Integrating Public Participation GIS applications into the Dutch environmental planning system

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Preface

With this, I present the thesis 'Integrating Public Participation GIS application into the Dutch environmental planning system'. A study to introduce an approach that has the potential to increase public participation in the Netherlands. The thesis has been conducted from March 2021 to February 2022 and is the last chapter of my study, Construction Management & Engineering (CME), at the Eindhoven University of Technology.

With this thesis, I hope to convince Dutch land-use planners and project initiators to see the added value of public involvement and provide them with an application to collect and process the information provided by the public.

After initially selecting land-use suitability assessment using Geographical Information Systems as my research topic, my first supervisor, ir. A.W.J. Borgers helped me narrow this topic down by placing Public Participation ahead of GIS. For this topic, literature research and a pilot study in Limbeek have been conducted to answer the research question. I wish to thank my first and second supervisors, ir. A.W.J. Borgers and dr.ing. P.J.H.J. van der Waerden, for their contributions to the design of the online questionnaire and later their feedback to my thesis.

I also wish to thank the respondents who participated in the online questionnaire. Without them, I could not have showcased the added value of the resulting approach.

Furthermore, I would like to thank my parents, sister, and friends for their contributions in counseling and mental support during my graduation period, which was made challenging by the implications of the corona crisis. Finally, my thanks go to Joran van de Hoef and the fellow students and staff from the study management program for their support, they helped me persevere when the going was tough.

I hope you will enjoy reading this thesis.

Mark Geelhoed

Eindhoven, February 9, 2022

Contents

Summary
Traditional public participation methods in environmental planning are plagued by low participation rates, caused by poor and ineffective communication, time and distance constraints, and planning experts deeming information provided by the public to be unstructured and subjective. All are causing a lack of public trust and a low acceptance of plans. Therefore, a process needs to be found to harness the knowledge of the crowds and convert it into structured, useful information. Public Participation Geographical Information Systems (PPGIS) applications have been identified to increase public participation and structure the collected information.

The research proposes a method to integrate a PPGIS application into the Dutch land-use planning and public participation system to improve public participation rates compared to their traditional counterparts. For this method, questions regarding the three critical aspects of successful PPGIS integration are answered:

- Applicability; by investigating which of the PPGIS variables - neighborhood characteristics as perceived by residents - are the most important and relevant to be considered in the Netherlands.
- Representativeness; by investigating how a PPGIS application can be embedded in the current legislative framework to achieve higher levels of representation and participation.
- Information quality; by investigating and showcasing how PPGIS variables and issues perceived by inhabitants can be measured and subsequently structured into useful qualitative information for land-use planners and decision-makers.

The question regarding applicability was formulated to find the variables deemed the most important by residents and most relevant for urban planners to consider in the Dutch land-use planning system. Finding these variables is important, as participation is unlikely to increase if residents are consulted on topics they do not find applicable or find challenging to report. On the other hand, urban planners have no reason to ask for issues seen as irrelevant or unusable by them. A three-step approach is used, first making an inventory of the (PPGIS) variables used in prior research and practice. Second, eliminating those that are not or sparsely used in the context of urban (re)development planning, as would be applicable in the Netherlands. Third, by eliminating those variables deemed unimportant in the data analysis on the WoON2018-data, a dataset considered to represent the Dutch population. This exploration found aesthetic, social, and noise to be the most important and relevant variables, followed by maintenance, safety, recreation, access to public transport, and mental health.

The study has identified that the new Environment & Planning Act, which will be enacted by July 2022, provides a framework suitable for PPGIS integration. This act prescribes that all initiatives that require an environmental permit also need to fill in a participation plan. The level of participation, ranging from 0 to 3, that is required depends on the project's scale, societal interest, media attention, and nuisances. The participation plan lists an online questionnaire as one of the possible public consultation and participation methods.

Therefore, this study uses an online questionnaire for its information quality showcase. This showcase pilot study is performed amongst the residents of the Dutch neighborhood Limbeek (in Eindhoven). In the pilot, the respondents were asked to:

- State their level of satisfaction with their neighborhood and ten neighborhood characteristics.
- Rank these neighborhood characteristics in order of importance.
- Select locations in and around their neighborhood they experience as positive or negative.
- Which neighborhood characteristic(s) they associate with those experiences.
- Their willingness to participate in community gatherings or questionnaires.

Of the 95 respondents, only 71 respondents provided their personal characteristics. Apart from gender, the sample was not representative for the full population of Limbeek.

The first question relating to information quality concerns the measurement of PPGIS variables. This measurement is achieved by comparing the satisfaction distributions reciprocally and with the national average, as present in the WoON2018 survey. This information provides insights into a neighborhood's (relative) strengths and weaknesses, as perceived by its inhabitants. The satisfaction scores revealed that the Limbeek residents were less satisfied with their neighborhood than the average Dutch citizen. Reciprocally comparing the neighborhood characteristics indicates that the respondents were the most satisfied with the accessibility to public transport and social properties. In contrast, the respondents are the least satisfied with their neighborhood's aesthetics, maintenance, and safety. With these individual satisfaction levels, a regression analysis was performed to investigate which neighborhood characteristics are the strongest contributors to the general satisfaction of that neighborhood and, by extension, which types of intervention can have the most significant impacts on that neighborhood's residents. The regression analysis indicated mental health, maintenance, building aesthetics, and personal safety to be the strongest predictors of general neighborhood satisfaction. These findings did not align with the importance of the characteristics, as ranked by the respondents. The characteristics ranked to be the most important were personal safety, accessibility to public transport, maintenance, and noise.

The second question regarding information quality investigates how issues perceived by the public can be structured into useful information for planning experts. The study uses a mapping tool to collect the selected locations by the respondents, registers whether the related experience with each location is positive or negative, and the association(s) with that experience. After collection, QGIS transforms this data into PPGIS point clouds and heatmaps of each association category. By doing so, this method can display differences in density, distribution, experience, and association for each of the PPGIS variables. When this knowledge is combined with the ranked neighborhood priorities, urban planners gain a reasonably accurate understanding of which type of interventions are desired (most) at any place within or near the neighborhood. With the positive heatmaps, urban planners know which areas are positively valued and for which reasons, and therefore need to be preserved. In total, 339 locations were selected in and around Limbeek, of which 188 locations had a combined total of 444 positive associations and 151 locations had a combined total of 313 negative associations. Aesthetics was most frequently selected of the positive associations, followed by recreation and social. Negative locations were often associated with traffic safety, aesthetics, personal safety, and noise. The heatmaps revealed that the respondents mostly valued a green area along the neighborhood's western border, containing a park, playground, football field, and allotment garden. It received high densities of positive associations for recreation, mental health, social, and aesthetics. They also positively valued the city center, a green park/forest, and an adjacent neighborhood, which all held aesthetic and recreational value and were perceived to be well-maintained. The highest densities of negative associations for personal safety, aesthetics, maintenance, noise, and traffic safety were found in the neighborhood's northeast corner. This area includes the neighborhood's grocery store and its car park, a busy intersection, and a new residential block under construction at the time of data collection. Other high densities of negative associations were found for the immediately adjacent stadium (noise and safety) and a nearby street (safety).

The final question is related to PPGIS achieving sufficient participation and representativeness when integrated into the Dutch land-use planning system, defined in the Environment & Planning Act. The majority of the pilot's respondents stated that they would be willing to fill in a questionnaire as (part of) their participation. This finding suggests that the integration of such a PPGIS application can achieve higher levels of representativeness than traditional public participation methods, such as community gatherings.

Samenvatting

Traditionele methoden voor publieksparticipatie bij ruimtelijke ordening worden geplaagd door een gebrek aan deelname. Dit gebrek wordt veroorzaakt door slechte en ineffectieve communicatie, tijd- en afstandsbeperkingen, en professionele ruimtelijke planners die door het publiek verstrekte informatie als ongestructureerd en subjectief beschouwen. Dit alles veroorzaakt een gebrek aan vertrouwen van het publiek in, en een lage acceptatie van bouwplannen. Daarom moet er een methode worden gevonden om de kennis van het publiek te benutten en te structureren in bruikbare informatie. Van Publieke Participatie Geografische Informatie Systemen (PPGIS)-toepassingen wordt verwacht dat ze deze kloof (deels) kunnen overbruggen en daarmee participatie vergroten.

Dit onderzoek stelt een methode voor om een PPGIS-toepassing te integreren in het Nederlandse ruimtelijke ordenings- en publieke participatiesysteem, en daarmee de publieke deelname en vertegenwoordiging te verbeteren. Voor deze methode worden de drie belangrijkste aspecten van succesvolle PPGIS-integratie onderzocht:

- Toepasbaarheid; door te onderzoeken welke van de PPGIS-variabelen - buurtkenmerken zoals waargenomen door bewoners - het belangrijkst en relevantst zijn om in de Nederlandse context toe te passen.
- Representativiteit; door te onderzoeken hoe een PPGIS-toepassing kan worden ingebed in het wettelijke kader om hogere niveaus van vertegenwoordiging en participatie te bereiken.
- Informatiekwaliteit; door te onderzoeken en te laten zien hoe PPGIS-variabelen en problemen die door bewoners worden ervaren, gemeten en vervolgens gestructureerd kunnen worden in bruikbare kwalitatieve informatie voor stedenbouwkundigen en besluitvormers.

De vraag naar de toepasbaarheid is geformuleerd om variabelen te vinden die door bewoners het belangrijkst en voor stedenbouwkundigen het meest relevant worden geacht om toe te passen in de Nederlandse ruimtelijke ordening. Dit is belangrijk, aangezien deelname waarschijnlijk niet zal toenemen als bewoners worden gevraagd naar onderwerpen die zij niet van toepassing vinden of moeilijk vinden om te melden. Anderzijds is er geen reden om te vragen naar onderwerpen die door stedenbouwkundigen als irrelevant of onbruikbaar worden gezien. Deze vraag wordt beantwoord in drie stappen, waarbij eerst een inventarisatie wordt gemaakt van de (PPGIS-)variabelen die in eerder onderzoek en in de praktijk zijn gebruikt. Ten tweede het elimineren van de variabelen die niet of weinig worden gebruikt op het gebied van stedelijke (her)ontwikkeling. Ten derde door de variabelen te elimineren die onbelangrijk worden geacht in de data-analyse op de WoON2018-data, een dataset die als representatief voor de Nederlandse bevolking wordt gezien. Op basis van deze verkenning bleken esthetiek, sociaal en geluid de belangrijkste en meest relevante variabelen, gevolgd door onderhoud, veiligheid, recreatie, toegang tot openbaar vervoer en mentale gezondheid.

De nieuwe Omgevingswet, die in juli 2022 van kracht wordt, biedt een kader dat geschikt is voor PPGIS-integratie. Deze wet schrijft voor dat alle initiatieven waarvoor een omgevingsvergunning nodig is, ook een participatieplan moeten invullen. Het vereiste participatieniveau, dat varieert van 0 tot 3, is afhankelijk van de omvang van het project, de maatschappelijke belangstelling, media-aandacht en mogelijke overlast voor omwonenden. In het participatieplan wordt een online vragenlijst genoemd als een van de mogelijke methoden voor openbare raadpleging en participatie.

Deze studie gebruikt een online vragenlijst voor de showcase van informatiekwaliteit, uitgevoerd onder de bewoners van de Nederlandse wijk Limbeek. Waarin de respondenten zijn gevraagd om:

- Hun tevredenheid met hun buurt en tien buurtkenmerken aan te geven.
- Deze buurtkenmerken in volgorde van belangrijkheid te rangschikken.
- Locaties in en rond hun buurt te selecteren die zij als positief of negatief ervaren.
- Welke van de buurtkenmerken ze associëren met die ervaringen.
- Hun bereidheid om deel te nemen aan buurtbijeenkomsten of online vragenlijsten.

Van de 95 respondenten hebben er 71 hun persoonlijke eigenschappen ingevuld. Deze groep respondenten was niet representatief voor de bevolking van Limbeek, behalve op het geslacht.

De eerste vraag over informatiekwaliteit betreft het meten van PPGIS-variabelen. Dit wordt gedaan door de tevredenheidsverdelingen onderling en met die van het landelijk gemiddelde te vergelijken. Deze informatie geeft inzicht in de (relatieve) sterke en zwakke punten van een wijk, zoals die door de bewoners worden ervaren. Uit de tevredenheidsscores bleek dat de inwoners van Limbeek minder tevreden waren met hun buurt dan de gemiddelde Nederlander. Ook op onderhoud, veiligheid en esthetiek van de bebouwing scoorde de buurt onder dat gemiddelde, maar was vergelijkbaar op het sociale vlak. Door de buurtkenmerken onderling te vergelijken blijkt dat de respondenten het meest tevreden waren over de bereikbaarheid van het openbaar vervoer en sociale eigenschappen. De respondenten blijken het minst tevreden te zijn over de esthetiek, het onderhoud en de veiligheid van hun buurt. Met deze individuele tevredenheidsniveaus werd ook een regressieanalyse uitgevoerd om te onderzoeken welke buurtkenmerken het sterkst bijdragen aan de algemene tevredenheid van de buurt, en welke soorten interventies de grootste bijdrage kunnen leveren voor de buurtbewoners. De regressieanalyse gaf aan dat mentale gezondheid, onderhoud, esthetiek van gebouwen en veiligheid de sterkste voorspellers zijn van algemene buurttevredenheid. Dit komt niet overeen met de door de respondenten opgestelde rankschikking. De belangrijkste buurtkenmerken waren veiligheid, bereikbaarheid openbaar vervoer, onderhoud en geluid.

De tweede vraag over informatiekwaliteit onderzoekt hoe door het publiek waargenomen problemen kunnen worden gestructureerd in bruikbare informatie voor planningsdeskundigen. Het onderzoek maakt gebruik van een mapping tool om de door respondenten geselecteerde locaties te verzamelen, te registreren of de gerelateerde ervaring positief of negatief is, en de bijbehorende associatie. Na verzameling transformeert QGIS deze in gegevens in PPGIS-puntwolken en heatmaps. Daarmee is deze methode in staat om verschillen in dichtheid, distributie, ervaring en associatie in een visualisatie weer te geven. Wanneer deze kennis wordt gecombineerd met de prioriteiten van de buurtbewoners, zoals gerangschikt door de respondenten, krijgen stedenbouwkundigen een vrij nauwkeurig inzicht in welk type interventies (het meest) gewenst zijn op elke plaats in of in de omgeving van de wijk. Met de positieve heatmaps weten stedenbouwkundigen ook welke gebieden positief gewaardeerd worden en om welke redenen, en dus behouden moeten blijven. In totaal zijn er 339 locaties geselecteerd in en rond Limbeek, waarvan 188 locaties samen 444 positieve associaties, en 151 locaties samen 313 negatieve associaties hebben. Van de positieve associaties werd esthetiek het meest gekozen, gevolgd door recreatie en sociaal. Negatieve locaties werden vaak geassocieerd met verkeersveiligheid, esthetiek, persoonlijke veiligheid en geluid. Uit de heatmaps bleek dat de respondenten vooral waarde hechtten aan een groenstrook langs de westgrens van de wijk, met daarin een park, speeltuin, voetbalveld en volkstuin. Het kreeg hoge dichtheden van positieve associaties voor recreatie, mentale gezondheid, sociaal en esthetiek. Ze waardeerden ook het stadscentrum, een groen park/bos en een aangrenzende wijk, die allemaal als esthetisch, recreatief en goed onderhouden werden ervaren. De hoogste dichtheden van negatieve associaties voor persoonlijke veiligheid, esthetiek, onderhoud, geluid en verkeersveiligheid werden gevonden in de noordoostelijke hoek van de wijk. Dit gebied bevat een supermarkt, een parkeerterrein, een druk kruispunt en een nieuw woonblok dat in aanbouw was op het moment van de gegevensverzameling. Andere hoge dichtheden van negatieve associaties werden gevonden voor het direct aangrenzende stadion (geluid en veiligheid) en een nabijgelegen straat (veiligheid).

De laatste vraag heeft betrekking op het bewerkstelligen van voldoende participatie en representativiteit van de PPGIS-toepassing wanneer het wordt geïntegreerd in het Nederlandse ruimtelijke ordeningssysteem, dat is gedefinieerd in de Omgevingswet. De grote meerderheid van de respondenten van de pilot geeft aan bereid te zijn om een vragenlijst in te vullen als (onderdeel van) hun deelname. Dit suggereert dat met de integratie van een PPGIS-toepassing hogere representativiteitsniveaus bereikt kunnen worden dan met traditionele methoden voor publieks-participatie, zoals gemeenschapsbijeenkomsten.

Abstract
Traditional public participation methods in environmental planning are plagued by low participation rates, caused by poor and ineffective communication, time and distance constraints, and planning experts deeming information provided by the public to be unstructured and subjective. All are causing a lack of public trust in the government and a low acceptance of its plans. Therefore, a method needs to be found to harness the knowledge of the crowds and convert it into structured, useful information. Public Participation Geographical Information Systems (PPGIS) applications have been identified to (partly) bridge this gap. Therefore, the research proposes a method to integrate a PPGIS application into the Dutch land-use planning and public participation system to improve public participation rates compared to their traditional counterparts. Questions regarding the three critical aspects of successful PPGIS integration for this method are answered. Applicability, by investigating which PPGIS variables - neighborhood characteristics as perceived by residents - are the most important and relevant to be applied in the Dutch context. Information quality, by investigating and showcasing how PPGIS variables and issues perceived by inhabitants can be measured and subsequently structured into useful qualitative information for land-use planners and decision-makers. Representativeness, by investigating how a PPGIS application can be embedded in the current legislative framework to achieve higher levels of representation and participation. For this showcase, a pilot study is performed in the Dutch neighborhood of Limbeek in Eindhoven. This pilot study consists of an online questionnaire in which residents were asked to state their level of satisfaction with their neighborhood and ten neighborhood characteristics, select locations in and around their neighborhood they experience as positive or negative, and which of the neighborhood characteristic(s) they associate with that experience. These locations are then inserted into QGIS to create positive and negative heatmaps for all PPGIS variables.

Keywords: Public participation, Public Participation Geographical Information Systems, Dutch land-use planning, Environment & Planning Act, Volunteered Geographic Information.

Glossary

EPA: Environment & Planning Act
GNS: General Neighborhood Satisfaction
PGIS: Participatory Geographical Information Systems
PPGIS: Public Participation Geographical Information Systems
PPGIS Variable: Neighborhood characteristics as perceived by residents
PV's: Placed Values
VGI: Volunteered Geographic Information
WoON: WoonOnderzoek Nederland, a housing survey conducted for the Dutch government.

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1. Introduction

Traditional public participation methods in environmental planning are plagued by low participation rates (Zolkafli, Liu, & Brown, 2017). These low rates of participation have several causes. First, poor and ineffective communication by planners towards the public about these methods (Zolkafli et al., 2017) and their usual analog approach creates time and distance constraints for the affected residents who would like to attend (Bijen, Toppen, Poll-van Dasselaar, & Geertman, 2016). While public insights are crucial for successful planning outcomes (Puppim de Oliveira & Paleo, 2016), these obstacles to public participation strongly affect these outcomes. These obstacles cause a lack of public trust in planners and distrust towards their plans, leading to a low acceptance rate (Friedmann, 1993; Zolkafli et al., 2017). This lack of trust and poor communication can cause the public to lose interest and refuse to participate in future planning processes (Zolkafli et al., 2017). This refusal to participate creates a knowledge gap between the public and planners.

This knowledge gap is widened by the skepticism of planners towards potential public contributions. This skepticism has increased since the development of GIS (Geographical Information Systems)-assisted land-use planning, which has gathered momentum since the beginning of the millennium (Brown, 2017). After introducing these tools, governments at all levels have spent considerable resources developing (extensive) geographical databases (Joerin, Thérialult, & Musy, 2001). This increasing digitalization of land management files (plans, procedures, and regulations) and databases allowed urban planners and decision-makers to increasingly prioritize urban sustainability (Abdullahi & Pradhan, 2018). These developments, however, generally use technical and scientific tools to find planning solutions (Zolkafli et al., 2017). With these tools, planners have increasingly bypassed the "wisdom of the crowds", which is seen as irrelevant information, in that it is subjective and unstructured by nature (Golobic & Marusic, 2007; RIVM, 2008). This perception widens the communication gap, leading to a negative public trust and participation spiral. Therefore, this spiral should be stopped first, and the knowledge gap between the public and the experts should be bridged (Maidin, 2011; Marzuki, 2015). Second, public experiences should be incorporated into the decision-making processes of (governmental) planning agencies (Brown & Reed, 2012).

As mentioned before, planning outcomes are most often successful if both expert- and local knowledge are used in design and decision-making processes (Brown, 2015; Golobic & Marusic, 2007). By doing so, the problems perceived by the residents can be solved. Therefore, an alternative approach needs to be found, in which the public is no longer bypassed, but their knowledge is considered a valid source of information by planners (Friedmann, 1993). Since 2000, several democratic countries have ordered their planning authorities to use public consultation. This demand follows the "democratic principle that those affected by planning outcomes should be directly included in the decision-making process" (Jankowski, Czepkiewicz, Młodkowski, Zwolinski, & Wójcicki, 2019; Kahila-Tani, Kytta, & Geertman, 2019). However, the legal requirements in these countries that enable consultation and nominal participation of individuals do not guarantee that the participation can be considered substantive or meaningful (Brown & Kyttä, 2014). Therefore, it is argued that this traditional, institutional approach favors active minorities and special interest groups, while the silent majority is underrepresented.

1.1 Developments in participatory mapping

Adjustments or additions to the traditional approach are desirable to make public participation more substantive and meaningful. These adjustments should no longer bypass and underrepresent the silent majority. Since 2010, participatory mapping has emerged as a method to bridge the communication gap and improve public participation, as it focuses on both the experts and the public (Maptionnaire, 2018a; Zolkafli, Liu, & Brown, 2017). Within this participatory mapping method, three concepts come forward: Participatory GIS (PGIS), Public Participation GIS (PPGIS), and Volunteered Geographic Information (VGI). These concepts aim to map relatively subjective experiences and are often referred to as softGIS. Here, the qualifying term "soft" refers to the subjective and qualitative nature of the attributes, in contrast to the "hard" spatial data layers usually associated with GIS.

1.1.1 PGIS and PPGIS

Both PGIS and PPGIS aim to involve communities and individuals into urban or rural planning processes (Brown & Kyttä, 2014). Nonetheless, they differ in the context they have been developed for and applied in. PGIS is primarily used in developing countries to investigate which key stakeholders, such as community leaders, are sampled in the mapping process. In contrast, PPGIS originates from already developed countries in which digital, web-based mapping methods are used to improve public participation processes. This method results in better-informed management decisions and improves the quality of planning (Brown & Kyttä, 2014; Kahila & Kyttä, 2009). Considering this, PPGIS is deemed more suitable for developed countries, such as the Netherlands, with sufficient digital infrastructure to harness spatially explicit information.

Public Participation GIS is a term originating from the USA (Aberley & Sieber, 2002). Its characteristics are summarized by Brown & Kyttä (2014): "The process emphasis is on the enhancement of public involvement to inform land-use planning and management, by urban and regional government planning agencies in developed countries. The quality of the mapped data is of primary importance as digital mapping technologies use an active, probability-based sampling approach. With data collected from individuals or households and owned by the governmental agencies." PPGIS has the "ability to turn regular people into experts of their living environment" (Maptionnaire, 2018b), as it enables them to select locations that are valuable to them.

However, the success of the integration of PPGIS tools in the planning process, as well as its capacity to bridge the knowledge divide between experts and the public in development planning, is strongly dependent on three factors: representability, quality of information, and applicability (Kahila-Tani, Broberg, Kyttä, & Tyger, 2016). Representability is the ability of the planners and process to reach and get a response from a correct representation of the public within and around the project area (Brown & Kyttä, 2014). Therefore, achieving a representative sample and collecting information from all groups improves general public acceptance of the proposed plans. The quality of information is related to the ability of the PPGIS to process the gathered data into qualitative and accurate information for the planners to use (Brown, Weber, & De Bie, 2015). This ability is closely linked to the applicability, which indicates which variables can be accurately derived from public participation and how these variables can be applied when land-use planning decisions are made (Brown & Kyttä, 2018; Santos, Gomes, & Santos, 2018).

1.1.2 Volunteered Geographic Information

At the same time, the emergence of Volunteered Geographic Information (VGI) as a new approach is equal to PGIS in terms of speed, scale, and representation (Verplanke, McCall, Uberhuaga, Rambaldi, & Haklay, 2016). It is another form of citizen-derived geographical information, described by Goodchild (2007) as: "the harnessing of tools to create, assemble, and disseminate geographic data provided voluntarily by individuals." Successful implementations of VGI data collection are already present in programs such as OpenStreetMap. Furthermore, Bijen, Toppen, Poll-van Dasselaar, & Geertman (2016) integrated VGI and 3D geo-information tools into PPGIS environments. They found that allowing citizens to place comments or ideas on a 2D map led to a better understanding of the plan(s) and a better representation of the citizen's environment. According to Marzuki (2015), this can improve communication with citizens.

1.2 Problem analysis

Prior research identified a need to bridge the gap between experts and the public regarding land-use planning in the Netherlands. The gap exists due to expert planners deeming information provided by the public to be unstructured or subjective and therefore irrelevant. While on the other hand, poor communication by the planners towards the public leads to a lack of public trust and a low acceptance of (land-use) plans. Therefore, a method needs to be found to harness the knowledge of the crowds and convert it into structured, relevant information. A solution proposed is the integration of web-based Public Participation Geographic Information Systems (PPGIS) tools into the traditional land-use planning and management to increase public participation and enhance the decision-making processes. The PPGIS tool gives inhabitants, as stakeholders, the opportunity to value their neighborhood on crucial aspects while formulating their concerns or suggestions and pinpointing the corresponding locations on a map. This volunteered geographic information will then be available to land-use planners in the before-design study of new (re)development plans and initiatives.

1.3 Research questions

From the problem analysis, the following main research question comes forward:

"How can PPGIS improve public participation in Dutch land-use planning?"

To answer this research question, several sub-questions need to be answered first. These sub-questions all describe one essential aspect of the main question. They are therefore closely linked to the key determinants of successful integration of PPGIS: applicability, representability, and information quality (Brown, 2015; Brown & Kyttä, 2014, 2018):

1. Which PPGIS variables are most valuable to include in land-use planning?
2. How can these PPGIS variables be measured?
3. How can issues perceived by the public be structured into useful information for planning experts?
4. How can PPGIS be integrated into the Dutch land-use planning system?

1.4 Research design

This report follows the research structure as presented in Figure 1. This structure has three columns that interlink at several sections. Each column is related to one of the core determinants of successful PPGIS integration: applicability, representability, and information quality and covers one (or more) of the sub-questions. Sub-question 1 aims to find the PPGIS variables deemed most applicable and important to be included in Dutch land-use planning by both the public and the planning experts. By first investigating the origins and use of PPGIS in prior research, an inventory is made of the used variables. This inventory is then gradually narrowed down by consulting relevant research and analyzing existing Dutch surveys. Prior PPGIS studies are also consulted to answer sub-question 4, which covers the potential applications for integration into the current Dutch participation system to achieve a sufficient level of representation. The last part of the literature research investigates how recent developments can improve these earlier applications and which challenges remain. The potential for integration in the Dutch public participation process, as defined by sub-question 4, is used to design a pilot study. This pilot study aims to answer sub-questions 2 and 3, regarding information quality, by measuring the most applicable variables from sub-question 1. The pilot also uses recent developments in PPGIS application to structure issues perceived by the public to a sufficient level of information quality. Last, by combining these findings and results, this research aims to showcase a method in which PPGIS can improve public participation in land-use planning in the Netherlands.

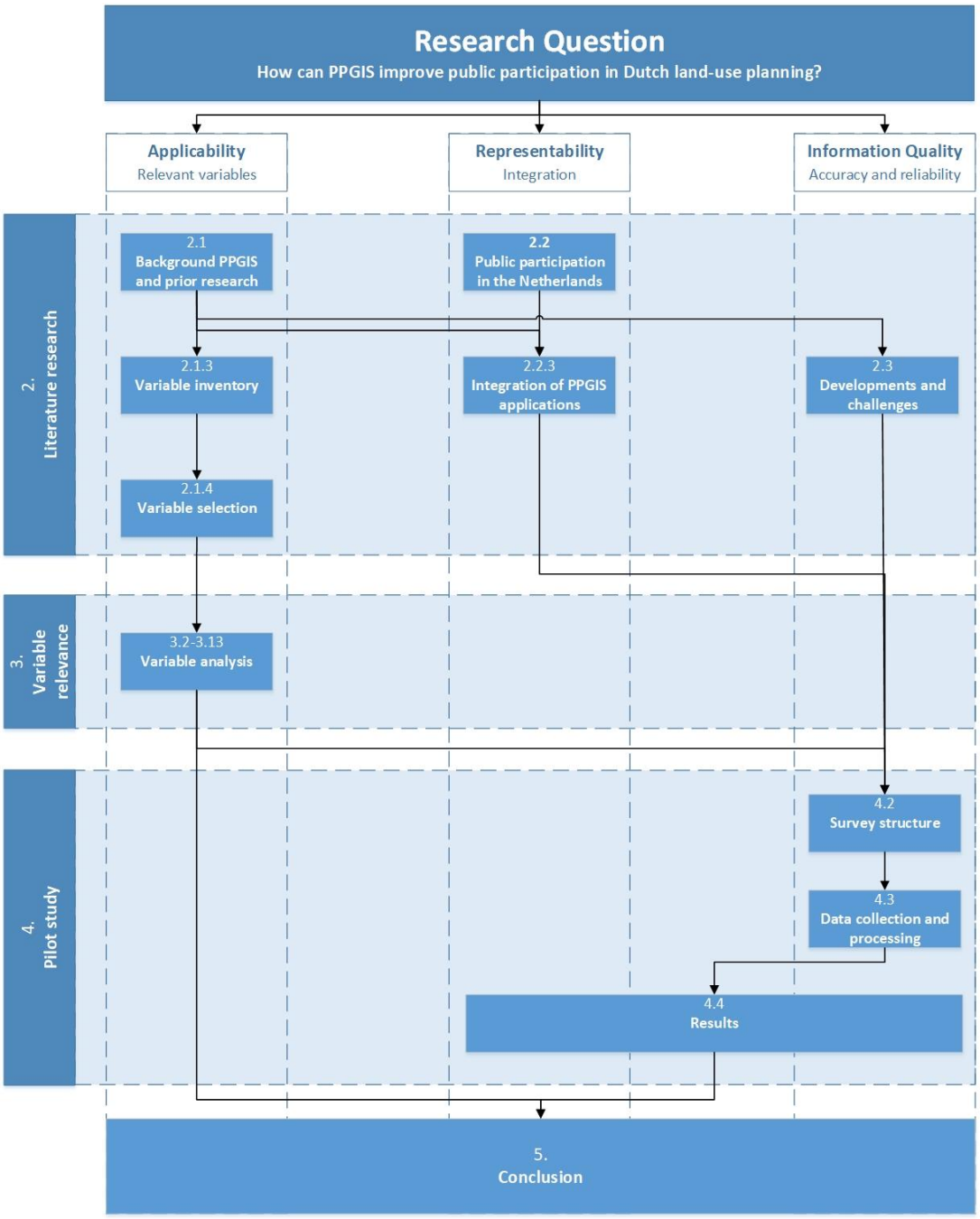

Figure 1: Research design and report Structure

1.5 Reading guide

As shown in Figure 1 the report proceeds with the literature research, in which an inventory is made of the variables used in prior research. This inventory is subsequently narrowed down based on the number of appearances of variables in relevant and applicable literature research studies. A section on the public participation process follows this section, which includes a description of the acts to which it is subjected. Then, chapter 3 continues with a variable analysis to identify the variables that were found to be most relevant and deemed to be important by (Dutch) residents. Chapter 4 then presents the set-up and results of a pilot study, in which these variables are used to measure residents' neighborhood satisfaction and find location-specific experiences. Respondents also stated their willingness towards public participation. Chapter 5 combines the findings of the previous chapters to answer the research questions set in section 1.3.

2. Literature research

This literature research consists of three sections, each covering one of the key determinants of successful PPGIS integration, thereby a foundation to achieve the research objectives is laid, which aids to answering all research questions set in section 1.3. Section 2.1 answers the first steps for sub-question 1 regarding the applicability, which PPGIS variables are the most valuable and applicable to be included in the public participation process. The results are analyzed further in chapter 3. Section 2.2 focuses on sub-question 4, representability, by charting the current land-use and redevelopment planning process in the Netherlands. Moreover, subsequently investigating how to integrate PPGIS in this process, such that all inhabitants have an equal chance of representation. Last, section 2.3 investigates how recent developments can improve information quality and what challenges remain for existing PPGIS approaches. This information is then used in chapter 4 to answer sub-questions 2 and 3.

2.1 Which PPGIS variables are most valuable to include in Dutch land-use planning?

As mentioned above, sub-question 1 centers around the opinions of both planning experts and researchers regarding public participation variables they find most important and should, according to them, be included in the land-use planning and decision-making process. This question will be answered by a three-step approach, as illustrated in Figure 2. Subsection 2.1.1 explores the origins of and the historical approaches towards PPGIS to increase the understanding of the applications, the contexts, and usage of PPGIS variables. Subsection 2.1.2 then consults the literature on the variables and methods used in previous PPGIS research and existing Dutch databases. These variables are combined in the inventory of subsection 2.1.3, which completes the first step. Subsection 2.1.4 then covers step 2, which selects the variables from the inventory used and deemed relevant by multiple studies.

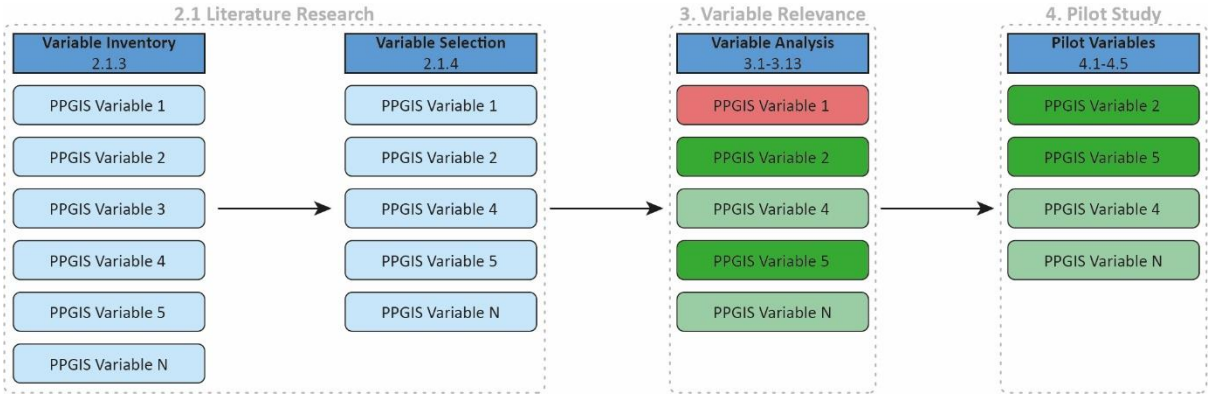

Figure 2: Three-step approach for sub-question 1

2.1.1 The origins of PPGIS

Originally, perceived landscape values were introduced in the United States to aid forest planning and subsequently developed for integration into other public areas (Brown & Kyttä, 2014). These landscape values were frequently applied to a relatively large geographic scale by combining perceived values with physical attributes. These relationships were then extrapolated to other, similar landscapes of which data was not readily available and to find essential land-uses and covers (Brown, 2013; Brown & Brabyn, 2012). However, "the mapping of the landscape values (…) is necessarily application-dependent because landscapes vary by size, scale and attribute of interest" (Brown, 2008). So, the operational definitions of the values should be adaptable for the planning application. Using landscape values to find (nature) areas essential to the ecosystem and inhabitants' satisfaction and should therefore not be significantly altered in their land use. Furthermore, optimizing the inhabitants' satisfaction with other areas can improve or expand specific landscape attributes to fit desired needs. Last, in case of complete neighborhood redevelopment, attention to specific landscape attributes can be given to aligning the preferences to the new neighborhood's desired demographic.

Development preferences were initially developed for tourism planning but have now achieved standardization. However, a degree of customization is inevitable for each application, depending on the landscape, scale, participants, and application needs (Brown & Kyttä, 2014). For example, wind and other energy developments are irrelevant for small-scale urban land-use plans, and the same applies to tourist accommodation in neighborhoods without touristic value. On the other hand, using development preferences to investigate whether inhabitants feel they have access to sufficient facilities. Its usage can also indicate whether respondents are satisfied with the land-use mix, for example, by allowing more high-rise buildings or changing the percentage of commercial surface areas in general. Other variables or factors can then answer the detailed fill of this change. The experiences of the respondents are probably the most relevant in urban-specific applications. By using these applications, inhabitants' experiences become quality factors of their living environment. These factors can almost directly be used as PPGIS variables and applied in land-use planning. The factors can be perceived regardless of the experienced environment, context, and scale.

A study by Brown & Kyttä (2014) performed a synthesis on the critical issues, and research priorities for PPGIS composed a list of the used spatial attribute definitions in the different PPGIS studies. They Divided the attributes into three categories: landscape values, development preferences, and experiences, as visible in Appendix I. This last category contains general, social, atmospheric, emotional, and aesthetic experiences. However, not all these variables are equally valuable and applicable for every location and neighborhood. Therefore, research needs to be conducted to the applicability of these variables to any specific area before results can be derived.

2.1.2 PPGIS variables in prior research

The first step in this analysis is to inventory the used variables in prior research, which is investigated for relevance and applicability in the variable selection. Brown & Kyttä (2014) studied the key issues and research priorities for PPGIS by conducting a synthesis of forty empirical studies. One of the fields of application discussed is the measurement of spatial attributes in participatory mapping (Brown & Kyttä, 2014). Therefore, this synthesis is used as the starting point of the variable inventory and complemented by the perceived variables from more recent literature and research conducted in the Netherlands.

Within the synthesis, two fields of application are distinguished: environmental planning and urban-specific applications. The adopted attributes and definitions within the field of environmental planning can be sub-divided into the areas of: "development preferences, national park experiences and perceived environmental impacts, climate change risks, transportation corridor qualities, urban park, and open space values, knowledge of landscape conditions, recreation resources, and ecosystem services" (Brown & Kyttä, 2014). The urban-specific applications include areas as: "environmental experiences (…), environmental affordances, everyday mobility and behavior patterns, (…) perceived

safety (…) and urban development preferences" (Brown & Kyttä, 2014). Within the current research, the urban-specific applications areas are the most relevant, as well as the urban parks and open spaces. Therefore, all consulted studies for the data process, classified within these relevant areas (see section 2.1.2.1) and the variables they used, see Appendix III. Subsequently, section 2.1.2.2 pursues this by investigating PPGIS studies performed in the Netherlands. Section 2.1.2.3 then adds to the inventory by consulting existing Dutch surveys on land-use planning and neighborhood satisfaction. Lastly, 2.1.2.4 presents the final selection.

2.1.2.1 Synthesis of used land-use variables and data collection methods

This subsection consults the relevant sources within the synthesis by Brown & Kyttä (2014). It emphasizes the used variables and the method by which the data was collected and processed, their relevance, and the results found regarding land-use planning. The order of the consulted studies is in line with the third row of Appendix III, grouped per research area.

Urban park and open space values

In 2008, Brown studied park values in Anchorage, Alaska, USA. The study used spatial data collected in a public survey, in which respondents placed dots on a map, associated with landscape variables. Three dots could be assigned per variable, resulting in a total of 1908 dots from 259 respondents. On average, Recreation is dominant (25.9%), followed by Natural (12.8%) and Wildlife (12.9%). Also, the more 'urban' the park, the greater the social/cultural variables, the reverse applies for the variables: Natural, Wildlife and Environmental Quality. Next to this, Scenic / Aesthetic received relatively high valuation in parks with outstanding views. The study concludes: "residents indicate a relatively strong relationship between park size and the diversity of park values and a weak, inverse relationship between distance from domicile and diversity of park values" (Brown, 2008). Within the context of the research and applicability towards Dutch land-use planning, a couple of issues need to be addressed. First, the research by Brown (2008) investigates park variables in Anchorage, a relatively low-density area compared to the Netherlands. Second, the focus of this research is on perceived park variables, whereas land-use planning also includes urban variables. Therefore, not all landscape values are equally applicable. The study concludes with the advice to prioritize larger but fewer parks placed nearby high-density living areas, over multiple small ones, as larger parks are often associated with various values at the same time.

