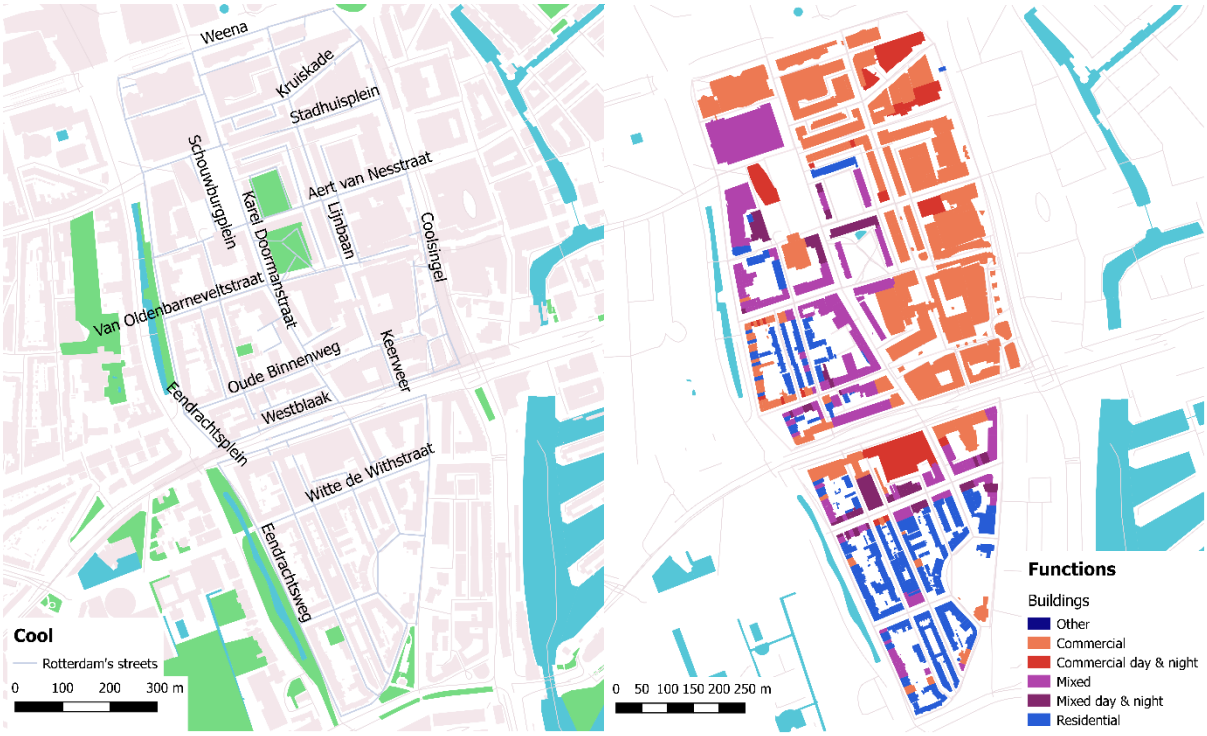


Figure 16: Cool's most important streets (left) and buildings' functions in the neighbourhood (right). Source: layers from Open Street Maps. Own maps.

Photograph 1: Commercial centre in Lijnbaan, before (left) and after (right) stores open (July/2017). Own photos.

Photograph 2: Bars and restaurants in Witte de Withstraat (left) and Stadhuisplein (right). Source: images.smulweb.nl (left) and www.fimek.nl (right).

Figure 17 presents the local (left) and global (right) integration analysis of Cool made with Space Syntax on top, and the local (left) and global (right) angular analysis below: red and orange shades indicate higher integration (or simpler paths), while darker greens and blues indicate less integration (higher segregation, or more complicated paths). They show that the main shopping area is highly locally integrated, while the residential area, to the south, is less so. The same applies to the global integration analysis. The angular analysis with low metrical radius predicts higher to-movement in Aert van Nesstraat, Oude Binnenweg, Lijnbaan, Karel Dormanstraat and Witte de Withstraat, while the angular analysis with high metrical radius rightfully predicts higher levels of through-movement on Westblaak, Weena and Coolsingel, around the neighbourhood. These results are in line with previous studies from Hillier and van Nes, that found that busier open shopping streets are usually located in streets with high local (metrical and axial) integration, while main routes are associated with higher global metrical and axial integration.

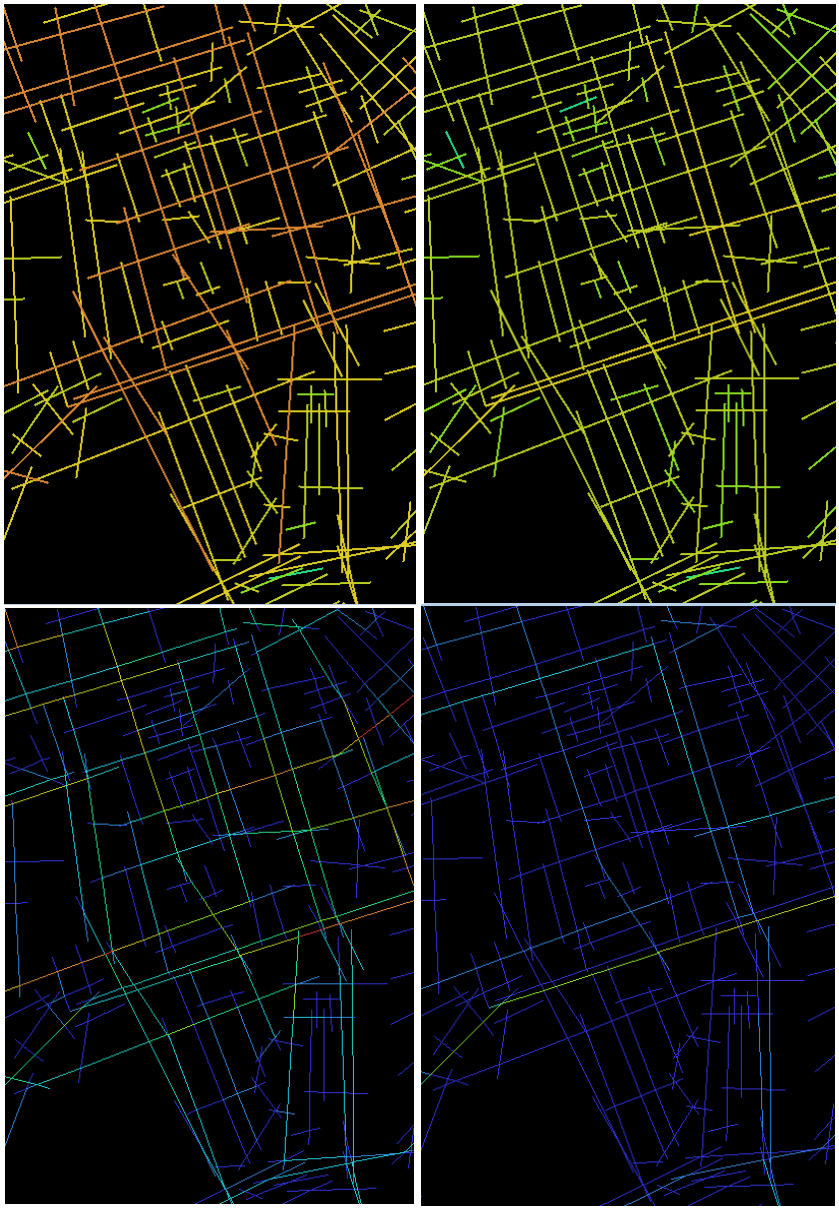


Figure 17: Local (left) and global (right) integration analysis of metrical distance (top) and angular metrical analysis (lower) of local (R02, left) and global (R20, right) radii in Cool generated with DepthMap.

Next, Figure 18 presents the density of entrances per 10m of street (left) and degree of inter-visibility of doors and windows on the ground floor. In the north area, some of the streets with

higher density of entrances are the Lijnbaan (main shopping street in the area, pedestrian-only), the Korte Lijnbaan, Oude Binnenweg (a street with shops, cafés and bars), Van Oldenbarneveltplaats and Witte de Withstraat (the main restaurant/bar street).

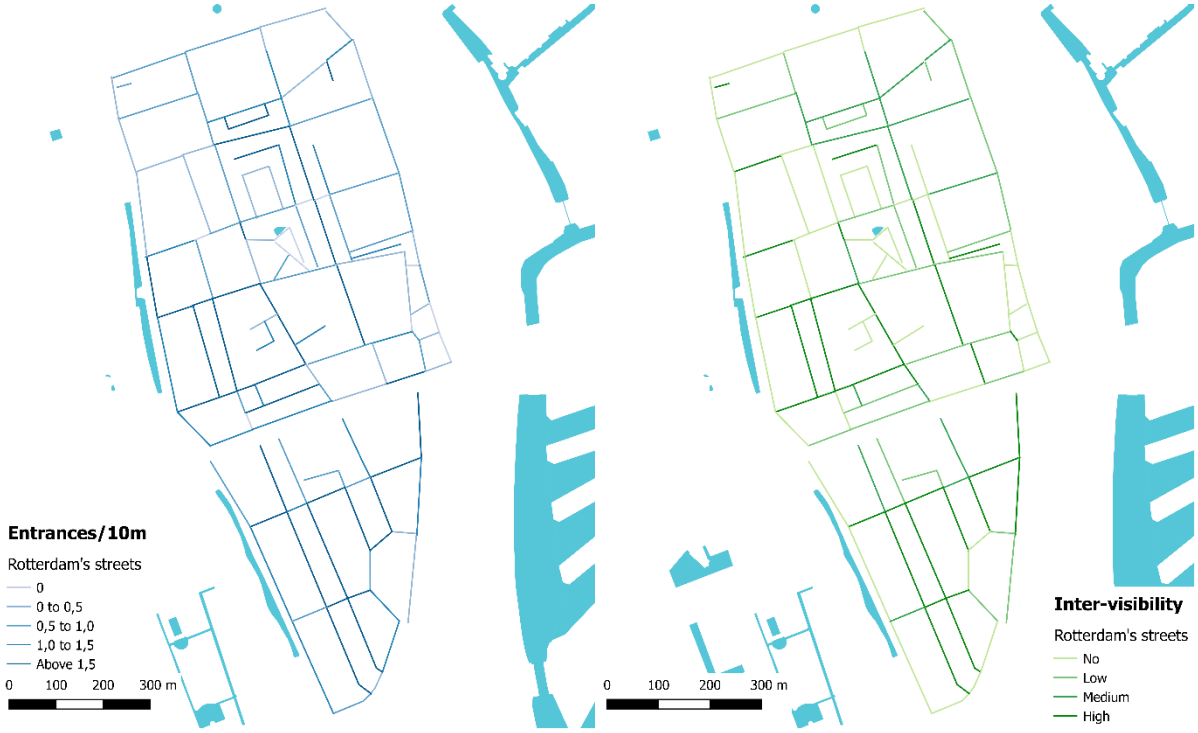


Figure 18: Density of entrances per 10m of street (left) and degree of inter-visibility of doors and windows on the ground floor (right). Own maps.

4.3.1.1. Movement

On a weekday, the city centre is rather empty before 9h30/10h, when stores open. Then it gets busier and reaches the peak flows of people in the afternoon, from 13h to 17h. Stores close around 18h, and by 19h the streets are nearly deserted, with the exemption of the streets with nightlife: Stadhuis and Oude Binnenweg. This shows that this northern part of the neighbourhood is mostly used by people who go shopping there, either inhabitants of the neighbourhood or visitors from the rest of Rotterdam, from other cities and also tourists from other countries.

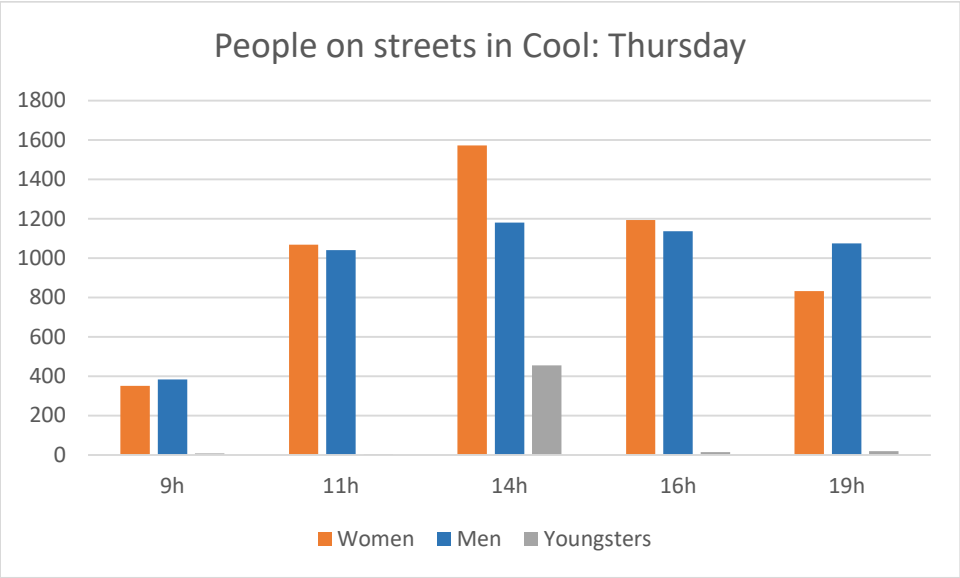
South of Westblaak, Witte de With street has attractive and varied stores, but attracts much more people with its bars and restaurants. There is little movement in the morning, some movement at lunch time, and the peak happens after working hours, when all tables on the sidewalks are full, as well as most space between them.

