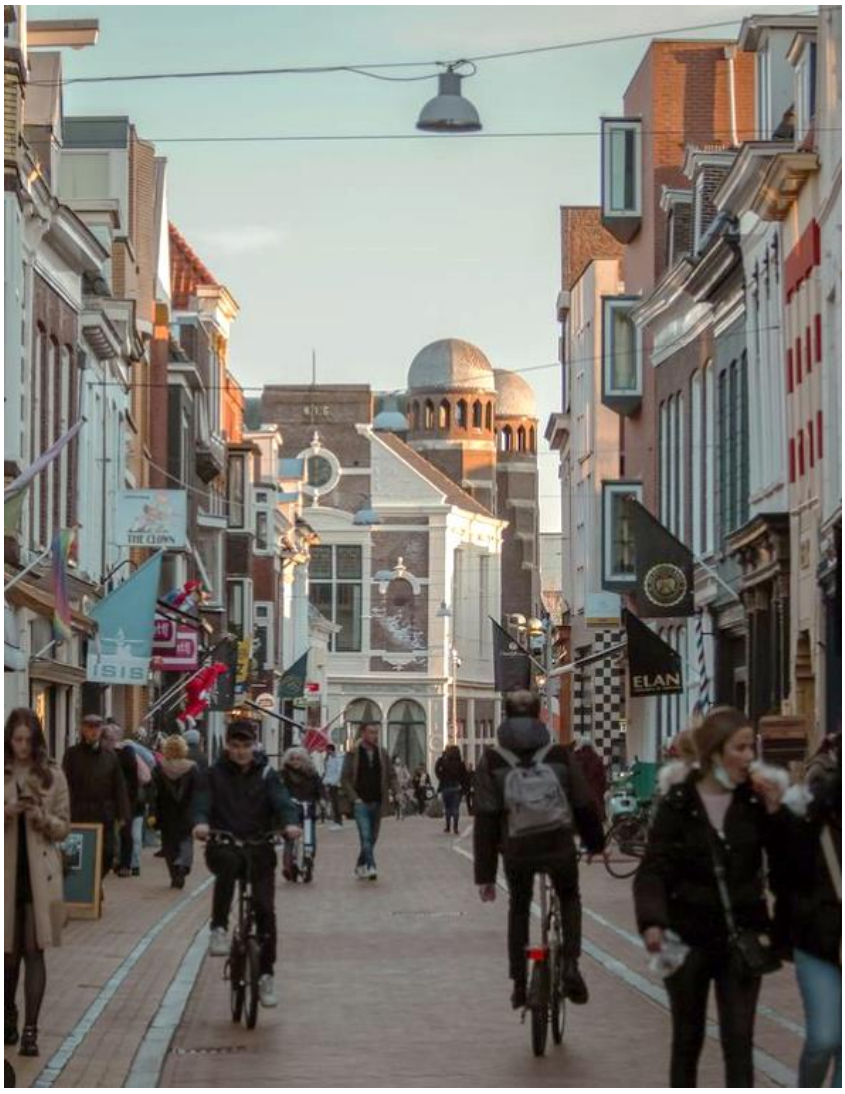
SUSTAINABLE STREET FURNITURE AND ITS EFFECT ON STREETSCAPE PERCEPTION



(Toerist In Eigen Stad, 2022)

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Abstract

The increasing importance of sustainability is found on a global scale as well as more locally. Street furniture is part of the streetscape and both can be sustainable. This research aimed to discover the effect that sustainable street furniture has on the perception of the streetscape in the inner city of Groningen. A mixed-method approach was used in this research. Quantitative data was gathered by observatory measurements by the author, in combination with a questionnaire to which pedestrians responded. The questionnaire contained questions about the current streetscape perception and questions about how the streetscape is perceived if sustainable street furniture were to be added. Results indicate that sustainable street furniture has a positive effect on the perception of streetscapes. Qualitative data explained that adding street furniture is not always desired. A combined analyses suggests that adding sustainable street furniture only has a positive effect under the right circumstances. However, additional research is required to better understand the possible difference in perception caused by day- and night time, as well as the effect on different street typologies.

Key words: *sustainable street furniture, streetscape, perception, sustainability, inner-city, Groningen.*

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1. Introduction

1.1 Background

On a global scale, sustainability is becoming increasingly important (Rockström et al., 2018). Sustainability mitigates the negative effects of global climate change which could harm our future well-being (Rockström et al., 2018). This importance has been recognized and is translated in the Sustainable Development Goals, or 'SDGs' (United Nations, 2015). The United Nations refers to goal 11 as: "*Make cities and human settlements inclusive, safe, resilient, and sustainable.*" (United Nations, 2015, p. 18). Sustainability in urban planning has become of critical importance in the shaping of urban design (Wheeler, 2016). This is the sustainable improvement of, for example, urban water infrastructure, waste management, and transportation. Despite its small size, street furniture has the potential to help achieve SDG 11. Furthermore, sustainability can be found in various concepts related to the urban environment, such as the *principles of new urbanism* (Medved, 2017).

Numerous researches evaluate the sustainable outcome of urban (re)development projects (Medved, 2017). On a smaller scale, street furniture plays a role in creating a more sustainable urban environment. Street furniture is everywhere in an urban area and is subject to a great variety of users (Lesan & Gjerde, 2020; Harsritanto, 2018). Street furniture includes but is not limited to benches, streetlamps, manhole covers, mailboxes, streetlamps, and trash receptacles. The well-being of users of the public space is related to the state and design of the streetscapes because good streetscapes facilitate our social needs (Harsritanto, 2018). Moreover, the behaviour and interactive state of dwellers are directly affected by the perception of streetscapes (Cavalcante et al., 2014). This implies that many users would benefit from an optimal, sustainable design of street furniture. Therefore, accounting for sustainable design principles in the implementation process of street furniture would be beneficial to users of urban areas.

Street furniture is one of the aspects of sustainable streetscapes (Ma et al., 2021). The street furniture provides the possibility to rest, drink, eat, interact, and enjoy being outside, making it of great social importance. Furthermore, its design can be significant for the elderly, youngsters, people with mobility issues, and visually impaired people because it can improve accessibility (Yücel, 2013; Klopotowska, 2020). Historically, street furniture and street furniture perception has been subject to change. For example, the introduction of cast-iron street furniture due to the Industrial Revolution has changed the streetscape in England drastically (Soffritti et al., 2020).

Academic relevance can be indicated by a research gap. In this research, a research gap has been found in the relation between sustainable street furniture and perception of the streetscape. Research has been conducted on the design principles of sustainable streetscapes. Little research has been conducted on the relation between perception and sustainable streetscapes. No study researched the effects of sustainable street furniture design on the perception of streetscapes.

1.2 Research Problem

It is expected that sustainable street furniture influences the perception of streetscapes because street furniture is one of the aspects that make up the streetscape. The aim of this research is to investigate the possibility of a causal relationship between sustainable street furniture and the perception of sustainable streetscape. Therefore, the following research question has been formulated:

"How does sustainable street furniture have an effect on the perception of streetscape in the inner city of Groningen?"

To answer the main research question, the following sub-questions are formulated:

- What factors influence human perceptions of streetscapes?
- What are the design principles of sustainable streetscape?
- What makes street furniture sustainable?
- How is the streetscape in the inner city of Groningen perceived?
- To what extent does the intention of the planners align with the pedestrian's perception of the streetscape in the inner city of Groningen?

