Low-traffic, high-resilience: leveraging spatial design for climate resilience

How spatial design features in low-traffic zones can contribute to climate resilience along the Westerkade

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Abstract

This research aims to examine how low-traffic zones can be made more climate-resilient by attempting to answer the main research question: How do the design features and infrastructure interventions along Westerkade street in Groningen contribute to the area's climate resilience and adaptation as a low-traffic zone? In addition to a literature review, the Westerkade in Groningen is taken as a case study and the ongoing project about the area by the municipality of Groningen is discussed. The area faces issues regarding water management, and the urban heat island effect and is to receive a new design to make it more in line with the low-traffic nature of the street. To deal with these issues, the new design of the area aims to connect seamlessly to the larger transport networks of the rest of the city and includes infrastructure made of durable materials while providing adequate facilities for pedestrians and cyclists alike. The problems of extreme precipitation can only partly be solved through the use of rain gardens and greenery, but the area will only be able to deal with 385m^3 out of the 900 m^3 of rain a 100-year storm will cause. Greenery and a tactical use of shade will in turn help deal with the effects of the urban heat island effect. The results show that making an area 100% resilient will not be possible. Planners should not aim at designing one final indefinite solution. The battle of climate resilience is a continuous cycle, adapting and evolving to address the ever-changing environmental challenges we face.

Contents

1. Introduction

The ever-increasing threat of climate change demands innovative solutions. According to Wilson and Piper (2010):

> Due to the alarming rate at which global emissions are increasing, the current and possible future rates of change, the risks of dangerous climate change, the need to stabilise carbon levels through mitigation of anthropogenic climate change and the need to adapt to expected changes at least over the next fifty years – major societal and individual responses are required. Climate change science classified these responses into two types: mitigation, reducing emissions to avoid unmanageable climate change, and adaptation, which entails making changes to activities and lifestyles to manage unavoidable climate change.

'The current mobility system relies heavily on privately owned cars, which results in high levels of emissions, material use, and use of scarce public space' (Meelen en Münzel, 2023). Decreasing the use of cars could help mitigate a part of the total emissions and free up public space which can be done by promoting the use of other modes of transportation like walking and cycling. The C40 Cities Climate Leadership Group (2019, no pagination) dictates that 'to encourage people to travel by foot or bike, cities need to rebalance the distribution towards people walking and cycling. Addressing this imbalance requires cities to redesign neighbourhoods and traffic systems to work in favour of people cycling and walking, and to discourage car use.' This redesign should thus focus on walking and cycling, emphasising the significance of low-traffic zones. Low-traffic zones are specifically designed to discourage the use of cars, and encourage walking and cycling, and thus is a good concept to help change activities and lifestyles mentioned by Wilson and Piper (2010).

However, although discouraging the use of cars and encouraging walking and cycling will help reduce the emission of greenhouse gases, it will not provide the answer to the other problems that are put forth by climate change such as the increase in rainfall, extreme weather events, and the heat island effect. Thus, specific urban design elements need to be integrated into the concept of low-traffic zones to create urban areas that are truly climate-resistant. Researching low-traffic zones and their climate resilience is a proactive step towards sustainable urban planning and transportation, which are crucial in mitigating climate change impacts.

One concept found in the world of spatial planning that is known to help reduce the effect of climate change is the concept of green infrastructure. According to Kumareswaran and Jayasinghe (2023, p. 5), 'green infrastructure has been interconnected with creating a healthy community, improving quality of life, mitigating adverse impacts of climate change, facilitating sustainable urban development, promoting economic development, building urban resilience, and addressing the issues of social equity, all of which promote a number of the underlying principles of sustainability.' The authors show that green infrastructure is more than just planting trees that can take CO_2 out of the air. It is about creating a well-functioning area that addresses the needs of and improves the life of the whole community.