The remainder area of Cool south of Westblaak is residential and has little movement at any time of the day. It has no shops and only one playground, where kids play in the morning and afternoon, and are replaced by young men (aged 15-30) playing sports in the evening.

The movement changes considerably from Monday (much quieter) to Thursday (much busier). At night, after stores close, the amount of women in the streets clearly decreases, specially on Monday.

Graph 14 shows that women are the majority of people in the streets of Cool during business hours (10h-18h, when shops are open), whereas men are the majority before and after stores close, as expected from the literature review. It is clear through observation that after business

hours women disappear from the streets[26], while men continue to be seen, mostly in bars and restaurants.



Graph 14: Men, women and groups of (young) men in the streets in Cool on a Thursday (July/2017). Own graph.

In the sequence, the total amount of people in a whole day are presented for the neighbourhood, including total amount of (young) men in groups, total men and total women.

[26] presumably, going home to assume culturally embedded gender roles, such as taking care of the kids and making dinner. It was also visible that most kids on the streets were accompanied by an adult woman.

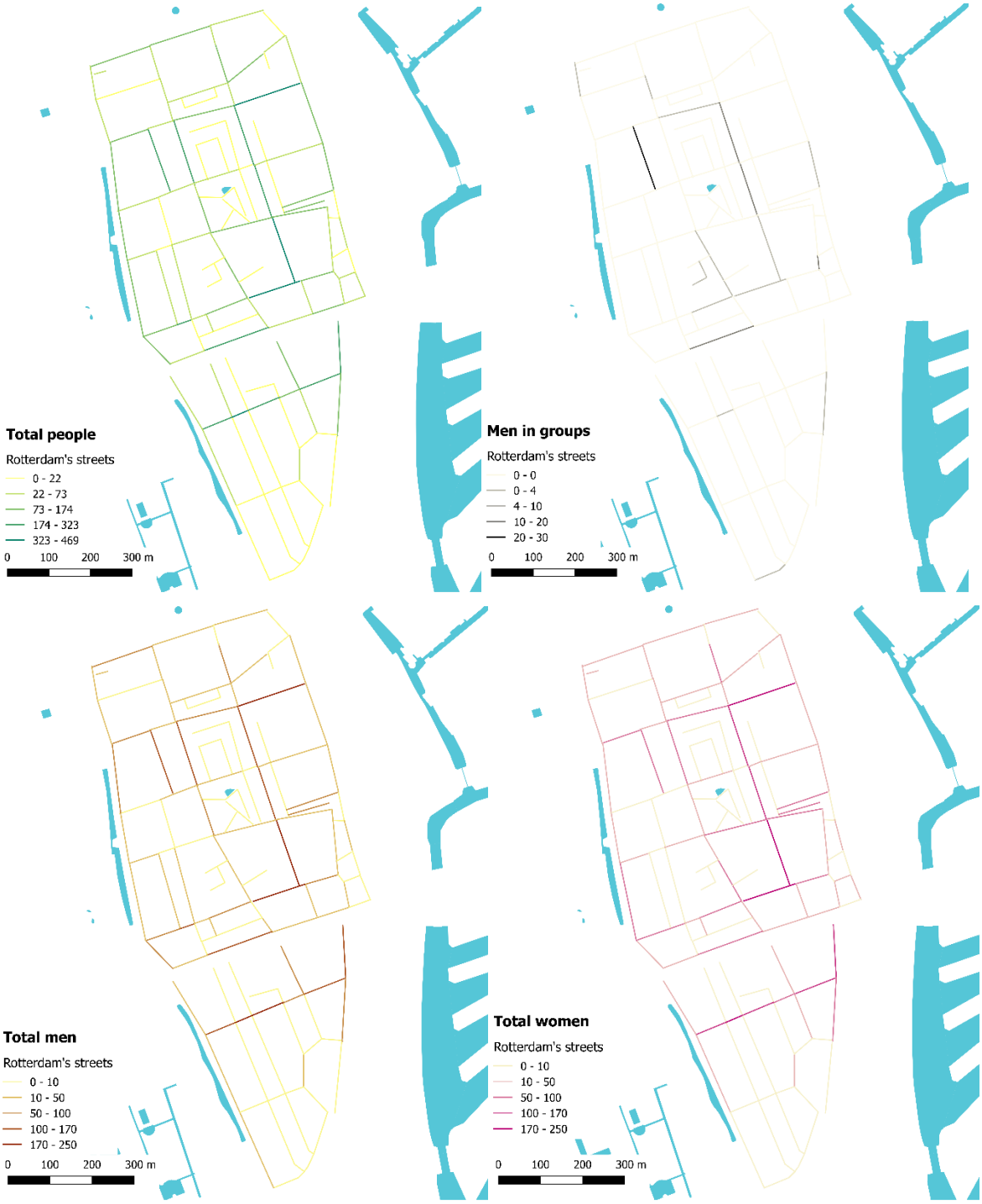


Figure 19: Total people in the street in Cool during a day (top-left), total (young) men in groups (top-right), total women (bottom-right) and total men (bottom-left). Own maps.

4.3.2. Nieuwe Westen

This is a mostly residential neighbourhood, with 19.224 inhabitants[27] and shopping functions in Nieuwe Binnenweg (see main streets on the map at the left of Figure 20), Vierambachstraat and some stores located in Burgemeester Meineszplein, Van Citterstraat, Beukelsdijk and

[27] http://wijkprofiel.rotterdam.nl/nl/2016/rotterdam//delfshaven/nieuwe-westen/

Arlbrechtskade. All businesses are located in mixed-use buildings with residences on the top floor(s), as observable in Figure 20 and Photograph 3, on the left.

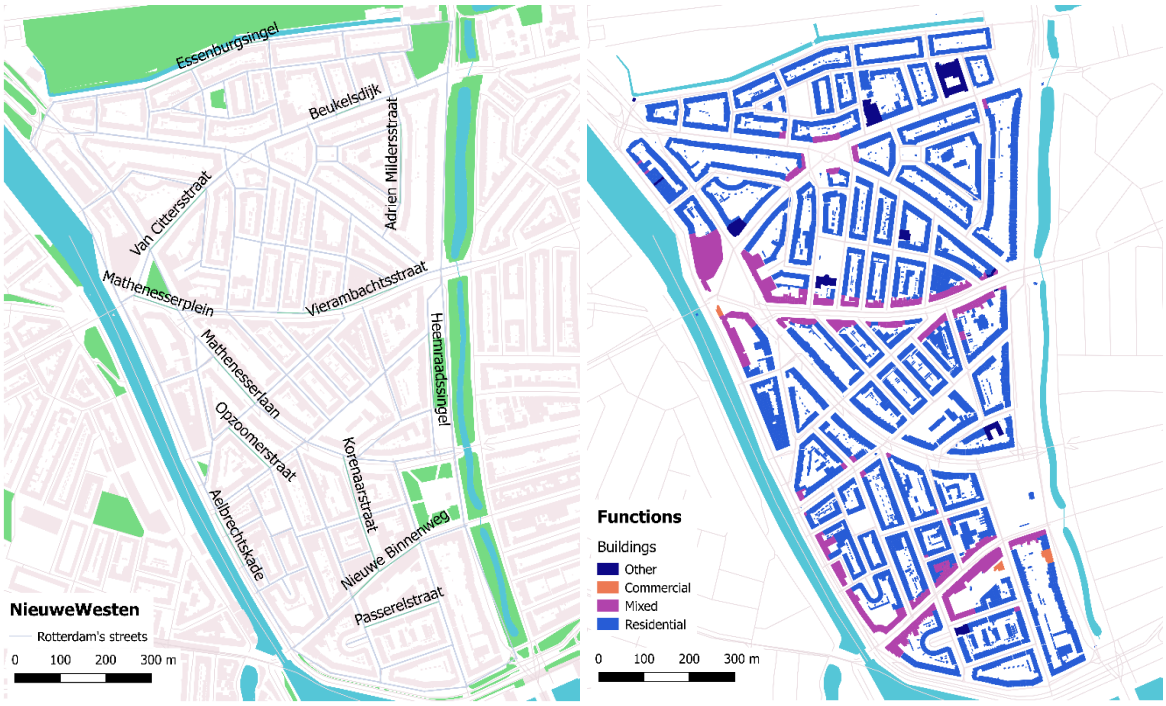


Figure 20: Nieuwe Westen's streets (left) and buildings' functions in the neighbourhood (right). Source: layers from Open Street Maps. Own maps.

Photograph 3: The commercial Vierambachstraat (left) and people in benches and waiting for the bus in Mathenesserplein (right) (Sep/2017). Own photos.

Similarly to the situation in Cool, Space Syntax analysis show the commercial streets to be some of the more locally- and globally-integrated ones in the neighbourhood (Figure 21), in both metrical and angular analyses: Van Cittersstraat, Beukelsdijk, Aelbrechtskade, Nieuwe Binnenweg and Vierambachstraat. The main routes are associated with through-movement in Aelbrechtskade and Nieuwe Binnenweg.

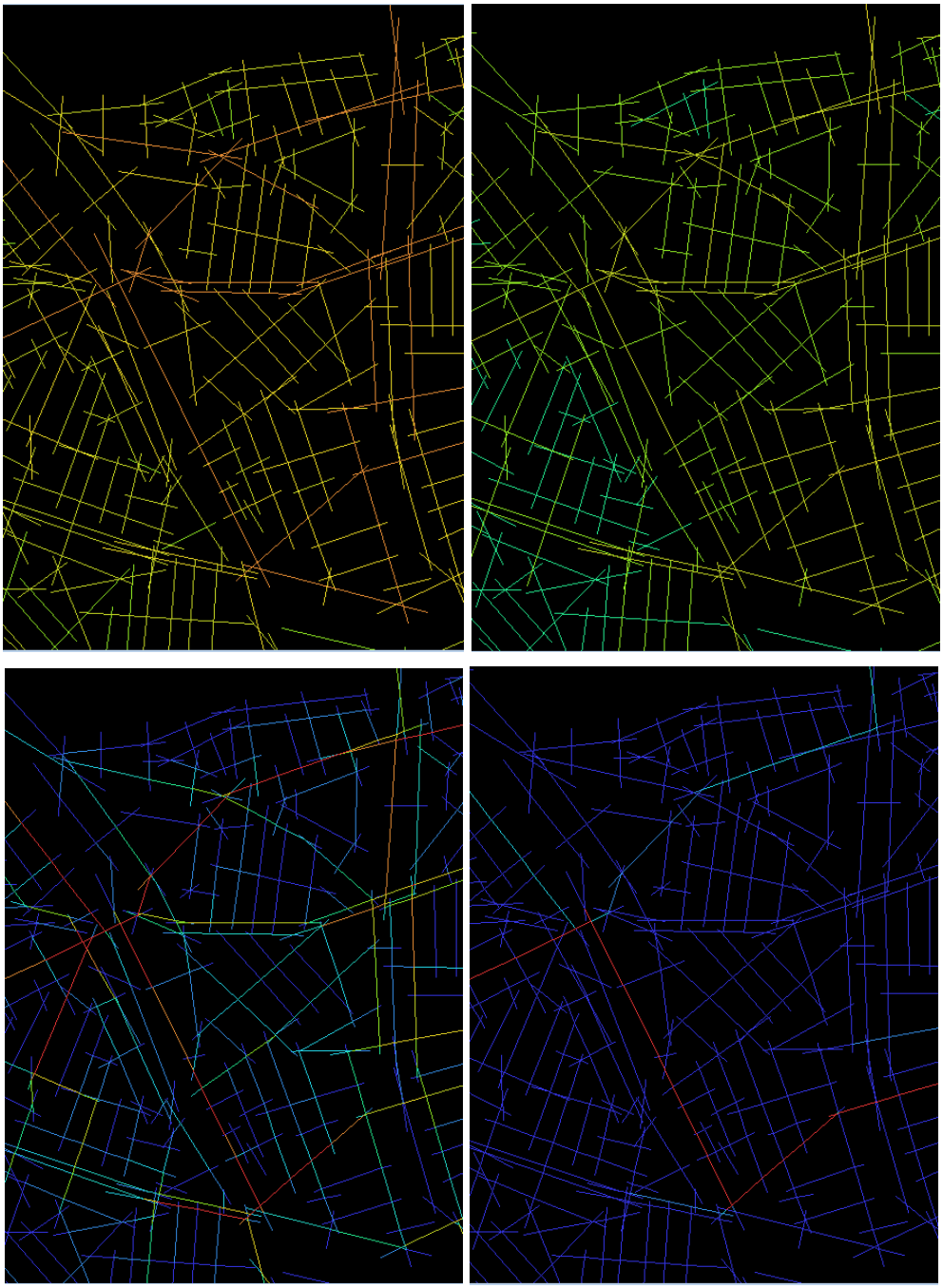


Figure 21: Local (left) and global (right) integration analysis of metrical distance (top) and angular metrical analysis (lower) of local (R02, left) and global (R20, right) radii in Nieuwe Westen.

Most of the neighbourhood's streets have a high density of entrances, which also ensures good inter-visibility (Figure 22). The exception is on the limits of the neighbourhood, due to the canals and wide streets that act as its boundaries.

Figure 22: Density of entrances per 10m of street (left) and degree of inter-visibility of doors and windows on the ground floor (right). Own maps.