In 2014, Brown, Schebella, & Weber applied internet-based PPGIS to examine the spatial distribution of physical activities and social, environmental, psychological and physical benefits in different park types in Adelaide, Australia. The authors aimed to find: which physical activities and park benefits are associated with different park types and whether some park types provide more health benefits to the community; whether the diversity of physical activities and park benefits differ per type; and how physical activities and park benefits are distributed based on park size and distance from home (Brown et al., 2014). In total, 242 respondents provided 5,469 mapped attributes for the spatial analysis. The online PPGIS data collection started with the opening screen to request an access code, followed by an informed consent screen. Afterwards, respondents were shown a Google Maps interface, in which 'icons' could be dragged and dropped. The icons related to physical activities, potential benefits, and potential actions to adapt to climate change. The respondents could place the icons on map locations where they engaged in the corresponding activity or enjoyed the attributed benefit. The participants completed a survey on their park use, self-reported personal health characteristics and socio-demographic information. This survey information was connected to the attributes, which was then connected to the location of the park (type). A significant association was found between park type and activity intensity. The largest percentage (59.9%) of high intensity activities was associated with parks with a linear lay-out, while the largest percentages of low intensity were associated with community (39.6%) and neighborhood parks (22.7%). Also, relations between park size and the total number of benefits and diversity of park benefits were found (Brown et al., 2014). These relations indicate that larger parks were associated with more diverse benefits, and higher intensity activities.

In 2007, Tyrväinen, Mäkinen, & Schipperijn published an article in which a systemic approach to collect perceived social values by residents in urban green areas was tested in Helsinki, Finland. The main research questions were: what kind of green area benefits are important to people; and how can these benefits be identified and linked to areas for planning purposes? The data of 1,000 randomly sampled residents, aged 15-75, was collected by postal survey. More than eighty percent of the respondents indicated green areas to be very important to the quality of their living environment; with recreation, nature, stress-relief and aesthetics mentioned as the most important benefits. In general, environmental deficits such as pollution, noise and shade were considered slightly less important than the social benefits. In terms of residents' opinions on management of the green areas, it was found that suburban areas should be kept green and sparsely built in the future, some green areas should be in natural state and city compaction should not take place in current green areas.

Social value maps were created to connect the perceived benefits to the existing green areas, which could be combined in a synthesis map, see Figure 3. The values in this map are listed in Table 1. The values relate to the variables: recreation, aesthetics, and nature.

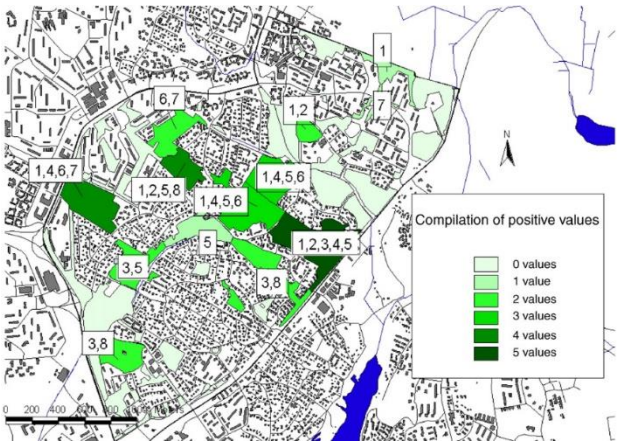

Figure 3: Synthesis Map by Tyrväinen et al. (2007)

The method aims to enable communication of green area values of otherwise silent groups. It starts with a paper map with pre-identified parks and green areas by a planning expert, on which the respondents can then attribute several positive and negative values. The resulting data is then processed by use of SPSS, and subsequently imported into QGIS. The maps show areas with existing qualities that should be sustained, as well as development areas where values are missing. When this is applied in land-use planning, the results show highlights of green areas that should be protected from being developed for other land-uses. The study concludes that social variables can be made visible in a GIS layer and used for city planning, as long the data is recorded systematically.

Table 1: Values used in synthesis maps

Value Number	Values Description	Values mentioned
Positive Values		
1	Beautiful landscape	72%
2	Valuable nature site	62%
3	The feeling of forest	70%
4	Space and freedom	71%
5	Peace and quiet	66%
6	Attractive parkland	23%
7	Opportunity for activities	78%
8	History and culture	44%
Negative values		
1	Noisy areas	54%
2	Unpleasant areas	50%
3	Scary areas	33%

In context of the current research, it is necessary to note that this study covers park land-use only, instead of multiple land-uses. However, the method that is used to make social value maps can also be applied on sections within neighborhoods and housing land-uses.

Environmental experiences

Kyttä, Kahila, & Broberg (2011) studied the perceived 'quality factors' of residents, where the factors are located, their accessibility and how they are affected by the structural characteristics of their urban settings. To achieve this, a social science approach with focus on environmental psychology theories was applied in a chain of four empirical studies in the urban environments around the Helsinki Metropolitan Area. With advertisements in local newspapers, libraries and city webpages, inhabitants were encouraged to participate in a user-friendly internet-based questionnaire. In total, 1,542 respondents from varying degrees of urban density were studied. A GIS-based query method, softGIS, was developed to collect and study the location-based perceived environmental qualities. This application, consisting of ten steps, enables the gathering of data on the organization of respondents' every-day lives, their behavior in their physical environment and which experiences they have on specific places. This method also allows decision- and policymakers to include questions on perceived environmental quality as input to urban policymaking.

Figure 4 presents the relationship model between the urban density and the experienced quality, and the variables playing a part in that model. Safety and crowding were found to be important factors to perceive densely build areas as poor (Kyttä et al., 2011). At the same time, mobility and a community feeling were important factors to a high perception of the densely built area. Aesthetic values were found to be important, regardless of the level of urban density, whereas restoration and the accessibility to physical activity were more important factors in sparsely build areas. Furthermore, the most frequently mentioned positive-quality factors were safety, peacefulness, child friendliness, tidiness, and closeness to nature. The most dominant negative qualities were restlessness, annoyance with traffic, insecurity, and untidiness. Other conclusions of the study were a strong association between low urban density and a high perceived quality of environment. Kyttä et al. (2011) also found the inhabitants willing and capable enough to evaluate their own living environments, but did only rarely mention quality factors related to locations far away from their homes.

The most applicable findings from this study concern the methodology of the research and the relations applicable in each of urban density categories. The softGIS methodology enables willing inhabitants to share their knowledge and experiences to transform them into useful information for urban planners.

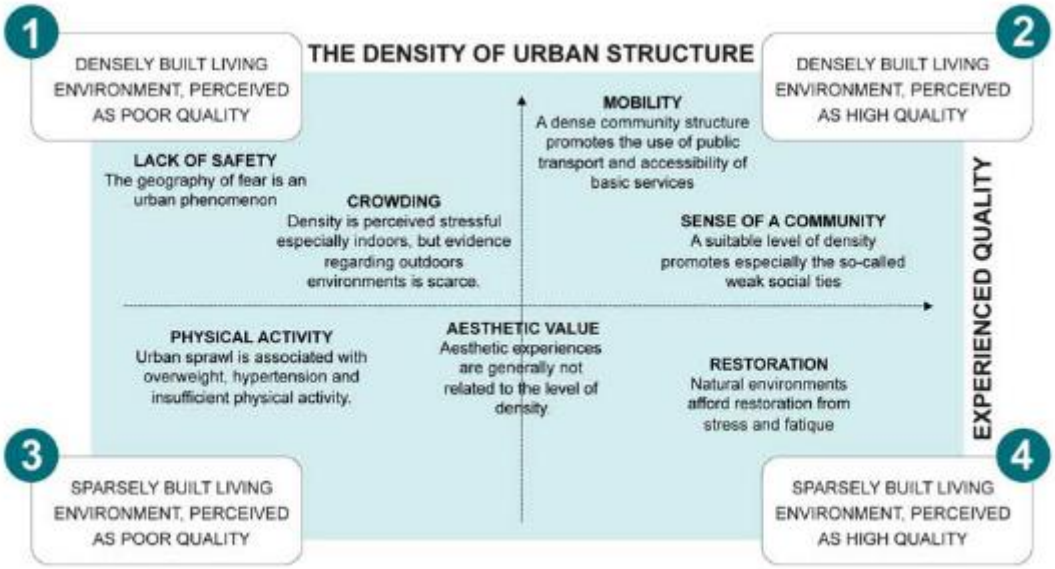

Figure 4: Fourfold model relationships between urban density and experienced quality (Kyttä et al., 2011)

Kyttä, Broberg, Haybatollahi, & Schmidt-Thomé (2016) aimed to study the social sustainability of urban environments in a context-sensitive manner, identifying the specific ways urban structural characteristics contribute to the behavioral, experimental and well-being outcomes. Data from 3119 respondents was gathered using an online PPGIS methodology, allowing places-based study of urban and suburban contexts in Helsinki, Finland. Structural equation modeling was then used to assess the contextual variation and the mediational role accessibility and perceived environmental quality linking urban structural characteristics to well-being outcomes. To allow for this context-sensitive approach, the conceptual model of social sustainability as presented in Figure 5 was designed. The model contains three different levels of sustainability.

- Bridge: explores active ways to change and promote eco-friendly behavior or stronger environmental ethics.
- Maintenance: focusses on the traditions, habits, preferences, and locations that people perceive as meaningful and worth maintaining or improving.
- Development: emphasis on how build environment contexts meet inhabitants' basic needs, such as health, housing, and education.

Figure 5: Conceptual model of social sustainability

This conceptual model is then further refined into the model of Figure 6, in which urban density and green area proportion are used as the urban characteristics. The scopes of quality and everyday networks are variables for accessibility. Perceived environmental quality is defined as a function of appearance, atmosphere, as well as social and functional quality.

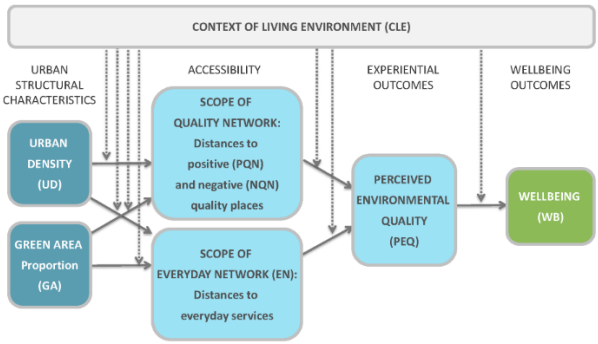

Figure 6: Structural model

The following conclusions were derived from the results of the study: in urban contexts, the perceived quality of the environment moderated the effect of the distances to everyday services on well-being. People were more content to travel further to everyday facilities, if the environment they travel through was experienced as pleasant. In sub-urban context, the quality mediated the effects of urban density on well-being. So, a higher density can be achieved whilst maintaining the same level of well-being, if the variables of perceived environmental quality are improved.

The results of this study provide insights in the interaction between the perceived environmental variables of respondents and the structural urban characteristics of a neighborhood. Furthermore, relations between the perceived variables and those regarding accessibility were found. However, the study emphasizes that the results are context-dependent on the population density, so the degree of population density or urbanization should be considered when the results of this study are applied to a different context.

Kyttä, Broberg, Tzoulas, & Snabb, (2013) aimed to design context sensitive, urban consolidation or densification planning strategies, to help finding unique solutions to restraining conflicts between planning experts and local residents. These conflicts exist due to resistance by local residents, who fear that densification policies will diminish the environmental qualities of their neighborhood, without receiving sufficient added value in return. A web based survey was conducted which helped to define the inhabitants' quality factors, a form "of PPGIS that allows the study of inhabitants' location-based experiences" (Kyttä et al., 2013). It is stated that the localization of inhabitant experiences is crucial to the applicability of social scientific knowledge to urban planning. This approach offers several benefits:

- "Researchers can produce usable, cartographic information for the planning sector, where maps and map-based tools are embedded in the culture and practices.
- The localization of residents' experiences and behavioral patterns attach them to specific design or planning solutions, which allow the production of ex-post evaluation information for urban planners.
- The geocoded 'soft', experiential knowledge gathered from residents can be simultaneously analyzed with the 'hard' register-based GIS data, which provides new, location-based research possibilities.
- The usefulness of localized information is not restricted to the planning sector because most information in policymaking contains a spatial component.
- Map-based data visualizations offer a good way to increase public debate".

Furthermore, it is argued that this "transactional person-environmental research anchors individual experiences and behavior strictly within the physical, social and cultural context in the time and place in which they occur" (Kyttä et al., 2013). This place-experience approach is accused of its primary focus on perceptions without paying much attention to the physical environment. Therefore, the role of the physical environment in person-environment research is also considered. It is emphasized that the visualization of affordances – "what the environment affords for a certain actor in a given context" - is one of the key objectives of planning experts, and by extension whether the affordances of spaces are being actualized for the users. The affordances perceived in the study are grouped in four categories: social, function, aesthetic, and atmosphere qualities (Kyttä et al., 2013). According to prior research by Bonaiuto, Aiello, Purugini, Bonnes, & Ercolani(1999), atmosphere was the most important, whereas function was found to be the least important quality. The authors highlight that location-based knowledge of residents' perceptions is both a theoretical and methodological challenge. However, "recent developments in GIS and particularly PPGIS create new possibilities for advances in location-based methodology development" (Kyttä et al., 2013). PPGIS improves accessibility for 'lay' persons and supports communication between stakeholders.

The PPGIS/softGIS method employed by the research gathered information on localized, perceived quality of residents, places of happiness, local services, perceived well-being of residents and suggestions for environmental improvements. The online questionnaire proceeded in a stepwise approach, so all respondents followed the same path. The respondents picked between address maps and aerial photos when using the mapping tools. Subsequently, point, areal and route information could be marked on a map. Afterwards, if the respondents had answered to the background question regarding their home neighborhood, the map auto centered on it to aid orientation. Last, respondents could pick one of the quality categories and mark an area on the map where this quality was perceived. In total, the respondents reported 10,324 locations, of which 62.8% were positive. It was found that many place locations overlapped, so therefore a grid-overlay was added. This visualized the density and the positive percentage of actualizations in an area, see Figure 7.

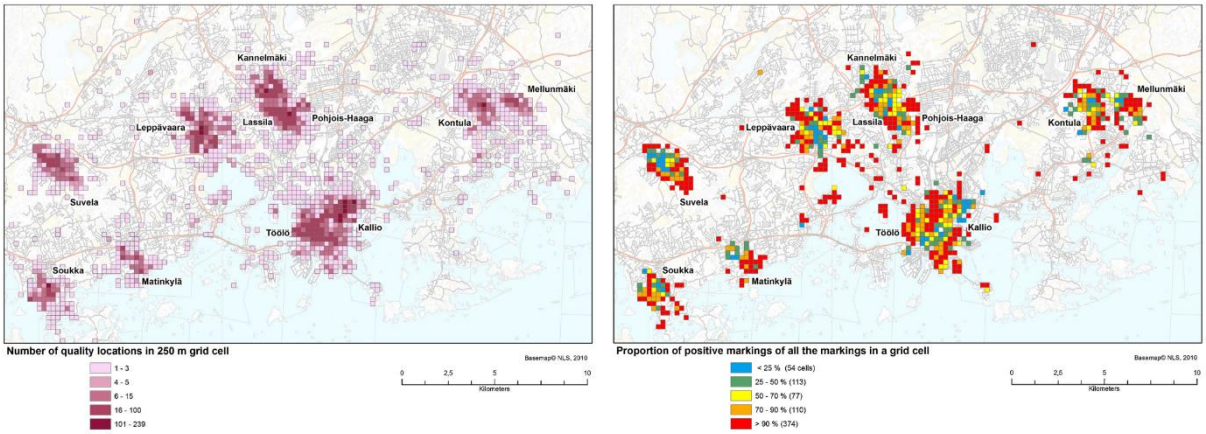

Figure 7: Density(left) and percentage of positive(right) quality locations on grid overlay, used by Kyttä et al.(2013).

The research concludes this approach to be a welcome addition to the existing repertoire of planning and participation methods, as it can attract respondents who are usually underrepresented, especially in urban densification projects. Even though the gathered data is not perfect, the scientific approach at least enables evaluation of the data quality. Another conclusion drawn from this research is to conduct the survey before any actual plan is drawn, to minimalize 'nimbyism' – the habit of protesting against something that impacts one's (locality) - and thereby improve reliability and validity of the findings.

Kyttä, Kuoppa, Hirvonen, Ahmadi, & Tzoulas (2014) used a location based PPGIS approach to measure perceived safety in retrofit neighborhoods, which are areas that are suitable for redevelopment, part of urban infill projects. The approach aimed at providing insights to prevent overly simplistic or deterministic thinking in safety planning, by conducting a case study in Espoo, an urban redevelopment area near Helsinki, Finland. The following categories of perceived safety are considered: fear of crime, scary people, traffic safety and accident safety (Kyttä et al., 2014). The research contained 303 respondents placing 2920 location points, of which 347 of scary people, 282 with fear of crime, 249 with traffic danger and 72 with accident danger.

Three approaches of neighborhood safety planning are considered the conventional segregated approach, which centers on target-hardening, installing barriers to crime and reducing escape routes. The integrated approach for neighborhood safety, promoting "diverse and mixed land-use patterns, to attract more people (…) to make streets more lively and safe" (Kyttä et al., 2014). However, both these approaches are focused heavily on physical attributes, whereas 'the social constitution of fear' approach places perceived safety and fear in a broader "social and geographical context, social relations and power structures" (Kyttä et al., 2014), encouraging location-specific safety planning measures. Comprehensive strategies and projects are advised to be performed in a communicative process of continuous community development with residents and new stakeholders, both public and private (Kyttä et al., 2014).

Similar to the research of Kyttä et al.(2013), the current research uses a grid raster GIS overlay to visualize the density of location points. It also provides the possibility to make a layer for each perceived danger type to see differences in prevalence of specific variables.

Environmental affordances

Kyttä, Broberg, & Kahila (2012) used logistics regression analysis to "determine the relationships between urban characteristics, children's environmental experiences and active behavioral patterns, and perceived health and BMI (Body Mass Index)". The urban characteristics are based on the geographical locations entered by the children, their home address, and special locations. A half kilometer radius is then added with softGIS to calculate the proportion of green structure, the residential density, and the age demographic of the population. With this methodology, the study concluded that moderate density promotes active school journeys and shorter distances to meaningful places. The children show similar patterns as adults in locating significant places close to home (over 50 percent within 500 meters) (Kyttä et al., 2011). Interestingly, a negative association was found between the percentage of green and both active school travel and the territorial range. The greener the living area, the more trips are undertaken either under supervision and/or by car.

The research by Broberg, Kyttä, & Fagerholm (2013) continues on the previous study by further investigating the association between urban density and children's independent mobility to their special places. The research sample contained 12,000 locations with affordances. These affordances were combined with objective GIS data on building density and quantity of green. This resulted in the conclusion that moderate urban density (30 housing units per hectare) promotes independent mobility amongst children. Furthermore, independent travel is more likely to take place in residential areas, compared to urban cores. Opposite to previous research, no relation between the amount of green and independent mobility was found. The largest diversity of affordances was found in densely populated areas without green, however green areas are important for neighborhood satisfaction.

Last, Broberg, Salminen, & Kyttä (2013) aimed to find urban structural characteristics that promoted physical activities to special places, identified by children themselves, similar to the topics of their previous research (Broberg, Kyttä, et al., 2013; Kyttä et al., 2012). Data was collected with a similar web based PPGIS method. However, this research did not use a grid-overlay to process their density of location inputs. Instead opting for a visualization in which a hollow circle is shown for each location, and this circle can be colored based on the variable and option that is attributed to it. From the results, it was concluded that urban areas featuring mostly single-family housing promote independent and active travel, whereas dense urban areas only promote independent travel.

Conclusion

From the relevant studies featured in the synthesis by Brown & Kyttä (2014), a number of lessons can be derived. First, it is important to note that most of the relevant surveys are conducted in Helsinki, Finland, by Marketta Kyttä. Therefore, not all findings may be equally relevant in the Netherlands. However, the literature research has provided a number of research methods, data collection and data application approaches that proved to reliably produce GIS layers of subjective variables from knowledge and experiences provided by the public. The structures of these approaches are summarized in Appendix II. Most of the data collection methods use (local) advertisements, community gatherings or voluntary panels to encourage residents to participate in internet-based questionnaires. These questionnaires often start with a small description of the research and what can be expected of the questionnaire. This is often followed by questions on personal characteristics, socio-economic background, and preferences, which allow checks for sample representatives and differences between the groups. Afterwards, some researchers asked their respondents to locate their homes on a map, similar to Google Maps, as people are accustomed to that. Respondents are shown a map with pre-selected areas by the researchers/city planners or are asked to locate areas important to them. Subsequently, they are asked to pick their associations to these places from a list of pre-selected variables, and are sometimes allowed to provide written explanation. At the end of the questionnaire, the respondents are thanked for their cooperation, can provide feedback on the questionnaire and/or subscribe for a lottery. This general questionnaire structure can be useful in the pilot, if specifications are made to the context and scale.

2.1.2.2 PPGIS variables in the Dutch research

Hilbers, Sijtsma, Busscher, & Arts (2021) developed a 'Place Value identifier' (PVI), which is a web-based value-mapping tool. This tool, designed for road infrastructure and spatial development projects, allows the developers to relate 'soft', PPGIS-identified, valuable places with 'hard' land-use data, in order to find and illustrate valued but unprotected places (Hilbers et al., 2021). By using public knowledge to find these places, planners can develop project alternatives which may enjoy higher public acceptance. The theoretical background reinforces the previous statements that PPGIS methods are becoming increasingly popular due to its ability to engage stakeholders (Hilbers et al., 2021) and to "capture spatially explicit information on intangible landscape values that can be integrated with existing planning approaches" (Ives et al., 2017). In the PVI, each Place Value (PV) is composed of the answers to: 'where?', 'what?' and 'whose?'. 'Where?' is a mapped feature (point, polyline or polygon) at a spatial location, 'What?' is an indication of an action (maintain, connect, strengthen or improve) that is desired, and 'Whose?' is the respondent's sustainability value profile. This profile is created by the respondent by dividing 100 points amongst the twelve sustainability values in the Sustainability Check (Dutch: Omgevingswijzer) (Rijkswaterstaat, 2021). So, all reported PV's from one respondent have the same participant profile (Hilbers et al., 2021).

The 'hard' GIS layers are taken from the Bestand Bodemgebruik 2015 (BBG2015) dataset (English: Land-Use File 2015), which contains the digital geometry of land-use in the Netherlands, containing layers on traffic, buildings, recreation and more (Centraal Bureau voor de Statistiek (CBS), 2021).

Data collection

The data was collected from 1044 respondents with an online survey (Hilbers et al., 2021). The respondents were invited by email to participate via ThesisTools, allowing equal accessibility all over the country, achieving a participation rate of 51 percent. The survey started with a short explanation of the aim of the research and questions regarding their general characteristics (age, gender, education level and postal code). Afterwards, an online map was shown, auto centered on the neighborhood of the previously entered postal code, in which three digital markers could be placed, each referring to a valuable place in their neighborhood. Then, a point, line or area could be drawn for each relevant marker was relevant. The ability to place (poly)lines and polygons on top of the standard, point-based, value mapping, increases its ability to recognize values compared to spanning larger areas (Hilbers et al., 2021). After placement, the respondents could choose one of the four actions: maintain, connect, improve or strengthen. After the mapping, the respondents filled in their sustainability value profile to complete the survey.

Data analysis

The research used descriptive statistics to analyze the personal characteristics of the respondents and their PVs. The spatial distribution was calculated with the Euclidian distance between the respondent's home and the PV, doing so also allowed the researchers to check whether the PVs were close enough to the homes and to determine the distribution over the country. These mapped locations of the 'soft' PVs were subsequently compared to the 'hard' spatial data of the Road Network (Dutch: Nationaal WegenBestand) and the Natura 2000 maps. The valued yet unprotected places were established in four steps with the use of QGIS3 (Hilbers et al., 2021):

1. The national and provincial roads were given a 200-meter buffer.
2. The mapped PVs within the buffers were clipped.
3. All areas that were also present in the Nature map were erased.
4. The remaining areas were identified as valuable yet unprotected places.

The PVs were then categorized based on the literature review by Brown, Reed, & Raymond (2020), who refined the synthesis performed by Brown & Kyttä (2014) (see the Landscape Value Column in Table 38, Appendix I). However, the authors included additional categories: Accessible, Nuisance, Neglected, and Development Potential.

The result of this procedure is shown in Figure 8. All valued yet unprotected places near major roads are categorized over which action is desired and why.

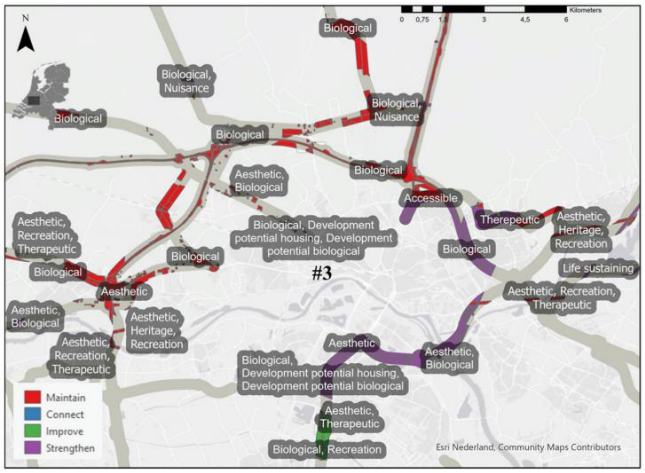

Figure 8: Valued yet Unprotected areas near major roads.

2.1.2.3 PPGIS variables in Dutch databases

Next to the variables derived from general literature, it is important to study the variables already used in the Dutch decision-making processes or public participation, on both national and regional level.

One important national survey to be considered is the WoON2018 Survey, see Appendix IV for an elaboration on its relevance, representativeness, and applicability. In short, the WoON survey is conducted every three years by the Dutch Ministry of Internal Affairs & Crown Relations and the Central Office for Statistics (Dutch: Ministerie van Binnenlandse Zaken en Koninkrijksrelaties (BZK) & Centraal Bureau voor de Statistiek (CBS)) and "is used to research the living quality and needs of inhabitants to support governmental policy-making" (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties (BZK) & Centraal Bureau voor de Statistiek (CBS), 2019). The access to the results of this survey is restricted, but access can be granted for research purposes. The 2018 survey contains data from 67,523 respondents on household composition, current and desired living situation, income and living costs, and is enriched with data from the Dutch Tax Office (Belastingdienst) and the Personal Base Registration (Dutch: Basisregistratie Personen (BRP)) (BZK & CBS, 2019). Several of these questions concern (the importance of) perceived variables. Some of these variables can be directly derived and others indirectly. Examples of direct questions are: "Importance of proximity of Public Transport", "Importance of proximity primary school" and "Importance of proximity of daily groceries". Examples of indirectly derived variables are the combination of the respondent's "satisfaction with the neighborhood" with satisfaction with perceived variables, such as "The buildings in this neighborhood are aesthetic", "I have a lot of contact with people in the neighborhood" and "I am afraid to be harassed or robbed in the neighborhood", which are related to the variables Scenic / Aesthetic, Social Interaction and Safety, respectively. By checking for correlation between general neighborhood satisfaction and satisfaction with specific neighborhood characteristics, an indication of the respondent's importance of the perceived variables can be derived. Other useful questions in this survey are related to reasons why respondents want to move or have moved neighborhood. The answer options provide the following perceived variables: parking issues, maintenance, safety(criminality), nuisance due to noise, lack of green spaces, and lack of facilities. Furthermore, the data contains information regarding respondents' characteristics, such as: age, level of education and country of birth. This allows to check whether different demographic groups value certain variables more than other groups. This information can aid municipal decision-makers in their design of public participation questionnaires for specific neighborhoods, to only ask the most relevant variables for the neighborhood's specific demographics. A full list of the relevant variables is presented in Appendix IV.II.

In 2010, Yucat B.V. developed the BuitenBeter App (English: Outside Better App), this app allows inhabitants to report perceived problems on the spot with a GPS location. The app is available nationwide but communicates with local governments based on the current GPS location or the registered municipality of the reporter. This way, the reported issues are directly communicated with the relevant municipality (or associated/responsible company) to fix the issue. Even though the app's reports are incidents on their own, repeating reports in one area can provide indications to structural problems. This app uses the top eleven reported problems as categories, such as littered garbage, bad road-surface, broken street furniture, graffiti and clogged sewage (Yucat B.V., 2021). Most of these categories fit within the variable 'neglected', as introduced by Hilbers et al. (2021) and the variable 'maintenance', as included in the WoON survey. Therefore, these variables are combined in the overarching variable 'maintenance'.

2.1.3 Variable inventory

Figure 9 presents the inventory of all variables used in the studies and surveys. The studies introduced all variables down to Noise/Nuisance. These variables are complemented with the variables that are already available from existing Dutch surveys and sources. The WoON2018 survey reinforces some variables found in the previous section, such as Social, Scenic / Aesthetic, Natural, Safety and Noise. New variables, such as proximity to Public Transport, proximity of Grocery Stores and Primary Schools, Maintenance and Population Density are also introduced.

From the top ten categories used by the BuitenBeter app, most are related to direct maintenance. Others, such as graffiti and broken furniture can be attributed to the safety variable. However, from those remaining, e.g.: bad road-surface, broken streetlights, overhanging tree branches, loose sidewalk tiles, and weeds are combined to reinforce the variable Maintenance.

Figure 9: Inventory of variables used in (Dutch) research and surveys

2.1.4 Variable selection

In step two, the most relevant variables from the inventory are selected, by consulting the sources that cover relevant areas of application, as presented in section 2.1.2.1. However, some of the variables in Appendix I are grouped due to similarities or overlap in their concepts. For example, 'development preferences' is considered as one variable, instead of the various specific preferences. Also, spiritual, historic, and future are all grouped as special places, while the psychological variable groups elements as: therapeutic, intrinsic, emotional, solitude/escape and intrinsic.

A variable is selected if it is used in four or more of the sources in the literature matrix of Appendix III. A variable is also selected if it is already present in Dutch surveys and databases. Table 2 summarizes the number of sources in which each variable has been used, a full inventory of the variables used by each research can be found in the literature matrix of Appendix III. The selected variables from the inventory for the variable analysis are presented in the right column of Figure 10.

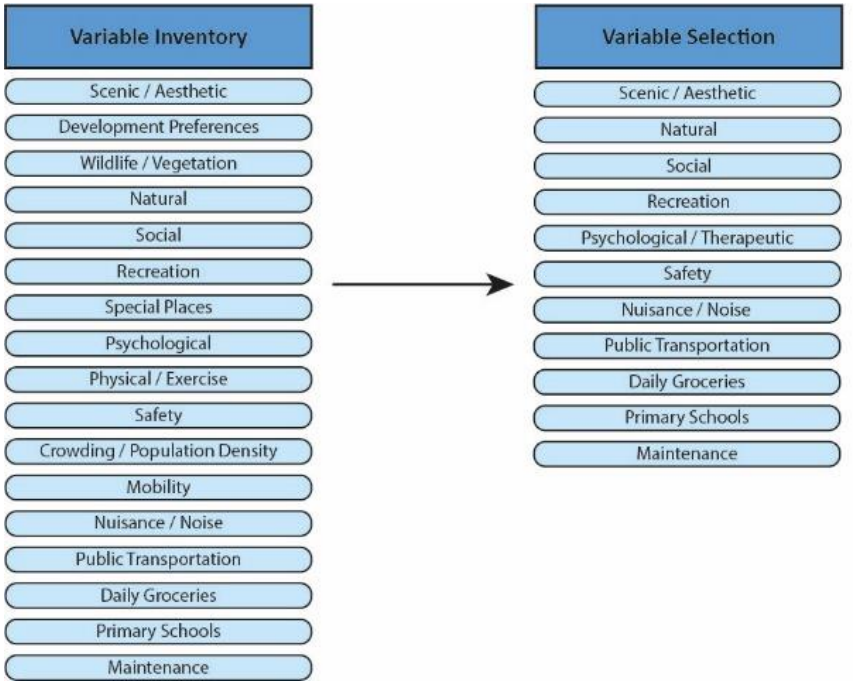

Figure 10: Variable inventory and variable selection

Table 2: PPGIS variable inventory

PPGIS Variables	Total
Scenic / Aesthetic	5
• Appearance	4
• Atmosphere	2
Development Preferences	2
• Economic	0
Wildlife / Vegetation	3
• Wilderness	0
• Marine	0
Natural	5
• Environmental	3
• Biological	0
• Life Sustaining	0
Social	7
• Cultural	2
• Lifestyle	1
• Learning	0
Recreation	4
• Hobbies	4
• Services	4
Special Places	1
• Future	1
• Historic	1
• Spiritual	0
Psychological	3
• Therapeutic	5
• Intrinsic	0
• Subsistence	0
• Solitude/escape	4
• Emotional	2
Physical / Exercise	3
Safety	5
• Traffic Safety	2
Crowding	2
• Congestion	0
Mobility	3
• Public transport	3
• Walking/cycling	2
• Private Car	2
Noise	3

2.2 Land-use planning and public participation in the Netherlands

The second determinant for successful integration of PPGIS is representability, the ability of the planners to design a process which reaches and gets response from a correct representation of the public within and around the project area (Brown & Kyttä, 2014). In other words, how to apply the developed PPGIS tools and found variables, so they can be integrated in the Dutch land-use planning processes with a sufficiently high level of representativity. Therefore, this section aims to answer sub-question 4: How can PPGIS be integrated into the Dutch land-use planning system? Subsection 2.2.1 takes the first step, by investigating the background, developments and applicable acts and regulations in which the land-use planning, and public participation processes are rooted. Subsection 2.2.2 continues by investigating the current public participation forms and corresponding participation rates. It also maps the Dutch land-use planning system within the currently enforced acts and procedures. Subsection 2.2.3 then concludes by introducing methods how PPGIS can be (further) integrated in this process.

2.2.1 Background and legislation of land-use and (re)development planning

In most of the international research, the developers assumed that their model will be used to find 'new' land for their desired functions. For example, to convert 'unused' land to agriculture or housing. In the Netherlands however, such new allocations are (almost) no longer possible, as the municipal and provincial governments have developed land-use plans for nearly all areas within its borders. Unspoiled areas and environments have become scarce since the 1980s (Van der Ploeg & Vlijm, 1978) and are likely to be non-existent past 2020. Another example of the aim of these international developers is the transformation of agricultural farmland to areas for housing. This is no longer common practice in the Netherlands, as transformations from nature or agriculture functions to housing or commercial functions – often to make place for new (urban) development projects – have become increasingly rare. This is a consequence of a change in evaluation approach: from a "mostly monetary cost-benefit analysis" (Van der Ploeg & Vlijm, 1978) to an increasingly complex evaluation, in which "the principles of sustainable development confront land-use planners with a paradox of two contradictory objectives: nature conservation and economic development" (Van Lier, 1998). According to Joerin et al. (2001), this increasing complexity is partly due to increased participation of public actors, as organizations with varying motives try to get their goals met in this public arena. Integration of a PPGIS application in the development of a land-use plan, can streamline the process by bridging the knowledge gap between the public and the experts in this 'public arena' (Zolkafli et al., 2017).

This notion of sustainable development and land-use has become increasingly prominent in the western world, and especially in the Netherlands (Van Lier, 1998). With a quarter of the countries' land mass being under current sea level, including its most densely populated areas, the Dutch government has a high urgency to take the lead in combating the rising sea levels (as a result of climate change) and to secure the safety of its inhabitants living under sea level (Delta Programme | Coast, 2013). A part of the Dutch policy centers around the concept of Multi-Layered Safety (MLS), as introduced in the "First National Water Plan 2009-2015" (Ministry of Transport Public Works and Water Management, 2009; Ribas Palom, Saurí Pujol, & Olcina Cantos, 2017). This was then superseded by the "National Water Plan 2016-2021" (Ministry of Infrastructure and the Environment & Ministry of Economic Affairs, 2015). In context of this MLS policy, the Netherlands has entered a new phase of urban renewal in land-use planning (Holtslag-Broekhof, 2018), in which currently developed areas are redeveloped with new, often high-density buildings (Dutch: inbreiding), or are even given back to nature (Ribas Palom et al., 2017). This is a contrast to policies in some other countries that focus on expanding cities and urban areas, primarily for economic development and associated monetary benefits.

Acts regarding environmental and spatial planning

Land-use and redevelopment planning in the Netherlands is regulated in the Spatial Planning Act, or Wro (Dutch: Wet ruimtelijke ordening). Its main aim is to improve sustainable, spatial quality in the Netherlands (Government of the Netherlands, 2020; Overheid.nl, 2020). These aims and regulations will be continued in the new Environment and Planning Act (EPA; Dutch: Omgevingswet) (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties (BZK), 2020a), which is scheduled to come into effect on the first of July 2022 (Government of the Netherlands, 2021b). With the EPA, the Dutch government aims to merge and simplify its rules for spatial development (Government of the Netherlands, 2021a). It "stipulates that citizens (…) must be able to participate in the early stages of the decision-making process (…), however, is not clear on how public participation will be achieved" (Travaglia, 2019).

The EPA describes how the spatial plans of the national, regional, and local governments are to be formulated at all levels. These decisions outline the expected spatial developments, as well as the manner in which they should be implemented. These expectations are then translated into environmental visions, policy papers that replace the governmental key planning decisions of the national government, regional plans of the provinces, and the structure plans of the municipalities (Government of the Netherlands, 2020).

In the EPA, the environmental plan is deemed the most important spatial planning tool (Government of the Netherlands, 2020). The plans always contain the rules and regulations for an area, it details where and what may be constructed at any place, as well as what its size and use is allowed to be. The rules and regulations come along with an illustrative map that shows and explains the land-use zones (Needham, 2014). If a party has an objection to a proposed or existing land-use plan, the party can take these issues to the municipal council. This council then assesses whether the objection is justified, and the land-use plan needs amendment. If no solution is found, the objector can take the case to the Council of State (Dutch: Raad van State), and if necessary, to the European Court for a final appeal (Borgers, 2019). The Netherlands is part of the European Union and therefore must abide to directives and procedures made by the European Union (EU) and European Committee (EC). These guidelines aim to achieve "economic, social and territorial cohesion" between all EU member states (European Union, 2014) and bring forward strategies for smart, sustainable, and inclusive growth (European Commission, 2010).

2.2.2 Public participation

This subsection investigating the current public participation forms and participation rates in the Netherlands in 2.2.2.1. Then, 2.2.2.2 elaborates the findings of a PPGIS application by Bijen et al. (2016) in Rotterdam, the Netherlands. Last, 2.2.2.3 maps the Dutch land-use planning process within the currently enforced acts and procedures.

2.2.2.1 Forms of public involvement

According to the Dutch Centre for Public Participation & Steinhauer (2012), five forms of public participation, with increasing levels of commitment and accountability, can be distinguished:

- Information exchange, in which stakeholders are informed and may ask questions during public gatherings.
- Consultation, in which stakeholders are invited to comment on proposals, either through formal procedures, surveys or gatherings.
- Advising, in which stakeholders may indicate problems and suggest solutions.
- Joint Production, in which stakeholders of different interests jointly design plans and projects with public officers and proponent.
- Joint decision-making, in which stakeholders jointly design and adopt solutions.

In practice however, the quality and level of innovation of the traditional Dutch participation policies has been rather disappointing, this can be attributed to a number of reasons: "First, the results are

often not specific and lack political weight in the participation process. Second, administrators, civil servants and politicians place emphasis on creating support and participation itself, rather than creating qualitative results. Third, creativity of participants is not stimulated with adequate techniques. Last, there is an incomplete explanation of the organization withing the participation process" (RIVM, 2008). These issues are rooted in a deeper, cultural explanation, in which the experts responsible for spatial planning find their own knowledge and qualities superior, and see therefore no need to ask the public for their knowledge or alternatives (RIVM, 2008).

Since then however, multiple initiatives have emerged to gradually open up this closed culture, gradually integrating first the market and afterwards the social communities (DRIFT, Roorda, Verhagen, Loorbach, & van Steenbergen, 2015). Unfortunately, not all groups within the Dutch society make equal use of the increased number of opportunities for participation. Most traditional forms of participation fail to engage with a group that broadly reflects the population of the research area (Michels, 2019; Uittenbroek, Mees, Hegger, & Driessen, 2019). Notably, citizens with a higher level of education are overrepresented and have more success in all forms of public participation, as they are better able to formulate themselves (Tonkens & Hurenkamp, 2019). Furthermore, younger citizens are often underrepresented, whilst the older age groups are overrepresented (Uittenbroek et al., 2019). Also, those who are unable to speak the dominant language, are often less likely to participate, as they either feel excluded or do not feel that they can contribute (Tonkens & Hurenkamp, 2019). All citizens are best motivated to participate if the subject of participation involves their experiences, including the topic of (perceived) safety. This topic has the most potential to include those with a lower education. Prior to 2000, men were more likely to participate than women, so equal public participation of men and women became a governmental goal (Bussemaker & Voet, 1998). Recently, public participation rates of higher educated women have increased (Ministry of Foreign Affairs, 2015). Additionally, it was found that citizens from households with child(ren) have higher rates of participation, which likely was due to a feeling of responsibility in the parents to provide for the future of their children (Bussemaker & Voet, 1998).

More recently, the city of Eindhoven launched its official city mobile app, to improve service delivery to citizens by dynamically offering only relevant information (OpenRemote, 2021). This app offers workflow solutions for project managers to perform targeted campaigns, by using location, time, and other conditions of app users. This allows them to conduct surveys to app-users or to ask them for feedback. A survey conducted in Eindhoven in 2020 showed that the municipality had received a 6.7 out of 10 for trust in municipal decision-making. However, only 20 percent of the respondents felt to have sufficient possibility to be involved in plans and developments (Gemeente Eindhoven, 2020).