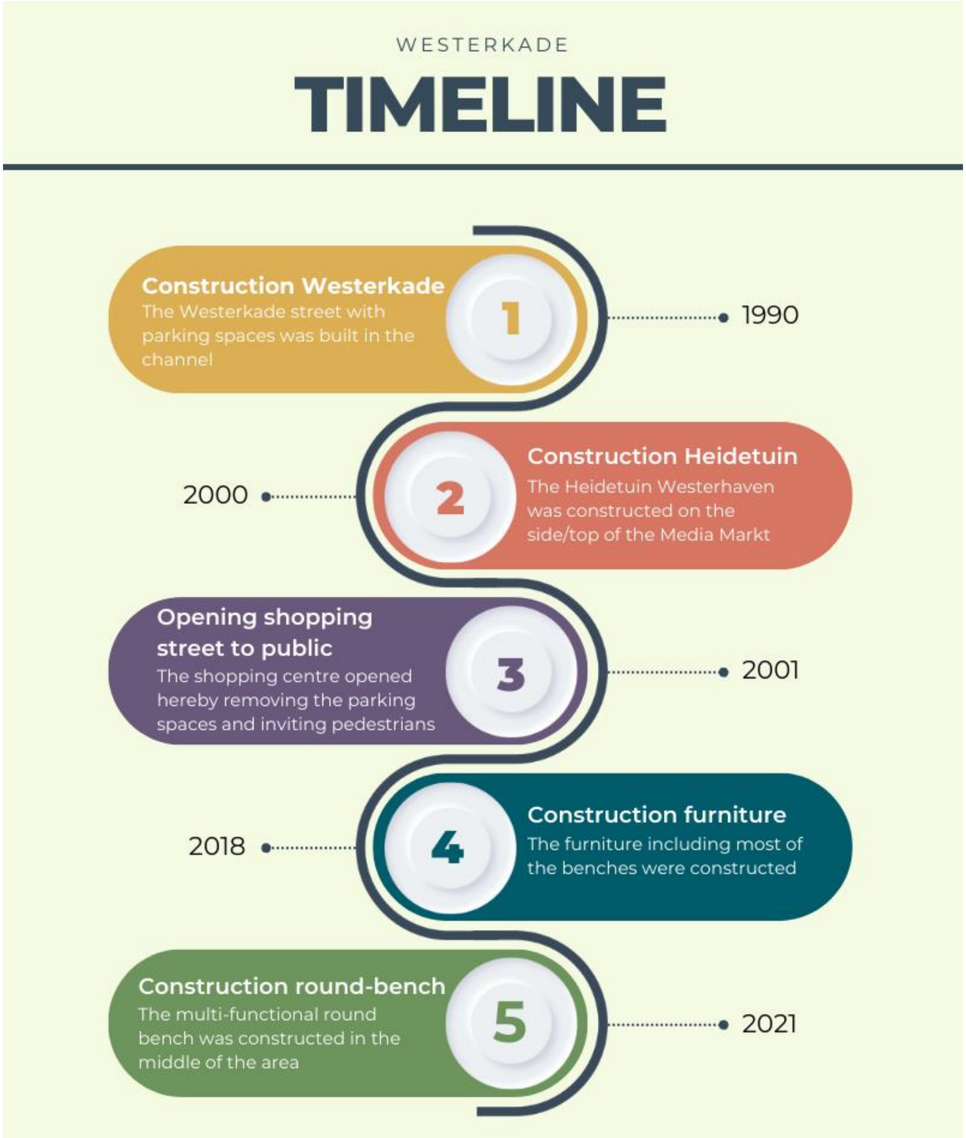

Figure 1. Timeline of construction Westerkade (Adapted from the author's work, 2024)

According to Openbare Ruimte (2021), the purchase of circular street furniture is inextricably linked to creating a future-proof, sustainable city. After all: continuing to purchase products whose materials are not reused contributes to the depletion of the earth, global warming and the increase in waste. It is therefore important that the street furniture and infrastructure is of adequate quality and longevity. The timeline in figure 1 (adapted from the author's work, 2024) shows the years certain elements of the infrastructure were built to later make it possible to determine the quality of the infrastructure present in the area.

1.1 Research Problem

In an attempt to reduce the effect of climate change through both aforementioned responses of mitigation and adaptation, this paper will explore specific urban design elements that can improve climate resilience and adaptation and how these design elements are incorporated into low-traffic zones that are meant to discourage the use of cars and encourage walking and cycling. Enhancing the climate resilience of low-traffic zones, or similar urban spaces, holds social and scientific significance by addressing sustainable urban design, environmental impact, and community well-being in research.

The area was chosen because the area is going through development as of 2024 in the hope of tackling many of the problems such as the management of excess rainfall, the urban heat island effect and infrastructure that gives conflicting messages about its purpose.

To substantiate the arguments, the low-traffic zone Westerkade shopping street will be used as an example. The area was chosen because the municipality of Groningen is currently working on a project about the Westerkade area that focuses on a number of the same indicators. To assess the current condition of the area, the proposed interventions will be discussed to demonstrate the situation that is present right now. The plan the municipality wants to integrate reflects the problems the shopping street faces right now.

The result will provide an overview of how spatial planners can design urban areas that are not only climate-resilient but also well-functioning areas with a high quality of stay where it is safe for pedestrians and cyclists alike to enjoy.

The research aims to explore the possibilities that low-traffic zones with integrated design elements focused on making urban areas more climate-resilient can offer.

The main research question can be further divided into sub-questions that each tackle certain design features or policies that further improve the climate resilience of the Westerkade shopping street.

Main research question: *"How do the design features and infrastructure interventions along Westerkade street in Groningen contribute to the area's climate resilience and adaptation as a low-traffic zone?"*

- *How does the integration of green infrastructure, porous pavements, and SuDS techniques within low-traffic zones contribute to climate resilience, specifically in terms of stormwater management and the reduction of flooding risks?*
- *How can elements within low-traffic zones be positioned to provide shade and mitigate the urban heat island effect?*
- *How can the thoughtful design of low-traffic zones, considering elements such as street furniture, infrastructure materials, and accommodations for active transportation modes like walking and cycling, contribute to enhancing the overall climate resilience of an area?*

2. Theoretical Framework

In the theoretical framework, definitions will be provided for the various concepts that are essential for a full understanding of the research. These concepts are the building blocks that will be used to support the arguments later in the paper. While there is a lot of information available about green infrastructure, the urban heat island effect, and urban greening, the relation with low-traffic zones is yet to be thoroughly defined.

2.1 Climate resilience

According to Meerow and Stults (2016) although it is difficult to define climate resilience because there is a wide range of interpretations of what resilience means, all definitions define urban climate resilience as a generic capacity to deal with climate impacts and disturbances. The two opposing main viewpoints can be narrowed down to recovering and “bouncing back” or transforming and “bouncing forward”. The latter is the preferred alternative due to the proactive rather than reactive stance. A combination of both stances could prove even more fruitful ensuring the preservation of the status quo as well as the ability to transform into a new version that can adapt to the ever-changing situation.