The following sub-question has been formulated for the additional research in Berlin:

- To what extent does the intention of the planners align with the pedestrian's perception of the streetscape of Bergmannstraβe?

1.3 Structure

Firstly, an explanation of relevant concepts and theories is explained in a theoretical framework. Secondly, a conceptual model is constructed based on the literature. Furthermore, the literature is the base on which the hypotheses are formulated. The qualitative and quantitative parts of this research are explained in the methodology section, as well as a detailed argumentation for this mixed-methods structure and a discussion on research ethics. The section thereafter both describes the results following the used methods, as well as provides a discussion on the quality of the gathered data in combination with the relevant theories. Then, a summary of the main findings of this study is provided. Lastly, the strengths and weaknesses of this study are reflected on and recommendations for further research are suggested.

2. Theoretical Framework

There is a number of relevant concepts that could clarify the potential relationship between sustainable street furniture and the perception of sustainable streetscapes.

Sustainability

Sustainability is "*the quality of causing little or no damage to the environment and therefore able to continue for a long time*." (Cambridge Dictionary, 2022, p. 1). Additionally, sustainability concerns maintaining the state of natural resources to ensure the well-being of future generations (Kuhlman, 2010; Scoones, 2007).

Sustainable Street Furniture

Street furniture is a term used to describe amenities and objects within urban public spaces that provide a variety of public functions (Wan, 2008). The inevitable presence of street furniture in public spaces plays a part in the liveability of citizens because of the interaction between humans and these public facilities (Siu & Wong, 2015). Yücel (2013) emphasizes the importance of street furniture for the elderly and people with restricted mobility, such as benches to rest on. Moreover, street furniture can create and develop a sense and identity of a place because that identity is formed by visible characteristics (Ghorab, 2014; Yücel, 2013; Prvanov, 2017). Consequently, sustainable street furniture is street furniture that has the ability to persist over time and has little to no negative impact on the environment (Prvanov, 2017). Therefore, street furniture that no longer fits within the desired image due to, for example, societal development or weather conditions, and is subject to replacement, is both inefficient and unsustainable (Chapman, 2009; Siu & Wong, 2015). Moreover, complex designs that need replacement quicker are unsustainable since they can be harmful to the environment and a waste of resources (Du, 2006).

5Rs

There are two concepts to measure the sustainability of street furniture: the 5Rs and the 3Rs. The 5Rs are five goals, of which two are added to the 3Rs. The 3Rs are the goals when creating sustainable street furniture and refer to the *reduce, reuse,* and *recycle* possibilities of street furniture design (Prvanov, 2017; Dhaou, 2021; Wan, 2008). The philosophy behind reduction is to limit, for example, energy consumption and light pollution (Dhaou, 2021). The reuse concerns, among others, effectively using natural resources such as solar and wind energy to power street furniture that requires energy (Dhaou, 2021). An example of recycling in sustainable street furniture is the usage of recycled and local materials for the production of trash receptacles (Dhaou, 2021). However, the three Rs do not cover all grounds of sustainable street furniture design. According to Aziz (2013), two Rs can be added; *repair* and *rethink*. Sustainable street furniture is repaired easily and requires little material (Wan, 2008). This is difficult with designs that are anchored to the ground and consist of one piece (Siu & Wong, 2015). The 'rethinking' of sustainable street furniture involves the thorough consideration of using material, for example, using less-complex designs requires fewer materials and is, therefore, more sustainable (Aziz, 2013). This can be seen to coincide with the three ways in which green street furniture can be designed according to Lin (1992), namely: *material* (recycled)*, operation* (rethink/reduce)*,* and *maintenance* (repair/reuse).

Sustainable Streetscape

Streetscapes are the "outdoor rooms" that are found when positioned on a street (Cullen, 1961). It is the physical design of built- and unbuilt urban space that is of evident impact on our liveability (Harvey, 2014). Moreover, Harsritanto (2018) defines it as urban fabric that is shaped to facilitate the basic needs of a human being. A sustainable streetscape is a long-lasting, functioning streetscape that provides positive effects for the users whilst aiding in

mitigating climate issues such as increased intensity of rainfall (Rehan, 2013; Tiwary et al., 2016). Four principles are composed that define the sustainability of a streetscape (Rehan, 2013). The *Urban Principle* includes how attractive, safe, and legible the streetscape is. This implies that a sustainable streetscape is aesthetically sound, is designed to guarantee the safety of all its users, and that prominent characteristics of a city are easily understood as being prominent. The *Social Principle* includes liveability and communal quality. This entails more than being a piece of infrastructure and acknowledges the desired presence of lively, interactive spaces for people to enjoy being present. Furthermore, with respect to the people that live in the street, elements of the streetscape such as its furniture, for example, trash receptacles, should not negatively affect their living experience. The *Economic Principle* stresses the use of sustainable material and recycled resources. Using recycled material that requires little maintenance is perceived as ideal. The *Environmental Principle* entails environmentally friendly qualities, as well as a historically and culturally matching image. This includes a positive effect on water quality and limited light pollution coming from the streetscape. Lastly, the sustainable streetscape enjoys a design that is in line with the historical and cultural context (Rehan, 2013; Prvanov, 2017; Aziz, 2013).

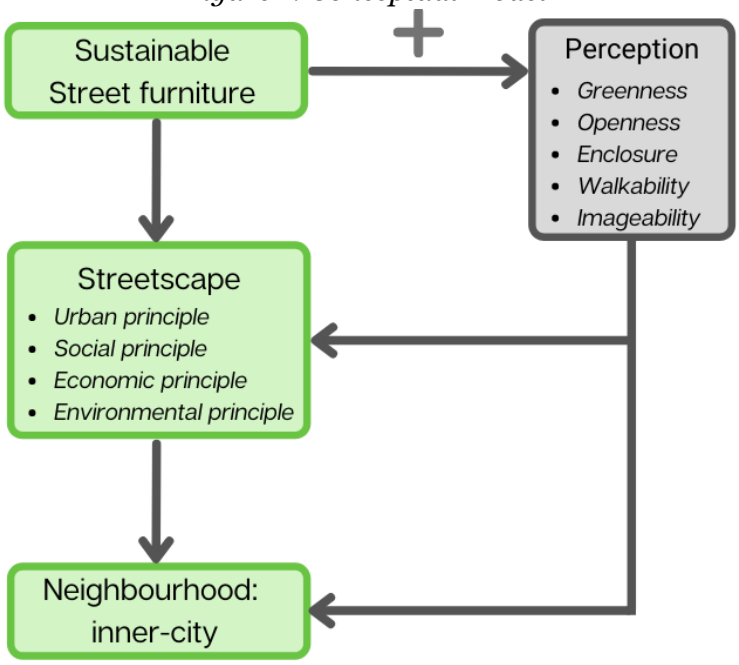
Perception

The perception of streetscapes is represented in five aspects. These are *greenness, openness, walkability, enclosure, and imageability* (Ma et al., 2021). Greenness indicates to what extent urban greenery is present within the streetscape. An example of street furniture that contains greenness are planters. Openness specifies how much of the sky is visible from a ground-level viewpoint. Walkability concerns the pleasure one experiences while moving by foot through the streetscape. Enclosure refers to people's perception of the spatial confinement of which a properly enclosed streetscape generates positive effects on liveability (Nasar, 1994). Lastly, imageability is the memorability to the users of urban space, generated by significant and visible features resulting in a pleasant street image (Ma et al., 2021).

