Implementing Fair Streets for school zones in the Netherlands

Evaluating stakeholder perspectives to achieve a "Fair Street" design for a school street in Delft: A multi-criteria decision approach.

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Preface

This thesis is the final project required to complete the Master's program in Transportation, Infrastructure, and Logistics at Delft University of Technology. The skills and knowledge gained during the courses in this master's program have been used and assessed during the duration of this thesis about the implementation of Fair Streets in school zones in the Netherlands.

I would like to express my gratitude to several individuals who supported me throughout this project. First and foremost, I would like to thank Sander Buningh from BAM Infra for giving me the opportunity to write my thesis for the company of BAM Infra. Also, his weekly guidance throughout this project with his valuable insights and connections helped me a lot during this process.

Additionally, I would like to thank all the experts who took the time to help me with answering project-related questions. Furthermore, I would like to thank the persons from the municipality, CWD and the parents association of the Blijberg, who I have interviewed during this project, for taking the time to answer my questions. I really enjoyed the conversations about the "Rechtvaardige Straat".

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E.M. van Veen
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Abstract English

Over the past century, with the advancement of the automobile industry, the evolution of urban landscapes has increasingly favored the facilitation of vehicular traffic over other forms of street life. Currently, up to 50% of city public space is consumed by car infrastructure. This vehicle-oriented layout has not only led to congested roads and extensive urban planning projects aimed at accommodating more vehicles but has also significantly diminished the role of the street as a social and community hub, compromising the safety and health of pedestrians and cyclists. In addition, this facilitation for vehicles is also worsening environmental problems, with the increase in impenetrable surfaces such as concrete and asphalt, a decrease in urban green space, and more extreme weather due to climate change creating an urban environment characterized by heat islands, overflowing streets, and poor biodiversity.

In protest of this car-centric urban design, a compelling Dutch counter-narrative has been created called the ”Rechtvaardige Straat” or ”Fair Street.” This philosophy advocates for a reimagined urban streetscape that prioritizes spatial justice, ensuring streets serve not just as conduits for cars but as vibrant spaces for social interaction, community building, and environmental sustainability (European Commission, 2023). This approach promotes safer, more sustainable, and more inclusive urban mobility. With this philosophy, the quality of the urban area will increase, and the use of the streets will be more fairly distributed among different users. However, this comes at the cost of car users by reducing the amount of space available for their transportation needs. Therefore, resistance from this particular group to extreme changes is very likely to occur. Literature suggests that different stakeholder interests create a barrier to implementing car-reducing policies also, low societal acceptance of measures results in political resistance (van der Lee, 2024). As a result, local governments are struggling to implement this Fair Street vision in actual residential neighborhood redevelopment.

Policy strategies to manage these barriers appear to be showing openness and flexibility in changing the measure to increase acceptability, creating measures that positively affect children’s health and safety and using trials for experiencing and getting familiar with new situations. However, the literature lacks evidence on the effectiveness of these strategies and how to merge them in practice. Therefore, this research will combine these success factors and look at methods to engage key stakeholders in making school environments fairer. The research will look at considerations for (temporary) infrastructural changes to improve the representation of the Fair Street principles in school environments and methods to identify the problem in the current situation so that targeted solutions can be made for each specific school environment. This research will address the following main research question:*”How can the Fair Streets principles for school zones in the Netherlands be implemented, considering the interests of different stakeholders?”*

To address this research question a case study is conducted at the Fuutlaan in Delft were an elementary school is located in a typical cauliflower residential area. The principles of Fair Street were divided into 6 main criteria for the Fuutlaan using a goal tree to structure the philosophy of the Fair Street into measurable criteria for the Fuutlaan. These main criteria are ”traffic safety,” ”sustainability,” ”inclusivity,” ”sociality,” ”car accessibility,” and ”bike accessibility.” Some of the main criteria were also divided into sub-criteria. ”Traffic safety” was divided into ”actual safety” and ”perceived safety.” ”Sustainability” was divided into the sub-criteria ”biodiversity,” ”heat resistance,” ”rainfall resistance,” and ”drought resistance.” ”Inclusivity” was divided into ”pedestrian accessibility” and ”special accessibility.”

The key stakeholders in the Fuutlaan were asked to consider these main criteria and their sub-criteria. This is done using the best-worst method in interviews with representatives from the parents of the school, residents, and municipality. The Best-Worst Method is a multi-criteria decision-making method commonly used to substantiate trade-offs between different criteria in policymaking (Rezaei, 2015a). Aggregating the responses from the interviews revealed that the stakeholders collectively consider ”sustainability” by far the most important main criterion on the street. Within this main criterion, rainfall resistance and heat resistance are considered the most important which corresponds to the municipality’s redevelopment project and the biggest issues that emerged from the climate impact scan of the

Fuutlaan. After ”sustainability,” ”inclusivity” and ”traffic safety” are seen as important criteria in street redevelopment. Remarkably, ”car accessibility” is seen by far as the least important criterion in the redevelopment of the Fuutlaan. This underscores the Fair Street thinking that streets are currently designed primarily for the facilitation of motorized traffic. Therefore, improvement of this criterion is least necessary according to the stakeholders interviewed. The weightings of these main criteria can also be seen in table 1.

Table 1: Aggregated normalized weights of the main criteria

	Traffic Safety	Sustainability	Inclusivity	Sociality	Car Access	Bike Access
Aggregated weights	0.159	0.337	0.160	0.129	0.084	0.131

Creating fairer school environments not only consists of creating spatial justice in the physical infrastructure, but it also requires changes in the use of the infrastructure by road users. Therefore, surveys are conducted among the road users of the Fuutlaan to get a good indication of the bottlenecks in the current situation. The answers of 6 parents and 11 residents revealed that especially the behavior of parents who bring their children to school by car creates unsafe situations in the current situation. However, because the survey received little response in the Fuutlaan, these findings are not very well founded. As a result, a second survey was conducted at the Blijberg elementary school in Rotterdam. Again, the answers of 86 parents showed strongly that parents' behavior created complicated, unclear situations around the school, which are perceived as unsafe. In this case study, it also became clear that the bicycle crossing on a 50 km/h road near the school and the two-way traffic in front of the school entrance were considered unsafe. This shows that the survey can provide a clear picture of the bottlenecks in the school environment, and with this, it also provides insight into targeted solutions for both physical and behavioral improvements of the environment around the school.
In addition to providing a good overview of the current situation, the surveys also asked about spatial considerations for different uses of street parking spaces. This helped create several new designs for the Fuutlaan redevelopment. The five different street designs that were conceptualized and evaluated through the Best-Worst Method to capture stakeholder priorities and preferences are:

- **Design 1, Renovation of Existing Fuutlaan:** This is a design created by the municipality of Delft and will become the final design for the Fuutlaan. It focuses on minor upgrades to the current infrastructure. The only difference in this design is that tiles with holes for growing grass will be placed at the parking spots, which will make the street slightly more climate-adaptive than in the current situation.
- **Design 2: Removal parking spots school side** This design was also created by the municipality and was the first version before the final design. It slightly improves current traffic safety by removing the cars on the school side, thereby improving visibility. For the rest, instead of parallel parking, this design uses perpendicular parking. Also, this design uses tiles with holes for growing grass in the parking spots.
- **Design 3, Shared Space Design:** This design is self-created and based on the shared space principles. This means that conventional signs and markings are removed, and pedestrians, cyclists, and cars are all mixed on the road. A requirement for shared space is that the road is well visible, and therefore, no cars should be parked on the street. This creates extra space being freed up for other activities, such as bicycle parking spaces, green spaces, or social gathering spaces.
- **Design 4, Car-Free Street:** In this design, no cars are allowed to drive in the street at all. This will make the Fuutlaan accessible only to cyclists and pedestrians. Also, in this design, the removal of car parking spaces frees up a lot of space for bicycle parking spaces, green spaces, or social gathering spaces.
- **Design 5, Fair renovation existing Fuutlaan:** This design is an adaptation of the definitive design of the municipality by looking more at implementing the Fair Street principles. As a result of the space reconsideration questions of the survey, car parking spaces were replaced accordingly

with bicycle parking spaces, greenery, and social gathering spaces based on the desires of road users.

The scores of the designs based on the different criteria of a Fair Street were determined using expert consulting and literature. These scores can be seen in table 2.

Table 2: Total Performance Designs

	Traffic Safety	Sustainability	Inclusivity	Sociality	Car Access	Bike Access	Total
Design 1	0.075	0.033	0.011	0.400	0.824	0.032	**0.150**
Design 2	0.337	0.693	0	0	1	0	**0.371**
Design 3	0.413	0.642	1	1	0	1	**0.702**
Design 4	1	0.642	0.276	1	0	1	**0.679**
Design 5	0.075	0.642	0.276	1	0.059	1	**0.537**

Given the preferences of the different stakeholders in the Fuutlaan that resulted from the interviews, the shared space design scored the best on the Fair Street criteria. Due to the extra space this design creates by removing car parking spaces, this design scores well on the criteria ”sustainability,” ”inclusivity,” ”sociality,” and ”bike accessibility.” Also, this design is based on the theory of improving ”traffic safety” in the street. Therefore, the criteria that are seen as most important by stakeholders are well met in this design. The definitive design from the municipality for the Fuutlaan scores the lowest. However, this has mostly to do with the fact that this design has been used as the basis for the creation of the new designs that met the principles of the Fair Street more.
From the two case studies conducted in this research, it can be concluded that the Best-Worst Method interviews combined with the survey's spatial reconsideration questions can help urban planners and designers create a fairer balance of different street activities in redeveloping school environments. However, it should be noted that answers given by the interviewees are still individual preferences, and therefore, it is recommended to create a large group of respondents through focus groups and wide survey distribution.
To implement fairer road users' behavior, the survey can be used to reflect on the parent's behavior in the street and how they contribute to an unfair school environment. Therefore, the survey can be used as an entry point for conversations and education to change parents' traveling behavior. In addition, the survey also shows what bottlenecks there are in the current design, allowing the municipality to make adjustments in the infrastructure to influence the behavior positively.
The methods explained show that the combination of conducting interviews and distributing surveys could lead to better-accepted changes in both physical infrastructure and road user behavior. Depending on the problems that arise in a specific case, this combination of methods can create well-founded actions to achieve fairer school environments and implementation of the Fair Street principles in school zones in the Netherlands.

Abstract Dutch

In de afgelopen eeuw, met de vooruitgang van de auto-industrie, is er bij de ontwikkeling van stedelijke gebieden steeds meer de voorkeur gegeven aan het faciliteren van autoverkeer boven andere vormen van het straatgebruik. Momenteel wordt tot 50% van de openbare ruimte in de stad in beslag genomen door auto-infrastructuur. Deze voertuiggeoriënteerde visie heeft niet alleen geleid tot overvolle wegen en uitgebreide stedenbouwkundige projecten gericht op het accommoderen van meer voertuigen, maar heeft ook de rol van de straat als sociaal openbare ruimte aanzienlijk verminderd, waardoor de veiligheid en gezondheid van voetgangers en fietsers in gevaar zijn gekomen. Bovendien verergert deze facilitering voor het autoverkeer ook de milieuproblemen, met de toename van ondoordringbare oppervlakken zoals beton en asfalt, een afname van stedelijk groen en meer extreme weersomstandigheden als gevolg van de klimaatverandering, waardoor een stedelijke omgeving ontstaat die wordt gekenmerkt door hitte-eilanden, overvolle straten en een slechte biodiversiteit.

Als protest tegen dit autogerichte stadsontwerp is er in Nederland een overtuigend tegengeluid ontstaan: de ”Rechtvaardige Straat”. Deze filosofie pleit voor een nieuw stedelijk straatbeeld dat ruimtelijke rechtvaardigheid vooropstelt en ervoor zorgt dat straten niet alleen dienen als doorgangen voor auto’s, maar ook als levendige ruimten voor sociale interactie, gemeenschapsvorming en ecologische duurzaamheid (European Commission, 2023). Deze benadering bevordert een veiligere, duurzamere en inclusievere stedelijke mobiliteit. Met deze filosofie zal de kwaliteit van het stedelijk gebied toenemen en zal het gebruik van de straten eerlijker verdeeld worden onder de verschillende gebruikers. Dit gaat echter ten koste van het gemak van de autogebruikers, omdat er minder ruimte voor de deur beschikbaar is voor hun vervoersbehoeften. Daarom is de kans groot dat deze groep weerstand zal bieden tegen extreme veranderingen. De literatuur suggereert dat verschillende belangen van belanghebbenden een belemmering vormen voor het implementeren van beleid om het autoverkeer terug te dringen en dat een lage maatschappelijke acceptatie van maatregelen leidt tot politieke weerstand (van der Lee, 2024). Als gevolg hiervan worstelen lokale overheden met het implementeren van deze Rechtvaardige Straat visie in daadwerkelijke herontwikkeling van woonwijken.

Beleidsstrategieën om met deze barrières om te gaan lijken te bestaan uit het tonen van openheid en flexibiliteit bij het veranderen van de maatregel om de acceptatie te vergroten, het creëren van maatregelen die een positief effect hebben op de gezondheid en veiligheid van kinderen en het gebruik van trials om nieuwe situaties te ervaren en ermee vertrouwd te raken. In de literatuur ontbreekt echter bewijs over de effectiviteit van deze strategieën en hoe ze in de praktijk kunnen worden samengevoegd. Daarom zal dit onderzoek deze succesfactoren combineren en kijken naar methoden om de belangrijkste belanghebbenden te betrekken bij het rechtvaardiger maken van schoolomgevingen. Het onderzoek zal kijken naar overwegingen voor (tijdelijke) infrastructurele veranderingen om de vertegenwoordiging van de Rechtvaardige Straat principes in schoolomgevingen te verbeteren en methoden om het probleem in de huidige situatie te identificeren, zodat gerichte oplossingen kunnen worden gemaakt voor elke specifieke schoolomgeving. Dit onderzoek richt zich op de volgende onderzoeksvraag: ”Hoe kunnen de Rechtvaardige Straat principes voor schoolzones in Nederland worden geïmplementeerd, rekening houdend met de belangen van verschillende stakeholders?

Om deze onderzoeksvraag te beantwoorden is een casestudy uitgevoerd aan de Fuutlaan in Delft waar een basisschool is gevestigd in een typische bloemkoolwijk. De principes van de Rechtvaardige Straat zijn opgedeeld in 6 hoofdcriteria voor de Fuutlaan waarbij gebruik is gemaakt van een doelenboom om de filosofie van de Rechtvaardige Straat te structureren in meetbare criteria voor de Fuutlaan. Deze hoofdcriteria zijn ”verkeersveiligheid”, ”duurzaamheid”, ”inclusiviteit”, ”socialiteit”, ”autobereikbaarheid” en ”fietsbereikbaarheid”. Sommige hoofdcriteria werden ook onderverdeeld in subcriteria. ”Verkeersveiligheid” werd onderverdeeld in ”werkelijke veiligheid” en ” waargenomen veiligheid”. ”Duurzaamheid” werd onderverdeeld in de subcriteria ”biodiversiteit”, ”hittebestendigheid”, ”regenbestendigheid” en ”droogtebestendigheid”. ”Inclusiviteit” werd onderverdeeld in ”toegankelijkheid voor voetgangers” en ”speciale toegankelijkheid”.

Aan de belangrijkste stakeholders in de Fuutlaan is gevraagd naar hun mening over deze hoofdcriteria

en de bijbehorende subcriteria. Dit is gedaan met behulp van de Best-Worst Methode in interviews met representatieve personen van de oudervereniging van de school, bewoners en de gemeente. De Best-Worst Methode is een multi-criteria besluitvormingsmethode die vaak wordt gebruikt om afwegingen tussen verschillende criteria in beleidsvorming te onderbouwen(Rezaei, 2015a). Het samenvoegen van de reacties uit de interviews onthulde dat de belanghebbenden ”duurzaamheid” verreweg als het belangrijkste hoofdcriterium in de straat beschouwen. Binnen dit hoofdcriterium worden bestendigheid tegen hevige regenval en hittebestendigheid als de belangrijkste aspecten gezien, wat overeenkomt met het herinrichting project van Tanthof Oost van de gemeente en de grootste problemen die naar voren kwamen uit de klimaatimpactscan van de Fuutlaan. Na ”duurzaamheid” worden ”inclusiviteit” en ”verkeersveiligheid” gezien als belangrijke criteria bij de herinrichting van straten. Opmerkelijk is dat ”auto bereikbaarhied” verreweg als het minst belangrijke criterium wordt gezien bij de herinrichting van de Fuutlaan. Dit onderstreept de filosofie van de Rechtvaardige Straat waarbij straten momenteel voornamelijk zijn ontworpen voor de facilitering van gemotoriseerd verkeer. Daarom is verbetering van dit criterium volgens de geïnterviewde stakeholders het minst noodzakelijk. De wegingen van deze hoofdcriteria zijn ook te zien in tabel 3.

Table 3: Aggregated normalized weights of the main criteria

	Traffic Safety	Sustainability	Inclusivity	Sociality	Car Access	Bike Access
Aggregated weights	0.159	0.337	0.160	0.129	0.084	0.131

Het creëren van rechtvaardigere schoolomgevingen bestaat niet alleen uit het creëren van ruimtelijke rechtvaardigheid in de fysieke infrastructuur, maar het vereist ook veranderingen in het gebruik van de infrastructuur door de weggebruikers. Daarom worden er enquêtes gehouden onder de weggebruikers van de Fuutlaan om een goede indicatie te krijgen van de knelpunten in de huidige situatie. De antwoorden van 6 ouders en 11 bewoners onthulden dat vooral het gedrag van ouders die hun kinderen met de auto naar school brengen onveilige situaties creëert in de huidige situatie. Echter, omdat de enquête weinig respons ontving in de Fuutlaan, zijn deze bevindingen niet erg gefundeerd. Als gevolg hiervan werd een tweede enquête uitgevoerd op basisschool de Blijberg in Rotterdam. Opnieuw toonden de antwoorden van 86 ouders sterk aan dat het gedrag van de ouders complexe, onduidelijke situaties rond de school veroorzaakte, die als onveilig werden ervaren. In deze casestudy werd ook duidelijk dat de oversteekplaats voor fietsers bij een 50 km/u weg vlak voor de school en het tweerichtingsverkeer voor de ingang van de school als onveilig werden beschouwd. Dit toont aan dat de enquête een duidelijk beeld kan geven van de knelpunten in de schoolomgeving, en daarmee ook inzicht biedt in gerichte oplossingen om de situatie rond de school te verbeteren.
Naast het verkrijgen van een goed overzicht van de huidige situatie, werd er in de enquêtes ook gevraagd naar ruimtelijke overwegingen voor verschillend gebruik van de parkeerplaatsen in de straat. Voor de Fuutlaan hielp dit bij het opstellen van verschillende nieuwe ontwerpen voor de herinrichting van de Fuutlaan. De vijf verschillende ontwerpen die zijn gemaakt en geëvalueerd aan de hand van de Best-Worst Methode om de prioriteiten en voorkeuren van de stakeholders vast te stellen zijn:

- **Ontwerp 1, Renovatie van bestaande Fuutlaan:** Dit is een ontwerp gemaakt door de gemeente Delft en zal het definitieve ontwerp voor de Fuutlaan worden. Het richt zich op kleine upgrades van de huidige infrastructuur. Waarbij het enige grote verschil is dat er tegels met gaten voor het groeien van gras op de parkeerplaatsen worden geplaatst, wat de straat iets klimaatadaptiever maakt dan in de huidige situatie.
- **Ontwerp 2: Verwijderen parkeerplaatsen aan de schoolzijde** Dit ontwerp is ook gemaakt door de gemeente en was de eerste versie voor het definitieve ontwerp. Het verbetert de huidige verkeersveiligheid enigszins door de auto's aan de schoolzijde te verwijderen, waardoor de zichtbaarheid wordt verbeterd. Verder, in plaats van parallel parkeren, gebruikt dit ontwerp haaks parkeren. Bovendien worden ook in dit ontwerp tegels met gaten voor het groeien van gras gebruikt voor de parkeerplaatsen.
- **Ontwerp 3, Shared Space Ontwerp:** Dit ontwerp is het eerste zelf ontworpen design en is gebaseerd op de principes van shared space. In dit ontwerp worden conventionele borden en markeringen verwijderd en delen voetgangers, fietsers en auto's door elkaar gemixt de weg. Een

vereiste van shared space is dat de weg goed overzichtelijk moet zijn en daarom worden er geen parkeerplaatsen voor auto's op de straat geplaatst. Dit creëert extra ruimte die vrijgemaakt wordt voor andere activiteiten, zoals fietsparkeerplaatsen, groen of ruimte voor sociale bijeenkomsten.

- **Ontwerp 4, Autovrije Straat:** In dit ontwerp mogen helemaal geen auto's in de straat rijden. Dit maakt de Fuutlaan alleen toegankelijk voor fietsers en voetgangers. Ook in dit ontwerp zorgt het verwijderen van parkeerplaatsen voor auto's voor veel ruimte voor fietsparkeerplaatsen, groen of sociale bijeenkomstruimte.
- **Ontwerp 5, Rechtvaardige renovatie bestaande Fuutlaan:** Dit ontwerp is een aanpassing van het definitieve ontwerp van de gemeente, waarbij er meer aandacht voor het implementeren van de Rechtvaardige Straat principes wordt gegeven. Als gevolg hiervan werden de parkeerplaatsen voor auto's vervangen op basis van de uitkomsten van de enquête. Dit leidde tot een eerlijkere verdeling van fiets- en autoparkeerplaatsen, groen en ruimtes voor sociale bijeenkomsten.

De uiteindelijke scores per criterium van de ontwerpen werden bepaald met behulp van deskundig advies en literatuur. Deze scores zijn te zien in tabel 4.

Table 4: Total Performance Designs

	Traffic Safety	**Sustainability**	**Inclusivity**	**Sociality**	**Car Access**	**Bike Access**	**Total**
Design 1	0.075	0.033	0.011	0.400	0.824	0.032	**0.150**
Design 2	0.337	0.693	0	0	1	0	**0.371**
Design 3	0.413	0.642	1	1	0	1	**0.702**
Design 4	1	0.642	0.276	1	0	1	**0.679**
Design 5	0.075	0.642	0.276	1	0.059	1	**0.537**

Gezien de voorkeuren van de verschillende stakeholders in de Fuutlaan die uit de interviews naar voren kwamen, scoorde het ontwerp met shared space het beste op de criteria van de Rechtvaardige Straat. Vanwege de extra ruimte die dit ontwerp creëert door het verwijderen van parkeerplaatsen voor auto's, scoort dit ontwerp goed op de criteria "duurzaamheid," "inclusiviteit," "sociaalheid," en "fietsbereikbaarheid." Ook zorgt shared space voor het verbeteren van de "verkeersveiligheid" op straat. Daarom worden de criteria die als zeer belangrijk worden beschouwd door de belanghebbenden goed vervuld in dit ontwerp. Het definitieve ontwerp van de gemeente voor de Fuutlaan scoort het laagst. Dit heeft echter vooral te maken met het feit dat dit ontwerp is gebruikt als basis voor het creëren van de nieuwe ontwerpen die meer voldoen aan de principes van de Rechtvaardige Straat.

Uit de twee casestudies die in dit onderzoek zijn uitgevoerd, kan worden geconcludeerd dat de interviews op basis van de Best-Worst Methode in combinatie met de ruimtelijke heroverwegingsvragen van de enquête stedenbouwkundigen en ontwerpers kunnen helpen om een eerlijker evenwicht te creëren tussen verschillende straatactiviteiten bij het herontwikkelen van schoolomgevingen. Het moet echter worden opgemerkt dat de antwoorden van de geïnterviewden nog steeds individuele voorkeuren zijn, en daarom wordt aanbevolen om een grote groep respondenten te creëren via focusgroepen en brede verspreiding van de enquête.

Voor de implementatie van eerlijker gedrag van weggebruikers kan de enquête worden gebruikt om een goede weerspiegeling te geven van het reisgedrag van de ouders op straat en hoe zij daarmee bijdragen aan een oneerlijke schoolomgeving. Daarom kan de enquête worden gebruikt als een startpunt voor gesprekken en voor educatie om het reisgedrag van ouders te veranderen. Bovendien toont de enquête ook aan welke knelpunten er zijn in het huidige ontwerp, waardoor de gemeente aanpassingen in de infrastructuur kan maken om het gedrag positief te beïnvloeden. De samengestelde methodiek toont aan dat de combinatie van het uitvoeren van interviews en het verspreiden van enquêtes kan leiden tot beter geaccepteerde veranderingen in zowel de fysieke infrastructuur als het gedrag van weggebruikers. Afhankelijk van de problemen die zich voordoen in een specifiek geval, kan deze combinatie van methoden goed onderbouwde acties op te stellen om rechtvaardige schoolomgevingen te creëren en zodoende de principes van de Rechtvaardige Straat te implementeren in schoolzones in Nederland.

Contents

1 Introduction

Every year, approximately 1.24 million persons globally lose their lives due to road traffic accidents, making it the eighth most significant contributor to mortality (Organization et al., 2013). Almost a quarter of these people who die in road collisions are pedestrians (Hannah et al., 2018). Also, in the Netherlands, between 2010-2019, 40% of the total traffic fatalities were pedestrians or cyclists (SWOV, 2020). This shows that active travel is still very unsafe, despite the policies of many municipalities to drive a modal shift from car use to active travel in the cities. Studies also show that children, along with the elderly, are the most vulnerable to pedestrian crashes among different age groups due to their unawareness (Fontaine & Gourlet, 1997). With 70% of the children projected to be living in cities by 2050 (Unicef, n.d.) and with 6,581 primary schools in the Netherlands (Ministerie van OCW, 2022a), there is a growing awareness for the well-being of pedestrians and bicyclists in school surroundings, where mostly children are involved in traffic. Achieving safer surroundings requires a change in the current urban mobility thinking. Currently, urban mobility is characterized by a car-centric mentality. With this mentality, residential neighborhoods and streets are still laid out to facilitate the best flow for cars (European Commission, 2023). Changing this mentality, along with the layouts of streets, creates a lot of resistance from car users. However, the street should serve many more functions, and therefore, the needs of all the different users should equally weigh in the use and layout of the street. It is a place where people play, live, and meet (BAM Infra, n.d.). Therefore, redesigning the limited space can lead to making all these activities possible in school surroundings. This leads to an increase in social welfare for both children as residents of school environments.

1.1. Problem description

1.1.1. The Fair Street

The concept of Fair Streets, which is the English translation of the Dutch innovation initiative "Rechtvaardige Straat" set up by Prof. Dr. Marco te Brömmelstroet in cooperation with BAM Infra, emerges as a compelling counter-narrative to the prevailing car-centric urban design philosophy. This innovation initiative was created to give meaning to the ideas of the book "The Right of the Fastest," written and compiled by Thalia Verkade and Marco te Brömmelstoet. This book reflects on the current way of thinking about road safety and argues that the child should not learn to look out for the cars, but the car should be a guest in the child's play area (Verkade & te Brömmelstroet, 2020). Through the Fair Street innovation initiative, people can indicate that they consider their street to be unfair by signing a manifest on the website. In addition, this initiative recently launched a Fair Street Week, in which people could nominate their streets as unfair. With 2143 people signing the manifest and over 300 submissions of unfair streets (De Rechtvaardigestraat, n.d.), the Fair Street philosophy becomes well spread. This philosophy advocates for a re-imagined urban streetscape that prioritizes spatial justice, ensuring streets serve not just as conduits for cars but as vibrant spaces for social interaction, community building, and environmental sustainability (European Commission, 2023). This approach promotes safer, more sustainable, and more inclusive urban mobility. Various activities, such as playing, traveling, and meeting people, can take place in the street. However, all of these activities require space, and hence, it is necessary to make trade-offs between different indicators of the Fair Street to achieve a fair balance of activities in the street. These indicators are illustrated in the mind map of the Fair Street, which can be seen in Figure 1.1.

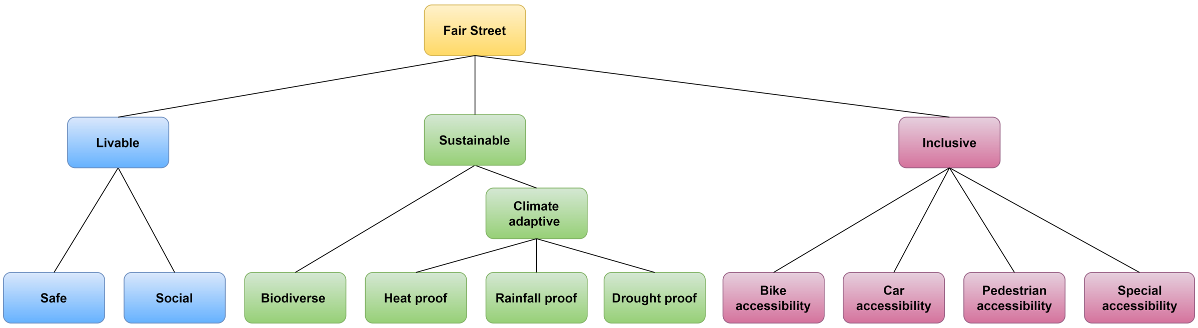

Figure 1.1: Decomposition of the Fair Street

A Fair Street can be characterized as a livable, sustainable, and inclusive street. From this, livability can be divided into safe and social streets. Safe streets are an indicator of the streets' traffic safety. This mainly involves looking at how vulnerable users such as pedestrians and cyclists can be protected from the forces of motorized traffic. Social streets mean that there is enough space for social interaction and the opportunity to meet and play in the street.
Sustainability consists of biodiversity and climate adaptivity of the street. Biodiversity indicates how many (native) plants and animal species can live in the street and continue to live there in the future. It is also an indicator of the amount of greenery in the street. The indicator climate adaptivity can be divided into the components of heat resistance, rainfall resistance, and drought resistance. Heat resistance indicates the extent to which the street is resistant to extreme heat and the extent to which the street can cool the area. Trees provide shade, and the leaves evaporate water, which has a cooling effect. The type of pavement material of the road also affects the amount of heat the street can absorb (Bouw adaptief, n.d.). Rainfall resistance indicates the degree to which the street can withstand heavy rainfall. This is partly due to proper sewer systems but also partly to the water permeability of the pavement. The street can drain water faster if the road consists of water-permeable pavement, such as grass concrete bricks or clinkers with open joints. In addition, trees also absorb a lot of rainfall and, with their leaves, ensure that water does not end up on the street all at once (Hiemstra, 2018). Drought resistance shows the extent to which the street can withstand long droughts. The street can be made extra resilient by constructing storage sewers or underground collection structures, but it can also be partially countered by constructing more water-retaining greenery in the city. This can be done in the form of trees and plants, as well as through the previously mentioned water permeable paving and soil structure improvements (Bouw adaptief, n.d.).
Inclusivity is an indicator of the degree to which the street is accessible to all types of road users. Hereby, inclusivity can be divided into the components of bicycle accessibility, car accessibility, pedestrian accessibility, and special accessibility. Bicycle accessibility examines how well the street is accessible by bike, including the number of bicycle parking spaces and facilities in the street. Car accessibility examines how well the street is accessible by car, including the number of car parking spaces in the street. Less parking spots mean that car drivers should park further away from their destination, increasing their travel time. Pedestrian accessibility examines how well the street is accessible for pedestrians, including the width of the sidewalk. Here, a sidewalk must be wide enough so that someone with a baby carriage or rollator can cross it without getting in the way of other pedestrians as they pass. Also, sidewalk passage should not be blocked by other transportation devices such as bicycles or cars. This correlates partly with the last indicator, Special accessibility. Special accessibility examines whether and how well the street is accessible to special forms of transportation. This refers to both pedestrians and cyclists who deviate from ”normal” users of the road. This involves both people with mobility limitations, such as people in wheelchairs, with rollators, or on special tricycles, as well as people carrying children in baby carriages or cargo bikes.
The goal of the innovation initiative is twofold. On one side, it tries to create awareness among people about the possibilities for redesigning public space with the Fair Street philosophy and the improvement

in social welfare it creates. On the other side, the initiative wants to arrange the actual implementation of Fair Streets with a fair balance of the indicators shown in figure 1.1.

1.1.2. Problem statement

Over the past century, with the advancement of the automobile industry, the evolution of urban landscapes has increasingly favored the facilitation of vehicular traffic over other forms of street life (Karndacharuk et al., 2014; Von Schönfeld & Bertolini, 2017). This vehicle-oriented layout has not only led to congested roads and extensive urban planning projects aimed at accommodating more vehicles but has also significantly diminished the role of the street as a social and community hub, compromising the safety of pedestrians and cyclists (Karndacharuk et al., 2014). This facilitation of vehicles is also worsening environmental problems, with the increase in impenetrable surfaces such as concrete and asphalt, a decrease in urban green space, and more extreme weather due to climate change creating an urban environment characterized by heat islands, overflowing streets, and poor biodiversity (Gillner et al., 2015).
In 2023, 341 bicyclists and pedestrians were killed. This is, on average, almost 1 per day and accounts for nearly half of the total number of traffic deaths in the Netherlands (SWOV, 2024). Although there has been increased attention in the Netherlands to making infrastructure safer (SWOV, 2018), the figures show that it is not yet effective enough (VVN, n.d.). The biggest contributor to these fatalities comes from motorized vehicles, as can be seen in figure 1.2. These vehicles go a lot faster than humans can walk. Therefore, collisions with pedestrians or cyclists often cause severe injuries, making them vulnerable on the roads (Hamilton-Baillie, 2008).

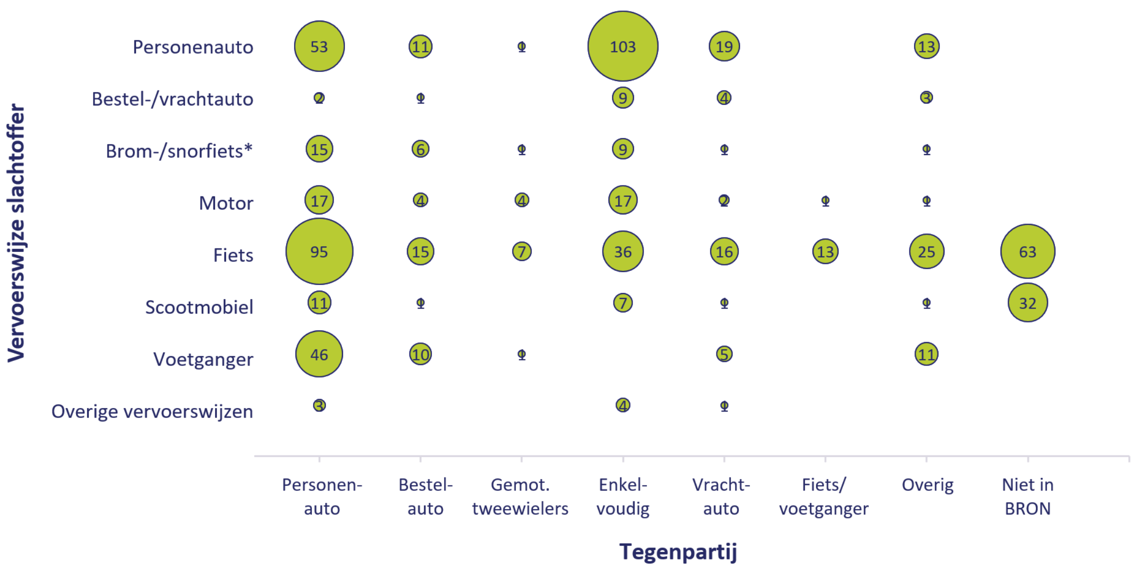

Figure 1.2: Amount of traffic deaths in 2023 by mode of transport and opposing side (SWOV, 2024)

With increasing urbanization and limited space in cities, choices must be made in the layout of street space. Currently, up to 50% of public space in cities is consumed by car infrastructure (KiM, 2022). In addition to parked cars being the reason for 20% of accidents involving bicyclists or pedestrians (KiM, 2022), the public space these cars take up hinders the pressing needs for climate adaptation, biodiversity preservation and also takes away the space for social interactions and place for children to play on the streets. Cities are increasingly struggling with the effects of heavy rains or extreme heat waves. Moreover, the literature shows that green and blue infrastructure helps to improve (ecological) health and facilitate social interaction (Chanse et al., 2021). Therefore, greening the city is essential to cope with the effects of climate change and rapid urbanization better in the future and make the city more livable (Chanse et al., 2021). In addition, air quality in cities remains too poor, leaving 84% of the Dutch population exposed to particulate matter and nitrogen dioxide values higher than the WHO advisory value (CROW, n.d.). This poor air quality in cities is mainly due to emissions from polluting motor vehicles. The enduring reliance on traditional parking norms further complicates the landscape, hindering the integration of alternative modalities and sustainable urban practices (Overheid.nl, 2022; Provincie Zuid-Holland, 2017).

Because of the unsafety cars create and the large share of urban space these cars occupy, it is important for cities to reduce the facilitation of car ownership and car use in the city. By doing so, the local authorities can create space for the other indicators of the Fair Street that are urgently needed to make the urban space more livable, sustainable, and inclusive and thereby align with the Fair Street philosophy as indicated in section 1.1.1.
However, the transition towards this Fair Streets philosophy is met with inherent resistance. Changes to the status quo, particularly those that could negatively impact certain stakeholders, often encounter opposition (van der Lee, 2024). Car users, in particular, will be constrained by this philosophy to restore the imbalance of dominance from the car-centric thinking of the past century. As a result, it is to be expected that there will be resistance to car-reducing measures from this stakeholder. This resistance can significantly hinder the application and implementation of Fair Street principles in urban redesign and the correct usage of the street after implementation. In addition, many municipalities seem to desire this redesign of public space. However, they lack the knowledge on how to implement this radical change. Therefore, specific policies and implementation of Fair Street principles in public spaces stagnate at only a policy vision.
The literature shows that redesigning streets based on the Fair Street principles of livability and sustainability positively affects safety, health, and the climate. This can be seen extensively in the literature review in Chapter 3. Much research has also been done on the importance of stakeholder involvement in transitions in mobility plans. However, there are only limited examples of methods to include stakeholders in the design process of redeveloping urban areas, highlighting the need for an inclusive and participatory approach that considers the concerns and needs of all stakeholders. The challenge lies in navigating this complexity and including all stakeholders to promote urban environments that are safe, sustainable, and contribute most to the well-being of all city residents.