Center for Climate and Energy Solutions (2019) simply narrows down climate resilience as the ability to prepare for, recover from, and adapt to the impacts of more frequent and severe weather, ocean warming and acidification, extended periods of drought and extreme temperatures, and other deleterious effects of climate change. Herein also lies the importance of climate resilience, to be able to deal with these effects. The effects of climate resilience pose a risk to the well-being of everyone on earth and thus it's paramount to prepare for them in advance.

2.2 Low-traffic zones

The concept of low-traffic zones has several synonyms and other related names that refer to the same idea such as pedestrian zone, restricted traffic area, vehicle-restricted area, etc. that are being used interchangeably by authors of various papers. Even the concept of superblocks can be put into the same category as the rest. Although, superblocks block all vehicular traffic from entering the inner parts of the blocks, instead of trying to slow down and hinder cars.

In this paper, the term low-traffic zone will be used as an umbrella to describe an urban area where vehicular traffic is intentionally restricted to create a safer space that promotes walking, cycling, and socializing but synonyms could be used to describe the same phenomenon. It is similar to a low-traffic zone neighbourhood except that term describes a residential area. According to Haringey Council (2021), LTNs are areas with quieter roads which feel safer, encouraging residents to walk, cycle, play and meet in a healthier and more inviting environment.

Restricted does not have to mean that cars are entirely forbidden in that particular urban area, rather the use of cars is disincentivized.

2.3 Green infrastructure

According to the Directorate-General for Environment (n.d.), green infrastructure is: “A strategically planned network of natural and semi-natural areas with other environmental features, designed and managed to deliver a wide range of ecosystem services, while also enhancing biodiversity.” The main purpose of green infrastructure is to improve the quality of the environment as well as the health and quality of life of citizens.

2.4 Urban heat island effect

Due to the urban heat island effect, it is important to create spaces that provide shade and cover, to cool down the temperatures in urban areas. The urban heat island effect is an occurrence where warmer temperatures are experienced in cities as opposed to other areas like rural areas. The reason for this temperature difference can be accounted for by the ability of the surface in each environment to absorb and hold heat. In rural areas, more plants can be found than in urban areas. Through a process called transpiration, plants can use water to act as a so-called ‘air conditioner’. This cools the plant down. Cities, on the other hand, have fewer plants and more materials with a dark colour. According to NASA (2023), Darker objects absorb all wavelengths of light energy and convert them into heat, so the object gets warm.

2.5 Urban greening

According to ANS Global (n.d.), urban greening is defined as: ‘public landscaping and urban forestry projects that create mutually beneficial relationships between city dwellers and their environments’. Urban greening aims to improve the quality of life of residents by adding more green spaces in urban areas. Urban greening may look similar to green infrastructure. Both concepts aim to create a more sustainable and liveable city. The difference between these two concepts is that green infrastructure is more focused on designing and providing various ecosystem services, often on a larger scale such as cities, while urban greening is more focused on improving aesthetic elements, often on a smaller scale such as a street.

2.6 Porous pavements and sustainable drainage systems (SuDS)

In rural areas, the ground is permeable and can absorb water. When rain falls, the water can infiltrate the ground and move downward into the soil, relieving the surface of the excess water. Because cities are mainly build-up of concrete and asphalt, the water from rainfall cannot penetrate the ground and needs to be transported by storm drains and gutters. Due to climate change, more extreme rainfall might occur that cannot be dealt with by storm drains and gutters alone. A combination of porous pavements and sustainable drainage systems can help deal with this excess rainfall. Porous pavements are made from materials that allow water to pass through them, acting similarly to how the ground can absorb water. The water can infiltrate the concrete or asphalt and can then temporarily be stored in the underlying layers of stone or gravel. After that the water then either infiltrates into the ground or is directed to a drainage system. Sustainable drainage systems or SuDS are a set of practices and techniques that use the principles of nature to act as drainage systems. They mimic the natural processes to slow down, capture and filter water. Some examples include green roofs, rain gardens and swales.

2.7 Resilient street furniture/infrastructure

In urban areas, numerous types of street furniture can be used by the public such as benches, trash cans, bollards, streetlights, bike racks, bus shelters, planters etc. These types of furniture face weather, and traffic and public wear and tear and thus need to be able to withstand a beating without breaking to prevent unnecessary repairs. That is why this furniture must be made from durable materials, designed to withstand extreme weather events, is flexible in the way it can be used, and has a climate-resistant coating or finish to ensure that it can be used safely for longer periods. The same is true for Infrastructure such as sidewalks, roads, pavements, traffic signals, traffic signs, crosswalks etc. These are important elements that collectively contribute to the functionality, safety and aesthetics of urban environments and ensuring their durability and resilience can go a long way in creating climate-resilient urban areas.

2.8 Active transportation modes

Active transportation modes are methods of traveling that require the involvement of physical activity, such as walking, cycling, skateboarding, rollerblading, or using a wheelchair in order to get from one place to another. These forms of traveling can be considered ‘active’ because they require physical movement as opposed to passive transportation modes that involve little to no physical activity on the part of the traveller. These modes of transportation can provide a number of health benefits while also being environmentally sustainable.