2.1 Conceptual Model

The conceptual model in figure 1, includes the relationships between the previously explained concepts. The level of sustainability of street furniture is measured via the 5R's. The presence of sustainable street furniture is expected to positively influence the perception of sustainable streetscape which affects the sustainability of a neighbourhood. Perception knows five indices, namely *greenness*, *openness*, *enclosure*, *walkability*, and *imageability*. The state of the streetscape is defined by four principles: the *urban principle*, the *social principle*, the *economic principle*, and the *environmental principle*. It is expected that sustainable street furniture has a positive causal relationship with the perception of sustainable streetscapes.

Figure 1: Conceptual Model



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2.2 Hypotheses

A streetscape that lives up to the urban-, social-, economic-, and environmental principles is considered a sustainable streetscape (Rehan, 2013). Street furniture is one of the components of the streetscape. Sustainable street furniture contains qualities that are expected to have a positive effect on the perception of sustainable streetscapes. In contrast, regular street furniture or even the absence of street furniture is expected to not have a positive effect on the perception of sustainable streetscapes.

3. Methodology

This research is part of the first edition of the program 'Sustainable Transformation Of Urban Regions In Europe' and is an Erasmus-funded academic partnership between the University of Groningen, Stockholm University, Politecnico di Milano, and Humboldt University Berlin. Combined effort resulted in a mixed-methods case study of Bergmannstraβe in Berlin. Similarly, in Groningen, both quantitative and qualitative data are collected. A mixed-methods approach is chosen because it allows to compensate for the potential downsides of both types of data collection (Punch, 2014). The qualitative data serves as in-depth information about policy choices made by the municipality. This is used as information to better understand the results of the quantitative data and to see if people perceive the streetscape according to how the municipality intended it to be perceived. The quantitative data is used to understand the influence of the different variables and viewpoints of different groups of respondents. Furthermore, quantitative data provides insights into the relationship between the independent variables and the dependent variables *satisfaction* and *sustainable experience*.

3.1 Quantitative data

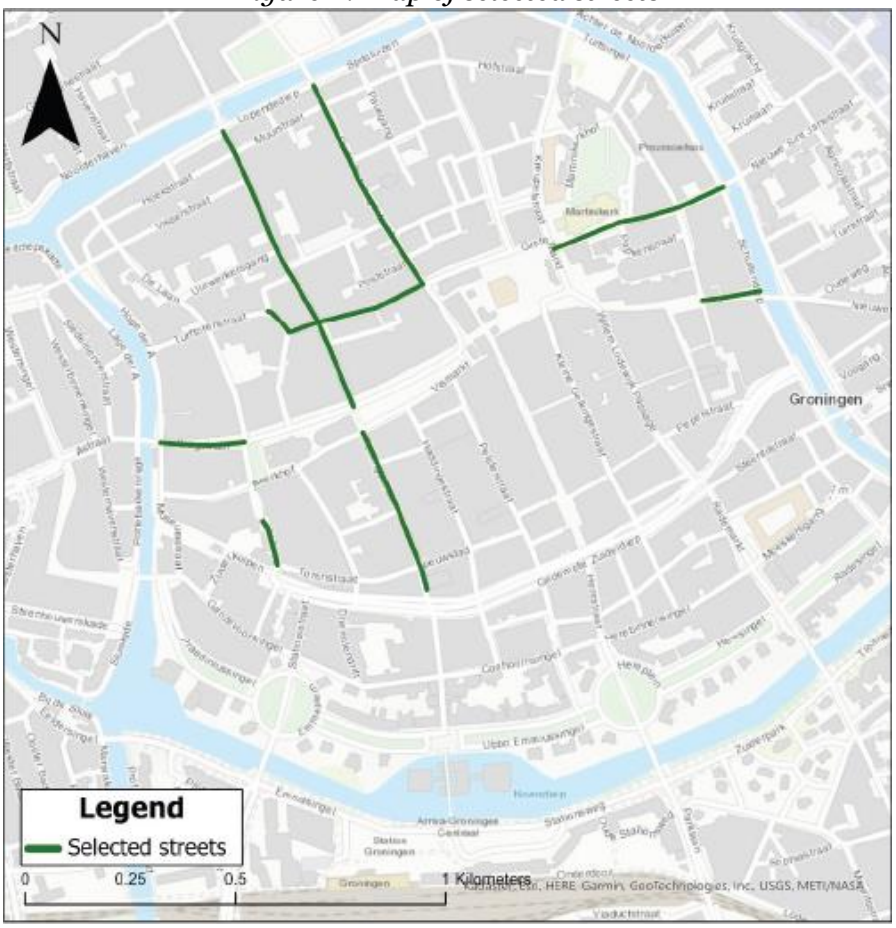
To answer the sub-questions about perception, quantitative data is collected. Quantitative data is chosen because it is particularly useful for answering questions about the opinions and attitudes of a population about environmental phenomena (Clifford et al., 2016). The quantitative data is obtained via the use of observations and a questionnaire. First, observations were made on all the selected streets. An overview is presented of each amount of street furniture that is present in combination with the length of the street. This provides objective information about the amount of street furniture present which can be used as a control variable to compare against the perception of the streetscape.

A questionnaire is used after the observatory measurements have been completed. The questionnaire consists of three parts and is available both in English and in Dutch (Appendix A). In the first part of the questionnaire, the respondents were asked to provide basic information about themselves. In the second part, the respondents were asked to select the street that they are currently on. Then, the respondents were asked to answer questions about their perception of the current streetscape that are based on the principles described in the theoretical framework. Thereafter, the respondents were asked how sustainable they perceive the street to be and how satisfied they are with the street. In the last part, the respondents saw a picture of three instances of sustainable street furniture. The images are selected based on the criteria for sustainable street furniture described in the theoretical framework. They were then again asked about their perception and satisfaction if the three examples were to be added to the streetscape. Pedestrians were asked to fill in the questionnaire, as opposed to asking residents of the streets. A selection of eleven streets in the inner city of Groningen was made to find respondents for the questionnaire (figure 2). The following streets have been selected:

- *Brugstraat*
- *Folkingestraat*
- *Grote Kromme Elleboog*
- *Martinikerkhof + Sint Jansstraat*
- *Munnekeholm (partially)*
- *Oude Kijk in 't Jatstraat + Stoeldraaierstraat*
- *Oude Boteringestraat*
- *Poelestraat (partially)*
- *Zwanestraat*

The Rode Weeshuisstraat is a comparably suitable street for this research. However, due to ongoing construction on this street at the time of this research, this street has been omitted for this research (Ruimte voor Jou, 2020). These streets have been selected based on what is possible within the given time constraints and the following requirements. Firstly, the streets are located within the inner city of Groningen. This is favourable because many dwellers that perceive streetscape can be found here. Furthermore, more respondents are likely to be users of the streets compared to those living on the researched streets. Moreover, these are not residential streets because those streets contain too little publicly used street furniture and are too quiet. Studying residential streets would require a longer period of conducting research in order to find enough respondents. Secondly, these streets are not public squares. Public squares are a different subject that will not be studied in this research. Thirdly, the selected streets are pedestrian-friendly and not made of asphalt. Streets with those qualities make it difficult to find respondents, in combination with being a more dangerous condition to obtain quantitative data using a questionnaire. In fact, all selected streets contain yellow pavement that was selected for its calm appearance (Gemeente Groningen, 2017). Lastly, the streets neither have living nor commerce as their main function but are rather a well-balanced mix between these typologies. The streets are part of the widely used inner-city of Groningen. Therefore, the list consists of a selection of comparable streets to find respondents for the questionnaire.