4.3.2.1. Movement

Movement in the neighbourhood is very small compared to that in Cool, even in the busiest streets. On a weekday, most people can be seen in the commercial areas: Vierambachstraat, Nieuwe Binnenweg and Mathenesserplein. Eventually groups gather to play in the sport courts in Hofstedestraat and Heemradsingel (Figure 23, top right). In the remainder of the neighbourhood, streets are residential and quiet (like Passerelstraat, in Photograph 4, left). The exceptions are Van Citterstraat and Beukelsdijk, that had comparatively more movement than expected, given their main residential functions.

Photograph 4: Passerelstraat, a typical residential street (left) and Aelbrechstkade: the west neighbourhood limit (right) (Sep/2017). Own photos.

Figure 23: Total people in the street in Nieuwe Westen during a day (top-left), total (young) men in groups (top-right), total women (bottom-right) and total men (bottom-left). Source: Van Nes and De Rooij (2015). Own maps.

4.3.3. Hillesluis

In addition to playing the role of shopping area (Photograph 5) south of the river Maas, Hillesluis is a mainly residential area, with 11.863 inhabitants[28]. The shops are concentrated in Groene Hilledijk, Beijerlandselaan, Beijlandse Passage, Hillevliet and Riederlaan, with some

[28] http://wijkprofiel.rotterdam.nl/nl/2016/rotterdam//feijenoord/hillesluis/

commercial land use also on Bree and Polderlaan, as shown in Figure 24 (map on the left, land use on the right). Like in Nieuwe Westen, businesses are located in mixed buildings with residential use on top.

Photograph 5: busiest shopping streets: Groene Hilledijk (right) and Beijerlandse Passage (left) (Aug, 2017). Own photos.

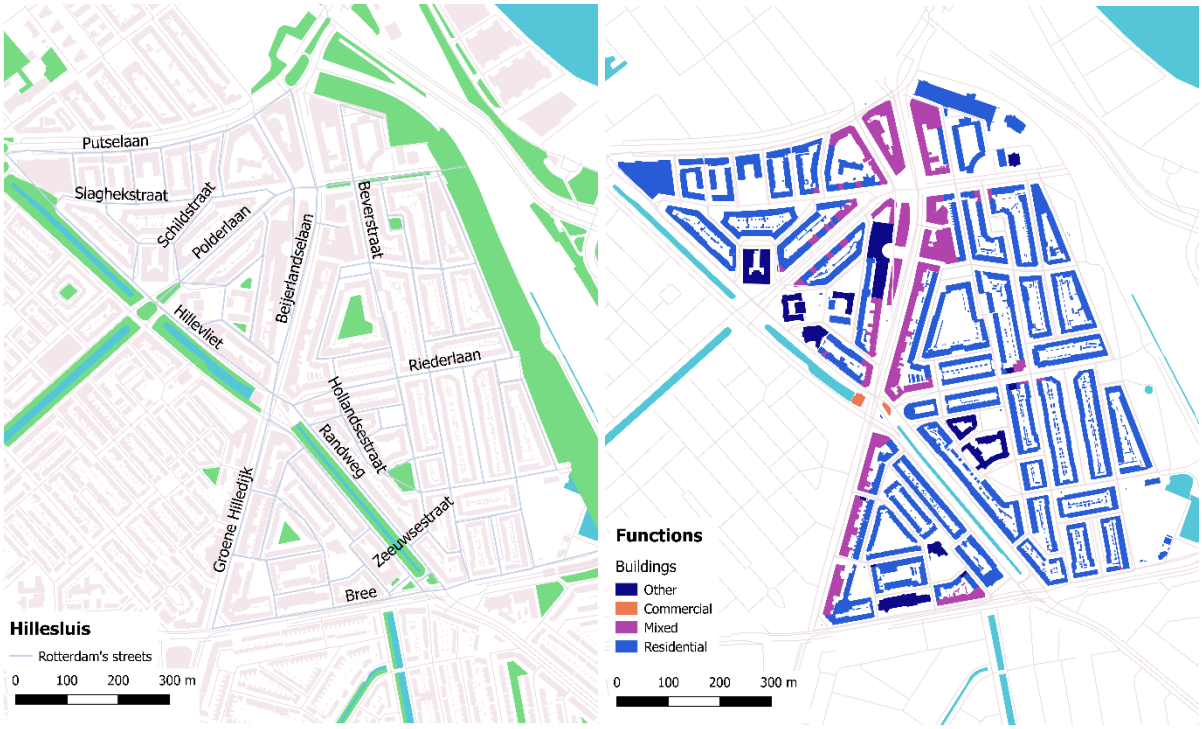


Figure 24: Hillesluis' most important streets (left) and buildings' functions in the neighbourhood (right). Source: layers from Open Street Maps. Own maps.

The mentioned shopping streets coincide with the best locally integrated axes in the area (upper-left on Figure 25), as well as with the segments with higher predicted-to-movement. Interestingly, angular analyses predicts that Groene Hilledijk has higher flows of people than Beijerlandselaan (as observation showed to be the case), even though this would not be obvious through simple observation of the map, since these streets seem to be the natural sequence of each other.

Global integration and through-movement analyses predict the streets with higher vehicular flows to surround Hillesluis: Breeweg, Groene Hilledijk and Hillevliet. As predicted by Hillier and van Nes, where high global and local integration, to and through movement coincide is where the liveliest shopping street can be found: Groene Hilledijk.

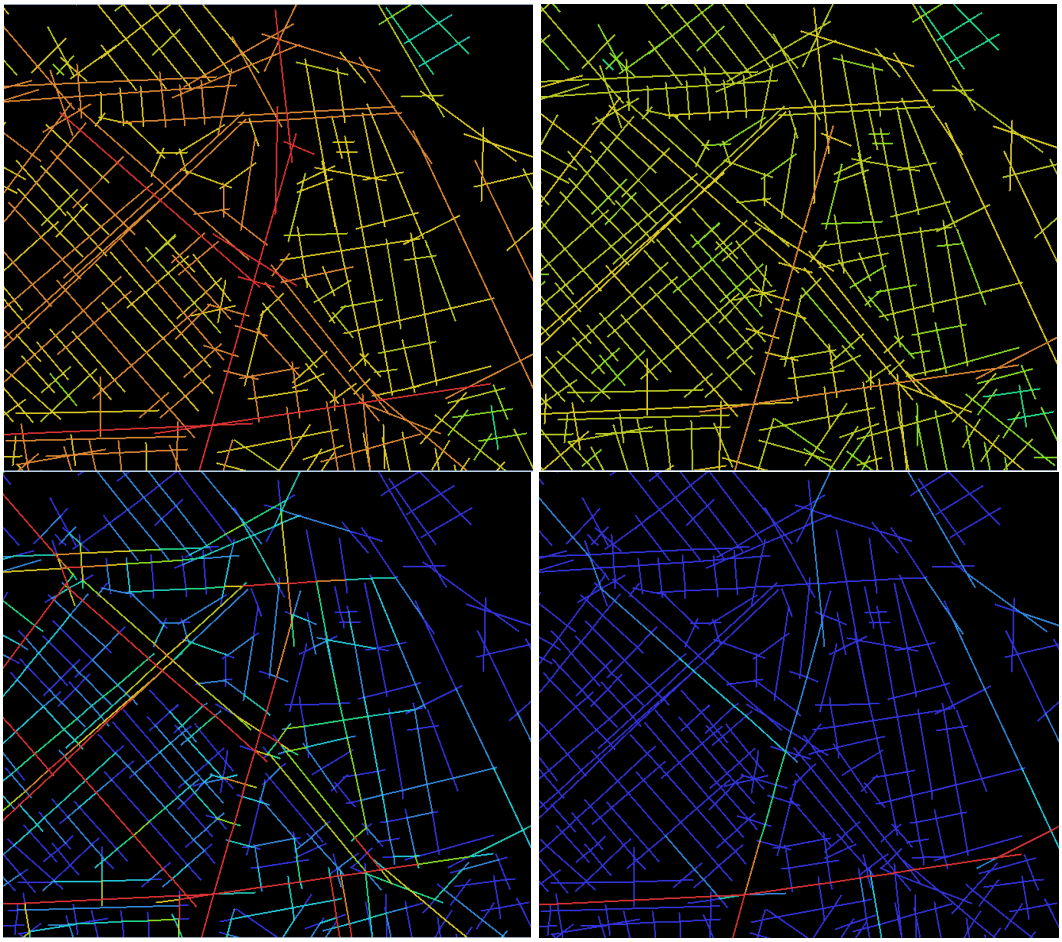


Figure 25: Local (left) and global (right) integration analysis of metrical distance (top) and angular metrical analysis (lower) of local (R02, left) and global (R20, right) radii in Hillesluis. Own analysis.

Inter-visibility depends on a certain density of entrances on both sides of street, which is the reason why streets by the side of canals or parks have reduced visibility, even when they have a high density of entrances, such as West-Varkenoordseweg. In other cases, such as Hillevliet and Randweg, the distance between both sides of the streets and the amount of vegetation and other obstacles to the vision explain the discrepancy between the amount of entrances and the inter-visibility.

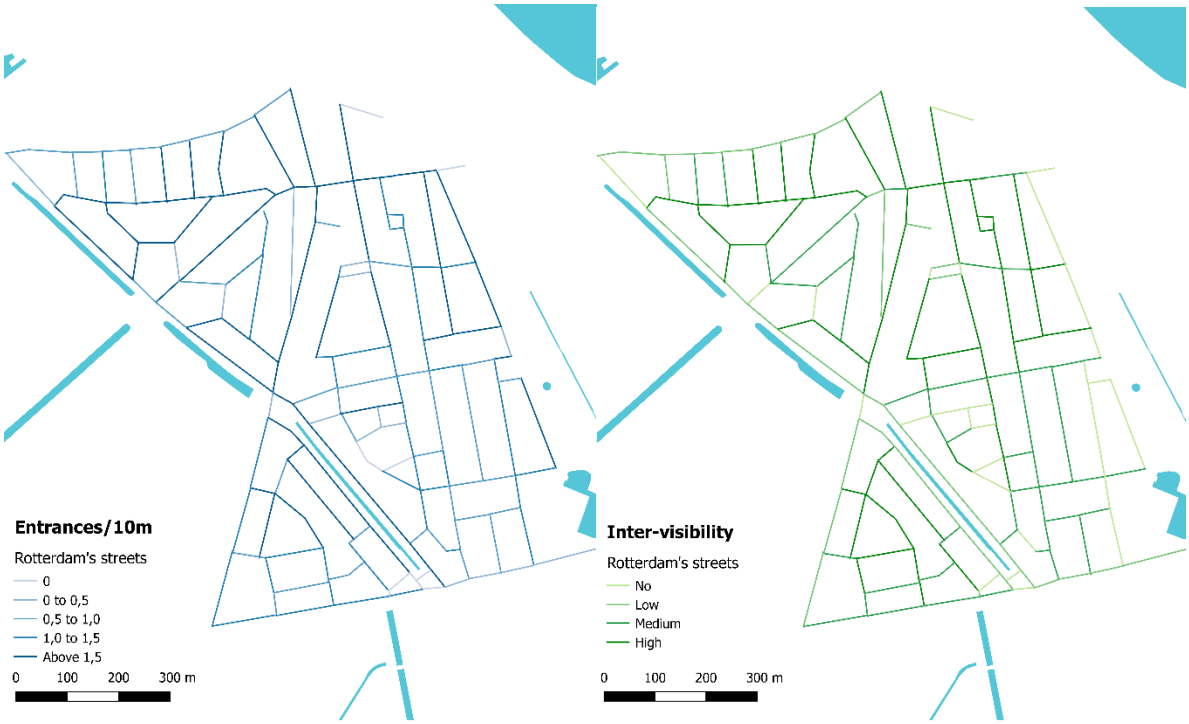


Figure 26: Density of entrances per 10m of street (left) and degree of inter-visibility of doors and windows on the ground floor (right). Own maps.

4.3.3.1. Movement

On a weekday, few people can be seen on the streets in most of the neighbourhood. The largest flows of pedestrians are found on the shopping streets Groene Hilledijk and Beijerlandse Passage. Women can be seen mostly in these shopping streets or at bus stops (Photograph 6, right). Elsewhere, even in streets with commercial use, people are scarce and space seems to be dominated by men: male shop owners, clients on sidewalk tables or men standing watch over the street (in what could perhaps be described as Oscar Newman's feeling of responsibility over the space), but the result is a feeling of hostility, rather than safety (Photograph 6, left). This might be due to the age, language or ethnic difference between these men and the researcher (as described by Fischer and Sprado, 2017), to the researcher's previous unfamiliarity with the neighbourhood (therefore, being in a defensive mindset), or really to the attitude of men in Hillesluis. Two young men on a bench asked the researcher what was the purpose of the photographs that were being taken.

Photograph 6: Men 'own' the streets (left, in Polderlaan) and women are most seen in bus stops (right, in Hilledijk). Own photos (August, 2017).