2.9 Conceptual model

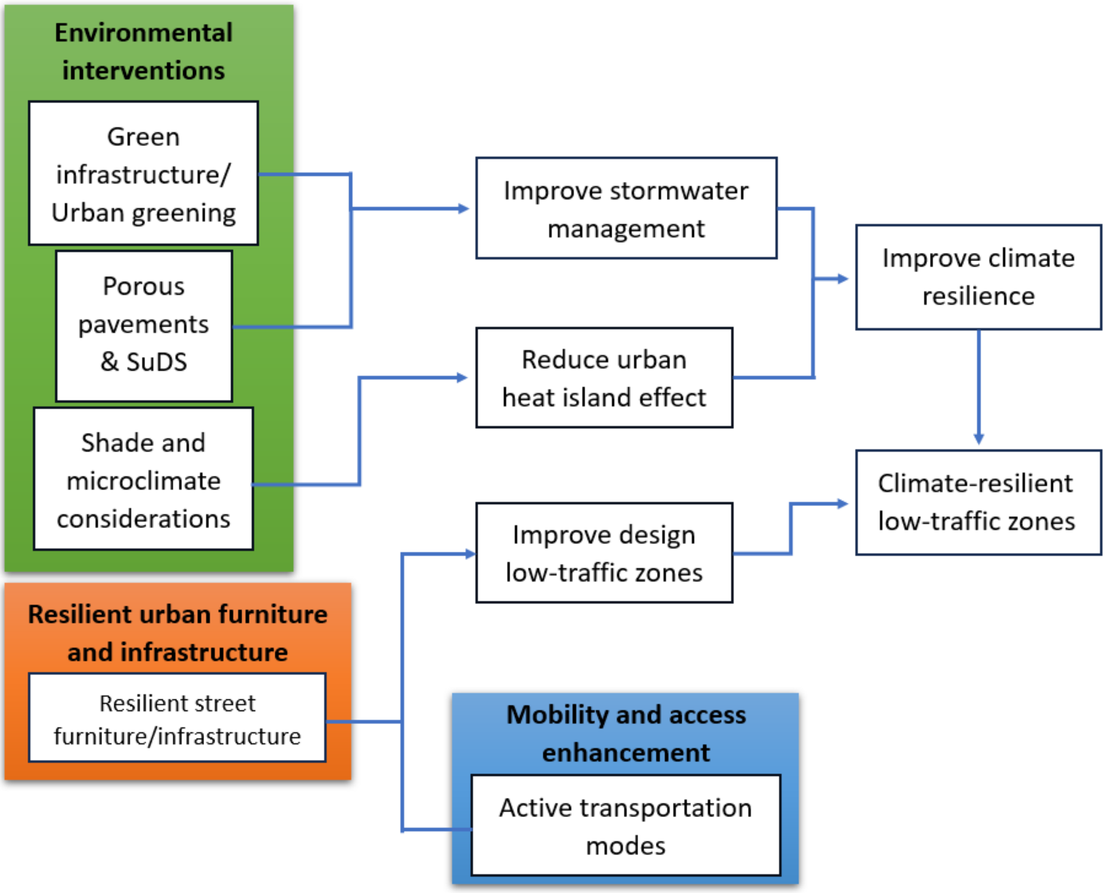

Figure 2. Conceptual model (Adapted from the author's work, 2024)

The model in figure 2 (Adapted from the author's work, 2024) shows the relation between the concepts that can help create climate-resilient infrastructure, in this case, climate-resilient low-traffic zones. Three different groups can be defined. The first group is environmental interventions. The concepts found in green infrastructure/urban greening in combination with porous pavements/SuDS will help improve the stormwater management of an area. This in combination with the reduced urban heat island effect found in shade and microclimate considerations will help improve the climate resilience of an area. The design of low-traffic zones is focused on pedestrians and cyclists alike and it needs to reflect that. Thus a combination of resilient street furniture/infrastructure with active transportation modes will help.

2.10 Hypotheses/Expectations

Due to the qualitative nature of the research that will be performed, the expectations are less nomothetic than the expectations that are considered when working on research of a quantitative nature. The hypothesis can be defined as such:

Specific design elements found in concepts focused on creating climate-resilient infrastructure can be used to create climate-resilient low-traffic zones. The effectiveness and overall compatibility with the environment are based on the specific nature of the place of interest.

3. Methodology

This section will outline what methods have been used to collect the data. The following subsections will describe the study area, the data collection methods and how ethical dilemmas that arose were dealt with.

3.1 Description of the study area

Data was collected in the Westerkade shopping street located just West of the inner city of Groningen. The area is a popular shopping street with a number of big stores and dining options. The main focus is to look at the walkable areas between the buildings from the intersection of the Astraat, Aweg, Westersingel and Hoendiepskade on one side and the Museumbrug on the other. On the North-East side, the area is connected to the Westerhavenstraat, in the East to Westerhaven and in the South to the Sluiskade. An important part is the roof garden Westerhaven as it plays a vital part in the disposal of excess rainwater in the area. An area calculator was used to determine the size of the area between the buildings which ended up being around 8277 m^2 as can be seen in figure 3 (google maps 2024).