Figure 2: Map of selected streets



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The aim was to collect the quantitative data by finding respondents for the questionnaire in appendix A. 300 flyers (Appendix F) containing a QR-code that directed the participants to the online Qualtrics questionnaire were distributed. This made it easier for respondents to participate in this research. The surveying took place on six days between April 15 and April 25, 2022. A peer student provided distributional assistance on three of these days. No data was collected during holidays, and all data collection days had sunny weather conditions. Nonprobability sampling was done by the researcher in the form of accessibility sampling (Clifford et al., 2016).

A slightly adjusted questionnaire is used in Berlin to answer the sub-question about the Bergmannstraβe (Appendix B).

Quantitative data analysis
The answers to the questionnaire by the respondents in Groningen were compiled in one dataset that is used for the quantitative data analysis. The following adjustments were made to the dataset before the data analysis. Out of the 103 responses, 14 responses were removed because they did not insert a location. 6 respondents stopped the questionnaire after the first page and did not answer the 'in this case' questions. Their answers on the first page will be used to measure the perception of the current streetscape. However, because they have not completed the questionnaire, the valid N value is reduced to 83. One respondent entered his year of birth instead of his age. His age has been calculated by subtracting his year of birth from 2022. *Enclosure* has not been translated into the questionnaire because a complex explanation is required before participants thoroughly understand this aspect. This aspect has therefore been analysed based on observatory measurements.

The questionnaire generated ordinal statistical information by asking opinions about the independent variables to be answered via the five-point Likert-type scale (Clifford et al., 2016). The relationship between independent variables such as the *greenness*, *openness*, or *number of benches* and the dependent variables of perception of the streetscape is analysed using descriptive statistics. A large sample size strengthens the conclusion about whether some variables have an effect on the perception of streetscape (Clifford et al., 2016). Furthermore, a Sign Test is used to determine whether a significant difference is measured in *satisfaction* and *sustainable experience* before and after respondents were asked to imagine the depicted sustainable street furniture in the current streetscape. This test is ideal to measure the satisfaction before and after changing a variable (Burt et al., 2009; Laerd Statistics, 2018)

3.2 Qualitative data
Additionally, three semi-structured interviews were conducted using a semi-structured interview guide (Appendix C). The aim of these interviews was to gain insight into the philosophies behind the street furniture policies in Groningen and Berlin. The interview in Groningen was conducted in Dutch and the interviews in Berlin were conducted in English. The interviews were semi-structured because open interviews could be difficult to link to the data of the questionnaire. Moreover, a semi-structured interview allows interviewees to elaborate on their point of view while preventing deviation from the purpose of the interview (McIntosh & Morse, 2015). A policy maker was interviewed in both cities, as well as a consultant who was active in the participatory process in Berlin. The semi-structured interviews contained elaborate questions that are related to the questionnaire (Appendix D). Before conducting the interviews, the results of the quantitative data were analysed to ask the interviewee if the statistics were to be expected.

Qualitative data analysis
After conducting the interviews, a narrative analysis approach was used to capture the main message of all interviews. A narrative analysis approach allows a researcher to understand the causes and effects behind the information that the interviewee provides while focussing on the institutional, cultural, and social context thereof (Kwan & Ding, 2008). The interviews are used in combination with existing policy documents from the municipalities to state clearly the stance of the municipalities about street furniture.

3.3 Ethical considerations
During the data collection process, the researcher acted in accordance with the Covid-19 regulations that are provided by the University of Groningen and the Dutch government in order to guarantee the safety of everyone involved in this research. Furthermore, the research ethics are based on Clifford et al. (2016).

Irrespective of the chosen type of data collection, the well-being of the respondents was taken into account. The neutrality of the researcher in relation to the respondents was stressed by not influencing the respondents when they were answering the questionnaire. The potential risk factors that could harm respondents were minimized, for example, by asking respondents to fill out the questionnaire on the side of the road that is inaccessible to cars. Furthermore, the possibly sensitive data regarding the personal information of the respondents is protected. Respondents were not asked to give their full names nor their address. The respondents were informed that the data will be deleted after this study and that location-specific data of the respondent will not be used and saved.

4. Results

4.1 Public perception of streetscape

The observatory measurements in table 1 show the presence of every specific type of street furniture per street. A distinction between *street lamps* and *street lamps hanging between buildings* is required because overhead street lamps do not congest the streetscape at ground level. Instead, they form an effective alternative to regular street lamps and provide enough lightning while having a more subtle presence at ground level. *Greenery* consists of singular trees and noticeable combinations of green that were present in front of buildings. Temporary green such as plants that café owners use to decorate their terraces are not included. All measured trash receptacles were public trash receptacles. Trash receptacles that require a card to open – and are therefore not publicly available for everyone – are not included. The *bicycle stands* measured are publicly available bicycle stands, each of which facilitates roughly five bicycles. The little over one hundred parking spots available in the study area cannot facilitate the dominant bicycle presence and public underground parking compensates for this (Groningen Fietsstad, 2022).