2.2.2.2 Findings by PPGIS applications in the Netherlands

Before the EPA came into force, Bijen et al. (2016) studied the integration of digital PPGIS with a case study in Rotterdam, the Netherlands. The study concluded that a potential for PPGIS was present in Dutch spatial planning in addition to the traditional, mostly analogue and offline public participation tools. These traditional tools have a low level of participation, due to time and distance constraints (Maptionnaire, 2018a; Marzuki, 2015). By introducing online PPGIS methods, Bijen et al. (2016) removed these constraints and respondents could contribute at any time. However, it was also found that citizen interaction was appreciated at public hearings. So therefore, it is argued that an online PPGIS environment should enhance the traditional offline methods of public participation, but not completely replace it. The research found most added value for online PPGIS for public participation in the decision-making process in the before-design study (Bijen et al., 2016). This is a phase in which inhabitants previously had no structured input. The before-design study, when comprising a distinct citizen-user and expert-user desires-fit has shown to improve participation efficiency, if participants are provided with a level of detail and presentation in line with their knowledge. Therefore, online PPGIS can aid in bridging the gap, while also increasing the trust in governing and planning bodies (Zolkafli et al., 2017).

2.2.2.3 Public participation process

In preparation of the EPA coming into force, the Dutch municipality of Eindhoven has reformulated its policy regarding the public participation process (Gemeente Eindhoven, 2021c) in the 'Guidance for development and building' (Dutch: Leidraad voor ontwikkelen en bouwen) (Gemeente Eindhoven, 2021b). This guideline is based on the participation method THINK!, as developed by the Dutch ministry of internal and kingdom affairs. The guideline demands that all initiatives that apply for a building permit, also need to fill in a participation plan as part of its permit application. This participation plan needs to cover ten 'ingredients' of the initiative: motive(s) and goal(s); prior stakeholder engagements; impact on the surroundings; contents for engagement; stakeholders; form of public participation (similar to those in subsection 2.2.2.); planning; participation organization; participation results; and participation feedback (Gemeente Eindhoven, 2021a). Initiators can assess the impact on the surroundings by filling in the 'Quickscan Participation', a tool developed by the municipality to uniformly assess the impact of building initiatives based on four questions: scale, (positive) general interest, societal attention and (potential) nuisances (Gemeente Eindhoven, n.d.). The first question is regarding the scale of the initiative, the four predefined scales from large to small are:

- "Metropolitan intervention: A large scale change in the city, often involving multiple (land-use) functions and infrastructural changes. Affects a large group of residents in and outside the municipality. For example: major redevelopment (…).
- Restructuring: A redevelopment of an area involving multiple lots, buildings or functions. This often involves the demolition and new construction or transformation of current buildings, including adjustments in the public space. For example: neighborhood renewal (…)
- Change of function: The land-use of existing buildings (usually one building or on one plot) changes as a result of the initiative (…).
- Home-bound activity: Small adjustments at home or to one house" (Gemeente Eindhoven, n.d.).

The three remaining questions can be answered on a scale from (very) large to not or negligible. This quickscan then provides the initiator with the required level of participation for the project, ranging from level 0 (no participation) to level 3 (intensive participation), see Figure 11. A high level of participation plan requires more extensive and higher forms of public involvement (summarized in 2.2.2.1). The illustration by the municipality even provides examples of participation methods for each level of participation plan, ranging from community gatherings (information evenings or discussion panels) to webinars, (online) questionnaires, brainstorms, or consultations.

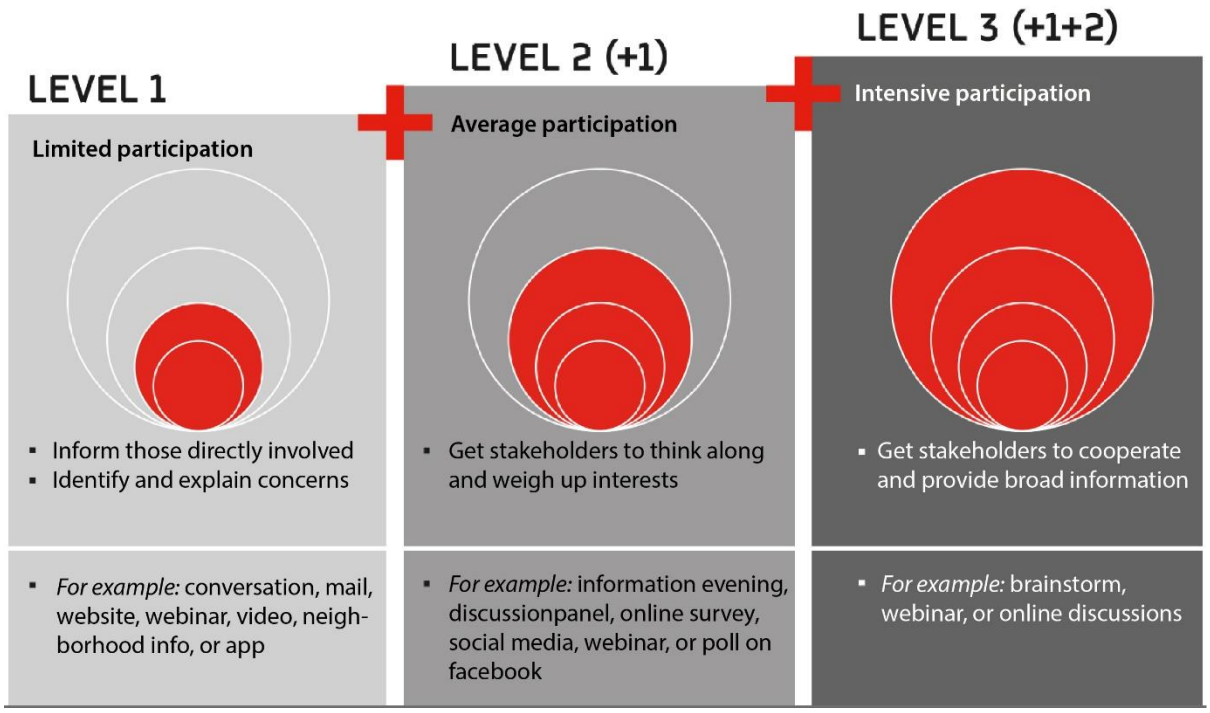

Figure 11: Dutch participation levels, translated from Gemeente Eindhoven (2021b)

2.2.3 Integration of PPGIS in the land-use planning and public participation process

Previous subsections have identified that the Dutch land-use planning system has come a long way in terms of public participation. This started with spatial planners deeming their own knowledge and qualities to be superior, and slowly included some traditional public participation methods, such as community gatherings, which failed to achieve representative participation. Today, the new Environment and Planning Act actively encourages the introduction of modern, web-based participation methods.

Prior research has also shown that Public Participation Geographic Information Systems have the potential to achieve higher levels of representativeness in the Dutch spatial planning process. Additionally, with the enactment of the EPA, the framework to integrate PPGIS has already been laid. It demands that, for every initiative that requires an environmental permit, the initiators have to fill in an impact assessment tool and submit a (corresponding) participation plan. Based on the level of impact, a certain level of participation needs to be met. Within the participation plan, the PPGIS tool should be required to be included as an online questionnaire, adapted to the assessed impact and corresponding level of participation, see also Figure 12:

- Level 0, home-bound activity: no participation and PPGIS application necessary.
- Level 1, change of function: limited participation, sent PPGIS questionnaire invitations to the residents of the affected plot and residents of the directly adjacent streets.
- Level 2, restructuring: average participation, sent PPGIS questionnaire invitations to the affected and bordering neighborhood(s).
- Level 3, metropolitan intervention: intensive participation, sent PPGIS questionnaire invitations to all areas containing residents that are likely to be affected.

The initial invitation, sent by email or by post, should inform the resident that he or she is likely to be impacted by the initiative, briefly explaining its core objectives. From this invitation, respondents should be able to access the questionnaire either by hyperlink or (QR-)code. The initiator(s) should also consider sending a follow-up or reminder, as this is expected to increase response rates by 40 percent (Edwards et al., 2002). If the initiative has received participation level 2 or 3, the municipality should

consider making the questionnaire accessible in the municipal app, so that inhabitants that are no nearby resident but do have interests in the development can also get involved. Last, a financial incentive, such as a prize lottery amongst the respondents could be considered. However, whilst inclusion would be able to increase the participation rate (of the silent majority) by up to 70 percent (Edwards et al., 2002), this financial incentive may also draw in respondents that do not necessarily care about the initiative.

The most crucial step to achieve plan acceptance and increased levels of participation and trust is in the feedback of the results (Friedmann, 1993; Zolkafli et al., 2017). This concern is shared by the Gemeente Eindhoven (2021a), which therefore demands that the results of the participation are shared with all stakeholders. In this feedback, the results of the participation need to be explained and changes to the initiative need to be showed. For the highest level of public support and trust, the results and feedback should be explained in public hearings and via email or post, for those unable to attend.

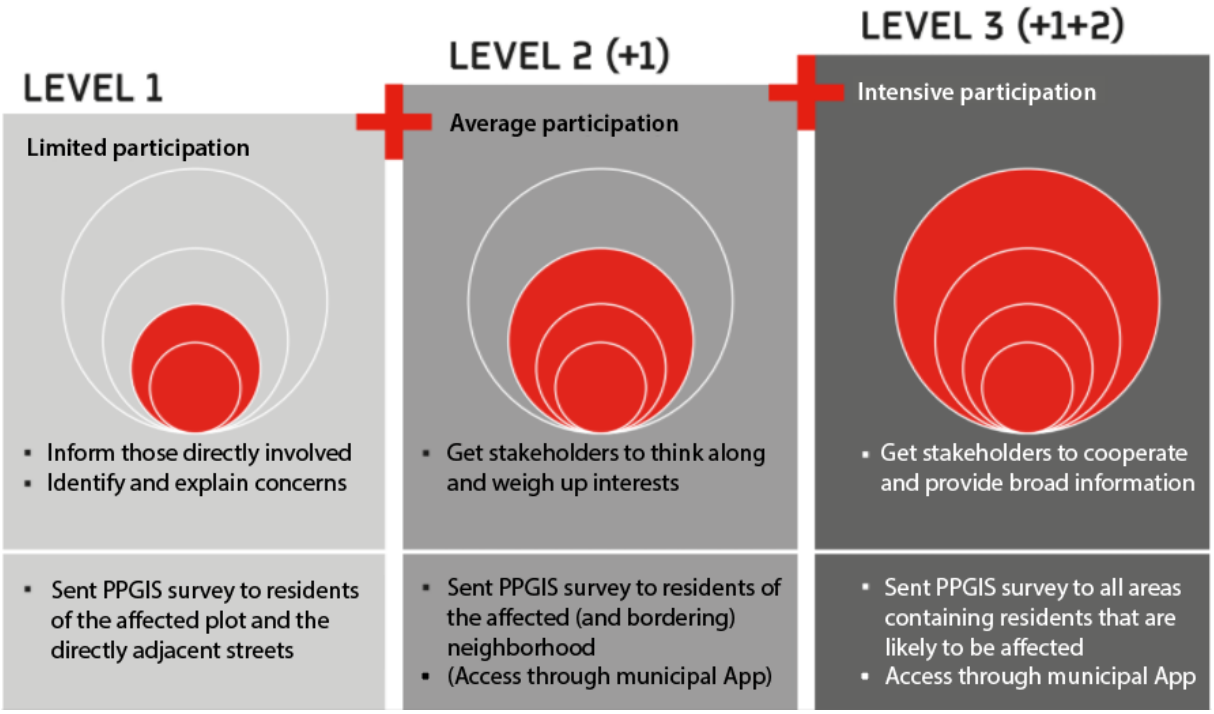

Figure 12: Proposal for integration of PPGIS application in Dutch environmental planning processes, illustration adapted from format designed by Gemeente Eindhoven (2021b)

2.3 PPGIS trends, developments, and challenges in recent literature

Since its introduction in 1963, the field of GIS has continuously grown and innovated. At the start of the millennium, the use of objective GIS layers has emerged as a valid tool in the land-use planner's toolbox (Brown, 2017). Continuous technological innovation then led to the introduction of subjective PPGIS layers in 2010, in which information was provided by the public (Zolkafli et al., 2017). With this level of progress, it is important to be aware of the most recent trends in the field, so the maximum level of information quality can be achieved. This section will elaborate on the most recent developments in PPGIS.

Kyttä et al. (2013) provide a reliable and scientific PPGIS approach to include residents' experiential knowledge in land-use planning and decision-making processes. It is relevant due to its application in urban densification processes and/or (re)development plans, which can be very useful for already existing neighborhoods in the Netherlands. Most interestingly, it introduced a grid overlay as a visual representation of the density of selected locations. This was applicable on a city-wide scale and can also be replicated on the neighborhood level. Hilbers et al. (2021) expanded the point-based localizations, by introducing polygons and polylines as markers, as the intuitive skills of respondents to work with online maps was found to have grown. However, combining points, polygons and -lines and transforming them into a grid overlay does not always produce fair visualizations. Therefore, attention needs to the paid to find a level of visualization that provides a high enough level of information quality for the applicable scale. Interestingly, Nenko & Petrova (2019) used heatmaps as visualizations for positive and negative emotional perceptions.

Traditional public participation tools have a relatively low level of participation and often fail to attract a representative group. "As the many participate a little and the few participate a lot" (RIVM, 2008) in the old-fashioned meet-ups and community gatherings (Kahila-Tani et al., 2019; OpenRemote, 2021). Bijen et al. (2016) described the time and distance constraints as partial reasons; inhabitants need to have the time available and the mobility to come to the community gathering. The longer the distance to the gathering, the fewer people are likely to participate. Those who feel very strongly about particular issues are most likely to participate. This creates a challenge for representativeness and the information quality of the new public participation methods (Marzuki, 2015). The desire to achieve a high level of participation while also limiting the impact of the loud minority should be balanced. so that a few very unhappy respondents cannot completely skew the results.

2.4 Conclusion

This literature research lays the foundations of the study by establishing starting points to answer all sub- and research questions. The chapter started with the origins of the 60-year history of PPGIS applications. During this period, a wide variety of PPGIS variables have been applied in a number of fields, ranging from natural landscape to development planning. An inventory of this variety of used variables has been made. These variables were selected for further analysis, if they were used in four or more studies performed in the fields of land-use and redevelopment planning, or if they are already present in the Dutch WoON2018 survey. This resulting selection is presented in Figure 13, these PPGIS variables will be analyzed on their importance and relevance to be applied in the Netherlands in the next chapter.

Figure 13: Selected variables

Subsequently, the Dutch legislation and regulations, as enacted in the Environment & Planning Act, have been mapped to find a framework in which a PPGIS application could be integrated. It was found that a PPGIS application should be integrated as (part of) an online questionnaire, for every (building) initiative that is required by the municipality to submit a level 2 or 3 (public) participation plan. However, the most crucial step to achieve plan acceptance and increased levels of participation and trust is in the feedback of the results. Therefore, the results of the Public Participation GIS application need to be shared with all stakeholders.

The last section investigated the trends, developments and remaining challenges found in recent PPGIS application studies. These developments and challenges need to be considered when designing the pilot study, so that accurate and qualitative information can be derived from issues reported and perceived by the public.

Integrating Public Participation GIS applications into
the Dutch environmental planning system

3. Variable relevance

This chapter performs the third step in the approach to answer the first sub-question; which PPGIS variables are most important to include in Dutch land-use planning? Steps one and two, the variable inventory and selection in subsections 2.1.3 and 2.1.4, answered this question from the point of view of the researchers and the planning experts. This third step, the variable relevance, aims to answer this question from the perspective of the 'lay' public/residents, by analyzing the variables to gain an indication on its importance and relevance for inclusion. Section 3.1 will start by introducing the dependent variables against which the variables will be measured. Afterwards, each section will cover one of the variables, in the order presented in Figure 13.

If a variable is available in the WoON2018 database, it's importance will be indicated via data analysis. For this data analysis, a Spearman rank-order correlation between the independent variables and the dependent variable Neighborhood Satisfaction is required (Lund Research Ltd, 2018), as all are measured on an ordinal scale. As the variables center around personal and mental perceptions in the field of sociology (UNC Chapel Hill, 2021), lower correlation values can be expected (Shortell, 2001). Correlations above 0.4 are considered to be relatively strong; correlations between 0.2 and 0.4 are moderate, and those below 0.2 are considered weak (Shortell, 2001). Therefore, the following indications are assigned: High ($\rho \geq 0.4$); Moderate/High ($0.3 \geq \rho > 0.4$); Moderate ($0.2 \geq \rho > 0.3$); Low/Moderate ($0.1 \geq \rho > 0.2$); and Low ($\rho < 0.1$). The variables with a significant correlation value exceeding 0.3 are included in the pilot, as these are typically deemed to be important (Field, 2009). Whereas those below 0.3 or without a direct statement in the survey are assessed based on the value and potential benefits, as found in the literature. Furthermore, the independent variables will be analyzed on their relations with the personal characteristics, as this provides background information for the pilot. Lastly, a multiple-regression analysis and variable interdependency analysis is performed, to gain insights in the similarities between the variables. All relevant statistics and figures of all variables are listed in order in Appendix V. The variables that are found to be of moderate importance or higher, will be included in the pilot.

3.1 Reference variables

Three variables within the WoON2018 are used as dependent variables. Most important is the respondent's general satisfaction with their current neighborhood. But also, the variables with the reasons for the respondent having or wanting to move neighborhood are considered.

Satisfaction with current neighborhood

The variables within the WoON 2018 are measured on their relationship with the dependent, ordinal variable: general satisfaction with their current neighborhood. To test the strength of this relation, Spearman's Correlation values will be used for relevant, independent variables that are also ordinal. The distribution of the respondents in Table 3 shows that a large majority of almost 85 percent is either satisfied (51.8%) or very satisfied (33.0%) with their current neighborhood. Contrarily, only 4.6 percent is either dissatisfied or very dissatisfied with their neighborhood.

Table 3: Satisfaction with the current neighborhood.

Satisfaction with the Current Neighborhood					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very Satisfied	22,276	33.0	33.0	33.0
	Satisfied	34,996	51.8	51.8	84.8
	Neither Satisfied, Nor Dissatisfied	7,137	10.6	10.6	95.4
	Dissatisfied	2,364	3.5	3.5	98.9
	Very Dissatisfied	750	1.1	1.1	100.0
	Total	67,523	100.0	100.0	

Reason for having moved neighborhood

However, not all selected variables have a directly related statement regarding the respondents' satisfaction on that topic. Therefore, a spearman's correlation value cannot be achieved. Instead, the reasons for wanting to or having moved neighborhood are analyzed. Table 42 in Appendix V.I provides insights in the number of respondents that moved, and the most important reason for them to do so. In total, 6,572 respondents in the sample have recently moved, whereas in the whole Netherlands 1.79 million people moved house (CBS, 2019). These numbers correspond to 9.7 percent in the sample and 10.4 percent for the Netherlands as a whole (CBS Statline, 2020).

The 6,572 respondents that moved were asked for their most important reason to move (Dutch: Belangrijkste reden vorige verhuizing). 642 (9.8%) of them stated that their previous neighborhood was the main reason to move. Subsequently these respondents were asked to select one or more reasons why they disliked the neighborhood. Table 4 shows the distributions of the reasons why respondents decided to move neighborhood. The three most frequent reasons - apart from other, undefined reasons - are: nuisance of neighbors (35.5%); changing demographics (30.5%); and nuisances by trash, demolition, smell, or noise.

Table 4: Reasons for having moved neighborhood

Reason for having moved								
English	Parking Issues	Dwelling Types	Poor Maintenance	Changing Demographics	Unsafe due to criminality	Nuisance of neighbors	Nuisances by trash, demolition, smell or noise	Other
Dutch	Parkeer-problemen	Type woningen in buurt	Slechte onderhoud van de buurt	Veranderende buurt-samenstelling	Onveiligheid door criminaliteit	Overlast bewoners	Overlast door rommel, vernieling, stank of lawaai	Anders
Yes (%)	16.5	23.4	17.3	30.5	21.5	35.5	28.3	36.9
No (%)	83.5	76.6	82.7	69.5	78.5	64.5	71.7	63.1
Total (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Reasons for wanting to move

Next to those who did recently move to a new house, are also those who have the desire to move. In the survey, 19,080 (28.3%) respondents stated that they wanted to move for one or more reasons, see Table 43 in Appendix V.VIII. From these, 4,771 (25.0%) stated that their neighborhood was one of their primary reasons for their desire to move. Subsequently they were asked to state which of the neighborhood factors played a role in their desire to move, see Table 5. These questions were answered by 3,090 respondents. The most stated reasons for wanting to move neighborhood are: nuisance by trash, demolition, smell or noise (33.2%), nuisance of neighbors (32.4%), and changing demographics (30.7%).

Table 5: Reasons for wanting to move neighborhood

Reasons for wanting to move neighborhood												
	Parking Issues	Dwelling Types	Poor Maintenance	Changing Demographics	Unsafe due to criminality	Nuisance of neighbors	Nuisances by trash, demolition, smell or noise	Green, Nature, Water Space,	Central, services, boring	Privacy, crowding, peace and quiet	Children, school, friends, playground	Other
Yes (%)	433 14.0	607 19.6	372 12.0	948 30.7	530 17.2	1,000 32.4	1,026 33.2	157 5.1	115 3.7	51 1.7	36 1.2	911 29.5
No (%)	2,657 86.0	2,483 80.4	2,718 88.0	2,142 69.3	2,560 82.8	2,090 67.6	2,064 66.8	2,933 94.9	2,975 96.3	3,039 98.3	3,054 98.8	2,179 71.5
Total (%)	3,090 100.0	3,090 100.0	3,090 100.0	3,090 100.0	3,090 100.0	3,090 100.0	3,090 100.0	3,090 100.0	3,090 100.0	3,090 100.0	3,090 100.0	3,090 100.0

3.2 Scenic / Aesthetic

The first variable that has come forward in the variable inventory, is the scenic and/or aesthetic quality of the neighborhood. This variable relates to the inhabitant's perception of the aesthetics of the neighborhood as a whole. The operation definition of this variable in the literature can be summarized as: Places or areas that you find beautiful, having attractive scenery, sights, smells, or sounds (Brown, 2008; Tyrväinen et al., 2007). This variable has been used in five of the relevant sources in the synthesis, see Appendix III.

Data analysis

Table 6: Building attractiveness

The buildings in my neighborhood are attractive	Frequency	%
Completely Agree	11,313	16.8
Agree	36,155	53.5
Neither Agree, Nor Disagree	13,468	1.9
Disagree	5,568	8.2
Completely Disagree	1,019	1.5
Total	67,523	100.0

Table 6 shows the distribution of the WoON 2018 respondents to the question: The buildings in my neighborhood are attractive (Dutch: "De bebouwing in deze buurt in aantrekkelijk"). Over 70 percent of the respondents deemed their neighborhood to be either aesthetically pleasant or very pleasant, with only 9.7 percent of respondents disagreeing or completely disagreeing with the statement. This indicates that the Dutch population in general is relatively positive about the build environment of the area they live in. The bar charts showing the relations between the perceived building aesthetics and the personal characteristics of the respondents shows interesting differences, see Appendix V.II. First, elderly people aged 55 years or older, are more likely (71.9-80.0%) to be happy with their neighborhood's building aesthetics than average (70.3%). In general, the older the respondent, the happier they are with the building's aesthetics in the neighborhood. Secondly, respondents living in suburban (73.0%), little urbanized or unurbanized (both 75.8%) areas are more likely to deem their neighborhood's buildings to be aesthetically pleasant or very pleasant. The inhabitants of very urbanized neighborhoods are most negative about the building aesthetics in their neighborhood (62.6%). When it comes to household composition, couples without children are more likely to live in neighborhoods with buildings that they deem aesthetically pleasing (74.2%). Whilst single-parent (60.9%) and non-family households (58.0%) are relatively unhappy with the building aesthetics of their neighborhood. No strong differences are visible amongst the level of education of respondents and their perceived neighborhood's aesthetics, as all range between 68.8 and 72.4 percent. Lastly, the data shows that respondents from a non-western ethnicity are more likely to disagree or strongly disagree with the statement (16.5%), compared to respondents with a Dutch (9.0%) or western (10.8%) ethnicity.

To investigate the value respondents put in the building aesthetics of their neighborhood, the relation between the general satisfaction with the neighborhood and the attractiveness of the neighborhoods buildings is checked. Figure 14 shows the result of the crosstabulation between general neighborhood satisfaction and satisfaction with the neighborhoods building aesthetics. It is clear that a large percentage of the respondents picked the same answer for both variable. So, people are satisfied with their neighborhood's building aesthetics were in general also satisfied with their neighborhood in general. A Spearman's Correlation is used to test the relation: resulting in a value of 0.466 with a significance of 0.000 (99% confidence). So, it can be concluded that people who deem the buildings in the neighborhood attractive are more satisfied with their neighborhood in general.

So, if in a neighborhood survey, a significantly higher percentage of respondents is found to disagree or completely disagree with the statement, municipalities should consider improving building aesthetics by redeveloping the most outdated buildings in the neighborhood. Thus, the variable scenic / aesthetic is a variable of high importance.

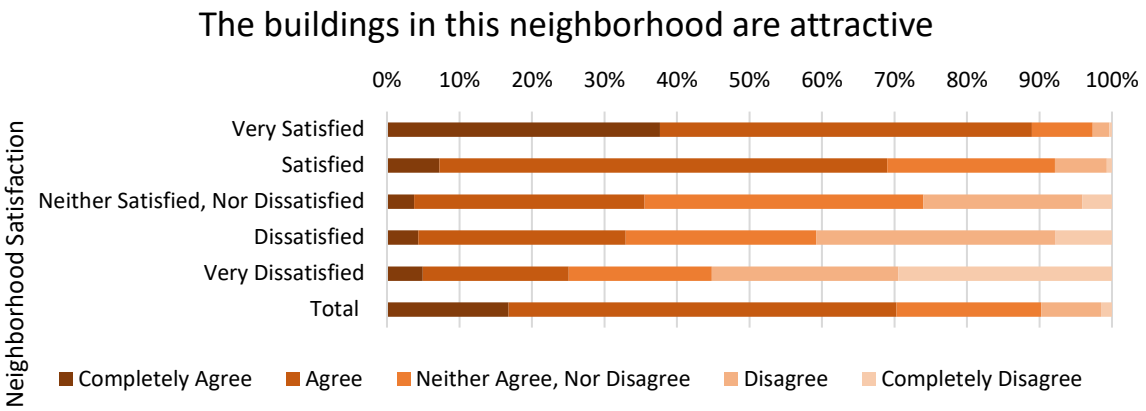

Figure 14: Relation between the respondent's general neighborhood satisfaction and the perceived building aesthetics

3.3 Natural

In the literature, the variable natural relates to the perceived natural qualities of a place, an area, or the neighborhood as a whole. The operational definition for natural used by Brown (2008) states: "places that have natural landscape features such as forests, wetlands, streams, and lakes". Furthermore, when faced with the variable of natural(ness), respondents expected rural, green areas and contacts with wild animals. In general, these areas were valued better than designed parks (Tyrväinen et al., 2007). The authors also argue that aesthetics and naturalness show significant correlation. This is supported by Kyttä et al. (2013), who found that the presence of nature and the aesthetics of the areas were two of the most mapped positive quality indicators.

Kyttä et al. (2016) used the indicators of 'Park', 'Forest' and 'Water' as indicators of the latent variable 'Green Areas' in their path-by-path analysis. The Green Areas variable is their equivalent for Natural. This grouping achieved the third-highest Chi-Square value out of seven. However, only water appeared to be significant. Lastly Broberg, Kyttä, et al. (2013) used the proportion of green structures as their indication for natural. These green structures were either, fields, forests, parks or water areas. It was found that green areas are important to stage activities, and that a high proportion of green significantly increases the probability of inhabitants liking the space.

Data analysis

Unfortunately, there is no statement in the WoON2018 survey that directly relates to the variable natural. Therefore, a Spearman's correlation cannot be conducted. However, from the 3,090 respondents who answered that they had the desire to move neighborhood, only 5.1 percent stated that (the lack of) green, space, nature and/or water was one of their reasons to consider moving, see Table 5.

So, considering the previous findings and results, the variable natural itself is in its current definition not found to be very important. Furthermore, due to its operation definitions in research, often referring to large, green landscapes, it is not as applicable within the context of urban redevelopment planning. However, due to its correlation with aesthetics, it can be considered that the variable natural can be the non-building side of the aesthetics variable. Considering this, the variable Natural is of low importance for inclusion in the survey.

3.4 Social

The variable 'Social' relates to the neighborhoods ability to invite, encourage and host social engagements between its inhabitants. In the literature, its operational value describes: "places to spend time and have fun with family, friends, and others" (Brown, 2008; Brown et al., 2014). On the other hand, Kyttä et al., 2016 argues a definition on social sustainability to involve accessibility and experiential outcomes, representing social equity and sustainability of community respectively. With experiential outcomes as (one of) the respondent's inputs, this variable is likely to be highly personal and subjective, as it depends on the personality of the respondents and the sense of community within the neighborhood, as some communities put more value on social quality than others (Kyttä et al., 2011). In total, the variable has been used seven times in research, the most of any variable in the literature research, see Table 2.

Data analysis

Within the survey, two questions relate to social interactions taking place within the neighborhood: "I live in a cozy neighborhood in which people help each other and do interact" and "I have a lot of contact with people in the neighborhood". However, the first question is used as the variable for social interaction, as its phrasing specifies the neighborhoods' ability to invite people together, whereas the second question appears to be more aimed at the respondent's personal characteristics to be able to interact with neighbors.

Table 7: Perceived social interaction

I live in a cozy neighborhood in which people help each other and do interact		
	Frequency	%
Completely Agree	5,468	8.1
Agree	26,489	39.2
Neither Agree, Nor Disagree	21,812	32.3
Disagree	11,181	16.6
Completely Disagree	2,573	3.8
Total	67,523	100.0

Table 7 shows the distribution of the respondents to the question: I live in a cozy neighborhood in which people help each other and do interact (Dutch: "Ik woon in een gezellige buurt waar mensen elkaar helpen en samen dingen doen"). This shows that most people agree with the statement (39.2%), closely followed by neither agree, nor disagree with 32.3 percent. Figure 15 shows the breakdown of the respondent's statements on perceived social interaction with the statement on their general neighborhood satisfaction. From this, it is apparent that a relatively small percentage of the respondents completely agree with the statement, even amongst those that are very satisfied with their neighborhood. On the other hand, of the 5,468 respondents stating to be very satisfied with the social interactions, 96.3 percent is either very satisfied (72.2%) or satisfied (24.1%). So, people who experience excellent social interactions in their neighborhood are also very likely to be satisfied with their neighborhood in general.

From Figure 43 in Appendix V.III can be derived that older respondents perceived the social qualities of their neighborhood to be slightly better than younger respondents. Furthermore, respondents living in less densely populated areas perceive their neighborhood to be cozier and host more interactions between inhabitants. When the distribution of perceived social qualities is broken down with the respondent's household composition, see Figure 45. It is visible that couples with/without child(ren) have the most positive perception (52% and 48.9%), followed by singles with/without child(ren) (43.1% and 41.7%) and lastly the non- family household respondents, of whom only 33.1 percent either agrees or completely agrees. Also, the level of education has a negative correlation with the perceived social qualities of the neighborhood, ranging from 53.1 percent of the respondents that completed their primary education down to 42.8 percent of those that have a master's degree or a doctorate. Lastly, respondents with a non-western ethnicity tend to have a less positive perspective on the social qualities of their neighborhood. As only 42.7 percent of them agreed or completely agreed, compared to the 46.6 percent amongst with western or 47.8 percent with a Dutch ethnicity.

The relation between the social interaction is checked by Spearman Correlation. Resulting in a value of 0.368 (moderate/high) with a significance of 0.000. So, it can be concluded that people who perceive more social interactions in their neighborhood are more likely to be satisfied with their neighborhood in general. Considering this result, the relations within the breakdowns and the emphasis within the literature, the variable social is of moderate/high importance.

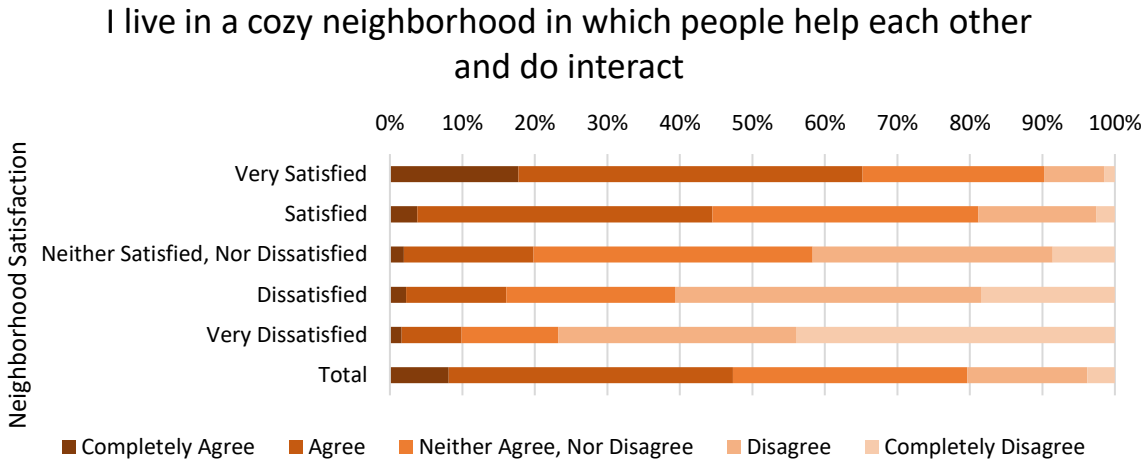

Figure 15: Relation between the respondent's general neighborhood satisfaction and the perceived social interactions

3.5 Recreation

In the literature, the variable 'Recreation' is defined by Brown et al. (2020) as: "Places that provide for my favorite (outdoor) recreation activities". Recreation is a use-related value, as it is associated with performing activities, often personal hobbies or the enjoyment of services. By making these recreational activities easily accessible, children's physical activities are supported (Kyttä et al., 2012). Furthermore, "accessibility to recreation areas and versatile services are among the structural features of a community that seem to support children's active lifestyle and independent mobility" (Broberg, Kyttä, et al., 2013).

In the researches by Brown (2008) and Hilbers et al. (2021), recreation was the variable that was most often selected (25.7%). Furthermore, it was found that the recreation value was often selected in areas where natural values were low. Suggesting that respondents often associate recreation with activities taking place on smaller and/or artificially designed areas. These opportunities are as seen by the respondents of Tyrväinen et al. (2007) the one of the main factors to enhance everyday well-being.

Data analysis

Unfortunately, there is no statement in the WoON2018 survey directly related to the respondents' opinions on their satisfaction with the recreation opportunities in their neighborhood. However, Table 5 shows that 3.7 percent of the respondents that desired to move neighborhood, want to because they deemed the neighborhood to be boring or lack services.

Despite only a relatively small percentage of respondents stating their neighborhood is boring or lacks facilities, the statement's formulation is not similar enough to assume that everyone who felt that also chose that option. Considering the benefits of accessible recreation for neighborhood and community, as well as the value respondents in previous research have put on it. The variable 'recreation' is assessed to be of moderate/high importance for inclusion. Therefore, it would be recommendable to include the variable 'Recreation' in further research and survey's measuring neighborhood satisfaction. A possible formulation for a WoON statement could be: "Satisfaction with recreation opportunities in my neighborhood". Which could be answered on a 5-point Likert scale.

3.6 Psychological / Therapeutic

The variable 'Therapeutic' is defined by Brown et al. (2020) as: "places are important because they make me feel better, physically and/or mentally". These therapeutic areas reduce depression and obesity, and improves fitness and perceived quality of life (Brown et al., 2014). Therefore, this variable measures whether inhabitants perceive their neighborhood to provide sufficient opportunities to come to rest and decompress. Hilbers et al. (2021) found that the variable therapeutic was mapped over 800 times, from a total of 3,132 PV's. Of these, 75 percent were not within protected Natura 2000 areas. This suggests that also places that provide psychological or therapeutic benefits do not necessarily have to be in nature, but can also be a general of place attachment to feel at peace (Brown et al., 2020).

Data analysis

In the WoON data, there is no direct statement related to psychological or therapeutic opportunities. However, Table 5 shows that 1.7 percent of the respondent stated that the crowdedness, (lack of) space, quiet, and privacy was one of the reasons why they considered moving neighborhood. However, similar to the variable recreation, the statement's formulation is not similar enough to assume that everyone who felt that also chose that option.

The literature and the data analysis provide opposing valuations for the variable therapeutic. Where the literature values its importance, emphasizing its mental health benefits, very little respondents state this to be a reason to move. However, without a direct statement, the importance cannot be sufficiently measured. Therefore, the variable is of low/moderate importance, or should be incorporated with the variable recreation.

3.7 Safety

The variable 'Safety' is defined as: the perception of the safety of the neighborhood. According to the literature, residential perception of safety is other related to the perceived cleanliness (Tyrväinen et al., 2007), social cohesion, diversity and vitality within the neighborhood (Kyttä et al., 2014). Also, a perceived safety and neighborhood building density have a negative correlation (Kyttä et al., 2011). The importance of feeling safe and secure in their environment, is one of the most important human needs for well-being and health (Hilbers et al., 2021). This is supported by the research by Kyttä et al., (2011), which found security and safety to be the most frequently mentioned positive-quality factors

Data analysis

Table 8 shows the distribution of the answers of the respondents of the WoON2018 Survey on the question: I am afraid to be harassed or robbed in this neighborhood (Dutch: Bang in deze buurt om lastiggevallen of beroofd te worden) (Ministerie van BZK & CBS, 2019). This distribution shows that just one in twenty respondent agrees or completely agrees with the statement, whilst 85 percent either disagrees or completely disagrees with the statement. This shows that a strong majority of the respondents feel safe in their own neighborhood. However, when this statement is broken down by personal characteristics, differences between various groups are apparent, see the bar charts in Appendix V.IV. Respondents aged 35-44 feel the safest in their neighborhood, with 87.6 percent either disagreeing or completely disagreeing. Compared to the those aged 75 and older (80.8%) or aged 17-24 (85.3%). Also, people very urbanized areas feel less safe compared to those living in the 'unurbanized' countryside. Furthermore, respondents with a household containing two adults felt safer compared to those with one adult. A positive relation exists between safety and level of education, so the higher educated the respondent, the more likely he/she is to feel safe in their neighborhood. Lastly, fewer respondents of non-western ethnicity felt safe (77.6%) than those in other groups (4.9-7.2%).

Table 8: Perceived safety

I am afraid to be harassed or robbed in this neighborhood			
		Frequency	%
Valid	Completely Agree	816	1.2
	Agree	2,923	4.3
	Neither Agree, Nor Disagree	6,336	9.4
	Disagree	31,856	47.2
	Completely Disagree	25,592	37.9
	Total	67,523	100.0

Figure 16 shows the relation between respondent's perceived safety and their general satisfaction with their neighborhood. This shows that people who are either satisfied or very satisfied with their neighborhood, perceive their neighborhood as safe or very safe. On the other hand, over forty percent of the respondents who are very dissatisfied with their neighborhood feel unsafe, of which half of them feels very unsafe. Conducting a Spearman Correlation on the two ordinal variables results in a value of -0.271, with a significance of 0.000. So, respondents that are more satisfied with their neighborhood are less likely to be afraid to be harassed or robbed in the neighborhood they live in.

Considering the emphasis in the literature, the significant differences between respondents' personal characteristics, as well as the strength of the relation between general neighborhood satisfaction and perceived safety, the variable safety is of moderate/high importance for inclusion.

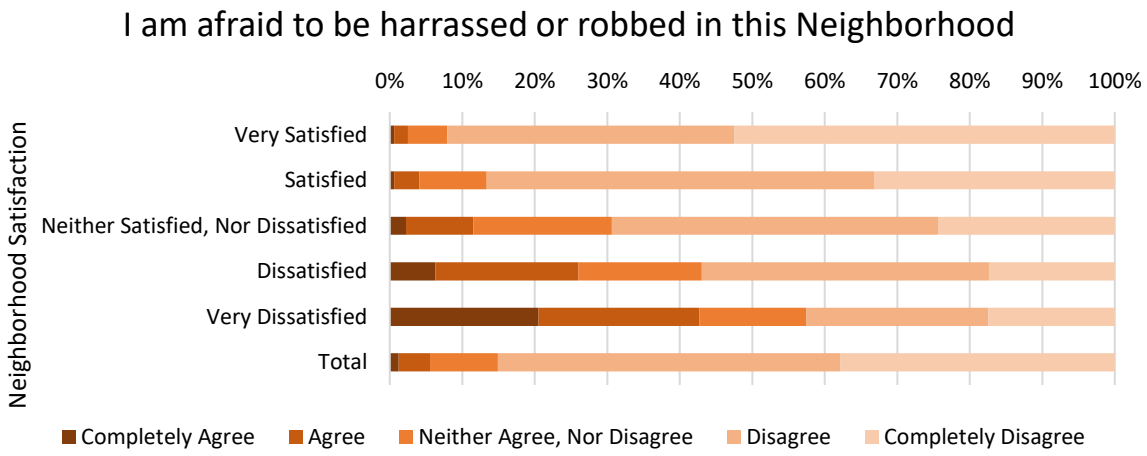

Figure 16: Relation between the respondent's general neighborhood satisfaction and perceived safety

3.8 Noise / Nuisance

The variable nuisance is de defined by Hilbers et al. (2021) as: “I perceive inconvenience or annoyance from something at this place”. This study found a strong relation between nuisance and the desire for improvement of an area, as “noise and vandalism decrease the experience social quality of areas” (Tyrväinen et al., 2007). Furthermore, the most nuisance by noise is perceived near main roads.