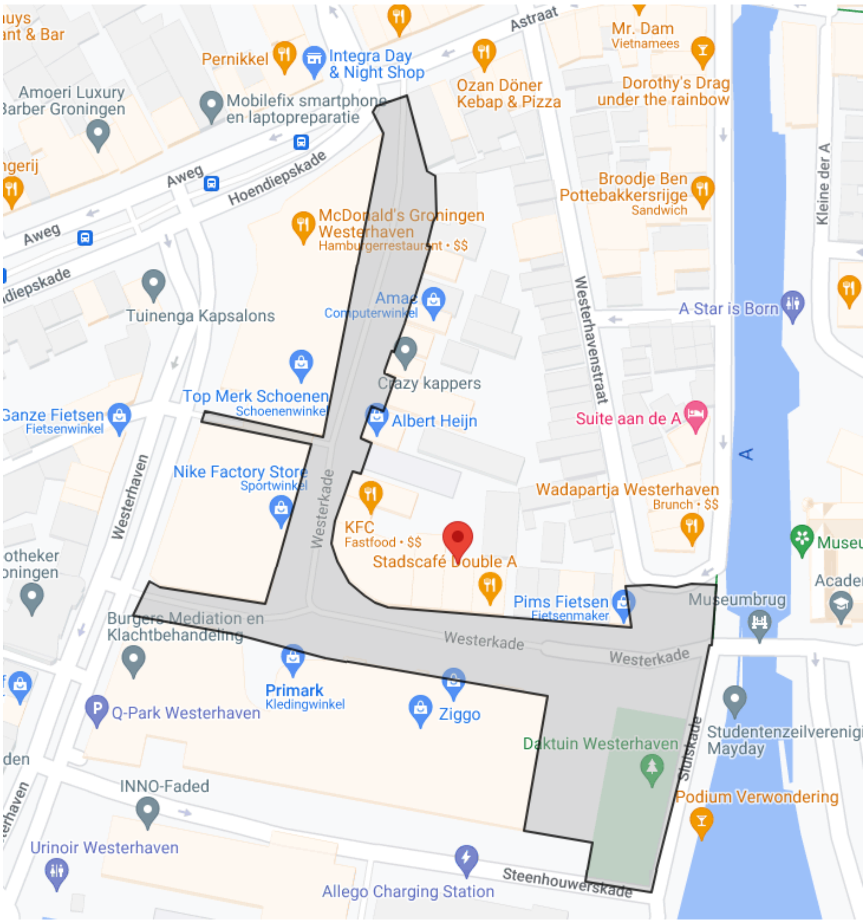

Figure 3. Defined area Westerkade (Google maps, 2024)

3.2 Data collection methods

For this research, a combination of qualitative and quantitative research methods was used. For the qualitative research methods, unstructured interviews were held with architect/urban designer Freek Wilkens and water advisor Richard Walters from the municipality of Groningen. These interviews were held to gain information about the study area regarding history, water management, traffic policies and future plans.

The reason for choosing unstructured interviews is that the unstructured nature of the conversation allows for the ability to pursue interesting facts or information that may arise and to continue asking questions about that topic to gain a more complete understanding of the study area.

The second form of qualitative research is in the form of photographic evidence. The reason for choosing this method is that photographic evidence allows for capturing details in the study area and provides context for the rest of the evidence. A camera phone was used to capture both the physical infrastructure and the dynamics of the space. The camera also recorded the time and day when the photos were taken for later analysis. The 90 photos were collected on Thursday 2/11/2023 between 1:57 and 2:10 p.m. This day and time was chosen because it was reasonably bright, with no rain, at 14 degrees, and with a strong wind. Reasonably good conditions to take photos. The fact that there was no rain was the most important element as rain would limit the amount of people that were out in the streets. This was especially important for observing the use of the available infrastructure and active modes of transportation such as walking and cycling. It had rained earlier that day. This allowed for the photographs to record the residual pools of water that the water management system failed to remove from the area.

Quantitative research was performed in the form of spatial analysis including measurements to capture the physical dimensions of the area. The measurements were made with a tape measurer and then documented using a pen and notebook. The main focus was to measure the size of the tree pits, small patches of green and other small areas that are difficult to measure utilising satellite imagery. The reason for choosing to perform these measurements is that they provide an objective basis for this research as opposed to the subjective nature of the qualitative research methods.

In terms of how the data will be processed, the data from the measurements and photographic evidence will be combined with further data gathered online into several maps using GIS combining then with the rest of the maps that were provided during the interviews. These maps will serve as the objective foundation on which conclusions can be drawn. The rest of the information that was provided during the interviews will be combined and analyzed against the data gathered from literature review. The case study of the Westerkade will then be used to provide real-life context and a chance to examine the effects of various measures have on the challenges that are presented.

3.3 Ethical considerations

The photographic evidence that was collected also documented the identity of numerous people on the street. Because of the public nature of the study, it is impossible to notify all the people who were visible in the photographs of their participation in the study. To solve this ethical problem, all people photographed were made unrecognisable by blurring their faces.

4. The results

In the upcoming discussion of the results, the multi-faceted plan proposed by the municipality of Groningen will be examined and how it aims to address the challenges the Westerkade is facing now. This will discussion will illustrate how a number of elements of climate resilience can be handled contributing to an overall increase in resilience of an area implementing the philosophical principles found in low-traffic zones.

4.1 Stormwater management and reduction of flooding risks

One of the parts of climate resilience that needs to be handled according to the Center for Climate and Energy Solutions (2019) is the ability of the area to deal with more frequent and severe weather. This weather results in an overflow of rainwater that must be soaked up by the ground and subsequently carried away and exposed. According to Mostert (2021), 'the impermeable surfaces that dominate the city prevent rainfall from being absorbed and accelerate the possibility of flooding, leading to economic loss and disruption.' Groningen and more specifically the Westerkade shopping street is no different. In the interview with urban water advisor Richard Walters, it became evident that one of the most prominent reasons for the project Westerkade is that the area needs to be prepared for the increase in severity and frequency of extreme weather events.