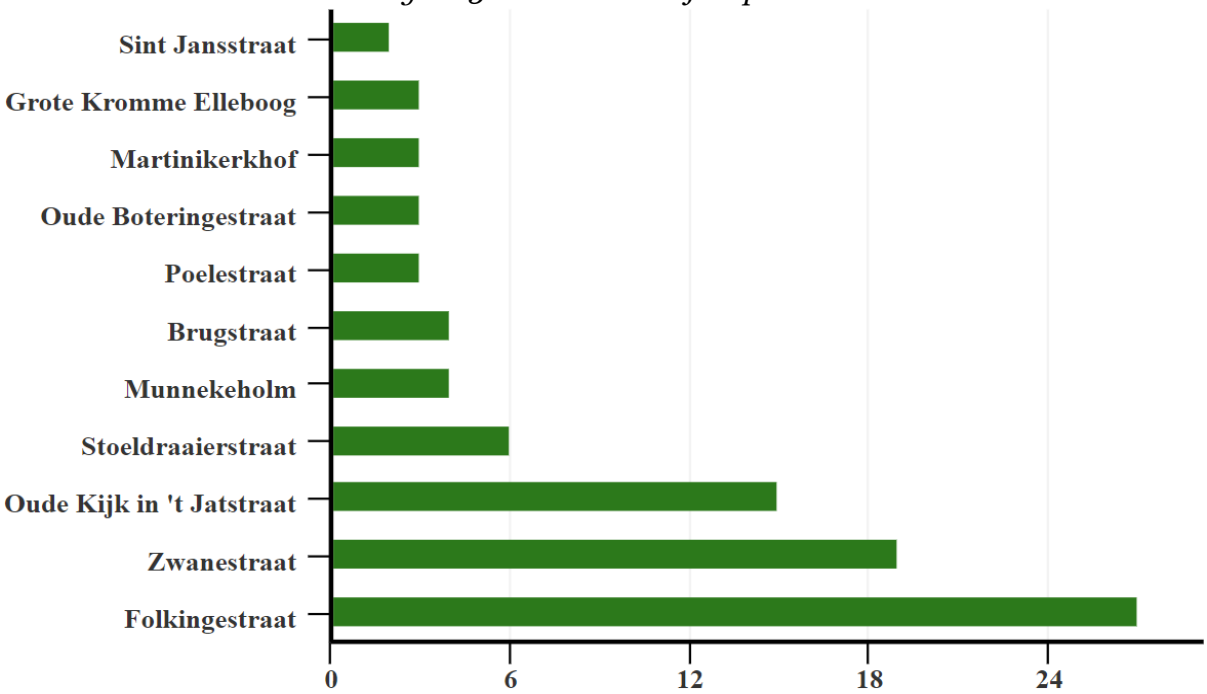
Table 1: Observatory measurements

Street	Lamp	Overhead lamp	Greenery	Trash receptacles	Benches	Bicycle stands	Street length (m)
Brugstraat	-	4	3	2	-	-	117
Folkingestraat	-	9	-	1	-	-	208
Grote Kromme Elleboog	-	3	-	-	-	-	70
Martinikerkhof	8	-	5	1	-	-	113
Munnekeholm	-	4	2	-	-	-	70
Oude Boteringestraat	-	14	-	3	-	2	319
Oude Kijk in 't Jatstraat	-	10	-	2	1	1	297
Poelestraat	-	3	1	-	2	-	70
Sint Jansstraat	2	3	6	2	-	8	140
Stoeldraaierstraat	-	8	1	4	1	12	117
Zwanestraat	-	6	-	2	4	-	158
Total	10	64	18	17	8	23	1679

Conducted by author (2022)

The average age of the respondents is 35, which is close to the average age of the inhabitants of the municipality of Groningen which is 38 (Gronometer, 2022). The municipality of Groningen consists of 49,8% men and 50,2% women (Gronometer, 2022). The distribution among respondents is 56,2% men and 41,6% women. One respondent preferred not to mention their gender, and one respondent answered 'genderqueer'. This constitutes the final 2,2%. The descriptive statistics are shown in figure 3 and table 2. The figure contains information about the distribution of responses and the table depicts pedestrians' perception of the current state of the streetscape in the inner city of Groningen. The Folkingestraat, Oude Kijk in 't Jatstraat, and Zwanestraat stand out with a higher number of responses compared to the other streets. This is expected to be because more pedestrians were either shopping in these streets or walking towards their destination via these streets.

Figure 3: Distribution of responses



Conducted by author (2022)

Table 2: Descriptive statistics

Variable	N	Mean	Minimum	Maximum	Std. Dev.
Enough Greenery	89	2,00	1	4	0,826
Enough Benches	89	2,46	1	5	1,088
Sustainability	88	2,59	1	4	0,811
Enough Pedestrian Space	87	3,32	1	5	1,176
Satisfaction	88	3,55	1	5	0,946
Clean	87	3,63	1	5	0,851
Feels Safe	89	3,65	1	5	0,955
Open Character	87	3,78	1	5	0,895
Unique Elements	86	3,79	1	5	0,883

Conducted by author (2022)

Table 3: Descriptive statistics

Variable	N	Mean	Minimum	Maximum	Std. Dev.
More sus. – Bicycle stance	83	2,99	1	5	1,042
More sus. – Bench	83	3,71	1	5	0,918
More sus. – Street lamp	83	3,73	1	5	1,072
More sat. – Bicycle stance	81	3,02	1	5	1,049
More sat. – Bench	79	3,85	1	5	0,818
More sat. – Street lamp	80	3,35	1	5	1,170

Conducted by author (2022)

The mean in tables 2 and 3 indicate to what extent respondents agree with the statements asked in the questionnaire. A score of 1 means 'strongly disagree' and 5 means 'strongly agree'. The colour orange in the table means that the overall opinion of the respondents is that they disagree, yellow indicates neutral, and green indicates that respondents agree. The amount of greenery and benches present in the streetscape is perceived to be relatively low, with a mean of 2,00 and 2,46 respectively. The variables *enough greenery* and *sustainability* have a

maximum score of 4, whereas all other variables have a maximum of 5. This indicates that no respondent strongly agreed that the streetscape is sustainable and that there is enough greenery present. All other variables have a mean of 2,5 and higher. The variables *open character*, *enough pedestrian space*, *clean*, and especially *unique elements* have a lower response rate compared to the other variables. The expected explanation is that it was unclear for some respondents how to interpret these variables.

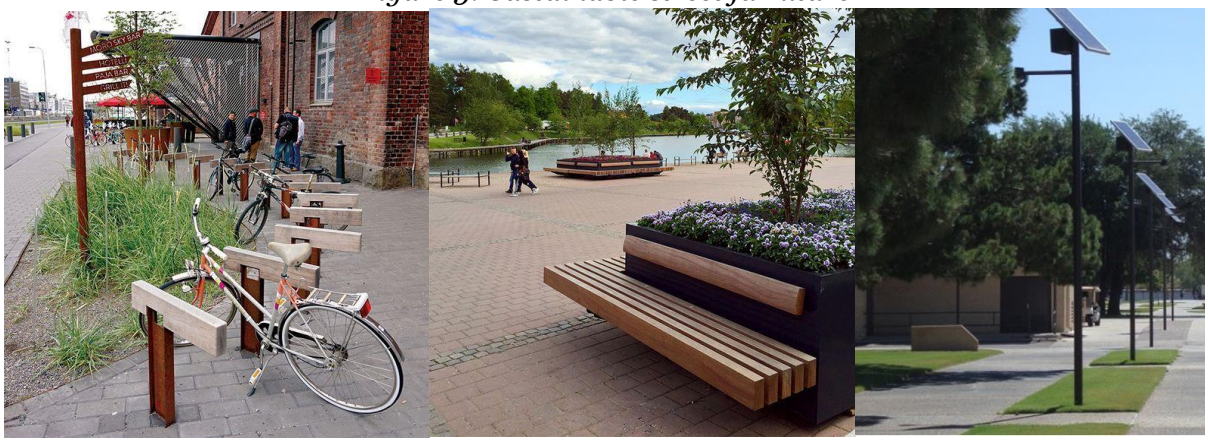
Table 4: Results Sign Test

	Sustainability – Bicycle stance	Sustainability – Bench	Sustainability – Street lamp	Satisfaction – Bicycle stance	Satisfaction – Bench	Satisfaction – Street lamp
Z	-1,823	-6,171	-5,926	-2,339	-1,714	-0,521
Asymp. Sig.	0,068	0,000	0,000	0,019	0,086	0,603

Conducted by author (2022)

Table 4 shows the result of a Sign Test in SPSS 26. The test indicates whether there is a statistically significant difference in *sustainable* and *satisfaction* streetscape perception of respondents after the sustainable street furniture in figure 5 is added. A significant difference is observed on a 95% confidence scale if the p-value is below 0,05. Adding the depicted bench and street lamp would significantly increase how sustainable respondents perceive the streetscape. Interestingly, implementing the bicycle stand has a significantly negative effect on the streetscape satisfaction. Furthermore, the bicycle stand does not change the sustainable streetscape perception. Similarly, adding the bench and street lamp would not significantly alter the perceived streetscape satisfaction.