Data analysis

The WoON survey distinguishes two elements of annoyance: ‘nuisance of neighbors’ and ‘nuisances by trash, demolition, smell or noise’. The nuisance by neighbors is perceived more on a local level, whereas the latter is perceived more on a neighborhood level. Table 4 and Table 5 show that 28.3 percent or more of the respondents stated that either of the nuisances are a reason to move neighborhood. Since both are named as a top three reason to move in both tables, the variable nuisance is of high importance. However, a follow-up should be included to investigate the nature of the nuisance: noise, smell, trash or vandalism.

3.9 Accessibility to public transport

In the research by Hilbers et al. (2021), the variable accessibility was described as: “Efficient use of existing and new roads, as well as connections of different modes of transport (car, bicycle, bus, tram) to save space, fuel and time”. However, in the light of climate change and emphasis towards increased sustainability, urban redevelopment planning should incorporate the use of sustainable methods of transport. This promotes children’s independent mobility, reduces the need for car traffic and traffic land use in the redeveloped area (Broberg, Salminen, et al., 2013). Therefore, the variable is defined as: places that provide a perception of accessibility by public transport.

Data analysis

Table 9 displays the distribution of the importance respondents attach to the accessibility of public transport (Dutch: Belangrijkheid nabijheid openbaar vervoer). This shows that almost 60 percent of the sample deems accessible public transport to be either important (36.4%) or very important (23.1%), whilst only 12.1 percent deems it to be unimportant (Ministerie van BZK & CBS, 2019). In Appendix V.V, it is visible that the importance is the highest amongst those in the youngest and to a less degree oldest age groups. Also, accessibility to public transport is increasingly valued in increasingly densely urbanized areas. Importance is also higher amongst the non-couple households and those with a non-western ethnicity. In general, a weak negative relation (-0.034) exists between neighborhood satisfaction and importance of accessibility to public transport. The WoON 2018 survey does not contain a statement on respondents’ satisfaction with the proximity of public transport in their neighborhood. Therefore, a fair comparison in the relations cannot be made, and a direct statement regarding satisfaction with accessibility should be included. However, judged from the statistics from Table 9, proximity to public transport is of moderate importance.

Table 9: Importance of proximity public transport

Importance of accessibility to public transport			
		Frequency	%
Valid	Very Important	15,610	23.1
	Important	24,602	36.4
	Little Important	19,153	28.4
	Not Important	8,158	12.1
	Total	67,523	100.0

3.10 Daily groceries

This variable is related to the respondent's perceived distance from their home to the nearest grocery stores. This proximity is important for respondents who prefer to use sustainable transport to do groceries or want to be able to do last-minute groceries. However, with the emergence of e-commerce, this variable might become somewhat less important in the future, as people are able to order groceries to their doorstep. Thereby eliminating the need to go to the store every day.

Data analysis

Unlike accessibility to public transport, the survey does differentiate between perceived importance and the satisfaction of the proximity to the grocery stores (Dutch: Tevredenheid over nabijheid winkels voor dagelijkse boodschappen). Table 10 shows the distribution of the respondent's answers to the statement: Importance of proximity daily grocery stores (Dutch: Belangrijkheid nabijheid winkels voor dagelijkse boodschappen) (Ministerie van BZK & CBS, 2019). About 84 percent of the sample deems the proximity of grocery stores to be either important (48.3%) or very important (35.6%). Furthermore, only 1.8 percent deems the proximity to be of no importance.

Table 10: Importance of proximity daily groceries

Importance of proximity daily grocery stores			
		Frequency	%
Valid	Very Important	24,067	35.6
	Important	32,623	48.3
	Little Important	9,625	14.3
	Not Important	1,208	1.8
	Total	67,523	100.0

Table 11 shows the distribution of the perceived satisfaction, the distribution of which is reasonably similar to that of the importance, with about 84 percent being either satisfied or very satisfied. Satisfaction with the proximity of daily grocery stores is distributed relatively evenly on all but two of the personal characteristics. Only degree of urbanization (0.160) and level of education showed a significant positive relation with the satisfaction with the proximity.

Table 11: Satisfaction with proximity daily grocery stores

Satisfaction with proximity daily grocery stores			
		Frequency	%
Valid	Very Satisfied	19,875	29.4
	Satisfied	36,914	54.7
	Neither Satisfied, Nor Dissatisfied	6,640	9.8
	Dissatisfied	2,996	4.4
	Very Dissatisfied	1,098	1.6
	Total	67,523	100.0

When performing a Spearman correlation on the relation between these ordinal variables, it results in a value of 0.195 with a significance of 0.000. So, people who are satisfied with the proximity of their daily grocery stores, are more likely to be satisfied with their neighborhood in general, this relation is also visible in Figure 17. The variable proximity to daily grocery stores is of moderate importance.

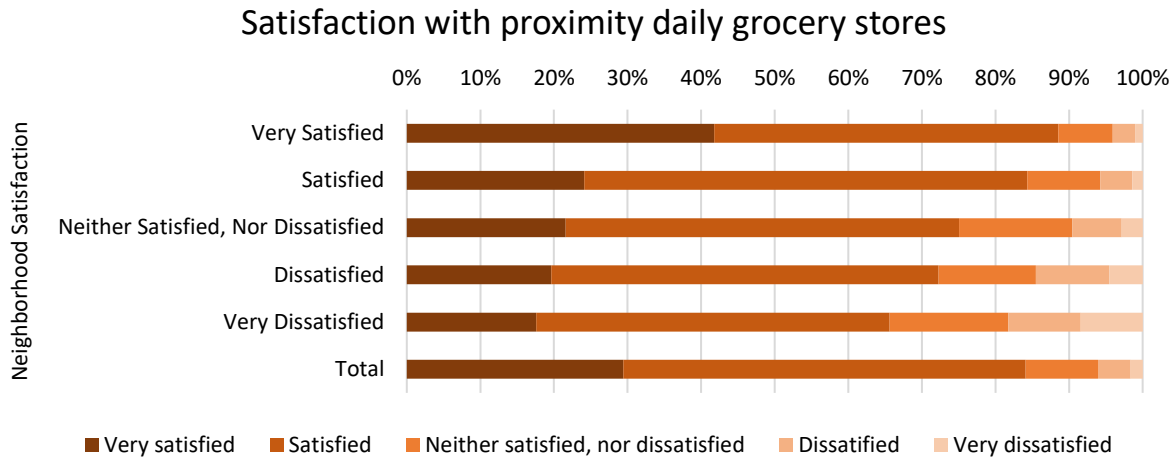

Figure 17: Relation between General Neighborhood Satisfaction and Satisfaction with Proximity of Daily Grocery Stores

3.11 Primary schools

The variable primary schools is associated with the perceived distance between the respondent's house and the nearest primary school(s). Smaller distances could improve children's individual or accompanied mobility in going to school on active travel modes.

Data analysis

Column 3 and 4 of Table 12 show the distributions of the respondents' answers on the statement: importance of proximity primary schools (Dutch: Belangrijkheid nabijheid basisscholen). Of the respondents, only 32.6 percent deemed it to be either important or very important. This is in contrast to the distributions of sections 3.9 and 3.10. However, primary schools are likely to be only important to respondents that are part of households with (young) children. As most households without children do not have a need for primary schools, except if couples want to have children in the near future. Therefore, columns 5 and 6 shows the distributions of only respondents that are part of a household with at least one child (selecting cases if respondents the household compositions equal 3 or 4). This distribution shows that 55 percent of this selection deems a proximity to a primary school to be either important or very important.

Table 12: Importance of proximity primary schools

Importance of proximity primary schools					
		All households		**Households with child(ren)**	
		Frequency	%	Frequency	%
Valid	Very Important	7,505	11.1	5,956	22.1
	Important	14,504	21.5	8,870	32.9
	Little Important	16,466	24.4	6,149	22.8
	Not Important	29,048	43.0	5,993	22.2
	Total	67,523	100.0	26,968	100.0

The distribution of the respondent's answers on the statement: satisfaction with proximity primary schools (Dutch: Tevredenheid over nabijheid met de basisscholen) is visible in Table 13 (Ministerie van BZK & CBS, 2019). Crucially, 84.6 percent of the respondents has not given an answer to this statement, while another 1.5 percent has answered that they did not know, or it was not applicable to them. With only 13.9 percent (9,382 out of 67,523) of the sample providing an answer, it is difficult to draw meaningful conclusions. It is visible that the strong majority of those that did answer are either satisfied or very satisfied with the proximity.

Table 13: Satisfaction with proximity primary schools

Satisfaction with Proximity Primary Schools			
		Frequency	Valid Percent
Valid	Very Satisfied	2,938	28.2
	Satisfied	5,292	50.8
	Neither Satisfied, Nor Dissatisfied	717	6.9
	Dissatisfied	337	3.2
	Very Dissatisfied	98	0.9
	Unknown / Not applicable	1,040	10.0
	Total	10,422	100.0

A Spearman Correlation of the relation between the ordinal variables neighborhood satisfaction with the satisfaction with the proximity to primary schools, results in a value of 0.213, with a significance of 0.000. So, for the respondents that are part of a household that has a need for a primary school, the higher the satisfaction with the proximity of the primary schools, the higher the satisfaction with the neighborhood in general. To summarize, the value of the variable 'primary schools' in surveys for land-use and (re)development planning purposes is low and should only be included in neighborhoods that have a high percentage of households with one or more children that attend primary school.

3.12 Maintenance

The variable maintenance is related to the residents perception of the (public) maintenance of the neighborhood, whether they feel the neighborhood is kept clean and tidy or neglected. Hilbers et al., (2021) used the term neglected instead of maintenance and described it as: "I feel this place is not receiving the proper attention". As described in 2.1.2.3, the BuitenBeter App enables residents to report several categories of poor maintenance to the relevant local governments. However, these organizations can only maintain public areas and buildings, whilst perceived maintenance also contains perceptions of private houses/buildings. Individually reporting poor maintenance to neighbors can cause unrest withing the neighborhood, but by combining the perception of multiple respondents, a stronger, less subjective argument can be made.

Data analysis

Table 14 shows the distribution of the respondents of the WoON 2018 survey on the statement: the dwellings in this neighborhood are well-maintained (Dutch: Woningen in buurt zijn goed onderhouden) (Ministerie van BZK & CBS, 2019). This shows that sixty percent of the respondents agree with the statement, with another 14.6 percent agreeing completely. On the other hand, 8.2 percent of respondents are unhappy (6.8%) or very unhappy (1.4%) with the maintenance of their neighborhood's dwellings. It needs to be noted that this does statement does not cover neighborhood maintenance as a whole, as it specifies dwelling maintenance. However, the perception of the maintenance of dwellings can be used as indication for the respondents view on neighborhood maintenance.

Table 14: Perceived neighborhood maintenance

The dwellings in this neighborhood are well-maintained			
		Frequency	%
Valid	Completely Agree	9,840	14.6
	Agree	40,545	60.0
	Neither Agree, Nor Disagree	11,578	17.1
	Disagree	4,603	6.8
	Completely Disagree	957	1.4
	Total	67,523	100.0

Figure 18 illustrates the relation between respondent's general neighborhood satisfaction and their perception on the maintenance of the dwellings in their neighborhood. It is interesting that amongst all degrees of neighborhood satisfaction, the largest percentage of respondents agreed with the statement. However, this percentage is only 27.9 percent for those which are very dissatisfied, whilst it is 67.4 percent of those which were satisfied. Also, from those who are very satisfied with their neighborhood in general, only 2.5 percent thinks the dwellings poorly maintained, and an even smaller amount of 0.6 percent deeming them very poorly maintained. This is in stark contrast to those who are very dissatisfied with their neighborhood, of them: 23.1 percent were neutral, 23.3 percent disagreed, and another 21.5 percent completely disagreed with the statement of maintenance. Appendix V.VII shows that the perception of maintenance increases with age and level of education but decreases with urbanization. Furthermore, couples with or without children are more likely to deem the buildings in their neighborhood to be well maintained, the opposite is more likely for those with a non-western ethnicity.

A Spearman Correlation of the ordinal variables gives a value of 0.391, with a significance of 0.000. Therefore, it can be concluded that people who perceive the dwellings in the neighborhood are well-maintained, are more likely to be satisfied with their neighborhood in general. Therefore, the variable maintenance is of moderate/high importance for inclusion.

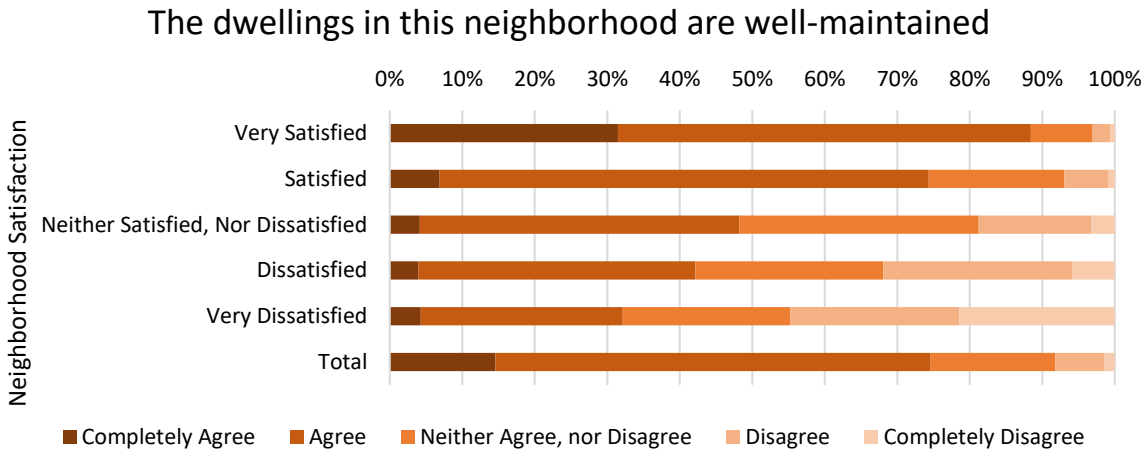

Figure 18: Relation between neighborhood satisfaction and perceived dwelling maintenance

3.13 Multiple regression analysis

Table 15 summarizes the Spearman correlation and indication values for each of the variables discussed in the variable and data analysis, as described in the previous subsections. Six variables had a representative statement in the dataset, of which four exceed ρ = 0.3, and are therefore directly included. However, to gain further insights into how the variable mutually stack up, a multiple regression analysis is performed. The resulting regression coefficients are presented in column 3 of Table 15 and equation 1. Considering these, the indication of social is set to high, due to a similar value to scenic / aesthetic, and daily groceries is set to low/moderate. The primary school variable is set to low/moderate, as it is only applicable for neighborhoods with a lot of young children. Table 44 in Appendix V.VIII shows the correlation values between the independent variables. The only notably strong interdependency is the 0.576 relation between the variables aesthetic and maintenance. This is logical, as both statements in the survey primarily concern the appearance of buildings. Therefore, it is recommended to differentiate between the aesthetic properties of the buildings and those of the public space. Furthermore, the satisfaction with maintenance should also be asked on the level of the neighborhood as a whole in future research.

Table 15: Variable summary from WoON2018 Survey

Variable	**Spearman Correlation***	**Multiple Regression Satisfaction***	**Indication**
Scenic / Aesthetic	0.466***	0.237***	High
Natural			Low
Social	0.368***	0.228***	High
Recreation			Moderate/High
Psychological / Therapeutic			Moderate
Safety	0.271***	0.161***	Moderate/High
Noise / Nuisance			High
Public Transport			Moderate
Daily Groceries	0.195***	0.091***	Low/Moderate
Primary Schools	0.213***	0.029***	Low/Moderate**
Maintenance	0.391***	0.103***	Moderate/High
		R = 0.583 Sum of Squares = 2,404.1***	

** Measured in relation to the General Neighborhood Satisfaction*
*** Depending on household composition of the neighborhood*
**** 99% confidence*

$$(1)\ S = -0.003 + 0.237 \cdot S_{Ae} + 0.228 \cdot S_{So} + 0.161 \cdot S_{Sa} + 0.091 \cdot S_{DG} + 0.029 \cdot S_{PS} + 0.103 \cdot S_{Ma}$$

In which:

S : General satisfaction with the neighborhood
S_{Ae} : Satisfaction with neighborhood (building) aesthetics
S_{So} : Satisfaction with social qualities of the neighborhood
S_{Sa} : Satisfaction with the perceived safety of the neighborhood
S_{DG} : Satisfaction with the proximity of daily grocery stores
S_{PS} : Satisfaction with the proximity of primary schools
S_{Ma} : Satisfaction with the maintenance in the neighborhood

3.14 Conclusion

To conclude, Figure 19 shows the full overview of the three-step variable analysis that aimed to find the PPGIS variable that are the most relevant and valuable to apply in Dutch land-use planning, thereby answering sub-question 1. This chapter started with the variables selected in subsection 2.1.4 based on the number of contributions in prior studies within relevant fields of application, and testing them on their relevance and applicability in the Netherlands. Six of the variables are tested on their importance and relevance by analyzing the WoON survey, which is considered to be representative for the Dutch population. The other five variables, which were not (directly) present within WoON Survey, are tested on the size of the contributions in the prior studies. It would be beneficial for future research if the WoON survey would adopt these variables in their future iterations. This exploration found aesthetic, social and noise to be the most important and relevant variables, followed by maintenance, safety, recreation, access to public transport and mental health. These variables will form the basis of the pilot study of chapter 4.

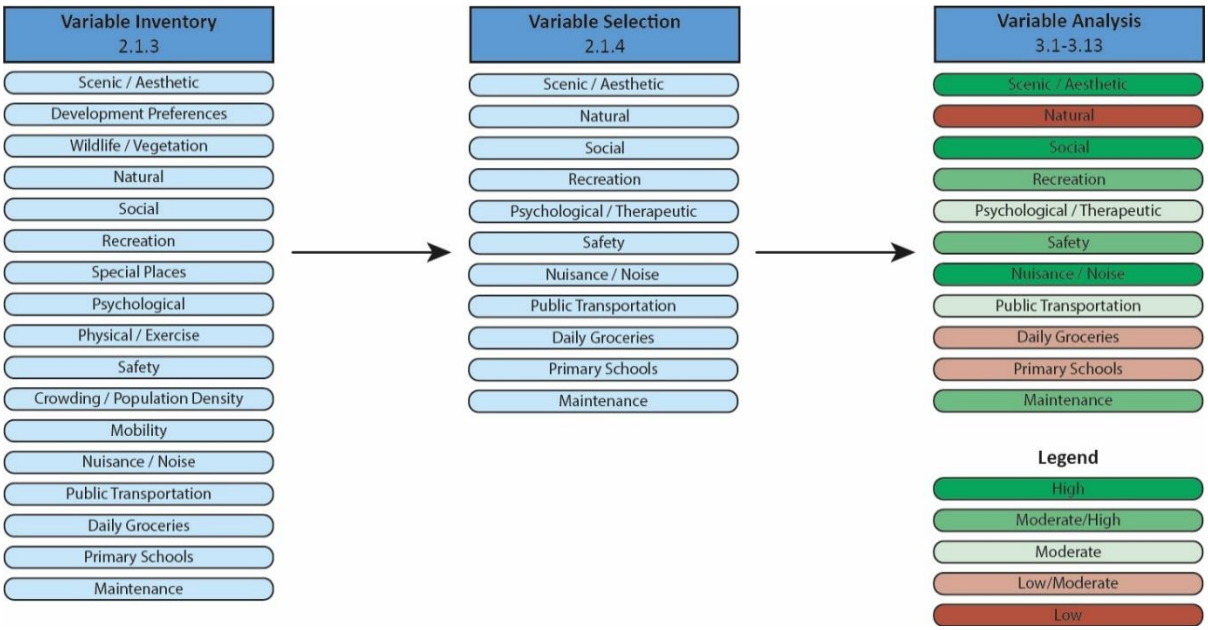

Figure 19: Overview three-step variable analysis

Integrating Public Participation GIS applications into
the Dutch environmental planning system

4. Pilot study

This pilot study combines the structure of existing softGIS applications (see 2.1.2.1) with the trends, developments and challenges from recent PPGIS literature (see 2.3) and the most important and relevant variables from the data analysis (see 3.13), to answer sub-questions 2 and 3. Testing whether the PPGIS pilot variables in Figure 20 can be measured accurately, whether publicly perceived issues can be structured into useful information for planning experts and can thereby increase public participation rates. It is also tested whether the pilot respondents are willing to use such PPGIS applications as part of their participation. Which then could indicate to which extent integration of such applications can improve representativity, as feedback on sub-question 4. This chapter starts with an introduction to the lay-out and demographics of the study area, the Limbeek neighborhood in the Dutch city of Eindhoven. Section 4.2 follows with an elaboration on the survey structure of the LimeSurvey questionnaire and section 4.3 details the data collection and processing methods. Section 4.4. then covers the results from the data collection and analyzing the data. Lastly, section 4.5 combines all information and results produced by the pilot study. This can then aid in answering the sub-questions as described above.

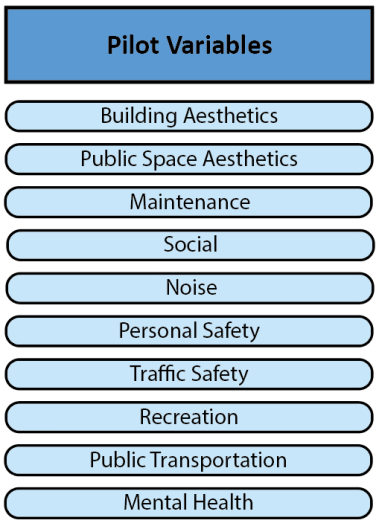

Figure 20: Limbeek pilot variables

4.1 Study area

The study area for the pilot is the neighborhood Limbeek. It is the most south-west area of the city district of Woensel-South, its geographical borders are the Eindhoven-Boxtel railway line in the south and west; the Marconilaan in the north, which is part of the main ring road around the city center; and the Boschdijk in the east, a connecting road between Eindhoven and Best. The neighborhood is connected by train via the Eindhoven Central Station to its south (about 500 meters from its southmost edge), and Eindhoven Strijp-S at its north-western corner. The nearest bus stops are Gemmastraat and Zernikestraat along the Boschdijk, and Glaspoort and Philips-stadium along the PSV-laan, directly opposite the railway. The Limbeek neighborhood is chosen because it can be separated in a northern and southern section, with different lay-outs, demographics and neighborhood characteristics. The sections are separated by Steenstraat, Kramerstraat, the southernmost section of the Lijmbeekstraat and the Zernikestraat, see Figure 21. Both sections are highly urbanized, and are divided into 85 ZIP-code areas, see Appendix VI.IV, 28 in Limbeek-South and 57 in Limbeek-North, all starting with 5612. Some picture of the area can be found in Appendix VII.

Figure 21: Limbeek-North and Limbeek-South

4.1.1 Limbeek-South

The southern section, Limbeek-South, has a "bloemkoolwijk" (English: Cauliflower Neighborhood) layout, which is characterized by a maze-like street pattern and few access- and exit roads. There is a strip of green space with a playground along its south-western border, between the Clara Wichmannstraat and the railway. Most of the dwellings, 754 of the 787, were constructed between 1980 and 1990. The buildings in the center, north and west of the section are single-family houses, consisting of 2.5-3 floors (Figure 100). Most of the 55 percent multi-family dwellings can be found as 4-7 floor apartment buildings on the eastern and southern edges of the section. In 2021, 64 percent of the dwellings were owned by a housing corporation, 20 percent are privately owned, and 16 percent are commercial rental (AlleCijfers.nl, 2021b). In 2021, 1,385 residents were registered in Limbeek-South, so the average household size is 1.7 residents per household, and the household density is 4,742 addresses per km² (AlleCijfers.nl, 2021b). Other neighborhood statistics are shown in Table 16 (note: all values are rounded to the nearest five).

Table 16: Limbeek-South Neighborhood Statistics (AlleCijfers.nl, 2021b)

Age (2021)	**Value**	**%**	**Gender (2021)**	**Value**	**%**	**Household Composition (2021)**	**Value**	**%**	**Education Level (2019)**	**Value**	**%**
0-14	165	11.9	Women	655	47.5	1-person household	475	57.9	Primary education	430	35.5
15-24	185	13.4	Men	725	52.5	Household without children	165	20.1	Secondary education	370	30.6
25-44	450	32.5	Other	0	0.0	Household with children	180	22.0	Higher education	410	33.9
45-64	390	28.2									
65+	190	13.7									
Total	1,380	100		1,380	100		820	100		1,110	100

4.1.2 Limbeek-North

The northern section, Limbeek-North, has a mixed layout, with 4-floor portico flats along its northern border and in its center (Figure 99). Its western border is characterized by 3-5 level buildings with commercial functions in the plinth (Figure 102). The remaining 20 percent of its urban tissue is made up of single-family dwellings. On its western edge, see Figure 97 and Figure 98, is a green strip (the Anthony van Leeuwenhoeklaan Park) with a large, fenced playground, a small football pitch, a dog off-leash area and an allotment garden. Of the 1,374 dwellings, 861 (62.7%) was built before 1970 and just under half (46.3%) of them are over 70 years old. In 2021, 58 percent is owned by a housing corporation, 19 percent is privately owned, and 23 percent is commercial rent (AlleCijfers.nl, 2021a). In 2021, 2,425 residents were registered in Limbeek-North, divided over 1,770 households (1.4 residents on average), resulting in a household density of 4,418 per km² (AlleCijfers.nl, 2021a). Other neighborhood statistics are shown in Table 17 (note: all values are rounded to the nearest five).

Table 17: Limbeek-North Neighborhood Statistics (AlleCijfers.nl, 2021a)

Age (2021)	**Value**	**%**	**Gender (2021)**	**Value**	**%**	**Household Composition (2021)**	**Value**	**%**	**Education Level (2019)**	**Value**	**%**
0-14	150	6.2	Women	955	39.3	1-person household	1,300	73.4	Primary education	450	20.1
15-24	650	26.7	Men	1,470	60.5	Household without children	325	18.4	Secondary education	820	36.6
25-44	1,105	45.5	Other	5	0.2	Household with children	150	8.5	Higher education	970	43.3
45-64	360	14.8									
65+	165	6.7									
Total	2,430	100		2.430	100		1,770	100.0		2,240	100

4.2 Survey structure

The pilot survey follows the structure as presented in Table 19, this structure is inspired by the common characteristics of previous SoftGIS methodologies, as found in 2.1.2.1 and summarized in Appendix II. The language of the questionnaire is linked to which QR-code is scanned, but the language can be manually changed at any point in the questionnaire. Providing an English version, next to one in the dominant language Dutch, aims to include those residents who feel uncomfortable expressing themselves in the dominant language, see subsection 2.2.2.

After scanning the QR-code on the invitation letter, respondents are referred to the introduction screen of the LimeSurvey questionnaire. This introduction expresses thanks for the respondents' interest, briefly explains what the survey is about and what is expected of them, see Appendix VI.II. Respondents are also informed that the survey takes about 10 minutes, and that they can email the researcher if they have any questions.

After the introduction, respondents are asked for their consent to participation, for which they have to declare that they are 17 years or older, feel sufficiently informed, and participate voluntarily. If they disagree, their participation is stopped. Next, they are asked if they allow their data to be used for future research or education purposes.

With their consent, the respondents commence the questionnaire, see Appendix VI.III for the full questions and answer options. To start, respondents are asked how satisfied they are with their neighborhood in general. Subsequently, they need to rank the five variables they value most, out of a list of ten, see Figure 73 in Appendix VI.III. These variables and their operational definitions, see Table 18, are based on the relevant variables from the variable analysis in chapter 3. However, the variables Aesthetic and Noise have been simplified, and psychological / therapeutic is renamed to mental health. Furthermore, the variable of aesthetic is split into both building and public space aesthetics, as suggested in section 3.13. Safety is split in personal and traffic safety, as they both represent a type of safety, but manifest differently.

Table 18: Variable definitions

Variable	Operation definition
Building Aesthetics	The aesthetic properties of the buildings in my neighborhood.
Public Space Aesthetics	The aesthetic properties of the public space in my neighborhood.
Maintenance	The maintenance of my neighborhood.
Social	The ease to make contact with other residents in my neighborhood.
Noise	The (lack of) noise disturbance in my neighborhood.
Personal Safety	The personal safety in my neighborhood
Traffic Safety	The traffic safety in my neighborhood.
Recreation	The opportunities for recreation and relaxation in my neighborhood.
Public Transport	The accessibility of public transport in my neighborhood.
Mental Health	The impact of my neighborhood on my mental health.

On the next page, respondents are shown a matrix in which they are asked to their satisfaction with each of the variables, formulated in their operational definitions. They can answer on a five-point Likert scale, or state to have no opinion, see Figure 74 (Appendix VI.III).

The following seven pages show a OpenStreetMap window of their neighborhood, the default location is set at the nearest GPS location on two decimals (DD): 51.45, 5.47. The scale is set on 15, showing the whole neighborhood and its immediate surroundings, see Figure 75. This is to help the spatial orientation of the respondents. On the first page, the respondents are asked to locate their preferred public transport stop on the map, and subsequently answer how often they use that stop. This question serves a double purpose, on one hand it checks whether the closest stop is also the one that the respondent uses, which is checked using their ZIP-codes. On the other hand, it helps respondents to get comfortable with the workings of the mapping tool, as they already know what they have to look for and where it is.

The six pages after that use the same mapping tool but ask respondents to select a maximum of three consecutive positive and then negative locations or objects. After selection, the respondents can select the characteristic(s) they associate with that location or object, and if applicable, write an explanation as to why they are satisfied or dissatisfied with the selected object.

Afterwards, the respondents were asked to provide some of their personal characteristics: age group, gender household composition; highest completed level of education; and ZIP-code. On the last page, they can state whether they would like municipalities to ask for their opinion in future (re)development plans; whether they would like to fill in a questionnaire as their input; and whether they would likely attend a community gathering to discuss these plans. These last questions are posed to check whether this new method is able to include more residents than the traditional public participation methods. Lastly, respondents can enter their e-mail addresses if they want to see the results of the research, as well as leaving a comment or feedback on the survey.

Table 19: Neighborhood Research Limbeek, Survey structure summary

Step	Title	Description / Data
1	Introduction	Introduction to the research
2	Consent	Letter of consent
3	Important neighborhood characteristics	• General Neighborhood Satisfaction (5-point Likert Scale) Pick and rank 5 most important neighborhood characteristics from 10 choices • Building Aesthetics • Public Space Aesthetics • Maintenance • Social • Noise Level • Personal Safety • Traffic Safety • Recreation / Relaxation • Accessibility to Public Transport • Mental Health
4	Satisfaction with neighborhood characteristics	Satisfaction with the neighborhood characteristics of step 3 (5-point Likert scale)
5	Introduction of the 'mapping tool'	OpenStreetMap, scaled to neighborhood level, centered to nearest GPS position (on 2 decimals) • Find preferred Public Transport stop
6	Localization of valued location / objects (3x positive, and 3x negative)	Place a pin on the map where an area is positively or negatively valued. • For each area, select associated characteristics. • Description in own words (optional)
7	Personal characteristics	Personal Characteristics; options similar to WoON2018 Survey • Age group • Gender • Household composition • Level of education • Degree of urbanization • ZIP-code (6-point)
8	Final Questions	Would you be willing to: • Be asked for your opinion? • Fill in a questionnaire? • Go to an information evening?
9	Ending	E-mail address Feedback about questionnaire

4.3 Data collection and data processing

The data is collected over a fortnight, between the 22nd of November and the 5th of December. 2.120 invitation flyers with the QR-codes were spread by going door-to-door in the neighborhood and posting an invitation letter in the postboxes between the 22nd and 25th of November, giving the residents at least 1.5 week to complete the questionnaire. This letter contains a brief explanation in both English and Dutch, with a unique QR-code per language, to access the survey, see Appendix VI.I. Expected response rates per regular flyer varies between one and five percent (Auraprint, 2019; Dor-2-Dor, 2021; SBS, n.d.), but this rate is expected to increase by about 30 percent, as the flyer contains

a survey for university research purposes (Edwards et al., 2002). By the 5th of November, 124 residents had scanned the QR-code, resulting in a responds rate of 5.8 per 100 flyers and 3.6 per 100 eligible residents, aged 17 or older.

After the data collection period has expired, the data that is gathered with the LimeSurvey questionnaire is downloaded and stored in a secure environment (SURFdrive). The e-mail addresses are immediately separated into a different file. This data is compatible with IBM SPSS Statistics 25, which is used to perform all statistical tests and calculations. These tests include: Chi-Square Value tests (to test for independences or differences); Spearman Correlations Coefficients (relations between ordinal variables), Multiple regression analyses (to assess the impact of multiple variables on the dependent variable); and t-tests (to measure differences in mean scores between groups).

4.4 Results

This section will cover the results that were derived from the survey. Subsection 4.4.1 describes the sample's representativeness. Subsections 4.4.2 and 4.4.3 aid to answer sub-question 2 by investigating how accurately the PPGIS are measured by the pilot, and what that means for the quality of the information that is derived. In which 4.4.2 describes and compares the samples' neighborhood satisfaction with similar satisfaction outcomes for the Dutch sample from the WoON2018 survey, and 4.4.3 continues with the comparisons between the neighborhood characteristics valued most by the respondents and the results of the regression analyses. These regressions aim to predict the general neighborhood satisfaction from the satisfactions with the individual neighborhood characteristics. Subsections 4.4.4 to 4.4.6 aim to answer sub-question 3 by structuring issues perceived by the public into useful, qualitative information for planning experts. 4.4.4 investigates whether the respondents experience issues regarding their accessibility to public transport by mapping their preferred public transport stops, modes and frequency of use, as insights in the PT use patterns of residents can aid to improve service. 4.4.5 and 4.4.6 cover the selected locations and corresponding positive and negative associations, and then transforms this information provided by the inhabitants into heatmaps using QGIS. Lastly, subsection 4.4.7 investigates the respondent's willingness to participate in future public participation processes. By consulting the respondents on their attitude towards the integration of this application as part of the public participation process, an indication to its representativity can be given as feedback on section 2.2.3.

4.4.1 Sample description

As mentioned before, 124 residents did scan the QR-code on the invitation flyer, of which eighteen (14.5%) were scanned in English and 106 (85.5%) in Dutch. However, only 95 (76.6%) of the respondents actually started the survey and only 71 (57.3%) respondents completed it. Table 46 in Appendix VI.V lists the distributions of personal characteristics of those that completed it and Figure 22 then compares the percentages to those of the potential respondents of Limbeek, see Table 47 (Appendix VI.VI). 30 of the respondents were females and 39 were males. The age distribution was spread equally over those younger and older than 45 years old. The 25–34-year-old group was the largest (32.4%), followed by 55-64 (19.7%) and 65–74-year-olds (16.9%). In terms of household composition, a strong majority (93.0%) does not include children, with 26 (36.6%) respondents from a one-person household and 32 (45.1%) from couples without children. Also, a high percentage (70.4%) of the respondents were highly educated, having completed at least a bachelor's degree at HBO or university level. 63 respondents filled in their ZIP-code, see Appendix VI.IV for the distribution. Of which 22 respondents were residents of Limbeek-South, 34 of North and seven were ambiguous, due to the codes HB, NJ and PE being located in both areas. Lastly, six of the surveys were completed in English.

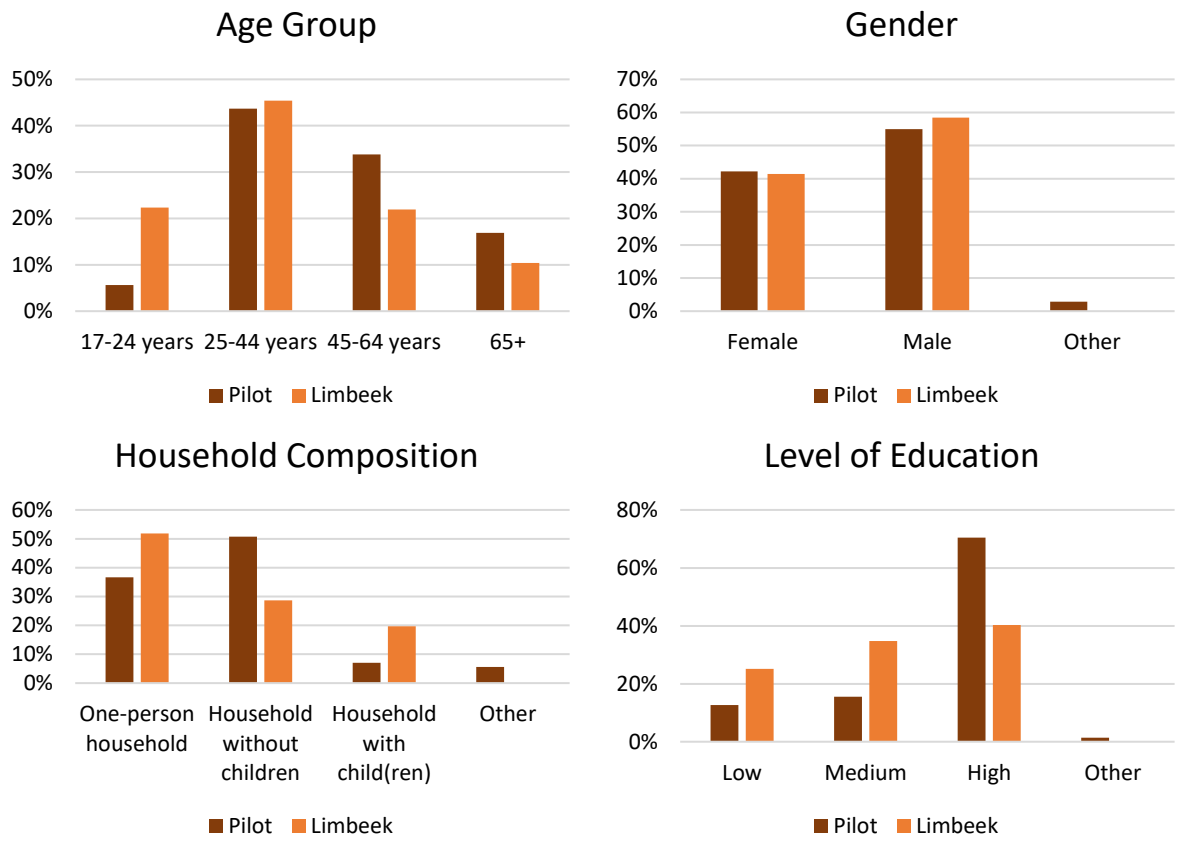

Figure 22: Pilot sample composition compared to potential participants in Limbeek

4.4.1.1 Respondent stopping point

Table 20: Survey answers and missing answer counts

Step	Answers	Missing answers (extra)
Consent	116	8
Important characteristics	95	29 (+21)
Satisfaction with characteristics	94	30 (+1)
Introduction of the 'mapping tool'	91	33 (+3)
Localization of valued locations	71	53 (+20)
Personal characteristics	71	53 (+0)
Final Questions	71	53 (+0)

With only 71 of the 95 (74.7%) respondents completing the survey, Table 20 shows during which of the in section 4.3 (Table 19) introduced steps, the respondents have stopped their participation. Eight residents who scanned the QR-code did not to start the questionnaire. 21 stopped during the consent step, either not fulfilling the requirements or not willing to participate under these conditions. Three respondents did not complete step 5, but a large group (20) stopped through step 6. This may be due to them not having six different places to suggest, and therefore getting bored by the repeating pages and opting out, also potentially residents were unable to master the mapping tool, or their phones did not support the mapping tool. However, all available answers will be used in the tests and analyses of the following sections, in the assumption that the distributions of the personal characteristics found in 4.4.1 for the 71 that finished the survey are representative for the 95 that started it.

4.4.1.2 Sample representativeness

To gain insights in the applicability of the results, a sample representativeness check is conducted on all personal characteristics traits, with data from AlleCijfers.nl (2021a, 2021b) and Statistics Netherlands (CBS) (2021). The expected number of respondents per category is shown in Appendix VI.VI, as well as an elaboration of the calculations.

Table 21 shows the results of the sample representativeness tests of the respondents, compared to the demographic make-up of the neighborhood Limbeek, according to Statistics Netherlands (CBS) (2021). For all representativeness checks, the category 'other/prefer not to say' is excluded. The sample is representative for the gender and the Limbeek North-South area distributions, based on their six-digit postal code, but it is not representative for the other personal characteristics.