In order to know if the drainage systems in an area are sufficient, they need to be able to withstand extreme weather events. A good measure is the so-called 100-year storm. According to Water Science School (2018), the term 100-year storm is used to define a rainfall event that statistically has this same 1-percent chance of occurring. According to urban water advisor Richard Walters, the area is supposed to be able to handle 60mm of rainfall. Due to the effects of climate change, that number can increase to 70mm of rainfall in the future. For the calculations, the measure of 60mm is used. The total surface area of where the rain falls or 'het invloedsgebied' in Dutch is measured by adding up the surface area of all the rooftops and the areas between the buildings. This results in roughly 15000 km^3 or 1,5ha. 1,5 x 60 = 900m^3. This means that in the worst-case scenario, the area needs to be able to deal with 900m^3 of rainfall.

Figure 4. Picture of pools of water (Adapted from the author's work, 2023)

As it is, the Westerkade Street is not equipped to deal with this problem. Even now, after only moderate precipitation, pools of water that collect can be seen throughout the area as made evident by figure 4 (photograph taken by author, 2023). According to Upper Midwest Water Science Center (2019), permeable pavement is a porous urban surface composed of open pore pavers, concrete, or asphalt with an underlying stone reservoir. Permeable pavement catches precipitation and surface runoff, storing it in the reservoir while slowly allowing it to infiltrate into the soil below or discharge via a drain tile. This could be a solution for the visible pools of water, but this is only an indication of the bigger underlying problem that all the water is collecting in certain places as indicated in figure 5 provided by Richard Walters during interview (2023), showcasing the lowest surface levels. The only place that is at least partly equipped to deal with the rainfall is the roof garden located in the southeastern part of the area where vegetated surfaces absorb the majority of rainfall, inevitably slowing down the process of surface runoff reaching drainage capacity.

Figure 5. Map of the surface levels (Figure provided by Richard Walters during interview, 2023)

The reason that water is collected primarily in the centre of the shopping street is because the area is at a lower elevation than the surrounding area at about one meter above sea level. It is likely to assume that the water flows towards and drains into the canal on the East side. However, the water flows from the centre of the city to the outskirts of the city. This is because the city of Groningen is located on the Hondsrug. This is the reason that there must be an alternative plan to prevent water from pooling in this particular area.

To deal with this problem, a combined approach of different measures needs to be put into action. In the plan for the area, a combination of two sections of 0,40m deep rain gardens, a measure from the urban greening initiative, and porous pavements with water storage underground are presented. Both are located at the opposite entrances of the shopping street in the North and East. The rain garden in the North is projected to be able to hold 335 x 0,40 = 135m^3 and the rain garden in the East to hold 250 x 0,40 = 100m^3 as can be seen in figure 6 provided by Richard Walters during interview (2023), showcasing the capacity of the proposed rain gardens. The water storage underground in the North and East combined should roughly be able to hold another 150m^3. The combined total of 135 + 100 + 150 =385m^3 is not even half of the 900m^3 the area will have to deal with in an extreme rainfall event that happens once every 100 years. When asked about this the urban water advisor Richard Walters responded that there is so far no plan to resolve this problem.

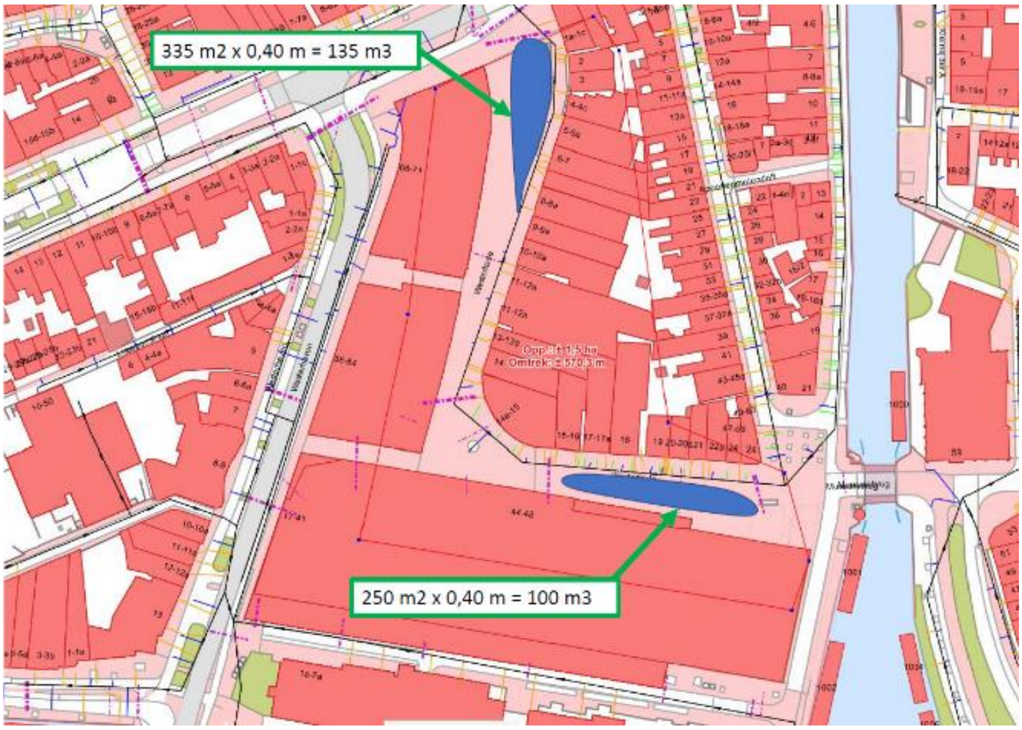

Figure 6. Capacity of rain gardens (Figure provided by Richard Walters during interview, 2023)

4.2 How to mitigate the urban heat island effect

According to Kleerekoper, van Esch and Salcedo (2012), due to climate change, there will be a rise in global temperature which will result in an increase in heat stress in the Netherlands. The phenomenon of urban heat islands, where warmer temperatures are experienced in cities as opposed to other areas like rural areas, will only aggravate this heat stress, especially in urban environments thereby intensifying the need for immediate action.