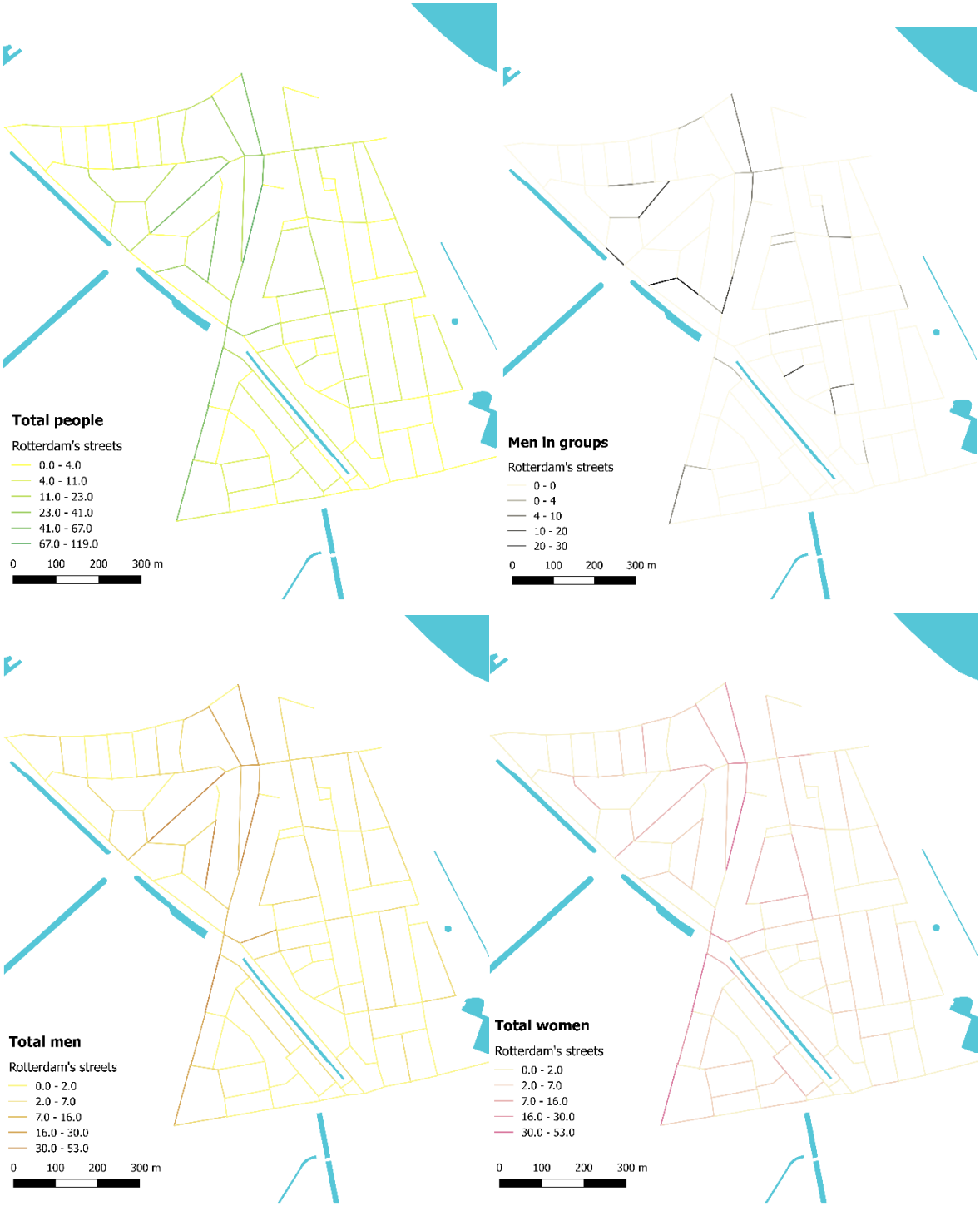


Figure 27: Total people in the street in Hillesluis during a day (top-left), total (young) men in groups (top-right), total women (bottom-right) and total men (bottom-left). Source: Van Nes and De Rooij (2015). Own maps.

4.3.4. Pendrecht

Pendrecht is a suburban residential neighbourhood, with 11.655 inhabitants[29] (in 2016) located south of the Zuiderpark (see map on the left in Figure 28). Differently from Cool and Hillesluis, that mostly follow the Dutch traditional pattern of buildings with entrances facing the street, Pendrecht has many of its buildings facing lawns and pedestrian walks, away from the streets themselves (Photograph 7). There is a shopping area that stretches from Slinge, the main

[29] http://wijkprofiel.rotterdam.nl/nl/2016/rotterdam/charlois/pendrecht/

avenue, to Plein 1953 (right of Photograph 8) and Krabbendijkestraat, in the center of the neighbourhood, and a few other shops in Zijpe street (on the north-west quadrant). Figure 28 (right) shows the land uses in the neighbourhood.

Photograph 7: A typical pedestrian street in Pendrecht (left), and Pendrecht's common buildings with entrances turned away from the street (right) (August, 2017). Own photos.

Photograph 8: Stores in Slinge (left) and in Plein 1953 (Aug/2017). Own photos.

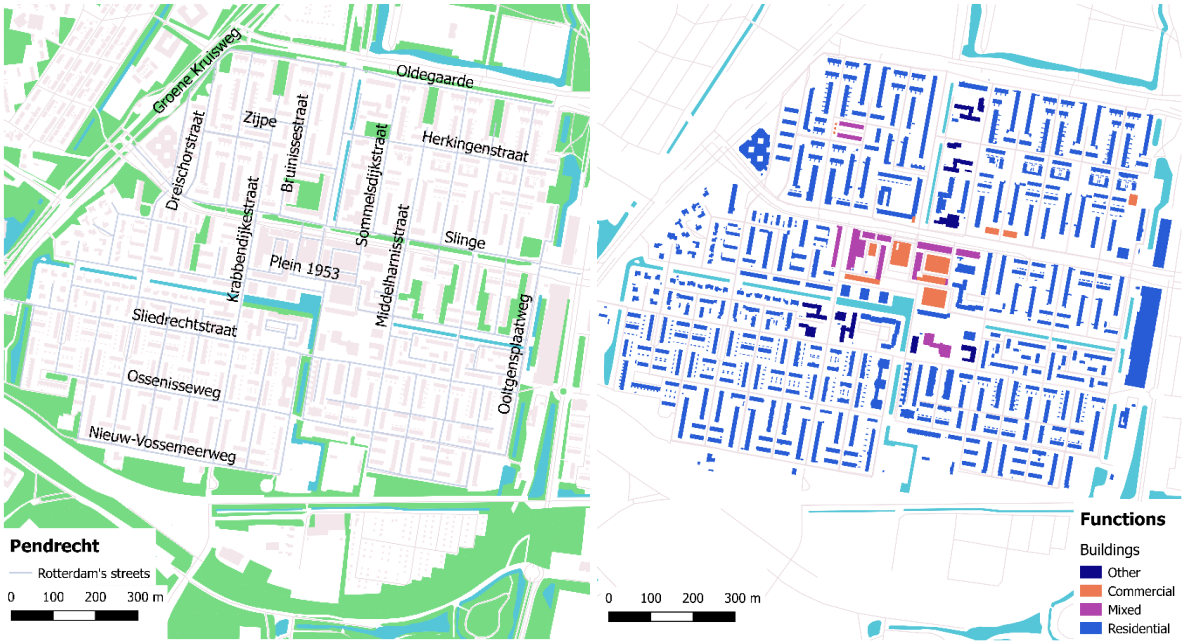


Figure 28: Pendrecht's most important streets (left) and buildings' functions in the neighbourhood (right). Source: layers from Open Street Maps. Own maps.

In Space Syntax analysis, only Slinge and Krabbendijkestraat appear as locally-integrated streets, showing where stores would naturally locate, as they do in Krabbendijkestraat. Plein 1953, however, does not appear as either locally integrated nor expected to attract to-movement, in Figure 29, which might explain why flows of people were quite low during the day, even though this is a main shopping area of the neighbourhood. Global analyses indicate Slinge and streets surrounding the neighbourhood as the attractors of through-movement and most globally-integrated.

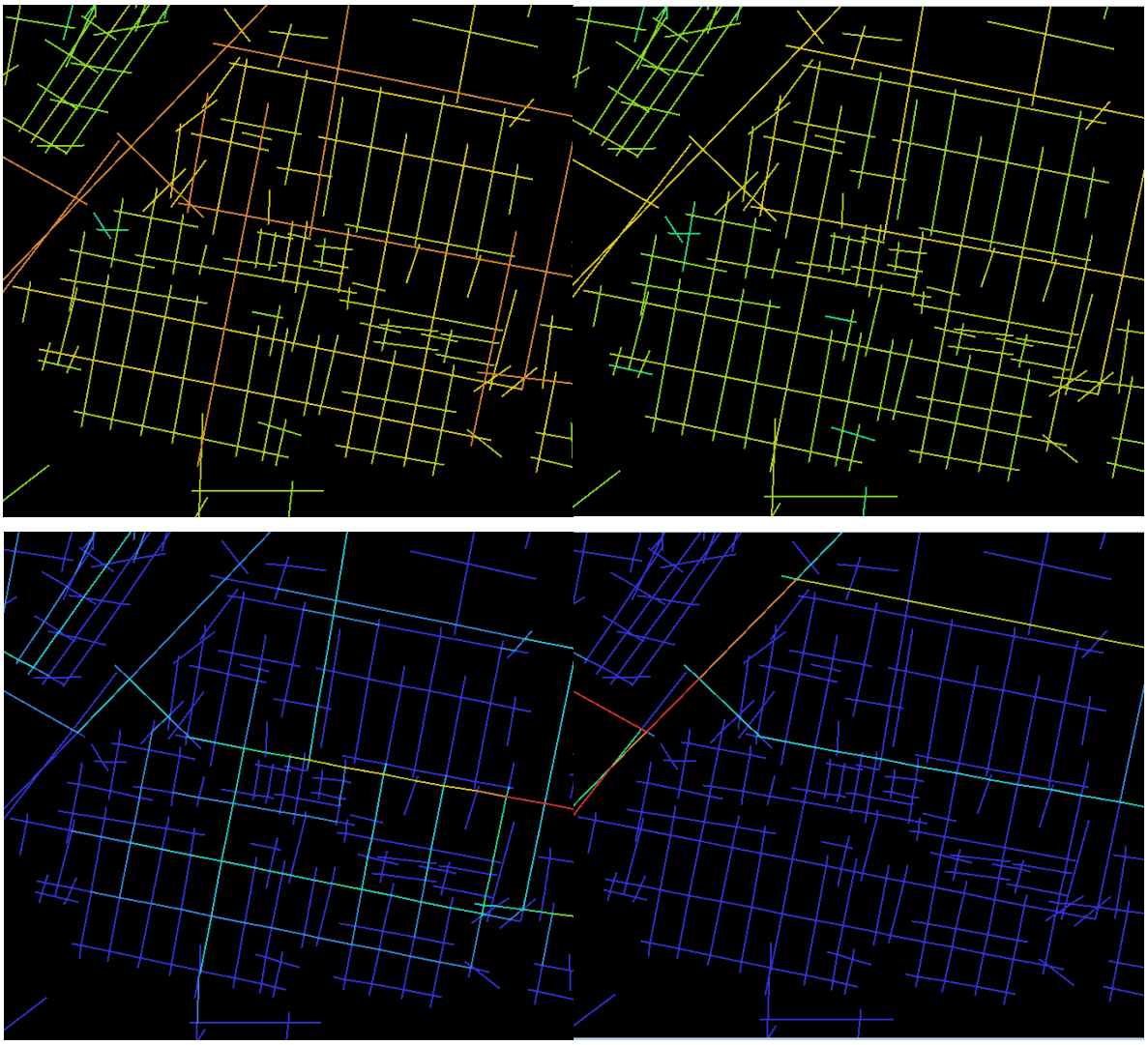


Figure 29: Local (left) and global (right) integration analysis of metrical distance (top) and angular metrical analysis (lower) of local (R02, left) and global (R20, right) radii in in Pendrecht through Space Syntax software DepthMap.

Inter-visibility in the neighbourhood is reduced in most streets, due to the large distances between buildings, or to the fact that each building faces a different direction. Some of the streets with higher density of entrances have them half a floor above the ground, in semi-private corridors that face the communal lawns.

Figure 30: Density of entrances per 10m of street (left) and degree of inter-visibility of doors and windows on the ground floor (right). Own maps.

4.3.4.1. Movement

The area is very quiet, with few people on the streets during the day, even in Plein 1953, Krabbendijkestraat and Slinge, the main shopping areas. It was surprising to see more people inside a supermarket than outside in the street. Most people on the streets were women, elderly people running errands or sitting in the plaza and young men who seemed to be just hanging around.