1.1.3. Research aim and relevance

One place where the negative impact of the car-centric urban design meets daily is in school surroundings. Five days a week, children must travel to and from school. There are 6,851 primary schools in the Netherlands (Ministerie van OCW, 2022a) with a total of 1,474,760 pupils (Ministerie van OCW, 2022b). Assuming that all these children have to get to and from school daily, this equates to nearly 3 million daily trips. Research by Transport for London shows that more than a quarter of morning peak car trips in London are for school drop-offs (Transport for London, 2018). Therefore, school trips greatly impact congestion during morning peak hours. In addition, they contribute significantly to unsafe school environments due to too much traffic at the drop-off of the children during peak hours. This leads to many dangerous situations in the streets around the school since children are more vulnerable to pedestrian crashes among age groups due to their unawareness of the danger in the streets (Fontaine & Gourlet, 1997). Though it is stated that playing outside is critical for children's health and well-being (Das & Banerjee, 2023). Therefore, creating a safe and inviting playing environment around school is of great importance. However, as mentioned earlier, this is very complex due to many stakeholders with conflicting interests in school environments. While parents primarily want the school environment to be as safe as possible for their children to attend school, residents sometimes have other priorities due to having to live in the street all year. In addition, the interests of the municipality also play a role since they also need to be able to maintain and finance the street, seeking to serve the interests of citizens as much as possible. There are also differences between users, where car users would rather see the amount of parking spaces on the street remain the same or even be increased, pedestrians and cyclists would have rather the opposite and see them disappear. Therefore, creating a fair balance of these different interests in the school environment is very challenging.
This research, therefore, aims to combine the interests of different stakeholders involved in making school zones fairer and implement them in a Fair Street design. In addition, this research aims to provide more insight into how the various stakeholders can be included in this process of (re) designing streets around school zones. This ultimately helps urban planners and schools in the Netherlands develop plans to make their school zones fairer.

This integration of end-users, policymakers, and other interest groups could lead to a fairer physical street layout and the appropriate fair use of the infrastructure, which together lead to fairer school surroundings. How this interaction works between the design of the environment and the end users' actual behavior is illustrated in figure 1.3.

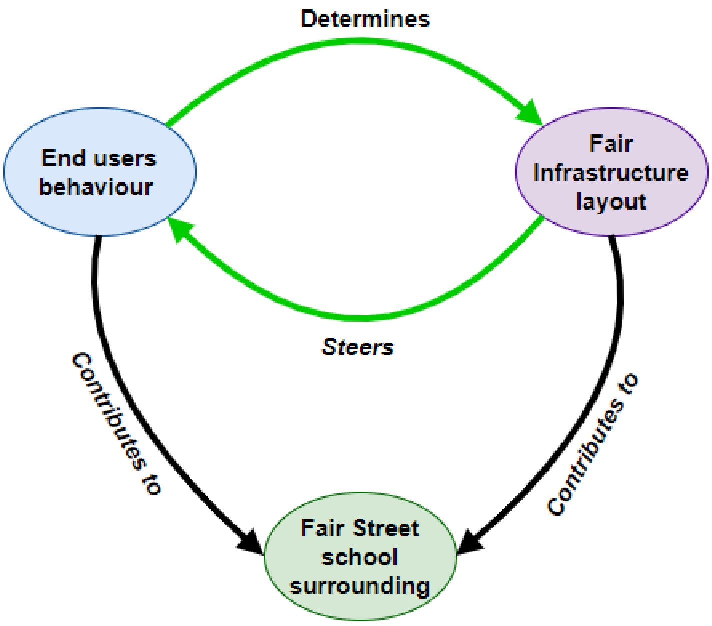

Figure 1.3: The interaction between infrastructure and people

This figure highlights the importance of changing the street's physical layout to steer road users' behavior and, together with changing road users' behavior, to create a Fair Street school surrounding.

1.1.4. Research questions

The following research question is formulated to meet the objective of the study:

How can the Fair Streets principles for school zones in the Netherlands be implemented, considering the interests of different stakeholders?

As mentioned earlier, implementing fairness in Street Designs is a complex task involving several stakeholders with different interests, which are case-specific per school environment. Because of this, the research question will be answered using a case study. By using a case study, this complex problem can be evaluated, and the methods used could be widely applied to other schools in the Netherlands. A condition for this is that the case must be representative for many schools in the Netherlands so that outcomes of the case study can provide good insight into the complexity of this problem.
The street that will be analyzed in this case study will be the Fuutlaan in Delft. Residents of the Fuutlaan have registered their street via the Fair Street manifest (De Rechtvaardigestraat, n.d.). In addition, the sewers in the neighborhood are being replaced, which means that the streets in the neighborhood all have to be taken out. This has caused the municipality of Delft to redevelop the neighborhood (Gemeente Delft, 2023). The Fuutlaan is a school street located in the so-called cauliflower neighborhood of Tanthof East in Delft. A cauliflower neighborhood is characterized by its winding dead-end streets that, like a cauliflower, branch out from an area access road that runs through the neighborhood. Cauliflower neighborhoods are very common and take up 20% of the housing in the Netherlands (Niederer, 2013). Since these neighborhoods were built in the 1970s and 1980s, many are outdated and need street renovation and redevelopment. This makes this type of street perfect for investigating the implementation of Fair Street principles in the redevelopment of the streets. In addition, the

Springwijs Elementary School, located at the Fuutlaan, is a public elementary school, which is the most common type of school (31%) in the Netherlands (Ministerie van OCW, 2022a). Due to these characteristics, this school street represents many school streets in the Netherlands. Therefore, the findings from this study will be easy to generalize for making more elementary school environments in the Netherlands safer. To do this, the following sub-questions are defined:

1. What are the Fair Street principles and how can they be measured into concrete criteria in the Fuutlaan?
2. Which stakeholders are involved and should be included in implementing a Fair Street in the Fuutlaan?
3. What is the problem in the current situation and how do street users evaluate this?
4. What are the interests of each stakeholder in the Fuutlaan?
5. What is the relative importance between indicators of the Fair Street for each stakeholder and how would they rate different designs?
6. How can these interests, together with the indicators of a Fair Street, be implemented in designs for the Fuutlaan?

The first two sub-questions are used as preparation for the methodology. The third, fourth, and fifth sub-questions are used to gather important data and input for the analysis and new designs. The sixth and last sub-question looks at the implementation of the outcomes into Fair Street designs. Together, these sub-questions can be used as an evaluation to create conclusions and recommendations on implementing Fair Streets in school zones.

1.1.5. Scope

Given the research and time limitations, a specific scope is established to keep this research manageable. The spatial scope of this research will be at the Fuutlaan in Delft, in particular, the part of the Fuutlaan that is right in front of the School. This demarcation is shown in figure 1.4.

Figure 1.4: Demarcation of the Fuutlaan for design scope

This demarcation is chosen to keep the stakeholders and, thus, the number of interviews manageable. Additionally, the demarcation is large enough to get a clear idea about the difference in space usage and preferences of different stakeholders yet small enough to keep the research manageable within the time span of this study. Also, this scope was chosen because this is the area in front of the school where most conflicts occur since this is where parents drop off their children. Furthermore, this study looks at the trade-offs between Fair Street indicators. These include safety, sociality, sustainability, and inclusiveness in the form of accessibility for all types of road users. Consequently, since the focus is on the importance of these indicators, the exact cost of how these indicators can be incorporated into the design is not included. This requires project-specific cost estimations. Also, this study simplifies the complex measurability of safety by estimating scores based on expert knowledge and available literature. In addition, accessibility of different modes is determined by the facilities available on the street itself. As a result, an analysis of different designs' effects on users' travel time is excluded. This is because such an analysis requires a large traffic database and the origins and destinations of a large area. Moreover, only visible modifications on the street are considered when making designs. As a result, everything that happens underground, such as improvements to the sewer systems, is not included in creating and scoring the designs.

1.2. Structure of the report

In this report, the methodology will be explained first. In this chapter, all the different methods that are used to find an answer to the main research question are explained. Subsequently, a literature review was done to analyze the current academic literature on the implementation of car-reducing policies and the effects of different indicators of the Fair Street. This review ultimately provides the scientific relevance of the research. After that, Chapter 4 identifies the problem of the current situation, looking at the current fairness of the street. This chapter also discusses the criteria for measuring fairness in the street, and new designs are developed using these criteria. Chapter 5 shows the results from the interviews with the stakeholders, after which the ranking of the different designs can be determined based on the interview results. Based on the results, the different designs are evaluated in Chapter 6. The survey is also analyzed and discussed in this chapter. This chapter concludes with an overall evaluation of the methodologies used for this study. Chapter 7 draws conclusions based on answering the research questions. Finally, Chapter 8 presents the research limitations and recommendations for both further research and specific recommendations for schools, parents, municipalities, and other parties wishing to implement Fair Streets in the future.

2
Methodology

This chapter explains the research methods used to answer the research (sub-)questions and mentions the methods' constraints and drawbacks.

2.1. Case study

To answer the main question: *How can Fair Streets for school zones in the Netherlands be implemented, considering the interests of different stakeholders?* a case study will be conducted at the Fuutlaan in Delft. In addition, the results will be complemented by looking at a second case study at the Blijberg School in Rotterdam. A case study is needed because this is a complex problem that involves multiple stakeholders with different interests, and the trade-offs that need to be made will always be valued differently per case. Therefore, analyzing a particular case can give insights into the process that can later be generalized for implementing Fair Streets in other school zones in the Netherlands. The disadvantage of a case study is that the results are often difficult to generalize to other settings since every case is unique. Therefore, choosing a case that is representative of a lot of other schools is necessary. The two cases will be discussed further in the following sections.

2.1.1. Fuutlaan in Delft

Since the Fuutlaan has characteristics and stakeholders similar to many other school zones in the Netherlands, it is used for this case study. First of all, all schools in the Netherlands face the same problem of dealing with a large number of people needing to be in the same place during the same time period, namely the opening and closing hours of the school. With 6,851 primary schools in the Netherlands (Ministerie van OCW, 2022a) and a total of 1,474,760 pupils (Ministerie van OCW, 2022b), nearly 3 million daily trips need to be made assuming that all these children have to get to and from school daily. This results in a lot of traffic moving towards the school around these pick-up and drop-off times, which leads to dangerous situations in school environments on a daily basis.
The Fuutlaan is a school street located in the so-called cauliflower neighborhood of Tanthof East in Delft. A cauliflower neighborhood is characterized by its winding dead-end streets that, like a cauliflower, branch out from an area access road that runs through the neighborhood. Cauliflower neighborhoods are very common and take up 20% of the housing in the Netherlands (Niederer, 2013). Since these neighborhoods were built in the 1970s and 1980s, many are outdated and need street renovation and redevelopment. So this makes this type of street perfect to investigate for a fair redevelopment. This is also the case for the neighborhood in which the Fuutlaan is located. This neighborhood has outdated sewers and will be replaced in 2024 (Gemeente Delft, 2023). Because this requires the removal of entire streets in the neighborhood, the neighborhood's redevelopment for sustainability and safety will be considered simultaneously. In addition, the Springwijs Elementary School, located at the Fuutlaan, is a public elementary school, which is the most common type of school (31%) in the Netherlands (Ministerie van OCW, 2022a). Also, because elementary schools in the Netherlands are often located in residential areas with 30 km/h zones and limited space due to the built environment, the stakeholders and problems involved in the redevelopment of the street are similar to lots of other school zones in

the Netherlands. Therefore, the approach of this case study is very generalizable for other cases in the Netherlands.
As mentioned earlier, the "Rechtvaardige Straat" or "Fair Street" principle is an innovation initiative concerned with redesigning streets and neighborhoods so that the needs of different types of users are given equal weight. Residents can sign a manifest from this initiative indicating that their street is unfair. This manifest has been signed by a resident of the Fuutlaan in Delft, who came in contact with BAM afterward. In this street, residents live in a social housing organization called Centraal Wonen Delft (CWD) in which various residents live in housing groups together. In this residential facility, residents do not live in isolated units, but groups of residents share the same common facilities in addition to having their own living units (Centraal Wonen Delft, n.d.). This makes the neighborhood socially engaged with each other. Also, residents of the Fuutlaan organized a car-free day the previous year. On this day, the street was transformed into a place where a variety of activities were organized by the residents and in which, temporarily, no cars were allowed. This initiative shows what Fair Street stands for and demonstrates that other street activities can also be made possible on the street if the facilities for cars are taken away. However, because it was only one day and took place during the summer vacation, organizing such a day did not solve the daily problems in the street. Especially during school hours when many children are dropped off to go to school. The figure below shows the daily struggle at the Fuutlaan with parked cars in the middle of the road and bicycles passing between them, leading to bad visibility and unexpected behavior.

Figure 2.1: Typical daily moment in the Fuutlaan

What also can be seen in the picture is that the Fuutlaan is a street with residential buildings on the right and an elementary school on the left with cars parked on both sides. With the residents on the right, the school on the left, and a children's drop-off place located at the zebra crosswalk in the middle of the street, this street involves many stakeholders who are affected by the situation in the Fuutlaan on a daily basis. More specific information about the current situation of the street will be explained further in chapter 4.1.

2.1.2. Blijberg in Rotterdam

During this project, it turned out that creating participation from various stakeholders in the Fuutlaan was difficult. This is due to the somewhat short time period in which this research had to take place.

Another factor for the stakeholders in Fuutlaan was that it was uncertain whether the results of this research would apply to actual adjustments in Fuutlaan. This is because the design of the municipality's redevelopment was already determined, and thus, few direct adjustments are possible. This resulted in the school directors not having time for an interview because of the busy period they were in at school. Therefore, they could not be included as a key stakeholder in the interviews. In addition, this made the distribution of the survey to parents very difficult, resulting in the survey being barely completed by parents.
A second school was approached to assess the impact of the survey. The Jenaplan School ”Blijberg” in Rotterdam was chosen because of its focus on cooperation and open-mindedness. This school encourages children to learn from each other by forming clusters of children of different ages. Thus, talking to each other is seen as a fundamental solution to problems (De Blijberg, n.d.). Moreover, the writer of the book ”The Right of the Fastest” is a parent at this school. Together with a teacher from the school, they organized an information moment for parents to educate them about the transformation of the streets around the school throughout the past century. Being present at this meeting allowed the parents to be aware of the usefulness of the survey, which helped in spreading the survey among other parents at the school resulting in a much greater response.
The school is located right in front of a 50 km/h ring road in Rotterdam as can be seen in figure 2.2. This causes children here to have to cross this dangerous road daily to get to their school, as shown with the blue marking in the overview of the approach routes for the school in figure 2.3. In addition to this dangerous road, the busy roads in the neighborhood surrounding the school during peak hours cause the traffic situation to be considered unsafe and very chaotic (appendix B.3). These roads, together with the approach routes of the cars, can be seen by the orange, green, and red lines in figure 2.3. In this case, in addition to the daily rush and problems that the school's opening hours create, there is also a dangerous crossing right in front of the school, making this case a little more special than the Fuutlaan case. In addition, there are 2 other schools present in this school environment, which are attached to the building of the Blijberg. This causes the streets around the school to be used not only by parents of the Blijberg but also by parents of the other schools, making it a very busy place during school peak hours.

Figure 2.2: Road crossing right in front of the Blijberg in Rotterdam (Google Maps, n.d.)

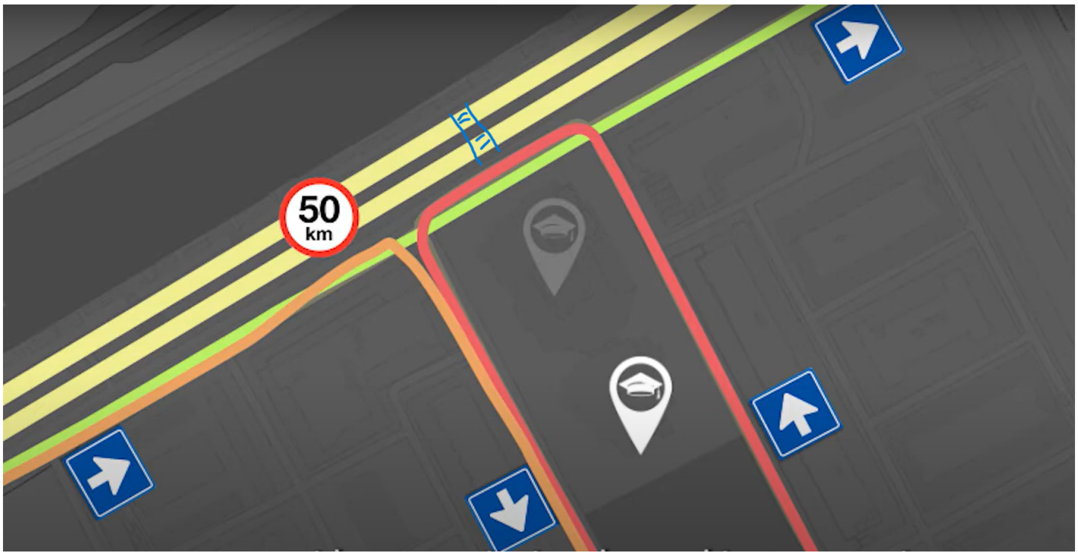

Figure 2.3: Different approach routes of the Blijberg

2.2. Sub-Methods

The main research question can be answered through the sub-questions. The methods used to answer the sub-questions are shown in table 2.1.

Table 2.1: Sub-questions with corresponding research method

How can Fair Streets for school zones in the Netherlands be implemented, considering the interests of different stakeholders?	
Subquestion	**Method**
1. What are the Fair Street principles and how can they be measured into concrete criteria in the Fuutlaan?	Goal tree & Expert consulting
2. Which stakeholders are involved and should be included in implementing a Fair Street in the Fuutlaan?	Stakeholder analysis
3. What is the problem in the current situation and how do street users evaluate this?	Interviews & real-life observations & survey
4. What are the interests of each stakeholder in the Fuutlaan?	BWM interviews and survey
5. What is the relative importance between indicators of the Fair Street for each stakeholder and how would they rate different designs?	Interviews & MCDM analysis
6. How can these interests, together with the indicators of a Fair Street, be implemented in designs for the Fuutlaan?	Requirement analysis, literature, survey results & BWM weights

To get an answer to the main research question for the Fuutlaan case, this research consists of 2 parts. The first part is structuring the problem, and the second part is processing the input into conclusions and recommendations for the Fuutlaan. The first part can be divided into three phases. The first two sub-questions are used for the orientation phase to develop criteria that can score fairness in the street and identify the key stakeholders that need to be involved in this process. The third, fourth, and fifth sub-questions are used in the information-gathering phase. These sub-questions create insight into the problem and the stakeholders' preferences. The sixth sub-question is used for the designing phase. In this phase, the designs for a Fair Street in the Fuutlaan will be created. Finally, in part two, the answers to all the sub-questions will be processed in the evaluation phase. The outcome of this phase will be the final conclusions and recommendations for the implementation of a Fair Street in the Fuutlaan. This research approach can be seen in figure 2.4.

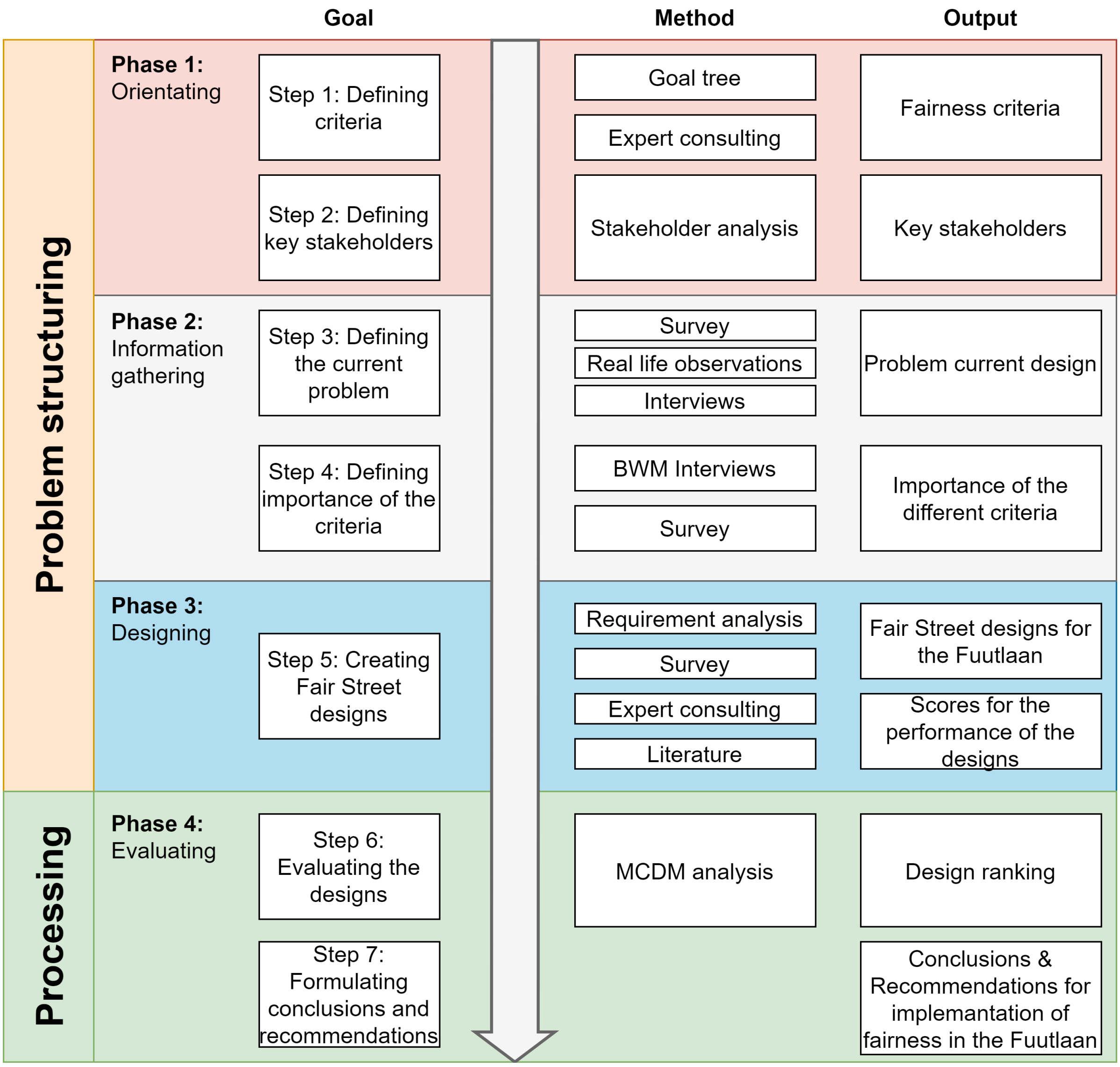

Figure 2.4: Research Approach

2.2.1. Problem structuring

Since applying the Fair Street principle in street designs is a complex task, the problem must first be structured. A structured problem provides a comprehensive specification of options/alternatives, a set of measurable criteria against which these alternatives are evaluated, identification and incorporation of all relevant stakeholder perspectives and the method used to evaluate the alternatives (Rezaei, 2023). In order to determine the alternatives, previously made designs by the Municipality will be used, and new designs will be created. This is done based on a requirement analysis. These requirements are developed by interviews with stakeholders, conducting a survey, discussions with experts, and real-life observations. The set of measurable criteria is determined in consultation with experts and is structured using a goal tree. The incorporation of relevant stakeholders will be identified based on a stakeholder analysis.

After identifying the designs and criteria, the designs will be evaluated using the outcomes of a Best-Worst Method (BWM).

Interviews

To gather information and data for this research, 2 types of interviews are used, unstructured informal interviews with experts are used for gathering information on specific topics and setting up designs and semi-structured interviews with key-stakeholders are used for determining their interests and weighting of various Fair Street indicators.
Unstructured, informal interviews are used for the expert interviews. An unstructured interview is a qualitative research method characterized by a free-flowing, conversational approach where the questions are adapted based on the interviewee's responses, without a predetermined set of questions (Wethington & McDarby, 2015). The advantage of this type of interview is that it could give deeper insights and provide a more comprehensive understanding of the interviewee's experience and viewpoints. Therefore, it is very beneficial for exploring complex topics, which is the case for better understanding the indicators of a Fair Street.
For the interviews with key stakeholders to find out how they weigh the different indicators of the Fair Street and determine their interests, a combination of structured and semi-structured interviews is conducted. A structured interview means that the interview questions are predetermined, and the same questions are asked for each respondent. A semi-structured interview is an interview with open research questions, but preexisting theory will be used to provide a guideline for the interview (Wethington & McDarby, 2015). In this way, it is possible to identify, in a semi-structured way, the interests of each stakeholder and what stakeholders believe is important for creating a Fair Street. Afterward, the importance of the predetermined criteria can then be asked in a structured format. The advantage of this is that the interviews can be targeted and thus do not take up too much time. Also, the structured way allows the interviews to be easily reproduced for other cases. The disadvantage is that criteria can be overlooked this way, even though they could have an impact on the fairness of the street. In this study, however, the criteria are determined through careful problem structuring in collaboration with experts to minimize this possibility.
The interview questions' structure and results can be found in appendix A.

Requirement analysis

A requirement analysis will be conducted to create new designs for the Fuutlaan. A requirements analysis for creating Fair Streets involves the systematic collection and interpretation of stakeholder data, requirements, and needs with the aim of understanding the design features to be included in different street layouts. This is a crucial step in the design process because it ensures that final designs meet user needs, legal requirements, environmental requirements, and functional specifications. Based on interviews with stakeholders, responses from the survey, conversations with experts, and real-life observations, constraints and objectives are established that the designs must meet. The constraints define the requirements that each design must meet, and the objectives show what the designs should preferably meet.

Stakeholder analysis

It is important to identify the stakeholders with their interests to come up with a well-structured problem. A stakeholder analysis will be used to answer sub-question 2. A stakeholder analysis is a process by which the characteristics of stakeholders and their influence on decision-making can be identified, and it helps define strategies for managing these stakeholders. This involves looking at the influence and interests of the stakeholders in this project (Brugha & Varvasovszky, 2000). Based on the stakeholder analysis, key stakeholders can be identified. The interviews with the key stakeholders will provide good insights into the most important stakeholders and their interests in different criteria of the Fair Street. This method, therefore, helps with the preparation for the interviews and the orientation of the problem.

Survey

To understand the current situation and the problems encountered, a survey among users will be conducted in addition to observations. This involves questions for parents and residents about what they think of the current traffic safety and what spatial use considerations they think are important for redesigning the street. In addition, the survey also identifies current travel behavior in the street by asking how residents and parents get to/from the Fuutlaan. These outcomes help determine current perceived safety among users and can help create case-specific solutions for improving the safety of the street. In addition, space use trade-offs show what users would like to see in their street. Therefore, the survey also gives insight into the interests of the Fair Street principles from the different road users.

The outcome of the spatial reconsideration of the survey from the Fuutlaan substantiates the various uses of space in the new designs.
However, the relevance and usefulness of the survey depend a lot on the number of users and type of users who complete the survey. During the study, it was found that distributing the survey to parents of the SpringWijs was very difficult. Therefore, a second survey was distributed among parents of the Blijberg in Rotterdam to determine the effect and relevance of the survey method. The structure of the survey questions and the survey results from both cases can be found in appendix B.

Expert consulting

In order to formulate the indicators of the Fair Street philosophy and to transform these indicators into measurable criteria for determining the fairness of a street, the writer of the book "The Right of the Fastest" has been interviewed. Also, experts with expert knowledge on a specific Fair Street criterion were consulted to establish the criteria scores for different designs. Hereby, the experts complement the existing literature. The experts are consulted based on unstructured, informal interviews. They will be asked for their views on the existing theories, their view on the Fair Street principles, and how they would include this in their field of expertise. A traffic expert is consulted regarding the factors of traffic safety and accessibility. For the sustainability factor, experts in sustainability for the possible climate adaptive applications in the street and ecologists are questioned about the effects of trees and plants on these climate adaptation points. For the factors of inclusivity and accessibility for bicycles, an expert from the cyclists' union will be interviewed who can tell us more about trends in the use of cargo bikes and special tricycles and the current state of accessibility for bicycles.
The statements that came out of these expert interviews will be referred to in the remainder of the report using the following table 2.2.

Table 2.2: Type of experts with their corresponding reference

Type of expert	Reference
Traffic expert	Expert A
Sustainability expert	Expert B
Ecology expert	Expert C
Cycling traffic expert	Expert D

Real Life Observations

Real-life observations help reveal the current situation and the bottlenecks the design encounters. It reveals current street usage patterns and safety issues. These observations help identify the problem and can also confirm results from the interviews and survey.

Goal tree

A goal tree is a hierarchical visual representation used to structure the problem by defining the broad objective and breaking this down into measurable sub-criteria. This facilitates a clear, organized approach for determining the measurable criteria that evaluate the different street designs. It also ensures that all essential aspects are considered and aligned with the overarching goal of creating Fair Street designs.

2.2.2. Literature review

To determine what the current scientific knowledge is about the inclusion of different indicators of a Fair Street in street designs, a literature study is conducted that reviews existing academic research on urban street design and the extent to which these environments support or hinder urban livability, sustainability, and safety. The literature review identifies gaps in the current literature, particularly regarding the integration of stakeholder's interests into urban designs and how these interests affect the practical implementation of such designs.
Some of the literature found came from informal interviews with experts. This led to the findings of the papers from Gemeente Leiden (2022), Provincie Zuid-Holland (2017), and Shoup (1997). Also, my supervisor from BAM recommended the thesis of Van der Lee (2024), which gave good insights into the success factors and barriers for the implementation of car-reducing policies. Search engines

Google Scholar and Scopus were used to find additional scientific literature. The following keywords were used and can be seen in table 2.3.

Table 2.3: Search strategy for identifying relevant papers

Keywords	**Truncation**	**Limitations**
Pedestrian, Safety	AND	*from 2013-now* and *articles only*
Shared Space, Safety	AND	*from 2010-now* and *articles only*
Building Environment, Active Travel	AND	*from 2013-now*
Climate adaptation, Urban Design	AND	*no limitations*
Urban Build Environment, Social Health	AND	*from 2013-now*
Stakeholder management, Urban Planning	AND	*from 2013-now*

2.2.3. Multi-Criteria Decision Making

As mentioned earlier, a Fair Street consists of several criteria that make the street more liveable, sustainable, and inclusive. A fair balance must be made between these different criteria to arrive at a fair design. Also, a fair balance in the preferences of different stakeholders should be made to create a fair street. This will be done using a Multi-Criteria Decision Making (MCDM) method. MCDM is a widely used method for making decisions about public issues (Rezaei, 2015a). MCDM problems come in two types: continuous and discrete MCDM problems(E. Zavadskas et al., 2015). The various criteria are discretized to make precise and quantifiable trade-offs, a process intended to structure the problem and make decision-making more efficient and to be more easily implemented. However, a drawback in this context is the simplification of certain factors, such as safety, which depends on many latent variables, and accessibility, which needs an extensive traffic database and detailed traffic counts. This makes it difficult to determine appropriate levels for discretization. Because of this, the different Fair Street criteria need to be reconsidered for the MCDM method per case. Moreover, the results are sensitive to the influence of the chosen intervals. However, within the scope of this study, this sensitivity is considered a minor problem because the chosen method helps in incorporating the fair street criteria into a design process and is, therefore, an indication for design directions. This means that the recommendations from this method do not need to be adopted literally one-to-one. When applying Multi-Criteria Decision-Making (MCDM) methodologies, a strategic decision can be made by initiating a pairwise comparison between alternatives (Leoneti & Gomes, 2022) or attributes (Bozóki et al., 2013). Yet relying solely on pairwise comparisons between alternatives is often insufficient (Kunsch, 2012). Therefore, this research focuses on pairwise comparisons between attributes. The complexity arising from a surplus of comparisons can lead to reduced concentration or increased complexity, affecting the consistency of responses. Consequently, the main challenge in pairwise comparisons is the formidable task of dealing with the problem of inconsistency (Rezaei, 2015b). This challenge becomes particularly significant in scenarios with many alternatives or attributes, increasing the likelihood of inconsistencies in judgments (Mi et al., 2019). The advantage of MCDM is that it enables stakeholders to make and substantiate decisions on complex issues where the factors of the decision are hard to quantify. The disadvantages of this method are that the questions are sometimes difficult to understand, and small differences in answers can already lead to major consequences for the final outcome. Also, determining importance is subjective, and thus, outcomes can be influenced. In addition, it is often difficult to identify and weigh all relevant criteria using this method (E. K. Zavadskas & Turskis, 2011). However, properly designing the interviews and clearly formulating the questions will largely tackle these problems.
Another widely used method for substantiating policy choices is social cost-benefit analysis (CBA). This more objective method supports policy decision-making by mapping all the costs and benefits from policy choices (Koopmans & Mouter, 2020). The impact on social welfare is measured in this method by converting the effects of a project into monetary terms. This makes it possible to calculate whether each Fair Street design is positive or negative for social welfare. However, the purpose of this study is to involve stakeholders in the decision-making process in order to arrive at a Fair Street. This makes it more important to identify the subjective preferences/weights of different stakeholders while conducting a CBA is more useful for identifying the final impacts on the society of a chosen design. In addition, as mentioned earlier, the effects are difficult to estimate. This makes it difficult to determine a particular design's exact effect on traffic safety, for example. For these reasons, an MCDM method was chosen instead of a CBA.

Best Worst Method

The Best Worst Method (BWM) will be used during the interviews with key stakeholders to optimize the pairwise comparison process and minimize the number of comparisons. This method evaluates each criterion against the most desirable and least desirable criteria (Rezaei, 2015a). Compared to alternative pairwise comparison techniques, the BWM requires fewer comparisons because only the most and least desirable criteria are compared. Consequently, the BWM involves a total of (2n - 3) comparisons, whereas a traditional Analytic Hierarchy Process (AHP) approach would require n(n-1)/2 comparisons for a comprehensive evaluation (Rezaei, 2015b). The simplicity of the BWM facilitates explanation to interviewees, and efficiency is further enhanced by the minimal number of equations required, making it suitable for this study. The efficiency of this method compared to AHP can be seen in figure 2.5.

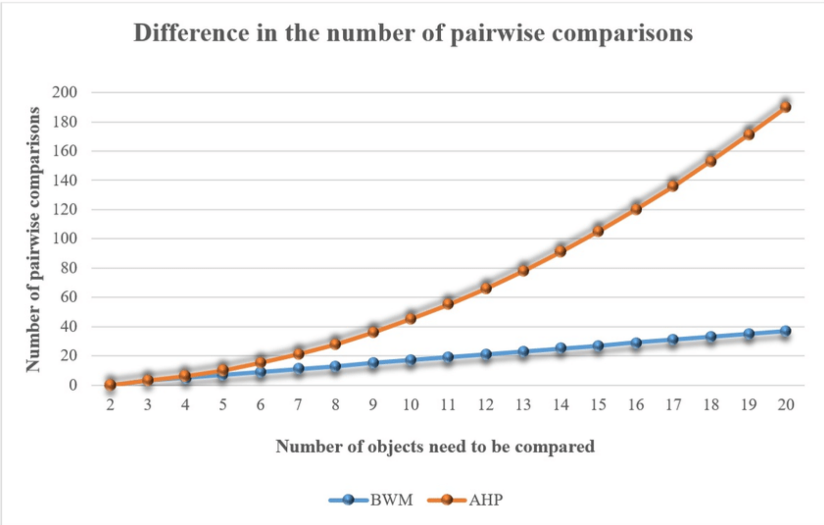

Figure 2.5: Number of pairwise comparisons needed per amount of criteria (Haseli et al., 2021)

The figure shows that the number of pairwise comparisons increases for AHP when the number of criteria becomes 4 or higher. As a result, this study uses the BWM method for all pairwise comparisons of 4 or more criteria. For pairwise comparisons of 2 criteria, the AHP method is still used. The difference in importance between the two criteria is measured using the rubric shown in figure 2.6.

Intensity of Importance	*Definition*	*Explanation*
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgement slightly favour one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgement strongly favour one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
Reciprocals of above	If activity *i* has one of the above non-zero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*	A reasonable assumption
1.1–1.9	If the activities are very close	May be difficult to assign the best value but when compared with other contrasting activities the size of the small numbers would not be too noticeable, yet they can still indicate the relative importance of the activities.

Figure 2.6: Rubric for the fundamental scale used for the pairwise comparisons (Saaty, 2008)

As mentioned earlier, the criteria are compared pairwise using a BWM method. The structure of questions can be found in appendix A.1 along with responses from the various stakeholders. Also, the mathematical model for calculating the different criteria weights is further explained in appendix A.5. To solve this mathematical model, a linear BWM solver has been used, which was created by Rezaei in 2016 for solving MCDM problems with the linear BWM (Rezaei, 2016). Because BWM first asks to compare the best criterion against the rest of the criteria and then asks again to compare the rest of the criteria against the worst criterion, the anchoring and adjustment bias is tackled. This bias occurs when a starting point of a decision process greatly affects the final outcome (J. T. Buchanan & Corner, 1997). Because the estimations are based on both the best and worst criteria, these two anchors cancel each other out. However, this type of questioning can cause answers to the first question to be inconsistent with answers given to the second question. Because of this, a consistency check must be performed (Liang et al., 2020). The calculation of this consistency check is further explained in appendix A.5.