To quantify the scope of the issue of the urban heat island effect, it is first important to map out the areas where the increase in temperature is most noticeable. This can be done using a heatmap as can be seen in the figure 7 (Klimaateffectatlas, 2023). According to Awati (2023), 'a heat map is a two-dimensional representation of data in which various values are represented by colours.' In the heatmap, it becomes evident how the effect of shade impacts the perceived temperature at certain places. In the north and east side of the area, the street is significantly wider than in the centre while the height of the surrounding buildings remains about the same. This means that the streets in those areas are exposed to the heat of the sun for larger parts of the day. The heat is then trapped in the bricks and radiates heat back to the people walking on the surface which in turn increases the perceived temperature in these areas to up to 42 degrees Celcius. The area around the museum bridge is impacted the most reaching perceived temperatures as high as 43 degrees Celsius. According to Freek Wilkens, due to the urban heat island effect, the perceived temperature can differ as much as 15 degrees on hot summer days.

Figure 7. Heatmap perceived temperature of Westerkade (Klimaateffectatlas, 2023)

According to Klimaateffectatlas (n.d.) By smartly designing cities the perceived temperature can be lowered and thus reduce heat stress. This can be done by positioning certain elements in a particular way or by adding vegetation which can be crucial in cooling the environment. According to (Armson et al., 2012; Tan et al., 2016; Wong and Yu, 2005), 'the impact of greenery on mitigating the UHI effect is reported between 4°C to 24°C'. 'Green spaces in cities mitigate the effects of pollution and can reduce the earlier mentioned urban heat island effect which refers to heat trapped in build-up areas according to Mair (n.d.). According to Mostert (2021)'. This is because greenery absorbs pollutants and retains less heat in comparison to pavements and buildings while also providing evaporation.

In the new design, measures should be considered that provide more shade and add greenery that absorbs pollutants, retains less heat, and increases evaporation. The orientation and height-width ratio of the streets can help provide more shade. In the case of the Westerkade, this is however not an option. The following plan is proposed as can be seen in figure 8 provided by Freek Wilkens during interview (2023), showcasing the proposed design for the Westerkade. In terms of greenery, more trees are planted throughout the area that provide both shade, absorb heat and deal with pollutants. The trees are located in the middle of the two sections of the street where, according to the heat map, the perceived temperature is the highest so it can provide shade at the optimal locations. In terms of absorbing heat and dealing with pollutants, the same can be said for the rows of bushes that encapsulate both sections of the design and the grass that is indicated by black cardboard in the model of the design. According to Freek Wilkens, the combination of these measures should be enough to deal with the higher perceived temperatures in the area.

Figure 8. Picture of proposed design Westerkade (Figure provided by Freek Wilkens during interview, 2023)

4.3 The impact of the design of low-traffic zones on enhancing climate resilience in an area

The design of our streets and infrastructure influences how we interact with the world. If we focus on building more infrastructure for cars, then it is likely to assume that cars will become more dominant. This can also be said for active transportation modes like walking and cycling. Walking and cycling are two modes of transportation that are not only good for the general health of our people by increasing their physical activity, they are also modes of transportation that do not emit any greenhouse emissions.

According to Hallisey (2022), since bicycles are human-powered and are not reliant on gasoline, the five metric tons of carbon dioxide a year that a typical passenger emits are eliminated. This reduction in emissions contributes to mitigating the effect of climate change including the decrease in extreme weather events thus improving climate resilience.

To ensure that more people cycle as an alternative to the car there first needs to be enough cycling infrastructure. This includes bike lanes, sufficient parking facilities and a well-connected cycling network. Van der Zee (2015) argues that the city of Groningen can be seen as the cycling capital of the world with about two-thirds of all trips made by bike. This indicates the quality and quantity of cycling facilities in the city. Apart from all the cycling infrastructure, to get people to cycle instead of driving a car, cycling needs to be a convenient and fast alternative.

The introduction of the traffic circulation plan in 1975 by former mayor of Groningen Jacques Wallage aimed to make the city centre car-limited yet still accessible by cars and to offer more space to pedestrians, public transport and cyclists as mentioned by Tsubohara (2007). This meant that if you wanted to move from one side of the city to the other side by car, it would no longer be possible to penetrate the core of the city. Instead, cars now have to use the ring road that loops around the city. This plan made cycling in Groningen more appealable as it was alternative mode of transportation that made it possible to reach every part of the city while being significantly faster than walking.

In terms of the shopping streets' stance on cycling, a stark dichotomy is revealed. During the interview with the architect/urban designer Freek Wilkens, it was revealed that it is not permitted to cycle in the shopping street. Nonetheless, the municipality is aware that people cycle there anyway, as made evident in figure 9 (photograph taken by author, 2023), probably because in almost every other similar area it is permitted. So, to make the area more in line with the rest of the city, the area is currently full of cycling infrastructure such as bicycle storage as can be seen in the pictures below. The presence of this infrastructure only confuses people more on the actual stance on cycling.