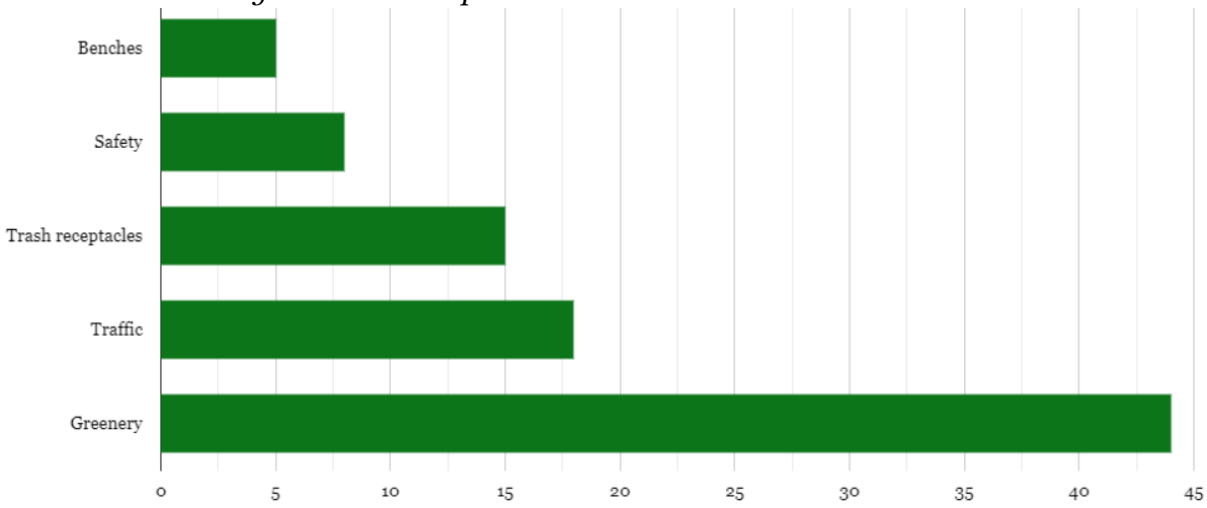
Figure 5: Sustainable street furniture



(Streetlife BV, 2018a; Streetlife BV 2018b; Solarlighting 2017)

Figure 6 depicts the answers to the open question 'Which elements do you consider to be the most important in a sustainable street?' The lower response to this question could be explained by the lack of public understanding of what defines a sustainable street. This is supported by one of the respondents who answered 'What is meant by a sustainable street?' The answers that mention the presence of trash receptacles can be explained by the sustainable nature of throwing away trash. Moreover, numerous respondents explicitly mentioned trash receptacles with the option to separate waste. Out of the traffic-related responses, most respondents preferred the absence of motorized vehicles in sustainable streets. Motorized vehicles are seen as unsustainable because of their emissions that have a negative effect on health and climate (Brückmann & Bernauer, 2020). The most recurring element that respondents considered important is greenery. This can be explained because greenery is one of the aspects of how sustainable streetscapes are perceived (Ma et al., 2021).

Figure 6: Most important elements in a sustainable street



Conducted by author (2022)

4.2 Street furniture policy of the municipality

Freek Wilkens is an urban designer who works for the municipality of Groningen. The municipality of Groningen has a plan for the inner city called "Leidraad voor de openbare ruimte van de binnenstad van Groningen" (2017). In this plan, the policy for street furniture in the inner city of Groningen is explained. The municipality has decided to keep a low amount of street furniture in the streets that are mentioned in this study. According to Freek Wilkens, this can be explained by the behaviour of people that visit the inner city, as well as the behaviour of people who live there. People tend to enter Groningen on their bicycles. Trash receptacles, and especially benches and street lights can function as bicycle parking for people who enter the city on their bicycles. This limits the amount of space on the sidewalks, in addition to the limitation in space that the presence of this street furniture causes. Moreover, a street light attracts waste from people because people perceive the street as 'messy' or 'cluttered' when there are objects on the sidewalk. Furthermore, the municipality has a philosophy in which they distinguish streets and squares. A street or square is either a place to stay and functions as a destination, or it functions as a means to get to a destination. The selected streets in this study all are categorized as a means to get to a destination. The municipality has decided to stimulate the public to use the squares and streets according to how the municipality has categorized them. For the streets that function as a means to get to a destination this means that there is a low number of benches because the presence of benches invites people to stay there longer. The public is then more inclined to perceive these streets as a destination, whereas they are not intended to be.

"Basically, we want as little street furniture in the inner city as possible.
That way as much free space as possible remains."

The municipality is improving the sustainability of street furniture. An example of this is currently being designed and produced by a local craftsman. He is making use of the removed yellow bricks – the bricks that form the yellow pavement that was a criterion for the street selection – to fabricate new benches. This circular use makes the street furniture sustainable while simultaneously being in line with the character of the inner city.

The municipality has opened multiple free underground public bicycle parking spaces in Groningen. This is a necessary addition to the limited number of bicycle stances measured in the study area to facilitate all bicycles (Groningen Fietsstad, 2022). Furthermore, this improves the walkability in the inner city of Groningen because bicycles that would have been parked on sidewalks and on squares are now being parked underground.

The limited amount of greenery that is being perceived by the public can be explained by the municipality. According to Freek Wilkens, three reasons result in this observation. Firstly, the presence of trees on sidewalks invites people to park their bicycles against them, resulting in a larger obstruction of pedestrian space. Secondly, trees invite people to litter, for example, people place their empty beer bottles against the trees. Thirdly, the inner city of Groningen knows a complex underground infrastructure consisting of cables, wires, sewage, etc. This complicates the planting of trees because the placement of the tree, as well as the growth of its roots, can cause damage to the underground infrastructure.

Adding sustainable street furniture improves how people perceive the streetscape regarding both satisfaction and sustainability. However, the desire of the public to add more sustainable street furniture does not match the intentions of the municipality. Although the municipality is aware of this desire, they argue that adding more sustainable street furniture in the inner city of Groningen causes problems that the public is not aware of.

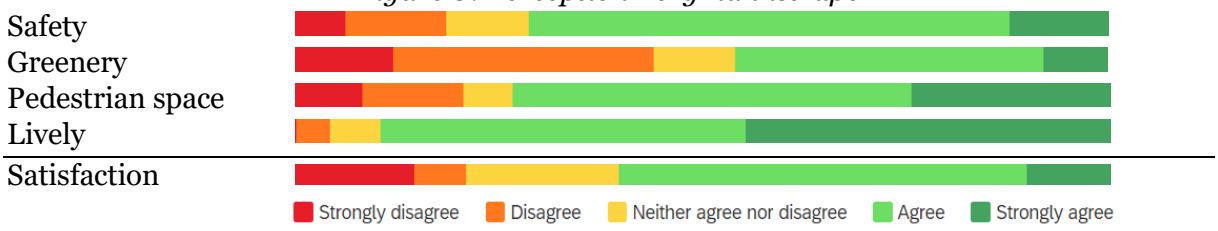
4.3 Berlin

The Bergmannstraβe in figure 7 is a pilot project in Berlin that started 9 years ago and uses a communicative approach that allowed the public to voice its opinion. The questionnaire distributed among pedestrians was answered 53 times and provided insight into the current streetscape perception of the public.

Figure 7: Bergmannstraβe.