3 Literature review

Urban redevelopment projects often focus on improving urban environments' livability, sustainability, or safety. This literature review reviews existing academic research on urban street design and assesses the extent to which these environments support or hinder urban livability, inclusivity, and safety. The research identifies gaps in the current literature, particularly regarding the integration of stakeholder perspectives into urban designs and how these perspectives affect the practical implementation of such designs.

3.1. Urban mobility and safety

Research shows that prioritizing the safety of vulnerable road users, including pedestrians and cyclists, in urban design significantly reduces vehicle speeds and pedestrian injuries (Morrison et al., 2003). This can be done by the traffic calming approach to reduce the negative effects of motor vehicle use. Traffic calming includes physical measures (e.g., speed bumps or chicanes), educational measures (e.g., awareness campaigns), and enforcement measures (e.g., legal speed limits) (Brown et al., 2017). The effectiveness of safety measures such as narrowing roadways, implementing refuge islands, and reducing speed contribute significantly to improving pedestrian safety (Gårder, 2004). Literature suggests that the human body can withstand speeds up to the maximum that humans can walk, which is around 30 km/h(Hamilton-Baillie, 2008). Speeds above this limit cause an exponential growth in the likelihood of fatal accidents. Moreover, studies show that certain demographic groups, especially the elderly and children, are more likely to be involved in accidents due to inattention and slow crossing (Kim et al., 2017). Also, these two groups are the most fragile in an accident due to their age. Because of these correlations between speed and fatality in pedestrian crashes Kim et al. (2017) emphasize the need for speed reduction measures (Kim et al., 2017). Abdel-Aty et al. (2007) show that the majority of school-aged children's crashes occurred in areas near schools (Abdel-Aty et al., 2007). Because children are vulnerable and often unaware of their surroundings, it is important to design the school environment accordingly. In addition to speed-reducing measures, creating a clearly visible road design is vital for the safety of the children since this enables drivers to respond to the unexpected behavior of children (Hamilton-Baillie, 2008). Therefore, speed reduction and better visibility measures may improve the livability of school zones. In addition, research from Wang et al. (2016) shows that urban design can encourage walking and cycling in residential neighborhoods (Wang et al., 2016). Thereby, sufficient facilities (e.g., wide sidewalks, cycling paths, bicycle parking space), greenery, safety, and public leisure space help overcome the barriers to walking or cycling. More children will walk or bike to school by enabling good walking and cycling infrastructure, which ensures the safety of the children. This results in less congestion on the roads and safer and cleaner air in residential areas due to the decrease in children being brought to school by car(Brown et al., 2017).

Currently, the Dutch road network follows the principles of "Sustainable Safety Road Traffic," which classifies roads into three different types: flow roads, residential access roads, and district connector roads. These classifications facilitate specific traffic functions, ranging from high-speed traffic to local accessibility, and enhance safety through structured traffic (SWOV, 2005). The key to reducing crashes is the principle of homogeneity, which dictates that vehicles of similar speeds and masses share the same space, minimizing collisions. Roads are designed for specific vehicle types to maintain consistent speeds and directions, and infrastructure such as separate lanes for cyclists and pedestrians is implemented when speeds exceed certain thresholds (15 km/h for pedestrians and 30 km/h for cyclists). This approach is consistent with the traditional theory of traffic separation, which aims to increase safety by reducing interactions between different types of road users (Hamilton-Baillie, 2008). Despite the fact that this vision led to a significant drop in traffic fatalities after its introduction, the number of traffic fatalities had remained almost at the same level every year since 2010 when the number of fatalities was 640. With 684 traffic deaths in 2023, a slightly rising trend is even appearing (SWOV, 2024). This can be seen in figure 3.1. In addition, there are still 25 to 45 traffic fatalities per year in Dutch residential areas with a 30 km/h limit (SWOV, 2018), suggesting that even well-implemented homogeneity principles may not completely prevent serious crashes.

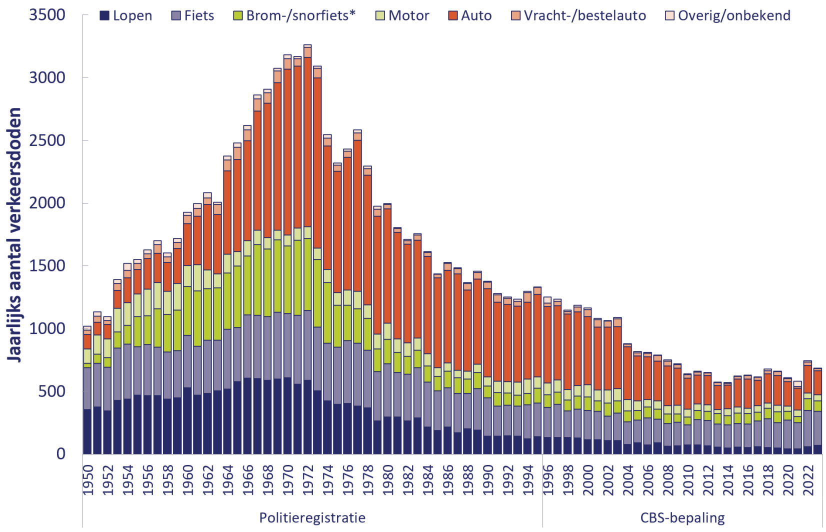

Figure 3.1: Number of traffic deaths in the Netherlands since 1950 (SWOV, 2024)

As a result, a new theory called shared space has been coming up as a counterpart. The shared space principle aims to remove traditional infrastructure barriers, promoting visibility and a moral imperative for diverse road users to share the same space (Hamilton-Baillie, 2008). Shared space, defined by Reid et al., enhances pedestrian movement by reducing motor vehicle dominance, encouraging users to share space without strictly defined rules (Reid, 2009). Kaparius et al. outline key conditions for a safe shared space, including low vehicular traffic, high pedestrian traffic, good lighting, and pedestrian-only facilities (Kaparias et al., 2012). Which makes shared space very location and case-specific and not applicable everywhere. However, what is also notable is that children and the elderly contribute to driver discomfort, heightening alertness of the drivers (Kaparias et al., 2012). Therefore, implementing shared space in school zones can lead to extra alert driving behavior. However, the success of this theory is also mixed, as several cities in the Netherlands have already stopped using shared space in their cities. The municipality of Den Haag decided in 2020 to stop shared space in their central city area after six years as it led to road users feeling unsafe (Gebiedsontwikkeling.nu, 2020).
There has been limited research on the effects of shared space. This makes it difficult to determine with certainty whether this road layout works better than the sustainably safe layout. This is also difficult because estimating the effect of a traditional improvement in places where shared space has now been applied (Methorst et al., 2007) is not possible. Research by Leeuwarden High School (2011) shows that the implementation of shared space in selected areas has yielded several benefits (Lutz & Foorthuis, 2011). For example, the number of traffic accidents has decreased, and the speed of motorized traffic has remained stable. In addition, accessibility for people in wheelchairs, rollators, or baby carriages has improved because the height difference between the sidewalk and roadway has been eliminated. Besides the traffic safety, this modification has also improved the spatial quality, which has been received positively. Despite these improvements, safety ratings are low, mainly due

to the perceived insecurity associated with shared space environments. This is also confirmed by Kaparias et al. (2012), which states that mixed traffic causes especially vulnerable groups to feel less safe (Kaparias et al., 2012). This subjective feeling of insecurity is especially pronounced among blind and visually impaired people due to the absence of traditional signs delineating safe areas on the street. Consequently, this ambiguity may discourage older people, who make up more than 70% of the visually impaired population, from using these spaces.

3.2. Sustainability in Urban Design

Climate change has gained increasing recognition in recent decades and has become a central element within international politics (Owen, 2020) (Swart et al., 2014). With the Paris Agreement, 196 parties agreed to ensure that the global average temperature does not increase more than 1.5 degrees Celsius compared to pre-industrial levels (United Nations, n.d.). The Paris Agreement is emerging as a landmark instrument, forcing countries to significantly reduce carbon dioxide emissions and strengthen their resilience to the impacts of climate change (Persson, 2019). Due to population growth and the trend of people moving to cities, combined with insufficient climate planning, cities suffer a significant loss of green spaces and biodiversity (Chanse et al., 2021). This greenery plays a vital role in our health and well-being, and due to its absence, urban areas, in particular, are facing the consequences of climate change with increasing urgency. Longer periods of extremely hot weather cause cities to become heat islands, negatively affecting health due to heat stress (Lundgren & Kjellstrom, 2013). An analysis by Steeneveld et al. (2011) showed that the heat island effect in most Dutch cities is significant and comparable to that in other European cities, with an average value of 2.3 degrees Celsius and 5.3 degrees Celsius as the upper limit in 95% of the calculated values per city or village (Steeneveld et al., 2011). This effect was measured not only in large cities but also in smaller towns and villages. In addition, this long-during heat causes extreme droughts in urban areas, while on the other hand, intense rainfall events cause flooding of urban roads (Wamsler et al., 2013). Such phenomena highlight the need to integrate climate adaptability into the design and construction of urban infrastructure, with a specific focus on making streets future-proof against the various impacts of climate change.
Chanse et al. provide a vision for climate-adaptive streets that contribute to city resilience by improving ecological health, facilitating social interactions, and mitigating environmental extremes (Chanse et al., 2021). Their research underscores the transformative potential of streets when designed with adaptability and sustainability at the forefront, aligning with global climate goals set forth in the Paris Agreement. This approach addresses the immediate challenges of climate change and contributes to the overall well-being of city residents by fostering environments that support social well-being, biodiversity, and ecological balance. Chanse et al. emphasize the importance of green and blue infrastructure in urban streets for improving social health (Chanse et al., 2021). Integrating green spaces into street designs contributes to social cohesion, provides places for meeting and recreation, and strengthens people's connection to nature, which in turn leads to better health and wellness outcomes. CSI Trees' research also shows that residents enjoy experiencing the seasons via the trees and that the trees attract butterflies and birds (Goossen et al., 2023). Furthermore, research by Chanse et al. (2021) indicates the importance of more biodiversity in the street due to the positive effect on street livability (Chanse et al., 2021). People spend 8 to 10 times more time in urban streets than in parks (Cabanek et al., 2020). This makes it important to bring the greenery of the parks back to the streets and thus make the streets an integral part of the health and well-being of the city (Chanse et al., 2021). So, given these results, it is very important to have a good biodiversity of both trees and plants, as well as the animals it attracts on the street.
However, making streets green and climate adaptive also costs significant investments, which causes not all cities to include this greening directly in their neighborhood renewals. Also, the increase in green space involves extra maintenance expenses because green space must be maintained according to a study of four sustainable neighborhood renovations in Leiden (Gemeente Leiden, 2022). This makes maintaining neighborhoods a bigger task than before. Therefore, the study recommended that maintainers be involved in the design phase of the redevelopment of neighborhoods. However, the same study also shows that there was discussion about the number of parking spaces in the redeveloped neighborhoods. Highlighting the importance of including residents in a co-design. This is because parking and additional green space are seen as both valuable in the street. In addition to the high investment and maintenance costs, the space required for implementing these green initiatives is

often a challenge for cities (Keivani, 2009). However, research by Leiden municipality shows that if climate adaptation and biodiversity are explicitly included in neighborhood redevelopment assignments, the neighborhood becomes less vulnerable to extreme rainfall, extreme drought, and extreme heat (Gemeente Leiden, 2022). This could prevent higher costs due to flooding or extreme drought in the future. Therefore, showing and educating people about these effects in the design phase is important to create acceptance of major environmental changes.

3.3. Effects of car accessibility on urban design

The reason why there are challenges in utilizing space is that cities are designed primarily around car traffic. The emphasis on quick transportation has resulted in other activities being neglected to make way for cars. Despite this, travel times have remained constant since 1950, as people in the Netherlands generally find it acceptable to travel 70 to 90 minutes a day. Marchetti explains this in his paper as the law of conservation of travel time (Marchetti, 1994). The ”law of conservation of travel time” implies that people tend to spend a constant amount of time traveling regardless of changes in transportation systems or infrastructure. Therefore, improving the accessibility of a location, like work, would allow people to live further away without spending less time commuting, making the roads busier. The fixation on quick car transportation has led to high parking standards being implemented in cities. CROW, a knowledge platform for mobility in the Netherlands, publishes parking standard guideline values to give an indication of how much vehicular traffic a residential area development can expect if there are no other mobility options (Provincie Zuid-Holland, 2017). These values are based on the national average, and it’s important to note that they should be reconsidered on a case-by-case basis (CROW, 2017). However, many municipalities tend to adopt or have adopted these guidelines in the past as the standard for constructing or redeveloping residential areas. This results in minimum parking requirements for every residential neighborhood, leading to car infrastructure occupying up to 50% of public space in cities (KiM, 2022). Research in 7 cities of the province of South Holland shows that these parking standards cause about 20% fewer homes to be constructed due to the parking requirement taking up space and extra costs for housing projects (Provincie Zuid-Holland, 2017). Parking spots, therefore, cost money and take up space. By building fewer homes, fewer parking spaces also need to be built. This makes projects financially feasible but at the expense of urban density. This effect is detailed by Professor Donald Shoup of the University of Los Angeles, concluding that parking standards create a downward spiral of urban thinning, traffic congestion, and less cost-effective public transit (Shoup, 1997). This downward spiral can be seen in figure 3.2.

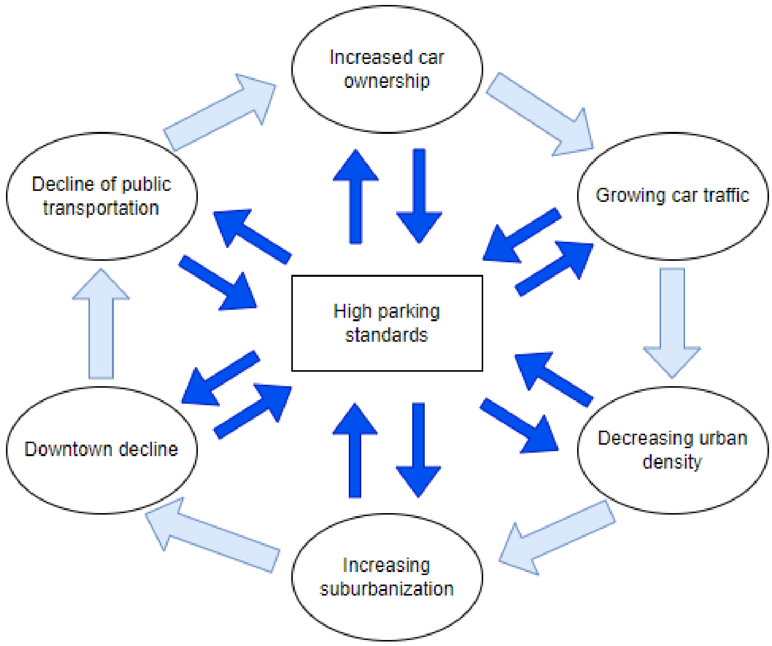

Figure 3.2: Effect of parking standards on urban density (Shoup, 1997)

With 229 cars per km2, the Netherlands has the highest spatial car density in the EU after the island of Malta. This is partly due to the high parking standards set for new housing construction. By facilitating good car accessibility, average car ownership in the Netherlands has gone from 0.8 to 1.1 cars per household since 1990. Also, 27% of the Dutch inhabitants have 2 or more cars per household. At the same time, a parked car takes up 40 times more space than a pedestrian, as shown in figure 3.3, and these cars are parked unused 96% of the time (KiM, 2022).

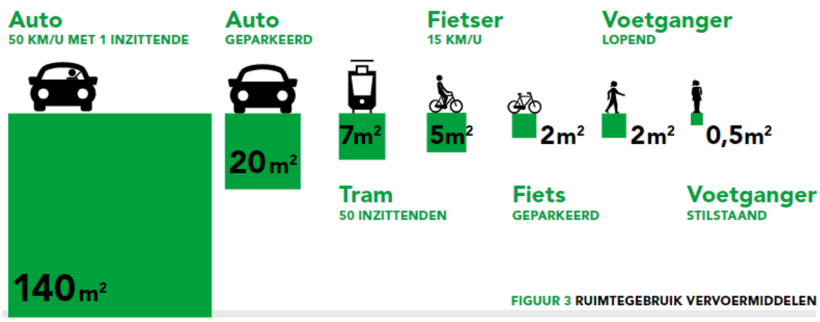

Figure 3.3: Space usage per transportation mode (Gemeente Amsterdam, 2017)

In big cities, parking standards are getting lower, and paid parking is becoming more common in various neighborhoods of the city. The largest cities in the Netherlands have implemented stricter parking policies, which resulted in only 40-50% of commuters driving their cars to the city from 15 kilometers or more away. In contrast, the G5-10 largest cities have a higher percentage of commuters driving to the city, with rates ranging from 65-80%. This indicates that big cities use parking standards to discourage car use within the city, while smaller cities use parking standards to support it. However, as shown in figure 3.4, this creates lots of congestion.

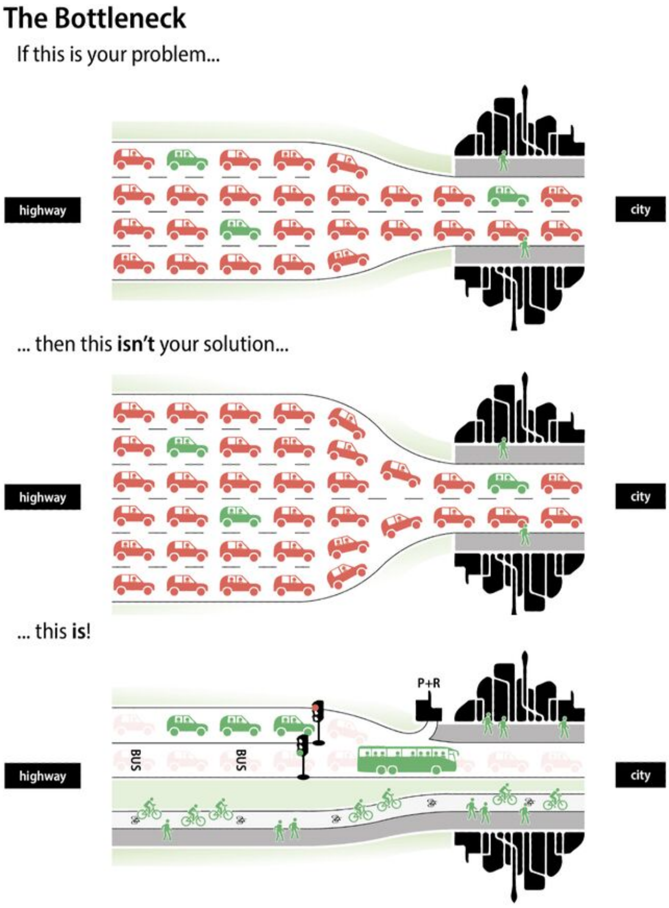

Figure 3.4: Solution for car congestion in the city

It is evident that altering the infrastructure designed for cars is challenging. Even though the area taken up by cars in a city can be utilized for other activities, it requires a shift from a long-established mentality that cannot be accomplished easily.

3.4. Stakeholder involvement in Urban Planning

To increase the community's involvement in sustainable urban planning, the European Commission has developed requirements that local authorities must comply with to draw up Sustainable Urban Mobility Plans. The involvement of stakeholders in decision-making is seen as a key element for the success of transitions in mobility plans (Lindenau & Böhler-Baedeker, 2014). Lidenau and Böhler-Baedeker (2014) show that there has been considerable research on participatory approaches for governments (Lindenau & Böhler-Baedeker, 2014). However, the effectiveness of these processes varies. Key obstacles include political will, limited resources, and the complexity of coordinating the interests of different stakeholders. To overcome these challenges, the authors propose more structured and strategic approaches to engaging the public and stakeholders, emphasizing the need for clear frameworks and sufficient resources to support these processes. Van der Lee also shows that there are barriers that can affect the effect of mobility plans (van der Lee, 2024). For example, different stakeholder interests create conflicts. In addition, low social acceptance can create political resistance. Success factors to avoid these barriers as much as possible are showing openness and flexibility when designing measures to increase acceptance. In addition, trials of new mobility policies ensure that the community can get used to measures before they are made final. Also, this paper indicates that measures are more likely to be accepted if they positively impact children's health and safety.

3.5. Conclusion and research gap

In concluding the findings from the literature review, it becomes clear that a safe school environment plays a vital role in minimizing accidents and improving the quality of life in the nearby environment. Studies on different design strategies to improve traffic safety have sparked a debate on the most effective way to achieve safer streets, often suggesting that reducing the dominance of vehicular traffic can reduce traffic-related hazards. However, such measures usually have a negative impact on automobile accessibility. Moreover, the introduction of urban green space not only improves health outcomes and increases the social value of urban areas but also strengthens resilience to the impacts of climate change. Yet the development of these green spaces often clashes with the need for automobile accessibility due to the limited space. Traditionally, urban planning has strongly favored car transportation, using as much as 50 percent of urban public space to meet the demand for driving. Repurposing this space for green and social uses could revolutionize urban areas and transform them into more attractive living environments, encouraging interactive and playful interactions on the street and promoting vibrant green space to enhance public life. Yet such transformations face considerable resistance from those who rely on cars. While some research has been conducted on the obstacles in implementing mobility initiatives and their varying success rates, there remains a notable research gap in how to effectively engage stakeholders in the redesign process to prioritize livability, sustainability and inclusiveness. Therefore, additional research on systematic and practical methods for integrating these values into urban streetscapes is essential. Therefore, this research focuses on ensuring active stakeholder involvement in the implementation of a fairer school environment to improve children's safety and health. Hereby, it combines the success factors for the implementation of mobility policies.

4
Problem structuring

To structure the problem, the current situation must first be analyzed to see what users are experiencing. This is done by looking at the current design, making observations in the street, and conducting a survey among residents. After that, the problem is structured by looking at the stakeholders who have a role in the street and their interests, the criteria for determining the fairness of the street, and creating the designs. Finally, the outcome of this chapter is a representation of the different designs with their scores on the different criteria of the Fair Street.

4.1. Current design

As mentioned earlier, the current design of the Fuutlaan is being modified due to the necessity of replacing the sewer system underground. In the process, the street will be redesigned to improve traffic safety and climate adaptivity of the street (Gemeente Delft, 2023). Fuutlaan is part of the access route to the Tanthof East neighborhood. This can be seen in figure 4.1, where the Fuutlaan is located at the orange part near the elementary school SpringWijs. As a result, it is a busy street in the mornings and evenings during peak hours due to the residents who have to leave or access the neighborhood to head to or come from work.

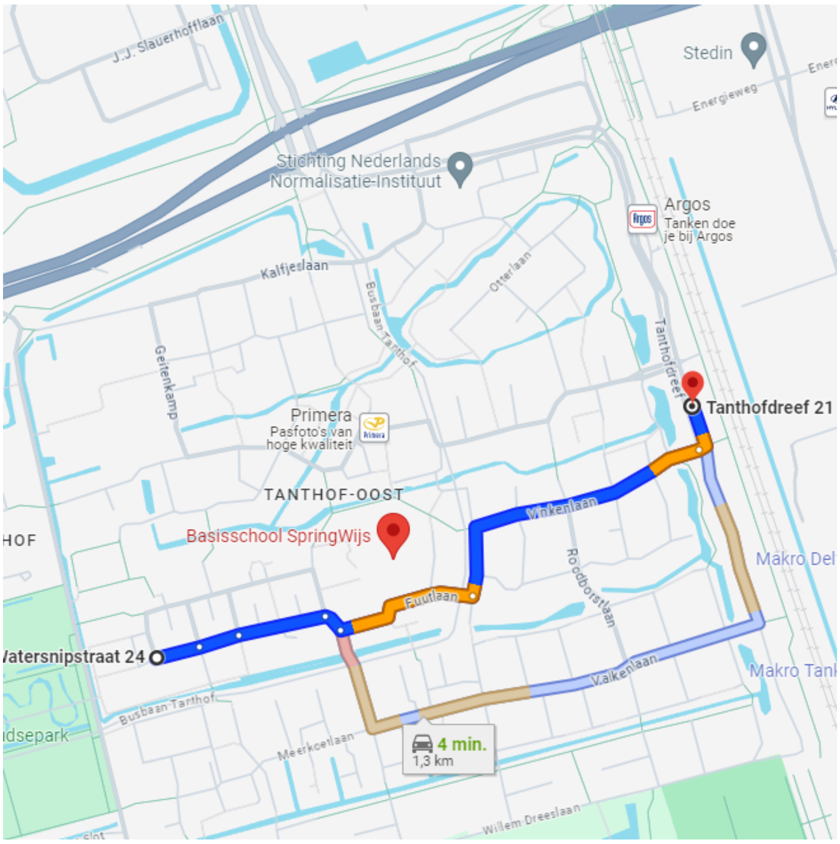

Figure 4.1: Fuutlaan as a district access route (Google Maps, n.d.)

There is also a school located in the street. This leads to the street being filled with parents bringing their children to school by car during school opening and closing times. This travel behavior during opening and closing times of the school creates bad visibility and unexpected behavior because the parents stop their cars in the middle of the road or on the sidewalks to drop off their children. This can be seen in figure 4.2, where a bicyclist has to slalom between two cars on the zebra pedestrian crossing to drive over the road.

Besides being a busy road, the current design has little speed reduction measures in the street. As shown in figure 4.2, the part of the Fuutlaan in front of the school is a fairly straight road, with a mild speed bump only in the middle near the zebra crossing. However, this speed bump is quite flat and does not provide the necessary speed reduction. As a result, in the current design, people often drive faster than the allowed speed of 30km/h.

Figure 4.2: Typical daily moment in the Futlaan

4.1.1. Fairness of the current design

To determine how fair the current design is, the indicators of livability, sustainability, and inclusiveness, as broken down in the decomposition of Chapter 1, will be considered (figure 1.1). These three components will be further examined in the following paragraphs.

Livability

The livability component can be divided into traffic safety and the street's sociality. Here, traffic safety consists of a part actual safety and a part perceived safety.
The current design is based on principles of sustainable, safe traffic philosophy to promote traffic safety. In this philosophy, homogeneity in speed and mass is seen as the key component for designing the street layout. Therefore, pedestrians are separated from cars and bicycles by sidewalks on the road. Because the Futlaan was built in the 70s and 80s, the layout is outdated and in need of renovation (Allecijfers.nl, 2023). This is indicated by the interviews and survey conducted among parents and residents (Appendix A, Appendix B.2), while real-life observations confirm this as well.
The infrastructure of the Futlaan is characterized by parking spots on both sides of the road, where the parking spots are made for parallel parking. There is only one speed reduction tool in the middle of the street: a moderately effective speed bump with a zebra crossing on top of it. This street design appears to undermine perceived safety, as reflected in survey results showing that 47% of respondents perceived the street as (very) unsafe. The average safety score of the Futlaan is 2.71 (appendix B.2) on a scale of 1 (very unsafe) to 5 (very safe), which classifies the perceived safety of the Futlaan as a little unsafe.
Actual safety can be illustrated by the number of traffic accidents. However, these numbers are not recorded per street. Therefore, the traffic accidents in the Vogelbuurt-West, the neighborhood in which the Futlaan is located, will be used. The number of traffic accidents in the Vogelbuurt-West was three in 2022 (Allecijfers.nl, 2024c). In addition, the V85 speeds observed on the street can provide valuable insights into the actual safety of the street (Expert A). Although specific speed measurements have not been conducted in the Futlaan itself, a study by SWOV at 10 different locations in South Holland indicates that the V85 speed on 30km/h roads with similar characteristics ranges between 36-40 km/h (Goldenbeld et al., 2017). This is in line with the real-life observations and the users' perception of the Futlaan. These findings imply that despite the intention for a lower speed limit, actual driving behavior exceeds the prescribed limits.

This two-sided analysis of traffic safety shows that improvements in both actual safety and perceived safety could still be made in the Fuutlaan, thereby improving the livability of the public space. According to the survey, this could be done by excluding cars in the street (permanently or between certain time periods), a kiss and ride, and extra speed reduction measures (appendix B.2). Also, creating better visibility appears from the literature to be effective for increasing safety (Hamilton-Baillie, 2008). This could also be a good option for the school side in the Fuutlaan.

There is limited space for social interaction in this section of the Fuutlaan. This has to do with the fact that the sidewalks are too narrow for pedestrians to stand still for a chat. This does not have much impact on parents, as they can often stand at the school's playground to meet with other parents. However, from the interview with the resident from CWD (appendix A.3), it appears that there is a need among the residents of the Fuutlaan for social gathering spaces on the street. The only space currently available is the widening of the sidewalk at the zebra crossing. These are 5 meters wide and 8 meters long on both sides. The meeting spaces in the current design can be seen in figure 4.3 on both sides of the zebra crossing.

Figure 4.3: Social meeting space in the Fuutlaan

Sustainability

The sustainability of the Fuutlaan is determined by the number of trees and plants on the street. The amount of greenery in the street determines the attractiveness of the street, which according to Chanse et al. (2021) and research from Goossen et al. (2023) improves social cohesion and leads to better health for residents (Chanse et al., 2021; Goossen et al., 2023). In addition, the amount of green space helps make the street more climate-adaptive. More green space helps to absorb extreme rainfall, cool the street during extreme heat waves, and retain groundwater during dry periods (expert B).
Currently, the Fuutlaan has 14 trees in the street, as shown in figure 4.4. The current trees standing in the Fuutlaan are Aesculus Hippocastanum trees (Gemeente Delft, n.d.-b).

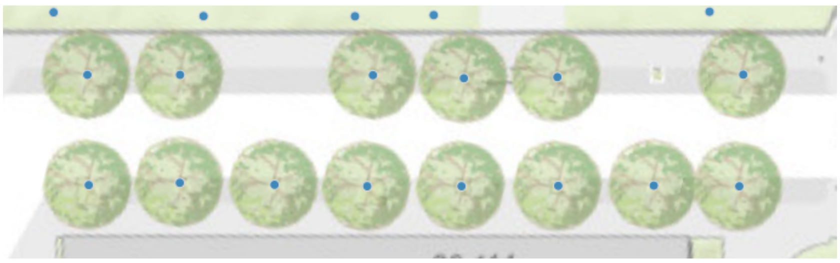

Figure 4.4: Trees at the Fuutlaan (Gemeente Delft, n.d.-b)

These trees affect the various factors of climate-adaptive streets. However, the exact influence of these trees is difficult to determine since other factors in the street also play a role in determining the climate adaptivity of the street, such as the size of the underground sewer or the permeability of the pavement of the street. A climate impact scan can be done to determine how climate-adaptive the current design is (expert B). This scan is made based on the 2022 Climate Impact Atlas (Klimaateffectatlas, 2022) and can be seen in appendix C.1. This climate impact scan shows that with the current situation, there is a very high probability of flooding during extreme rainfall. This is also the reason that the municipality will replace the current sewer system (interview municipality, appendix A.2). In addition, extreme heat stress can be experienced on hot summer days in the current situation. This is in line with the current problems that an increasing number of cities are currently facing (Chanse et al., 2021). This emphasizes the importance of sufficient cooling greenery in the street. The current situation does score well on the components of drought and flooding risk. The expected ground decline for 2100 due to drought is mild, although sedimentation sensitivity due to elevation is high. The probability of flooding on the Futlaan is very low. This is based on the safety requirements of the water defense structures in the surrounding area.

Inclusivity

The inclusivity indicator indicates the extent to which the street is accessible to everyone. This considers accessibility by car, bicycle, pedestrian, and special transportation.
How accessible a particular location is can be determined based on what is available within 15 minutes of travel. This is based on the 15-minute city concept in which all necessary facilities in a city should be maximally within 15 minutes of walking or biking distance (Sdoukopoulos et al., 2024). Figure 4.5 shows the areas that can be reached from the Fuutlaan per mode of transportation. Whereby the blue area represents places that can be reached within 15 minutes by car, the red area represents places that can be reached within 15 minutes by bicycle, and the orange area represents places that can be reached within 15 minutes of walking.

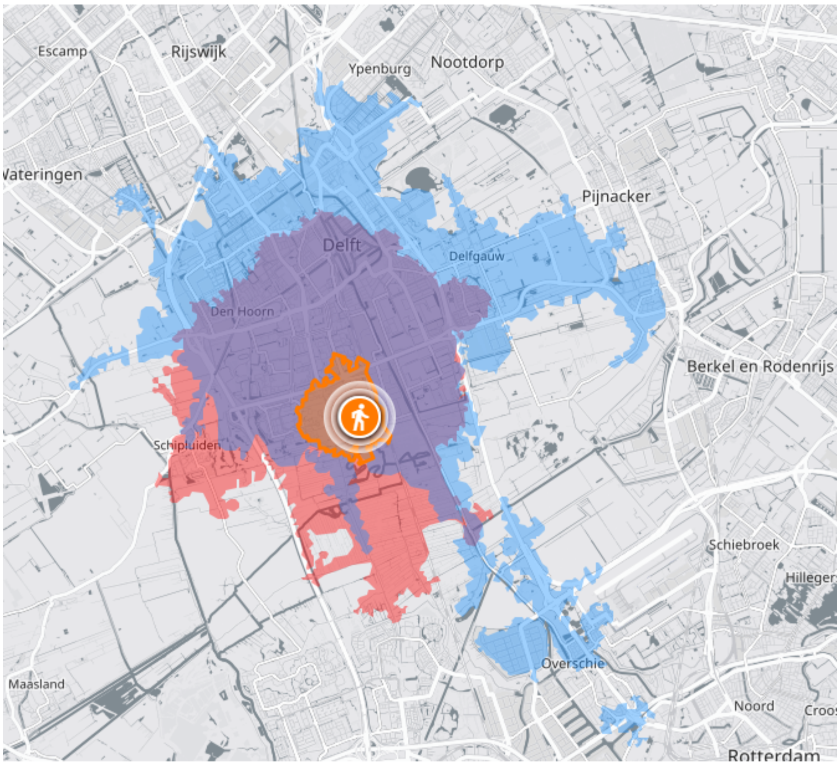

Figure 4.5: Accessibility per modality within 15min of the Fuutlaan (TravelTime, 2023)

The figure shows that the Fuutlaan can be reached by car (blue) from anywhere in Delft within 15 minutes. In addition, the area extends from the north of Rotterdam to the south of Ypenburg and from the west of Berkel en Rodenrijs to the east of Wateringen. When zooming in a bit for bicycle traffic (red), it can be seen that it already covers a slightly smaller area. However, large parts of Delft are still accessible, and the area extends all the way to surrounding villages and the north of Schiedam. Finally, when zooming in all the way to the area accessible for pedestrians (orange), it can be seen that the Fuutlaan is only accessible for the Tanthof-east area. Since the SpringWijs is a normal public elementary school, most of the children on the school will live in this area. The zoomed-in maps for bicycle distance and pedestrian distance can be seen in appendix D.1.

However, the facilities for each mode of transportation, including special transportation, are more important for the inclusiveness indicator. This requires examining the facilities at the street level. In this regard, in the Fuutlaan, the width of the sidewalk, the number of bicycle parking spaces for both normal and special bicycles, and the parking spaces for cars are examined. The sidewalk should be wide enough for people with baby carriages or rollators to pass each other without having to step off the sidewalk. In the current situation, the sidewalk is about 2 meters wide. This allows people with baby carriages to just pass each other. However, the survey and observations have shown that during pick-up and drop-off times of the school, which are the periods when most baby carriages come to the Fuutlaan, cyclists have to park their bikes against the fences due to the lack of bicycle parking spaces. This causes the sidewalk to become narrower and, consequently, pedestrian accessibility decreases. In addition, cars are being parked on the sidewalk at several places, making the sidewalk completely inaccessible for pedestrians. This can be seen in figures D.3, D.4, D.5 in appendix D.1.
The number of bicycle parking spaces in the current situation is limited to a portable bicycle rack that can hold 4 normal bicycles. This limited parking space is by far not enough to handle the demand for bicycle parking space from parents during their children's pickup and drop-off. This causes many bikes to be parked against the fences of the school square or on the sidewalk near the crosswalk, as shown in figure D.3 in appendix D.1. This also causes special bikes, such as cargo bikes, to be parked on the sidewalk, as shown in figure D.4 or even against the railings at the crosswalk, as shown in figure D.6 in appendix D.1. This unstructured way of parking bikes hinders other activities, such as walking on the sidewalk or the place for social meetings in the street. In addition, the survey shows that 65% of the users agree with the statement that there should be more bicycle facilities and fewer car facilities in the school environment (appendix B.2). It can be concluded from this that the bicycle facilities are below standard in the current situation. Therefore, the inclusivity in the Fuutlaan is very low. In terms of automotive facilities, the street currently accommodates 14 parking spaces. Surveys and observations indicate that during peak drop-off and pick-up times, these spaces are insufficient for all cars, resulting in numerous vehicles being parked on the sidewalk (appendix D.1). Given that automobiles occupy a significant amount of space, almost the entire street is already occupied by parking spots, making adding more spaces challenging. Consequently, it becomes crucial to explore options for encouraging parents to switch to alternative transportation modes or drop their children off in a different place.

4.1.2. Stakeholder analysis

A stakeholder analysis is a process by which the characteristics of stakeholders and their influence on decision-making can be identified. It helps define strategies for managing these stakeholders. This involves looking at the influence and interests of the stakeholders in this project (Brugha & Varvasovszky, 2000). The stakeholder analysis and interviews with the key stakeholders will provide good insights into the stakeholders and their interests in making the Fuutlaan fairer.

1. **Municipality Delft**
   The municipality of Delft has included sustainability, health, and safety as core values for area development in their environment vision for 2040 (Gemeente Delft, n.d.-c). When redeveloping neighborhoods, it is necessary to consider safety and sustainability in the design of neighborhood roads. In addition, the municipality is also the project leader for the redevelopment of Tanthof East, where their goal is to improve the district's water drainage by replacing the sewer system and greening the neighborhood (interview municipality, appendix A.2. Therefore, the municipality of Delft has a high interest and influence in creating a fair street for the Fuutlaan.