Figure 9. Cyclists on the Westerkade (Adapted from the author’s work, 2023)

This endorsement of cycling is confirmed in the new design of the shopping street. In the areas between the buildings 119 new cycling parking spots will be placed and 85 cycling spots in the shopping street itself as can be seen in figure 10 provided by Freek Wilkens during interview (2023), showcasing a map of the proposed design for the Westerkade. The new design reforges the relationship of the Westerkade with the rest of the cycling network solidifying the bond and making it part of the rest of the cycling city of Groningen.

Figure 10. Picture of a map of the proposed design Westerkade (Figure provided by Freek Wilkens during interview, 2023)

Apart from cycling, both the old and new designs also provide infrastructure for pedestrians. In the old design, several benches or similar seating areas can be found. The new design goes a step further by not only providing adequate seating but also providing an adventurous route on both the North and East sides of the shopping street which encourages parents and their kids to walk. An example of such an adventurous route can be seen in figure 11 provided by Freek Wilkens during interview (2023), showcasing an small obstacle course for children. Freek Wilkens noted that the new design is more focused on providing additional incentives for people to choose to walk by making the area more suitable for parents with children.

Figure 11. Adventurous obstacle course for children (Figure provided by Freek Wilkens during interview, 2023)

Besides incentivizing the use of active transportation modes likes walking and cycling, a climate resilient area also needs to have resilient infrastructure and furniture that can last. According to Openbare Ruimte (2021), the purchase of circular street furniture is inextricably linked to creating a future-proof, sustainable city. After all: continuing to purchase products whose materials are not reused contributes to the depletion of the earth, global warming and the increase in waste. It is therefore important that the street furniture is of adequate quality and longevity to ensure that little extra waste is created.

In figure 1 (Adapted from the author's work, 2024), a timeline is displayed showcasing the construction dates of various elements currently found in the Westerkade. This information can be used to compare the durability of the various materials used. Freek Wilkens provided the information that the furniture is made from a combination of Iroko wood, concrete and stainless steel. The bulbs constructed in 2001 that are there to discourage traffic from parking or driving in specific areas visible in figure 12 (photograph taken by author, 2023) are made from concrete. After almost 23 years of wear and tear, these bulbs are still functional and are not yet ready for replacement. The same can be said for the garbage bins visible in the same figure. These were constructed around the same time as the concrete bulbs and apart from the paint chipping of some of them, they are still in a functional state.

Figure 12. Garbage bin next concrete bulb (Adapted from the author's work, 2023)

As for the benches that can be found all over the Westerkade and the more iconic c-shaped bench in the middle of the area as seen in figure 12 and figure 13 (photograph taken by author, 2023) respectively, it is more difficult to determine the durability and longevity. The regular benches were built in 2018 and are thus only about 6 years old. The c-shaped bench in the middle of the area was built in 2021 making it only 3 years old. As mentioned by Freek Wilkens that these benches normally last at least 20 years, it is difficult to determine if these specific benches are of adequate quality.

Figure 13. C-shaped bench in the middle of the Westerkade (Adapted from the author’s work, 2023)

5. Conclusion

From the findings can be concluded than in order to make a low-traffic zone climate resilience, a number of factors need to be takin into account. The nature of the low-traffic zone calls for the need for measures dedicated to creating an environment build out of durable materials that can survive the test of time that is focused pedestrians and cyclists alike. The area needs to provide adequate facilities for the people in the area while also providing a purpose for their being there such as certain facilities for children. The infrastructure should not only cater to the needs of pedestrians and cyclists but also needs to connect seamlessly with the surrounding transport networks such as the cycling network to convince people to walk or cycle rather than take the car. The low-traffic zone needs to become part of the city while also being able to function as a separate entity.

At the same time, the area needs to be able to handle a multitude of different threats caused by the effects of climate such as extreme weather events like excessive precipitation and high temperatures. In terms of rain, the area should be able to deal with a storm that comes once every one hundred thus forcing spatial planners to make well-functioning drainage systems a priority. In terms of the temperature, the effect of the urban heat island effect needs to be mitigated in areas where excessive temperatures are measured. These effects can be minimized by providing shade at tactical locations. For both challenges the impact of greenery is unmistakable. Greenery is a good option for storing water in the form of rain gardens. In terms of reducing the urban heat island effect, greenery retains less heat as opposed to other urban elements.

For the Westerkade shopping street, the most prominent threat is that of an excess of precipitation. A combination of measures is needed to solve the problem, but sometimes, even that is not enough. In the case of the Westerkade, as mentioned before, the problem concerning the drainage of water is up until now not solved showing that it is not always possible to make an area a 100% resilient against extreme weather events. Every location has its own sets of challenges and opportunities and it is for the spatial planners the task to realize the best possible outcome. There will be never be one final indefinite solution. The battle of climate resilience is a continuous cycle, adapting and evolving to address the ever-changing environmental challenges we face.

Concerning future research, further studies could investigate the effects the placement of certain elements in the area have on the wind patterns and how that in turn will have effect on the perceived temperature in low-traffic zones. Also, the longevity of the furniture that has been placed more recently is yet to be tested as it has not experienced enough years of wear and tear to draw a definitive conclusion.

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