(Tagesspiel, 2021; author, 2022)

Figure 8: Perception Bergmannstraβe



Conducted by author (2022)

Figure 8 shows that the streetscape is perceived as safe, walkable, and lively. This can be explained by the low-speed limit for cars, in combination with speed bumps. Furthermore, the diversity of stores and restaurants in combination with the publicly available seating increases how walkable and lively the streetscape is perceived. This public seating has a positive social influence which is reflected in the positive responses (Allameh, 2020). Interestingly, the streetscape perception scores average on *greenery*, although the street contains objectively more greenery compared to the studied streets in Groningen. This indicates the subjectivity of perception and can be explained by the high amount of greenery present in Berlin that sets a high standard for people in Berlin. 60% agree to be satisfied with the Bergmannstraβe streetscape, which is lower than expected. A higher percentage is expected due to the ongoing communicative process which allows the public to be involved in the planning process of the street. This is supported by the first interviewee dr. Dirk von Schneidemesser who is a researcher and consultant who actively participated in the project. The second interviewee is Roland Schmidt who is head of the Public Space Department in the region. Roland Schmidt said that a project like the Bergmannstraβe involves trial and error, and emphasized the necessity of similar pilot projects to increase the overall satisfaction. Furthermore, the municipality experiences less administrative burden and can implement changes quicker in the street because of its pilot project classification. Additionally, the qualitative findings show that although the satisfaction is not at its maximum yet, it has seen an increase in the previous years due to the implementation of publicly desired changes such as a bicycle lane and public seating. Lastly, due to the communicative nature of the project there are more improvements to be expected in the near future.

5. Discussion

According to Ma et al. (2021), *greenness, openness, walkability, enclosure, and imageability* are the five aspects that influence the perception of the streetscape. The imageability is measured with the variable *unique elements* and has the highest mean of all variables. The variable *open character* has the second-highest mean and measured the openness of the current streetscape. The characteristic facades of buildings in Groningen, together with the absence of high-rise buildings could explain these outcomes. Furthermore, the main characteristic that relates to *enclosure* and influences the perception of the streetscape is the presence of buildings of roughly the same height (Ewing & Handy, 2009). Observations on the selected streets show that nearly all researched streets contain this quality. The greenness is measured with the variable *enough greenery* and scores relatively low. The objectively low amount of greenery observed in the selected streets serves as a confirmation of this outcome. Greenery is understood to increase the sustainability of streetscapes and the low amount of greenery perceived and observed could explain why the mean of sustainable perception is one of the lowest (Tiwary et al., 2016).

Four principles define a sustainable streetscape (Rehan, 2013). The urban principle requires that users of the streetscape perceive it as safe. The outcome of the mean of variable *feels safe* is 3,65 and indicates that the respondents feel safe. The social principle requires that people are able to interact and stay on the street. The low score of the variable *enough benches* in combination with the low number of benches observed suggests that the streets in the inner city of Groningen are subject to improvement. Furthermore, the importance of benches for the elderly and people with mobility restrictions is stressed in the literature (Moran et al., 2014; Tiwary et al., 2016; Yücel, 2013; Klopotowska, 2020). However, the qualitative findings imply that no increase in benches in the selected streets can be expected due to the unwanted sidewalk impediment, the attraction of littering, and their categorisation of the streets.

The economic principle which focuses on sustainable material and recycled recourses is being answered to by the municipality. The use of old yellow bricks that once made up the streets to create benches is a perfect example of a sustainable improvement of the streetscape (Harsritanto, 2018). However, it is unclear where these new benches can be expected to be located, given the viewpoint of the municipality mentioned above. The environmental principle entailing environmentally friendly, as well as historical and cultural qualities also favours the project with recycled yellow bricks (Rehan, 2013). Furthermore, according to this principle, street lamps that use solar energy should have a positive effect on the perception of respondents (Rehan, 2013). Interestingly, this only improved how sustainable the respondents perceived the streetscape. The satisfaction of respondents did not change significantly if they imagined solar-powered street lamps to be added to the streetscape. An explanation for this could be that the selected streets currently have sufficient street light. Moreover, most of the lightning on the selected streets is attached between buildings and therefore does not occupy any pedestrian space. One way to retain the overhead position of street lamps while measuring up to the environmental principle is to implement solar-powered overhead lighting.

Reflecting on hypotheses

The hypothesis that sustainable street furniture has a positive effect on the perception of streetscapes can partially be confirmed based on the quantitative findings. Adding the selected bench and street lamp would increase the sustainable perception of the streetscape. However, adding the bicycle stance has no significant effect on the sustainable perception and even has a negative effect on streetscape satisfaction.

6. Conclusion

Findings

A mixed-methods approach was used to find out whether sustainable street furniture has a positive effect on the perception of sustainable streetscapes. The corresponding research question was: "*How does sustainable street furniture have an effect on the perception of streetscape in the inner city of Groningen?*"

The factors that influence human perceptions of streetscapes are greenness, openness, walkability, enclosure, and imageability, according to the literature. A sustainable streetscape is safe, allows for people to interact, implements recycled and sustainable material, is environmentally friendly, and has historical and social qualities. Street furniture, which can be found in a sustainable streetscape, is sustainable when it measures up to the 5R's. These include reuse, reduce, recycle, repair, and rethink. The current streetscape in the inner city of Groningen is mainly perceived as lacking enough benches and greenery. Furthermore, in almost all cases of added sustainable street furniture, respondents were significantly more satisfied with the streetscape. Moreover, in all cases of added sustainable street furniture, respondents perceived the streetscape as more sustainable. This indicates that the addition of sustainable street furniture positively influences the satisfactory perception of the streetscape. More significantly, it positively influences the sustainable perception of the streetscape. Lastly, relatively unknown repercussions of adding street furniture result in a municipal policy that differs from the desires of the public. Arguably, the desires of the public could change if the repercussions of adding street furniture were known.

Berlin

The communicative approach in the Bergmannstraβe resulted in positive streetscape perceptions. Simultaneously, the satisfaction response was lower than expected. Based on the quantitative and the qualitative findings, this can be explained by the poor state of the streetscape before the project started, in combination with a strongly opinionated public that has high expectations.

Reflection

This research is subject to possible limitations. For example, the validity of this research could be negatively influenced by the unknown biases of the researcher. An adequate sample size has been ensured to prevent chance from negatively influencing the validity of the research. Furthermore, the results of this study cannot be used to make general statements. Firstly, because the policies of the municipality can be different per municipality. Secondly, the selected street typology is specific for Groningen. Therefore, an attempt to replicate this study in a different country or city is expected to have different outcomes. This is partially confirmed by the outcomes of the case study in Berlin. Furthermore, the questionnaires were answered in sunny weather conditions and during the day. This could influence the outcome of this research, for example, because people understand 'safety' as traffic safety during the day, whereas during night time it could be understood as safety in terms of crime.

The results of this research are a new addition to existing academic knowledge. Although the perception of sustainable streetscapes has been the subject of research before, the influence of sustainable street furniture on the perception of streetscapes was still undiscovered. Furthermore, the comparison between the street furniture policy of the municipality and the perception of the public adds insights that are beneficial for both municipalities and the public. Lastly, a similar evaluation of the Bergmannstraβe suggests that generalization of comparable research is difficult.

Recommendations

Future recommendations include a larger study area to create a more complete understanding. Secondly, the number of questions in the questionnaire could be increased and made more specific to avoid unclarities. Furthermore, a comparison between different street typologies can increase the understanding of this topic. Lastly, the municipality could reconsider its current policy to increase seating availability in the inner city to allow people with restricted mobility and the elderly to rest.