2. **Centraal Wonen Delft (CWD)**
   Centraal Wonen Delft (CWD) is a social housing organization that has residential blocks located at the Fuutlaan in which various residents live in housing groups together. In this residential facility,

residents do not live in isolated units, but groups of residents share the same common facilities in addition to having their own living units (Centraal Wonen Delft, n.d.). This form of living causes CWD residents to be very interested in social interaction with the surrounding community. The CWD represents the interests of the residents at the Fuutlaan (Centraal Wonen Delft, n.d.). Since the Fuutlaan is located along the homes of CWD, CWD has a high interest and an important vote in redesigning the Fuutlaan.

3. **Elementary school SpringWijs**
The SpringWijs is an elementary school located at the Fuutlaan. The school aims to create a safe and active environment for the children at school. In addition, since it is a public elementary school, the school has a district function to allow children of different talents and backgrounds to learn and live together (Springwijs, n.d.-b). Since the Fuutlaan is directly at the entrance for the school's kindergarten classes, this is the arrival route for parents to pick up or drop off their children for school. As a result, SpringWijs has a strong interest and an important vote in the redesign of the Fuutlaan.

4. **Elementary school RKBS De Regenboog**
RKBS De Regenboog is an elementary school located in the same building as Springwijs. However, the entrance is on the Kraanvogelstraat, which is a side street of the Fuutlaan. As a result, many children go to their schools via the Fuutlaan on their way to school. Also, parents who bring their children to school by car will park their cars in the Fuutlaan. Therefore, the school is also affected by the redesign of the Fuutlaan.

5. **Elementary school CBS De Waterhof**
CBS De Waterhof is an elementary school located in the same building as Springwijs. However, the entrance is on the Lepelaarstraat, which is at the extension of the Fuutlaan. Because of this, there will be children and parents from this school traveling through the Fuutlaan. However, they will not stop here to drop off their children. Therefore this school has a small interest in the redesign of the Fuutlaan.

6. **Parents Association “Vrienden van SpringWijs”**
”Vrienden van Springwijs” is an association composed of up to 11 parents of children at the SpringWijs elementary school. The purpose of the parents' association is to create interest and involvement in the school among parents. In addition, it wants to make a positive contribution to the development of the school and the organization of activities at the school (Springwijs, n.d.-a). Therefore, the parents association represents the interests of the parents at the school. The Fuutlaan is the approach route for parents of the school to drop off their children. As a result, parents have a strong interest in the redesign of the Fuutlaan. However, because they only interact with the Fuutlaan while picking up and dropping off their children, their influence on the redesign is lower than the influence of the residents.

7. **Avalex**
Avalex handles the collection and processing of household waste and raw materials on behalf of the municipality of Delft (Avalex, n.d.). As a result, they also collect the waste in the Fuutlaan. This gives Avalex a small interest in the redesign of the Fuutlaan. It also appears from the survey and observations that Avalex has an influence on the traffic safety of the street because the collection of waste during opening or closing times of the school causes dangerous and chaotic situations (appendix B.2).

8. **Bycicle Union**
The Fietsersbond or Bycicle Union is an association with over 32,000 members, representing the interests of cycling in the Netherlands (Fietsersbond, n.d.). They want better and well-maintained bike lanes. The organization also wants to raise awareness for cyclists with disabilities by incorporating tricycles and hand bikes into the design of infrastructure (Fietsersbond, 2021). Because of its large member base, the cyclists' union has an important vote in the redevelopment of neighborhoods. However, the interest is more limited in the specific case of the Fuutlaan.

9. **EBS bus**
EBS provides public transportation in the Rotterdam Den Haag metropolitan region. As a result, they provide bus service 64, which has a bus stop at the beginning of the Fuutlaan (EBS, n.d.). EBS, therefore, ensures that Fuutlaan is properly accessible by public transport for the residents

and parents of SpringWijs. Because of this, EBS has a great impact on the accessibility of the Fuutlaan redevelopment. However, the interest of EBS in the Fuutlaan redevelopment will be quite low because their service route is at the edge of the project area.

10. **NS**
NS has train station Delft Campus at 15 min walking and 4 min biking distance. Besides making Delft South accessible by train, NS also offers after-travel services in the form of OV bikes (NS, n.d.). This allows NS to provide public transport accessibility to the Fuutlaan. In the current situation, these OV bikes are not available at the station. As a result, NS affects accessibility for residents of Fuutlaan and children coming to the schools from outside the region.

11. **Residents of Vogelbuurt-West**
Since the Fuutlaan is a district access road to the Vogelbuurt-West, the residents of the Vogelbuurt-West have a strong interest in the redesign of the Fuutlaan. The impact of these residents on the entire redesign of Tanthof East is significant. However, the impact on the Fuutlaan specifically is lower.

12. **Residents Delft**
The rest of Delft's residents have little interest and little impact on the Fuutlaan. This is because most of Delft's residents hardly ever need to visit the Fuutlaan.

These stakeholders can be divided based on their influence on and interest in the Fuutlaan redesign. In doing so, they are divided into four boxes, as shown in figure 4.6. The stakeholders that fall in the yellow box have little interest and little influence and, therefore, only need to be monitored. The stakeholders in the blue box have little interest but a lot of influence on the Fuutlaan redesign. As a result, these stakeholders need to be informed, and where necessary, agreements can be made about their influence on the Fuutlaan redesign. The stakeholders in the orange box have a lot of interest in but little influence on the Fuutlaan redesign. As a result, these stakeholders must be kept satisfied. Finally, the stakeholders in the green box have a lot of interest and a lot of influence on the Fuutlaan redesign. As a result, these stakeholders must be closely managed, and thus, these stakeholders are included in the interviews for the Fuutlaan redevelopment.

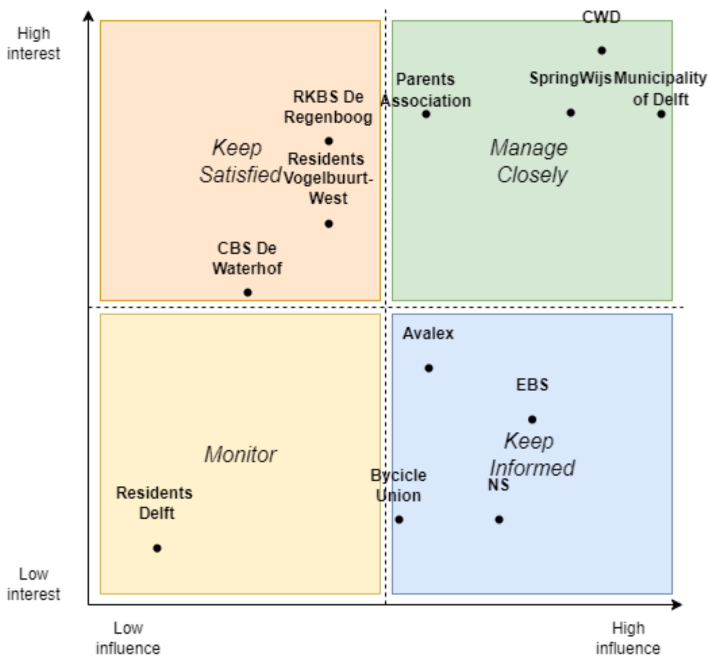

Figure 4.6: Power Interest Grid stakeholders

As can be seen in figure 4.6, the stakeholders in the blue box are mostly public services who work in order for the Government. As a result, by engaging in dialogue with these parties, the municipality of Delft can ensure that the public transport accessibility of the Fuutlaan can be increased and that garbage is no longer collected in the street during busy periods. In addition, the interview with the cyclists' union teaches us that it is important when constructing new roads to build the street as flat as possible to improve the accessibility of the Tanthof for tricycles and hand bikes. In addition, it can be seen that the orange box contains the residents and schools in the area. Because they are located near the Fuutlaan, it is important to include these stakeholders in the redesign of the entire Tanthof Easst, but as far as the Fuutlaan is concerned, they only need to be kept satisfied.

4.2. Fairness criteria

A goal tree has been used to determine the criteria that could measure the "Fairness" of the various alternatives. This goal tree is based on the indicators and sub-indicators of the Fair Street principle, which can be seen in figure 1.1 from chapter 1. The goal tree with the final main criteria and sub-criteria for measuring the Fairness of the designs are shown in figure 4.7.

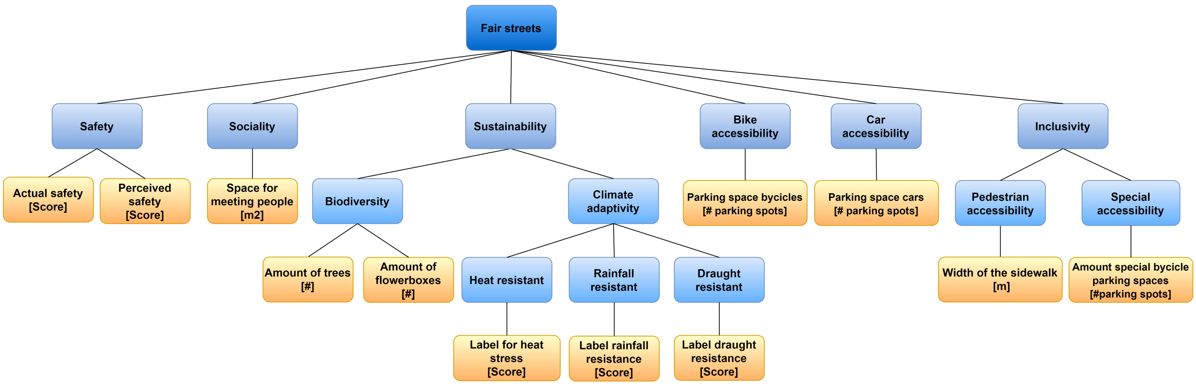

Figure 4.7: Decision tree Fair Street

Street Fairness will be measured in the interviews by 6 main criteria. These criteria are Traffic Safety, Sustainability, Inclusivity, Sociality, Car Accessibility and Bike Accessibility. In addition, some main criteria are also divided into sub-criteria. Road safety is measured by actual and perceived safety. Sustainability is measured using the sub-criteria of biodiversity, heat resistance, rainfall resistance, and drought resistance. Finally, inclusivity is measured by pedestrian accessibility and special transportation accessibility. Although the four forms of accessibility in the Fair Street decomposition all fall under inclusivity (figure 1.1), the criteria for bicycle and car accessibility are separated from the inclusivity criterion. This was done to avoid confusion about the meaning of this inclusivity criterion. How these main and sub-criteria are weighed against each other is shown in the interview format that can be seen in appendix A. Further explanation about these criteria can be seen in the following paragraphs.

Traffic Safety

Traffic safety depends on many factors, making it difficult to measure. Because of this, the traffic safety factor for the interviews is divided into actual safety and perceived safety.
A common indicator used in road safety analyses to measure actual safety is to look at the V85 speed (expert A). The V85 speed is the speed driven by 85% of all vehicles and is a good indicator of the actual speeds driven on a road. It is reflective of the speeds that most drivers consider reasonable and safe for the conditions (Esposito et al., 2011). Although nationally representative data on driving speeds on 30km/h roads are not available, a field experiment in the province of South Holland by SWOV showed that the V85 speed is between 36 and 40km/h at the locations measured (Goldenbeld et al., 2017). Although the survey and observations confirm the feeling that these speeds are also driven on the Fuutlaan, this has not been measured objectively. In addition, estimating the speeds that will be driven in the new designs is even more difficult. As a result, the sub-criterion actual safety for the various designs is estimated by a score between 1 very unsafe and 5 very safe. These scores are estimated based on the interview with expert A and the information from the literature about the different safe road layout theories. The resulting scores per design are explained in section 4.3.

Perceived safety in the street is also important. This has to do with the fact that based on the speeds driven and number of incidents that happen in the street, a street may be objectively safe, but the behavior in the street may feel unsafe to users. This can negatively impact the street's inclusiveness by causing people to avoid the street because of the unsafe feeling. Therefore, the influence of designs on perceived safety will also be included as a criterion and is also estimated by a score between 1 very unsafe and 5 very safe. Current perceived safety has been measured by the survey among road users (appendix B.2). However, the literature and expert knowledge of expert A are used to estimate the perceived safety of the new designs. The resulting scores per design are explained in section 4.3.

Sociality

To enhance the livability of the street, there must also be sufficient space in the street for social interaction. For the designs, the amount of sociality is determined by the amount of m2 space in the street for meeting people. In doing so, people should not get in the way of other people's transportation habits. This means that the sidewalk and the section of the road on which people drive do not count as spaces to meet. However, parking lots can be transformed into meeting places by placing modular parklets. These can be designed in a variety of types and put down on the site of a parking lot. An example is shown in figure 4.8.

Figure 4.8: Modular parklet meeting space (Detail.de, n.d.)

Another form of adding social meeting space in the street can be seen in the picture in figure 4.9. Here, coffee stands are placed at the parking spots to organize a neighborhood meeting to bring residents and parents of the school together. This was done in front of the Blijberg school in Rotterdam.

Figure 4.9: Coffee stands on parking spots

In the newly created designs, these types of parklets are used to create additional m2 of social space at the parking spots from the current design. This was used in the designs as an addition to the already existing social gathering space at the zebra crossing, as discussed in section 4.1. The resulting scores per design are explained in section 4.3.

Sustainability

As previously mentioned in section 4.1, street sustainability is determined by the greenery in the street. To determine the sustainable condition of the designs, biodiversity and climate adaptivity will be considered. In this biodiversity can be divided into the amount of trees, flower boxes and grass tiles. Climate adaptivity can, in turn, be divided into heat resistance, rainfall resistance, and drought resistance.
The biodiversity in the street mainly affects the perception of residents and users. According to Chanse et al. (2021) and research from CSI Trees (2023), it improves social cohesion and improves residents' health. The score for the biodiversity criterion for each design will be measured based on the number of trees in the street and the number of parking spaces that have greenery on them. This does not differentiate between car parking spaces with grass tiles or flower boxes put in place of a car parking space. On the other hand, the climate adaptability of the street mainly affects how future-proof the street is. According to the climate adaptivity scan from Sweco, the street of the future must be resistant to extreme rainfall, flooding, extreme drought, and extreme heat (Sweco, n.d.). However, flood risk depends only on location (parts of the Netherlands are protected by dikes) and not on how the streets are laid out. In addition, the climate impact scan performed for the current situation shows a very low flooding risk for the Fuutlaan. Therefore, it is not included as a score for the street designs.
To determine a score for these sub-criteria for the designs, only the effects of trees on street climate adaptation will be looked at. However, it is very difficult to determine the exact effect of a tree on the climate impact (expert C). This is because it depends on many factors, such as the tree's age, growth space, width of the tree, etc. Nevertheless, based on a project at the University of Wageningen, a species table of common trees in the Netherlands has been drawn up, giving a global indication of how well these trees score on various climate adaptation topics (Hiemstra, 2018). This tree species table shows the positive contribution of over 100 tree species to climate, water management, air quality, and biodiversity in the city and can be seen in appendix C.2. It includes the scores of drought tolerance, warming reduction, and rainfall interception for each tree. Here the score of drought tolerance is given on a scale of 0 to 3 stars. 0 stars equals no tolerance to drought, and the stars increase from low tolerance (1) to moderate tolerance (2) to high tolerance, which equals 3 stars. The scores for reduction of warming run from low contribution to the reduction of warming (1), moderate contribution to the reduction of warming (2), to high contribution to the reduction of warming (3 stars). Finally, the scores for rainfall interception run from low interception (1), moderate interception (2) to strong interception of rainfall (3 stars) (Hiemstra, 2018). This table will be used to measure the scores of heat-, rainfall- and drought resistance. This is done by multiplying the number of trees of a given species in the design by the number of stars that the tree species scores per criterion.
Currently, there are Aesculus hippocastanum trees in the Fuutlaan (Gemeente Delft, n.d.-b). According to the table, these trees score 3 stars on heat resistance, 2 stars on rainfall resistance, and 0 stars on drought resistance (Hiemstra, 2018). This means that these trees have very poor resistance to extreme droughts, requiring watering in times of drought.
A future-proof tree that scores well on heat, rainfall, and drought resistance and fits well in the current conditions of the Fuutlaan is the Populus Tremula. This tree scores 3 stars on heat resistance, 2 stars on rainfall resistance, and 3 stars on drought resistance (Hiemstra, 2018). In addition, this tree can grow on clay and loam soil, which the current soil of the Fuutlaan consists of. As a result, this tree is chosen for the designs where new trees will be planted. The resulting scores per design are explained in section 4.3.

Bike Accessibility

Bicycle accessibility is determined by the amount of bicycle parking spaces on the street. The designs use so-called bicycle staples, which can accommodate 1 bicycle per side of the staple. To make room for bicycle parking spaces, the same idea as the modular parklet can be used in a car parking lot, as previously mentioned, for sociality. This is called a bicycle parking deck and is shown in figure 4.10. Such a bicycle deck has enough parking space for 10 bicycles.

Figure 4.10: Bicycle racks on bicycle deck (Fietsvlonders.nl, n.d.)

In the newly created designs, these bicycle decks are used to create additional parking spaces for bikes. In addition, in the designs on the widened sidewalk sections near the crosswalk, there has also been made room for bicycle staples. The resulting scores per design are explained in section 4.3.

Car Accessibility
To assess the effect of the car accessibility criteria, the amount of car parking spaces on the street is considered. It is impractical to comprehensively analyze car travel times. Such an analysis would require an extensive traffic database and detailed traffic counts, which is beyond the time and logistical scope of the project. Therefore, parking availability emerges as a feasible and indicative measure of car accessibility in the street. It also indicates the stakeholder's preference regarding the street's use of space. The parking spaces in the current situation are 5m long and 2m wide, which is approximately equivalent to the regulations for the current size of parallel parking spots (TU Delft, n.d.). With a size of 10 m^2 these parking spots take up a lot of space. This space can be used for other activities in the new designs. The number of parking spots for cars per design can be seen in section 4.3.

Inclusivity
Inclusivity assumes the degree to which the street is accessible to all types of users, in particular, the most vulnerable and uncommon type of road users. Because there is an elementary school on the street, it is likely that vulnerable groups will also come to the street. These vulnerable groups include, on the one hand, parents who come to school with a baby in a baby carriage or a cargo bike to pick up their child and, on the other hand, grandparents/grandmothers who come to pick up their grandchildren with a rollator or special tricycle. Interviews with the cyclists' union have shown that the number of cargo bikes and elderly people with special tricycles is increasing significantly (expert D). This makes it increasingly important to make accessibility available for these special bikes.
The main criteria of inclusivity are measured in the interviews by pedestrian accessibility and special accessibility. Pedestrian accessibility involves accessibility for people with baby carriages or rollators and is measured by the width of the sidewalk. This is because the wider the sidewalk is, the more accessible the street is for people with baby carriages or rollators. The width of the sidewalk per design will be explained in section 4.3.
Special accessibility involves accessibility for people with a cargo bike or special tricycle and is measured by the number of bike spaces that can accommodate a special bike. Since only bicycle racks, as shown in figure 4.10, are used in the designs, the space between 2 bicycle racks is suitable for one cargo bike or special tricycle. Parking capacity for special bicycles per design can be found in section 4.3.

4.3. Designs redevelopment Fuutlaan

For the redevelopment of the Fuutlaan, various designs have been made in order to compare against each other. In this process, 2 designs were already created by the municipality. Besides, 3 designs

were created based on the survey, input from the interviews and a requirement analysis. These 5 designs will be evaluated based on the fairness criteria from section 4.2.
The initial two designs were developed by the municipality of Delft in response to a 2017 mandate to redesign the Tanthof area to improve traffic safety and climate adaptivity in the district. The first design emphasized increasing green spaces within the neighborhood and improving safety along Fuutlaan by removing parking spaces adjacent to the school, as reflected in Design 2. Due to the high costs associated with the initial design, budgetary constraints led to a revised version that largely maintains the current state of Fuutlaan but incorporates additional greenery through the use of grass tiles in parking areas designated for vehicles (appendix A.2). This revised version is illustrated in Design 1 and will be used as the basis for the new designs.
Beyond the municipality's contributions, three additional designs were conceptualized based on a requirement analysis. One design draws upon the theories of shared space. In this design, pedestrians can walk on the road mixed with cars and bikes. This results in significant space being freed up due to the elimination of fixed parking spaces within a shared space environment for better visibility. This concept is depicted in Design 3. The fourth design explores the possibility of a car-free street. In this design, cars are not allowed on the street at all. The street will become a big bicycle lane maintaining the same lay-out as before. However, because no more car parking spaces are needed in this design, this design also has plenty of space for other activities. This concept is depicted in Design 4. The last design is based on making the current design more fair. Herein, the street still remains accessible to cars, and only the car parking spaces have been partially replaced for the use of other activities. The distribution of the different space usage is based on the results of the survey.
The requirement analysis used for the new designs and the scores on the criteria of all the designs will be discussed in subsequent sections.

4.3.1. Requirement analysis

This section will discuss the design process for creating the new designs. These designs will be based on different safer street lay-out theories. The literature has shown that two theories can be distinguished in making streets safer. The traditional theory assumes separating different road users so that the possibility of conflict can be reduced (C. Buchanan, 2015). This theory is characterized by physical barriers, traffic signals, signs, and road markings. The counterpart of this theory is the newer Shared Space principle. Herein, the idea is to remove the traditional infrastructure separating the different road users and use good visibility and moral imperative to allow different road users to share the space with each other on the same road (Hamilton-Baillie, 2008). These two theories are the basis for the fair street designs for the Fuutlaan. Also, a design where no cars are allowed in the street at all is being considered. Subsequently, based on a requirement analysis, these designs are created. In addition, experts within BAM who are familiar with analyzing road safety will be consulted. In this way, several useful designs will be made, which can be ranked based on the importance of the different criteria resulting from the interviews.

The requirement analysis examines the requirements that the designs must meet. Within this context, a distinction can be made between constraints and objectives. Constraints are considered mandatory and indicate the criteria that the design must meet. On the other hand, objectives are preferences and indicate the ideals the design should fulfill as much as possible.

Constraints:

- The Fuutlaan should be accessible without obstruction to emergency vehicles so that they can be on the scene quickly during emergencies (RVO, 2012)
- The Fuutlaan should be as accessible within 15 minutes for bikes and pedestrians as in the current situation (accessibility areas, appendix D.1)

Objectives:

- **Safety:**
  1. The Fuutlaan could preferably have 0 traffic accidents (Gemeente Delft, 2020)
  2. The v85 speed in the Fuutlaan could preferably be under 30km/h (Gemeente Delft, 2020)
- **Sociality:**

1. The Fuutlaan could preferably have more than 80 m^2 social space (current situation)
2. The Fuutlaan could preferably have benches to sit on (interview CWD, appendix A.3)

- **Sustainability:**
  1. The Fuutlaan could preferably have a heat resistance score of A (climate impact scan, appendix C.1)
  2. The Fuutlaan could preferably have a rainfall resistance score of A (Sweco, n.d.) (climate impact scan, appendix C.1)
  3. The Fuutlaan could preferably have a drought resistance score of A (climate impact scan, appendix C.1)
  4. The Fuutlaan could preferably more greenery in the street (survey results, appendix B.2)
- **Car & Bike accesibility:**
  1. The Fuutlaan could preferably have 0.7 parkingspots within 400m for cars per household (Overheid.nl, 2021)
  2. The Fuutlaan could preferably have 0.75 parkingspots within 400m for cars per class room (Overheid.nl, 2021)
  3. The Fuutlaan could preferably have 5 parkingspots for bikes within 50m per 10 students (TU Delft, n.d.)
- **Inclusivity:**
  1. The Fuutlaan could preferably have enough parking space for special bikes (real life observations, appendix D.1 figure D.6)
  2. The Fuutlaan could preferably have a sidewalk wide enough for 2 buggies to pass each other (real life observations, appendix D.1 figures D.3, D.4)

As can be seen in the requirement analysis, there are very few hard constraints. However, the street must remain accessible to emergency services, and accessibility to the school must not be degraded so much that it becomes impossible for children within the Tanthof East area to reach the school within 15 min of walking or biking. In this way, the school retains its local function. Because the Fair Street principles mainly look at how the space could be arranged differently, the Fair Street principles are mainly objectives that should be strived for as much as possible in the design. Therefore, A new design must have a fair balance for all the different activities demanded in the street. These constraints and objectives are taken into account when creating the designs.

4.3.2. Outcomes spatial reconsiderations survey

To include fairness in the designs, spatial reconsiderations need to be made. These spatial reconsiderations deal with the activities that can take place instead of car parking in the space of a parking lot. This can be accomplished by modular parklets and bicycle parking decks, as previously indicated in section 4.2. In this way, a parking lot can be transformed into a social gathering place, a flower box, or a bicycle deck. To get a fair balance of these activities on the street, the survey asked about these trade-offs in space use. Each respondent was asked if they would rather have activity j or a car parking spot in their street. They were then asked how much more important they thought that choice was on a scale of 1 (equally important) to 5 (extremely much more important). The following formula is then used to determine the score for each activity. Here, the score 1 (equally important) was substituted for 0, as neither activity is preferred in this case.

$$Score_j = \sum_{i \in I_{activityj}} (Score_i) - \sum_{i \in I_{parking}} (Score_i)$$

In this formula, $Score_j$ is the outcome of the summation of all the scores for the respondents i who chose activity j subtracted by the summation of all the scores for the respondents i who chose the car

parking activity.
The share for each activity is then determined based on the following formula.

$$Share_j = Score_j / \sum_{j \in J}(Score_j)$$

In this formula, $Share_j$ can be calculated by dividing the score of activity j by the summation of the scores of all the activities. An important detail here is that the score for special accessibility is halved because bicycle parking decks for special bikes are the same as parking decks for normal bikes, and therefore, it is already partly included in the form of a bicycle deck for normal bicycles.
Ultimately, each share is multiplied by the 14 parking spaces from the current situation. This can be seen in the following formula.

$$Parkingspots_j = Share_j * 14$$

In this formula, the number of parking lots occupied by activity j is calculated by multiplying the share of activity j by the total number of parking spaces from the current situation. The outcome is then rounded to an integer number. The outcomes of the number of parking spots per activity can be found in table 4.1 for designs 3 and 4, where car parking spots are totally excluded in the street and in table 4.2 for the last design in which car parking is also included in the street. The tables' last column shows the parking spots' color for the corresponding activity in the visual representations of the designs shown in figures 4.13, 4.15 and 4.17.

Table 4.1: Parking spots per activity designs 3 and 4

Activity	**Score survey**	**Share**	**#Parkingspots**	**Color**
Sustainability	15.8	0.327	5	Green
Inclusivity	6.5*	0.135	2	Grey
Bike access	14.4	0.298	4	Grey
Sociality	11.6	0.240	3	Light blue

*The score of inclusivity has been halved

Table 4.2: Parking spots per activity design 5

Activity	**Score survey**	**Share**	**#Parkingspots**	**Color**
Sustainability	15.8	0.306	4	Green
Inclusivity	6.5*	0.126	2	Grey
Bike access	14.4	0.279	4	Grey
Sociality	11.6	0.225	3	Light blue
Car access	3.25	0.063	1	Black

*The score of inclusivity has been halved

4.3.3. Design 1: Renovation existing Fuutlaan

The first design is based on the municipality's final redesign (Gemeente Delft, n.d.-a). In this design, the situation remains almost identical to the current situation, with car parking on both sides. The number of trees decreases in this design, but grass tiles are placed in all the car parking spaces. There is also room in this design for fixed bicycle parking spaces where, in the current situation, there is only a movable bicycle rack. Since it is most similar to the current situation and this design has also become the municipality's final design, this design can be seen as the status quo, which can be used for the newly made designs. The design can be seen in figure 4.11.

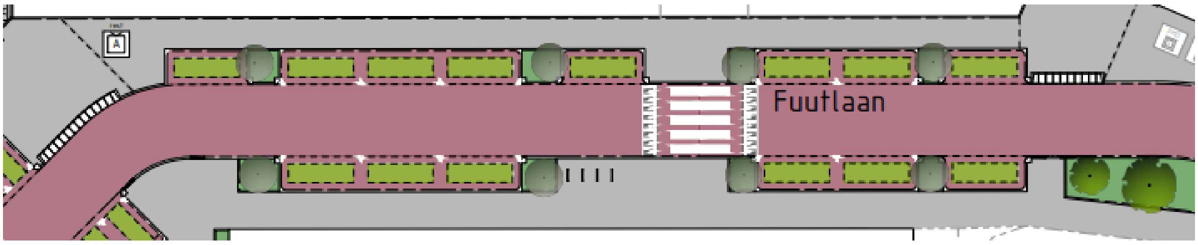

Figure 4.11: Fuutlaan design 1: Renovation existing Fuutlaan (Gemeente Delft, n.d.-a)

Based on this design, the following scores for the criteria named in section 4.2 were established. The score for actual safety will be neutral since this design is similar to the current situation. Therefore, the score will be a 3. The score for perceived safety is 2.71. The score follows from the survey and implies that users consider the current situation to be between neutral and unsafe (survey results, appendix B.2.

The score for sociality in this design is 80m^2 and is based on the 2 widenings of the sidewalk at the zebra crossing, which are 8 meters long and 5 meters wide on both sides. This does not include the piece where the bicycle parking is located. Therefore, it is the same as the current situation.

The score for biodiversity is based on 8 trees and 14 parking spots with grass tiles. This brings the total score for biodiversity to 22. The scores for climate adaptivity are based on 8 Aesculus Hippocastanum trees, which are the currently existing trees at the Fuutlaan. This type of tree scored 3, 2, and 0 stars for respectively heat resistance, rainfall resistance, and drought resistance based on the tree species table of Hiemstra (Hiemstra, 2018), which can also be seen in appendix C.2. This results in a score of 24 stars for heat resistance, 16 stars for rainfall resistance, and 0 stars for drought resistance in this design.

There are 4 bicycle parking staples placed, which can accommodate 8 normal bicycles (2 on both sides of the staple). In addition, there are 14 car parking spaces, which corresponds to the current situation. For the inclusivity criterion, this design has 2m wide sidewalks and is based on the current sidewalk width. In addition, the 4 parking staples provide 5 parking spaces for special bicycles since a special bicycle can also be placed at either end of the bicycle staples in this design.

4.3.4. Design 2: Removal parking spots school side

The second design was actually the first design for the redevelopment of Tanthof East by the municipality of Delft. This design was eventually modified due to budget cuts in the design and complaints from the neighborhood about cutting down existing trees. This led to Design 1, which is discussed above, eventually being created. This design is based on the safety improvement of creating better visibility by removing the parking spots on the school side. This creates a better overview of the people entering or leaving the schoolyard. Parking spots have also been changed from parallel parking to perpendicular parking, which, according to research by the Knowledge Institute for Mobility Policy, causes up to twice as few accidents (KiM, 2022). This is due to the visibility that parallel parked cars obstruct. This type of parking has created more room for additional parking spaces, on which grass tiles are also placed. However, the additional parking spaces do take up space away from the meeting space in the current situation. The design can be seen in figure 4.12.

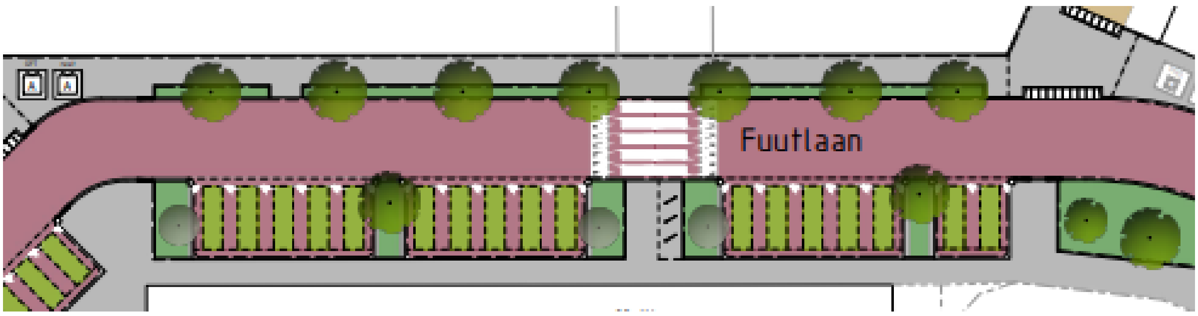

Figure 4.12: Fuutlaan design 2: Traditional safety improvement

Based on this design, the following scores for the criteria named in section 4.2 were established.
For actual safety, this design is similar to the current situation. Due to the absence of additional speed reduction measures, the v85 speed will most likely remain the same as in the current situation. However, the visibility of the road will be improved by eliminating the parking spaces on the school side. This will give the street a better overview, an important factor for traffic safety according to Hammilton-Baillie (Hamilton-Baillie, 2008). Therefore, the score for actual safety will be 3.5. This implies a slight improvement in road safety, which falls between neutral and safe on the score scale. The score for perceived safety will be 4, which indicates a safer perception of the end-users than the current situation. This is because the effect of improved visibility on the school side is expected to be perceived as safer among the end-users.
The score for sociality in this design is only 60m^2 and is based on the 2 widenings of the sidewalk at the zebra crossing. This design has even less space at the pedestrian crossing because the area where bicycle staples were used in the previous design is now also used for parking spaces. As a result, the area for social interaction on this side of the road has been halved to still make room for the bike racks. Therefore, the social meeting space on this side of the road is only 4 meters long and 5 meters wide.
The score for biodiversity is based on the 12 trees that will be planted in this new design and 17 parking spots with grass tiles. This brings the total score for biodiversity to 29. The scores for climate adaptivity are based on 3 Aesculus Hippocastanum trees, which are the currently existing trees at the Fuutlaan, and 9 Populus Tremula trees, which have better scores on climate adaptivity. This Populus Tremula tree sort scores 3, 2, and 3 stars for respectively heat resistance, rainfall resistance, and drought resistance based on the tree species table of Hiemstra (Hiemstra, 2018), which can be seen in appendix C.2. This together with the 3 Aesculus Hippocastanum trees provides a score of 36 stars for heat resistance, 24 stars for rainfall resistance and 27 stars for drought resistance.
In this design, 3 bicycle parking staples are placed, which can accommodate 6 normal bicycles (2 on both sides of the staple). In addition, there are 17 car parking spaces, which is an improvement of 3 parking spaces compared to the current situation.
This design has 2m wide sidewalks for the inclusivity criterion based on the current sidewalk width. In addition, the 3 parking staples provide 4 parking spaces for special bicycles since a bicycle can also be placed at either end of the bicycle staples.

4.3.5. Design 3: Shared Space

The third design is based on the shared space principle, which states that mixing pedestrians, cyclists, and cars encourages drivers to be more attentive and reduce their speed (Lee & Kim, 2019). Essential conditions for this design include clear visibility throughout the street and social control to monitor speed violations (Hamilton-Baillie, 2008). Theoretically, this should enhance actual safety by reducing speed and increasing street visibility. However, the literature indicates mixed traffic can make vulnerable groups feel less safe, lowering perceived safety (Kaparias et al., 2012). To maintain good street visibility, roadside car parking in the street is not possible, freeing up space for activities like bicycle parking, flowerboxes, or social modular parklets. Therefore, the parking spots in the current situation are used for other activities. In the street's new layout, shown in figure 4.13, the green parking spots correspond with flowerboxes, light blue parking spots with social modular parklets and grey parking spots with bicycle parking platforms. The proportions of these different activities are based on the outcomes of the survey shown in table 4.1. Furthermore, figure 4.14 shows an AI-generated street view of how the Fuutlaan could look with a shared space design.

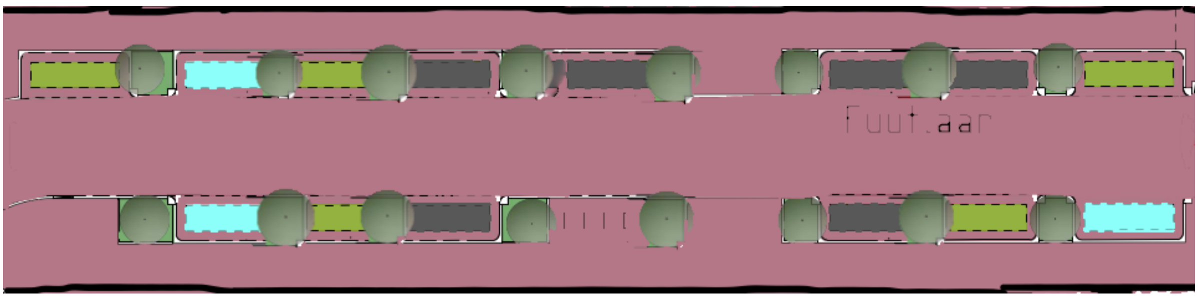

Figure 4.13: Fuutlaan design 3: Shared Space

Figure 4.14: Futlaan AI design for Shared Space (NL Netherlands, n.d.)