Table 21: Sample representativeness compared to Limbeek, from Statistics Netherlands (CBS) (2021)

Personal Characteristic	df	Chi-Square Value	Asymptotic Significance (2-sided)
Age	3	16.472	.001
Gender	1	0.1107	.732
Household composition	2	22.229	.000
Education level	2	28.260	.000
North-south	1	0.492	.483

As the Limbeek North and South area are representatively distributed in the sample, Chi-Squared tests are performed to check whether the make-up of personal characteristics in these subsamples are significantly similar, see Table 22. The test shows that a significant difference exists between the age groups of respondents from the North and South. This is according to expectations, see Table 16 and Table 17, which show large differences in the percentages of all age groups. No significant differences were found for the other personal characteristics.

Table 22: Sample comparison Limbeek-South and Limbeek-North

Personal Characteristic	df	Chi-Square Value	Asymptotic Significance (2-sided)
Age	5	20.498	.001
Gender	1	0.009	.924
Household composition	5	4.502	.480
Education level	4	3.379	.497

4.4.1.3 Conclusion

The QR-code scanning rate of eligible residents per flyer is 5.8 percent, so within the expected range of 1.3 to 6.5 percent, see section 4.4. However, with only 95 residents starting the survey and 71 completing it rate of 73.9 percent, the survey completion rate dropped to 3.5 percent per flyer, and 2.07 surveys completed per 100 eligible residents.

The sample is not representative for the entire Limbeek population. Only for gender and the north-south distribution, the sample represents the population of the neighborhood Limbeek. The other personal variables are not representative, as the sample is made up of predominantly higher educated residents, of which most are part of a household without children.

Compared to traditional public participation, the age group distribution mostly follows the expected participation rates, in that older people are increasingly likely to participate, excluding those in retirement age (Uittenbroek et al., 2019). However, the 25-34 years age group is the extreme outlier here, making up 32.4 percent (23) of the respondents. There are no significant differences between the subsamples North and South, except respondents from Limbeek-North being significantly younger than those from Limbeek-South.

4.4.2 Limbeek neighborhood satisfaction

To gain better insights in the satisfaction of the Limbeek respondents with their neighborhood, the respondent's satisfaction with the neighborhood in general and the individual neighborhood characteristics are compared with the Dutch average as presented in the WoON2018, see section 3.1.

4.4.2.1 Comparing neighborhood satisfaction

Figure 23 shows the distributions of the respondent's scores regarding their satisfaction with their neighborhood and individual neighborhood characteristics. If available, the percentages are compared with the relevant scores from the WoON2018, which represents the Dutch national average. A full overview of the exact distributions can be found in Table 48 in Appendix VI.VII, as well as Chi-Square tests to check for similarities between variable distributions (Table 23). All variables are measured on the same ordinal 5-point Likert scale, but the questions allow the respondents to state to have no opinion (Figure 74). However, note that 'no opinion' was considered as a missing value. The Chi-Squared values of Table 23 proves that distributions of the Limbeek sample and the WoON2018 sample are significantly different for general neighborhood satisfaction, building aesthetics, maintenance and personal safety. Figure 23 then indicates that the residents of Limbeek are less satisfied with their neighborhood in general and these three neighborhood characteristics than the average Dutch person. However, the distributions of the satisfaction with the social qualities are not significantly different. So, the respondents have a comparable level of satisfaction with Limbeek's social properties as the average Dutch resident has with their neighborhood.

Table 23: Sample comparison Limbeek and Dutch neighborhood satisfaction

Variable	Chi-Squared Value	Asymptotic Significance (df = 4)
General neighborhood satisfaction	115.560	.000
Building aesthetics	112.547	.000
Maintenance	89.802	.000
Social	7.173	.127
Personal safety	167.594	.000

By ranking the variables on their satisfaction scores, Limbeek's weaknesses as perceived by its residents can be identified. This is done by adding up the numbers of respondents that were dissatisfied and very dissatisfied with that neighborhood characteristic. From most dissatisfied to least dissatisfied: building aesthetics (35), personal safety and traffic safety (both 30), maintenance (29), noise (26), public space aesthetics (25), recreation (22), social (16), mental health (13), public transport (5). So, the Limbeek sample appears to be most dissatisfied by the neighborhood's physical attributes and the lack of maintenance of it, which may have affected their feelings of safety in the neighborhood.

Doing the same with the numbers of respondents that were satisfied and very satisfied gives an indication to Limbeek's perceived strengths. In order: public transport (73), social (44), personal safety (42), noise (41), maintenance and traffic safety (40), public space aesthetics (39), recreation and mental health (30), building aesthetics (27). As expected, public transport is rated the best by a big margin, followed by social. Notable is personal safety as third best, whilst it was also the second worst. A Chi-Square test of the 56 respondents that entered their zip-code showed that a significant difference (X^2 = 15.893; df = 4; sig. = 0.003) exists between the satisfaction with personal safety and residential area. With respondents from Limbeek-South seeming more satisfied with their personal safety than those of Limbeek-North. No significant relations were found between satisfaction with personal safety and the other personal characteristics.

Table 24: Crosstab satisfaction with personal safety and residential area

	Satisfaction with the personal safety in your neighborhood					
Residential area	Very satisfied	Satisfied	Neutral	Dissatisfied	Very dissatisfied	Total
Limbeek-South	0	16	4	1	1	22
Limbeek-North	1	8	7	15	3	34

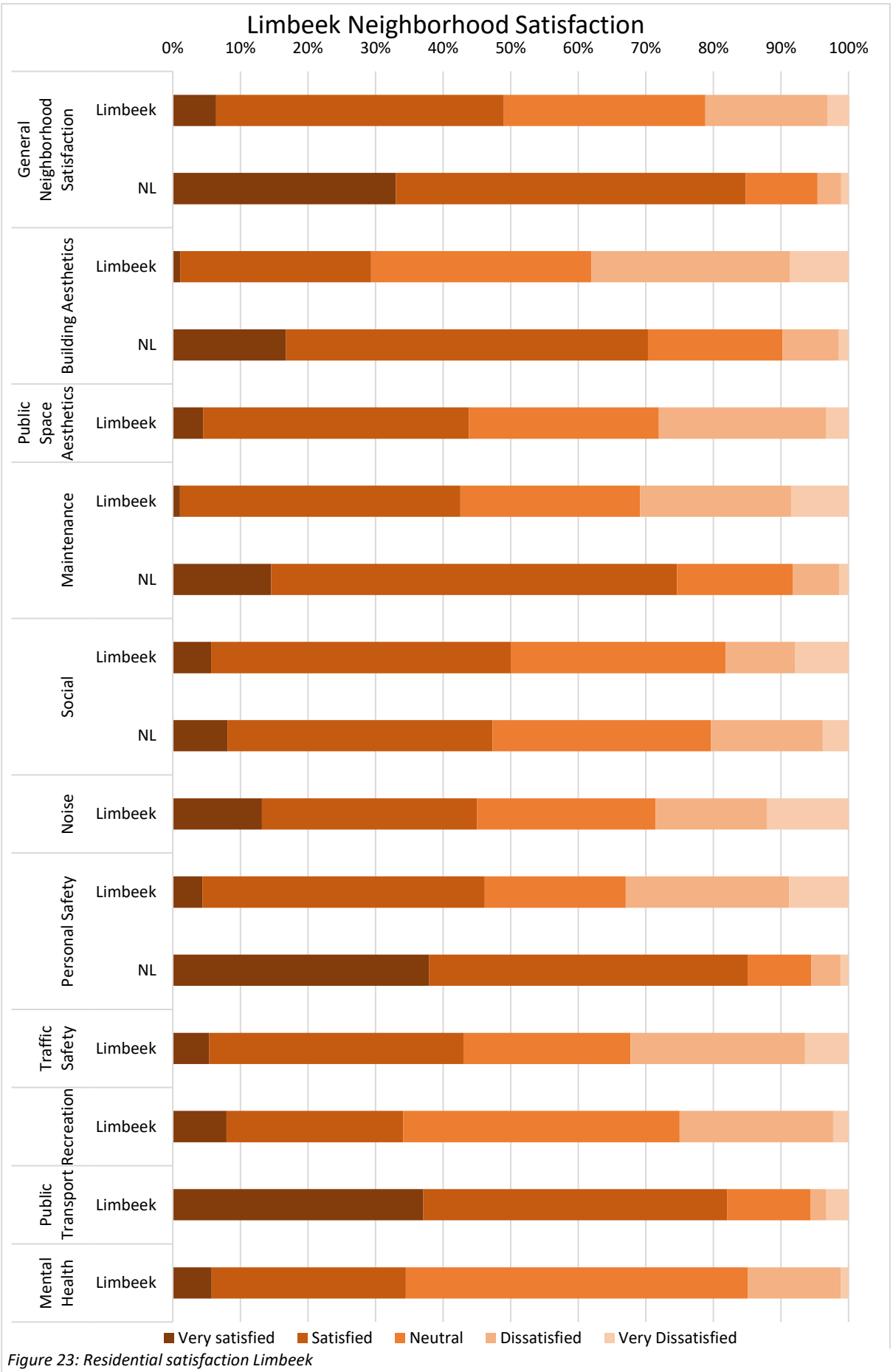

Figure 23: Residential satisfaction Limbeek

4.4.2.2 Correlations and interdependencies.

Spearman correlation coefficients are calculated to test for relations between the distributions of the individual ordinal variables, see Table 25. The individual contributions of the variables to the general neighborhood satisfaction will be covered in 4.4.3.2. The rank correlation coefficients revealed strong interdependencies (ρ > 0.4) between mental health and personal safety and traffic safety; personal safety and noise and traffic safety; and between recreation and public space aesthetics. Comparing these interdependent relations with those in Table 44, shows that all but one (maintenance to social) of the relations found to be significant in the WoON2018 are also significant for the Limbeek sample, albeit with different correlation coefficients. Indicating that most of relations that were present in the Limbeek sample, also exist for the Netherlands as a whole.

Table 25: Spearman correlation coefficients

	Spearman correlation coefficient	**Interdependencies (Spearman correlation coefficient)**			
	General Satisfaction	**Building Aesthetics**	**Public Space Aesthetics**	**Maintenance**	**Social**
Building Aesthetics	.440**				
Public Space Aesthetics	.464**	.263*			
Maintenance	.468**	.224*	.396**		
Social	.289**	.332**	.048	.026	
Noise	.387**	.247*	.050	.209*	.314**
Personal Safety	.580**	.300**	.210	.275**	.297**
Traffic Safety	.526**	.292**	.305**	.359**	.165
Recreation	.103	.246*	.471**	.148	-.026
Public Transport	.174	-.122	.047	.004	.065
Mental health	.601**	.362**	.338**	.246*	.339**

Interdependencies					
	Noise	**Personal Safety**	**Traffic Safety**	**Recreation**	**Public Transport**
Personal Safety	.447**				
Traffic Safety	.349**	.566**			
Recreation	-.199	-.042	.095		
Public Transport	.071	.0.40	.054	.258*	
Mental health	.300**	.581**	.460**	.176	.131

***Correlation is significant at the 0.01 level (2-tailed)*
**Correlation is significant at the 0.05 level (2-tailed)*

4.4.3 Comparing valued neighborhood characteristics

Next to the statements regarding their satisfaction with characteristics of their neighborhood, the survey asked the respondents to rank these neighborhood characteristics on importance without the geographical context. With this information, urban planners know which neighborhood characteristics they should prioritize when making land-use or redevelopment plans.

4.4.3.1 Most valued characteristics

The second question of step 3 asked the respondents to rank five from a list of ten neighborhood characteristics in order of most to least important (Figure 73). The importance of the characteristics is ranked in two ways: the total frequency, and a weighted rank, see Table 26. In the total frequency, its rank is determined by the total number of times a characteristic is selected, regardless its position. Whereas the weighted rank assigns a factor 5 to rank 1, 4 to rank 2, and so on (Hillmer, 2020). Both methods show that the characteristics maintenance, noise, personal safety and accessibility to public transport are the most important for the respondents. Closely followed by public space aesthetics. Traffic safety, however, scores a lot better in the total frequency than in the weighted rank, as it wasn't valued as most important by any respondent, but was mainly selected as 3rd, 4th and 5th most important. On the other hand, public transport and noise are selected relatively frequently as most or second most important. Oddly, public space aesthetics is selected relatively often in rank 1, 4 and 5.

Table 26: Most valued neighborhood characteristics

Most valued neighborhood characteristic									
	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Score	Rank	Weighted Score	Rank
	N	N	N	N	N				
Building Aesthetics	7	4	6	4	9	30	8	86	9
Public Space Aesthetics	13	5	5	13	10	46	5	136	5
Maintenance	11	13	14	4	13	55	2	170	3
Social	7	8	7	7	5	34	7	107	6
Noise	12	17	6	8	7	50	4	169	4
Personal Safety	17	8	11	12	8	56	1	182	2
Traffic Safety	0	7	8	12	9	36	6	85	10
Recreation	3	12	4	6	7	32	8	94	7
Public Transport	16	11	15	8	3	53	3	188	1
Mental Health	6	5	8	6	4	29	10	90	8
Total	92	90	84	80	75	421		1307	

4.4.3.2 Multiple regression analysis

Another way to approach the most important neighborhood characteristics is by performing a multiple regression analysis, to see which characteristics have the largest impact on the general neighborhood satisfaction. Five separate regression analyses are performed, the first is based on the Limbeek data and takes only the characteristics building aesthetics, social, personal safety, and maintenance into account to compare with the WoON2018. However, the regression analysis in section 3.13 also included the satisfactions with proximity of the daily grocery stores and primary schools. Therefore, this regression was repeated without these variables, as they are not available in the Limbeek data.

So, the first multiple regression analysis is performed to predict the general neighborhood satisfaction in Limbeek from building aesthetics, maintenance, social and personal safety. The variables predict general neighborhood satisfaction reasonably as $R^2 = 0.576$. The variables safety, maintenance and buildings aesthetics add statistically significantly to the prediction at the five percent significance level, while social adds to the prediction at the ten percent level. The results are presented in Table 27 and equation 2.

$$(2)\ S = -0.257 + 0.174 \cdot S_{Ae} + 0.332 \cdot S_{Ma} + 0.143 \cdot S_{So} + 0.359 \cdot S_{Sa}$$

Table 27: Regression analysis coefficients equation 2, based on Limbeek data

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
(Constant)		-.257	.314		-.817	.416
Satisfaction with building aesthetics	S_{Ae}	.174	.078	.178	2.218	.029
Satisfaction with maintenance	S_{Ma}	.332	.071	.361	4.650	.000
Satisfaction with social properties	S_{So}	.143	.078	.146	1.835	.070
Satisfaction with personal safety	S_{Sa}	.359	.071	.412	5.055	.000
Dependent Variable: General Neighborhood Satisfaction						

A similar multiple regression analysis is based on the WoON2018-data. This model performs less well than the model for Limbeek; $R^2 = 0.326$. All variables are significant at the five percent level, resulting in Table 28 and equation 3.

$$(3)\ S = 0.185 + 0.265 \cdot S_{Ae} + 0.121 \cdot S_{Ma} + 0.199 \cdot S_{So} + 0.163 \cdot S_{Sa}$$

Table 28: Regression analysis coefficients equation 3, based on WoON2018 data

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
(Constant)		0.185	0.010		18.621	0.000
Satisfaction with building aesthetics	S_{Ae}	0.265	0.004	0.287	73.770	0.000
Satisfaction with maintenance	S_{Ma}	0.121	0.004	0.122	31.652	0.000
Satisfaction with social properties	S_{So}	0.199	0.003	0.237	70.099	0.000
Satisfaction with personal safety	S_{Sa}	0.163	0.003	0.171	51.906	0.000
Dependent Variable: General Neighborhood Satisfaction						

The comparison between the regression coefficients of Table 27 and Table 28 shows that when similar variables are used, the Limbeek sample has a better fit for predicting the general neighborhood satisfaction than the WoON2018 sample (R^2= 0.576 versus 0.326). All variables are significant predictors in both regressions. For Limbeek however, the variable social has a lower level of confidence than in the WoON2018 regression. This makes sense, considering the smaller sample. Despite all predictors being significant, differences exist between the regression coefficients, as the satisfaction with building aesthetics is the strongest predictor in the WoON2018 sample. Whereas it is the third strongest in the Limbeek sample. On the contrary, for the Limbeek sample, the variables maintenance and safety are the highest, whilst they are the lowest in the WoON2018 regression.

A third multiple regression analysis is performed to predict the general neighborhood satisfaction in Limbeek from all available variables: building aesthetics, public space aesthetics, maintenance, social, noise, personal safety, traffic safety, recreation, public transport and mental health. This regression model predicts the dependent variable rather well, with R^2 = 0.711. Both aesthetic variables, maintenance, recreation, public transport and mental health are significant at the five percent level, and the variable personal safety is significant at the ten percent level, see Table 29.

From this analysis, it is visible that this expanded model has a better fit (R^2 = 0.711) than the previous regression analyses. However, the variables social, noise and traffic safety have no (significant) effect on the general neighborhood satisfaction in Limbeek. Oddly, the satisfaction with the number of opportunities for recreation shows a negative effect on the general neighborhood satisfaction. This finding is highly unexpected, and likely caused by its significant correlation with both building and public space aesthetics (see Table 25).

Table 29: Regression analysis coefficients including all Limbeek pilot variables

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
(Constant)	S	-0.891	0.345		-2.582	0.012
Satisfaction with building aesthetics	S_{Ae}	0.215	0.081	0.221	2.645	0.010
Satisfaction with public space aesthetics	S_{PSA}	0.217	0.084	0.222	2.583	0.012
Satisfaction with maintenance	S_{Ma}	0.248	0.074	0.268	3.350	0.001
Satisfaction with social properties	S_{So}	0.082	0.072	0.087	1.146	0.256
Satisfaction with noise	S_{No}	0.043	0.067	0.056	0.639	0.525
Satisfaction with personal safety	S_{Sa}	0.156	0.084	0.180	1.845	0.070
Satisfaction with traffic safety	S_{TS}	0.136	0.084	0.150	1.613	0.112
Satisfaction with recreation	S_{Re}	-0.187	0.093	-0.184	-2.010	0.049
Satisfaction with public transport	S_{PT}	0.167	0.073	0.171	2.271	0.026
Satisfaction with mental health	S_{MH}	0.221	0.104	0.188	2.123	0.038
Dependent Variable: General Neighborhood Satisfaction						

Due to this finding and the small sample size, a fourth regression is performed without the insignificant variables in Table 29. Now, R^2 = 0.680 and all variables are significant, see equation 4 and Table 30.

$$(4)\ S = -0.660 + 0.253 \cdot S_{Ae} + 0.186 \cdot S_{PSA} + 0.271 \cdot S_{Ma} + 0.209 \cdot S_{Sa} - 0.183 \cdot S_{Re} + 0.149 \cdot S_{PT} + 0.310 \cdot S_{MH}$$

Table 30: Regression analysis coefficients equation 4

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
(Constant)	S	-0.660	0.332		-1.992	0.050
Satisfaction with building aesthetics	S_{Ae}	0.253	0.076	0.259	3.301	0.002
Satisfaction with public space aesthetics	S_{PSA}	0.186	0.083	0.190	2.245	0.028
Satisfaction with maintenance	S_{Ma}	0.271	0.070	0.296	3.850	0.000
Satisfaction with personal safety	S_{Sa}	0.209	0.074	0.245	2.827	0.006
Satisfaction with recreation	S_{Re}	-0.183	0.089	-0.177	-2.057	0.043
Satisfaction with public transport	S_{PT}	0.149	0.073	0.150	2.039	0.045
Satisfaction with mental health	S_{MH}	0.310	0.101	0.266	3.079	0.003
Dependent Variable: General Neighborhood Satisfaction						

The coefficients show that satisfaction with mental health (0.310) is the strongest predictor to the general neighborhood satisfaction, followed by maintenance (0.271), building aesthetics (0.253) and personal safety (0.209). These findings are in line with the results from the individual correlation coefficient of Table 25, in which the strongest correlations with general neighborhood satisfaction are found for the variables mental health and personal safety (ρ > 0.5), followed by building aesthetics and maintenance (ρ > 0.4). The variables public space aesthetics and traffic safety were also strongly correlated to general satisfaction (ρ > 0.4), but were not strong in the regression model, likely due to their high correlations with maintenance and personal safety respectively. The negative coefficient for the satisfaction with recreation is also present in this regression model. Therefore, a fifth regression analysis is performed without the variable recreation and presented in Table 31. This analysis resulted in a fit of R^2 = 0.681, with the variables social and traffic safety being insignificant, but the other variables were significant with at least 90 percent confidence. Similar to the previous regressions, the variables maintenance and mental health are the strongest predictors, however building aesthetics did reduce in strength. Which is likely due to the correlation found between building aesthetics and recreation, see Table 25.

Table 31: Regression analysis Limbeek without satisfaction with recreation

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-.982	.344		-2.857	.006
Satisfaction with building aesthetics	.141	.077	.147	1.836	.071
Satisfaction with public space aesthetics	.154	.079	.158	1.947	.056
Satisfaction with maintenance	.222	.076	.240	2.929	.005
Satisfaction with social properties	.082	.073	.087	1.114	.269
Satisfaction with noise	.113	.064	.147	1.749	.085
Satisfaction with personal safety	.176	.085	.204	2.063	.043
Satisfaction with traffic safety	.123	.084	.137	1.467	.147
Satisfaction with public transport	.132	.070	.136	1.890	.063
Satisfaction with mental health	.191	.107	.164	1.793	.077
a. Dependent Variable: General Neighborhood Satisfaction					

From the regression analyses can be derived that the variables mental health, maintenance, personal safety and building aesthetics are the strongest predictors of general neighborhood satisfaction. With the information from this section, urban planners and decision-makers should prioritize implementing measures that improve maintenance and personal safety in the neighborhood, as they come forward in the results from both the multiple regression analysis and ranked characteristics. Public transport is deemed important by respondents, but does not need further improvement, as satisfaction is already high. Strong attention should also be paid to the variables mental health and building aesthetics, as they are strong in the regression models.

With the combined information of the satisfaction with and the value placed on maintenance, the municipality should consider developing a better maintenance plan to address the locations that need better maintenance the most on the short term. These locations are discussed in 4.6.6.2. The same could be done for safety, but this is likely to be harder to improve on the short term.

4.4.4 Preferred public transport stop

In step 5 of the survey, 85 respondents selected their preferred public transport stop on the mapping tool, whilst also indicating how often they use it. This step is predominantly introduced to make the respondents acquainted with the mapping tool, as they already know where the location of their preferred stop is.

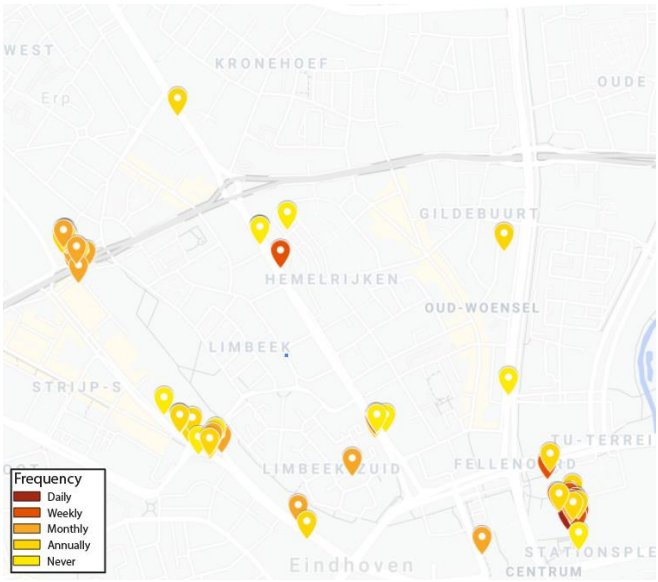

Figure 24: Distribution of selected Public Transport stops

Regardless, this information can still provide urban planners with the public transport preferences of the neighborhood's residents and potential accessibility issues. With these insights, planners can improve service by improving connections or see whether stops are obsolete or need better placement. Figure 24 is made by processing the geographical data of the preferred public transport stops, the relevant variables are exported from SPSS to a .csv file format, then inserted in Google spreadsheets, and subsequently opened with Google My Maps for easy visualization, in which darker red represent higher frequencies, and yellow lower frequencies.

With this information, Table 32 is created, displaying the distribution of attributed frequencies of each PT stop, in which the column 'Total used' excludes the respondents that stated to never use their preferred stop. A significant relation was found between the frequency of PT stop use and the preferred PT stop mode (X^2 = 15.220, sig. = 0.004). From this is derived that the train stations are the most preferred and most frequently used public transport stops for the residents of Limbeek. Glaspoort has been selected as the most used bus stop, with twelve respondents. This stop is likely to be popular due to twelve busses going to Eindhoven Central Station every hour during daytime and three separate lines connecting to Eindhoven Airport, Veldhoven and Oerle.

Table 32: Frequencies of preferred public transport stops

Preferred Public Transport stop name	**How often do you use this stop?**						
	Daily	Weekly	Monthly	Annually	Never	Total used	Percent
Eindhoven Central Station	2	8	8	7	2	25	36.2
Eindhoven Strijp-S	0	4	10	6	1	20	29.0
Boschdijk Zernikestraat	0	1	0	3	4	4	5.8
Boschdijk Gemmastraat	1	1	0	0	3	2	2.9
Boschdijk Wattstraat	0	0	0	1	0	1	1.4
Glaspoort	0	2	4	6	5	12	17.4
Philips-stadium	0	0	1	1	0	2	2.9
Piazza	0	0	1	0	0	1	1.4
Fontys Rachelsmolen	0	0	0	1	0	1	1.4
Gildelaan	0	0	0	0	1	0	0.0
Unknown	0	0	1	0	0	1	1.4
Total	3	16	25	25	16	69	100

Limbeek is relatively unique in its proximity to multiple public transport stops and hubs, this likely caused most of the respondents to be (very) satisfied with their accessibility to public transport, as presented in 4.4.2 (Figure 23). Relations between satisfaction with accessibility of public transport and public transport usage patterns were insignificant. However, these tests and relations are likely to be more relevant for areas with fewer public transport options or a lower rate of satisfaction with its accessibility.

4.4.5 Placed associations

Step 6 of the survey enabled the respondents to select up to three locations or objects they are satisfied and three locations or objects they are dissatisfied with (Figure 75). For each selection, they were asked to pick the neighborhood characteristics that are associated with these (dis)satisfactions. This section describes the compositions of the associated characteristics to the placed locations and compares them to the literature research. Section 4.4.6 breaks down the placements of pins for each characteristic and transforms them into heatmaps.

4.4.5.1 Selected associations

In total, 188 satisfactory locations with 440 associations were selected by 75 respondents, averaging 2.34 associations per place. The right half of Figure 25 breaks down the 440 associations. Aesthetics has the most associations (23.2%) as it is selected for 54.3 percent of the place locations, followed by recreation (18.6%) and social (16.8%). These first two were also dominant in the findings of Brown (2008) & Tyrväinen et al. (2007). Whereas social is not so dominant in the literature, but is not as surprising, as the respondents have said to be relatively satisfied with the social properties of their neighborhood, see Figure 23. At the same time, the community feeling was found to be an important factor to a high perception of densely built area by Kyttä et al. (2011).

62 respondents selected a total number of 151 negative place locations, with a combined 307 associations, averaging 2.03 associations per selected location. The break-down of Figure 25 shows that traffic safety is the most selected association, followed by aesthetic, personal safety, noise and maintenance. The negative associations with noise and safety are also found by (Tyrväinen et al., 2007). The other negative associations can also be explained by the relative dissatisfaction with the maintenance and feelings of unsafety in the neighborhood, as found in 4.6.3.

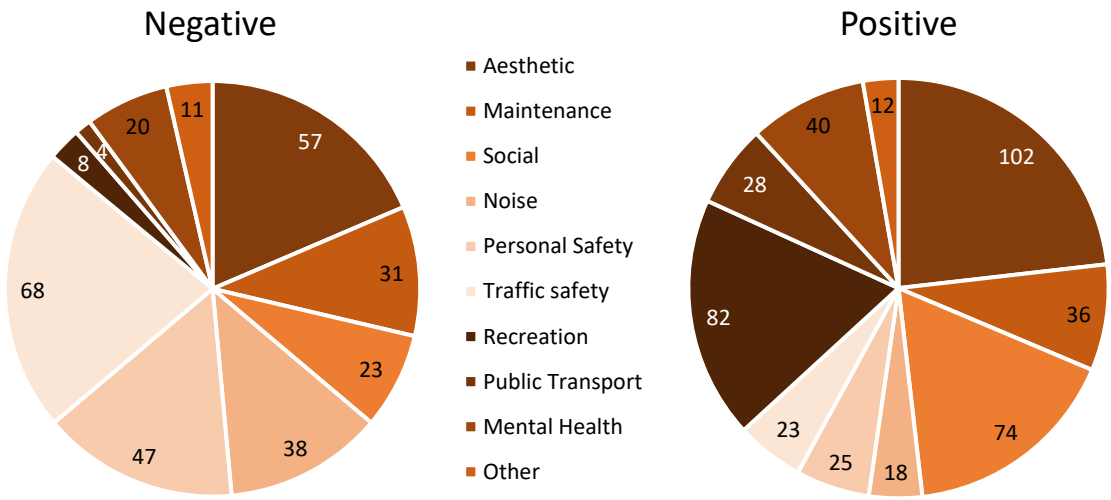

Figure 25: Place value associations

4.4.5.2 Relations between number of associations and satisfaction

Table 33 explores whether relations exist between the satisfaction of the respondents and the number of associations they have selected from any of the variables. For this test, all respondents that did not select any locations are removed. Then for each neighborhood characteristics, a variable is calculated in which every positive association is counted as +1 and every negative association counted as -1. As respondents can only select three positive and three negative locations, the variable ranges from -3 to 3. From the Spearman correlations can be derived that relations at the 95 percent confidence level exist for maintenance and noise, and relations at the 90 percent confidence level exist for public space aesthetics and mental health. Which proves that respondents that are dissatisfied with either of these four variables are more likely to select locations that they negatively associate with that variable, and vice versa. Most interestingly is the relation between the total number of positive and negative selected locations and the general neighborhood satisfaction, which proves that respondents who are satisfied with their neighborhood are more likely to select positive locations than those that are dissatisfied.

Table 33: Relation between association and satisfaction (without respondents refusing to select any location)

Satisfaction	Valid Cases	Spearman Correlation Coefficient	Sig.
General satisfaction	78	-.291	.010
Building aesthetic	78	-.182	.111
Public space aesthetic	75	-.213	.066
Maintenance	79	-.331	.003
Social	75	-.096	.413
Noise	78	-.286	.011
Personal safety	77	-.082	.480
Traffic safety	78	-.054	.639
Recreation	75	-.052	.656
Public transport	77	-.115	.317
Mental Health	72	-.221	.063

4.4.6 Structuring publicly perceived issues

QGIS3 is used for visualizations and enumeration of the distribution of the selected locations. For this, a QGIS model is designed, see Figure 26. As input, the relevant columns are exported from SPSS into a .csv file. In this file, the value of the negative associations is changed from '1' to '2', for differentiation between positive and negative locations. The six selected locations per respondent are then placed in one list. This .csv file is then added as a text separated layer inserted into QGIS, CRS (Coordinate Reference System): EPSG:1426 - WGS 84. This layer is the starting point for the model. The first step in the model is the reprojection of the points in the layer to CRS: EPSG:28992 - Amersfoort / RD New. Then, for each variable, locations are selected if the variable attribute has a value of 1 (positive) or 2 negative. These selected locations are then isolated from the full attribute table and displayed on the map. As discussed in 2.1.2.1 and 2.3, Kyttä et al.(2013) used a grid overlay to visualize the density of the selected locations and the proportions of (positive) affordances for each grid cell, Figure 7. However, this research was conducted on a city-scale, with 250x250m grids, which received up to 239 localizations per cell. This study is conducted on a neighborhood scale, and therefore received fewer localizations. Therefore, the method of Nenko & Petrova (2019) is chosen to visualize these selected points by creating a positive and a negative heatmap for each of the association categories. In these heatmaps, all locations that have the specific association receive a value 1 with a radius of 100 meter, in which the value gradually decreases in outward direction. To allow equal comparison between the heatmaps of the association, the minimum heatmap value is set at 0 and the maximum at 5. For future research however, the radius and values can be changed manually, based on sample size, research area or density (Hilbers et al., 2021; Kyttä et al., 2013).

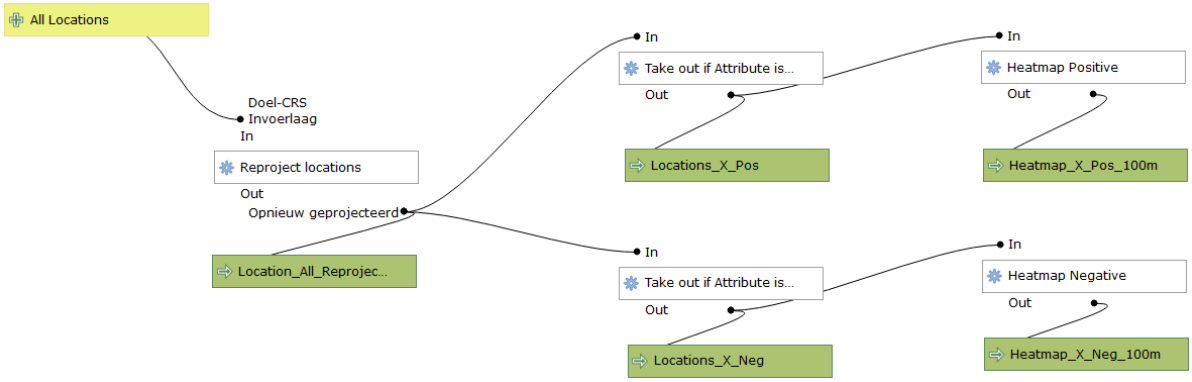

Figure 26: Location process model for one variable

Figure 27 shows the distribution of the locations selected by the respondents that they are satisfied (green) or dissatisfied (red) with, in Limbeek or its immediate surroundings. In total, 211 locations were selected within the neighborhood, whereas 128 were placed outside of the neighborhood boundaries, which are grouped into broader neighboring areas, see Table 34.

From this table and figure can be derived that the many respondents also place value on the areas surrounding their neighborhood, as 37.8 percent of the selected location are not located within. The respondents of Limbeek positively value Eindhoven's City Centre, the Philips de Jongh Park and the adjacent area Strijp-S, see Figure 78, likely because they provide retail, leisure or recreation opportunities. Whereas the Kruisstraat and the Philips Stadium are mostly valued negatively, which is also clear from the heatmap in Figure 79, likely due to safety and noise disturbance.

Table 34: Placements outside Limbeek

Area	Number of placements	% Positive
City Centre	26	84.6
Erp	6	66.7
Kruisstraat	28	42.9
Philips de Jongh Park	7	100.0
Philips Stadium	13	38.5
Philipsdorp	3	33.3
Strijp-S	29	89.7
Other	16	75.0
Total	128	69.5

Furthermore, within the neighborhood, 58 locations were selected in or near the Anthony van Leeuwenhoeklaan Park, of which 84.5 percent was positive. Other areas that were selected frequently are located along the borders of the neighborhood. To investigate what their (dis)satisfactions with these locations are about, these locations are broken down in distributions and heatmaps for each variable in the following subsections. With this information, urban planners gain insights towards which type of interventions are desired at any location in and around the neighborhood. To allow equal and fair comparison, the scale of all maps is set on 1:15000 and a heatmap radius of 100 meters, with a density range of 0-5. Exceptions are the heatmaps with all associations (Figure 78 and Figure 79), which have a density range of 0-10.

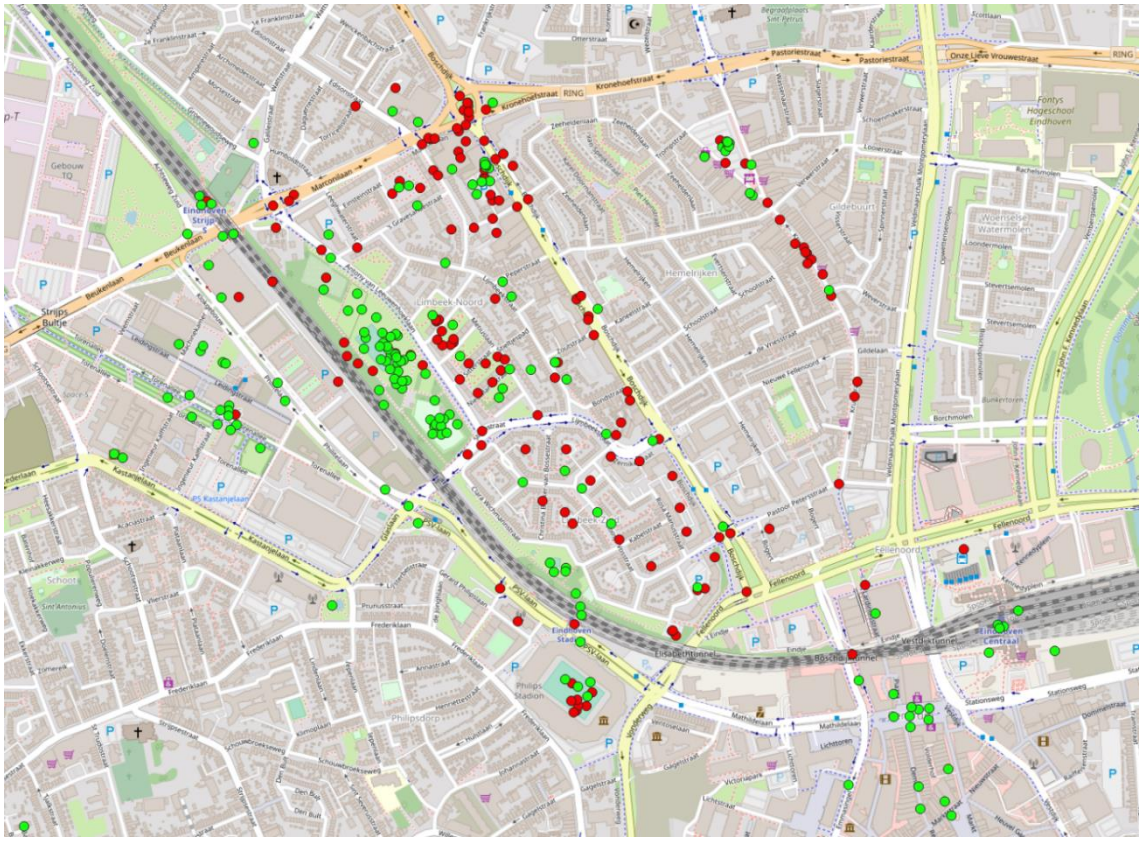

Figure 27: Positive and negative locations

4.4.6.1 Aesthetics

Figure 80 shows the distribution of the 159 selected locations with an aesthetic association, of which the 102 positive locations are processed in the heatmap of **Error! Reference source not found.** and the 57 negative locations are shown in Figure 28. Figure 29 shows that high densities of positive locations are placed in the playground (Figure 98) and on the football field of the Anthony van Leeuwenhoeklaan Park, the western green areas within the neighborhood in general, the city center and the neighboring Strijp-S neighborhood.

The highest densities of negative associations are placed near the grocery store in the north-east of the neighborhood one spot in the center of the neighborhood (Figure 99) and along the Kruisstraat, which is outside the neighborhood limits, see Figure 28. With a 100-meter radius, the selected locations almost completely cover the neighborhood, but are spread equally.