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8. Appendices

Appendix A: Questionnaire Groningen

Street perception

Start of Block: Default Question Block

Thank you for participating in this study. This study is part of my thesis for the Bachelor 'Spatial Planning and Design' at the University of Groningen.
Answering this questionnaire takes approximately 5 minutes and is completely voluntary.
Your answers are anonymous and you can stop the questionnaire any time you want.
If you do not want to fill in an answer you can leave it blank. Your data will be handled with care and after analysing the data will be deleted.
The data will not be used for further scientific research and will not be made available for third parties.

The data is not accessible for third parties.
If you have any further questions about the questionnaire and/or this research you can send me an email: m.m.sewandono@student.rug.nl.

At the top right corner, you can choose another language.
Rechtsboven kan een andere taal gekozen worden.

Page Break

Location In which street are you currently?

- ○ Brugstraat (1)
- ○ Folkingestraat (2)
- ○ Grote Kromme Elleboog (3)
- ○ Martinikerkhof (4)
- ○ Munnekeholm (11)
- ○ Oude Boteringestraat (5)
- ○ Oude Kijk in 't Jatstraat (6)
- ○ Poelestraat (7)
- ○ Sint Jansstraat (8)
- ○ Stoeldraaierstraat (9)
- ○ Zwanestraat (10)

Age What is your age?

_____

Gender What is your gender?

- ○ Man (1)
- ○ Woman (2)
- ○ Prefer not to say (3)
- ○ Other, namely; (4) _____

Primary occupation What do you consider to be your primary occupation?

- ○ Paid work (1)
- ○ Looking for work (2)
- ○ Student (3)
- ○ Retired (4)
- ○ Other (5)

Perception Street perception

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
There is enough greenery visible in this street (1)	○	○	○	○	○
There are enough benches in this street (2)	○	○	○	○	○
This street has an open character (3)	○	○	○	○	○
There is enough space for pedestrians in this street (4)	○	○	○	○	○
There are unique elements visible in this street (5)	○	○	○	○	○
This street feels safe (6)	○	○	○	○	○
This street is clean (7)	○	○	○	○	○
I experience this street as sustainable (8)	○	○	○	○	○
I am satisfied about this street (9)	○	○	○	○	○

Elements What elements do you consider to be the most important in a sustainable street?

_____

_____

_____

_____

_____

End of Block: Default Question Block

Start of Block: Block 1

Cases Look at the following images. Now imagine that this street furniture is added to the street where you are currently located.

Bike
In this case ...

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
... I experience the street as more sustainable than the current situation (1)	○	○	○	○	○
... I am more satisfied about the street (2)	○	○	○	○	○

Bank
In this case ...

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly disagree (5)
... I experience the street as more sustainable than the current situation (1)	○	○	○	○	○
... I am more satisfied about the street (2)	○	○	○	○	○

Street lamp
In this case ...

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
... I experience the street as more sustainable than the current situation (1)	○	○	○	○	○
... I am more satisfied about the street (2)	○	○	○	○	○

End of Block: Block 1

Start of Block: Block 2

Email I would like to receive an update regarding the results of this research:

○ Yes, my e-mail address is: (1) _____

○ No (2)

End of Block: Block 2

Appendix B: Questionnaire Berlin

Appendix B: Questionnaire Bergmannstraβe

Bergmannstraße

Start of Block: Block 1

Q1 Thank you for participating in this study. We are four students from Stockholm, Groningen, and Berlin and we are researching urban design. Answering this questionnaire takes approximately 2 minutes and is completely voluntary. Your answers are anonymous and you can stop the questionnaire any time you want. If you do not want to fill in an answer you can leave it blank. Your data will be handled with care and after analysing the data will be deleted. The data will not be used for further scientific research and will not be made available for third parties.

End of Block: Block 1

Start of Block: Default Question Block

Q2 What is your age?

_____

Q3 What is your gender?

- ○ Male (1)
- ○ Female (2)
- ○ Prefer not to say (3)
- ○ Other, namely: (4) _____

Q4 What do you consider to be your primary occupation?

- ○ Paid work (1)
- ○ Looking for work (2)
- ○ Student (3)
- ○ Retired (4)
- ○ Other (5)

Q5 Perception Bergmannstraße

	Strongly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)
There is enough greenery visible in this street (1)	○	○	○	○	○
There is enough space to sit in this street (2)	○	○	○	○	○
This street has an open character (3)	○	○	○	○	○
There is enough space for pedestrians in this street (4)	○	○	○	○	○
There are unique elements visible in this street (5)	○	○	○	○	○
The design of this street is appealing to me (6)	○	○	○	○	○
This street feels safe (7)	○	○	○	○	○
This street is clean (8)	○	○	○	○	○
I experience this street as lively (9)	○	○	○	○	○
I am satisfied with this street (10)	○	○	○	○	○

End of Block: Default Question Block

Appendix C: Interview guide Groningen

Opening
-Short introduction
-Informing the interviewee about the research and the recording of the interview
-Informing the interviewee about the research ethics and what the recorded material will be used for
-Verbal consent for the recording of this interview and using this interview for my thesis

Central Questions
-What can you tell me about yourself? (Profession, age, experience, etc.)
-Can you explain what the current street furniture policy is? (Is there a policy for the entire municipality or are there policies per neighbourhood?)
-What is the philosophy behind the streets in the inner city with yellow pavement?
-Are there goals or requirements for the sustainability of street furniture? (Yes; what goals? No; why not?)
-How do you perceive the current streetscape in the inner city of Groningen? (And how do you think other people perceive it?)
-How do you believe the street furniture to have an effect on the streetscape?
-What will be added in a new street furniture policy?

Probing questions
-Could you give me an example?
-Could you explain this in more detail?
-Why do you think that?
-Was that your intention?
-How do you know this to be true?

Closing
-Summarize the interview
-Ask the interviewee if he/she has any additional remarks
-Thank the interviewee

Appendix D: Interview guide Berlin

Interview guide
Opening
-Short introduction
-Informing the interviewee about the research and the recording of the interview
-Informing the interviewee about the research ethics and what the recorded material will be used for
-Verbal consent for the recording of this interview and using this interview for my thesis

Central Questions
-What can you tell me about yourself? (Profession, age, experience, etc.)
- what was/is your role at transforming Bergmannstraße?
-in what way did you include the public?
- any potential conflict?
- did the public opinion changed the direction of the project?
-in what way is it temporary and why?
-is there anything you would have done differnetly? (lessons learned)
- do you consider the Project as succsesfull?

Probing questions
-Could you give me an example?
-Could you explain this in more detail?
-Why do you think that?
-Was that your intention?
-How do you know this to be true?

Closing
-Summarize the interview
-Ask the interviewee if he/she has any additional remarks
-Thank the interviewee

Appendix E: Syntax SPSS

```
DESCRIPTIVES VARIABLES=Perceptie_1 Perceptie_2 Perceptie_3 Perceptie_4
Perceptie_5 Perceptie_6
    Perceptie_7 Perceptie_8 Perceptie_9 Fiets_1 Fiets_2 Bank_1 Bank_2 Lantaarn_1
Lantaarn_2
  /STATISTICS=MEAN STDDEV MIN MAX.

NPAR TESTS
  /SIGN=Perceptie_8 Perceptie_8 Perceptie_8 Perceptie_9 Perceptie_9 Perceptie_9 WITH
Fiets_1 Bank_1
    Lantaarn_1 Fiets_2 Bank_2 Lantaarn_2 (PAIRED)
  /MISSING ANALYSIS.
```

Appendix F: Flyer questionnaire Groningen