Based on this design, the following scores for the criteria named in section 4.2 were established.
The literature suggests that car drivers slow down as a result of shared space (Lee & Kim, 2019). This is partly because cars must adjust their speed to the speed of pedestrians and cyclists, but also because car users feel less comfortable speeding in these environments(Esposito et al., 2011). Also, a condition of a good shared space environment is that the street is clear, so there are no cars parked in the street. This will give the street good visibility, which is an important factor for traffic safety according to Hammilton-Baillie (Hamilton-Baillie, 2008). Therefore, the actual safety of this design will be better, and a score of 4 will be given, which indicates that the design is safer than the current situation. The score for perceived safety will be 1, which is very unsafe compared to the current situation. This is because end users perceive shared space as unsafe, which may cause the elderly or vulnerable groups to avoid shared spaces (Methorst et al., 2007).
The score for sociality in this design is 110m^2 and is based on the same 2 widenings of the sidewalk at the zebra crossing as design 1 with the addition of the 3 parking spots that will be transformed into social space using the modular parklets. These parking spots are 5 meters long and 2 meters wide.
The score for biodiversity is based on 16 trees and 5 flower boxes which are placed on top of the parking spots. This brings the total score for biodiversity to 21. The scores for climate adaptivity are based on 14 Aesculus Hippocastanum trees, which is the current amount of the existing trees at the Fuutlaan, and 2 Populus Tremula trees added between the parking spots that currently do not have a tree as can be seen in figure 4.4. These Populus Tremula trees, together with the 14 Aesculus Hippocastanum trees, provide a score of 48 stars for heat resistance, 32 stars for rainfall resistance, and 6 stars for drought resistance.
Based on the initial design, 4 bicycle parking staples were placed on the sidewalk. An additional 6 bicycle decks were placed, based on the outcomes of the survey shown in table 4.1. This gives the Fuutlaan bicycle parking capacity for 68 bicycles. In addition, however, there are no car parking spaces left, making the car parking capacity 0.
Since pedestrians are allowed to walk on the road in shared space, the width of the sidewalk is equal to the width of the road. Therefore, the width for this inclusivity criterion is 6 meters. In addition, the 4 parking staples from the first design provide 5 parking spaces for special bicycles, and the 6 bicycle decks add another 24 spots by adding 4 special bicycle spots per bicycle deck. This leads to a score of 29 parking spots for the special accessibility criterion.

4.3.6. Design 4: Car Free

The fourth design is based on a car-free Fuutlaan. This results in the safest possible environment for the school. However, it will cause no more car accessibility in the Fuutlaan. This forces parents and residents to park their cars outside the street. In addition, cars that normally use Fuutlaan as an access road for the district must re-route via Meerkoetlaan and Vinkenlaan. This route is also reflected in figure 4.1, in which Google Maps already shows this route as an alternative route. This alternative route will probably be more congested in this scenario, which could lead to a mode shift for some people due to the increased travel time for cars. By eliminating the car parking spaces on the street, this design also has plenty of space for other activities, just as in the shared space design. Therefore, the parking spots from the current situation are also replaced with flowerboxes, social modular parklets, and bicycle parking platforms in this design. In the street's new layout, shown in figure 4.15, the green parking spots correspond with flowerboxes, light blue parking spots with social modular parklets, and grey parking spots with bicycle parking platforms. The proportions of these different activities are based on the outcomes of the survey shown in table 4.1. Furthermore, figure 4.16 shows an AI-generated street view of how the Fuutlaan could look like with a car-free design, making space for lots of green in the street.

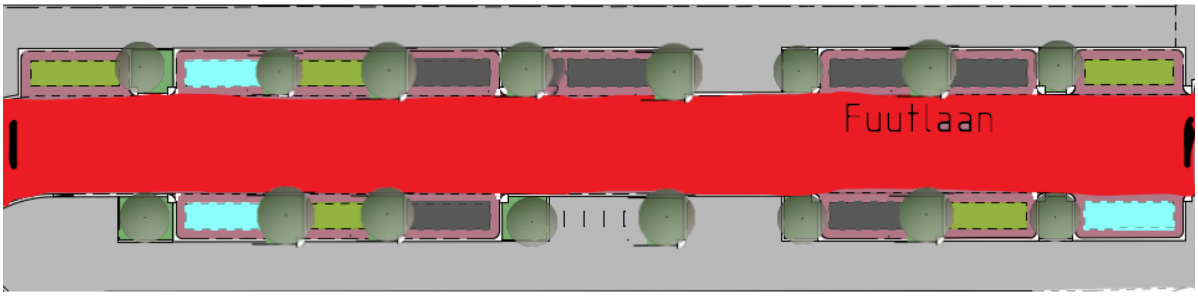

Figure 4.15: Fuutlaan design 4: Car Free

Figure 4.16: Fuutlaan AI design for Car Free (NL Netherlands, n.d.)

Based on this design, the following scores for the criteria named in section 4.2 were established.
In this design, no cars are allowed to drive across the street. This makes both actual and perceived safety in the street very safe. This gives the score on both criteria a 5 (very safe).
The score for sociality in this design is the same as in the shared space design, which is 110m^2 and is based on the same 2 widenings of the sidewalk at the zebra crossing as design 1 with the addition of the 3 parking spots that will be transformed into social space using the modular parklets. These parking spots are 5 meters long and 2 meters wide.
The score for biodiversity is based on 16 trees and 5 flower boxes which are placed on top of the parking spots. This brings the total score for biodiversity to 21. The scores for climate adaptivity are also based on 14 Aesculus Hippocastanum trees, which is the current amount of the existing trees at

the Fuutlaan, and 2 Populus Tremula trees added between the parking spots that currently do not have a tree, just like in the shared space design. These Populus Tremula trees together with the 14 Aesculus Hippocastanum trees provides a score of 48 stars for heat resistance, 32 stars for rainfall resistance and 6 stars for drought resistance.
Based on the initial design, 4 bicycle parking staples were placed on the sidewalk. An additional 6 bicycle decks were also placed based on the proportions coming from the space reconsiderations of the survey. This makes the bicycle parking capacity 68 bicycles. In addition, however, there are no cars allowed in the street, making the car parking capacity 0.
For the inclusivity criterion, this design again has 2m wide sidewalks based on the current sidewalk width. In addition, the 4 parking staples from the first design provide 5 parking spaces for special bicycles, and the 6 bicycle decks that will be added create another 24 spots by adding 4 special bicycle spots per bicycle deck. This leads to a score of 29 parking spots on the special accessibility criterion.

4.3.7. Design 5: Fair renovation existing Fuutlaan

The fifth and last design is an improvement in fairness of the final redesign of the municipality based on the Fair Street principles. This design's street layout remains almost identical to the current situation. However, the car parking spots on both sides are replaced using the outcomes of the survey shown in table 4.1. In this design, the activity of car parking is, however, included in determining these proportions of the different activities in street use. The number of trees will be kept the same in this design as in the shared space and car-free designs. By eliminating most of the car parking spaces on the street, this design also has plenty of space for other activities, just as in the shared space design. Therefore, the parking spots from the current situation are in this design also replaced for flowerboxes, social modular parklets, and bicycle parking platforms. In the street's new layout, shown in figure 4.17, the green parking spots correspond with flowerboxes, light blue parking spots with social modular parklets, grey parking spots with bicycle parking platforms, and the black parking spots remains a car parking spot with gras tiles included. The proportions of these different activities are based on the outcomes of the survey shown in table 4.1.

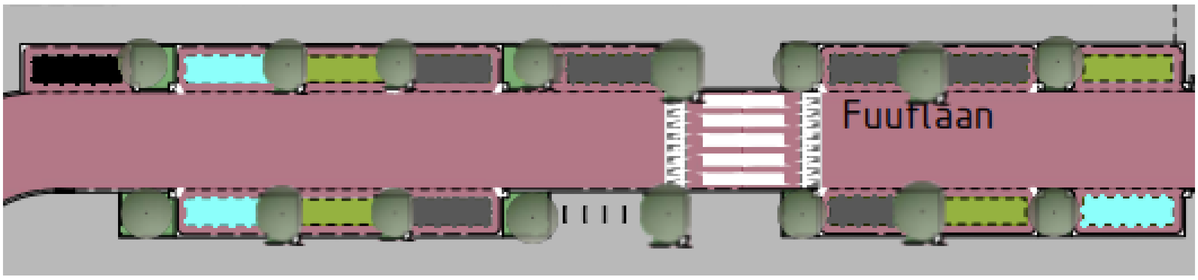

Figure 4.17: Fuutlaan design 5: Fair renovation existing Fuutlaan

Based on this design, the following scores for the criteria named in section 4.2 were established. Traffic safety will be the same as in the first design, since the street layout will remain the same. The score for actual safety will be neutral since this design is similar to the current situation. Therefore the score for actual safety will be a 3. The score for perceived safety is a 2.71. The score follows from the survey and implies that users consider the current situation to be between neutral and unsafe (survey results, appendix B.2.
The score for sociality in this design is the same as in the shared space design, which is 110m^2 and is based on the same 2 widenings of the sidewalk at the zebra crossing as design 1 with the addition of the 3 parking spots that will be transformed into social space using the modular parklets. These parking spots are 5 meters long and 2 meters wide.
The score for biodiversity is based on the 16 trees in the street, 4 flower boxes that are placed on top of the parking spots, and the one car parking spot with grass tiles that remains in this design. This brings the total score for biodiversity to 21. The scores for climate adaptivity are also based on 14 Aesculus Hippocastanum trees, which is the current amount of the existing trees at the Fuutlaan, and 2 Populus Tremula trees added between the parking spots that currently do not have a tree, just like in the shared space design. These Populus Tremula trees together with the 14 Aesculus Hippocastanum

trees provides a score of 48 stars for heat resistance, 32 stars for rainfall resistance and 6 stars for drought resistance.
Based on the initial design, 4 bicycle parking staples were placed on the sidewalk. An additional 6 bicycle decks were also placed, based on the proportions coming from the outcomes of the survey. This makes the bicycle parking capacity 68 bicycles. In addition, one parking spot for cars remains in this design, making the car parking capacity in the street 1.
For the inclusivity criterion, this design again has 2m wide sidewalks based on the current sidewalk width. In addition, the 4 parking staples from the first design provide 5 parking spaces for special bicycles, and the 6 bicycle decks that will be added create another 24 places by adding 4 special bicycle spots per bicycle deck. This leads to a score of 29 parking spots on the special accessibility criterion.

4.3.8. Performance matrix Designs

Based on the explanation per criterion of each design discussed in the previous sections, a performance matrix can be constructed for these designs. This performance matrix shows how each design scores on each criterion.

Table 4.3: Performance Matrix Alternatives

	Traffic Safety	***Sustain-ability***	***Inclusivity***	***Sociality***	***Car-access***	***Bike-access***
Design 1	**Actual:** 3 **Perceived:** 2.71	**Biodivers:** 22 greenery **Heat:** 24 stars **Rainfall:** 16 stars **drought:** 0 stars	**Width sidewalk:** 2m **Special bike spots:** 5	**Meeting space:** 80m2	**Parking spots:** 14	**Parking spots:** 8
Design 2	**Actual:** 3.5 **Perceived:** 4	**Biodivers:** 29 greenery **Heat:** 36 stars **Rainfall:** 24 stars **drought:** 27 stars	**Width sidewalk:** 2m **Special bike spots:** 4	**Meeting space:** 60m2	**Parking spots:** 17	**Parking spots:** 6
Design 3	**Actual:** 4 **Perceived:** 1	**Biodivers:** 21 greenery **Heat:** 48 stars **Rainfall:** 32 stars **drought:** 6 stars	**Width sidewalk:** 6m **Special bike spots:** 29	**Meeting space**: 110m2	**Parking spots:** 0	**Parking spots:** 68
Design 4	**Actual:** 5 **Perceived:** 5	**Biodivers:** 21 greenery **Heat:** 48 stars **Rainfall:** 32 stars **drought:** 6 stars	**Width sidewalk**: 2m **Special bike spots:** 29	**Meeting space:** 110m2	**Parking spots:** 0	**Parking spots:** 68
Design 5	**Actual:** 3 **Perceived:** 2.71	**Biodivers:** 21 greenery **Heat:** 48 stars **Rainfall:** 32 stars **drought:** 6 stars	**Width sidewalk:** 2m **Special bike spots:** 29	**Meeting space:** 110m2	**Parking spots:** 1	**Parking spots:** 68

From this table, it can be noted that not a single design dominates another design. This means that not one design scores better than another on all the criteria. Design 1 scores second highest on the criterion ”car accessibility,” thereby outperforming designs 3, 4, and 5. Design 1 also scores higher on ”sociality” than design 2, thereby outperforming design 2 in this criterion. Design 2 scores the highest on the criterion ”car accessibility.” Therefore, this design outperforms all the other designs on this criterion. Design 3 scores the highest on ”inclusivity,” and thereby, it outperforms all the other designs on this criterion. Design 4 scores the highest on ”traffic safety,” therefore, it outperforms all the other designs in this criterion. Design 5 scores the highest on ”sociality”, therefore this design outperforms designs 1 and 2. In addition, design 5 scores higher on ”car accessibility” than designs 3 and 4. Therefore, it outperforms these designs on this criterion.

5 Results

In this chapter, the interview results will be presented. From these outcomes, the weights per (sub-)criterion can be calculated and will be presented per stakeholder. The different weights will then be merged into aggregated weights per (sub-)criterion. The chapter will conclude with the performance of the different designs based on the aggregated weights that emerged from the stakeholder interviews.

5.1. Results Best-Worst Method Interviews

As discussed earlier in the methodology, key stakeholders are interviewed using the BWM. This method asks which criterion the stakeholder considers most important (best criterion) and which is least important (worst criterion). Then, using the rubric shown in figure 5.1, the respondents are asked on a scale from 1 to 9 how much more important they think a criterion is relative to the best or worst criterion. The interviews with questions and answers per stakeholder can be found in appendix A. Also, the calculation of the criteria weights and the consistency check for checking the respondents' answers are explained in this appendix. This section will present the interview results and the weights per criterion. The section concludes with the weights of the different stakeholders being merged into aggregated weights per (sub-)criterion.

Intensity of Importance	*Definition*	*Explanation*
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgement slightly favour one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgement strongly favour one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
Reciprocals of above	If activity *i* has one of the above non-zero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*	A reasonable assumption
1.1–1.9	If the activities are very close	May be difficult to assign the best value but when compared with other contrasting activities the size of the small numbers would not be too noticeable, yet they can still indicate the relative importance of the activities.

Figure 5.1: Rubric for the fundamental scale used for the pairwise comparisons (Saaty, 2008)

5.1.1. Results Municipality Delft

For the main criteria, the municipality indicated that they considered ”sustainability” the most important (best criterion), while they considered ”sociality” the least important (worst criterion). When asked to compare the best criterion to the other criteria based on the scoring table in figure 5.1, table 5.1 emerged. In this table, the best criterion, ”sustainability,” is compared with all the other criteria. The other criteria are also compared to the worst criterion, ”sociality.” This can be seen in table 5.2.

Table 5.1: Best main criterion compared to others by municipality

Best to Others	Traffic Safety	Sustainability	Inclusivity	Sociality	Car Access	Bike Access
Sustainability	3	1	3	7	3	3

Table 5.2: Others compared to worst main criterion by municipality

Others to Worst	*Sociality*
Traffic Safety	5
Sustainability	7
Inclusivity	3
Sociality	1
Car Access	3
Bike Access	5

These tables show that the municipality considers the best criterion, “sustainability,” slightly more important than all the other criteria except ”sociality.” For this worst criterion, ”sustainability” is seen as very much more important than ”sociality.” When comparing all the criteria against the worst criterion, it can be noticed that the criteria “inclusivity” and “car accessibility” are seen as slightly better than the worst criterion, “sociality.” “traffic safety” and “bike accessibility” are seen as more important than “sociality,” and as indicated earlier, the municipality considers “sustainability” very much more important than “sociality.”
After implementing these results in the relevant BWM formulas for calculating the weights presented in appendix A.5, the following weights for the main criteria were retrieved. Together with the input-based consistency ratio (CR) and the associated threshold value for the consistency check, these weights can be found in table 5.3.

Table 5.3: Weights main criteria by municipality

	Traffic Safety	Sustainability	Inclusivity	Sociality	Car Access	Bike Access	CR	Threshold
Weights	0.147	0.371	0.147	0.043	0.147	0.147	0.190	0.303

This table shows that ”sustainability” has the highest weight, which is 0.371, and ”sociality” has the lowest weight, only 0.043. The other criteria all have a weight of 0.147. Since the input-based consistency ratio (CR) is lower than the associated threshold, the municipality’s answers are consistent.

For the sub-criteria of ”sustainability,” the municipality indicated that they considered ”rainfall resistance” most important, while they considered ”drought resistance” least important. The following tables emerged when the same comparing questions were asked as with the main criteria. Table 5.4 shows the pairwise comparisons of the best criterion, ”rainfall resistance,” to all the other criteria, and table 5.5 shows the pairwise comparisons of the other criteria compared to the worst criterion ”drought resistance.”

Table 5.4: Best sub-criterion compared to others by municipality

Best to Others	Biodiversity	Heat Resistance	Rainfall Resistance	Drought Resistance
Rainfall Resistance	5	3	1	7

Table 5.5: Others compared to worst sub-criterion by municipality

Others to Worst	*Drought Resistance*
Biodiversity	3
Heat Resistance	5
Rainfall Resistance	7
Drought Resistance	1

These tables show that the municipality considers the best criterion, “rainfall resistance,” slightly more important than ”heat resistance,” more important than ”biodiversity,” and much more important than the worst criterion, ”drought resistance.” When comparing all the criteria against the worst criterion, it can be noticed that the responses are similar. ”Biodiversity” is seen as slightly more important, ”heat resistance” is seen as more important, and ”rainfall resistance” is seen as much more important than the worst criterion, ”drought resistance.”
After implementing these results in the relevant BWM formulas presented in appendix A.5, the following weights for the sub-criteria were retrieved. Together with the input-based consistency ratio (CR) and the associated threshold value, these weights can be found in table 5.6.

Table 5.6: Weights sub-criteria by municipality

	Biodiversity	Heat Resistance	Rainfall Resistance	Drought Resistance	CR	Threshold
Weights	0.220	0.132	0.578	0.071	0.190	0.246

This table also shows that the most important sub-criterion, ”rainfall resistance,” has the highest weight with 0.578, similar to the best criterion from the main criteria. Besides, the least important sub-criterion, ”drought resistance,” has the lowest weight, with only 0.071. Again, the answers given are consistent since the CR is lower than the threshold.

For the ”traffic safety” sub-criteria, the municipality indicated that ”actual safety” was rated a 4 compared to ”perceived safety.” This implies a moderate plus importance according to the fundamental scale for pairwise comparisons shown in figure 5.1. The weights of the two sub-criteria are then calculated using the formulas for a 2-criteria pairwise comparison given in appendix A.5. This results in a weight of 0.8 for ”actual safety” and 0.2 for ”perceived safety.”

Among the sub-criteria of ”inclusivity”, the municipality gave ”pedestrian accessibility” a 5 compared to ”special accessibility”. This implies a strong importance according to the fundamental scale for pairwise comparisons shown in figure 5.1. Using the formulas for a 2-criteria pairwise comparison again, the weighting results in 0.833 for ”pedestrian accessibility” and 0.167 for ”special accessibility.”

5.1.2. Results Centraal Wonen Delft

For the main criteria, the residents of CWD indicated that they considered ”sociality” the most important (best criterion), while they considered ”car accessibility” the least important (worst criterion). When asked to compare the best criterion to the other criteria based on the scoring table in figure 5.1, table 5.7 emerged. In this table, the best criterion, ”sociality,” is compared with all the other criteria. The other criteria are also compared to the worst criterion, ”car accessibility.” This can be seen in table 5.8.

Table 5.7: Best main-criterion compared to others by CWD

Best to Others	Traffic Safety	Sustainability	Inclusivity	Sociality	Car Access	Bike Access
Sociality	5	1	3	1	7	5

Table 5.8: Others compared to worst main-criterion by CWD

Others to Worst	*Car Access*
Traffic Safety	3
Sustainability	7
Inclusivity	5
Sociality	7
Car Access	1
Bike Access	3

These tables show that the residents of CWD consider the best criterion, “sociality,” equally important as ”sustainability,” slightly more important than ”inclusivity,” more important than ”traffic safety,” and ”bike accessibility,” and much more important than ”car accessibility.” When all the criteria are compared to the worst criterion, ”car accessibility,” it can be seen that these answers are similar, except being reversed.
After implementing these results in the relevant BWM formulas presented in appendix A.5, the following weights for the main criteria were retrieved. Together with the input-based consistency ratio (CR) and the associated threshold value, these weights can be found in table 5.9.

Table 5.9: Weights main criteria by CWD

	Traffic Safety	Sustainability	Inclusivity	Sociality	Car Access	Bike Access	CR	Threshold
Weights	0.079	0.335	0.132	0.335	0.039	0.079	0.190	0.303

This table shows that ”sociality” and ”sustainability have the highest weights, which are 0.335, and ”car accessibility” has the lowest weight, only 0.039. Among the other criteria, “inclusivity” still scores reasonably well with 0.132. However, the criteria “traffic safety” and “bike accessibility” both score only 0.079. The CWD’s answers are consistent since the input-based consistency ratio (CR) is lower than the associated threshold.

For the sub-criteria of ”sustainability,” the residents of CWD indicated that they considered ”heat resistance” most important, while they considered ”drought resistance” least important. The following tables emerged when the best sub-criterion to the other sub-criteria and the other sub-criteria to the worst sub-criterion were compared pairwise. Table 5.10 shows the pairwise comparisons of ”heat resistance” to the other criteria, and table 5.11 shows the pairwise comparisons of the other criteria to ”drought resistance.”

Table 5.10: Best sub-criterion compared to others by CWD

Best to Others	Biodiversity	Heat Resistance	Rainfall Resistance	Drought Resistance
Heat Resistance	3	1	3	3

Table 5.11: Others compared to worst sub-criterion by CWD

Others to Worst	*Drought Resistance*
Biodiversity	1
Heat Resistance	3
Rainfall Resistance	1
Drought Resistance	1

These tables show that CWD considers the best criterion, “heat resistance,” slightly more important than the other criteria. When comparing all the criteria against the worst criterion, it can be noticed that the responses are similar. ”Biodiversity” and ”rainfall resistance” are seen as similarly important as ”drought resistance,” and ”heat resistance” is seen as slightly more important than ”drought resistance.” After implementing these results in the relevant BWM formulas presented in appendix A.5, the following weights for the sub-criteria were retrieved. Together with the input-based consistency ratio (CR) and the associated threshold value, these weights can be found in table 5.12.

Table 5.12: Weights sub-criteria by CWD

	Biodiversity	Heat Resistance	Rainfall Resistance	Drought Resistance	CR	Threshold
Weights	0.167	0.500	0.167	0.167	0	0.167

In this table, the most important sub-criterion, ”heat resistance,” scores the highest with a weight of 0.5. The other sub-criteria all score 0.167. For these sub-criteria, the answers from CWD are again consistent. This is due to the CR being 0, and therefore, it is lower than the threshold.

For the ”traffic safety” sub-criteria, the residents of CWD indicated that ”actual safety” was rated a 7 compared to ”perceived safety.” This implies a very strong importance according to the fundamental scale for pairwise comparisons shown in figure 5.1. The weights of the two sub-criteria are then calculated using the formulas for a 2-criteria pairwise comparison given in appendix A.5. This results in a weight of 0.875 for ”actual safety” and 0.125 for ”perceived safety.”

Among the sub-criteria for ”inclusivity,” the residents of CWD gave ”pedestrian accessibility” a 1 compared to ”special accessibility.” This implies equal importance according to the fundamental scale for pairwise comparisons shown in figure 5.1. the formulas for a 2-criteria pairwise comparison given in appendix A.5, the weighting results in 0.5 for ”pedestrian accessibility” and 0.5 for ”special accessibility.”

5.1.3. Results Parents Association

For the main criteria, the parents' association ”Vrienden van Springwijs” indicated that they considered ”traffic safety” the most important (best criterion), while they considered ”car accessibility” the least important (worst criterion). After this, the best criterion, ”traffic safety,” was again compared to the other criteria, and the other criteria were compared to the worst criterion, ”car accessibility. ” Based on the scoring table from figure 5.1, table 5.13 showing the pairwise comparisons of ”traffic safety” to the other criteria and table 5.14 showing the pairwise comparisons of the other criteria to ”car accessibility,” emerged.

Table 5.13: Best main-criterion compared to others by ”Vrienden van Springwijs”

Best to Others	Traffic Safety	Sustainability	Inclusivity	Sociality	Car Access	Bike Access
Traffic Safety	1	3	3	5	5	3

Table 5.14: Others compared to worst main-criterion by ”Vrienden van Springwijs”

Others to Worst	*Car Access*
Traffic Safety	5
Sustainability	3
Inclusivity	3
Sociality	2
Car Access	1
Bike Access	3

From these tables, it can be seen that the parents association considers ”traffic safety” slightly more important than ”sustainability,” ”inclusivity,” and ”bike accessibility.” It also shows that ”traffic safety” is considered more important than ”sociality” and ”car accessibility.” When looking at the criteria compared to the worst criterion, ”car accessibility”, it can be noticed that ”traffic safety” again is considered as more important than ”car accessibility”. In addition, the criteria ”sustainability”, ”inclusivity” and ”bike accessibility” are considered slightly more important. Also, ”sociality” scores a 2 compared to ”car accessibility”. This means that ”sociality” is considered between equally and slightly more important than ”car accessibility”.

These results give the following weights calculated with the BWM formulas presented in appendix A.5. Together with the input-based consistency ratio (CR) and the associated threshold value, these weights can be found in table 5.15.

Table 5.15: Weights main criteria by ”Vrienden van Springwijs”

	Traffic Safety	Sustainability	Inclusivity	Sociality	Car Access	Bike Access	CR	Threshold
Weights	0.394	0.149	0.149	0.087	0.068	0.149	0.25	0.255

In this table, the most important criterion, ”traffic safety,” has the highest weight, with 0.394. After that, the criteria ”sustainability”, ”inclusivity,” and ”bike accessibility” all have a weight of 0.149. Because of the very small higher importance of ”sociality” in comparison with ”car accessibility,” these criteria score 0.087 and 0.068, respectively.

For the sub-criteria of ”sustainability,” the parents’ association ”Vrienden van Springwijs” indicated that they considered ”biodiversity” the most important (best criterion), while they considered ”drought resistance” the least important (worst criterion). The following tables emerged with the answers from the comparisons for the sub-criteria. Table 5.16 shows the pairwise comparisons of the best criterion, ”biodiversity,” to the other criteria, and table 5.17 shows the pairwise comparisons of the other criteria to the worst criterion, ”drought resistance.”

Table 5.16: Best sub-criterion compared to others by ”Vrienden van Springwijs”

Best to Others	Biodiversity	Heat Resistance	Rainfall Resistance	Drought Resistance
Biodiversity	1	3	2	5

Table 5.17: Others compared to worst sub-criterion by ”Vrienden van Springwijs”

Others to Worst	*Drought Resistance*
Biodiversity	4
Heat Resistance	2
Rainfall Resistance	3
Drought Resistance	1

The tables show that the parents’ association considers ”biodiversity” almost as important as ”rainfall resistance” since this score is between as important and slightly more important. In addition, ”biodiversity” is considered slightly more important than ”heat resistance” and more important than ”drought resistance.” Compared to the worst criterion, ”drought resistance,” biodiversity is considered between slightly more important and more important, ”rainfall resistance” is considered slightly more important, and ”heat resistance” is seen as almost as important with a score of 2.

After implementing these results in the relevant BWM formulas presented in appendix A.5, the following weights for the sub-criteria were retrieved. Together with the input-based consistency ratio (CR) and the associated threshold value, these weights can be found in table 5.18.

Table 5.18: Weights sub-criteria by "Vrienden van Springwijs"

	Biodiversity	Heat Resistance	Rainfall Resistance	Drought Resistance	CR	Threshold
Weights	0.465	0.172	0.259	0.103	0.05	0.199

"Biodiversity" has the highest weight with 0.465, followed by "rainfall resistance" with 0.259. "Heat resistance" and "drought resistance" scored the lowest with 0.172 and 0.103 respectively.

For the "traffic safety" sub-criteria, the parents' association "Vrienden van Springwijs" indicated that "actual safety" was rated a 3 compared to "perceived safety." This implies a moderate importance according to the fundamental scale for pairwise comparisons shown in figure 5.1. The weights of the two sub-criteria are then calculated using the formulas for a 2-criteria pairwise comparison given in appendix A.5. This results in a weight of 0.75 for "actual safety" and 0.25 for "perceived safety."

Among the subcriteria of "inclusivity", the parents' association "Vrienden van Springwijs" gave "pedestrian accessibility" a 5 compared to "special accessibility". This implies a strong importance according to the fundamental scale for pairwise comparisons shown in figure 5.1. Using the formulas for a 2-criteria pairwise comparison given in appendix A.5, the weighting results in 0.833 for "pedestrian accessibility" and 0.167 for "special accessibility."

5.1.4. Aggregated Results

Now that the individual weights for the main and sub-criteria are known, they must be merged to arrive at aggregate weights. To come to aggregate weightings, the decision maker was asked to indicate a ratio to what extent each stakeholder's responses are considered in the final decision. In this case, the municipality is the decision maker since they decide how the redevelopment of the Fuutlaan will look like. The municipality indicated that the ratio for municipality, residents, and parents equals 40-40-20, respectively. In order to then calculate the aggregated weights, the geometric mean has been used. This calculation can be seen in the following formula.

$$w_{aj} = w_{j1}^{ShareSH_1} * w_{j2}^{ShareSH_2} * w_{j3}^{ShareSH_3}$$

In this formula is w_{aj} the aggregated weight for criterion j. w_{j1}, w_{j2} and w_{j3} are the individual weights of the municipality, residents of CWD and parents' association "Vrienden van Springwijs", respectively. $ShareSH_1$, $ShareSH_2$ and $ShareSH_3$ are the shares indicated by the municipality and equals 0.4-0.4-0.2, respectively.

However, the sum of all these aggregated weights is not equal to 1. Therefore, the aggregated weights still need to be normalized so that the summation of the weights of the different criteria together equals 1. This is done using this formula:

$$w_j^{norm} = w_{aj} / \sum_{j \in J} (w_{aj})$$

After the calculation and normalization of the aggregated weights, the aggregate weights for the main criteria emerged and are shown in table 5.19.

Table 5.19: Aggregated normalized weights of the main criteria

	Traffic Safety	Sustainability	Inclusivity	Sociality	Car Access	Bike Access
Aggregated weights	0.159	0.337	0.160	0.129	0.084	0.131

From this table, it can be concluded that the three stakeholders together think "sustainability" is by far the most important criterion for the redevelopment of the Fuutlaan. After that, "inclusivity" and "traffic safety" are important criteria followed shortly by "bike accessibility" and "sociality." The criterion "car accessibility" is collectively seen by the 3 stakeholders as the least important criterion, with a score of only 0.084.

After calculating and normalizing the aggregated weights for the sub-criteria from "sustainability," the aggregate weights for these sub-criteria emerged and are shown in table 5.20.

Table 5.20: Aggregated normalized weights of the sustainability sub-criteria

	Biodiversity	Heat Resistance	Rainfall Resistance	Drought Resistance
Aggregated weights	0.262	0.272	0.343	0.123

This table shows that "Rainfall resistance" is considered to be the most important factor for the Fuutlaan. This is followed by the criteria "biodiversity" and "heat resistance," which score about equally in weighting. "Drought resistance" is considered the least important on the street as this sub-criterion scores only 0.123.

After calculating and normalizing the aggregated weights for the sub-criteria from "traffic safety," the aggregate weights for these sub-criteria emerged and are shown in table 5.21.

Table 5.21: Aggregated normalized weights of the safety sub-criteria

	Actual Safety	Perceived Safety
Aggregated weights	0.825	0.175

This table shows that "actual safety" is seen as way more important than "perceived safety."

After calculating and normalizing the aggregated weights for the sub-criteria from "inclusivity," the aggregate weights for these sub-criteria emerged and are shown in table 5.22.

Table 5.22: Aggregated normalized weights of the inclusivity sub-criteria

	Pedestrian Access	Special Access
Aggregated weights	0.724	0.276

This table shows that a wider sidewalk is seen as way more important than special biking facilities.

5.2. Ranking

Now that the aggregate weights are known, the performance of the different designs can be calculated. This is done using the performance matrix discussed earlier in chapter 4 and multiplying the scores of this matrix with the aggregated weights from section 5.1.4. The performance matrix is shown in table 5.23.

Table 5.23: Performance Matrix Alternatives

	Traffic Safety	***Sustain-ability***	***Inclusivity***	***Sociality***	***Car-access***	***Bike-access***
Design 1	**Actual:** 3 **Perceived:** 2.71	**Biodivers:** 22 greenery **Heat:** 24 stars **Rainfall:** 16 stars **drought:** 0 stars	**Width sidewalk:** 2m **Special bike spots:** 5	**Meeting space:** 80m2	**Parking spots:** 14	**Parking spots:** 8
Design 2	**Actual:** 3.5 **Perceived:** 4	**Biodivers:** 29 greenery **Heat:** 36 stars **Rainfall:** 24 stars **drought:** 27 stars	**Width sidewalk:** 2m **Special bike spots:** 4	**Meeting space:** 60m2	**Parking spots:** 17	**Parking spots:** 6
Design 3	**Actual:** 4 **Perceived:** 1	**Biodivers:** 21 greenery **Heat:** 48 stars **Rainfall:** 32 stars **drought:** 6 stars	**Width sidewalk:** 6m **Special bike spots:** 29	**Meeting space**: 110m2	**Parking spots:** 0	**Parking spots:** 68
Design 4	**Actual:** 5 **Perceived:** 5	**Biodivers:** 21 greenery **Heat:** 48 stars **Rainfall:** 32 stars **drought:** 6 stars	**Width sidewalk**: 2m **Special bike spots:** 29	**Meeting space:** 110m2	**Parking spots:** 0	**Parking spots:** 68
Design 5	**Actual:** 3 **Perceived:** 2.71	**Biodivers:** 21 greenery **Heat:** 48 stars **Rainfall:** 32 stars **drought:** 6 stars	**Width sidewalk:** 2m **Special bike spots:** 29	**Meeting space:** 110m2	**Parking spots:** 1	**Parking spots:** 68

To be able to compare the scores from the different criteria, it is necessary to normalize the scores of the criteria to a uniform scale before aggregating them. This normalization facilitates the direct comparison of criteria that may originally vary in size, units, or range. The normalization process is done with the formula 5.1 to adjust scores to a common scale.

$$x_{\text{norm}} = \frac{x - x_{\text{min}}}{x_{\text{max}} - x_{\text{min}}} \tag{5.1}$$

After the normalization, an overall value per design can be calculated using this normalized performance per criterion and multiplied with the aggregated weight per criterion. This is done using the following formula.

$$V_i = \sum_{j=1}^{n} w_j p_{ij}$$
$$w_j \geq 0, \sum_j w_j = 1$$

The resulting normalized scores for the main criteria are tabulated in table 5.24. The total performance of each design is presented in the last column of this table and follows from the summation of the scores per criteria multiplied by their weight.

Table 5.24: Total Performance Designs

	Traffic Safety	Sustainability	Inclusivity	Sociality	Car Access	Bike Access	Total
Design 1	0.075	0.033	0.011	0.400	0.824	0.032	**0.150**
Design 2	0.337	0.693	0	0	1	0	**0.371**
Design 3	0.413	0.642	1	1	0	1	**0.702**
Design 4	1	0.642	0.276	1	0	1	**0.679**
Design 5	0.075	0.642	0.276	1	0.059	1	**0.537**

From this table, it can be concluded that design 3, the shared space design, scores the highest of all designs with a score of 0.702. This design is then closely followed by design 4, the car-free design. From the self-created designs, design 5 scores the lowest, with 0.537. However, this score is still much higher than the scores from the municipality's designs. From these designs, design 2 scores still reasonably with 0.371, but design 1, which is the final design from the municipality, scores very low with only 0.150.

The same performance calculations have been done for the sub-criteria of sustainability, traffic safety, and inclusivity and can be seen in tables 5.25, 5.26, 5.27, respectively. The total performances per main criterion for each design have also been used in table 5.24 and are equal to the summation of the score per sub-criterion multiplied by the aggregated weight per sub-criterion. This resulted in the corresponding alternative's main criterion score.

Table 5.25: Sustainability Performance Designs

	Biodiversity	Heat Resistance	Rainfall Resistance	Drought Resistance	Total
Design 1	0.1	0	0	0	**0.033**
Design 2	1	0.5	0.5	1	**0.693**
Design 3	0	1	1	0.222	**0.642**
Design 4	0	1	1	0.222	**0.642**
Design 5	0	1	1	0.222	**0.642**

Table 5.26: Traffic Safety Performance Designs

	Actual Safety	Perceived Safety	Total
Design 1	0	0.428	**0.075**
Design 2	0.25	0.75	**0.337**
Design 3	0.5	0	**0.413**
Design 4	1	1	**1**
Design 5	0	0.428	**0.075**

Table 5.27: Inclusivity Performance Designs

	Pedestrian Access	Special Access	Total
Design 1	0	0.04	**0.011**
Design 2	0	0	**0**
Design 3	1	1	**1**
Design 4	0	1	**0.276**
Design 5	0	1	**0.276**

From these tables it can be concluded that design 2 scores highest on ”sustainability” due to the high scores on ”biodiversity” and ”drought resistance”. This design is then closely followed by the self-created designs 3, 4, and 5, which score the same on all the sub-criteria. Design 1 scores very poorly on ”sustainability” due to the lowest scores on each sub-criterion except biodiversity. However, with 0.1, it also scores very low on this criterion as well. In terms of “traffic safety,” Design 4 scores the highest by scoring highest on both sub-criteria. After that, designs 3 and 2 also score reasonably well on “traffic safety.” However, designs 1 and 5 scored very poorly, with a score of only 0.075. In terms of inclusivity, design 3 by far scored the best, achieving the highest score on both sub-criteria. After that, designs 4 and 5 scored the best by also scoring highest on “special accessibility.” Designs 1 and 2 scored very poorly by scoring 0.011 and 0 on this criterion, respectively.

6 Evaluation of the results

This chapter thoroughly analyzes the results of the BWM analysis and the survey. The results from chapter 5 are closely examined, and the whole methodology used during the process will be evaluated. The challenges encountered during the process are evaluated, and the case specifications are assessed to explore the possibility of generalizing this methodology for future cases.