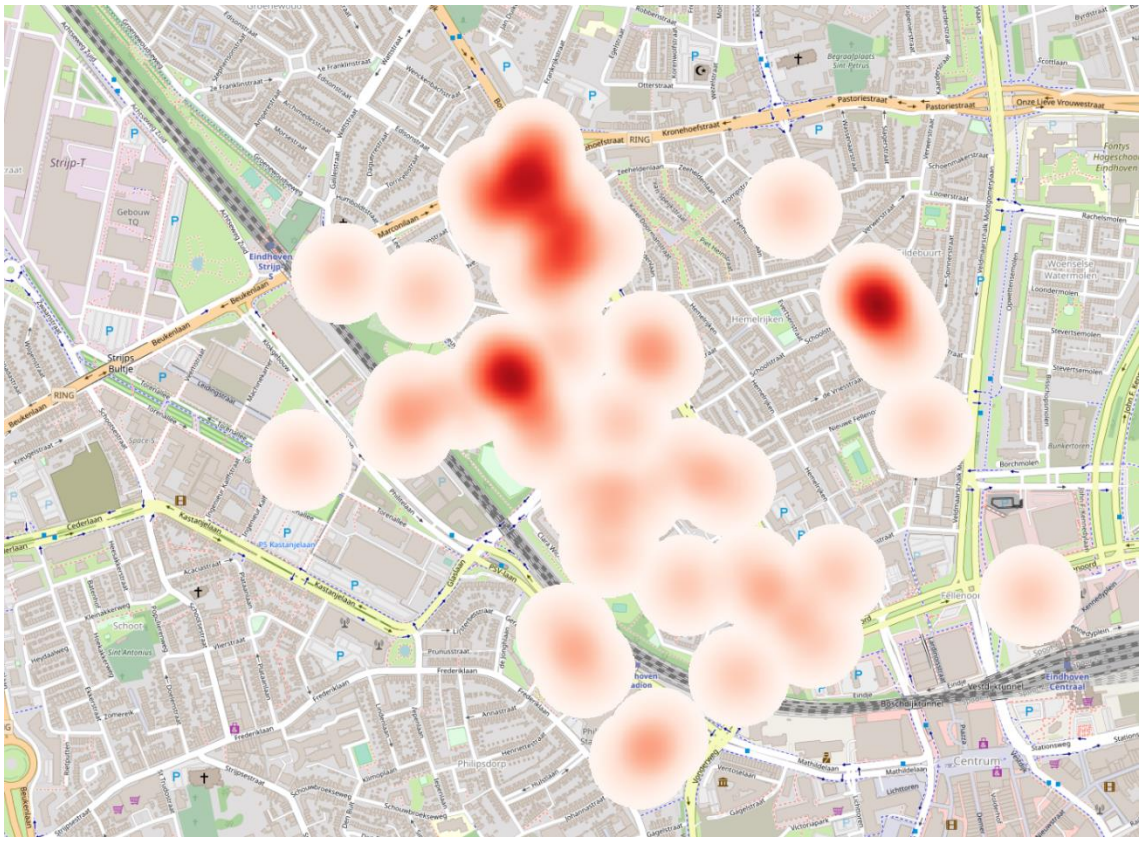

Figure 28: Negative aesthetic heatmap

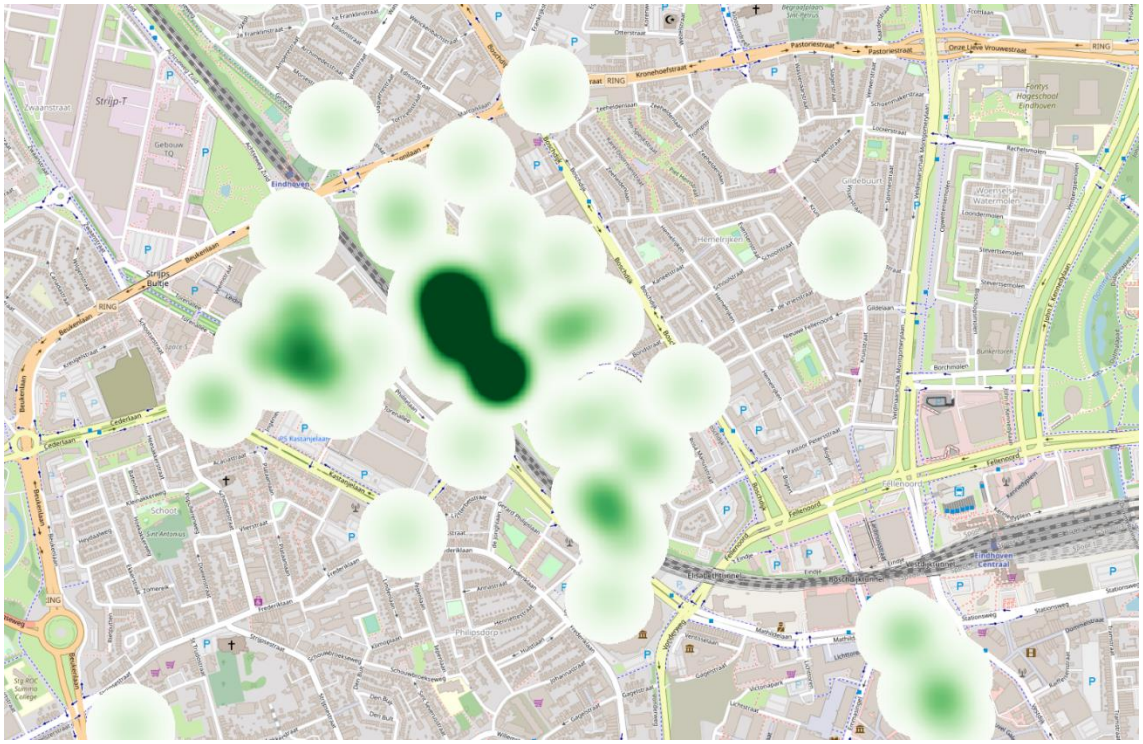

Figure 29: Positive aesthetics heatmap

4.4.6.2 Maintenance

The distribution of the 67 locations with maintenance as an association is shown in Figure 81, and the heatmap of the 31 negative locations is shown in Figure 30 (left). From this heatmap, two areas with a high density of negative association are apparent: one over the portico flats in the center of Limbeek-Noord (Figure 99) and one over the grocery store and its adjacent parking lots. In the comments, respondents often refer to the poor state of, and the lack of service at, the garbage disposal point near the grocery store. Whereas a high density of satisfactory maintained locations can be found over the Anthony van Leeuwenhoeklaan Park, see Figure 30 (right). With this information, the municipality knows where in the neighborhood better maintenance of the public space is desired most, and/or needs more attention to prevent negligence in the future. This information is especially useful considering the respondent's satisfaction level with maintenance and the importance placed on it in sections 4.4.2 and 4.4.3.

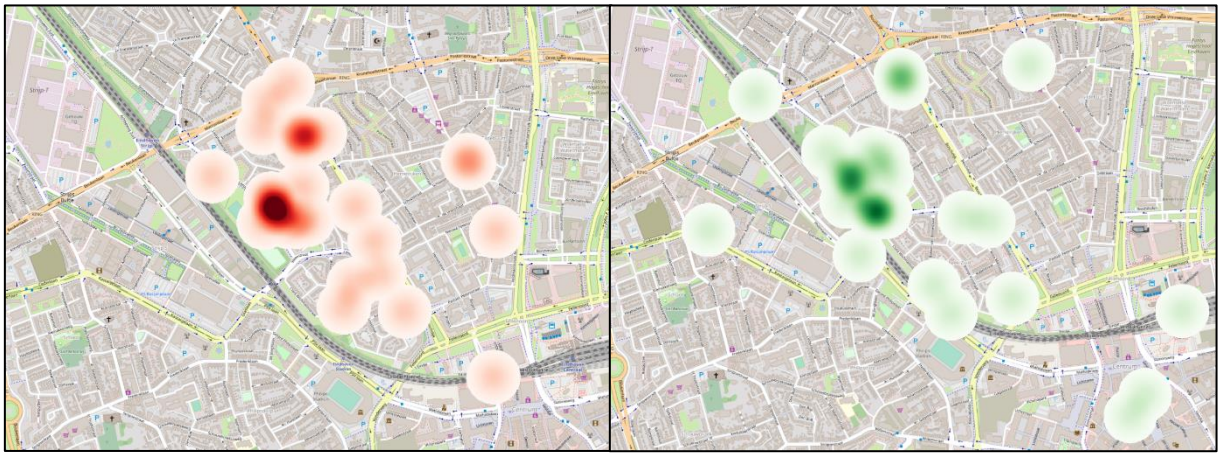

Figure 30: Negative and positive heatmaps with maintenance associations

4.4.6.3 Social

Figure 82 shows the distribution of the 97 selected locations with a social association. Of these, only 23 were negative, this low percentage (23.7%) is in line with the relatively high social satisfaction of the neighborhood's residents. The resulting negative heatmap in Figure 31 also shows no high density of social dissatisfaction, only one medium density area over the central portico flats, several respondents attribute the dissatisfaction to loiterers. The positive heatmap in Figure 31 illustrates that the Limbeek Residents experience high social satisfaction outside their neighborhood in Strijp-S, the city center and the Woenselse Markt. Within the neighborhood, a high density of positive social locations is selected in the Anthony van Leeuwenhoeklaan Park. Respondents describe the area as a nice place to meet other neighborhood residents.

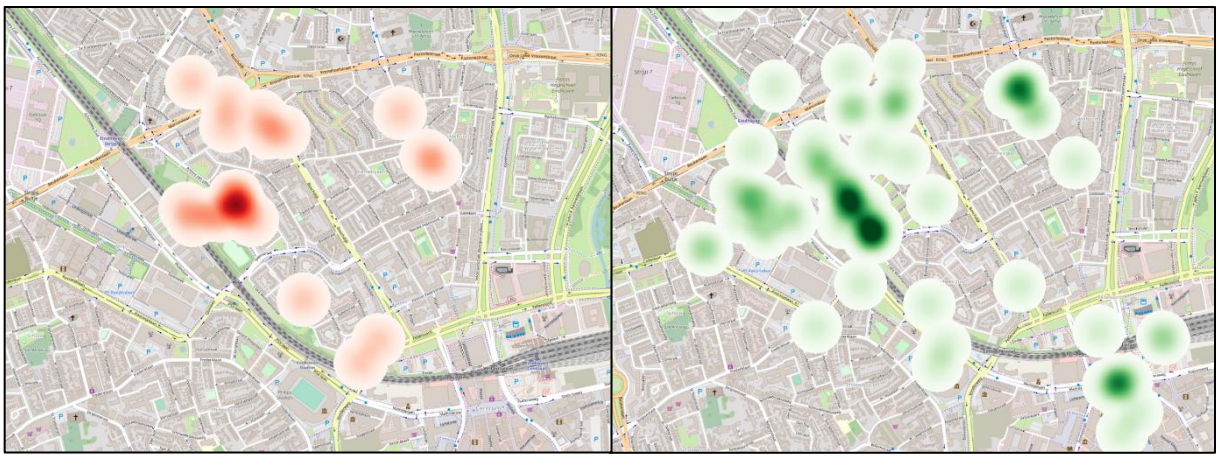

Figure 31; Negative and positive heatmaps with social associations

4.4.6.4 Noise

Figure 83 (in Appendix VI.VIII) displays the distribution of the 56 selected locations, of which 18 had a positive (green) and 38 had a negative (red) association with noise. The related heatmaps are shown in Figure 32. The negative heatmap below shows that most of the noise disturbance is experienced from the Philips stadium in the south and along the Marconilaan ring road in the north, especially near the north-east intersection. Some other noise disturbances are experienced by the Boschdijk and the trains passing by. However, other residents reported not to be so bothered with the noise from the railway.

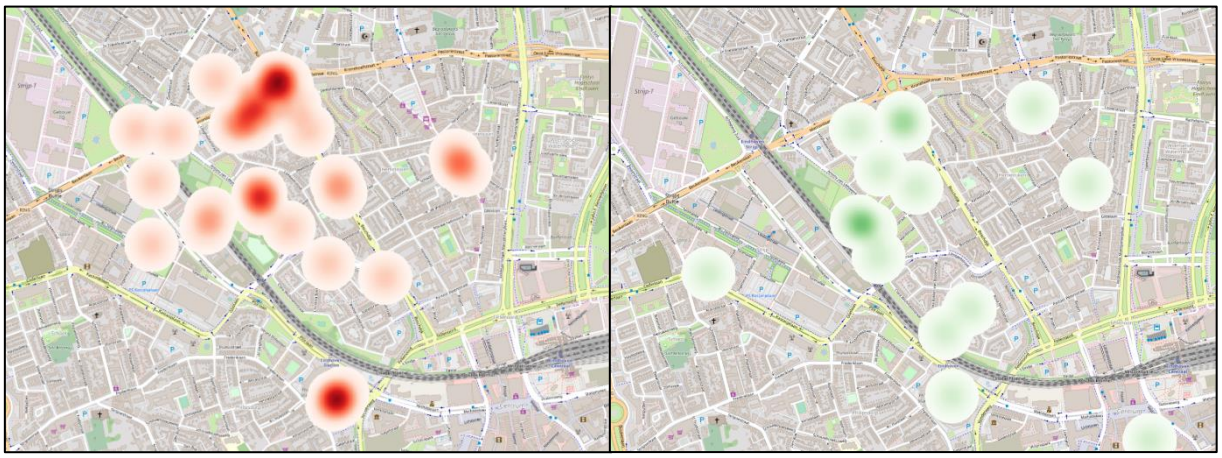

Figure 32: Negative and positive heatmap with noise associations

4.4.6.5 Personal Safety

The 73 locations what were associated with personal safety are distributed as shown in Figure 84. The 47 negative locations produced the heatmap of Figure 33. Which shows that the highest density of unsafety in the neighborhood is experienced around the entrance (Figure 104) and parking lot (Figure 103) of the grocery store in the north-east. Another area that is experienced as unsafe is the Kruisstraat. The 25 locations that were associated to be safe did not produce high densities in or around the neighborhood, see Figure 34**Error! Reference source not found.**. With this information, the municipality should consider implementing measures near the high-density areas that would improve (perceived) safety. As safety and was found in 4.6.3 and prior research by Kyttä et al. (2011) to be one of the important factors to perceive a densely build areas, such as Limbeek, as poor.

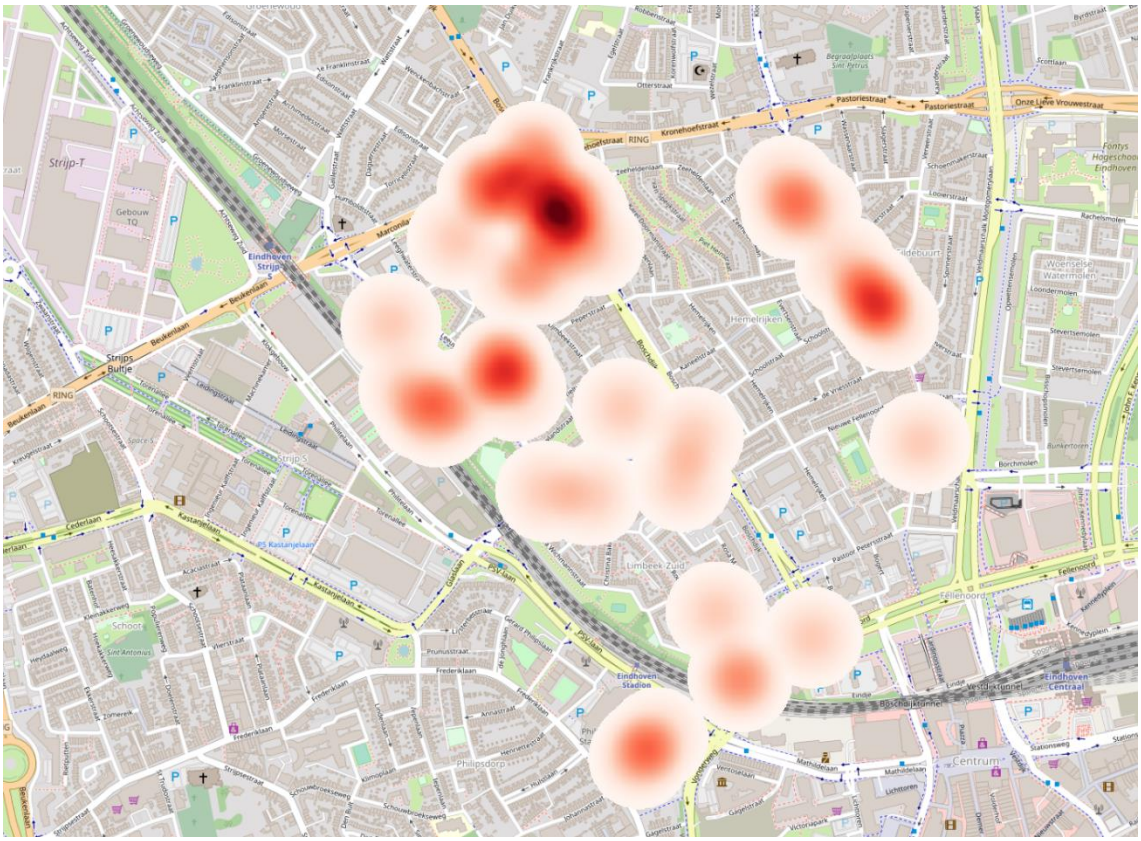

Figure 33: Negative personal safety heatmap

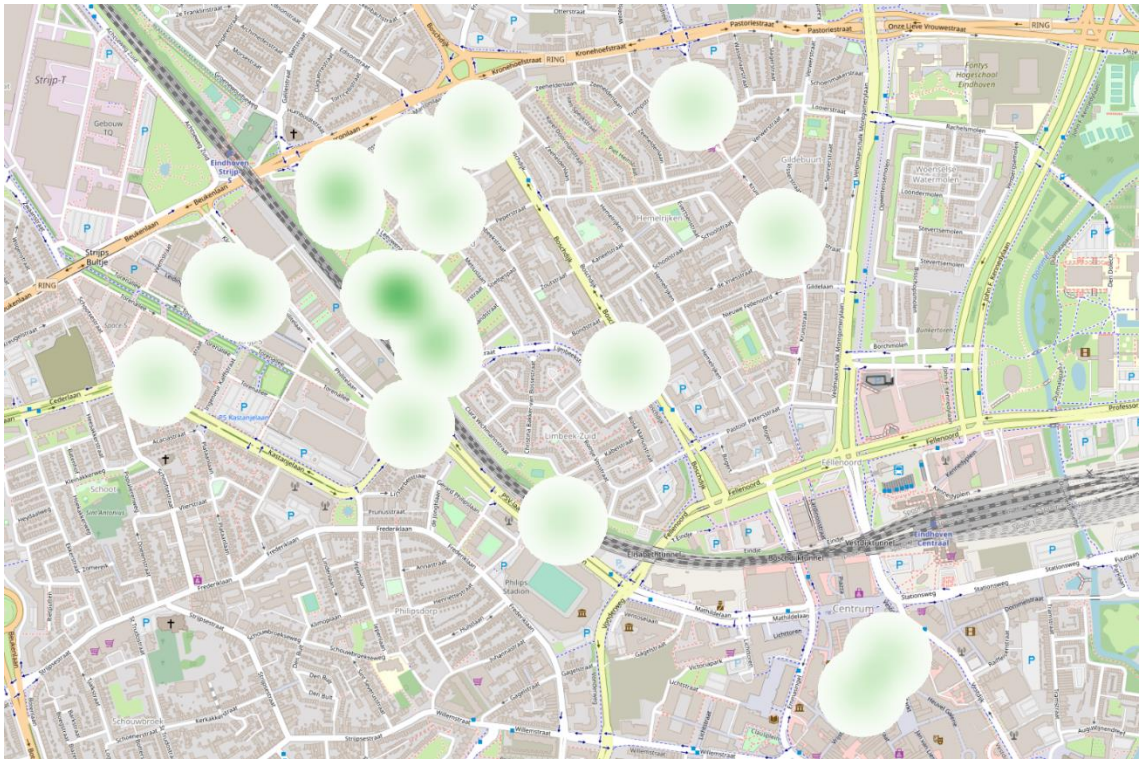

Figure 34: Positive personal safety heatmap

4.4.6.6 Traffic Safety

Figure 35 and Figure 85 show the distribution and related heatmaps of the 91 selected locations with a traffic safety association. The negative heatmap below shows that respondents find the (road)crossings along the eastern and northern border to be unsafe. The highest density is found over the Boschdijk and Marconilaan intersection (north-east) and to a lesser extent the crossing of the Marconilaan and the Anthony van Leeuwenhoeklaan (north-west). Another area that is perceived to be relatively unsafe is the Anthony van Leeuwenhoeklaan along the football field. With this information, the municipality knows where improvements to traffic safety are deemed to be the most desirable.

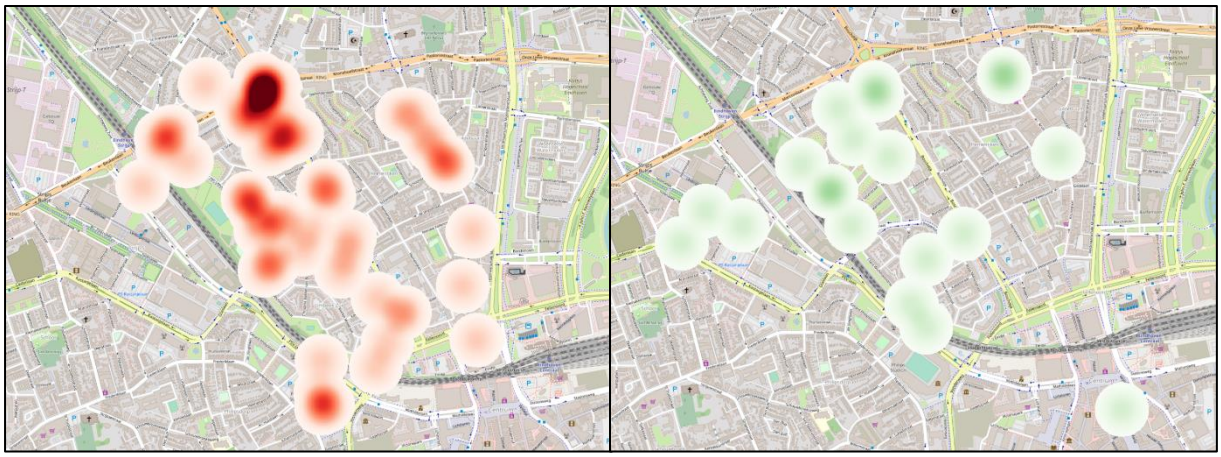

Figure 35: Negative and positive heatmap with traffic safety associations

4.4.6.7 Recreation

The distribution (Figure 86) and heatmaps (Figure 87 and Figure 88) of the 90 locations associated with recreation show that respondents of Limbeek value recreational opportunities outside their own neighborhood. As they positively associated Eindhoven city center, Strijp-S and the Philips de Jongh Park with recreation. The recreation locations selected within the neighborhood are almost exclusively placed in the green strip on the western edge along the railway.

4.4.6.8 Public Transport

As mentioned in subsection 4.6.5, only 32 locations were selected that were associated with public transport, see Figure 89. With only 4 negatively associated locations, no real insights could be derived from the heatmap in Figure 91. The positive associations had medium densities at both train stations, see Figure 90.

4.4.6.9 Mental Health

60 locations with a mental health association were selected by the respondent and are distributed as shown in Figure 92. The only area with a high density of positive locations according to the heatmap (Figure 93) is over the Anthony van Leeuwenhoeklaan Park, predominantly the playground and football field. Figure 94 shows only one area of medium density, over the portico flats at the center of Limbeek-North.

4.4.6.10 Other

Figure 95 shows the distribution of the 23 locations that had an association that respondents could place amongst the other categories. Six of the positive ones were related to the presence of facilities for (grocery) shopping. Some of the negative association used formulated by the respondents are: parking issues, some of which are reported to be caused by the Philips-Stadium; locations that were (re)developed without their involvement, and complaints about the (allegedly) excessive transport of dangerous goods over the railway.

4.4.6.11 Conclusion

From the locations and associations selected by the Limbeek sample. Respondents seem to appreciate not only locations in, but also areas in near proximity of their neighborhood, mostly because they provide them with opportunities for recreations, as they are deemed to be aesthetically pleasing and well-maintained. Other nearby areas, such as the football stadium, are negatively valued by respondents, as they deem it to cause noise disturbance and dangerous (traffic) situations in and around the neighborhood. Within the neighborhood, the heatmaps showed that, within the neighborhood, the green strip along its western border (the Anthony van Leeuwenhoeklaan Park), is the most positively valued area by a large group. This most frequent positive associations with this area are aesthetic, social, recreation and mental health. This agrees with the findings of Brown (2008) and Brown et al. (2014), who concluded that larger parks are often associated with multiple variables and benefits. Two areas with a high negative density are visible in several maps, in the north-east and in the center of the neighborhood. The north-eastern area, which contains a grocery store, its parking lot, and a large intersection, has the largest area and the highest negative density. Many respondents were dissatisfied with the area's personal safety, noise disturbance and traffic safety, and to a lesser extent with its maintenance and aesthetics. The area in the center, containing residential portico flats, causes most dissatisfaction over maintenance social and traffic safety. The crossing in the north-west also came forward as negative from the traffic safety heatmap.

The pilot study introduced a mapping tool in an online questionnaire environment. This tool collects the selected locations experienced as positive or negative by respondents, and it also registers the associations experienced in these locations. QGIS is then used to transform the locations and associations into GIS point clouds and heatmaps for each association category. By doing so, this method is able to display differences in density, distribution, experience, and association for each of the PPGIS variables. The created heatmaps have radiuses of 100 meters, density values set in a range from 0 to a maximum at 5. For future use, this study recommends considering changing the radius and values to fit the sample size, research area, or respondent density, as also advised by Hilbers et al. (2021) and Kyttä et al. (2013). The study also advises selecting an average density just above the maximum number of locations that one respondent can select. This setting prevents one single respondent from creating a hotspot on his own.

4.4.7 Willingness to participate

Step 8 of the survey posed three statements to the respondents regarding their willingness to participate, the results are presented in Table 35. Whether they liked to be consulted by the municipality, if they would be willing to fill in a questionnaire and if they would attend an information gathering. 87.3 percent of the 71 respondents stated that they would like to be consulted, and 7 percent being unsure. On the second statement, 84.5 percent stated that they would be willing to fill in a questionnaire as (part of) their input. Lastly, only 38.0 percent of the respondents said that they would definitely attend an information evening organized by the municipality, with another 38.0 percent stating that they were uncertain whether they would attend.

Table 35: Respondents' willingness to participate

In case the municipality would be making plans for the improvement of your neighborhood:						
	Yes	%	No	%	Uncertain	%
Would you like it if the municipality asked for your opinion?	62	87.3	4	5.6	5	7.0
Would you be willing to fill in a questionnaire?	60	84.5	2	2.8	9	12.7
Would you go to an information evening in your neighborhood?	27	38.0	17	23.9	27	38.0

The respondent's answers to these statements provide insights in potential increase of public participation by integrating this pilot to supplement the traditional public participation process of community gatherings. For this, the respondents that stated not to be asked for their opinion are excluded. From the 67 respondents that answered with 'yes' or 'uncertain' on the statement regarding their willingness to be consulted by the municipality for their opinions, none stated that they were not willing to fill in a questionnaire, see Table 36. Only 26 (38.8%) of these 67 respondents stated that they would definitely attend a community gathering. With 25 (96.2%) of them stating that they were also willing to fill in a questionnaire as part of their participation. From the 25 that were uncertain to and the 16 that would not attend, 22 (88.0%) and 12 (75.0%) respectively stated that they were willing to fill in a questionnaire. These percentages indicate that the inclusion of this pilot into the public participation process has the potential to increase the number of participants. Additionally, most of those that would normally already participate, also stated to be willing to use it as an extra participation method.

Table 36: Crosstab willingness filling in questionnaire and willingness to attend information evening

	Would you be willing to fill in a questionnaire?			Total
Would you go to an information evening in your neighborhood?	Yes	No	Uncertain	
Yes	25	0	1	26
No	12	0	4	16
Uncertain	22	0	3	25
Total	59	0	8	67

The following paragraphs test whether differences exist within personal characteristics of the groups that are willing to participate in information evenings and/or filling in questionnaires, and to compare this with the results of the literature research, see section 2.2.2. For all tests, the category 'other/prefer not to say' is excluded. Furthermore, due to the low number of cases and as we to understand what percentage of respondents would definitely participate, the categories 'no' and 'uncertain' are merged for both statements regarding willingness to participate. Furthermore, personal characteristics are grouped similar to those in the sample representativeness test. A full breakdown of the personal characteristics and willingness to participate is shown in Appendix VI.IX.

The Chi-Square test found a relation between the respondents' age and their willingness to attend an information evening. With Table 49 in Appendix VI.IX suggesting that the respondents who would certainly attend a community gathering are part of an older age groups than those who would not or are uncertain to attend. This result is in line with the findings of Uittenbroek et al. (2019). The Chi-Squared tests in Table 37 found no relations between respondents' willingness to definitely attend an information evening gathering and the other personal characteristics. So the findings in prior research of higher (willingness towards) participation amongst males, households with children, the higher educated and those speaking the dominant language (Bussemaker & Voet, 1998; Tonkens & Hurenkamp, 2019), were not found for the Limbeek sample.

Table 37: Chi-Square tests willingness to participate

Personal characteristics	df	Willingness to attend an information evening?		Willingness to fill in a questionnaire?	
		Chi-Square Value	Sig.	Chi-Square Value	Sig.
Age	3	8.224	.042	1.736	.629
Gender	1	.193	.660	3.408	.065
Household composition	2	.879	.644	.437	.804
Education	2	1.199	.549	2.888	.236
Language	1	.061	.804	1.202	.273

Table 49 shows that responding females in Limbeek are 16.4 percent points more likely to be willing to fill in a questionnaire than males (93.3% to 76.9%). The Chi-Square test found a relation with 90 percent confidence between the willingness to fill in a questionnaire and the gender of the respondents, see Table 37. No statistically significant relations were found between willingness to fill in a questionnaire and the other personal characteristics. For education level however, more data would be desired to further investigation, as the crosstab indicates that the respondents with a lower (88.9%) and medium (100%) education level are more likely to fill in a questionnaire than their higher educated counterparts (80.0%).

Conclusion

The results from the survey agree with a prior finding (Uittenbroek et al., 2019) that a relation exists between the respondents' age groups are their likelihood to attend public gatherings, while no significant relationships with the other personal characteristics were found. This age difference was not found for the willingness to fill in a questionnaire, but it was found that females were more likely to be willing to fill in a survey than males.

These results indicate that a questionnaire can help to include more residents to the public participation process, as a large majority of the Limbeek sample who would otherwise not attend a traditional community gathering, stated to be willing to fill in a questionnaire as (part of) their input. Including a questionnaire in the public participation process is likely to generate a more equal participation rate amongst the age groups, compared to only community gatherings. However, it needs to be noted that more data would be required to better check the relations between respondents' willingness to participate and their personal characteristics.

4.5 Conclusion

A pilot study is conducted in the Dutch neighborhood of Limbeek, Eindhoven. 95 residents participated in a web-based LimeSurvey questionnaire, which could be accessed from a QR-code on a door-to-door posted leaflet, the survey had an effectual rate of 4.5 respondents per 100 leaflets and 2.8 per 100 eligible residents. With this survey, the research aimed to answer sub-questions 2 and 3, both related to the key determinant information quality. The survey is designed to gain insights in the Limbeek resident's satisfaction with ten individual neighborhood characteristics and with the neighborhood in general, as well as investigating which characteristics they valued most. Respondents were then introduced to a mapping tool in which they could select GPS locations they were (dis)satisfied with, and what association(s) these experiences caused. To process the GPS information gathered by the mapping tool, a QGIS model is used to structure these publicly perceived issues and benefits into GIS heatmaps for each neighborhood characteristic. Last, they were asked whether they deemed this survey to be a suitable method for them to participate in governmental decision-making processes. With this information, feedback can be given on sub-question 4, whether the integration of a PPGIS application would succeed in improving representativeness.

The data sample was not representative to all of Limbeek's demographics, apart from the gender distribution. Notable was the high number of participants that were part of the 25–34-year age group and those that were part of a household without children. The sample was representatively distributed over the North and South areas, with equal gender, household and education distributions for both areas. Whereas participants from the north appeared to be younger on average.

The general neighborhood satisfaction of the Limbeek sample was significantly below the Dutch national average. The respondents were also less satisfied with their neighborhood's (building) aesthetics and maintenance than the average Dutchman as well as with their feelings of safety in their neighborhood. However, their satisfaction with the social properties was representative to the Dutch average, according to the WoON2018 data. Comparing the individual characteristics shows that the respondents were the most satisfied with their accessibility to public transport. This satisfaction was high amongst all respondent groups, regardless of frequency of use, preferred transport mode or whether their preferred PT-stop was the closest. The respondents are the least satisfied with their neighborhood's aesthetics, maintenance and both personal safety and traffic safety. As these variables have significant interdependencies, it appears that the Limbeek's physical attributes and the lack of maintenance of it, have a negative effect on the respondent's feelings of safety and mental health in the neighborhood.

The findings of the ranked characteristics did not completely align with those of the multiple regression analysis. The characteristics that were valued the highest were, personal safety, accessibility to public transport, maintenance and noise, whereas the regression analysis indicated mental health, maintenance, personal safety and building aesthetics to be the strongest predictors of general neighborhood satisfaction. The regression analysis also concluded that the Limbeek sample satisfaction is strongest predicted by personal safety and maintenance, whilst the WoON2018 satisfaction is strongest predicted by building aesthetics and social. This difference for the variable social can be explained by the Limbeek's below average general satisfaction but average social satisfaction, compared to the WoON2018.

In total, 339 locations were selected on the mapping tool by the respondents in and around Limbeek, of which 188 locations had a combined total of 444 positive associations and 151 locations had a combined total of 313 negative associations. Of the positive associations, aesthetics was most frequently selected, followed by recreation and social. A high frequency of recreative and aesthetical associations are in line with the literature, whereas social was not found as often in prior research. Negative locations were often associated with traffic safety, aesthetics, personal safety and noise. All but the aesthetics were also found in the literature. Furthermore, relations were found between respondents' satisfaction with maintenance, noise, (public space) aesthetics and mental health and the number of associations they selected for that respective neighborhood characteristic. Most interestingly, respondents who are satisfied with their neighborhood in general are more likely to select positive locations than those who are dissatisfied.

With these selected locations, positive and negative heatmaps for all variables were created in QGIS. With these GIS layers, municipal planners can transform public sourced information into ready-to-use data layers of respondent's experiences. The data from Limbeek revealed that the respondents mostly valued a green strip along the neighborhoods' western border, containing a park, playground, football field and allotment garden. It received high densities of positive associations for recreation, mental health, social and aesthetics. They also positively valued the city center, a green park/forest and an adjacent neighborhood, which all held aesthetic and recreational value, and were perceived to be well-maintained. On the other hand, high densities of negative associations were found for the immediately adjacent stadium (noise, personal and traffic safety) and a nearby (grocery) shopping street (personal safety). On the neighborhood boundary, medium to high densities of negative traffic safety associations were found for nearly all of the northern and eastern road crossings. The highest densities of negative associations for personal safety, aesthetics, maintenance, noise and traffic safety were found in the north-east corner of the neighborhood. This area includes the neighborhood's grocery store and its carpark, a busy intersection and a new residential block which was under construction at the time of data collection.

The results confirm findings from the literature that residents in older age categories are more likely to attend public gatherings. This age difference was not found for those willing to fill in a questionnaire, but women were significantly more likely to be willing to fill in a questionnaire. But most important is the indication that a questionnaire can help to include more residents to the participation process, as 82.9 percent of the respondents that would not or were not sure to attend a gathering, are willing to fill in this questionnaire as part of their participation, whereas 96.2 percent of those who would attend at gathering would fill in the questionnaire as part of their participation as well.

Integrating Public Participation GIS applications into
the Dutch environmental planning system

5. Conclusions and recommendations

This report aims to answer the research question: how can Public Participation Geographical Information Systems (PPGIS) improve public participation in Dutch land-use planning? The scope of this paper is to find a method to increase the public participation rates in Dutch land-use planning by integrating a PPGIS application in this process. The recommendations in this paper follow from the conclusions on four sub-questions regarding the three key criteria for a successful PPGIS integration: applicability, representability, and information quality. Applicability is answered by selecting the PPGIS variables that are the most important and relevant within the Dutch context. It is then investigated and showcased how PPGIS variables and issues perceived by inhabitants can be measured and structured into useful qualitative information for land-use planners and decision-makers. Last, this research mapped the applicable laws and regulations in which the method can be embedded to achieve optimal representativeness.

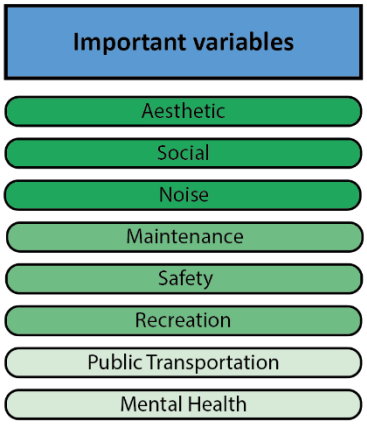

Figure 36: Most important variables, based on WoON2018-data and relevant studies

As participation is unlikely to increase if residents are consulted regarding topics not relevant to them, the first sub-question focuses on applicability. A three-step approach is used to find the variables deemed most important by residents and most relevant for urban planners to include in Dutch land-use planning. First, an inventory of the (PPGIS) variables used in prior research and practice is made. Second, those variables that are not or sparsely used in the context of urban (re)development planning, as would be applicable in the Netherlands, are eliminated. Third, by those variables which are deemed unimportant in the analysis of the WoON2018 data (Ministerie van Binnenlandse Zaken en Koninkrijks-relaties (BZK) & Centraal Bureau voor de Statistiek (CBS), 2019), which is a dataset considered to be representative for the Dutch population, are eliminated. This exploration found aesthetic, social, and noise to be the most important variables, followed by maintenance, safety, recreation, access to public transport, and mental health, see Figure 36. This study uses the combined knowledge and variables from a multitude of prior studies conducted in various contexts and fields. This study adds to the literature by processing this knowledge to find, group, and define the most important variables for implementation in the Netherlands. For example, the variables maintenance and public transport are not used frequently in international literature. However, the variable analysis indicated these to be relevant and important for application in the Netherlands. Furthermore, the Limbeek pilot study respondents ranked these variables amongst their top three of the variables contributing most to their general neighborhood satisfaction. Studies aiming for similar applications in other countries can use the inventory as a starting point to their literature research. However, the variable selection and analysis process should then be adapted to the area and context in which they are to be applied.

The second sub-question is related to information quality: 'how can PPGIS variables be measured?' This question is answered in the form of a pilot study, which asked the respondents to state their level of satisfaction with the relevant neighborhood variables and their satisfaction with their neighborhood in general. By comparing these distributions reciprocally and with the national average, as presented in the triennial WoON survey, insights are gained into the neighborhood's (relative) strengths and weaknesses, as perceived by its inhabitants. With these individual satisfactions, regression analyses can be performed to see which neighborhood characteristics are the most substantial contributors to the general satisfaction of that neighborhood, and by extension, which types of intervention can have the most significant impacts on that neighborhood's residents.

Sub-question 3, also related to information quality, states: 'how can issues perceived by the public be structured into useful information for planning experts?' The mapping tool collects the selected locations by the respondents, registers whether the related experiences are positive or negative, and the experienced association(s). After collection, QGIS transforms this information into PPGIS point clouds and heatmaps of each association category. By doing so, this method can display differences in density, distribution, experience, and association for each of the PPGIS variables. When this knowledge is combined with the ranked neighborhood's priorities, urban planners are provided with a reasonably accurate understanding of which type of interventions are desired (most) at any place within or near the neighborhood. Additionally, the positive heatmaps show urban planners the positively experienced areas and why they must be preserved.

The findings on sub-questions 2 and 3 illustrate that an online questionnaire, when combined with a mapping tool, has the potential to produce useful and sufficiently qualitative information for urban planners and decision-makers. This research expands the literature by introducing another method to translate publicly perceived issues into heatmaps on a neighborhood scale while still displaying differences in density, distribution, experience, and association.

The final sub-question is related to PPGIS achieving sufficient representativeness when it is integrated in the Dutch land-use planning system. The study has identified that the new EPA (Environment & Planning act), which is due to be enacted by July 2022, provides a framework suitable for PPGIS integration. This act prescribes that for all (building) initiatives that require an environmental permit, a participation plan needs to be submitted. The level of participation, ranging from 0 to 3, that is required depends on the project's scale, societal interest, media attention, and nuisances. The participation plan lists an online questionnaire as one of the possible methods of public consultation and participation. The large majority of the pilot's respondents stated that they would be willing to fill in a questionnaire as (part of) their participation. This suggests that PPGIS integration can achieve higher levels of representativeness than traditional public participation methods, such as community gatherings.

Combining the findings on the sub-questions provides the literature and Dutch spatial planning practice with a PPGIS approach that can potentially increase public participation in land-use planning processes. The study presents a procedure to find the most applicable variables, a method to survey these variables and structure issues perceived by the public into sufficiently qualitative information. With respondents of this survey indicating that the method has the potential to achieve better representativeness than traditional public participation tools, the main aim of this project may have been reached. Naturally, the steps taken in the approach need to be adapted to fit the context and legislation of each application.

5.1 Limitations and recommendations

The largest limitation of this research is the small sample size, which was also not representative for the neighborhood. Therefore, no strong conclusions can be drawn from the results. Also, the pilot was conducted in Limbeek, which is unique in its adjacency to many public transport stops and hubs. The results are unlikely to be applicable for other neighborhoods, but future research to other neighborhoods should investigate this.

The results have shown that a significant number of respondents did not complete the questionnaire, partly causing the small sample size. 25 percent of the respondents that started the survey stopped halfway through, and therefore did not fill in their personal characteristics, as this was the last step of the survey. Therefore, the research has assumed in its analyses that the distributions of the personal characteristics of the 71 respondents that completely finished the survey are representative of the 95 that started it. This assumption cannot be checked from the sample data, so this might not be the case. Therefore, no comparisons between the full 95 satisfactions and preferences of different groups or respondents were made. In practice however, urban planners should be able to make these

comparisons, when sufficient personal characteristics data is available. A potential improvement could be changing the order of the questionnaire, either by starting the questionnaire with the personal characteristics, or by inserting them before the introduction of the mapping tool. This way, the personal characteristics of the respondents are known, even if they do not know how to operate the mapping tool, or do not have any (more) input for these steps. Another improvement would allow respondents to automatically skip the remaining maps if they do not select a location in one of the maps, reducing the minimum number of maps shown from six to two (at least one positive and one negative).

Furthermore, the mapping tool of the survey should be expanded by allowing respondents to map areas (polygons) or streets ((poly)lines), instead of only placing points, as is suggested by Hilbers et al. (2021). This research was unfortunately unable to implement this within the LimeSurvey environment. It is therefore recommended to either develop this within LimeSurvey, or to find other survey environments that support this tool.