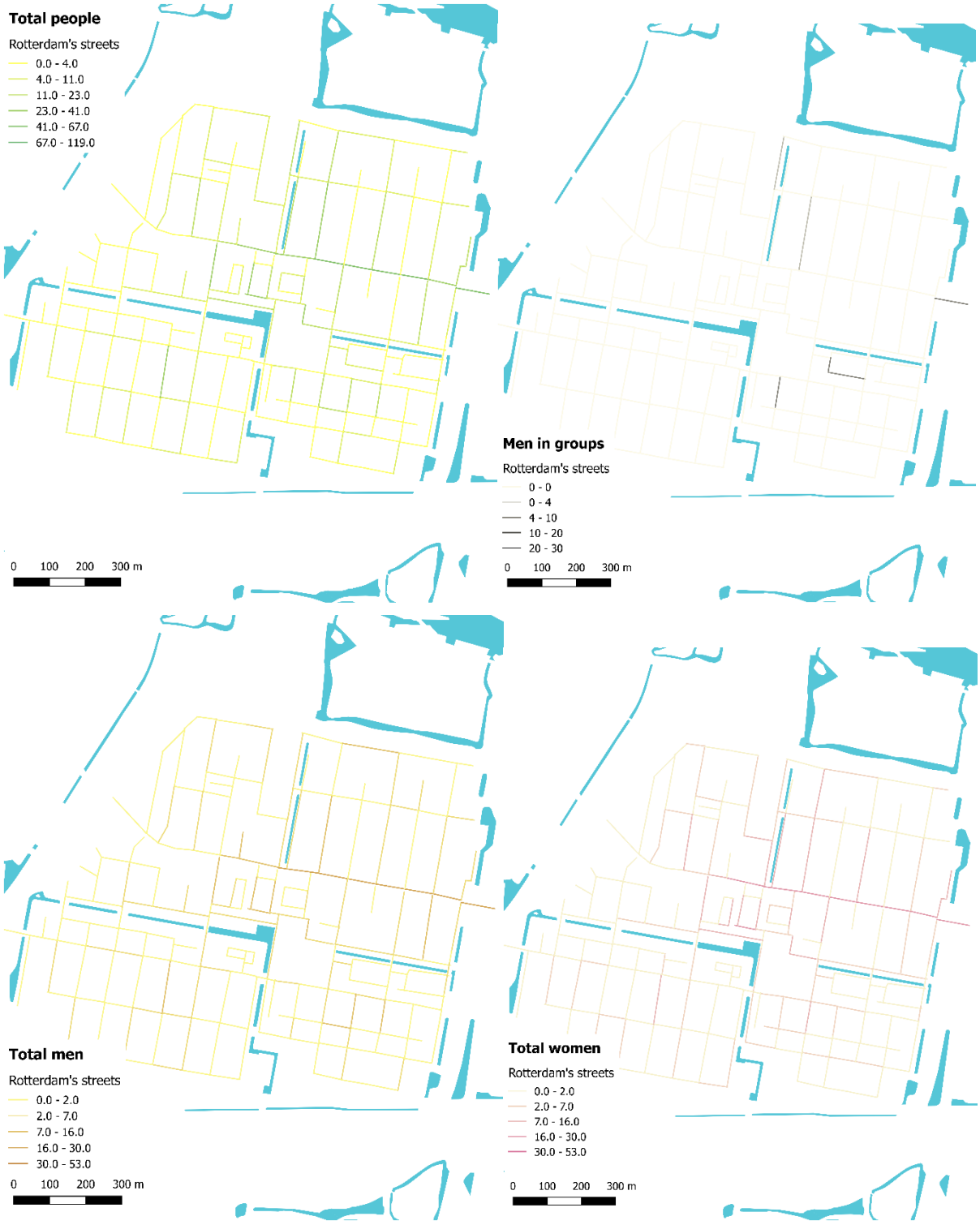


Figure 31: Total people in the street in Pendrecht during a day (top-left), total (young) men in groups (top-right), total women (bottom-right) and total men (bottom-left). Source: Van Nes and De Rooij (2015). Own maps.

4.4. Relationship between sexual violence and spatial features of streets

In this section, a comparison is made between the spatial features of streets and sexual violence cases reported. Graphs are used for the analysis of variables one by one, and statistical models are explored to combine explanatory variables.

4.4.1. Statistical models

The data availability in this research creates two possibilities to calculate statistical models to predict sexual violence cases' distribution based on spatial features of the built environment and based on the people who use the space. One is to aggregate spatial features (which have been collected at block level) into street level (which is the scale at which police reports are available). The other possibility is to disaggregate the police records in blocks. In lack of better proxy, such disaggregation is based on the length of each block proportionately to the total street length (which is not an ideal scenario). The possible consequences are that, in the first case, the individualities of each block's features are lost in the street-level aggregation, thus 'homogenising' the independent variables. In the second case, dividing the number of sexual violence cases equally per block assumes that every block in a street is equally dangerous, which is just as unrealistic. In the face of such adversities, both models were created and are presented hereafter. Table 6 summarises the sample size in each neighbourhood.

Table 6: Characteristics of the modelled space

Neighbourhood	Metres of streets	Street segments (Blocks)	Streets
Cool	13161	134	48
Hillesluis	19306	171	59
Nieuwe westen	26303	190	75
Pendrecht	26013	213	65
Total	**84783**	**708**	**247**

4.4.1.1. Statistical model per block

Table 7 summarizes the variables used in the construction of the Poisson model, and Table 8 presents the three best models obtained in STATA for these variables.

Table 7: Summary of variables for the Poisson model at block scale

Variable	Obs.	Mean	Std. Dev.	Min	Max
Crimes per block	708	.196	.81	0	19
Total women	708	9.75	24.82	0	254
Angular low	708	47838	79836	810	639966
Local Integration	708	1.21	.096	.84	1.47
Crimes per woman	708	.032	.096	0	1
Function	708	.55	.66	0	2

Table 8: Resulting Poisson models at block scale

	(1)	(2)	(3)
VARIABLES	Crimes per block	Crimes per block	Crimes per block
Total women (Tw)	0.0118***	0.0126***	0.0174***
	(0.00)	(0.00)	(0.00)

Crimes per woman (Cw)		3.231***	3.136***
		(0.38)	(0.35)
Local Integration (Li)	3.258***	4.294***	
	(1.19)	(1.14)	
Function (F)	0.797***	0.725***	
	(0.14)	(0.14)	
Angular low (Al)			2.08e-06**
			(0.00)
Constant (c)	-6.663***	-8.112***	-2.383***
	(1.45)	(1.42)	(0.13)
Observations	708	708	708

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

(1) Crimes in a street block = 0.0118*Tw +3.258*Li +0.797*F -6.663

The resulting model shows significant positive correlation between the amount of women in the streets, the local integration, the function of the street (whether it is commercial, mixed or residential) and the occurrence of sexual crimes. Although counter-intuitive at first sight, this result may be explained by the fact that there can be no crimes where there are no women, and that most women can be seen in the shopping areas, which are located in blocks more integrated locally (as seen in the space syntax maps in section 4.3). Most importantly, non-residential streets that may be safe during the day become more dangerous during the night, when natural surveillance (both of eyes *to* the street and of eyes *on* the street) disappears. These hypotheses are supported by the positive correlation between the function of buildings and the occurrence of cases (as 'zero' represents solely residential and values closer to '2' represent non-residential): predominantly commercial streets are associated with higher incidence of crimes, which is in line with the findings of Hillier and Sahbaz (2008) on street robbery.

(2) Crimes in a street block = 0.0126*Tw +3.231*Cw +4.294*Li +0.725*F -8.112

The second model shows the amount of crimes per woman as an additional positive correlate of the total amount of crimes; and the third model includes the measure of to-movement (angular analysis with low metrical radius) as a positive significant variable of the sexual crimes against women in a block:

(3) Crimes in a street block = 0.0174*Tw +3.136*Cw +2.08*e-06*Al -2.383

This result can be explained by the fact that commercial blocks are attractors of movement and tend to have higher to-movement. If commercial blocks are associated with higher rates of sexual violence, then it is expected that higher to-movement will be associated with it, as well.

4.4.1.2. Statistical model per street

Table 9 summarizes the variables used in the construction of the Poisson model, and Table 10 presents the two best models obtained in STATA for those variables.

Table 9: Summary of variables for the Poisson model at street scale

Variable	Obs.	Mean	Std. Dev.	Min	Max
Crimes (2012-2017)	247	.57	1.75	0	19
Crimes person	247	.019	.094	0	1
Crimes woman	247	.032	.125	0	1
Total women	247	28.0	77.2	0	721
Local Integration	247	1.19	.088	.94	1.47
Global Integration	247	.65	.033	.57	.76
Angular low	247	33,499	64,333	810	608091
Angular high	247	2,653,867	1.41e+07	62614	1.51e+08
Function of buildings	247	.54	.60	0	2
Constitutedness	247	.89	.29	0	1
Visibility	247	1.53	1.16	0	3
Density of entrances	247	1.20	.63	0	2.98

Table 10: Resulting Poisson models at street scale

	(1)	(2)
VARIABLES	Crimes1217	Crimes1217
Crimes per woman (Cw)	2.679***	2.890***
	(0.37)	(0.36)
Total women on street (Tw)	0.00346***	0.00499***
	(0.00)	(0.00)
Local Integration (Li)	6.832***	9.609***
	(1.12)	(1.36)
Function street (F)	0.996***	
	(0.14)	
Visibility street (V)	-0.141*	-0.179**
	(0.08)	(0.08)
Angular low (Al)		-2.17e-06*
		(0.00)
Constant (c)	-10.05***	-12.52***
	(1.42)	(1.68)
Observations	247	247

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

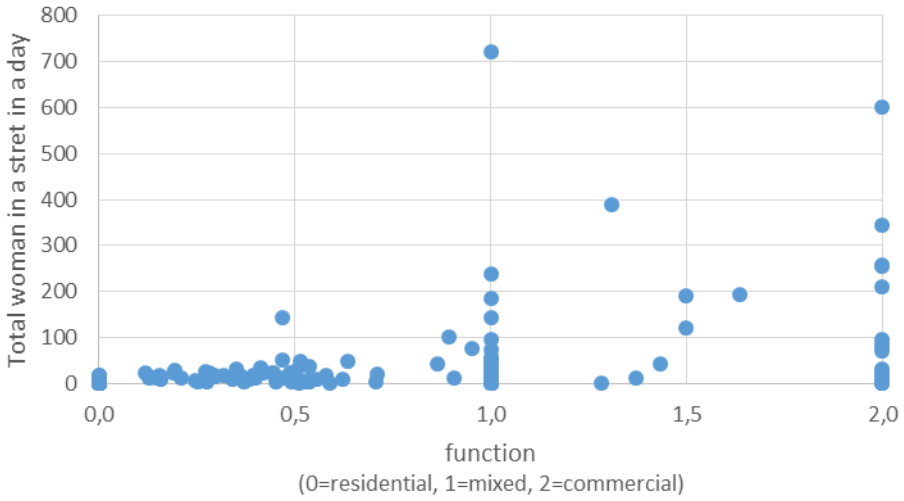
(1) Crimes in a street = 2.68*Cw +0.0035*Tw +6.83*Li +0.996*F -0.14*V -10.1

The resulting models at street scale are mostly similar to those at block scale. For the first model, there is a positive and high correlation between crimes per woman, the amount of women on a street, the local integration and the function of the street, and negative correlation with visibility. This means that higher flows of woman, higher rates of crimes per woman, higher local integration and more commercial streets are associated with more crime, while higher inter-visibility of entrances and doors is correlated with lower amounts of sexual crimes per street. The association between more women and commercial streets with crime has been covered in the previous segment (the statistical models at block level). The negative relation between inter-visibility of entrances and the incidence of crime is in line with Jane Jacobs school of thought, according to which greater natural surveillance results in greater safety in the streets.

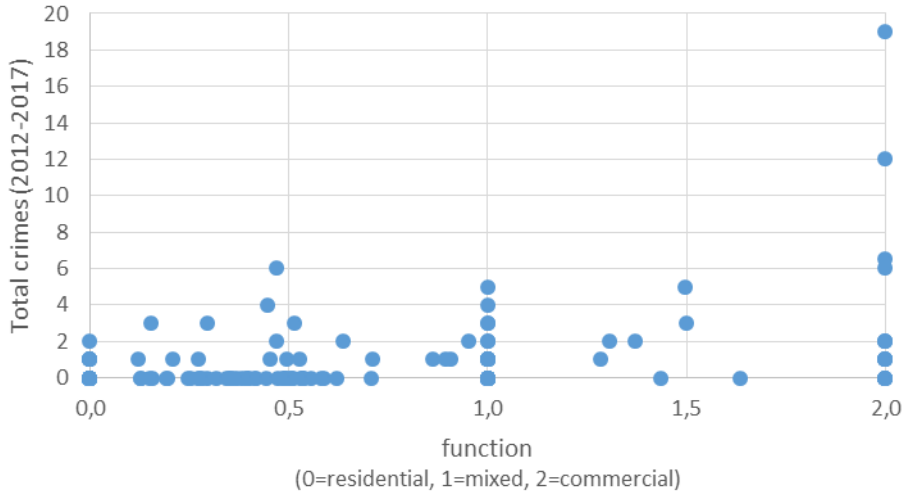
(2) Crimes in a street = 2.89*Cw +0.0050*Tw +9.61*Li -0.18*V -2.17e-6*Al -12.5

The second model includes angular low values instead of the street function. It indicates that streets with larger to-movement are correlated with lower number of crime reports. The difference between the sign of to-movement at street scale and at block scale could indicate that, on average, a street with higher flow of people has fewer crimes (specially in residential neighbourhoods), but the block that attracts such movement (usually a commercial one), has more crimes because of the lack of surveillance after stores close.

To illustrate the relationship between the variables, Graph 15 presents the distribution of total women in a street in a day according to the street function: although it is not determinant, there is a clear tendency of higher amounts of women to be associated with non-residential streets. Next, Graph 16 shows a certain association between higher incidence of sexual violence and non-residential streets.



Graph 15: Total women on the street per street function



Graph 16: Total crimes per street per street function

4.5. Characteristics of streets with higher incidence of sexual violence

This section presents an analysis of the characteristics of streets where sexual violence happens.

4.5.1. Cool

Figure 32 highlights streets with most sexual violence reports, streets with most reports per 100 meters, and blocks with most reports per pedestrian (from the average of pedestrians counted in a weekday) in Cool. Their details are presented in Table 11 (most cases) and Table 12 (most cases/woman in the street).