6.1. Evaluation of the designs

The BWM results of chapter 5 properly identify the preferences and priorities of the various stakeholders. This section analyzes the preferences of the municipality, the residents of the Fuutlaan, and the parents of elementary school the Springwijs.
The municipality highlighted ”sustainability” as the most important criterion containing ”rainfall resistance” as the most important sub-criterion. This is in line with the vision of the municipality of Delft to make the city climate adaptive (Gemeente Delft, 2020). The importance of the sub-criterion is also in line with the project to redevelop the Tanthof East and replace the sewer system (Gemeente Delft, 2023). Which is based on improving water drainage during rainfalls. On the other hand, ”sociality” is seen by the municipality as least important in the street, which is consistent with the current thinking that the street is currently meant primarily for transportation and not a place for people to meet.
On the contrary, CWD residents indicated ”sociality” as the most important criterion in the street and ”car accessibility” as the least important. This shows that residents strongly prefer social interaction in the street and desire an environment that facilitates this social interaction. This could be because the residents live in an open residential community. Therefore, social interaction with the environment is seen as valuable.
The parents association indicated that ”traffic safety” was the most important criterion in the street. This is consistent with the idea that parents mainly want their children to be able to travel safely to school, and therefore, their children’s safety is priority number one. The criteria ”car accessibility” and ” sociality ” are seen as least important in the street. This partly has to do with the fact that the school mainly has a district function, and thus, the children often live within walking or biking distance from the school. In addition, bringing children to school by car contributes to creating a more unsafe school environment. On the other hand, the school at the Fuutlaan has a large schoolyard where parents can stand while waiting for their children. Because of this, space for sociality can be seen as unnecessary by the parents.
Based on the importance ratios assigned by the Municipality (40% each for the municipality and the residents and 20% for the parents), the aggregated weights show that ”sustainability” is collectively seen as the most important criterion. After that, ”inclusivity” and ”traffic safety” are also very important and thus can be seen as the key factors in determining the fairest design for the Fuutlaan. The criterion ”car accessibility” scored by far the lowest. This indicates that Fair Street’s philosophy is also present in the Fuutlaan. The results show a greater need for other activities, such as greenery and inclusivity than for improving car accessibility.
Based on these aggregated weights, it emerges that design 3, the shared space design, scores highest

on the Fair Street criteria. This design scores best of all designs on the criteria of ”inclusivity,” ”sociality,” and ”bike accessibility.” In addition, this design also scores well on the criterion ”sustainability” and has the second highest score for ”traffic safety.” This is because this design creates a lot of space for other, more desired activities by eliminating car parking in the street. Interestingly, design 1, the municipality’s final definitive design, scores the worst on the fairness criteria. This is partly because this design had to compromise on sustainability due to budget constraints. However, this design was also taken as the starting point for the self-created designs, which were based more on the fairness criteria. Because the focus on some fairness principles, such as inclusivity for all users and space for sociality, was not included it was to be expected that this design would score the lowest. Among the self-created designs, design 5, the fair renovation of the current Fuutlaan, scored the lowest. This is because this design gives little to almost no improvement of ”traffic safety” compared to the current situation, while the other 2 self-created designs score high on this. Other than that, this design does score slightly higher on ”sustainability” and ”car accessibility,” but these differences are not significant enough to overcome the negative difference for ”traffic safety.”

6.2. Evaluation of the survey

The Fuutlaan survey was completed by a total of 17 participants, of which 11 were residents, and 6 were parents, as can be seen in appendix B.2. This represents approximately 10% of the number of residents in CWD’s residential buildings, which contain around 100 residents (Centraal Wonen Delft, n.d.). Considering that SpringWijs has a total of 324 children in their school, the percentage of respondents for this survey is less than 2% (Allecijfers.nl, 2024a). Therefore, it cannot be said with certainty that the survey accurately reflects what users in the street perceive. Nevertheless, the results give some idea of the current issues in the street. Almost half (47%) of the respondents indicated that they consider the Fuutlaan as (very) unsafe. In addition, the survey shows that improper parking and fast driving are seen as reasons for unsafety in the Fuutlaan, which were mentioned 11 and 9 times, respectively. As solutions, the respondents mainly suggested temporary car-free zones on the street, poles to prevent illegal parking on sidewalks, and a kiss-and-ride system to improve safety. This shows that users’ behavior when dropping off and picking up children is considered dangerous. However, the respondents also suggested implementing speed reduction measures to improve safety around the school. This recommendation aligns with the fact that 53% of them identified fast driving as a major cause of danger. Therefore, improving the infrastructure with speed reduction measures could also be a potential solution to create a safer environment around the school. In addition to the questions about safety, the survey also asked about space use considerations that users would like to see in the street. These results were in line with the results from the interviews with the key stakeholders. The survey revealed that mainly there is a great need for additional bicycle parking spaces in the street. This was indicated by 82% as more important than car parking spaces in the street. This is also consistent with the observation in the street of all the bicycles being placed against the fence when dropping off and picking up children. More green space and wider sidewalks are also seen by many people (76%) as more important than car parking. This underlines the negative impact associated with the space provided for the car infrastructure.

The effect of a good spreading of the survey is shown at the Blijberg in Rotterdam (appendix B.3. Here, the survey was completed by 86 parents, which is 21% of the number of children at the school (Allecijfers.nl, 2024b). This provides better validation of the survey results. In addition, this participation ensures that there is likely more support and desire to make the school environment safer. 62% of the parents indicated that they consider the school environment from the Blijberg as (very) unsafe. The survey also showed that the high traffic volume around the school (52%) was mainly mentioned as a reason for the unsafety in the school environment. The busy traffic, narrow streets, and the dropping of children by car in the middle of the street make the traffic situation unclear and dangerous. In addition, these stopped cars cause bicyclists to behave dangerously by riding with their bikes on the sidewalk or randomly showing up between cars to pass them. Also here, the survey shows that the behavior of road users greatly influences traffic unsafety in the school environment, which is in line with the outcomes of the Fuutlaan survey. However, in addition to behavior, the crosswalk at the 50 km/h road was also mentioned as a reason for unsafety (24%). This shows that besides changing behavior, change in the physical infrastructure is also needed to improve safety in this school environment. Also, here, the questions about spatial reconsideration were asked. This revealed that bicycle parking spaces and

wider sidewalks are greatly needed since 88% and 83% of the respondents indicated that this is more important than car parking spaces. In addition, greenery and social meeting spaces were indicated by more than 70% of the respondents as more important than car parking spots.
The results from the survey clearly show where the collective bottlenecks are and, therefore, where changes need to be implemented. Despite being two different schools with different characteristics, the results from the surveys also appear to be similar. Especially the behavior of the parents shows that this is a common problem for most schools in the Netherlands. Therefore, this is relevant information for the municipality for the redevelopment of the area. Also, the survey provides a good reflection of the parents' travel behavior. This travel behavior causes both at the Fuutlaan and the Blijberg for a significant share of unsafety in the street. These survey answers could be used for educating the parents an showing it as a reflection for the road users to help with understanding and improving the behavior of road users. In addition to improving traffic safety, the survey also helps to identify preferences in space use in the street. This helps the municipality determine which activities in the street deserve more space and creates more acceptance among users. In addition, completing the survey helps users think collaboratively about solutions for both traffic safety and space usage considerations, which also contributes to better social acceptance and participation in the redevelopment of the street.

6.3. Evaluation of the methodology

This research aimed to find an implementation strategy for integrating stakeholder interests and the Fair Street principles to make school zones fairer. Therefore, this section will discuss the framework of methods for implementing fairer school zones. Implementing fair school zones is two-sided. On the one hand, the physical infrastructure can be modified to provide more space for activities other than car transport and to influence road users' driving behavior. On the other hand, changing road users' behavior by educating and involving them contributes to creating fairer school environments.
Including the users in the design process is important to create acceptance and correct use of redeveloped streets. The combination of BWM interviews and the space reconsideration questions from the survey ensures that, in addition to a mathematical basis for the trade-offs in space usage (interviews), a statistical basis can also be given for the fair improvements that, according to the users, should take place in the street (survey).
The interviews help determine fairness for trade-offs in space use. The results outline what the various interviewees consider as most important in the street and, therefore, highlight the indicators of a Fair Street that need the most attention in the redevelopment of the street. However, the nuances of this method are that key stakeholders need to be chosen carefully since only a limited number of people can be interviewed. The number of key stakeholders to be interviewed depends on the case-specific situation. The people in the Fuutlaan live in a residential community, therefore a person, who knows much about the persons living in this community, can make a proper assessment of the preferences within the community. However, this does not exclude the fact that the answers given in the interview are still primarily based on the preferences of this one person. Answering on behalf of the preferences of all residents on the street will be even harder in other situations where people live on their own. Also, the Fuutlaan case study showed that it is not always a given that key stakeholders want to participate in creating a fairer street design. In this case, the school was too busy to conduct an interview, so they were not included in the BWM analysis. As a result, the school's perspective is not included in the Fair Street design, which may result in lower acceptance of the redevelopment by this particular stakeholder. Therefore, a good stakeholder approach and involvement are of great importance.
Since these interviews can only be held for a limited number of key stakeholders, it is also important to have a large response to the survey. The survey asks similar questions about space use considerations. Therefore, the survey can also help provide insight into which Fair Street indicators should be given more attention in the street. This provides more input from different people with different interests if the response on the survey is high. In addition, the survey can provide a good foundation for the outcomes of the interviews or, conversely, shows in the opposite case that the key stakeholder interviewed is not representative enough of the rest of the stakeholder group. Therefore, the interviews combined with the survey results can help urban designers determine the spatial trade-offs in a new fair design.
As indicated earlier, not only the physical infrastructure must be modified, but also the behavior of road users has an impact on creating a fair school environment. Because of this, the survey also asks how

to improve safety in the environment and how people move to the school environment. This survey shows that the behavior of parents who bring their children by car causes the school environment to be considered unsafe. Changing this behavior is, therefore, essential and cannot be achieved only by modifying the physical infrastructure. The survey provides a good reflection of this unfair behavior and can be used to educate parents on fair use of the school environment.
Figure 6.1 shows how the different indicators of the Fair Street could be implemented in a street and which persons could help with implementing this.

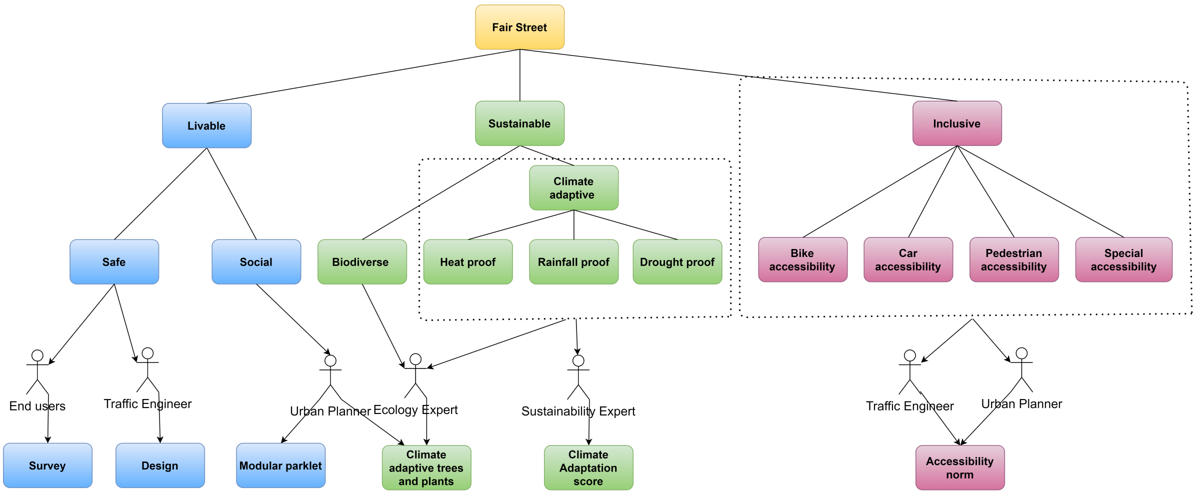

Figure 6.1: Measures per indicator of the Fair Street

For the measures of modular parklets, amount of trees and plants that result in a climate adaptation score, and the accessibility norm, the output from the interviews, along with the space use considerations from the survey, can be used to achieve a fair balance in the street redesign. The survey helps make the users' behavior fairer, which, as shown in the figure, leads to safer design and streets. Finally, an ecologist can help determine the best trees and plants that can be planted to make the street as climate-adaptive as possible and optimize biodiversity.

The absence of the school as a key stakeholder in the interviews shows that approaching and engaging the key stakeholders must be done carefully. Because the school was in an extremely busy period, the timing of this research was off. In addition to the short time frame of this research, the school also lacked a practical commitment to actual changes in the Fuutlaan. This is because the municipality already has a final design for the street. Therefore, they thought there was not much left to change. However, the involvement of this stakeholder is critical for creating more responses on the survey, as can be seen at the Blijberg. Which, therefore, could ultimately have an effect on the behavior of end users on the street. This shows that the success of the survey is very dependent on the necessity for change in the street. At the Blijberg, the parents themselves felt that change was really needed, and thus, the distribution of the survey here went much more smoothly. In comparison with the Fuutlaan, it may be that the parents and the school did not feel the necessity very much due to the fact that a definitive design of the municipality is already in place, and therefore, the effect of the survey was estimated as less effective.
In evaluating the survey methodology, a notable incident involving feedback from a parent at the Blijberg School in Rotterdam highlights both the strengths and potential biases of the survey structure. The parent expressed concerns that the survey seemed biased towards changes affecting car usage and underscored the importance of maintaining accessibility for children commuting from distant locations, emphasizing that car accessibility should not be compromised. This incident reveals a dual aspect of the survey's impact. On the one hand, it demonstrates the survey's effectiveness in eliciting diverse viewpoints, which are crucial for developing a balanced and fair street design and solutions. On the other hand, the focus on automotive changes may discourage proponents of car use within the school environment from participating in the survey. This could lead to their preferences being under-

represented.

Other potential methods can still be used to increase the impact of the interviews and surveys on implementing Fair Streets. For example, asking the interview questions in focus groups can ensure that the different perceptions within a stakeholder group are better incorporated into the BWM analysis. The advantage of this is that it creates a broader picture of the preferences among a stakeholder group, leading to better acceptance of implementing these preferences in a design. The disadvantage of this group decision-making is that the opinion of someone in the group can influence the opinion of the rest, which can ultimately lead to the incorrect filling of the preferences. Also, group discussion can lead to the interviews taking longer, reducing the BWM method's efficiency. Furthermore, arranging such focus groups and dates for interviews makes the process of interviewing a lot more complex.
To give stakeholders a better idea of the positive effects of rearranging and using the street differently, VR simulation can show how the street can look different if less space is allocated for car parking and used for other activities. This can help with the acceptance of changes in the street. It can also help change the behavior of road users and thus ensure fairer behavior among users.
Finally, educating road users can ensure that their behavior is positively changed. Organizing a Fair Street week at the school can improve acceptance and get people on board with the Fair Street philosophy. During this week, all kinds of fun activities can be organized in the street and at school, where children, parents, and residents can all learn about our current car-centric mentality and its effect on the public environment around schools. To conclude this week, agreements can be made with the school, parents, residents, and the municipality to make the environment fairer jointly.

7 Conclusion

This section will answer the research question formulated to meet the objective of the study and the sub-questions established to answer the main research question. The main research question to be answered by this study is:

How can the Fair Streets principles for school zones in the Netherlands be implemented, considering the interests of different stakeholders?

To address this research question, six sub-questions were formulated, and the answers will be discussed in chronological order in the next section. Afterwards, the answer to the main question is given.

7.1. Answers sub-research questions

What are the Fair Street principles, and how can they be measured into concrete criteria in the Fuutlaan?

The Fair Street principles are visualized in figure 1.1 in Chapter 1 and can be categorized under livability, sustainability, and inclusivity. Here, livability is seen as a safe and social street. Sustainability is seen as green and climate-adaptive streets, which are heat, rain, and drought-proof. Inclusivity is seen as street accessibility for all types of road users. This includes cars, bicycles, pedestrians, and special forms of transportation such as cargo bikes and special tricycles and pedestrians with baby carriages or rollators. These principles can be measured in the streets via the criteria established using the goal tree in figure 4.2 in Chapter 4. The main criteria include traffic safety, sociality, sustainability, bike accessibility, car accessibility, and inclusivity. These main criteria are assessed through various sub-criteria: actual and perceived safety in the Fuutlaan (traffic safety), m^2 meeting space in the Fuutlaan (sociality), trees and flower boxes and the effect of the trees on climate adaptivity of the Fuutlaan (sustainability), bicycle and car parking spots in the Fuutlaan (bike and car accessibility), and sidewalk width and dedicated bicycle parking spaces in the Fuutlaan (inclusivity).
This case focused on replacing the current parking spaces with other activities such as sociality, greenery, and bicycle parking. These can be temporarily created in the form of modular parklets and bicycle parking decks. Therefore, trials can be used to get users used to the renewed situation. Although the exact implementation of the various activities may vary per case, this breakdown via the goal tree ensures that the criteria for Fair Streets at other school zones in the Netherlands can also be identified.

Which key stakeholders are involved and should be included in implementing a Fair Street in the Fuutlaan?

The key stakeholders involved in the Fuutlaan are the municipality, the residential housing cooperation CWD, the elementary school SpringWijs, and the school's parents association. However, the school board could not participate in this research due to the lack of time. Therefore, this stakeholder has not been interviewed. In this case, the municipality is also the problem owner since they need to decide on the definitive design of the Fuutlaan. However, because they have a public function, they want the design to meet the needs of society as much as possible. In addition, involving the stakeholders in the design process creates better acceptance of the policy measures. Therefore, the residents and the school are also seen as essential stakeholders by the municipality because they are both located at the Fuutlaan and directly affected by it. Finally, the parents of the children are an essential stakeholder. Although they do not live or are located in the Fuutlaan, they do visit the Fuutlaan twice a day during the week to drop off or pick up their children. Therefore, they also have a significant influence on traffic safety and driving behavior in the street and are included as a critical stakeholder for implementing a Fair Street in the Fuutlaan.

Although housing corporations like CWD with their shared living spaces are not common in the Netherlands, these key stakeholders will be similar in most school environments throughout the country. Because most schools are often located in residential areas as well, with the implementation of Fair Streets, the interests of the municipality, residents, school, and parents always need to be dealt with. The stakeholders' approach is very important to create much participation among all these key stakeholders in making school environments fairer. The two case studies also show that the daily problems in school environments are often partly caused by the parents who bring their children to school. This indicates that involving parents in the process is very crucial.

What is the problem in the current situation and how do street users evaluate this?

Mainly during the pick-up and drop-off of children at school, when many cars are wrong-parked on sidewalks or stop in the middle of the road, the street is considered unsafe. This is typical for the daily struggles of most of the school zones in the Netherlands. Also, the current design causes drivers to drive faster than 30km/h on the street due to the lack of speed-decreasing measures. Additionally, bikes are placed against the fences, making sidewalks badly accessible for (special) pedestrians. Lastly, the climate impact scan shows that the street scores poorly on heat and rainfall resistance. Therefore, the current design of the Fuutlaan needs to improve on all the principles of livability, sustainability, and inclusivity of the Fair Street. This is due to the low perceived traffic safety in the street, the need for more social gathering space, the narrow sidewalks, insufficient greenery in the street and the little facilities for normal and special bikes in the street.

While every situation will be case-specific, many streets in the Netherlands do not comply with one or more indicators of Fair Street. The Fair Street manifest demonstrates this signed more than 2000 times and the self-nominations of more than 300 streets in the Netherlands for the most unfair street in the Netherlands during the week of the Fair Street (De Rechtvaardigestraat, n.d.). In addition, the number of pedestrian and cyclist fatalities, from which 10-15% still occur in 30km/h zones, shows that traffic safety is still insufficient also in 30km/h zones in the Netherlands (Berends & Stipdonk, 2009). Also, the survey of the Blijberg school in Rotterdam showed that, despite the different locations, there are shared issues common to most school zones in the Netherlands. This is due to the peak rush of picking up and dropping off children and the wrong driving behavior of parents connected with it. The surveys conducted among the users of the Fuutlaan and the parents of the Blijberg identify these problems well and, combined with real-life observations and interviews, can help with structuring the problem.

What are the interests of each stakeholder in the Fuutlaan?
And
What is the relative importance between indicators of the Fair Street for each stakeholder and how would they rate different designs?

The interests of the various stakeholders are very much in line with what could be expected beforehand. The municipality especially considers ”sustainability” in the street as very important due to their mobility plan 2040 to make urban roads greener and more climate-adaptive (Gemeente Delft, 2020). After that, ”traffic safety” and ”accessibility” for all road users are considered important. For the municipality, ”sociality” is seen as the least important. This confirms the current philosophy of streets in residential areas being primarily meant for transportation and not as a connector for social public space. The residents consider ”sociality” and ”sustainability” in the street as especially important. That they consider ”sociality" important was to be expected because they live in a shared living community with other residents. Therefore, social interaction is considered very valuable for these residents. In addition, looking at the sustainability criterion, "heat resistance" is considered especially important, as it helps reduce heat on hot summer days. The residents consider "car accessibility" as the least important. Lastly, parents mainly consider "road safety" very important. This is because, for the parents, their child's safety is the main concern, and they spend less time in the street than the residents living there. Because of this, "sociality" and "car accessibility" are rated as least important. The schoolyard provides enough meeting space for parents while waiting for their children. In addition, cars are the biggest contributor to traffic unsafety in the street, and therefore, most parents who do not travel by car to the Fuutlaan want them to be restricted in the street. When merging these different interests into aggregated weights, the "sustainability" criterion becomes by far the most important. Within this criterion, the sub-criteria rainfall and heat resistance are considered the most important, corresponding to the municipality's redevelopment goal and the climate impact scan for the Fuutlaan C.1. After that, "inclusivity" and "traffic safety" are also seen as important criteria. "Car accessibility" becomes by far the least important criterion. This reconfirms once again that the current layout of the street is primarily car-oriented. Hence, improving this criterion is considered the least needed in the Fuutlaan. This indicates that street fairness can be improved if other, more necessary, activities are created in exchange for car parking.

This results in the shared space design being the best option for the redevelopment of the Fuutlaan. This is due to the extra space it provides by removing all the parking spots for cars. This design scores best of all designs on the criteria of "inclusivity," "sociality," and "bike accessibility." In addition, this design also scores well on the criterion "sustainability" and has the second highest score for "traffic safety." Remarkably, the definitive design of the Fuutlaan that will be implemented by the municipality scores the lowest. However, this is mainly due to the fact that the new designs are based on this definitive design but have been improved based on the Fair Street principles.

While key stakeholders may have different interests in other cases, the survey also circulated at the Blijberg shows that most parents consider traffic safety the most important in school environments. However, the importance of the school being accessible can vary between schools since some schools have special education, which attracts children from further away. This was shown in the Blijberg case by the email received from a concerned parent who underlined that accessibility for children from the other side of Rotterdam should not be neglected. The interests of the municipality and residents can vary widely by location. This is because different municipalities may have different priorities in their policy visions. In addition, the interests of residents strongly depend on the type of neighborhood in which the school is located. This is why conducting these interviews and surveys helps identify these interests.

How can the interests of the stakeholders together with the indicators of a Fair Street be implemented in designs for the Fuutlaan?

The interests of the stakeholders are questioned in the survey based on the preference for different space reconsiderations. The survey results helped determine spatial reconsiderations in the street layout for new designs of the Fuutlaan. In these designs, the parking spots from the municipality's definitive design are used for other space usage based on the outcomes of the survey.

The weightings of the different Fair Street criteria that resulted from the interviews ultimately determine how high each design scores. Therefore, for future use of this methodology, these weightings can also be used to determine a fair balance in various activities in the street. In addition, the survey can confirm or complement these trade-offs with its space reconsideration questions. Because the survey is answered by a greater amount of people, it gives a better picture of what the majority of users care about most. However, performing the interviews ensures that the questions are better understood by respondents and pairwise comparisons based on the best and the worst criterion can be made.

However, according to the literature, radical changes may encounter much resistance. As a result, it is better to start with trials in the street. This can be done using modular parklets and bicycle parking decks, which can be removed after a few months. After road users have become familiar with and accepted the renewed situation, permanent infrastructure changes can replace these temporary solutions. However, if this change is not accepted by the users or creates lots of resistance, it can also be removed again. These trials could be done before the actual redevelopment of a street.

7.2. Answer main research question

How can the Fair Streets principles for school zones in the Netherlands be implemented, considering the interests of different stakeholders?

This thesis has explored the multifaceted challenge of redesigning urban school zones in the Netherlands through the lens of the ”Rechtvaardige Straat” or ”Fair Street” philosophy. The case studies focused on the Fuutlaan in Delft and the Blijberg in Rotterdam and comprehensively analyzed the daily recurring problems in school zones. This led to the conclusion that both physical adjustments to the infrastructure, as well as behavioral changes to road users, can lead to making the school environment fairer.

From the case study at the Fuutlaan, it can be concluded that the framework of methods, as illustrated in the research approach in Figure 7.1, provides a clear road map for engaging stakeholders in implementing Fair Streets. It creates a good overview of the problems that arise in school environments. From the surveys conducted at both the Fuutlaan and the Blijberg schools in Rotterdam, it can be concluded that most of the schools in the Netherlands face the same sort of daily struggles in the school environment. Therefore, this research approach could be widely used for other school zones in the Netherlands. In addition, the interviews and surveys ensure that stakeholders feel involved in making choices about the design of a street they deal with daily. This helps with creating more acceptance for street redevelopments. However, it is very important that the stakeholder approach and involvement are done properly to increase participation and acceptance. This was reflected by the school board’s unwillingness to cooperate in this study. The effect was reflected in the few responses from parents on the survey. In addition, it is important that stakeholders are well-educated about the positive effects of a fairer street layout and its use of it. This was particularly evident from the survey, which showed that users themselves are often the cause of unsafe behavior. Therefore, it is not only important that the physical infrastructure is adapted to create Fair Streets, but also the user behavior must be adapted for the correct use of Fair Streets. However, this need and will are present since both the interviews and the surveys indicate that there is a lack of other activities, such as greenery and social gathering space, in the Fuutlaan case. Consequently, this methodology helps in making grounded choices for a fairer balance of implementing these activities into Fair Street and creating more awareness of the positive effects of this Fair Street.

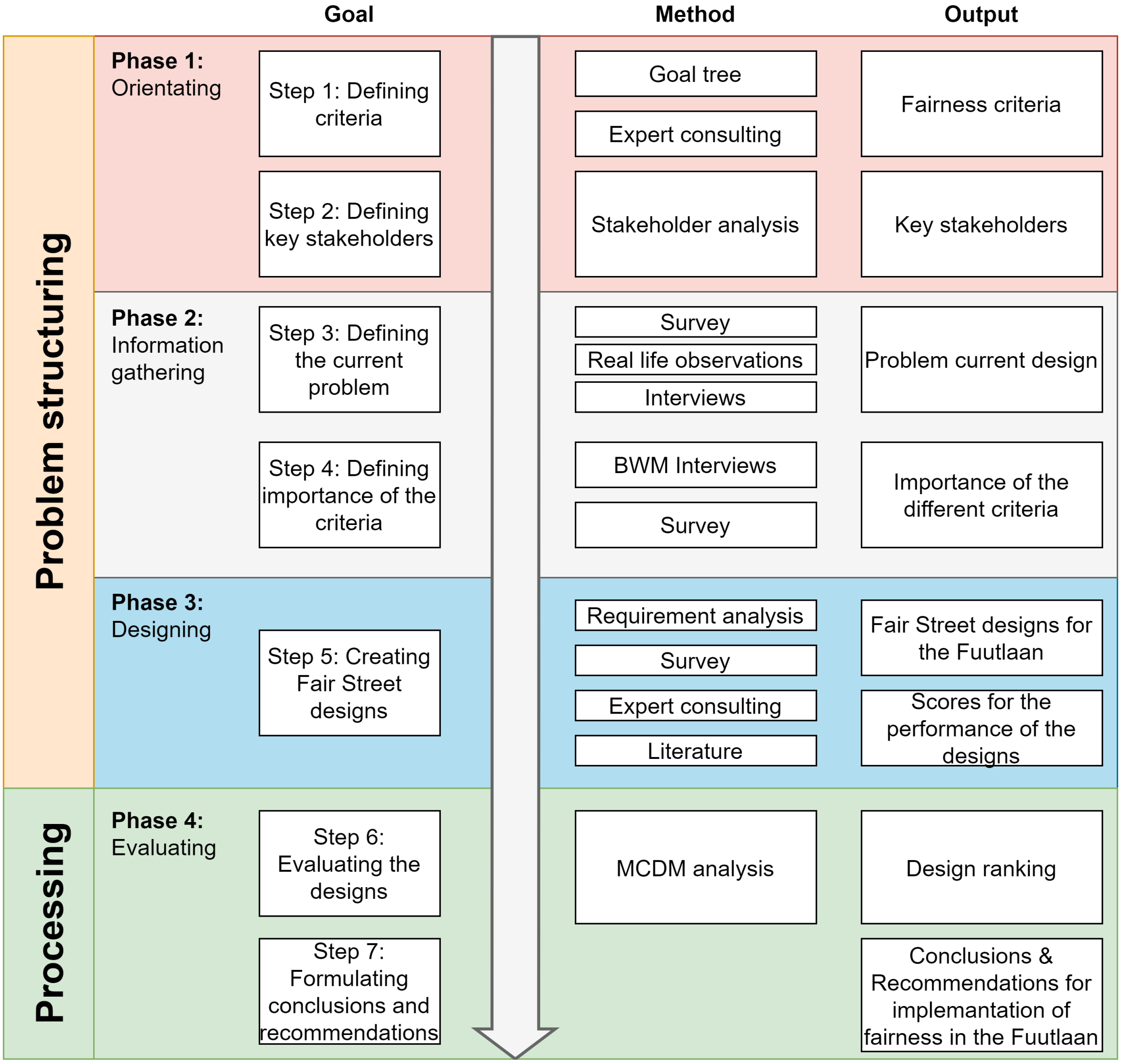

Figure 7.1: Research Approach

8

Research limitations & Recommendations

8.1. Research limitations

Several assumptions and limitations were made throughout the research to keep the study within the scope of available time for this master's thesis. These will be discussed in this section, along with the methodologies' limitations.

Scope limitations

As mentioned earlier, a demarcation was chosen within this case study by looking only at the section of the Fuutlaan bordering the school to keep stakeholders as well as the size of the designs limited and analyzable within the time scope. However, the redevelopment project focused on the redevelopment of the whole neighborhood Tanthof-East. Therefore, in this study, the effects on the whole neighborhood for the street designs of the Fuutlaan were not included. These effects can be characterized as network effects. Modifications such as a car-free road on the Fuutlaan will affect traffic in the rest of the neighborhood since this is the road for approaching the neighborhood. Removing parking on the street may also increase parking pressure in the rest of the neighborhood.
Because a final design was already available from the municipality, it was decided to base the new designs on this final design. As a result, the designs are limited in design freedom. It could, therefore, be possible to create additional greenery or inclusivity in the street without removing parking spaces. There will be more freedom in this process when creating designs for new neighborhood renovation projects. Also, because a final design of the municipality had already been created, this research could have had little direct effect on the Fuutlaan case itself. This has led to little cooperation from the school and, therefore, a low response to the survey by the school's parents.

Method limitations

As indicated earlier, the criteria for Fair Street have been simplified and broken down into smaller parts using the goal tree. As a consequence, important aspects such as safety, accessibility, and sustainability are somewhat oversimplified, which means that not all facets of these complex factors have been taken into account while creating the designs. Also, the costs for the various designs are not included in this study because these trade-offs are made at the governance level while this method addresses stakeholders' space use decisions. This could result in the best-scoring design not being financially feasible for the municipality.
Another limitation of the chosen Best-Worst Method is that it requires working towards consistency of answers. Although this ensures that given answers are logically correct, it may not fully reflect the correctly intended considerations of the interviewees.
Some limitations also occurred within the survey. The low response rate to the Fuutlaan survey meant that these answers were not very generalizable to the opinions of all users. However, these answers

were used to create the new designs' spatial considerations. As a result, the designs created may not necessarily represent the common preferences of all road users. Also, the questions about these reconsiderations caused the survey to feel biased by some respondents toward modifying the school environment rather than maintaining the current situation.
In addition, throughout the process, the time of year may affect the answers given by respondents. In the summer, there may be a greater need for pedestrian and bicycle infrastructure than in the winter, which can then indirectly affect the answers given by respondents.

8.2. Recommendations further research

This research can be used for follow-up research on implementing Fair Streets. Follow-up research on the social science aspects is needed to see the effect of different types of people living in a neighborhood. The type of persons living in a neighborhood can vary a lot in the Netherlands, and therefore, the best way of approaching these different types of persons could be different. This became clear in this research, where the lack of cooperation from a key stakeholder, such as the school board, makes conducting interviews or distributing the survey more difficult. Therefore, the right approach of key stakeholders is of great importance. Also, the effect of different solutions could vary. In villages, there is more social control because people know each other. In (large) cities, the mindset is often much more individualistic. In addition, neighborhoods or schools with many foreign-born people may cause communication difficulties through interviews and surveys. How to approach these different cases requires further research.
Further research can also be done on the use of focus groups when conducting the interviews. Focus groups will better reveal the preferences within a stakeholder group. These focus groups could use discussions and voting to determine which Fair Street criteria they consider most important. Here, it is important that the focus group is a good representation of the entire stakeholder group. The limitation of this method, however is that arranging these focus groups is very complex and could greatly slow down the process.
The use of VR simulation can help create a better understanding of the Fair Street philosophy and the effects of redesigning the street. Virtual reality shows how a street can be used differently, which helps with creating acceptance of changes in the street. Therefore, this method could also be used in combination with the methods discussed in this research.
Using the survey as a reflection of the behavior of parents is one way to get road users to modify their behavior. However, further research on educating road users is of great importance since it can help increase behavior changes. It is more difficult to reach the residents from the street. Therefore, if they are the cause of unfair behavior in the school environment, further research must be done to see how their behavior could change.
Further research is also needed on the effects of Shared Space. Little is known about the difference between Shared Space road improvements and Sustainable Safety road improvements, making it hard to rate their effects on traffic safety.
Research is also still in progress to determine the “most climate-adaptive” tree species. Understanding which trees are most resistant to climate change and, therefore, are most climate adaptive is of great importance for the efficient placement of greenery in the street. Therefore, further research on these tree species is of great importance for creating climate-adaptive streets in the Netherlands.

8.3. Recommendations municipality

It is important for the municipality of Delft to demonstrate openness and flexibility when creating designs for Fair Streets. In addition, it helps to start redeveloping environments based on the Fair Street philosophy in school environments since this will positively affect children's health and well-being while having the most consensus among stakeholders for environment improvements. Therefore, school environments are a good starting point for implementing Fair Streets. Also, schools are central meeting points, making it easier to bring people together for education meetings.
However, for car reduction measures, it may actually help to include entire neighborhoods at the same time. Therefore, a recommendation will be to arrange car parking at central points on the edge of the neighborhood so that streets in the center of the neighborhood get more space for placing greenery and social meeting spaces. This will increase the neighborhoods' livability and could also be combined with the placement of mobility hubs so that people can travel the last parts to and from home with shared

mobility. People should be well informed about these measures to understand the positive effects of this change. Temporary changes also help to create acceptance for policy measures. This can be done through bicycle decks and modular parklets to familiarize people with the spatial transformations. If they are not accepted, they can be removed again because they are replaceable. These tests can be done before the final redevelopment of the neighborhood. This way, changes in the street can be tested beforehand. These parklets can also help bring dynamic effects into the street. For example, more bike spots or meeting spaces can be created in the summer, while in the winter, they can be turned into car parking spaces when there is more demand for car accessibility. This could also be done for the Fuutlaan to experiment with different uses of street space. However it should be noticed that first a whole education program should be arranged to inform the environment about these changes.
For the 5 to 10 largest cities in the Netherlands, it is recommended that they discourage driving to work by car, whereby they can take the 4 largest cities of the Netherlands as an example given that they have reduced the number of commuters from a far distance. Also, for other big cities outside this top 10 that attract commuters from other places, it is recommended to discourage this type of transportation. For this, they can promote car parking at the edge of the city by implementing paid parking in the cities and increasing public transport or shared mobility to maintain accessibility to the city centers. However, it is essential that car restriction measures, as well as other accessibility improvement measures, are applied. This will increase both the incentive for switching and the facilities for switching to other transportation. With the parking moved to the edge of the city, a lot of space is freed up in the urban streets. For the municipality, it is recommended to use the Best-Worst Method interviews to create a good understanding of what would be the best replacement for this. An example of a solution for car reduction in the cities is shown in figure 8.1.
To implement green and climate-adaptive streets, it is suggested that asset managers who need to maintain the greenery are included in the design process. This is because they will be responsible for upkeep after construction. Also, an extra budget should be made available for the upkeep of biodiversity. Although this will cost more money initially, it will repay itself later, as streets will be more resilient to the effects of the climate, preventing larger expenses in the future. Therefore, potentially, the social benefits that greenery provides outweigh the costs. Additionally, educating the community about the benefits of climate-adaptive streets can increase neighborhood acceptance of these measures.