The recruitment of respondents in the neighborhood should be improved. Going door-to-door with flyers generated a low percentage of respondents, with an effectual rate of 4.5 respondents per 100 leaflets and 2.8 respondents per 100 eligible residents, which is within the expectation of this data collection method (Auraprint, 2019; Dor-2-Dor, 2021; Edwards et al., 2002; SBS, n.d.). This low rate can be explained partly by residents not seeing the flyer between their post or being hesitant to scan an unverified QR-code that is delivered to them by irregular post (Edwards et al., 2002). Also, the invitation informed residents that the municipality has no short-term plans for their neighborhood; this may reduce their feeling of urgency or necessity to participate. In practice, the invitation should be spread via a verified link or QR-code, as part of a letter and/or e-mail sent by the municipality, or be accessible through the municipal app. Creating higher levels of trust and urgency, but also providing the choice to fill in the survey by using both laptop and mobile phone may increase participation.

The variable analysis found a strong interdependency between the variables aesthetic and maintenance. This is logical, as both statements in the survey primarily concern the appearance of buildings. Therefore, it is recommended to differentiate between aesthetics of the buildings and maintenance of the neighborhood as a whole in future research.

It would benefit the method's ability to find a Dutch neighborhood's perceived strengths and weaknesses if the future WoON survey adopted the same statements regarding satisfaction as used for this questionnaire in the pilot study. By doing so, all neighborhood characteristics can be individually compared to the Dutch national average.

The scope of this research was to find a method in which a PPGIS application could be successfully integrated in the Dutch land-use planning, in which the focus has been on the before-design study, as suggested by Bijen et al. (2016). However, applications for other stages of the building process can be further researched, such as giving feedback on the first drafts of the plans or in the post-design stage.

5.2 Practical implications

The research proposes that this PPGIS application should be integrated as (part of) an online questionnaire for every initiative that requires a level 2 or 3 participation plan, often entailing land-use changes and interventions on a neighborhood or city (district) level. This questionnaire should be sent to the affected residents by letter and email, and should be accessible from the municipal sites and apps. A trimmed down version could also be used for participation level 1, if it involves an impactful (land-use) change to a single building block, in which residents from directly adjacent streets and houses should be allowed to share their opinion. However, the scale and range should be adjusted for the reduced number of expected respondents. To optimize the functionalities of the PPGIS tool, achieving higher acceptance of plans and increasing public trust, all initiators should be required to place a high priority on sharing the results and the feedback of the PPGIS application with all

stakeholders. Emphasis should be on the changes that are made with the feedback and explaining why other feedback has been disregarded.

When these PPGIS application results find areas with a high density of negative associations, the planners can learn what aspects are causing the issue(s) and can act accordingly. Depending on the aspects, short- or long-term decisions should be taken. Areas that are experienced to be poorly maintained or have poor traffic safety, should receive an intervention on the short term. Once larger plans are made that also encompass the other perceived issues, such as building aesthetics and personal safety, these temporary interventions should be incorporated to achieve a long-term fix. By allowing respondents to elaborate their complaint(s) regarding their associations, even more specific and targeted interventions can be performed. On the other hand, when an area receives a high density of positively perceived experiences, planners know that no (major) intervention is necessary regarding the corresponding aspects. In case changes need to be made to change/redevelop this area due to other priorities, planners should be delicate and further involve the public into the plans, protecting the aspects that are valued positively to the best extent.

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Appendix

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Appendix I: PPGIS variables

Table 38: Spatial Attributes used in different PPGIS, according to table 5 and 6 of Brown & Kyttä(2014).

Landscape values	Development preferences	Experiences
Aesthetic/scenic	Tourism accommodation	Aesthetic/scenic
Economic	Tourism services	Crowding/congestion
Recreation	Urban Development	Solitude/escape
Life sustaining	Rural residential development	Social interaction
Learning/scientific	Industrial development	Trail-based activity
Biological	Wind energy development	Other physical activity/ adventure
Spiritual	Natural resource development	Overnight stay/camping
Intrinsic	Energy development	Learning/discovery
Historic	Tourism development	Positive wildlife/vegetation experience
Future	Other development	Noise
Subsistence	No development	
Therapeutic		
Cultural		
Wilderness		
Marine		
Social		
Special Places		

Appendix II: Structure of SoftGIS applications

Table 39: Structure of SoftGIS Applications

Number	Title	Description / Data
1	Introduction	Introduction to the research
2	Background information	Age, Gender, Family type, Occupation, Car ownership, Income, Housing type, House type, Size of dwelling, , Childhood environment, Situation of filling the questionnaire, earlier participation.
3	Identification (optional)	Alias, Password
4	Picking quality factors	• Pick 1-5 positive quality factors from a list • Pick 1-5 negative quality factors from a list
5	Introduction of the 'mapping tool'	• Mark home location • Describe personal meaning of home
6	Location and actualization of positive and negative quality factors	The application saves the picked quality factors of step 4 • Actualization of quality factors • Mark maximum three locations per quality factor For every location a small query opens: For positive factors • Accessibility, • Means of transport • Description in own words (optional) For negative factors: • Possibility to avoid • Disturbance at special time of day • Description in own words (optional)
7	Questions of city planners	• Locations of places and building to be preserved • Location of places that could be attractive to move to • Preferred floor height of new buildings • Characteristics that make the center attractive
8	Location of basic services	Location of workplace, day care, study place, daily grocery store(s), schools and other activities
9	The perceived well-being	Health 2000 survey
10	Ending	Feedback about questionnaire Open comments

Appendix III: Literature matrix PPGIS variables inventory

Table 40: Inventory of PPGIS variables used in sources from synthesis Brown & Kyttä in 2014

PPGIS Variables	Source										Total
	Urban Park and Open Space Values			Environmental Experiences				Environmental Affordances			
						Development Preferences	Perceived Safety		Everyday mobility and behavior patterns		
	Brown, 2008	Brown, Schebella, & Weber, 2014	Tyrväinen, Mäkinen, & Schipperijn, 2007	Kyttä, Kahila, & Broberg, 2011	Kyttä, Broberg, Haybatollahi, & Schmidt-Thomé, 2016	Kyttä, Broberg, Tzoulas, & Snabb, 2013	Kyttä, Kuoppa, Hirvonen, Ahmadi, & Tzoulas, 2014	Kyttä, Broberg, & Kahila, 2012	Broberg, Kyttä, & Fagerholm, 2013	Broberg, Salminen, & Kyttä, 2013	
Scenic / Aesthetic	X		X	X				X	X		5
- Appearance					X	X		X	X		4
- Atmosphere					X	X					2
Development Preferences	X					X					2
- Economic											0
Wildlife/Vegetation	X		X		X						3
- Wilderness											0
- Marine											0
Natural	X		X		X	X			X		5
- Environmental		X		X		X					3
- Biological											0
- Life Sustaining											0
Social	X	X		X	X	X		X	X		7
- Cultural			X			X					2
- Lifestyle						X					1
- Learning											0
Recreation	X		X					X	X		4
- Hobbies	X					X		X	X		4
- Services					X	X		X	X		4
Special Places	X										1
- Future	X										1
- Historic			X								1
- Spiritual											0
Psychological		X						X	X		3
- Therapeutic			X	X		X		X	X		5
- Intrinsic											0
- Subsistence											0
- Solitude/escape			X			X		X	X		4
- Emotional						X	X				2
Physical / Exercise		X	X	X							3
Safety			X	X			X	X	X		5

- Traffic Safety						X	X				2
Crowding - Congestion				X					X		2 0
Mobility - Public transport - Walking/cycling - Private Car				X X		X X X X				X X X X	3 3 2 2
Noise			X					X	X		3

Appendix IV: WoON2018 survey

This section will elaborate on the procedures and motivations with which the WoON Survey is conducted, followed by section IV.I, which introduces the relevant variables within the survey. Then section IV.II will discuss the sample representativeness test that is performed for five key personal characteristics, with regards to public participation in land-use planning.

The WoON, or in full: WoonOnderzoek Nederland (Housing Survey of the Netherlands), "is the most important research for the development, instrumentalization and evaluation of the Dutch housing policies, and is the most used research by the Dutch Government and other parties on the subject of housing" (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties (BZK), 2020b). Since 2006, this research is conducted triennially by the Dutch Ministry of BZK and CBS (Central Office for Statistics). The sample is gathered in two ways: base research and oversampling. The base research approaches 40000 randomly sampled respondents to fill in the complete survey (Gouweleeuw & CBS, 2020). Oversampling is conducted by local governments, commissioned by collaborating parties, to achieve insights in the housing market of their municipality. All successfully performed questionnaires together form the base file of the WoON. This base file contains information on six themes: household composition and social-economic position; dwelling ownership, characteristics and satisfaction, accessibility and costs; desired housing and moving behavior; living environment satisfaction and livability; living and healthcare; and sustainability. This information provides: "input for regional housing demand figures and housing preferences; regional coordination between municipalities with regard to housing; development of a municipal housing vision and the substantiation of the housing policy; and performance agreements with housing associations" (Ministerie van BZK, 2020)

IV.I Relevant variables

Table 41 below shows the relevant (PPGIS) variables the research derives from the WoON 2018 survey, conducted by the Dutch ministry of BZK and the CBS. The first column contains the variables that can be directly derived from the question. An empty cell indicates a question that is used for indirect derivation, or a question from which relates to multiple variables. The second column lists the row (and question) number of the question in the original dataset. Column three presents the interpreted English question, and in italics the original question in Dutch. Columns four and five list the translated answer options, as well as their related level of measurement.

Table 41: Relevant PPGIS variables within WoON2018 Database

(PPGIS) Variable	Row/ Question Number	Question	Level of Measurement	Options
Age	Row 701	Age Respondent (7 classes) Leeftijd Respondent (7 klassen)	Ordinal	1 = 17-24 years old 2 = 25-34 years old 3 = 35-44 years old 4 = 45-54 years old 5 = 55-64 years old 6 = 65-74 years old 7 = 75 years and older
Population Density	Row 690	Degree of Urbanization in Neighborhood Stedelijkheid van de buurt	Ordinal	1 = Very urbanized (≥2500 addresses per km²) 2 = Urbanized (1500-2500 addresses per km²) 3 = Suburbanized (1000-1500 addresses per km²) 4 = Little urbanized (500-1000 addresses per km²) 5 = Unurbanized (<500 addresses per km²) 6 = Unknown
Household Composition	Row 709	Household composition (5 classes) Samenstelling Huishouden (5 klassen)	Nominal	1 = One-person 2 = Couple 3 = Couple + child(ren) 4 = One Parent + child(ren) 5 = Non-family household

Level of Education	Row 722	Education level (5-classes) Hoogst behaald onderwijsniveau respondent 5-deling	Ordinal	1 = Primary school 2 = Middle school 3 = High school 4 = Bachelor's degree 5 = Master's degree or doctorate 6 = Unknown
Ethnicity	Row 714	Ethnicity (3 classes) Etniciteit respondent naar herkomst (3 klassen)	Nominal	1 = Dutch 2 = Non-western 3 = Western
	13.1 Row 245	Satisfaction with Neighborhood Tevredenheid met huidige woonomgeving	Ordinal	1 = Very satisfied 2 = Satisfied 3 = Neither satisfied, nor dissatisfied 4 = Dissatisfied 5 = Very dissatisfied 8 = Refused to answer
Aesthetic / Scenic	13.2 Row 246	The buildings in this neighborhood is aesthetic. De bebouwing in deze buurt is aantrekkelijk	Ordinal	1 = Completely agree 2 = Agree 3 = Neither agree, nor disagree 4 = Disagree 5 = Completely disagree 8 = Refused to answer
Maintenance	13.3 Row 247	The buildings in this neighborhood are well-maintained De bebouwing in deze buurt is goed onderhouden	Ordinal	1 = Completely agree 2 = Agree 3 = Neither agree, nor disagree 4 = Disagree 5 = Completely disagree 8 = Refused to answer
Social Interaction	13.10 Row 254	I have a lot of contact with people in the neighborhood Ik heb veel contact met andere buurtbewoners	Ordinal	1 = Completely agree 2 = Agree 3 = Neither agree, nor disagree 4 = Disagree 5 = Completely disagree 8 = Refused to answer
Social Interaction	13.13 Row 257	I live in a cozy neighborhood in which people help each other Ik woon in een gezellige buurt waar mensen elkaar helpen en samen dingen doen	Ordinal	1 = Completely agree 2 = Agree 3 = Neither agree, nor disagree 4 = Disagree 5 = Completely disagree 8 = Refused to answer
Safety	13.16 Row 260	I am afraid to be harassed or robbed in this neighborhood Bang in deze buurt om lastiggevallen of beroofd te worden	Ordinal	1 = Completely agree 2 = Agree 3 = Neither agree, nor disagree 4 = Disagree 5 = Completely disagree 8 = Refused to answer
Daily Groceries	13.27 Row 286	Importance of proximity daily grocery stores Belangrijkheid nabijheid winkels voor dagelijkse boodschappen	Ordinal	1 = Very important 2 = Important 3 = Little important 4 = Not important 8 = Refused to answer
Public Transportation	13.28 Row 287	Importance of accessibility Public Transport Belangrijkheid nabijheid openbaar vervoer	Ordinal	1 = Very important 2 = Important 3 = Little important 4 = Not important 8 = Refused to answer
Primary School	13.29 Row 288	Importance of proximity primary schools Belangrijkheid nabijheid basisscholen	Ordinal	1 = Very important 2 = Important 3 = Little important 4 = Not important 8 = Refused to answer
Daily Groceries	13.30 Row 289	Satisfaction with proximity daily grocery stores Tevredenheid over nabijheid winkels voor dagelijkse boodschappen	Ordinal	1 = Very satisfied 2 = Satisfied 3 = Neither satisfied, nor dissatisfied 4 = Dissatisfied 5 = Very dissatisfied 8 = Refused to answer

Primary Schools	13.31 Row 290	Satisfaction with proximity primary schools Tevredenheid over nabijheid met de basisscholen	Ordinal	1 = Very satisfied 2 = Satisfied 3 = Neither satisfied, nor dissatisfied 4 = Dissatisfied 5 = Very dissatisfied 6 = Unknown / Not applicable 8 = Refused to answer
	14.42 Row 384	Most important reason for having moved Belangrijkste reden vorige verhuizing	Nominal	1 = Health or need for healthcare 2 = Study 3 = Work 4 = Financial reasons 5 = Previous dwelling 6 = Neighborhood previous dwelling 7 = Living closer to family 8 = Other 98 = Refused to answer
	14.46 Row 388-395	Reason for having moved neighborhood Reden (verhuizing) woonomg(eving)	Nominal	1 = Parking issues 2 = Dwelling types 3 = Poor maintenance 4 = Changing demographics 5 = Criminality 6 = Nuisance due to inhabitants 7 = Nuisance due to noise, demolishing or smell 8 = Other
	18.21 Row 466-473	Reason for wanting to move Verhuisreden	Nominal	1 = Health or need for healthcare 2 = Study 3 = Work 4 = Financial reason 5 = Previous dwelling 6 = Neighborhood previous dwelling 7 = Living closer to family 8 = Other
	18.28 Row 478-490	Reason for wanting to move neighborhood Reden verhuiswens woonomg(eving)	Nominal	1 = Parking issues 2 = Dwelling types 3 = Poor maintenance 4 = Demographics 5 = Criminality 6 = Nuisance due to inhabitants 7 = Nuisance due to noise, demolishing or smell 8 = Green, space, nature, water 9 = Centrum, facilities, boring 10 = Privacy, too crowded, peace and quiet 11 = Children, school, friends, playing space 12 = Other
	21.17 Row 536	Location desired dwelling Ligging gewenste woning	Ordinal	1 = City center 2 = Within 15 min walking distance of city center 3 = Over 15 min walking distance of city center 4 = City suburb 5 = Countryside 6 = No preference
	21.20 Row 539-547	Desired Neighborhood Gewenste buurt	Nominal	1 = Many detached houses 2 = Many semidetached houses 3 = Many terraced houses 4 = Many multi-story houses (max 4 floors) 5 = Many flats 6 = Predominantly dwellings with modern architecture 7 = A lot of green spaces 8 = A lot of water 9 = No preferences

IV.II Sample representativeness

This research aims to use the WoON survey 2018 (Ministerie van BZK & CBS, 2019), to investigate the relationships between respondent's household characteristics and the satisfaction with the living environment and livability of their neighborhood. For this, the representativeness of the WoON 2018 Survey is checked by comparing five key characteristics from the sample to data from sources describing the whole Dutch population. These sources are either directly taken the Dutch CBS or derived from the United Nations Department of Economic and Social Affairs (PopulationPyramid.net, 2019). The characteristics are in order: Age, Neighborhood Density, Household Composition, Level of Education and Country of Birth. The importance of knowing the sample's representativeness is high, because it determines to what extend the findings from the sample are applicable to the whole population.

To summarize, the sample of the 2018 WoON survey is reasonably representative of the population of the Netherlands as a whole. As four of the five key characteristics have reasonably low or explainable differences between sample and population. Only the Ethnicity shows differences over five percent in two of three options. The sample is sufficiently large to provide meaningful distributions of most variables to derive (cor)relations between different variables. However, caution should be taken when interpreting results from categories with large differences between the sample and the population.

Appendix V: WoON 2018 results and figures

This appendix aims to provide more detailed information on the relations between the variables analyzed in chapter 3, and the personal characteristics, using the WoON 2018 dataset. Every section will cover one variable that is deemed relevant and present in the dataset. Each section (apart from the first) consists of six paragraphs, each detailing the relationship with one of the personal characteristic variables, and the general neighborhood satisfaction, with the use of a bar chart.

V.I Reasons for moving

This section breaks down the reason(s) stated by the respondents that have recently moved (Table 42) or desire to move (Table 43). The first is the frequency table of statement 14.42 of the WoON2018 survey, the most important reason for having moved. The second is the combination of the frequency tables of statements 18.28.1-18.28.12.

Table 42: Most important reason for having moved

Most Important Reason for having moved					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Health or need for healthcare	399	,6	6,1	6,1
	Study	345	,5	5,2	11,3
	Work	519	,8	7,9	19,2
	Financial reasons	596	,9	9,1	28,3
	Previous dwelling	1261	1,9	19,2	47,5
	Neighborhood previous dwelling	642	1,0	9,8	57,2
	Living closer to family	565	,8	8,6	65,8
	Other	2245	3,3	34,2	100,0
	Total	6572	9,7	100,0	
Missing	System	60951	90,3		
Total		67523	100,0		

Table 43: Reasons for desiring to move

Reason(s) for wanting to move									
	Total	Health or need for healthcare	Study	Work	Financial	Dwelling	Neighborhood	Closer to family	Other
Yes (%)	19080 28.3%	3358 17.6%	877 4.6%	2100 11.0%	2355 12.3%	9198 48.2%	4771 25.0%	1880 9.9%	1028 5.4%
No (%)	48443 71.7%	15722 82.4%	18203 95.4%	16980 89.0%	16725 87.7%	9882 51.8%	14309 75.0%	17200 90.1%	18052 94.6%
Total	67523 100.0%	19080 100.0%	19080 100.0%	19080 100.0%	19080 100.0%	19080 100.0%	19080 100.0%	19080 100.0%	19080 100.0%

V.II Scenic / Aesthetic

This section details the relation between the variable Scenic / Aesthetic and the personal characteristics, as well as general neighborhood satisfaction. The question related to this variable in the WoON2018 database is: “The buildings in this neighborhood are aesthetic”.

Age

Figure 37 shows the relation between the respondent’s age and their statement on their neighborhood’s building aesthetics has a Spearman correlation value of -0.056, with an approximate significance of 0.000 (99% confidence).

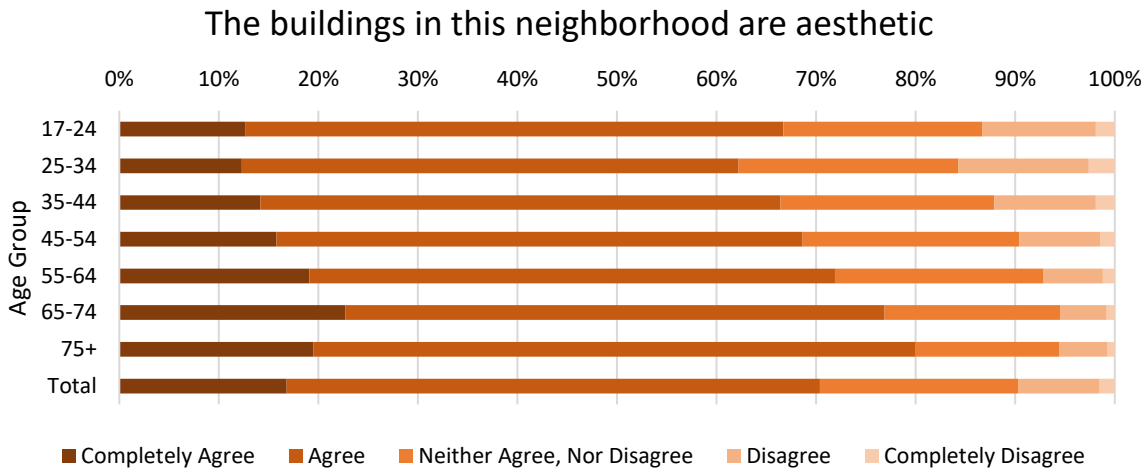


Figure 37: Relation between age groups and perceived neighborhood building aesthetics

Degree of urbanization

Figure 38 shows the relation between the respondent’s degree of urbanization and their statement on their neighborhood’s building aesthetics has a Spearman correlation value of -0.121, with an approximate significance of 0.000 (99% confidence).

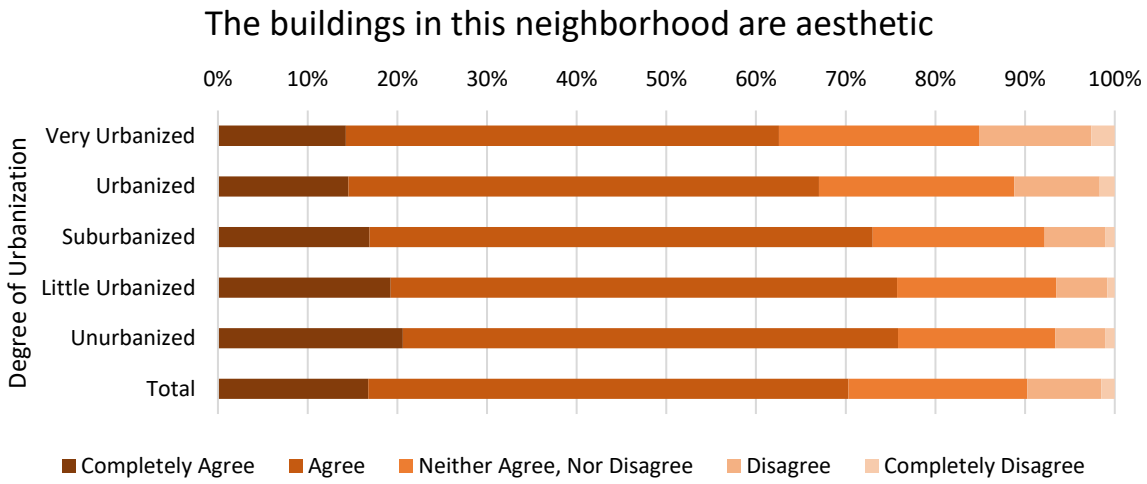


Figure 38: Relation between level of urbanization and perceived neighborhood building aesthetics

Household composition

Figure 39 shows the relation between the respondent's household composition and their statement on their neighborhood's building aesthetics has a chi-square value of 1142.9, with an asymptotic significance of 0.000 (99% confidence).

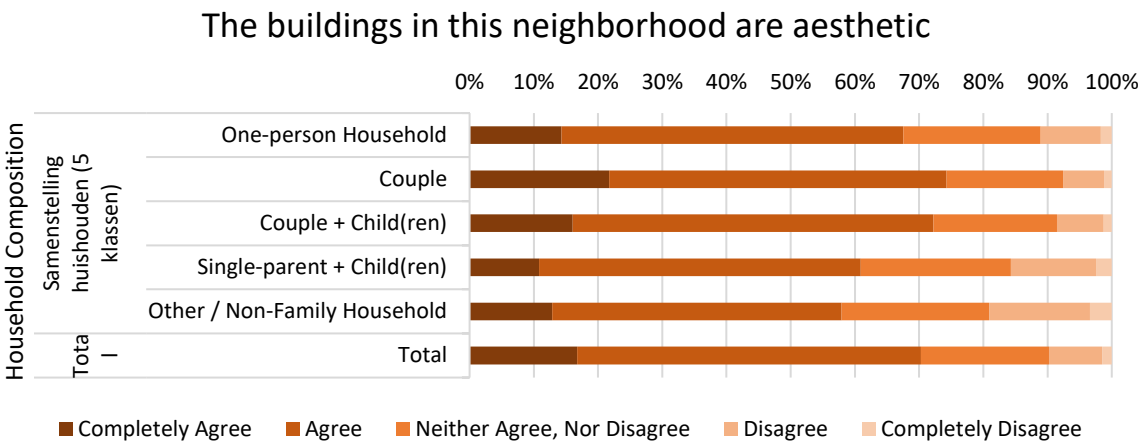


Figure 39: Relation between household composition and perceived neighborhood building aesthetics

Level of education

Figure 40 shows the relation between the respondent's level of education and their statement on their neighborhood's building aesthetics has a Spearman correlation value of -0.034, with an approximate significance of 0.000 (99% confidence).

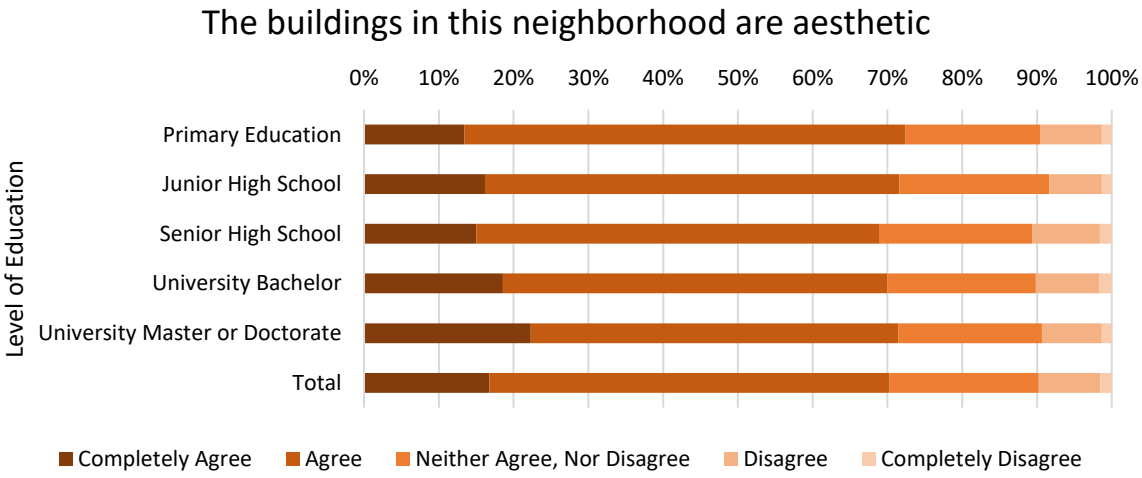


Figure 40: Relation between level of education and perceived neighborhood building aesthetics

Ethnicity

Figure 41 shows the relation between the respondent's ethnicity and their statement on their neighborhood's building aesthetics has a chi-square value of 457.2, with an asymptotic significance of 0.000 (99% confidence).

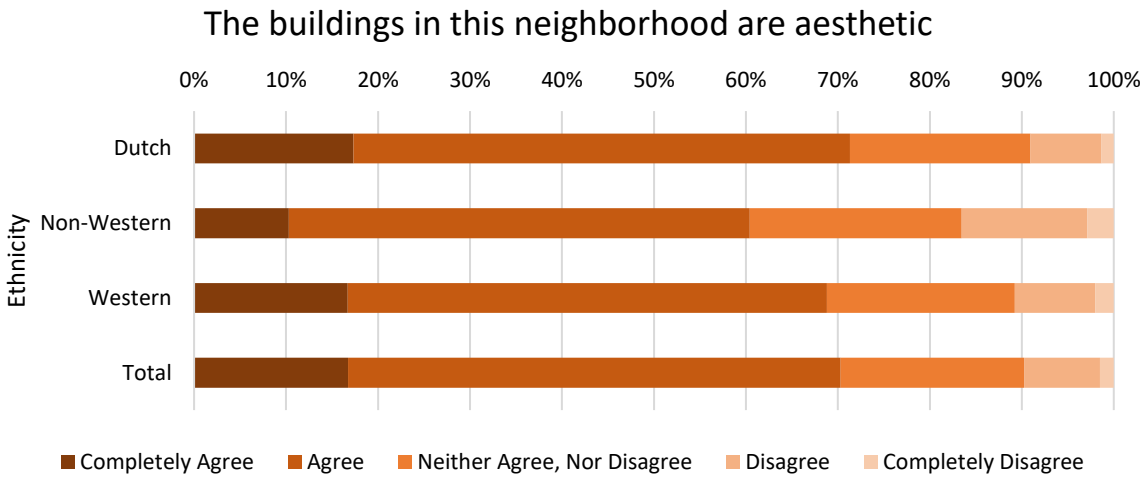


Figure 41: Relation between ethnicity and perceived neighborhood building aesthetics

Neighborhood satisfaction

Figure 42 shows the relation between the respondent's general neighborhood satisfaction and their statement on their neighborhood's building aesthetics, it has a Spearman correlation value of 0.466, with an approximate significance of 0.000 (99% confidence).

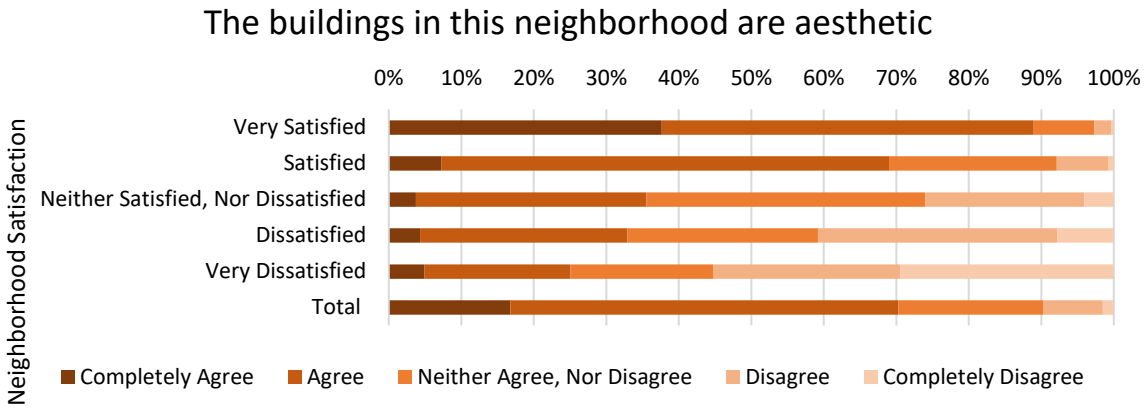


Figure 42: Relation between general neighborhood satisfaction and perceived neighborhood building aesthetics

V.III Social

This section details the relations between the variable Social and the personal characteristics, as well as general neighborhood satisfaction. The statement related to this variable in the WoON2018 database is: “I live in a cozy neighborhood in which people help each other and do interact”.

Age

Figure 43 shows the relation between the respondent’s age and their statement on their neighborhood’s social qualities has a Spearman correlation value of -0.064, with an approximate significance of 0.000 (99% confidence).

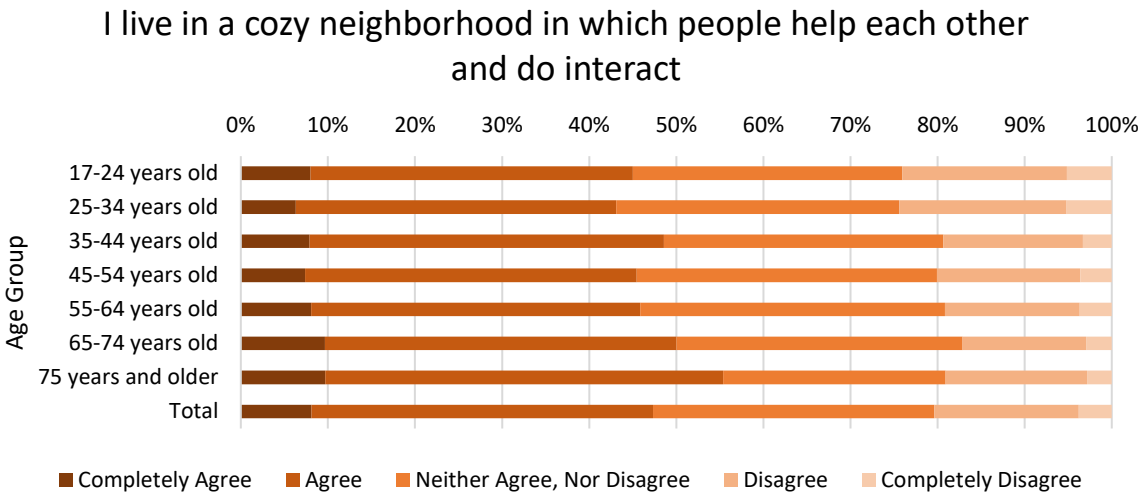


Figure 43: Relation between age and perceived social qualities of the neighborhood

Degree of urbanization

Figure 44 shows the relation between the respondent’s degree of urbanization and their statement on their neighborhood’s social qualities, it has a Spearman correlation value of -0.155, with an approximate significance of 0.000 (99% confidence).

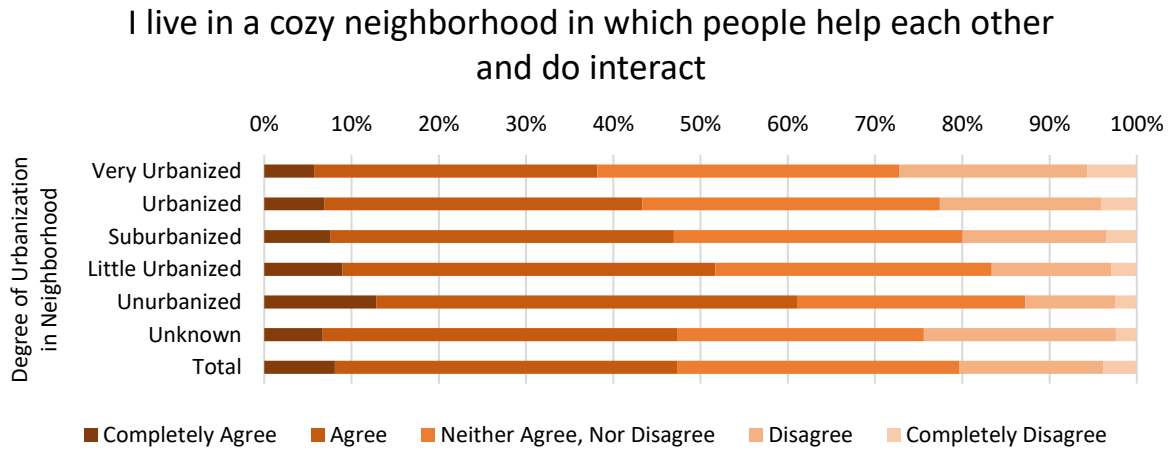


Figure 44: Relation between degree of urbanization and perceived social qualities of the neighborhood

Household composition

Figure 45 shows the relation between the respondent's household composition and their statement on their neighborhood's social qualities, it has a chi-square value of 931.8, with an asymptotic significance of 0.000 (99% confidence).

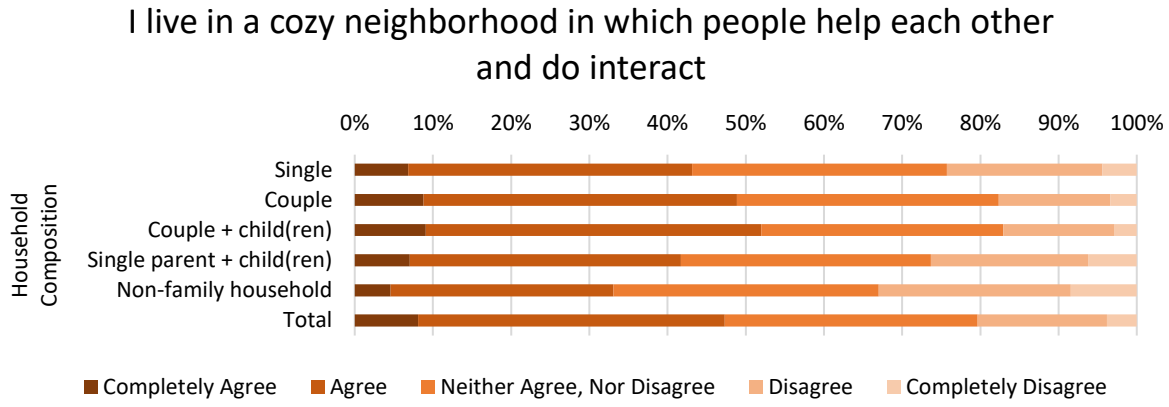


Figure 45: Relation between household composition and perceived social qualities of the neighborhood

Level of education

Figure 46 shows the relation between the respondent's level of education and their statement on their neighborhood's social qualities, it has a Spearman correlation value of 0.043, with an approximate significance of 0.000 (99% confidence).

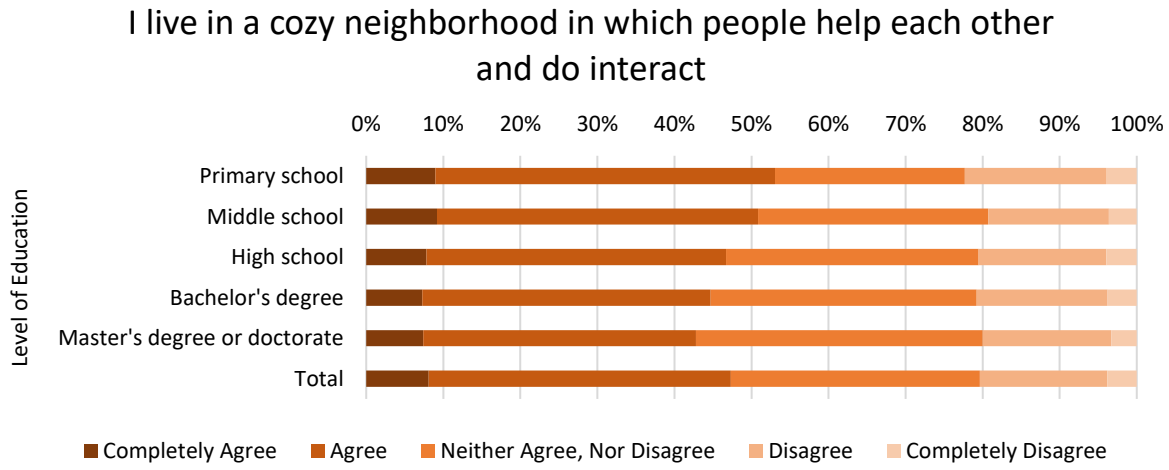


Figure 46: Relation between level of education and perceived social qualities of the neighborhood

Ethnicity

Figure 47 shows the relation between the respondent's ethnicity and their statement on their neighborhood's social qualities, it has a chi-square value of 99.8, with an asymptotic significance of 0.000 (99% confidence).

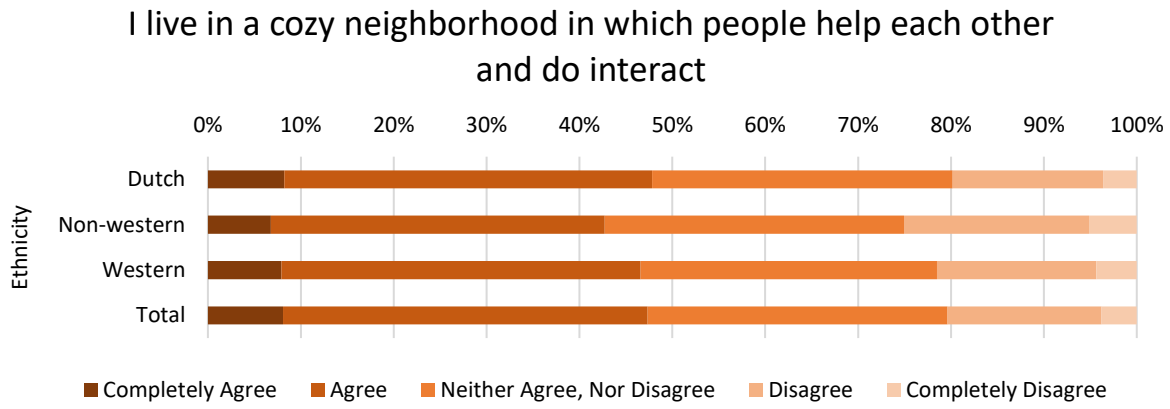


Figure 47: Relation between ethnicity and perceived social qualities of the neighborhood

Neighborhood satisfaction

Figure 48 shows the relation between the respondent's general neighborhood satisfaction and their statement on their neighborhood's social qualities, it has a Spearman correlation value of 0.368, with an approximate significance of 0.000 (99% confidence).