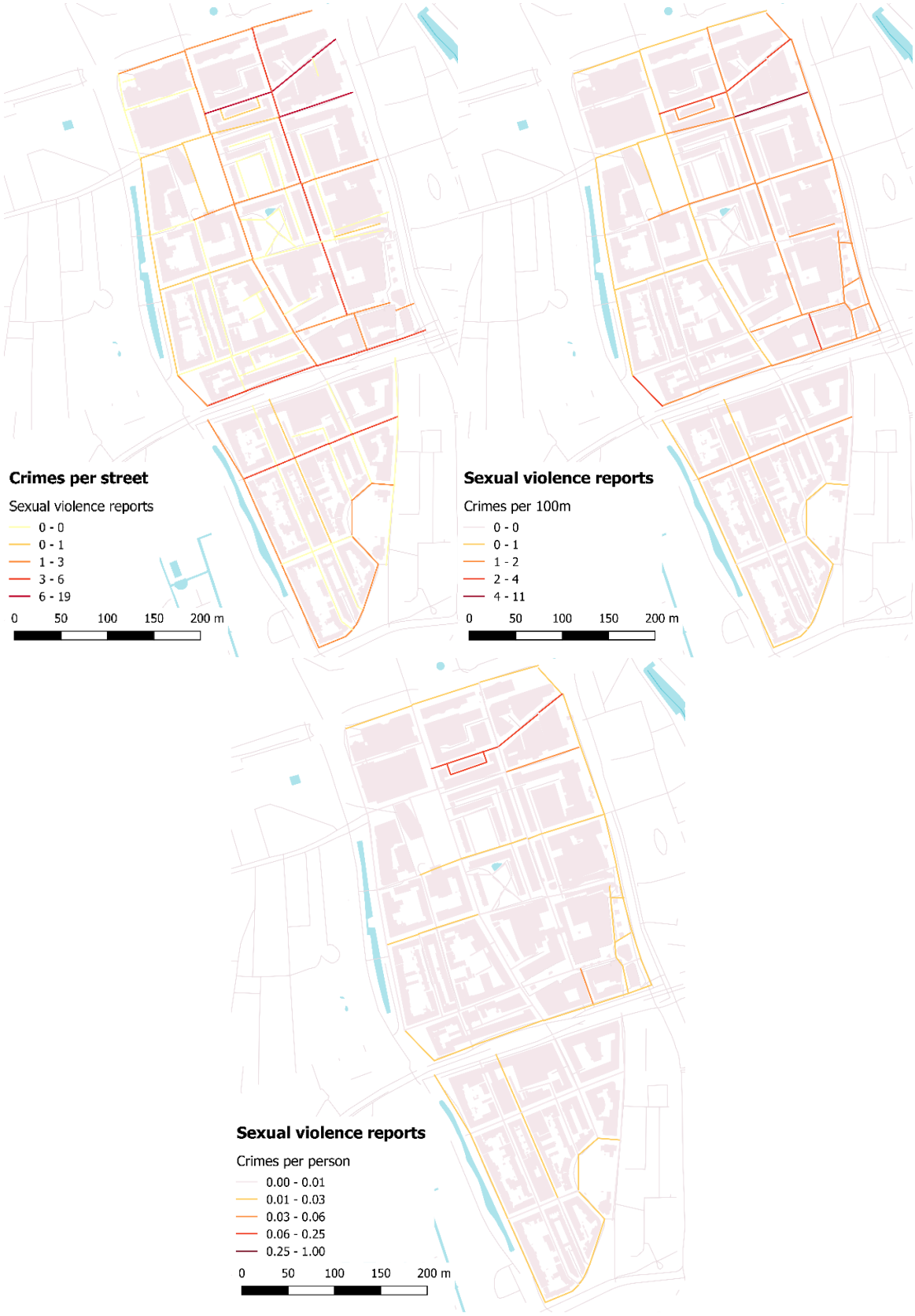


Figure 32: Streets with more sexual violence (left), with more reports per 100m (centre) and more reports per person (right) in Cool. Source: Rotterdam police, own analysis and maps

The five most dangerous streets in Cool based on the total number of reported cases in the 2012-2017 period, are Stadhuisplein, Kruiskade, Coolsingel, Lijnbaan and Westblaak, which

are all commercial, constituted streets that attract tens, even hundreds of people in a day. However, dividing the number of crimes by the number of women seen on the street in a weekday, the riskiest streets change considerably: Kruiskadehof, Kruiskade, Boomgaardstraat, Keerweer and Stadhuisplein. This list includes streets that have very low flows of people (Kruiskadehof, Boomgaardsstraat, one being a service street - behind shops and restaurants - and the other residential, respectively), and streets with high amounts of crime (Kruiskade and Stadhuisplein).

Stadhuis and Kruiskade are nightlife spots. Visibility is low in Coolsingel, Westblaak and Kruiskadehof, and the density of entrances is specially low in Coolsingel and Keerweer, as can be seen in the tables below.

Table 11: Five most dangerous streets in Cool – total amount of reports

Name	Crimes ('12-'17)	Crimes/ woman	Crimes/ 100m	Total women	Total young men	Total people	Angular low	Angular high	Local Integr.	Global Integr.	Function	Visibility	Density of entrances
Stadhuisplein	19	0,07	11,43	254	0	469	20035	508299	1,28	0,67	Non-res	2,0	0,9
Kruiskade	12	0,17	3,75	70	0	145	21410	409221	1,24	0,66	Non-res	3,0	0,9
Coolsingel	6,5	0,03	0,63	257	11	525	86826	11519603	1,31	0,70	Non-res	0,5	0,3
Lijnbaan	6	0,01	0,93	602	15	1140	81385	1882594	1,28	0,68	Non-res	2,8	1,4
Westblaak	5	0,03	1,01	192	7	407	89461	3094166	1,30	0,71	Non-res	0,7	0,9

Table 12: Five most dangerous streets in Cool – crimes/woman

Name	Crimes ('12-'17)	Crimes/ woman	Crimes/ 100m	Total women	Total young men	Total people	Angular low	Angular high	Local Integr.	Global Integr.	Function	Visibility	Density
Kruiskadehof	1	0,50	0,76	2	0	4	5387	183909	1,02	0,58	Non-res	0,0	2,2
Kruiskade	12	0,17	3,75	70	0	145	21410	409221	1,24	0,66	Non-res	3,0	0,9
Boomgaardsstraat	1	0,09	0,30	11	0	31	27692	775486	1,24	0,67	Mixed	2,2	2,0
Keerweer	2	0,09	2,55	22	0	42	7445	188412	1,22	0,67	Non-res	3,0	0,4
Stadhuisplein	19	0,07	11,43	254	0	469	20035	508299	1,28	0,67	Non-res	2,0	0,9

Based on the apparent convergence between Cool's non-residential land use, night time activities and high incidence of sexual violence reports, Figure 33 illustrates solely non-residential or mixed non-residential/residential buildings that are open in the evening and, in some cases, at night, together with the streets with most criminal events. Although there might be a correlation between the two factors, it is not determinant (for instance, Schowburgplein,

that concentrates a big cinema complex and restaurants, has a low rate of reported sexual violence).

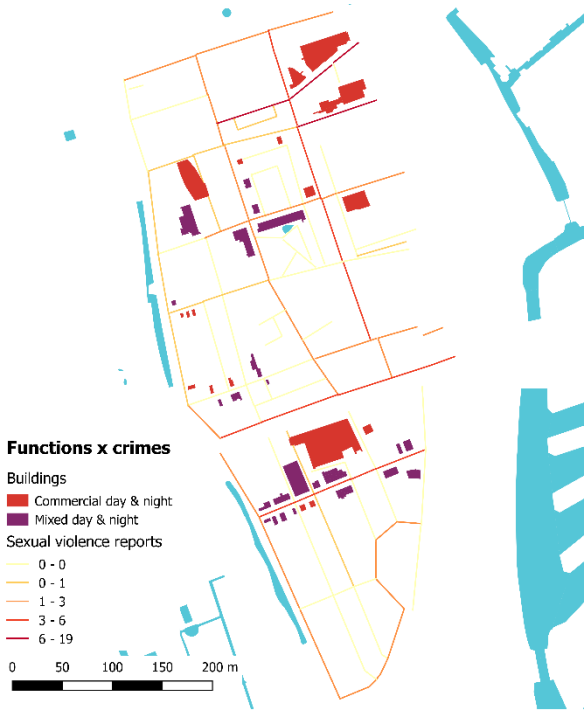


Figure 33: Functions of buildings x sexual crimes in the streets of Cool

4.5.2. Nieuwe Westen

Figure 34 shows streets with more incidents, streets with most reports per 100 meters, and blocks with most reports per pedestrian (from the average of pedestrians counted in a weekday). It is noteworthy that the riskier streets (those with higher rate of crimes/person) are not the most important pedestrian streets.

Figure 34: Streets with more sexual violence (left), with more reports per 100m (centre) and more reports per person (right) in Nieuwe Westen. Source: Rotterdam police, own analysis and maps.

Mathenesserplein, is the only commercial street amongst the most dangerous of Nieuwe Westen (both in absolute numbers and in crimes/woman). The others are mostly residential. Yet, all of them have a high density of entrances, and only Essenburgsingel has poor visibility. All of the streets in the riskiest list (Table 14) have extremely low pedestrian flows during the day.

Table 13: Nieuwe Westen's five most dangerous streets – total amount of reports

Name	Crimes ('12-'17)	Crimes/ woman	Crimes/ 100m	Total women	Total young men	Total people	Angular low	Angular high	Local Integr.	Global Integr.	Function	Visibility	Density of entrances
Beukelsdijk	4	0,17	0,53	24	4	49	214349	11987178	1,34	0,67	Residential	2,6	1,8
Essenburgsingel	3	0,17	0,20	18	0	27	13944	321375	1,10	0,59	Residential	0,0	1,7
Heemraadssingel	3	0,06	0,20	49	29	128	79026	1455107	1,28	0,66	Residential	0,8	1,8
Mathenesserlaan	2	0,04	0,18	49	4	112	45398	2151135	1,24	0,65	Residential	2,4	1,7
Mathenesserplein	2	0,17	0,45	12	13	63	94925	2940314	1,26	0,64	Mixed	2,0	1,6

Table 14: Five most dangerous streets in Nieuwe Westen – crimes/woman

Name	Crimes ('12-'17)	Crimes/ woman	Crimes/ 100m	Total women	Total young men	Total people	Angular low	Angular high	Local Integr.	Global Integr.	Function	Visibility	Density of entrances
Opzoomerstraat	1	1,00	0,58	1	0	4	14191	234321	1,19	0,63	Mixed	3,0	1,8
Passerelstraat	1	0,33	0,37	3	2	10	7331	208686	1,18	0,64	Mixed	2,0	1,8
Beukelsdijk	4	0,17	0,53	24	4	49	214349	11987178	1,34	0,67	Residential	2,6	1,8
Essenburgsingel	3	0,17	0,20	18	0	27	13944	321375	1,10	0,59	Residential	0,0	1,7
Mathenesserplein	2	0,17	0,45	12	13	63	94925	2940314	1,26	0,64	Mixed	2,0	1,6

4.5.3. Hillesluis

Figure 35 shows streets with more incidents, streets with most reports per 100 meters, and blocks with most reports per pedestrian (from the average of pedestrians counted in a weekday). As in Nieuwe Westen, some of the riskier streets (those with higher rate of crimes/person), such as Hollandsestraat and Zeeuwsestraat, are not the ones with higher absolute number of sexual violence reports.

Figure 35: Streets with more sexual violence (left), with more reports per 100m (centre) and more reports per person (right) in Hillesluis. Source: Rotterdam police, own analysis and maps.

In Hillesluis, most-dangerous streets (in both absolute numbers and risk) have considerable density of entrances and are mostly residential, with the exception of Beijerlandselaan. The streets with higher rates of crimes per woman all have very low flows of people (Table 16).

Table 15: Five most dangerous streets in Hillesluis – total amount of reports

Name	Crimes ('12-'17)	Crimes/ woman	Crimes/ 100m	Total women	Total young men	Total people	Angular low	Angular high	Local Integr.	Global Integr.	Function	Visibility	Density of entrances
Beijerlandselaan	4	0,04	0,63	96	36	254	187998	10573190	1,45	0,74	Mixed	3,0	1,8
Randweg	3	0,19	0,51	16	2	28	71416	858300	1,34	0,71	Residential	1,0	1,6
Hillevliet	1	0,50	0,26	4	12	25	87522	1184901	1,36	0,70	Residential	1,0	1,5
Hollandsestraat	1	0,33	0,24	3	0	10	13022	314025	1,19	0,65	Residential	1,8	0,8
Schildstraat	1	0,20	0,44	5	12	24	15570	326015	1,18	0,63	Mixed	2,3	1,2

Table 16: Five most dangerous streets in Hillesluis – crimes/woman

Name	Crimes ('12-'17)	Crimes/ woman	Crimes/ 100m	Total women	Total young men	Total people	Angular low	Angular high	Local Integr.	Global Integr.	Function	Visibility	Density of entrances
Hillevliet	1	0,50	0,26	4	12	25	87522	1184901	1,36	0,70	Mixed	1,0	1,5
Hollandsestraat	1	0,33	0,24	3	0	10	13022	314025	1,19	0,65	Mixed	1,8	0,8
Schildstraat	1	0,20	0,44	5	12	24	15570	326015	1,18	0,63	Mixed	2,3	1,2
Randweg	3	0,19	0,51	16	2	28	71416	858300	1,34	0,71	Residential	1,0	1,6
Bree	1	0,08	0,14	12	0	21	608092	144356529	1,41	0,76	Mixed	1,8	1,1

4.5.4. Pendrecht

Figure 36 shows streets with more incidents, streets with most reports per 100 meters, and blocks with most reports per pedestrian (from the average of pedestrians counted in a weekday). As in previous neighbourhoods, the riskier streets (those with higher rate of crimes/person), Groene Kruisweg and Dreichorstraat, do not have a high absolute number of sexual violence reports.