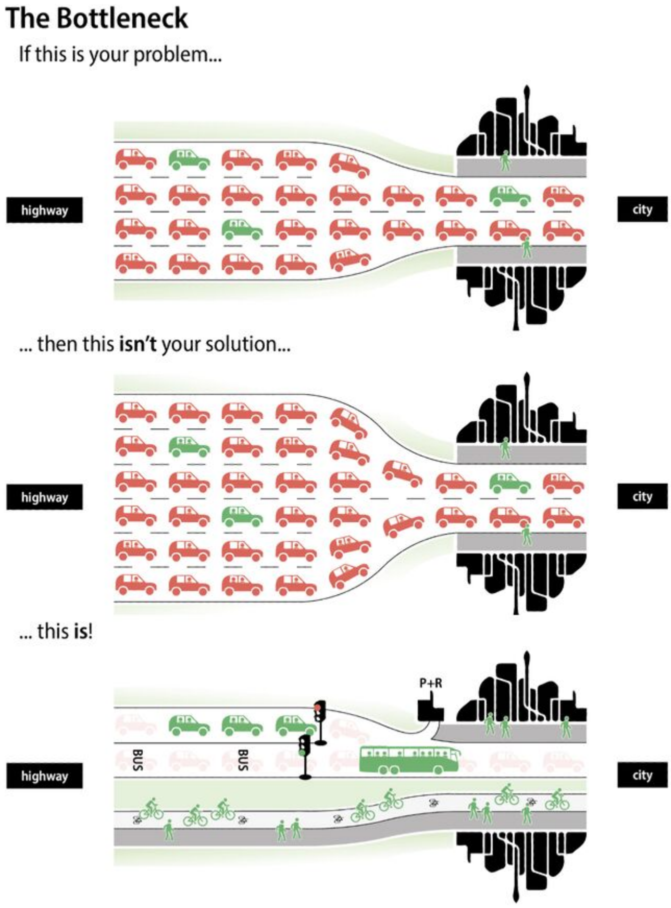

Figure 8.1: Solution for car congestion in the city

8.4. Recommendations for schools

For the elementary school, the SpringWijs at the Fuutlaan, it is recommended that educational meetings are organized to discuss parents' driving behavior and its effects on traffic safety in the street. However, due to the busy periods of the school, this will most likely not come from within the school itself. Because of this, it is recommended that concerned parents organize this for the school, with the school only having to provide meeting rooms and distribute information among parents.
The survey indicated that mainly wrong parking and children dropping off in the middle of the street lead to dangerous situations in the street and limit pedestrian accessibility. Therefore, the school could present the results of the survey to the parents. However, organizing a whole theme week could have more impact and also create the opportunity to organize other fun activities for the children. At the Blijberg, an event took place where coffee stands had been placed in the space of five parking spots in front of the school. This featured fun games for children and a conversation about how the neighborhood can collectively make the schoolyard greener. Photos of this can be found in appendix E. Also, the high demand for bike parking shows that arrangements could be made between the school and parents to park bikes in the schoolyard, leaving the sidewalk free.

For schools in general it is recommended to use the survey as an entry point for conversations with parents in order to make the school environment more fair jointly. Because many of the problems around the school are caused by bringing children to school by car, part of the problem can be solved by adjusting parents' behavior. The survey helps to understand the consequences of parents' transportation behavior, and it can also present the possibilities of what else could be done with the space if car parking in front of the school is not needed.
As a follow-up to the survey, arrangements can be made about the desired behavior in the school en-

vironment, and, in addition, the results can be taken to the municipality in case the survey shows that physical measures in the street need to be taken as well. In addition, schools can organize a Fair Street Week to make both children and parents aware of what can be done differently in the street to make the street fairer. This week could possibly be concluded in celebration with the installation of a portable pump track for the children and the signing of an agreement on changes in behavior and environment between the school, parents, and the municipality. This has already been done in Soest and can be seen in appendix E.
For more efficient survey processing, it may be recommended to merge the questions on ”where in the area it is unsafe” and ”why the area is unsafe.” Many respondents mixed up these questions, making analysis difficult. In addition, predetermining solutions ensure that respondents' preferences emerge, whereas before, the same thing was often meant in slightly different terms.

8.5. Recommendations for parents

For the parents of the SpringWijs, it is recommended that awareness of the Fair Street philosophy be created among the parents and the school board. Due to the busy schedule of the school, there is little need for the school board to get involved in changing the environment around the school according to the Fair Street principles. Because of this, in the case of the SpringWijs, it is better if parents themselves organize meetings to educate about the principles of the Fair Street among the parents. Of course, the school can facilitate this by arranging rooms and also distributing information about the meetings.
The same can be recommended for parents of schools in general. The case of the Blijberg school in Rotterdam showed that the need to change the school environment often starts with a few parents who encounter daily problems in the school environment. Because of this, gathering a group of parents first who want to help change the current situation is good. Then, by organizing fun, low-barrier events, starting a conversation with other parents and residents is possible. A good example is the coffee corners that can be placed in the place of parking spaces (appendix E). After these events, slightly more formal meetings can then be organized in which road users are shown the effect of their travel behavior on safety and fairness in the school environment. These events can then be concluded with a Fair Street week in which, by means of a mountain bike course on a pump track, all stakeholders come together to agree on how to make the behavior and infrastructure around the school environment fairer. It is, however, important to note that conversations should always begin very low-key without forcing the Fair Street philosophy. Eventually every parent wants the best place for its children, therefore listening to everybody's needs is better than only preaching your own needs.

8.6. Recommendations for BAM

As a private company, BAM can assist in spreading and implementing the Fair Street philosophy. In this, spreading the message is especially important since few people yet realize the unfairness of years of auto dominance. In addition, BAM can assist schools with the process of making school environments more fair. Since schools are often very busy but would like improvements to their school environment, BAM can take on most of the tasks and thereby reduce the barrier for the school. As a mediator, BAM can assist parents' meetings and contact municipalities. BAM also has the ability to place a mobile pumptrack on the schoolyard, which allows BAM to help organize events at schools.

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A

Interviews

In this appendix the interview questions format will be discussed. Furthermore, the answers from the different stakeholders are shown. This appendix will conclude with the mathematical model used for calculating the weights per stakeholder. Hereby the consistency check for checking the consistency of the answers will also be discussed.

A.1. Interview format

The interview questions are based on the BWM method. Therefore the first questions that need to be asked are:

- Q1: *Which criterium do you think is the most important?*
- Q2: *Which criterium do you think is the least important?*

These questions are used as input for the pairwise comparisons. Since the BWM asks for the scale of importance of the best criterion compared to the others and the other criteria compared to the worst criterion, the tables shown in figure A.1 can be filled in using the following questions:

- Q3: *How much more important do you think the best criterion is compared to criterion X?*
- Q4: *How much more important do you think criterion X is compared to the worst criterion?*

Criteria Number = 6	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6
Names of Criteria	Traffic Safety	Sustainability	Inclusivity	Sociality	Car Access	Bike Access

Select the Best	Traffic Safety

Select the Worst	Sustainability

Best to Others	Traffic Safety	Sustainability	Inclusivity	Sociality	Car Access	Bike Access
Traffic Safety						

Others to the Worst	Sustainability
Traffic Safety	
Sustainability	
Inclusivity	
Sociality	
Car Access	
Bike Access	

Figure A.1: Format BWM Main Criteria

The same is done for the sub-criteria from ”sustainability”. First the best and worst sub-criterion are identified using the following questions:

- SQ1: *Which sub-criterium of "sustainability" do you think is the most important?*
- SQ2: *Which sub-criterium of "sustainability" do you think is the least important?*

Then these answers are used as input for filling in the tables in figure A.2. This is done based on the following questions:

- SQ3: *How much more important do you think the best sub-criterion of "sustainability" is compared to sub-criterion X?*
- SQ4: *How much more important do you think sub-criterion X is compared to the worst sub-criterion of "sustainability"?*

Criteria Number = 4	Criterion 1	Criterion 2	Criterion 3	Criterion 4
Names of Criteria	Biodiversity	Heat resistance	Rainfall resistance	Draught resistance

Select the Best	Biodiversity

Select the Worst	Heat resistance

Best to Others	Biodiversity	Heat resistance	Rainfall resistance	Draught resistance
Biodiversity				

Others to the Worst	Heat resistance
Biodiversity	
Heat resistance	
Rainfall resistance	
Draught resistance	

Figure A.2: Format BWM Sustainability Criteria

The criteria "traffic safety" and "inclusivity" consist of only 2 sub-criteria. Therefore for these criteria the following questions were asked:

- TQ1: *For "traffic safety", which criterion do you think is more important "actual safety" or "perceived safety"?*
- TQ2: *How much more important do you think this sub-criterion is compared to the other sub-criterion?*
- IQ1: *For "inclusivity", which criterion do you think is more important "pedestrian accessibility" or "special accessibility"?*
- IQ2: *How much more important do you think this sub-criterion is compared to the other sub-criterion?*

A.2. Interview results Municipality

In this section the answers of the municipality will be discussed. Furthermore some specific questions about the project were asked for the municipality. The answers on these questions can be found below. For the main criteria:

- Q1: *Which criterium do you think is the most important?*
- A1: *Sustainability*
- Q2: *Which criterium do you think is the least important?*
- A2: *Sociality*
- Q3: *How much more important do you think the best criterion is compared to criterion X?*
- A3: *Answers are shown in table 5.1*
- Q4: *How much more important do you think criterion X is compared to the worst criterion?*
- A4: *Answers are shown in table 5.2*

For the sub-criteria:

- SQ1: *Which sub-criterium of "sustainability" do you think is the most important?*
- SA1: *Rainfall resistance*
- SQ2: *Which sub-criterium of "sustainability" do you think is the least important?*
- SA2: *Drought resistance*
- SQ3: *How much more important do you think the best sub-criterion of "sustainability" is compared to sub-criterion X?*
- SA3: *Answers are shown in table 5.4*
- SQ4: *How much more important do you think sub-criterion X is compared to the worst sub-criterion of "sustainability"?*
- SA4: *Answers are shown in table 5.5*
- TQ1: *For "traffic safety", which criterion do you think is more important "actual safety" or "perceived safety"?*
- TA1: *Actual safety*
- TQ2: *How much more important do you think this sub-criterion is compared to the other sub-criterion?*
- TA2: *4. Decisions are mostly made based on numbers. Therefore measuring the safety is more important than the perceived safety. Also some situations in which safety is perceived low, can be the most safe environments. Shared Space is one example of this.*
- IQ1: *For "inclusivity", which criterion do you think is more important "pedestrian accessibility" or "special accessibility"?*
- IA1: *Pedestrian accessibility*
- IQ2: *How much more important do you think this sub-criterion is compared to the other sub-criterion?*
- IA2: *5, since a wider sidewalk is for everyone and facilities for special vehicles is only for a limited group.*

Specific questions for this stakeholder:

- Q1: *If you had to divide the influence of the municipality, residents, and parents, what percentage of influence does each stakeholder get on the final weights for each criterion?*
- A1: *40-40-20*
- Q2: *From the 2 redevelopment designs of the Tanthof-East, which one is going to be the final design and why?*
- A2: *The modified redesign of Tanthof-East will be the final design. The initial design was outsourced to an engineering company in which there was a major focus in the design on making the neighborhood climate adaptive. However, this plan was later budgeted down because greening the neighborhood would become too expensive. There were also some complaints from residents in the neighborhood about too few car parking spaces in their street. Also, in the new design, 127 trees had to be cut down to plant new trees, leading to resident discontent.*
- Q3: What is the municipality's opinion on bringing down the parking standards and the number of parking spaces at the door?
- A3: *We created a new mobility plan in which the pedestrian is number one. In this, active travel should be promoted more, and so the municipality's policy is to reduce parking standards as much as possible. However, this encounters many complaints from the neighborhood, complicating implementing these lower parking standards. As a municipality, you also want to keep the environment happy as much as possible.*

A.3. Interview results CWD

In this section the answers of a resident from CWD will be discussed. Furthermore some specific questions about the Fuutlaan were asked. The answers on these questions can be found below. For the main criteria:

- Q1: *Which criterium do you think is the most important?*
- A1: *Sociality*
- Q2: *Which criterium do you think is the least important?*
- A2: *Car accessibility*
- Q3: *How much more important do you think the best criterion is compared to criterion X?*
- A3: *Answers are shown in table 5.7*
- Q4: *How much more important do you think criterion X is compared to the worst criterion?*
- A4: *Answers are shown in table 5.8*

For the sub-criteria:

- SQ1: *Which sub-criterium of ”sustainability” do you think is the most important?*
- SA1: *Heat resistance*
- SQ2: *Which sub-criterium of ”sustainability” do you think is the least important?*
- SA2: *Drought resistance*
- SQ3: *How much more important do you think the best sub-criterion of ”sustainability” is compared to sub-criterion X?*
- SA3: *Answers are shown in table 5.10*
- SQ4: *How much more important do you think sub-criterion X is compared to the worst sub-criterion of ”sustainability”?*
- SA4: *Answers are shown in table 5.11*
- TQ1: *For ”traffic safety”, which criterion do you think is more important ”actual safety” or ”perceived safety”?*
- TA1: *Actual safety*
- TQ2: *How much more important do you think this sub-criterion is compared to the other sub-criterion?*
- TA2: *7*
- IQ1: *For ”inclusivity”, which criterion do you think is more important ”pedestrian accessibility” or ”special accessibility”?*
- IA1: *Special accessibility*
- IQ2: *How much more important do you think this sub-criterion is compared to the other sub-criterion?*
- IA2: *1, I think they are evenly important*

Specific questions for this stakeholder:

- Q1: *What do you currently miss in the Fuutlaan?*
- A1: *Right now, I’m actually missing easily approachable meeting places where people come together to talk. For example, benches or bus shelter-style seats where for example the elderly can take a break on their way to the supermarket and have a chat with others currently sitting or walking by.*

A.4. Interview results Parents association

In this section the answers of a parent from the parents association will be discussed. For the main criteria:

- Q1: *Which criterium do you think is the most important?*
- A1: *Traffic safety*
- Q2: *Which criterium do you think is the least important?*
- A2: *Car accessibility*
- Q3: *How much more important do you think the best criterion is compared to criterion X?*
- A3: *Answers are shown in table 5.13*
- Q4: *How much more important do you think criterion X is compared to the worst criterion?*
- A4: *Answers are shown in table 5.14*

For the sub-criteria:

- SQ1: *Which sub-criterium of "sustainability" do you think is the most important?*
- SA1: *Biodiversity*
- SQ2: *Which sub-criterium of "sustainability" do you think is the least important?*
- SA2: *Drought resistance*
- SQ3: *How much more important do you think the best sub-criterion of "sustainability" is compared to sub-criterion X?*
- SA3: *Answers are shown in table 5.16*
- SQ4: *How much more important do you think sub-criterion X is compared to the worst sub-criterion of "sustainability"?*
- SA4: *Answers are shown in table 5.17*
- TQ1: *For "traffic safety", which criterion do you think is more important "actual safety" or "perceived safety"?*
- TA1: *Actual safety*
- TQ2: *How much more important do you think this sub-criterion is compared to the other sub-criterion?*
- TA2: *3*
- IQ1: *For "inclusivity", which criterion do you think is more important "pedestrian accessibility" or "special accessibility"?*
- IA1: *pedestrian accessibility*
- IQ2: *How much more important do you think this sub-criterion is compared to the other sub-criterion?*
- IA2: *5*

A.5. Mathematical model for calculating weights

In order to determine which design is ultimately the most fair, the different designs are tested on multiple fair street criteria. This leads to a performance matrix and can be seen in chapter 5.2. From the responses of the stakeholder interviews, which can be found in the appendix sections above, weights can be calculated for each criterion using the linear BWM solver from Rezaei (Rezaei, 2016). The optimal weights for the given answers are calculated using the following optimization model.

$$\min_j \max \left\{ \left| \frac{W_B}{W_j} - a_B j \right|, \left| \frac{W_j}{W_W} - a_j W \right| \right\}$$

s.t.

$$\sum_j W_j = 1$$

$$W_j \geq 0, \forall j$$

Where :

- W_B is the weight of the most important criteria
- W_j is the weight of criteria j
- W_W is the least important criteria
- $a_B j$ is the preference of the best criterion over criterion j
- $a_j W$ is the preference of criterion j over the worst criterion

The model searches for the optimal weights for each criterion where an optimal weight equals

$$\frac{W_B}{W_j} = a_B j \quad and \quad \frac{W_j}{W_W} = a_j W$$

The sum of all the weights should be 1 and there can be no negative weights.

Since this model needs to minimize the maximal absolute difference between these fraction of the weights and the preferences of the best criterion over j and criterion j over the worst criterion, the model is converted to this model:

$$\min \quad \xi$$

s.t.

$$\left| \frac{W_B}{W_j} - a_B j \right| \leq \xi, \quad \forall j$$

$$\left| \frac{W_j}{W_W} - a_j W \right| \leq \xi, \quad \forall j$$

$$\sum_j W_j = 1$$

$$W_j \geq 0, \quad \forall j$$

This model is used to find the weights for pairwise comparisons of 3 or more criteria. The weights of a pairwise comparison with only 2 criteria are calculated with the following 2 formulas:

$$W_A = \frac{a}{1+a} \quad and \quad W_B = \frac{1}{1+a}$$

Where W_A is the weight of the more important criterion and W_B is the weight of the less important criterion. ”a” represents the degree of importance based on scale shown in the rubric in figure 2.6.

Because BWM first asks to compare the best criterion against the rest of the criteria and then asks again to compare the rest of the criteria against the worst criterion, the anchoring and adjustment bias is tackled. This bias occurs when a starting point of a decision process greatly affects the final outcome (J. T. Buchanan & Corner, 1997). Because the estimations are based on both the best criterion and the worst criterion these two anchors cancel each other out. However, this type of questioning can cause answers to the first question to be inconsistent with answers given to the second question. Because of this, a consistency check must be performed (Liang et al., 2020). This is done using the following formula.

$$CR^{I} = \max_{j} CR_{j}^{I}$$

$$CR_{j}^{I} = \begin{cases} \dfrac{|a_{Bj} \times a_{jW} - a_{BW}|}{a_{BW} \times a_{BW} - a_{BW}} & a_{BW} > 1 \\ 0 & a_{BW} = 1 \end{cases}$$

CR^{I} is the *global* input-based consistency ratio for all criteria, CR_{j}^{I} represents the *local* consistency level associated with criterion *j*.

Figure A.3: Formula to find consistency ratio

In which a_Bj is the preference of the best criterion over j, a_jW is the preference of criterion j over the worst criterion and a_BW is the preference of the best criterion over the worst criterion. The local consistency ratio CR'_j for each criterion is calculated using these preferences, considering whether the preference is equal to, greater than, or less than 1. The global consistency ratio CR' is then the maximum of these local consistency ratios. The consistency is acceptable if CR' does not exceed a certain threshold, which depends on the number of criteria that are being compared and is provided in the threshold table A.4.

Criteria / Scales	3	4	5	6	7	8	9
3	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667
4	0.1121	0.1529	0.1898	0.2206	0.2527	0.2577	0.2683
5	0.1354	0.1994	0.2306	0.2546	0.2716	0.2844	0.2960
6	0.1330	0.1990	0.2643	0.3044	0.3144	0.3221	0.3262
7	0.1294	0.2457	0.2819	0.3029	0.3144	0.3251	0.3403
8	0.1309	0.2521	0.2958	0.3154	0.3408	0.3620	0.3657
9	0.1359	0.2681	0.3062	0.3337	0.3517	0.3620	0.3662

Figure A.4: Table with threshold values CR

B
Survey

B.1. Format Survey

B.1.1. Type of road users

1. Q1: *Are you a parent from the SpringWijs or a resident at the Fuutlaan?*
2. Q2: *How do your kids mostly travel to school (parent) or how do you travel mostly to a daily activity (resident)?*

B.1.2. Safety

1. Q1: *How safe do you think the traffic safety in the street is based on a scale from 1 (very unsafe) to 5 (very safe)?*
2. Q2: *Which places in the school environment do you consider as unsafe?*
3. Q3: *What do you consider as unsafe about these places?*
4. Q4: *What could help improving the traffic safety?*
5. **Statements about traffic safety:** *Answers range from 1 (totally disagree) to 5 (totally agree)*
6. Q5: *Statement: " Car drivers generally drive too fast on the Fuutlaan"*
7. Q6: *Statement: "The sidewalk on the side of the school should be cleared from car parking spots so that the street becomes more visible."*
8. Q7: *Statement: "The school environment should be free of cars around school opening and closing times."*
9. Q8: *Statement: "The school environment should be, like a shopping street, designed so that pedestrians, cyclists and cars can mix together in which cyclists and cars are guests."*

B.1.3. Road usage

1. Q1: *What are the reasons that your child (parents) goes to school walking or by bike?* or *What are the reasons that you go to your daily activity walking or by bike?*
2. Q2: *What are the reasons that you bring your child to school by car?* or *What are the reasons that you go to your daily activity by car?*
3. Q3: *What do you think is more important in the street? A parking spot for a car or parking space for 10 bikes?*
4. Q4: *On a scale of 1 (equally important) to 5 (extremely more important), how much more important do you find this?*
5. Q5: *What do you think is more important in the street? A parking spot for a car or parking space for a special bike (cargo bike or trycicle)?*

6. Q6: *On a scale of 1 (equally important) to 5 (extremely more important), how much more important do you find this?*
7. Q7: *What do you think is more important in the street? A parking spot for a car or plants or a tree with the space of a parking spot?*
8. Q8: *On a scale of 1 (equally important) to 5 (extremely more important), how much more important do you find this?*
9. Q9: *What do you think is more important in the street? A parking spot for a car or benches/space for meeting people?*
10. Q10: *On a scale of 1 (equally important) to 5 (extremely more important), how much more important do you find this?*
11. Q11: *What do you think is more important in the street? Enough space for cars to pass each other or enough space on the sidewalk for people with a buggy or rollator to pass each other?*
12. Q12: *On a scale of 1 (equally important) to 5 (extremely more important), how much more important do you find this?*
13. **Statements about bike facilities:** *Answers range from 1 (totally disagree) to 5 (totally agree)*
14. Q13: *Statement: "There should be more facilities for bicycles and fewer facilities for cars in the school environment"*

B.2. Survey results Fuutlaan

In this section the answers from the survey, based on the format presented earlier, from the Fuutlaan are presented.

B.2.1. Type of road users

1. 6 parents (35%) and 11 residents (65%)
2. 2 car (12%), 9 bike(53%) and 6 pedestrian (35%)

B.2.2. Safety

1. 47% find the Fuutlaan (very) unsafe and on average the current perception of road safety scores a 2.71 (between unsafe and neutral)

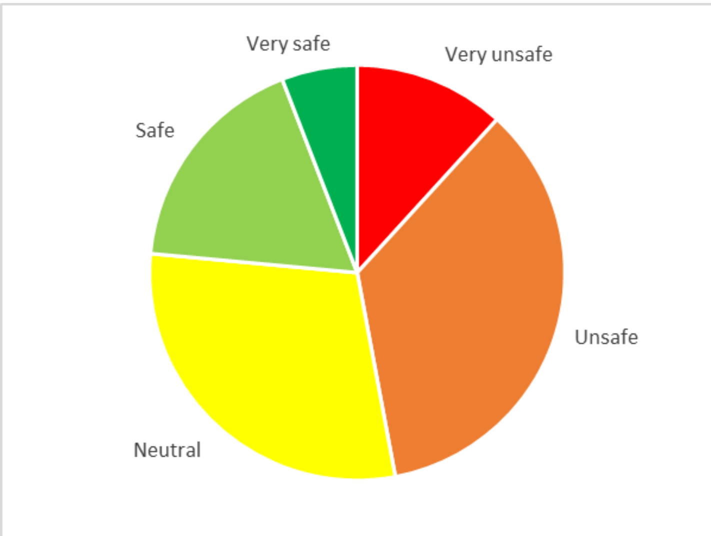

Figure B.1: Safety perception current Fuutlaan

2.

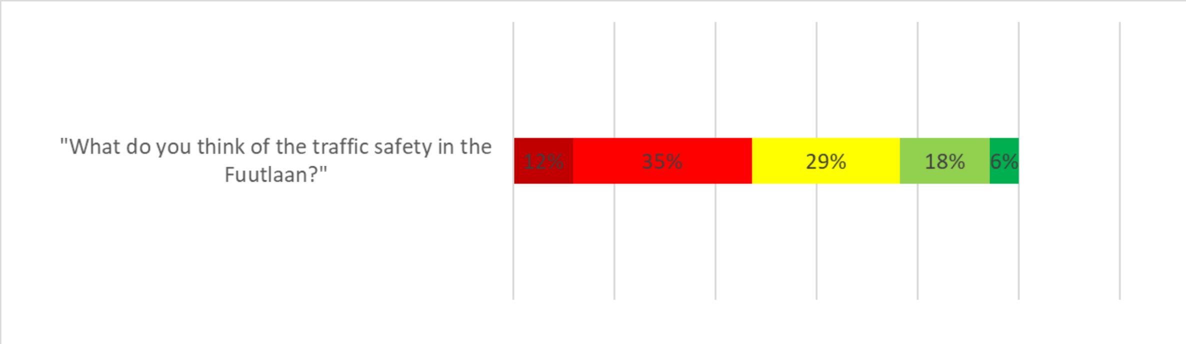

Figure B.2: Stacked bar safety perception current Fuutlaan

3.
4. **Dangerous places:**
   (a) Fuutlaan in front of school (13 times)
   (b) S-curve at corner Kokmeeuwstraat (4 times)
   (c) Crosswalk buslane (2 times)
   (d) Kraanvogelstraat (2 times)
   (e) Around the whole school (1 time)
   (f) Bridge at basketball court (1 time)
   (g) Vinkenlaan (1 time)
5. **Reasons for Danger:**
   (a) Incorrect parking of cars (11 times)
   (b) Cars drive to hard (9 times)
   (c) Too much traffic (8 times)
   (d) Bad visibility (6 times)
   (e) Sidewalk too narrow (2 times)
   (f) Incorrect driving scooters (2 times)
   (g) Stopping on the road to drop off children (1 time)
   (h) Width of the street (1 time)
   (i) Avalex and package deliverers at opening/closing school hours (1 time)
6. **Solutions to improve safety:**
   (a) Car free street (6 times)
   (b) Kiss and ride (4 times)
   (c) Car free during opening and closing hours (4 times)
   (d) Speed reduction measures (4 times)
   (e) Sidewalk poles (4 times)
   (f) One-way traffic (3 times)
   (g) traffic low streets (3 times)
   (h) Wider sidewalk (2 times)
   (i) No parkingspots school side (2 times)
   (j) Fixed drop off spot parents (2 times)

7. **Statements:**

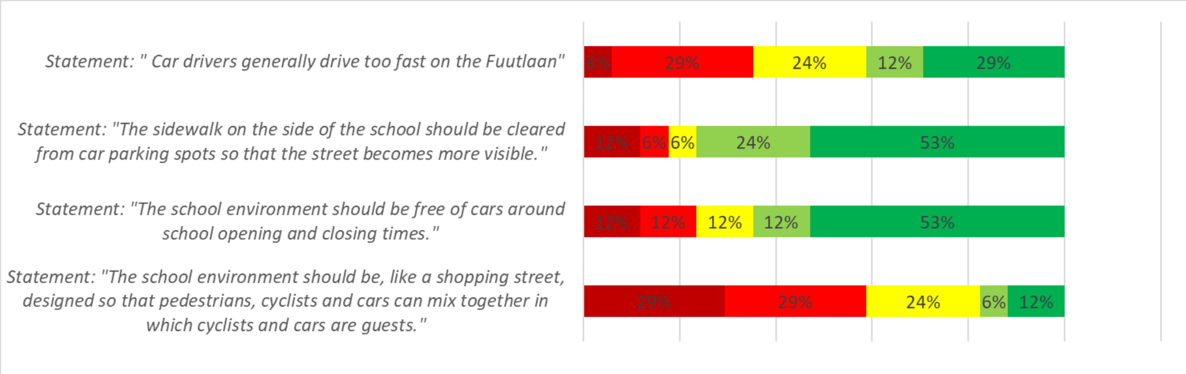

Figure B.3: Statements about trafic safety in the Fuutlaan

B.2.3. Road usage

1. **Reasons for walking or biking:**
    (a) It is healthy
    (b) It increases my children's autonomy
    (c) It is quicker
    (d) It is environmentally friendly
    (e) Quality time with my children
    (f) It is quieter
    (g) It is safer
2. **Reasons for car driving:**
    (a) School/activity is too far to go with other modality
    (b) Bad weather
    (c) Immediately going somewhere else (e.g. work)
3. **Spatial use considerations:**
4. 82% find it more important to add parking spots for 10 bikes in the street instead of a parking lot for cars. These bike parking spots have a relative importance of 2,57 which is between slightly more important and more important.
5. 76% find it more important to add parking spots for special bikes in the street instead of a parking lot for cars. These special bike parking spots have a relative importance of 2,32 which is between slightly more important and more important.
6. 76% find it more important to add trees and plants in the street instead of a parking lot for cars. These trees and plants have a relative importance of 2,82 which is between slightly more important and more important.
7. 59% find it more important to add social meeting space in the street instead of a parking lot for cars. This social meeting space has a relative importance of 2,07 which is a little more than slightly more important.
8. 76% find it more important to add wider sidewalks instead of a wider car road. These wider sidewalks have a relative importance of 3,36 which is between more important and much more important.
9. **Statements**
10. 65% (totally) agrees with more bicycle facilities and fewer car facilities in the school environment

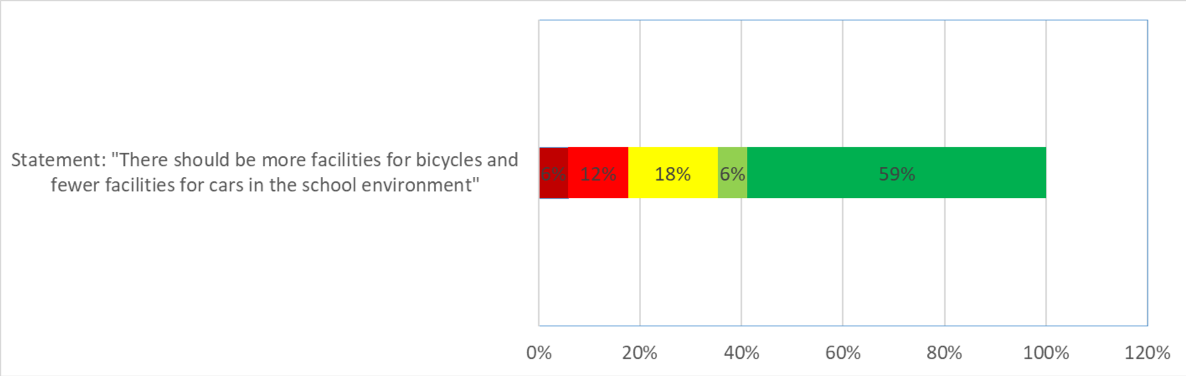

Figure B.4: Statement about facilities in the street

11.

B.3. Survey results Blijberg

In this section, the answers for the survey, based on the format discussed earlier, from the Blijberg are given. What can be noticed is that only the parents were asked to fill in the survey; therefore, the first question for identifying if the respondent is a resident or parent is left out.

B.3.1. Type of road users

1. 86 parents
2. 16 car (19%), 59 bike(69%) and 11 pedestrian (13%)

B.3.2. Safety

1. 62% find the school environment (very) unsafe and on average the current perception of road safety scores a 2.34 (between unsafe and neutral)

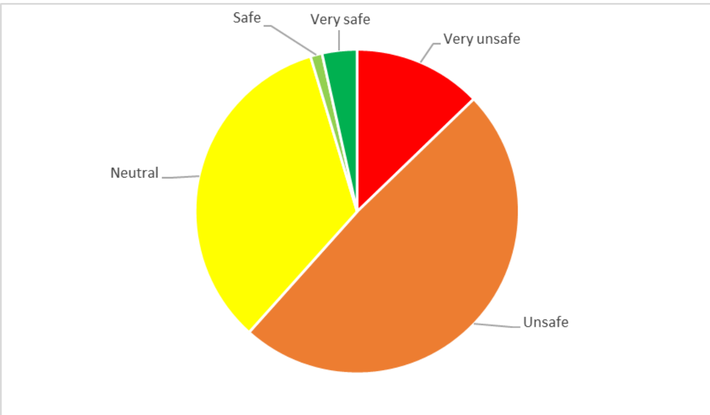

Figure B.5: Safety perception Blijberg

2.
3. **Dangerous places:**
   (a) In front of the school (56 times)
   (b) Noorderhavenkade (47 times)
   (c) Bycicle crossing at 50km/h road in front of school (38 times)
   (d) Sonmanstraat (6 times)

(e) Other side roads (1 time)

4. **Reasons for Danger:**
    (a) Too much (mixed) traffic (45 times)
    (b) Stopping on the road to drop off children (25 times)
    (c) Unsafe crossing 50km/h road (21 times)
    (d) Cars drive to hard (19 times)
    (e) Wrong parking (15 times)
    (f) Road to narrow (10 times)
    (g) Sidewalk too narrow (10 times)
    (h) Incorrect driving scooters (2 times)
    (i) Unsafe crossing Noorderhavenkade (9 times)
    (j) Driving behavior cyclists (6 times)
    (k) Carbage collect services and package deliverers at opening/closing school hours (7 times)
5. **Statements:**

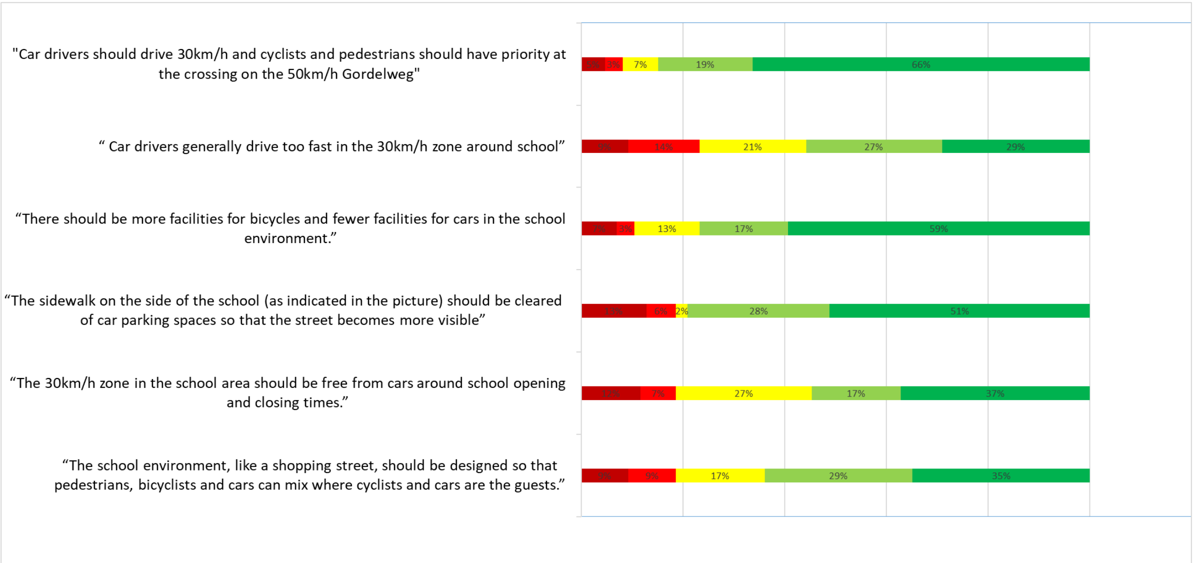

Figure B.6: Statements about trafic safety in the school environment

6.

B.3.3. Road usage

1. **Reasons for walking or biking:**
    (a) It is healthy
    (b) It increases my children's autonomy
    (c) It is nearby
    (d) It is environmentally friendly
    (e) Quality time with my children
2. **Reasons for car driving:**
    (a) School/activity is too far to go with other modality
    (b) Bad weather

(c) Immediately going somewhere else (e.g. work)
(d) Route is to dangerous for my children

3. **Spatial use considerations:**
4. 85% find it more important to add parking spots for 10 bikes in the street instead of a parking lot for cars.
5. 77% find it more important to add parking spots for special bikes in the street instead of a parking lot for cars.
6. 76% find it more important to add trees and plants in the street instead of a parking lot for cars.
7. 71% find it more important to add social meeting space in the street instead of a parking lot for cars.
8. 83% find it more important to add wider sidewalks instead of a wider car road.
9. **Statements:**
10. 76% (totally) agrees with more bicycle facilities and fewer car facilities in the school environment

C

Climate adaptivity

C.1. Climate adaptiveness scan

Figure C.1: Extreme rainfall impact scan (Klimaateffectatlas, 2022)

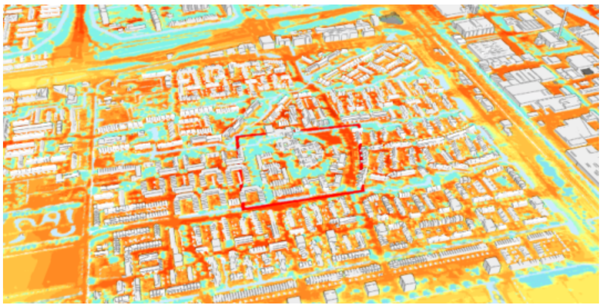

Figure C.2: Heat resistance impact scan (Klimaateffectatlas, 2022)

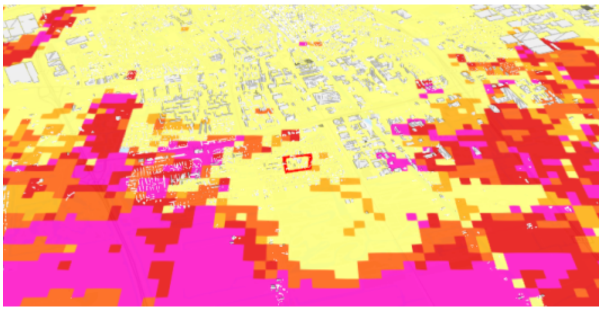

Figure C.3: Expected land decline impact scan (Klimaateffectatlas, 2022)

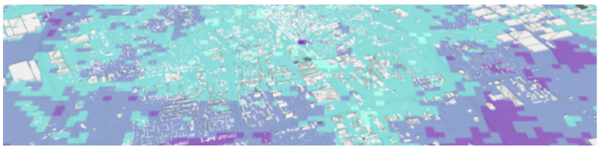

Figure C.4: Sedimentation sensitivity due to elevation impact scan (Klimaateffectatlas, 2022)

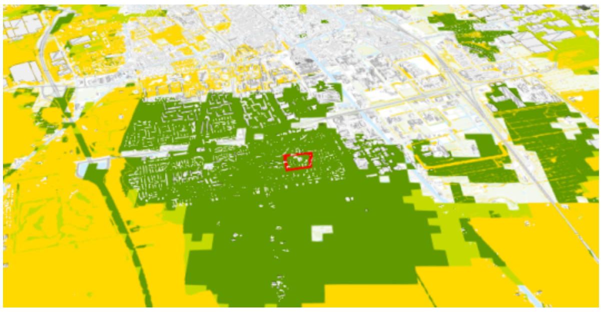

Figure C.5: Flooding probability impact scan (Klimaateffectatlas, 2022)

C.2. Climate adaptive tree species

WETENSCHAPPELIJKE NAAM	GROOTTE	GROENBLIJVEND	WINTERHARDHEID	TOLERANTIE DROOGTE	TOLERANTIE STROOIZOUT	BEPERKEN OPWARMING	INTERCEPTIE NEERSLAG	VERDRAAGT ZEER NATTE PERIODE	VERDRAAGT DROGE PERIODE
Acer baergerianum	★★★★		★★★	★★		★★★			
Acer campestre	★★★		★★★	★★★	★	★★	★		
Acer negundo	★★★★		★★★	★		★★★	★	★	★★
Acer platanoides	★★★★		★★★	★★		★★★	★★		
Acer pseudoplatanus	★★★★		★★★	★★		★★★	★★		
Acer rubrum	★★★★		★★★	★	☆	★★★	★		★
Acer saccharinum	★★★★		★★★	☆		★★★	★★	★	★★
Acer tataricum ssp. Ginnala	★★		★★★	★★	★	★★	★★		
Aesculus hippocastanum	★★★★		★★★	☆		★★★	★★		
Aesculus x carnea	★★★		★★★	★	☆	★★★			
Alnus cordata	★★★		★★★	★	★	★★	★★		
Alnus glutinosa	★★★		★★★	☆	★	★★	★★	★★	★
Alnus incana	★★★		★★★	★★	★	★★	★	★	★★
Alnus spaethii	★★★★		★★★	★★	★	★★			
Amelanchier arborea	★		★★★	☆	★	★			★
Amelanchier lamarckii	★★		★★★	☆	★	★			★
Betula nigra	★★★★		★★★	★	☆	★★	★★	★	★
Betula papyrifera	★★★★		★★★	☆		★★			
Betula pendula	★★★		★★★	★★		★★	★★		
Betula pubescens	★★★		★★★	☆		★★	★★	★	★
Betula utilis	★★★★		★★	☆	☆	★★			
Carpinus betulus	★★★		★★★	★	☆	★★	★★		★★
Castanea sativa	★★★★		★★★	☆	☆	★★★	★★		
Catalpa bignonioides	★★★		★★★	★	☆	★★			
Cedrus atlantica = C. libani ssp. Atlantica	★★★★	🍃	★★	★★		★★			
Cedrus deodara	★★★★	🍃	★★	☆		★★			
Cedrus libani	★★★★	🍃	★★	★★		★★			
Celtis australis	★★★		★★★	★★	☆	★★	★★		
Celtis occidentalis	★★★★		★★★	★★		★★	★★		
Cercidiphyllum japonicum	★★★		★★★	☆	☆	★★	★		
Cercis canadensis	★★		★★★	☆		★	★★		
Cercis siliquastrum	★★		★★	★★	☆	★	★★		
Chamaecyparis lawsoniana	★★★★	🍃	★★★	★		★	★★		
Cornus mas	★		★★★	☆		★	★		★
Corylus colurna	★★★		★★★	★	☆	★	★		
Crataegus coccinea	★		★★★	★	☆	★	★		
Crataegus x lavallei	★		★★★	★	☆	★	★		
Crataegus monogyna	★★		★★★	★	☆	★	★		
Elaeagnus angustifolia	★		★★★	★★	★	★			
Fagus sylvatica	★★★★		★★★	☆	☆	★★★	★★		
Fraxinus angustifolia	★★★		★★★	★	★	★★	★★		★★
Fraxinus excelsior	★★★★		★★★	☆	★	★★★	★★		★
Fraxinus ornus	★★★		★★	★★	★	★★	★★		
Fraxinus pennsylvanica	★★★★		★★★	★	★	★★		★	★★
Ginkgo biloba	★★★★		★★★	★★		★	★★	★	★★
Gleditsia triacanthos var. inermis	★★★★		★★★	★★★	★	★★	★★		
Gymnocladus dioicus	★★★		★★★	★★★		★			
Ilex aquifolium	★★★	🍃	★★	☆		★	★★		
Juglans nigra	★★★★		★★★	★★		★★★	★★		
Juglans regia	★★★★		★★★	★		★★★	★★		
Koelreuteria paniculata	★★		★★	★★★		★			
Larix decidua	★★★★		★★★	☆		★★	★★		
Liquidambar styraciflua	★★★★		★★★	★	☆	★★	★★	★	★
Liriodendron tulipifera	★★★★		★★★	☆	☆	★★★	★★		
Magnolia grandiflora	★★★★	🍃	★	★★		★★	★		
Magnolia spp.	★ – ★★★		★★ – ★★★	☆	☆	★ – ★★★	★★		
Malus baccata	★★		★★★	★		★	★		
Malus tschonoskii	★★		★★★	★		★	★		
Malus cv's	★ – ★★		★★★	★		★	★		
Metasequoia glyptostroboides	★★★★		★★★	★		★★		★★	★
Morus alba	★★★		★★★	★		★★	★★		
Morus nigra	★★★		★★★	☆		★★	★★		
Parrotia persica	★★★		★★★	★★		★★			
Paulownia tomentosa	★★★		★★	☆		★★	★★		
Picea abies	★★★★	🍃	★★★	★		★★	★★★		
Picea pungens	★★★★	🍃	★★★	★		★★			
Pinus nigra	★★★★	🍃	★★★	★★		★★	★★		
Pinus strobus	★★★★	🍃	★★★	★		★★			
Pinus sylvestris	★★★★	🍃	★★★	★★		★★	★★		
Platanus occidentalis	★★★★		★★★	★★	★	★★★	★★	★	★★
Platanus orientalis	★★★★		★★★	★★	★	★★★	★★		
Platanus x acerifolia = P. x hispanica	★★★★		★★★	★★	★	★★★	★★	★	★★
Populus alba	★★★★		★★★	★★	★	★★★	★★		
Populus nigra	★★★★		★★★	★★	★	★★★	★★		★
Populus tremula	★★★★		★★★	★★★	★	★★★	★★		
Populus x canadensis	★★★★		★★★	★	★	★★★	★★		★
Populus x canescens	★★★★		★★★	★	★	★★★	★★		★
Prunus avium	★★★★		★★★	☆	☆	★★★	★		
Prunus cerasifera	★★		★★★	☆	☆	★	★		
Prunus cerasus	★★		★★★	☆	☆	★	★		
Prunus maackii	★★★		★★★	★	☆	★★	★		
Prunus padus	★★★		★★★	★	☆	★★	★		
Prunus sargentii	★★		★★★	★	☆	★★			
Prunus serrulata	★★		★★★	★	☆	★			
Prunus spinosa	★		★★★	★	☆	★			
Prunus virginiana 'Shubert'	★★		★★★	★	☆	★			
Pyrus calleryana	★★		★★★	★★★	☆	★			
Quercus cerris	★★★★		★★★	★	★	★★★	★★		★
Quercus coccinea	★★★★		★★★	★	★	★★★	★★		★
Quercus frainetto	★★★★		★★★	★	★	★★★	★★		★★
Quercus ilex	★★★★	🍃	★	★★	★	★★	★★	★	★
Quercus palustris	★★★★		★★★	★	★	★★★			
Quercus petraea	★★★★		★★★	★	★	★★★	★★		
Quercus robur	★★★★		★★★	★★	★	★★★	★★		★
Quercus rubra	★★★★		★★★	★	★	★★★	★★		
Robinia pseudoacacia	★★★★		★★★	★★★	★	★★	★★		
Salix alba	★★★★		★★★	★		★★★	★★	★★	★★
Salix babylonica	★★		★	☆		★★	★★	★★	★
Salix x sepulcralis	★★★★		★★★	★		★★		★★	★★
Sambucus nigra	★★		★★★	★		★	★		★
Sophora japonica (Styphnolobium jap.)	★★★★		★★★	★★★	★	★★			
Sorbus aria	★★★		★★★	★★		★★	★		
Sorbus aucuparia	★★★		★★★	★		★	★		★★
Sorbus intermedia	★★★		★★★	★		★			
Sorbus latifolia	★★★		★★★	★		★			
Sorbus x thuringiaca	★★★		★★★	★		★			
Tamarix gallica	★★		★★★	★★		★	★		
Taxodium distichum	★★★★		★★★	★★		★★	★★	★★	★
Taxus baccata	★★★	🍃	★★★	★★		★★	★★		
Thuja occidentalis	★★★★	🍃	★★★	☆		★★	★★		
Thuja plicata	★★★★	🍃	★★★	★		★★	★★		
Tilia americana	★★★★		★★★	★	☆	★★★	★★		
Tilia cordata	★★★★		★★★	★	☆	★★★	★★		
Tilia platyphyllos	★★★★		★★★	★	☆	★★★	★★		
Tilia tomentosa	★★★★		★★★	★★	☆	★★★	★★		
Tilia x europaea	★★★★		★★★	★	☆	★★★	★★		
Ulmus cv's	★★★ – ★★★★		★★★	★★		★ – ★★★			★
Ulmus laevis	★★★★		★★★	★★		★★★			
Ulmus pumila	★★★★		★★★	★		★★★			★
Zelkova serrata	★★★★		★★★	★★		★★	★★		

Figure C.6: Tree species and their climate adaptation score

D

Accesibility Fuutlaan

D.1. Accesibility

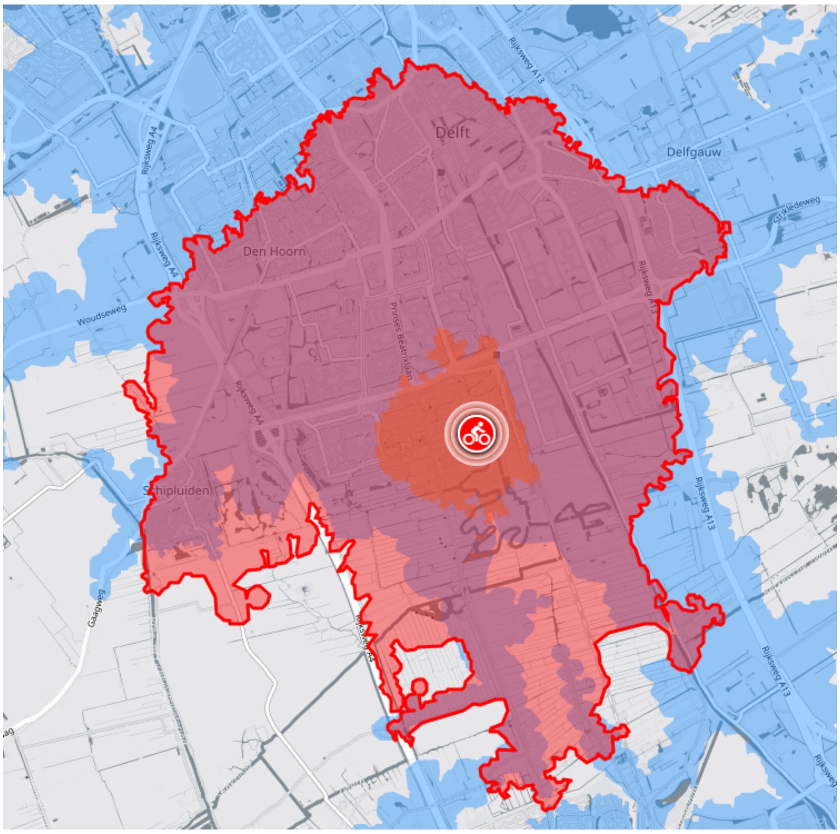

Figure D.1: Bicycle accessibility within 15min of the Fuutlaan (TravelTime, 2023)

Figure D.2: Pedestrian accessibility within 15min of the Fuutlaan (TravelTime, 2023)

D.2. Inclusivity

Figure D.3: Bikes parked on the sidewalk

Figure D.4: Cargo bikes parked on the sidewalk

Figure D.5: Cars parked on the sidewalk

Figure D.6: Cargo bike parked on the zebra crossing

E

Events at schools

Figure E.1: Coffee stands on parking spots

Figure E.2: Children playing between the coffee stands at the Blijberg

SoesterCourant.nl

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Deel je nieuws Abonneren

PREMIUM ARTIKEL LOKALE JOURNALISTIEK UIT SOEST

Altijd bij de les in het verkeer

ONDERWIJS • Foto: Jaap van den Broek • ma 2 okt., 09:46

Een mountainbiker ontwijkt met een 'jump' wethouder Osman Suna.

SOEST

Leerlingen, hun ouders en docenten van de Ludgerusschool zijn vorige week druk in de weer geweest met de verkeersveiligheid rondom de school aan de Vosseveldlaan. De werkweek werd vrijdag feestelijk afgesloten met onder andere stunts, een rap, hapjes en drankjes.

Laatste premium nieuws

3-10 PREMIUM 'Binnen twee maanden bouwen op TBS-terrein'

2-10 PREMIUM Werkstraf voor betasten van

Figure E.3: Safety week in Soest

F

Scientific paper

Implementing Fair Streets for school zones in the Netherlands: *Evaluating stakeholder perspectives to achieve a "Fair Street" design for a school street in Delft: A multi-criteria decision approach.*

E.M. van Veen

In response to the automobile-oriented urban street designs, this study explores the implementation of "Fair Streets" in school zones in the Netherlands. This research aims to create a transition from only vehicle prioritization to also a focus on social, environmental, and community functions on streets around school zones. Currently, up to 50% of public space in cities is allocated to car infrastructure, leading to significant social and environmental drawbacks. This research uses a multi-criteria decision-making method, applying the Best-Worst Method (BWM) for interviews and surveys amongst key stakeholders at the Fuutlaan in Delft to evaluate stakeholder perspectives and integrate various needs into renewed street designs. The interviews reveal a strong preference for a more sustainable design, emphasizing the need for resistance to rainfall and heat, which aligns with the municipality's redevelopment goals. Also, designs that reduce car parking space in favor of inclusivity and traffic safety are desired, reflecting a shift towards a more fair use of street space. However, the acceptance of this redevelopment among some car users remains low, causing resistance. Therefore, this study advocates for policy adaptations that increase the feasibility and acceptance of such transformative urban designs. Recommendations for practice include involving the stakeholders early in the planning process and keeping them well-informed and educated about changes in the neighborhood. Also, creating trials with space usage changes and providing sufficient transportation alternatives are recommended. For further research, it is important to focus mainly on this topic's social aspect. To increase acceptance and participation, methods are needed to approach and convince people to support a fairer street.

Keywords: *Fair Street Design, Shared Space, Stakeholder Management, MCDM, BWM*

I. Introduction

Every year, approximately 1.24 million persons globally lose their lives due to road traffic accidents, making it the eighth most significant contributor to mortality (Organization et al., 2013). In the Netherlands, between 2010-2019, 40% of the total traffic fatalities were pedestrians or cyclists (SWOV, 2020) mainly caused by crashes with motorized vehicles (SWOV, 2024). This highlights the critical need for safe, active travel infrastructure. In addition, with the advancement of the automobile industry, the evolution of urban landscapes has increasingly favored the facilitation of vehicular traffic over other forms of street life (Karndacharuk et al., 2014)(Von Schönfeld & Bertolini, 2017). This has led to 50% of the public space in cities being consumed for car infrastructure (KiM, 2022). This vehicle-oriented urban design has, therefore, not only led to congested roads but has also significantly diminished the role of the street as a social and community hub, compromising the safety of pedestrians and cyclists (Karndacharuk et al., 2014). Moreover, these designs worsen environmental problems by increasing impenetrable surfaces and reducing green spaces, which contribute to urban heat islands and low biodiversity in the cities (Gillner et al., 2015). With the pressing need for climate adaptation and traffic safety in the cities, local governments desperately want to reduce car use and car ownership in the cities. This is in line with the philosophy of the Fair Street initiative, which advocates for a re-imagined urban streetscape that prioritizes spatial justice, ensuring streets serve not just as conduits for cars but as vibrant spaces for social interaction, community building and environmental sustainability (European Commission, 2023). This re-imagined philosophy frees up space for greenery and social meeting space while reducing the hazards these cars create. However, the transition towards this Fair Streets philosophy is met with inherent resistance from car users. Changes to the status quo, particularly those that could negatively impact certain stakeholders, often encounter opposition (van der Lee, 2024). Therefore early involving stakeholders in the planning process for a fair redevelopment of streets is necessary to increase acceptance from the road users.

A. Research objective and research question

One place where the negative impact of the car-centric urban design meets daily is in school surroundings. Five days a week, children must travel to and from school. There are 6,851 primary schools in the Netherlands (Ministerie van OCW, 2022a) with a total of 1,474,760 pupils (Ministerie van OCW, 2022b). Assuming that all these children have to get to and from school daily, this equates to nearly 3 million daily trips. Since, in addition to residents also, parents and school staff must come to this location daily, there are many stakeholders with different interests present in school environments. This research, therefore, aims to combine the interests of these different stakeholders involved in making school zones fairer and implement them in a Fair Street design. In addition, this research aims to provide more insight into how the various stakeholders can be included in this process of (re) designing streets around school zones. Which ultimately helps urban planners and schools in the Netherlands to develop plans for making their school zones fairer. This integration of end-users, policymakers, and other interest groups could lead to not only a fairer physical street layout but also the appropriate fair use of the infrastructure, which together leads to fairer school surroundings. How this interaction works between the design of the environment and the end users' actual behavior is illustrated in Figure 1.

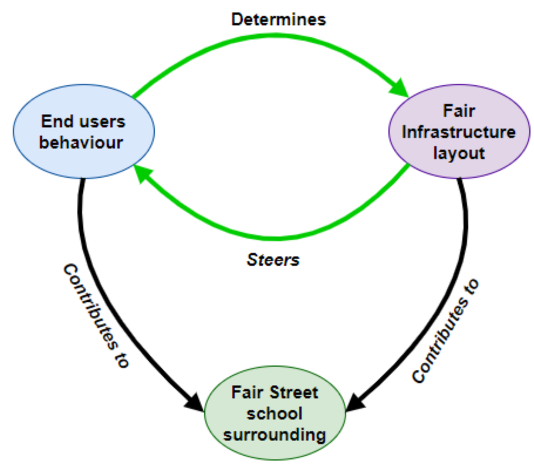

Figure 1. The interaction between infrastructure and people

To create these Fair Street school surroundings, the following main research question has been used:

How can the Fair Streets principles for school zones in the Netherlands be implemented, considering the interests of different stakeholders?

To answer this question, a case study has been used to investigate the integration of the stakeholders of a school street, called the Fuutlaan, in Delft into the design process for creating a Fair Street. A set of measurable Fair Street criteria is defined so that stakeholders can be asked about the relative importance of these criteria in the Fuutlaan. A multi-criteria decision-making method called the Best-Worst Method (BWM) has been used for the interviews and surveys amongst key stakeholders. All together, this combination of methods can serve as a framework for municipalities and schools to help with implementing Fair Streets in school environments in the Netherlands.

II. Literature summary

Research shows that prioritizing the safety of vulnerable road users, including pedestrians and cyclists, in urban design significantly reduces vehicle speeds and pedestrian injuries (Morrison et al., 2003). This can be done by the traffic calming approach to reduce the negative effects of motor vehicle use. Traffic calming includes physical measures (e.g., speed bumps or chicanes), educational measures (e.g., awareness campaigns), and enforcement measures (e.g., legal speed limits) (Brown et al., 2017). Reducing the speed driven by car drivers to speeds slower than 30 km/h decreases the likelihood of fatal accidents significantly (Hamilton-Baillie, 2008). Also, increasing the street's visibility helps significantly to prevent accidents. Especially in school surroundings were mostly children, who are less aware of the hazards from cars in the street (Kim et al., 2017). Due to this unawareness and lack of visibility, most crashes of school-going children happen in the area near the school (Abdel-Aty et al., 2007). Therefore, ensuring good traffic safety and sufficient walking and cycling infrastructure in school environments is especially important. This allows more children to walk and bike (autonomously) to school, leading to less congestion, higher safety, and cleaner air in residential areas (Brown et al., 2017).

Theories for improving traffic safety show that road safety can be achieved with 2 contradictory approaches. The first theory, which is the traditional method, aims to separate modalities with different speeds and masses as much as possible (SWOV, 2005). Interactions with these different modalities need to be limited (Hamilton-Baillie, 2008). Therefore, according to this theory, pedestrians are separated from other traffic at speeds above 15 km/h and cyclists at speeds above 30 km/h. Although this layout creates a basis for creating a safer environment, the picture in Figure 1 shows that not only the layout of the infrastructure but also the behavior of the users affects traffic safety in the environment. Out of this thought, a new theory called shared space emerged. The shared space principle aims to remove traditional infrastructure barriers, promoting visibility and a moral imperative for diverse road users to share the same space (Hamilton-Baillie, 2008). Shared space, defined by Reid et al., enhances pedestrian movement by reducing motor vehicle dominance, encouraging users to share space without strictly defined rules (Reid, 2009). However, Kaparius et al. outline key conditions for a safe shared space are low vehicular traffic, high pedestrian traffic, and good visibility (Kaparias et al., 2012). Therefore, creating successful shared space surroundings mostly requires a drastic change of the building environment. Besides that, there has been limited research on the effects of shared space. This makes it difficult to determine with certainty whether this road layout works better than the traditional theory. This is also difficult because it is impossible to estimate the effect of a traditional improvement in places where shared space has now been applied (Methorst et al., 2007). Further research is therefore needed to better determine the effects of shared space on traffic safety.

Also, climate change has gained increasing political recognition in recent decades (Owen, 2020) (Swart et al., 2014). Due to population growth and the trend of people moving to cities, combined with insufficient climate planning, cities suffer a significant loss of green spaces and biodiversity (Chanse et al., 2021). This greenery plays a vital role in our health and well-being, and due to its absence, urban areas, in particular, are facing the consequences of climate change with increasing urgency. Longer periods of extremely hot weather cause cities to become heat islands, negatively affecting health due to heat stress (Lundgren & Kjellstrom, 2013). Also, flooding sewers from heavy rainfall causes streets to become increasingly inaccessible to pedestrians or cyclists (Wamsler et al., 2013). Such phenomena highlight the need to integrate climate adaptability into the design and construction of urban infrastructure, with a specific focus on making streets future-proof against the various impacts of extreme weather. Chanse et al. provide a vision for climate-adaptive streets that contribute to city resilience by improving ecological health, facilitating social interactions, and mitigating environmental extremes (Chanse et al., 2021). Integrating green spaces into street designs contributes to social cohesion, provides places for meeting and recreation, and strengthens people's connection to nature, which in turn leads to better health and wellness outcomes. In addition, it significantly helps with absorbing rain during heavy rainfall and provides cooling during extreme heat (Bouw adaptief, n.d.). However, sufficiently greening the streets and making them climate-adaptive requires space mostly occupied by car parking. Currently, up to 50% of the public space in cities is used for car infrastructure. Research on sustainable neighborhood renovations in Leiden shows that residents consider parking space and extra green space in the street to be very valuable (Gemeente Leiden, 2022). This highlights the challenging task for municipalities to balance these needs with the limited space available in the cities.

Decades of focus on facilitating the smooth flow of cars have caused residents to become used to the norm of having a car parking spot at their doorstep. This led to cities creating parking norms for the minimum of parking spots within a certain distance of a household (CROW, 2017). Despite this, travel times have remained constant since 1950, as people in the Netherlands generally find it acceptable to travel 70 to 90 minutes a day and, therefore, will live only further away from their work. Marchetti explains this in his paper as the law of conservation of travel time (Marchetti, 1994). The effects of these parking standards were already researched by Professor Donald Shoup in 1997 and are illustrated in Figure 2

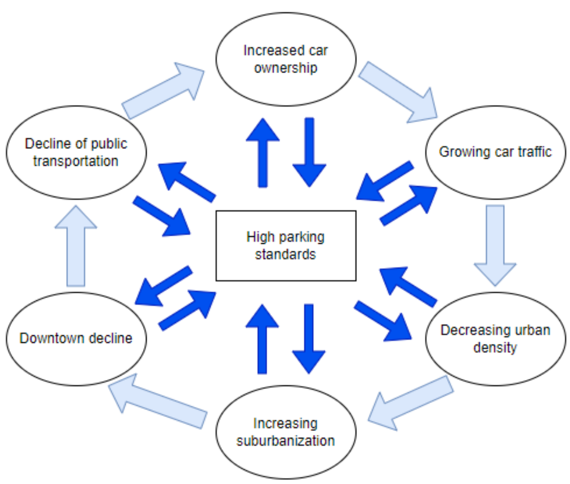

Figure 2. Effect of parking standards on urban density (Shoup, 1997)

Even though the area taken up by cars in a city can be utilized for other activities that improve the livability and health in the cities, it requires a shift from a long-established mentality to which people have become very attached.

To create acceptance for changing the current street layout into more livable and sustainable streets, involving stakeholders in the decision-making (Lindenau & Böhler-Baedeker, 2014) is key. Lidenau and Böhler-Baedeker (2014) show that there has been considerable research on participatory approaches for governments (Lindenau & Böhler-Baedeker, 2014). However, the effectiveness of these processes varies. Key obstacles include political will, limited resources, and the complexity of coordinating the interests of different stakeholders. To overcome these challenges, the authors propose more structured and strategic approaches to engaging the public and stakeholders, emphasizing the need for clear frameworks and sufficient resources to support these processes. Van der Lee also shows that there are barriers that can affect the effect of mobility plans (van der Lee, 2024). For example, different stakeholder interests often create conflicts. In addition, low social acceptance can create political resistance. However success factors to avoid these barriers as much as possible are showing openness and flexibility when designing measures to increase acceptance. In addition, trials of new mobility policies ensure that the community can get used to measures before they are implemented definitively. Also, this paper indicates that measures are more likely to be accepted if they positively impact children's health and safety.

This creates a knowledge gap in the literature, indicating that limited research has been done on effective methods of integrating stakeholders into the decision-making process for politically sensitive decisions. As a result, this study will research the integration of stakeholders into the design process for implementing Fair Streets. In doing so, most of the success factors of van der Lee's thesis (van der Lee, 2024) will be merged by looking at stakeholder integration for implementing temporary physical modifications in a school's street.

III. Methodology

As mentioned earlier, this research uses a case study from a school street called the Fuutlaan in Delft to answer the main research question. A case study is needed because this is a complex problem that involves multiple stakeholders with different interests, and the trade-offs that need to be made will always be valued differently per case. Therefore, analyzing a particular case can give insights into the process that can later be generalized for implementing Fair Streets in other school zones in the Netherlands.

To get an answer to the main research question for the Fuutlaan case, this research consisted of 2 parts. The first part is structuring the problem, and the second part is processing the input into conclusions and recommendations for the Fuutlaan. The first part can be divided into three phases. First, the orientation phase is used to develop criteria that can score fairness in the street and identify the key stakeholders that need to be involved in this process. This is done by making a goal tree for structuring the Fair Street indicators into measurable criteria for the Fuutlaan. This construction of the goal tree is accompanied by expert consulting to better understand the Fair Street philosophy and check the correct criteria are used in the goal tree. The key stakeholders are identified using a stakeholder analysis.

Secondly, the information-gathering phase. This phase creates insight into the current problem and the stakeholders' preferences in the street. The current problem is identified using a survey among road users, real-life observations, and interviews with key stakeholders. The stakeholders' preferences will be identified using Best-Worst Method interviews and space reconsideration questions. A Best-Worst Method interview is a multi-criteria decision-making method used for making decisions about complex public issues. This method asks key stakeholders about their most important (best) criterion and their least important (worst) criterion of fairness in the street. Subsequently, the other criteria' importance can be compared to the best and worst criterion. This enables the determination of what stakeholders consider important in the street and what they consider less important so that trade-offs in the street can be made more grounded.

Thirdly, the design phase. In this phase, the designs for a Fair Street in the Fuutlaan will be created, and scores for the fairness criteria will be allocated. The creation of the designs is based on a requirement analysis and the survey's space reconsideration questions. The scoring is done using expert consulting for expert-specific criteria and literature.

Finally, in part two, the answers to all these phases will be processed and combined in the evaluation phase. In this phase, the preferences of the different stakeholders will be combined and used to calculate the ranking of the different designs for the Fuutlaan. The outcome of this phase will be the final conclusions and recommendations for the implementation of a Fair Street in the Fuutlaan. The full research approach can be seen in figure 3.

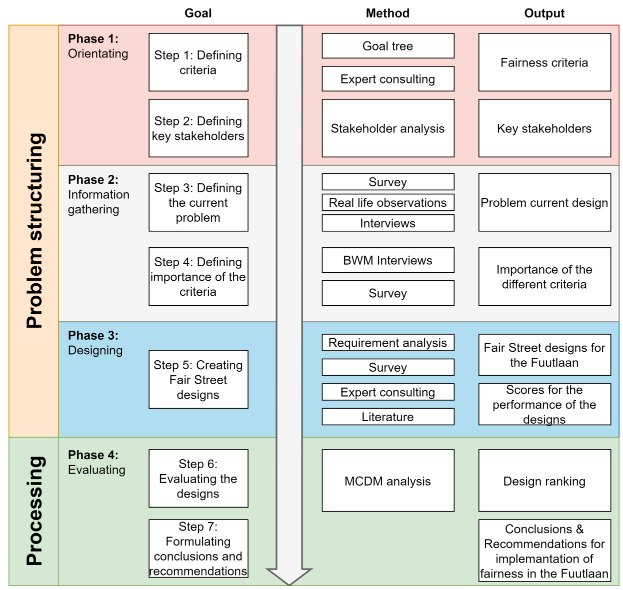

Figure 3. Research Approach

IV. Results

The results from the survey at the Fuutlaan showed that mainly the behavior of the parents self cause an unsafe school surrounding. This is due to wrong parking and stopping in the middle of the road to drop off their children. This shows that a lot can be achieved in terms of traffic safety in school environments by educating and changing parents' driving behavior. However, it also emerged that people were driving too fast in the street. This shows that adjusting the physical infrastructure can also help improve traffic safety in the school environment. However, the survey at the Fuutlaan received a low amount of responses. The completion of the survey by only 17 people, including 11 residents and only 6 parents, partly because the school at the Fuutlaan did not want to participate in this survey. This shows the importance of a good stakeholder approach for the distribution of the survey.

This led to the distribution of a second survey at another elementary school in Rotterdam so that the effect and potential of the survey could still be properly assessed. With the responses of 86 parents at this elementary school in Rotterdam, the results of this survey showed that participation through a good stakeholder approach increases significantly. This survey also confirmed the results of the Fuutlaan survey, since this survey also revealed that the behavior of parents/road users is mainly the reason for unsafe school environments. Wrong parking and stopping in front of the school to drop off children again appeared to be the main cause of unsafety in the school environment. However, frequent responses indicated that people were driving too fast and that crossing the 50km/h road right in front of the school entrance caused many dangerous situations. This indicates that here, too, modification of the physical infrastructure can help improve traffic safety in the school environment.

The Best-Worst Method interviews were conducted among the key persons from the municipality, the residents association, and the school's parents association. However, as indicated earlier, the school board did not want to participate, and therefore, the preferences of this stakeholder are not considered in this research. The results, which can be seen in Table 1, showed that among all the stakeholders, sustainability was considered by far the most important. Followed by traffic safety and inclusivity, which are also seen as important criteria for improvement in the street. Car accessibility scored by far the lowest, which underscores the Fair Street philosophy that streets are currently designed primarily for the facilitation of motorized traffic. Therefore, improvement of this criterion is least necessary according to the stakeholders interviewed.

Table 1. Aggregated normalized weights of the main criteria

	Traffic Safety	Sustainability	Inclusivity	Social-ity	Car Access	Bike Access
Weight	0.159	0.337	0.160	0.129	0.084	0.131

For the redevelopment of the Fuutlaan, the municipality has already created two designs. The first design was focused on improving sustainability by creating more greenery in the street. However, this design became too expensive, and therefore, the definitive design of the municipality became very similar to the current situation with some little modifications.
Three new designs were created in this study from the requirement analysis and the space reconsideration questions from the survey. The first design is based on the theory of shared space in which no car parking is allowed in the street, creating additional space for other activities. In the second design, no cars are allowed on the street at all. Consequently, the street is transformed into a bicycle path. The final design is based on improving the municipality's definitive design using fair street reconsiderations. In all the designs, the car parking spaces are (temporarily) occupied by greenery, social meeting spaces, and bicycle parking spaces based on the outcomes from the space reconsideration questions of the survey. Only in the last design is there still space for one car parking spot. The scores for these designs were then determined using expert consulting and literature. These scores can be found in Table 2.

Table 2. Total Performance Designs

	Traffic Safety	**Sustainability**	**Inclusivity**	**Sociality**	**Car Access**	**Bike Access**	**Total**
Definit Design	0.075	0.033	0.011	0.400	0.824	0.032	**0.150**
First Design	0.337	0.693	0	0	1	0	**0.371**
Shared Space	0.413	0.642	1	1	0	1	**0.702**
Car Free	1	0.642	0.276	1	0	1	**0.679**
Fair improved	0.075	0.642	0.276	1	0.059	1	**0.537**

The total scores per design can be calculated using the aggregated weights per criteria from Table 1. These total scores can be seen in the last column of Table 2.
Given the preferences of the different stakeholders that resulted from the interviews, the shared space design scored the best on the Fair Street criteria. Due to the

extra space in this design created by removing car parking spaces, this design scores well on the criteria "sustainability," "inclusivity," "sociality," and "bike accessibility." Also, this design is based on the theory of improving "traffic safety" in the street. Therefore, the criteria that are seen as very important by stakeholders are well met in this design. The definitive design from the municipality for the Fuutlaan scores the lowest. However, this could mostly have to do with the fact that this design has been used as the basis for the creation of the new designs that met the principles of the Fair Street more.

V. Conclusion

From the case study, it can be concluded that the framework of methods, as illustrated in the research approach in Figure 3, provides a clear road map for engaging stakeholders in implementing Fair Streets. It creates a good overview of the problems that arise in school environments. In addition, the interviews and surveys ensure that stakeholders feel involved in making choices about the design of a street they deal with daily. However, it is very important that the stakeholder approach and involvement are done properly to increase participation and acceptance. In addition, it is important that stakeholders are well-educated about the positive effects of a fairer street layout and its use of it. This was particularly evident from the survey, which showed that users themselves are often the cause of unsafe behavior. Therefore, it is not only important that the physical infrastructure is adapted to create Fair Streets, but also the user behavior must be adapted for the correct use of Fair Streets. However, this need and will are present since both the interviews and the surveys indicate that there is a lack of other activities, such as greenery and social gathering space, in the Fuutlaan case. Consequently, this methodology helps in making grounded choices for a fairer balance of these activities in the street.

VI. Discussion & Recommendations

To keep the study within the scope of available time for this master's thesis several assumptions and limitations were made in this study. These limitations are an entry point for further research. This study only looked at a single street that was located in front of the school to limit the amount of stakeholders for this research. Therefore, the solutions are also based only on this single street. What the effect of these solutions will be on the rest of the neighborhood is unknown and not taken into account. In addition, the designs are based on an existing final design by the municipality. As a result, the designs are limited in design freedom. More design freedom could lead to better optimal solutions. Also, the criteria and its scores were simplified, because actual effects were difficult to estimate. Therefore not all the effects of complex factors like traffic safety, accessibility and sustainability were taken into account. In addition, the space reconsideration questions of the survey used to create the designs are based on a low number of responses, making them not statistically significant.

A. Recommendations for further research

For further research it is recommended to do follow-up research on the social part of this study. A good approach of the stakeholders is very important to create enough participation. This participation is needed to create better acceptance for implementing Fair Streets. This will allow for further research on how different types of populations influence the acceptance of car-reducing measures. Research can also be done on the use of focus groups to conduct interviews. This gives better insight into the desires of a large group, however, is more complex to conduct as a researcher. In addition, applications such as VR can help provide insight into the effects of a Fair Street. This helps create acceptance for the change. Further research is also needed on climate adaptive trees. Understanding which trees are most resistant to climate change and therefore are most climate adaptive is of great importance for the efficient placement of greenery in the street.

B. Recommendations for municipalities and schools

For municipalities considering implementing Fair Streets or other forms of car reduction measures in their municipality, it is advisable to involve stakeholders early in the process. This stakeholder involvement can be done based on the framework of methodologies that are discussed in this paper. Showing openness and flexibility for changes results in increased acceptance by the stakeholders. Also, trials with temporary physical changes help stakeholders get used to the changes, which also increases acceptance. In addition, it helps to start redeveloping environments based on the Fair Street philosophy in school environments since this will positively affect children's health and well-being. Therefore, school environments are a good starting point for implementing Fair Streets. Also, schools are central meeting points, making bringing people together for education meetings easier. However, for car reduction measures, it may actually help to include entire neighborhoods at the same time. Therefore, a recommendation will be to arrange car parking at central points on the edge of the neighborhood so that streets in the center of the neighborhood get more space for placing greenery and social meeting spaces. This will increase the neighborhoods' livability and could also be combined with the placement of mobility hubs so that people can travel the last parts to and from home with shared mobility. Lastly, it is important for municipalities to properly educate and inform the environment about the positive social effects of removing parking spaces.

For schools or parents from schools, it is recommended to organize educational meetings at school to discuss parents' driving behavior and its effects on traffic safety on the street. Creating awareness among the parents ensures collaborative thinking about solutions in the school environment. In addition, conducting the survey can ensure that sufficient justification can be gathered for creating awareness at the municipality to modify the traffic situation in the area.

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