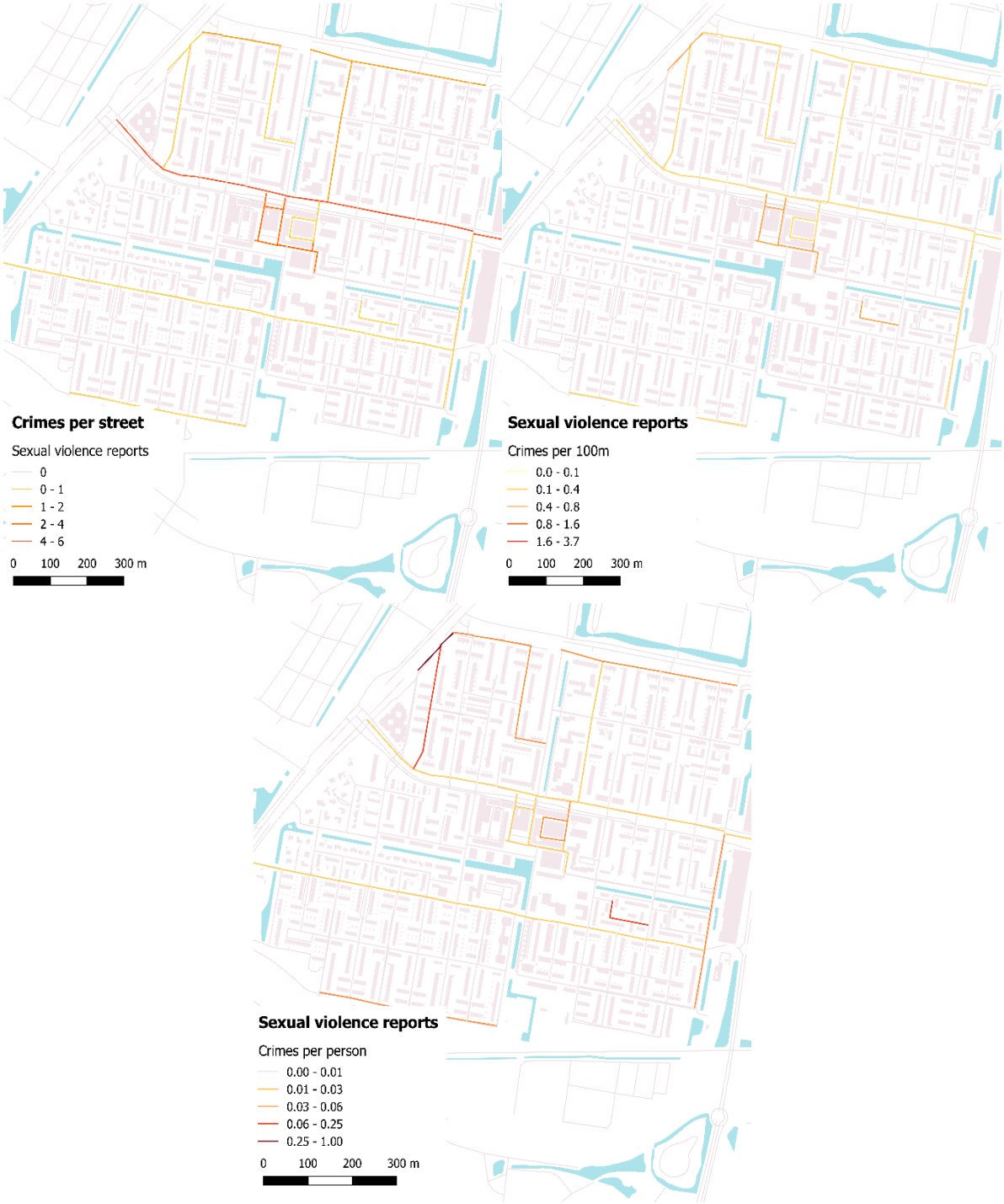


Figure 36: Streets with more sexual violence (left), with more reports per 100m (centre) and more reports per person (right) in Pendrecht. Source: Rotterdam police, own analysis and maps

Pendrecht's most dangerous streets (in absolute numbers) include Plein 1953 and Slinge, which are commercial or at least partly so. The riskier streets (in both absolute and proportional number) have very low visibility, which is no surprise in a neighbourhood built in the post – war period according to modernist ideals. However, comparison with the riskier streets in Nieuwe Westen seem to show that density of entrances and inter-visibility do not play a determinant role, since they are both high in Nieuwe Westen's riskier streets, and low in Pendrecht's riskier streets (in both absolute numbers and crimes/woman). Lastly, all streets in Table 18 have low flows of people.

Table 17: Pendrecht's five streets with most sexual violence reports

Name	Crimes ('12-'17)	Crimes/ woman	Crimes/ 100m	Total women	Total young men	Total people	Angular low	Angular high	Local Integr.	Global Integr.	Function	Visibility	Density of entrances
Slinge	6	0,04	0,34	143	9	276	76969	10809872	1,35	0,72	0,5	0,0	0,4
Plein 1953	3	0,04	0,46	73	0	125	9742	278219	1,16	0,65	1,0	0,3	0,4
Oldegaarde	2	0,14	0,18	14	0	34	17237	551524	1,17	0,66	0,0	0,0	1,2
Sommelsdijkstraat	2	0,04	0,27	24	4	42	5433	170509	1,08	0,62	1,0	0,0	1,3
Baarlandhof	1	0,05	0,29	19	0	28	12147	465554	1,15	0,65	1,0	0,0	1,2

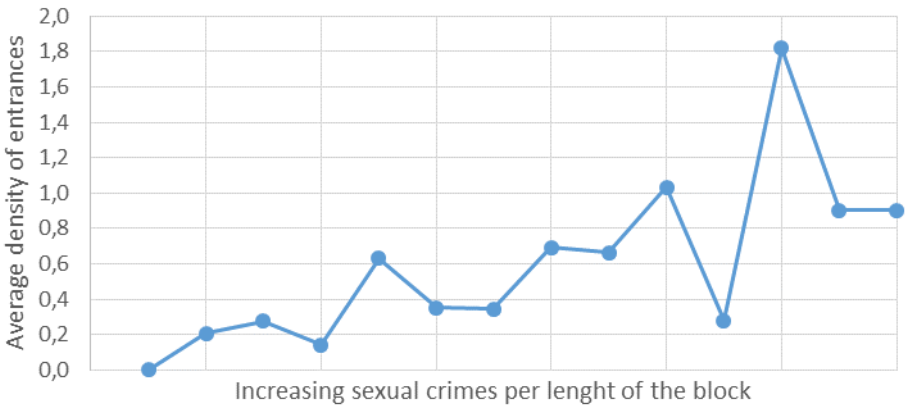
Table 18: Pendrecht's five streets with most crimes/woman

Name	Crimes ('12-'17)	Crimes/ woman	Crimes/ 100m	Total women	Total young men	Total people	Angular low	Angular high	Local Integr.	Global Integr.	Function	Visibility	Density of entrances
Groene Kruisweg	1	1,00	0,57	1	0	1	6020	66251	1,09	0,66	Mixed	0,0	0,3
Papendrechtstraat	1	1,00	0,46	1	5	6	5210	194992	1,12	0,64	Residential	1,0	1,3
Dreischorstraat	1	0,20	0,29	5	0	9	12614	562190	1,28	0,70	Residential	0,0	0,0
Oldegaarde	2	0,14	0,18	14	0	34	17237	551524	1,17	0,66	Residential	0,0	1,2
Nieuw-Vossemeerweg	1	0,13	0,13	8	0	16	5867	469294	1,13	0,64	Residential	0,0	0,3

4.5.5. General characteristics

Inspired by Hillier and Sahbaz (2008), the next analyses are conducted by grouping street blocks by the rate of sexual violence reports per 100 metres. This facilitates patterns to emerge without the influence of the length of the block (since, statistically speaking, longer blocks can be expected to have more violence reports). It also allows us to investigate whether blocks with higher rates of sexual crime per unit of length have different characteristics from those with lower rates, as Hillier and Sahbaz investigated with street robbery.

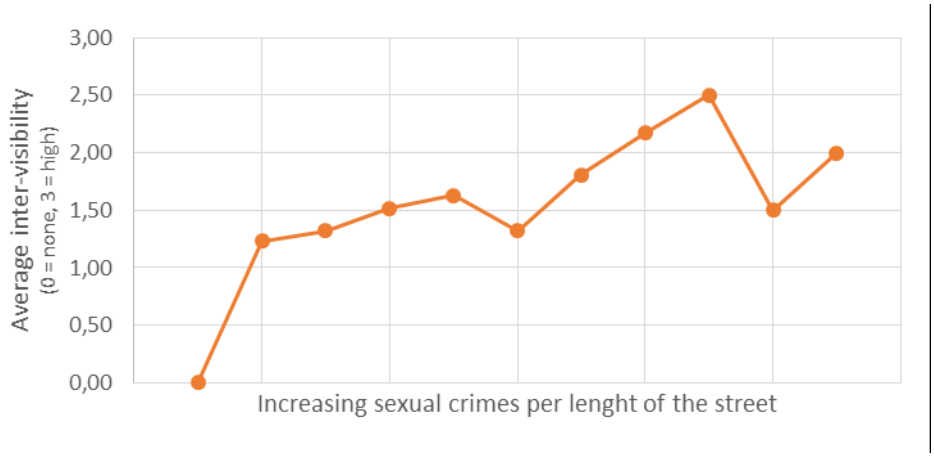
Graph 17 shows a tendency of higher densities of sexual violence to be associated with higher densities of entrances, although three of the last four points seem to indicate a second curve with smaller average densities of entrances to be associated with high levels of crime. This supports the hypothesis raised previously in this study about the different mechanisms that govern sexual violence in public spaces: one in non-residential blocks and another in residential areas.



Graph 17: Average density of entrances with increasing incidence of sexual violence per length of the block

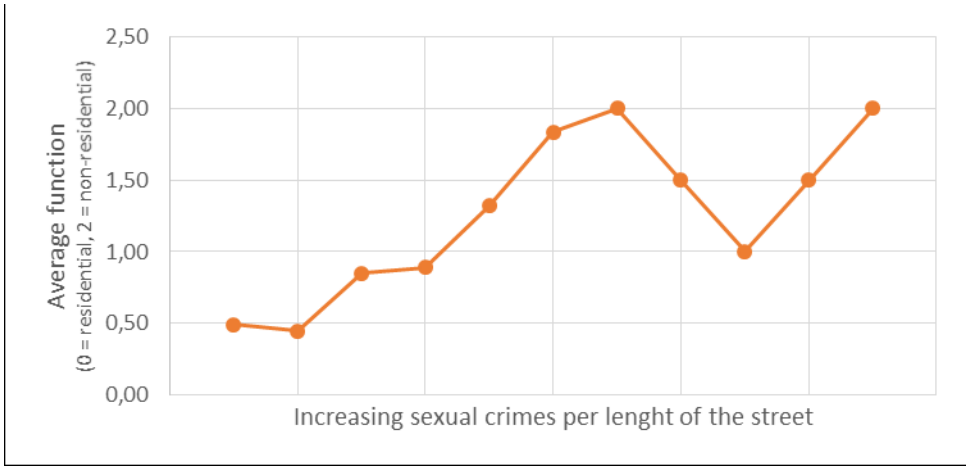
Some patterns are easier to visualize grouping streets instead of blocks. It is the case of the inter-visibility of entrances, presented in Graph 18, which shows an association between higher densities of crime per block and higher inter-visibility (at some time of the day). This is in line

with the previous graph, since higher densities of entrances are related to better inter-visibility (when entrances are well distributed on both sides of the street).



Graph 18: Average inter-visibility versus increasing incidence of sexual violence per length of the block.

Concluding, Graph 19 shows a tendency of commercial streets to be associated with higher densities of crime, supporting the two previous graphs: commercial streets have higher densities of entrances and inter-visibility, but only while stores are open. Some of the higher rates of crime per street length are associated with streets with some share of residential use (a value of 1,0 indicates mixed streets, that typically have stores on the ground floor and residences on the upper floors).



Graph 19: Average function versus increasing incidence of sexual violence per length of the block

Chapter 5: Comparison and discussion

The objective of this research, to answer 'what is the relationship between spatial features of the built environment and women's safety against sexual violence in the streets of Rotterdam?' can be interpreted as 'what are the mechanisms that predict the occurrence of sexual violence in space?' The analyses of results obtained in this study provide an idea of why Oscar Newman advocated the separation between inhabitants and intruders: crime is such a complex, intricate issue, that it seems easier to separate everyone, and guarantee physically that no menace will come near. However, if urban planners want to guarantee that cities continue being a place of opportunities for the citizens – and a safe one - the objective of the streets as public space must be to minimize risk by design.

This research is a first step on the path to analyse gender-based sexual violence in the streets from a quantitative perspective. The results indicate that neither Jane Jacobs' nor Oscar Newman's scenarios can be defended individually. On one hand, numerous cases reported to the police happened in places with large flows and mixes of people, supporting Newman's view that strangers are dangerous. On the other, evidence seems to support Jacob's proposal of mixed uses, with an important condition: that residences are important to provide safety in commercial areas, more than the other way around (Hillier and Sahbaz, 2008).

This study was structured in five sub-questions which are answered ahead, based on the results presented in Chapter 4.

Concerning sub-question number 1, the spatial distribution of gender-based sexual violence in the streets of Rotterdam can be understood as the combination of at least two very different patterns. At neighbourhood scale, some of the areas with higher absolute[30] numbers of sexual violence against women are the central neighbourhoods that concentrate most of the nightlife and leisure opportunities, such as Cool and Stadsdriehoek. The second pattern of most dangerous neighbourhoods (in absolute numbers) is composed of suburban neighbourhoods like Groot Ijsselmonde and Zuiderpark. Yet, dividing the number of cases by the amount of people in the streets during the day shows that Cool is the less risky of the four neighbourhoods that this study focused on.

Sexual violence cases reported to Rotterdam's police show notable resemblance with Fischer and Sprado's spatial distribution of sexual harassment: both are more common in places with a culture of entertainment in the streets and in late night shopping in the city centre. This seems to confirm the idea of sexual harassment as an indicator of escalation for further abuse or, alternatively, that lighter and heavier forms of sexual violence are governed by similar mechanisms.

Analysis of the police data points to a different dimension of cases that must be investigated: the time factor. Different types of neighbourhoods show different patterns of when sexual violence took place: central areas had more cases during the night (12 a.m. to 6 a.m.), and on Saturdays and Sundays, while residential and suburban neighbourhoods had more cases during the afternoon or evening, and in different days of the week.

With respect to sub-question number 2, the socioeconomic analysis of neighbourhoods did not reveal clear associations with the incidence of sexual violence. Nevertheless, results indicate that neighbourhoods where a higher share of residents know their neighbours tend to have less reports of sexual violence, which is in line with the theories that social networks (by Jane

[30] The absolute number of cases refers to how many cases were reported in a neighbourhood, for example, without considering number of inhabitants, streets, flows of pedestrians, etc.

Jacobs) and social organization (as mentioned by Drawve et. al, 2016) are associated with more safety in a neighbourhood. Drawve et al (2016) mention Morenoff & Sampson (1997) and Sampson (2012) when they affirm that there is a well-established effect of the neighbourhood on crime, but more research is needed to ascertain such relationships with gender-based sexual violence.

For sub-question number 3, the examination of Cool, Hillesluis, Nieuwe Westen and Pendrecht according to the spatial features of the built environment characterize the first two as commercial centres (even though Cool serves a different scale of customers), while the last two are predominantly residential. As proposed by van Nes and de Rooij (2015), the amount of people on the streets during the day is an important factor in understanding how space is used. It showed how Hillesluis attracts people in a local radius, while Cool has a wider radius of attraction, both for shopping and leisure. It also drew attention to the fact that different people use streets in different ways throughout the day and night. Results of the observation of amounts of people using streets ('people counting') were in line with Rapino and Cooke (2011): women were the majority in the streets in commercial hours, and the minority outside of that, which is in consonance with the gender roles of caring for the house and kids. Children were also more frequently seen in the streets with an adult woman than with a man.

The four neighbourhoods present mostly high density of entrances and inter-visibility between them, with the exceptions of Pendrecht and of the streets that delimit these areas. Space Syntax analysis showed a good correlation between higher local integration and to-movement with most important shopping streets in each neighbourhood, while higher global integration and through-movement indicators were good predictors of main routes (usually around each area), as predicted by previous studies by Hillier, López and van Nes.

To answer sub-question 4, about the relationship between the spatial distribution of gender-based sexual violence and spatial features of neighbourhoods, statistical analysis was used through pooled Poisson regression models. The models were created at street scale (with a sample of 247 streets) and at block scale (with a sample of 708 blocks). The resulting models at both scales show highly significant positive correlation between the amount of women in the streets, the local integration, the function of the street (whether it is residential, mixed or non-residential) and the occurrence of sexual crimes. Although counter-intuitive at first sight, these results may be explained, first, by the fact that there can be no crimes where there are no people. Second, most women in the streets can be found in the shopping areas (non-residential, which correspond to higher function values in the model). Third, shopping areas are located in blocks more integrated locally (as seen in the space syntax maps in section 4.3). Most importantly, non-residential streets that may be safe during the day become more dangerous during the night, when natural surveillance (both of eyes *to* the street and of eyes *on* the street) disappears. These hypotheses are supported by the positive correlation between the function of buildings and the occurrence of cases: predominantly commercial streets (such as Stadhuisplein, Lijnbaan and Witte de Withstraat) are associated with higher incidence of crimes, which is in line with the findings of Hillier and Sahbaz (2008) about street robbery. Another similarity with Hillier and Sahbaz is that street sexual violence results indicate that mixed use is safer when there is a higher share of residences (comparing absolute numbers in Cool with residential neighbourhoods), in line with what Hillier and Sahbaz (2008) found.

The street-scale statistical models contain the inter-visibility of entrances as a significant negative correlate of crime, which supports Jane Jacobs' school of thought, according to which greater natural surveillance results in greater safety in the streets. Finally, some of the statistical models include angular low values (to-movement indicator), but the sign varies between the street scale (-) and the block scale (+) models. The difference could indicate that, on average,

a street with higher flow of people has fewer crimes (especially in residential neighbourhoods), but the block that attracts such movement (usually a commercial one) has more crimes because of the lack of surveillance after stores close.

The last sub-question, number 5, regards the spatial features of streets where sexual harassment takes place. The analysis of riskier streets in the four neighbourhoods suggests two groups of streets: those with non-residential, usually commercial, function, and those with very low flows of people. In univariate analyses, more crimes per street/block length are associated with non-residential function, higher density of entrances and higher inter-visibility. As explained before, commercial streets tend to have a high density of entrances and inter-visibility between them, so it makes sense that the three variables show the same (positive) association with crime, from this point of view. On the other hand, this result indicates the need to further investigate the time component of cases, since many reports in the city centre were associated with the night period, when stores are closed, so there is actually low density of entrances and no inter-visibility.

Finally, the main research question 'what is the relationship between spatial features of the built environment and women's safety from sexual violence in the streets of Rotterdam?' can be answered. Based on the results of this research, it is shown, for certain, that the relationships are not simple and are not unique, at least for the four neighbourhoods analysed. Correlations were found between the spatial distribution of gender-based sexual violence and the function of the street, the density of entrances, the inter-visibility of doors and windows at ground level, local integration and angular analyses with low metrical radius. However, these variables are interdependent: streets with high inter-visibility have at least medium density of entrances, commercial streets usually have high density of entrances and, therefore, high inter-visibility between them. High local integration and to-movement are associated with non-residential functions. Therefore, the findings require further investigation before generalizations can be made.

A second conclusion is that other elements are essential in the analysis of the spatial distribution of sexual violence in the streets: the amount of people in the streets and the time component of crimes. The amount of people in the street has a twofold influence as generator of crime (since sexual violence cannot happen without both victim and perpetrator), and as social control (as most perpetrators will avoid being caught in the act). The time component has the power to change the use of space drastically: commercial streets that burst with life during opening hours can turn into ghost streets after closing hours. The amount of entrances and inter-visibility may not physically change, but they cease to exert social control when there is no one in the stores.

Third is the conclusion that there seems to be more than one mechanism that governs the spatial – and temporal - distribution of sexual violence in the streets. Grouping crime reports into sets with similar characteristics, the following patterns appear:

- Some cases are associated with nightlife streets and occur in the period from 12 am to 6 am (see Graph 3, Graph 6 and Graph 8). They could be imagined to result from excessive substance consumption – either by the victim, the criminal, or both;
- Other cases may take place in empty shopping streets outside commercial hours. These are associated with commercial or mixed (commercial and residential) streets, before opening or after closing hours (such as Keerweer, in Graph 6);
- Other cases are associated with streets with small flows of people in residential neighbourhoods (such as Essenburgsingel and Heemraadssingel, in Table 13);
- The remaining (significant) share of cases do not fall into any of the previous categories.

Comparing the results with the conceptual framework presented in Chapter 2 (Figure 5), it seems appropriate to add the time component to it, as shown in Figure 37.

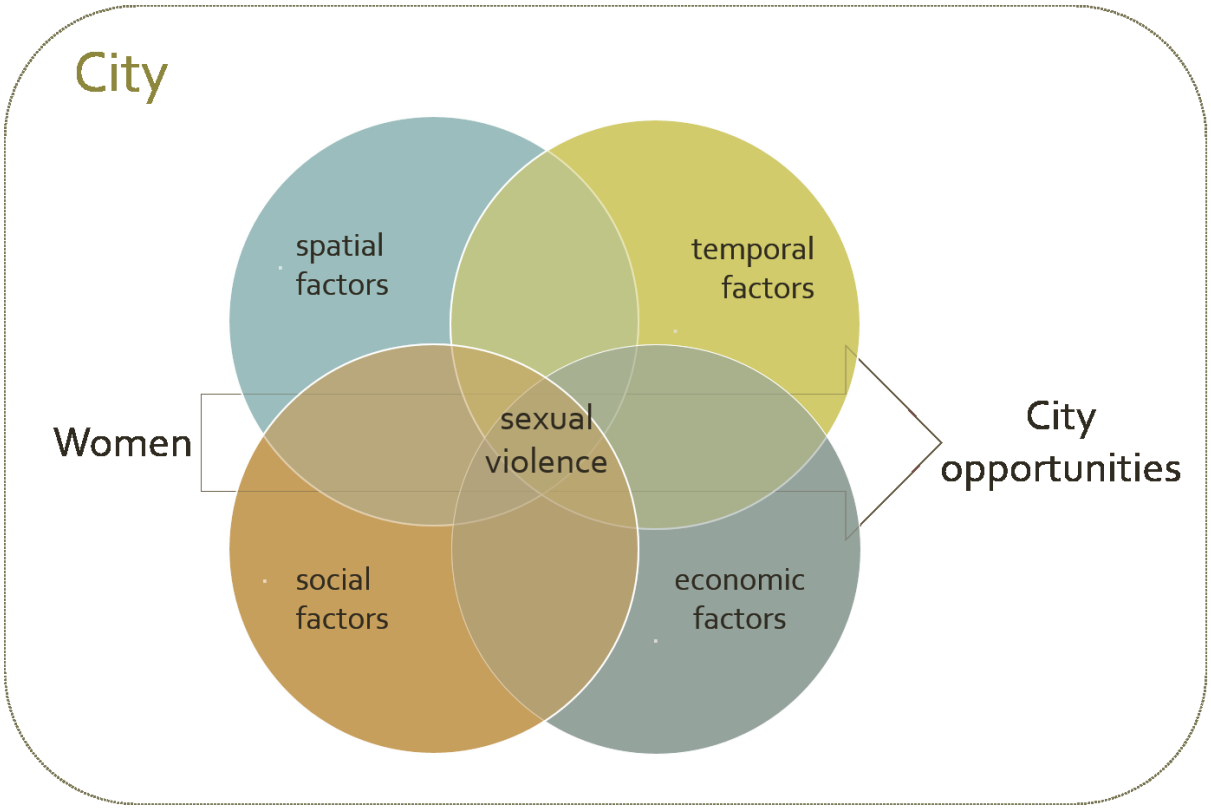


Figure 37: Revised conceptual framework

Research findings also indicate that theories from the field of crime research, such as Routine Activities Theory (RAT), Crime Generators and Attractors (CGA), and Social Disorganization Theory may provide the foundation for the development of a specific theory for sexual violence in public spaces.

Reflecting briefly on the research methodology, sexual violence data provided by the police confirms the importance of the topic of women's safety in public spaces in Rotterdam, and the results of this study suggest that additional research is necessary to improve understanding of the matter. Nevertheless, the findings were in line with previous researches in the fields of sexual harassment in the streets, crime research, street robbery in public spaces, and gender differences in the use of streets. Although the relationships studied in this research exist and are worthy of further investigation, internal validity revealed to be a challenge due to the high level of inter-dependency between variables that were initially expected to be independent.

Chapter 6: Conclusion - challenges for future research and indications for urban design practice

As a first step on the path to understand gender-based sexual violence in the streets from a quantitative perspective, this research has revealed important topics of study for future research. They include the temporal aspect of space, the relationship between people, space and time (how different people use space differently at different times of the day/night), the various mechanisms that seem to be on the background of the spatial distribution of sexual violence, and previous theories and studies that seem well suited as basis for the development of a sexual violence theory for public spaces. Future research should study how space changes over time. How the visibility, density of entrances, amount of people on the street change from daytime (when stores are open) to night-time (when they close). Specific attention needs to be given to what happens during the night to flows of people, etc., since the present research focused on daytime flows only (from 8h to 22h). The strategy of 'static snapshots' of people counting also needs further development to improve its reliability.

In the future, additional variables or larger samples should be included to enhance external validity, allowing the identification of patterns amongst similar neighbourhoods, since the present research did not find decisive results within the four analysed neighbourhoods. Regarding the data analysis, upcoming research may benefit from using different strategies to single out the relationship between each variable and sexual violence in the streets. Drawve et al (2016) proved that risk terrain modelling (RTM) could be used to create models that predict neighbourhood violent crime better than previous tools, by considering both characteristics of the built environment and 'social factors known to be robust correlates of levels of crime and violence' (p. 21). This could be an interesting tool for future research in the field of sexual violence specifically.

Challenges for the future include improving the representativeness of gender-based sexual violence reports: both in relation to the amount of cases that are reported and regarding the amount of information gathered for each case (as a significant part does not include the gender of the victim nor of the perpetrator).

Concerning urban policy practice, results suggest that women's safety in residential streets could benefit from a design that includes residences on both sides, with good inter-visibility between entrances. In commercial areas, land use should allow and encourage the inclusion or construction of residences, to provide mixed-use. However, more research is needed to confirm these ideas. Nevertheless, this study has shown that urban planning lacks gender equality concerning the designers and planners themselves. Therefore, safety of women in the city can certainly benefit from greater gender equality in the employment of urban practitioners, and from the inclusion of gender mainstreaming in urban design.

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