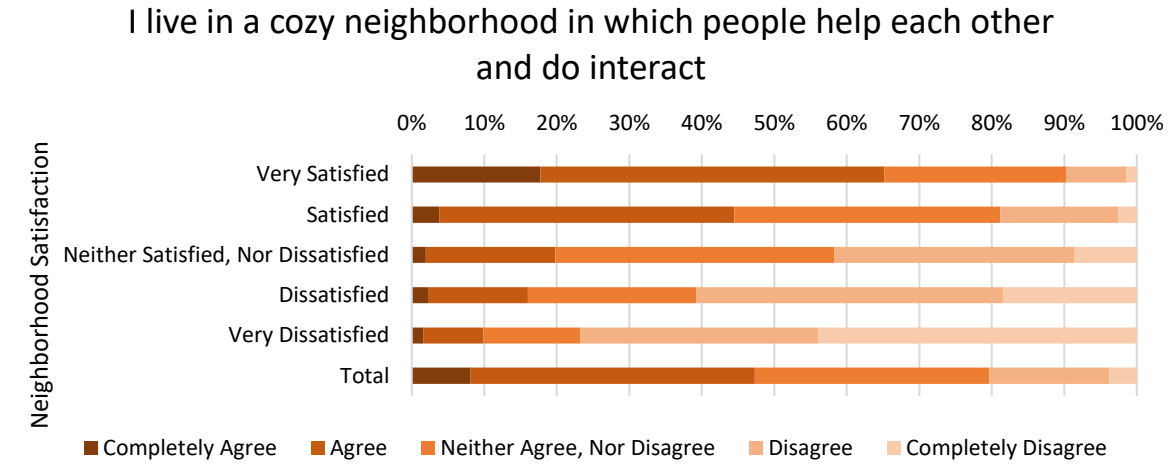


Figure 48: Relation between general neighborhood satisfaction and perceived social qualities of the neighborhood

V.IV Safety

This section details the relations between the variable Safety and the personal characteristics, as well as general neighborhood satisfaction. The statement related to this variable in the WoON2018 database is: “I am afraid to be harassed or robbed in this neighborhood”.

Age

Figure 49 shows the relation between the respondent’s age and their statement on their perceived safety in the neighborhood has a Spearman correlation value of -0.091, with an approximate significance of 0.000 (99% confidence).

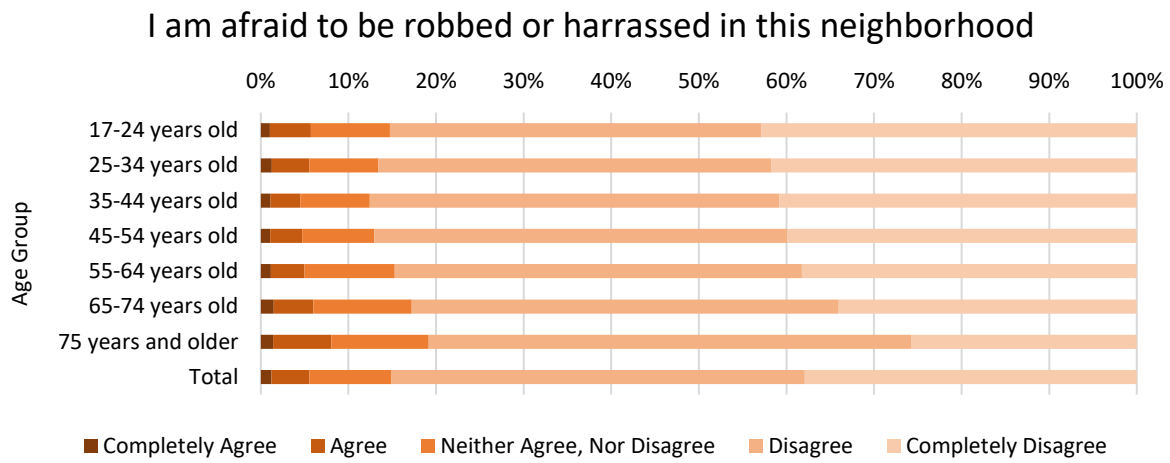


Figure 49: Relation between age and perceived safety in the neighborhood

Degree of urbanization

Figure 50 shows the relation between the respondent’s degree of urbanization and their statement on their perceived safety in the neighborhood, it has a Spearman correlation value of 0.147, with an approximate significance of 0.000 (99% confidence).

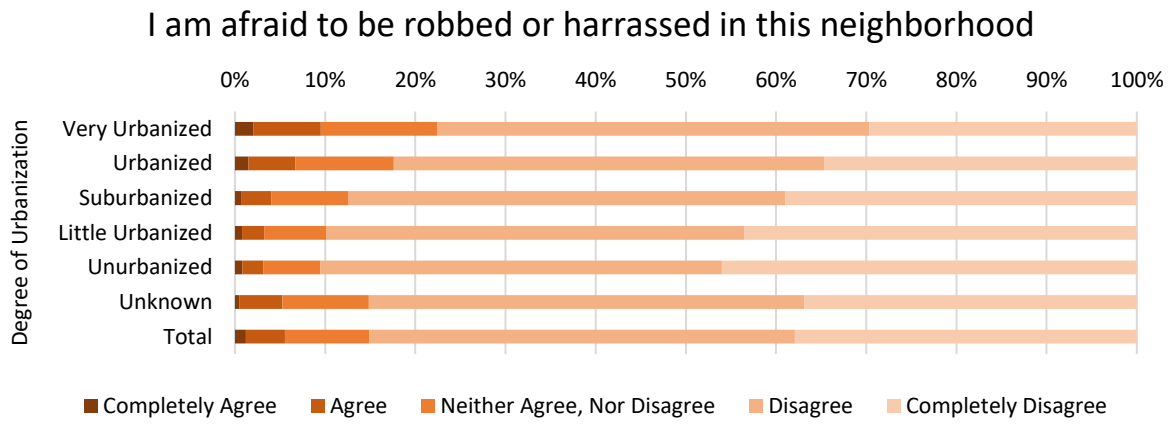


Figure 50: Relation between degree of urbanization and perceived safety in the neighborhood

Household composition

Figure 51 shows the relation between the respondent's household composition and their statement on their perceived safety in the neighborhood, it has a chi-square value of 1,103.6, with an asymptotic significance of 0.000 (99% confidence).

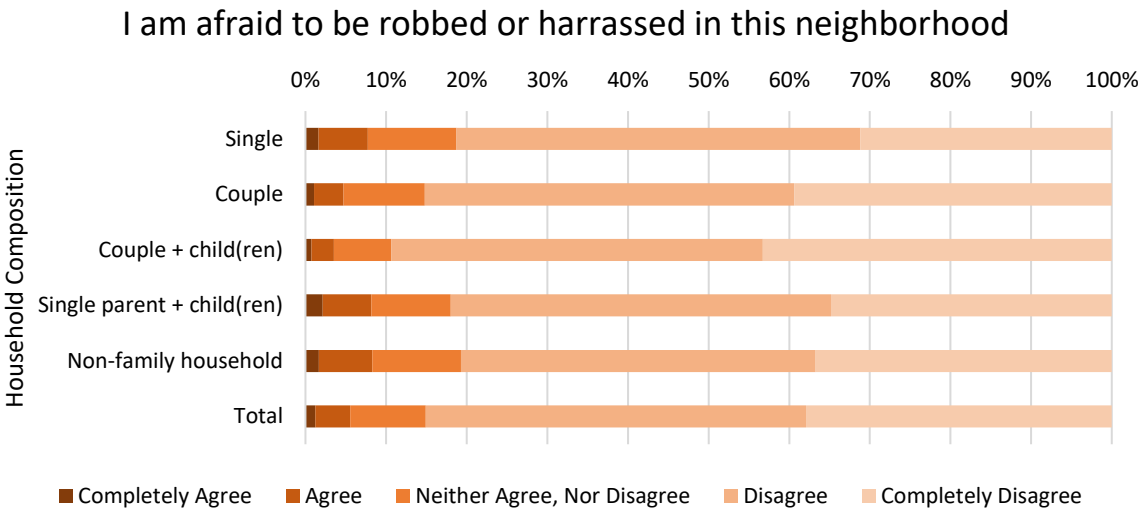


Figure 51: Relation between household composition and perceived safety in the neighborhood

Level of education

Figure 52 shows the relation between the respondent's level of education and their statement on their perceived safety in the neighborhood, it has a Spearman correlation value of 0.101, with an approximate significance of 0.000 (99% confidence).

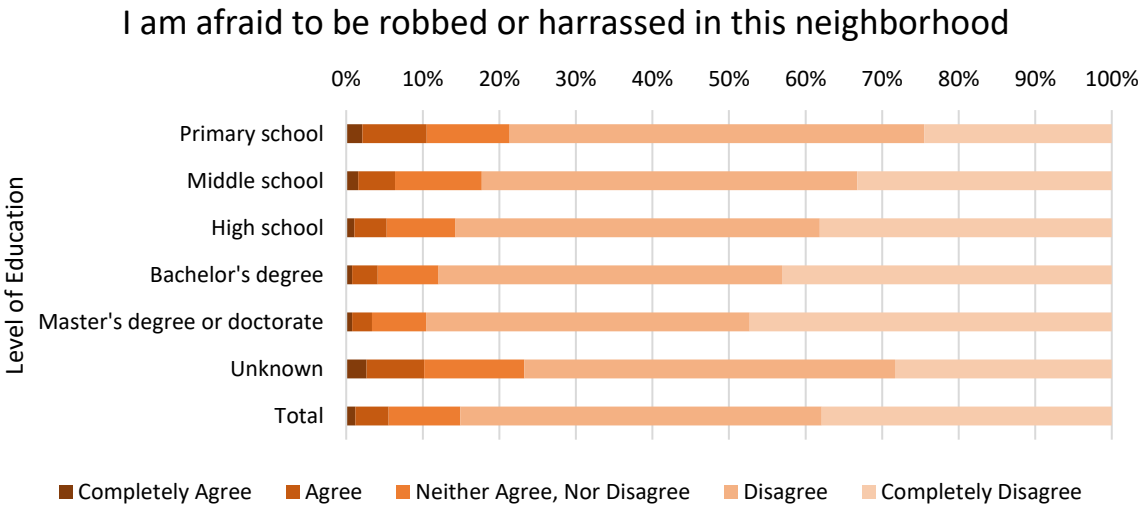


Figure 52: Relation between level of education and perceived safety in the neighborhood

Ethnicity

Figure 53 shows the relation between the respondent's ethnicity and their statement on their perceived safety in the neighborhood, it has a chi-square value of 454.1, with an asymptotic significance of 0.000 (99% confidence).

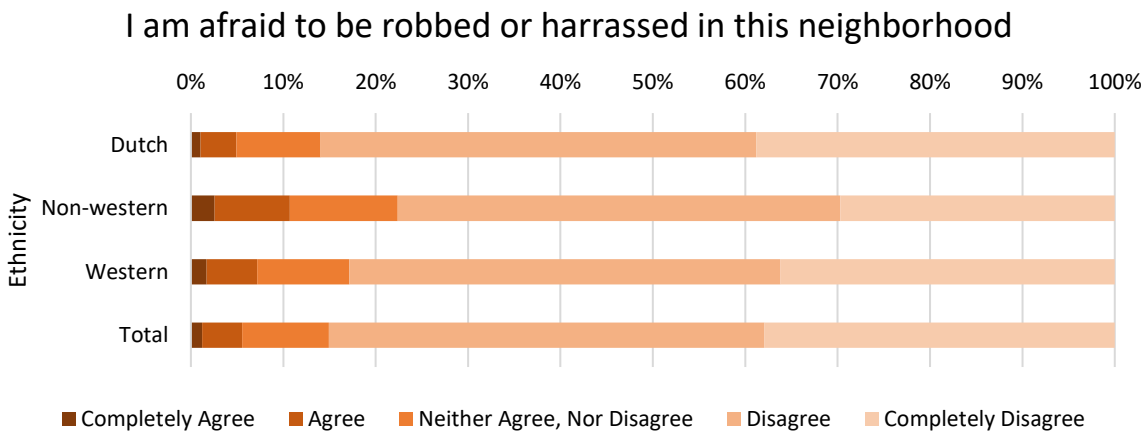


Figure 53: Relation between ethnicity and perceived safety in the neighborhood

Neighborhood satisfaction

Figure 54 shows the relation between the respondent's general neighborhood satisfaction and their perceived safety in the neighborhood, it has a Spearman correlation value of -0.271, with an approximate significance of 0.000 (99% confidence).

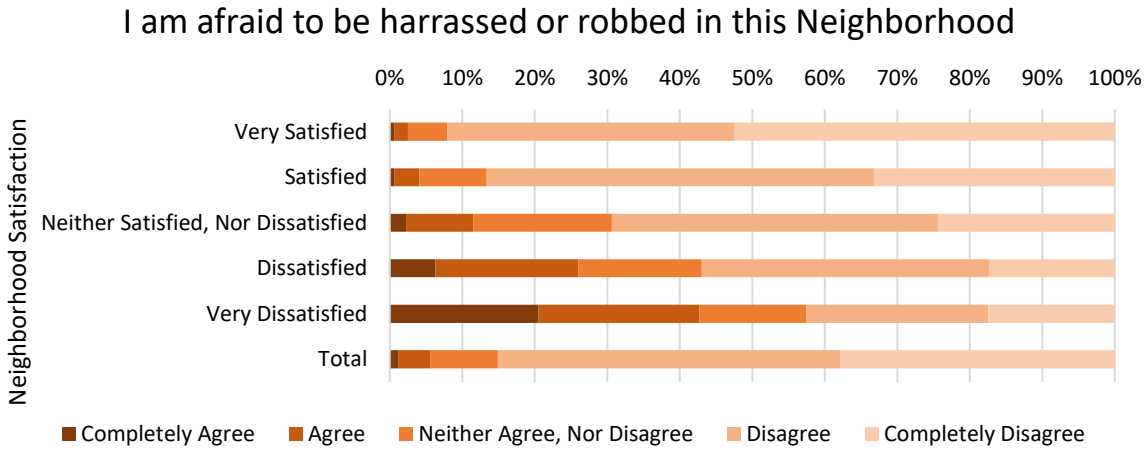


Figure 54: Relation between general neighborhood satisfaction and perceived safety in the neighborhood

V.V. Accessibility to public transport

This section details the relations between the variable accessibility to public transport and the personal characteristics, as well as general neighborhood satisfaction. The statement related to this variable in the WoON2018 database is: “Importance of accessibility to public transport”.

Age

Figure 55 shows the relation between the respondent’s age and their statement on the importance of accessible public transport has a Spearman correlation value of 0.070, with an approximate significance of 0.000 (99% confidence).

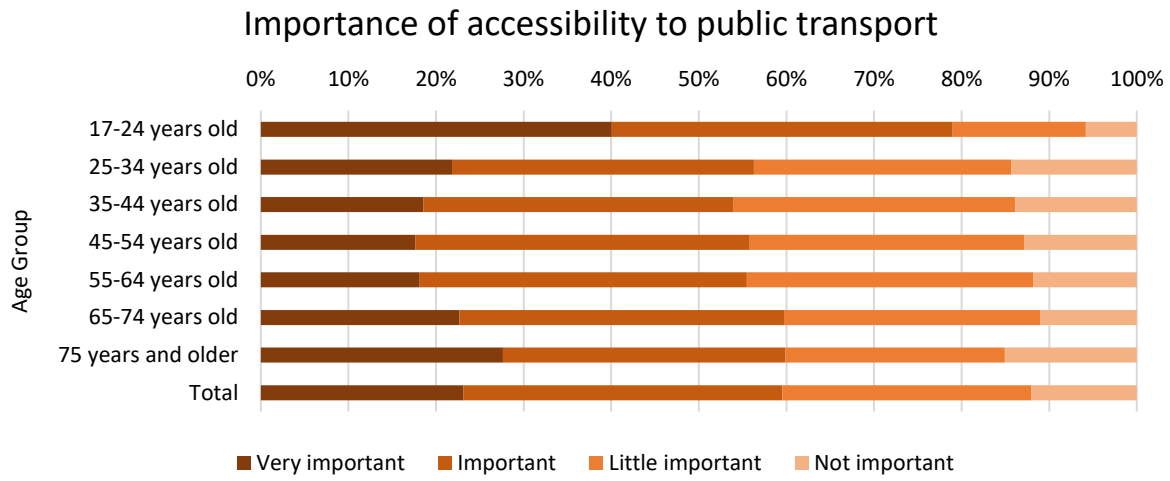


Figure 55: Relation between age and importance of accessibility to public transport

Degree of urbanization

Figure 56 shows the relation between the respondent’s degree of urbanization and their statement on the importance of accessible public transport, it has a Spearman correlation value of 0.228, with an approximate significance of 0.000 (99% confidence).

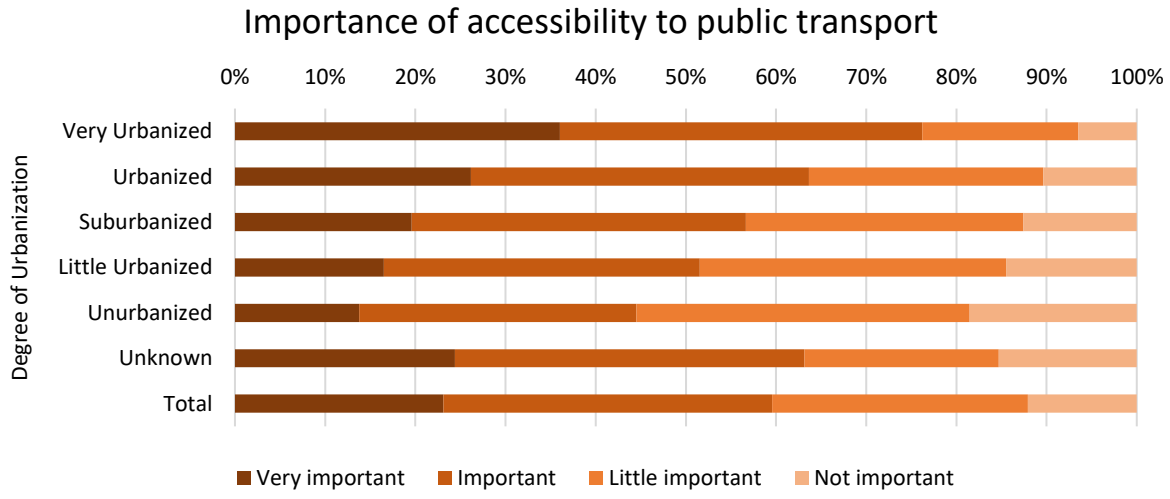


Figure 56: Relation between degree of urbanization and importance of accessibility to public transport

Household composition

Figure 57 shows the relation between the respondent's household composition and their statement on the importance of accessible public transport, it has a chi-square value of 892.6, with an asymptotic significance of 0.000 (99% confidence).

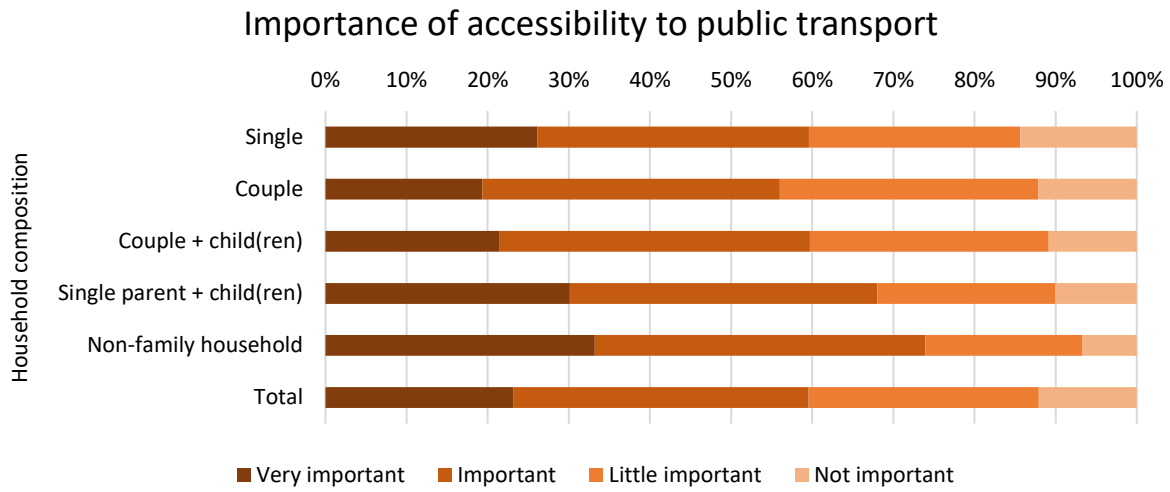


Figure 57: Relation between household composition and importance of accessibility to public transport

Level of education

Figure 58 shows the relation between the respondent's level of education and their statement on the importance of accessible public transport, it has a Spearman correlation value of -0.028, with an approximate significance of 0.000 (99% confidence).

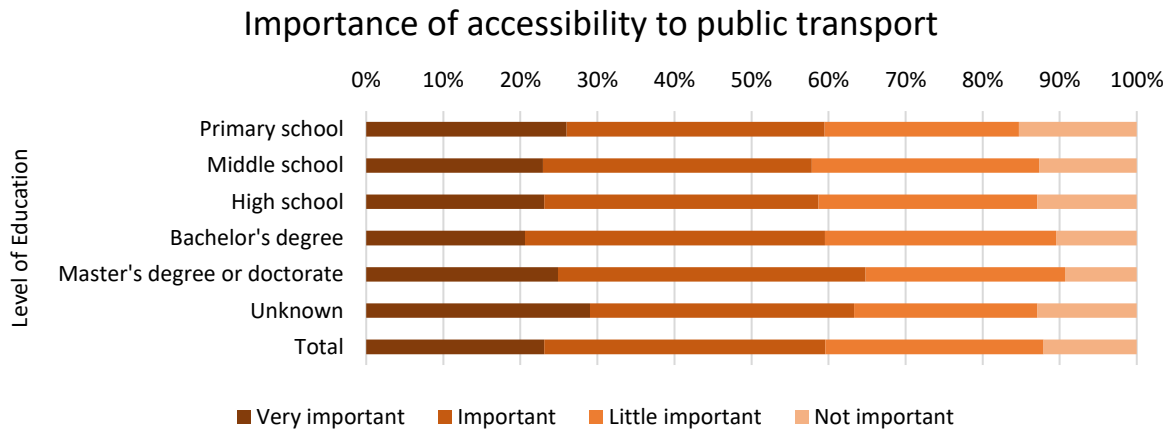


Figure 58: Relation between level of education and importance of accessibility to public transport

Ethnicity

Figure 59 shows the relation between the respondent's ethnicity and their statement on the importance of accessible public transport, it has a chi-square value of 2481.5, with an asymptotic significance of 0.000 (99% confidence).

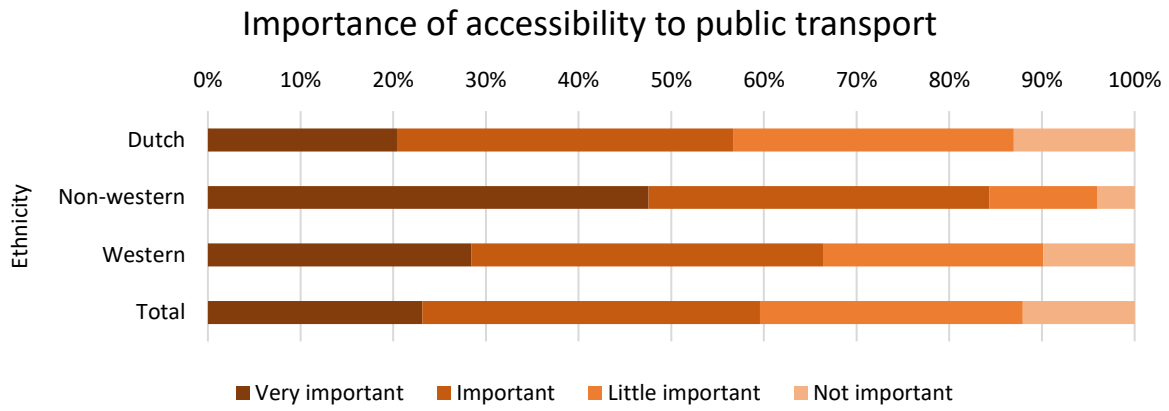


Figure 59: Relation between ethnicity and importance of accessibility to public transport

Neighborhood satisfaction

Figure 60 shows the relation between the respondent's general neighborhood satisfaction and their statement on the importance of accessible public transport, it has a Spearman correlation value of -0.035, with an approximate significance of 0.000 (99% confidence).

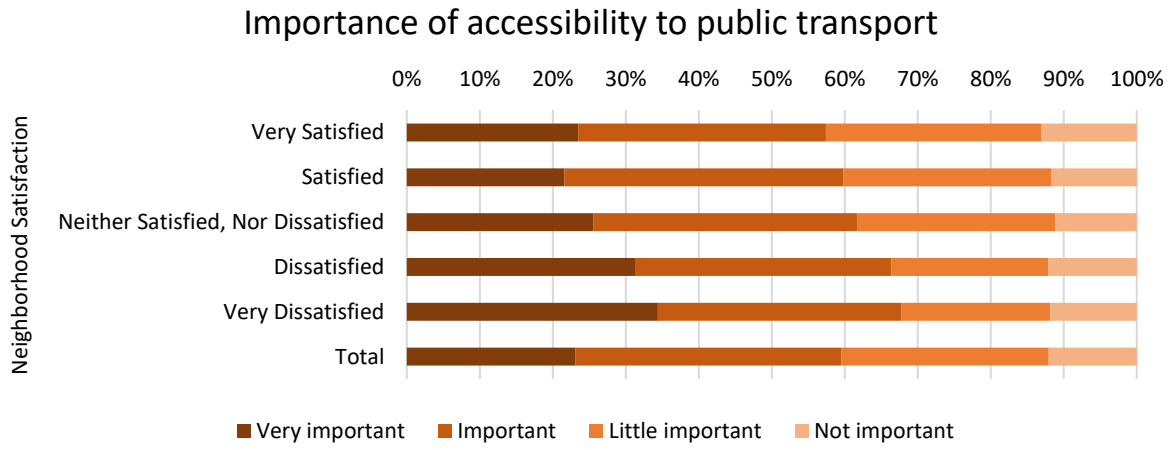


Figure 60: Relation between neighborhood satisfaction and importance of accessibility to public transport

V.VI Grocery Stores

This section details the relations between the variable (proximity to) grocery stores and the personal characteristics, as well as general neighborhood satisfaction. The statement related to this variable in the WoON2018 database is: “Satisfaction with proximity daily grocery stores”.

Age

Figure 61 shows the relation between the respondent’s age and their satisfaction with the proximity of daily grocery stores has a Spearman correlation value of 0.009, with an approximate significance of 0.020 (95% confidence).

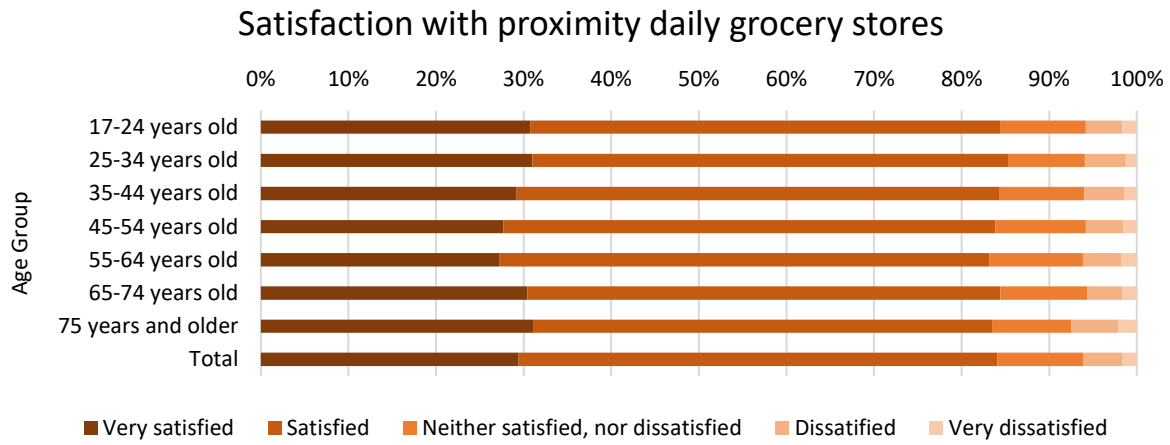


Figure 61: Relation between age and satisfaction with proximity of daily grocery stores

Degree of urbanization

Figure 62 shows the relation between the respondent’s degree of urbanization and their satisfaction with the proximity of daily grocery stores, it has a Spearman correlation value of 0.160, with an approximate significance of 0.000 (99% confidence).

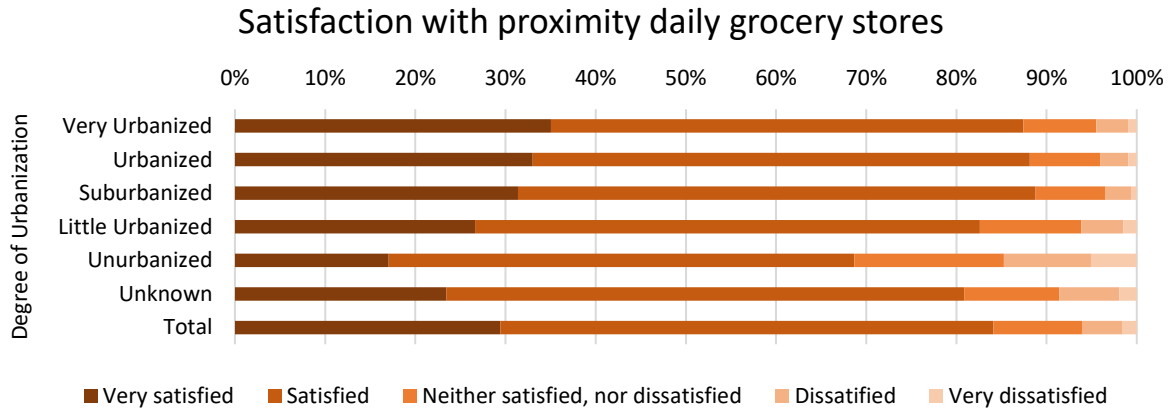


Figure 62: Relation between degree of urbanization and satisfaction with proximity of daily grocery stores

Household composition

Figure 63 shows the relation between the respondent's household composition and their satisfaction with the proximity of daily grocery stores, it has a chi-square value of 73.3, with an asymptotic significance of 0.000 (99% confidence).

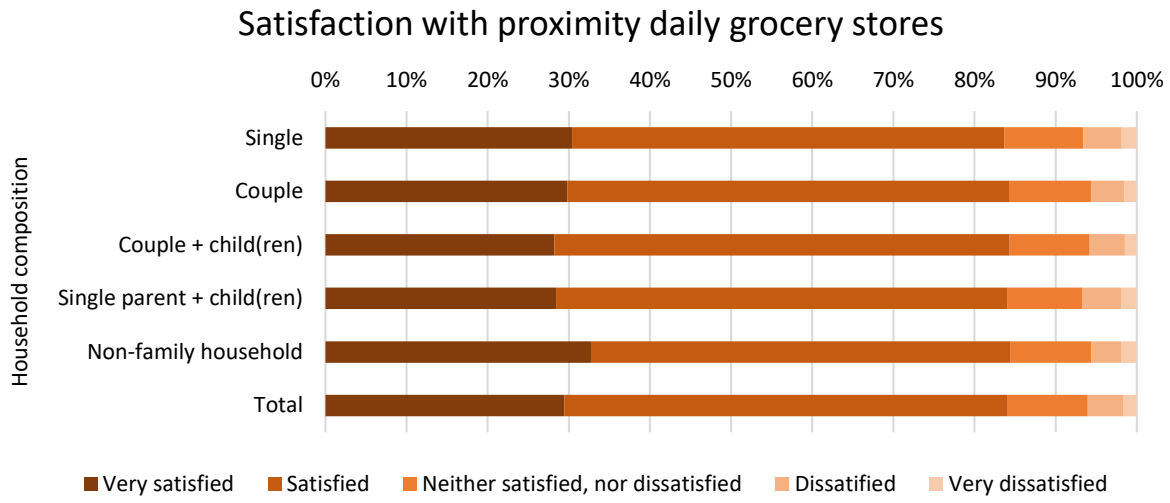


Figure 63: Relation between household composition and satisfaction with proximity of daily grocery stores

Level of education

Figure 64 shows the relation between the respondent's level of education and their satisfaction with the proximity of daily grocery stores, it has a Spearman correlation value of -0.025, with an approximate significance of 0.000 (99% confidence).

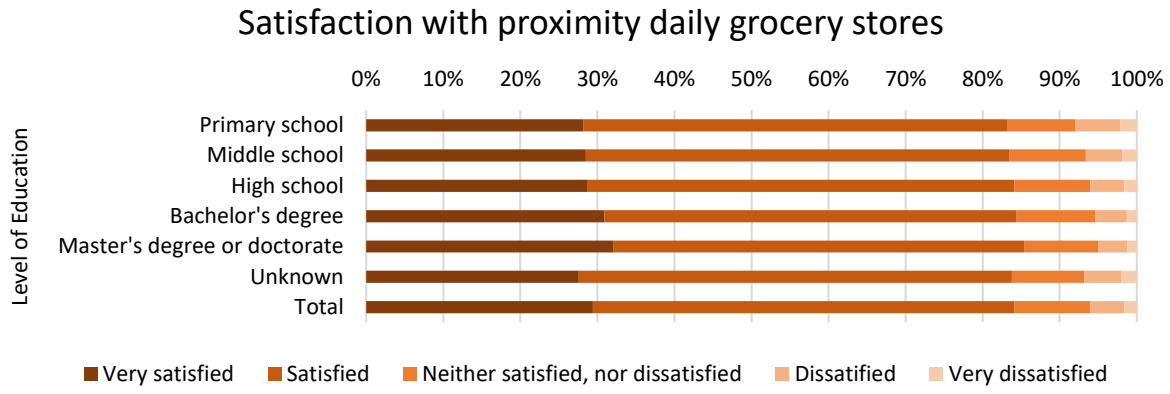


Figure 64: Relation between level of education and satisfaction with proximity of daily grocery stores

Ethnicity

Figure 65 shows the relation between the respondent's ethnicity and their satisfaction with the proximity of daily grocery stores, it has a chi-square value of 15.9, with an asymptotic significance of 0.044 (95% confidence).

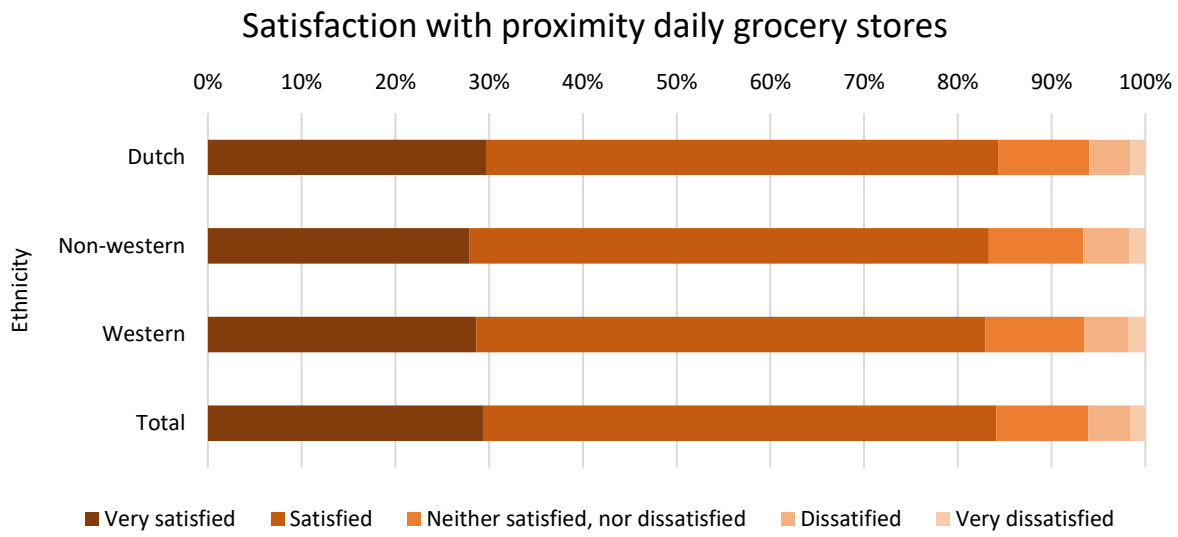


Figure 65: Relation between ethnicity and satisfaction with proximity of daily grocery stores

Neighborhood satisfaction

Figure 66 shows the relation between the respondent's general neighborhood satisfaction and their satisfaction with the proximity of daily grocery stores, it has a Spearman correlation value of 0.195, with an approximate significance of 0.000 (99% confidence).

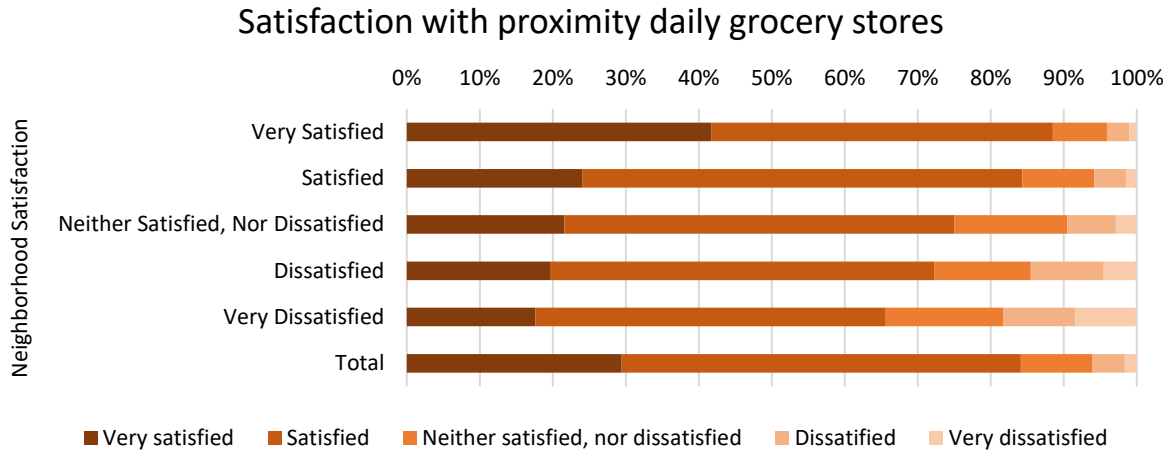


Figure 66: Relation between neighborhood satisfaction and satisfaction with proximity of daily grocery stores

V.VII Maintenance

This section details the relations between the variable neighborhood (building) maintenance and the personal characteristics, as well as general neighborhood satisfaction. The statement related to this variable in the WoON2018 database is: “the dwellings in this neighborhood are well-maintained”.

Age

Figure 67 shows the relation between the respondent’s age and their perception on neighborhood dwelling maintenance has a Spearman correlation value of -0.107, with an approximate significance of 0.000 (99% confidence).

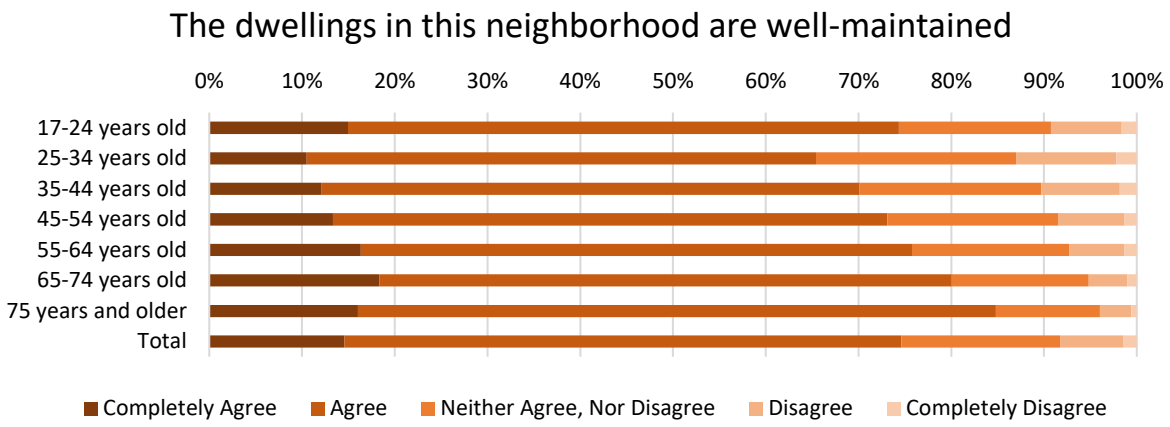


Figure 67: Relation between age and perception of neighborhood dwelling maintenance

Degree of urbanization

Figure 68 shows the relation between the respondent’s degree of urbanization and their perception on neighborhood dwelling maintenance, it has a Spearman correlation value of -0.177, with an approximate significance of 0.000 (99% confidence).

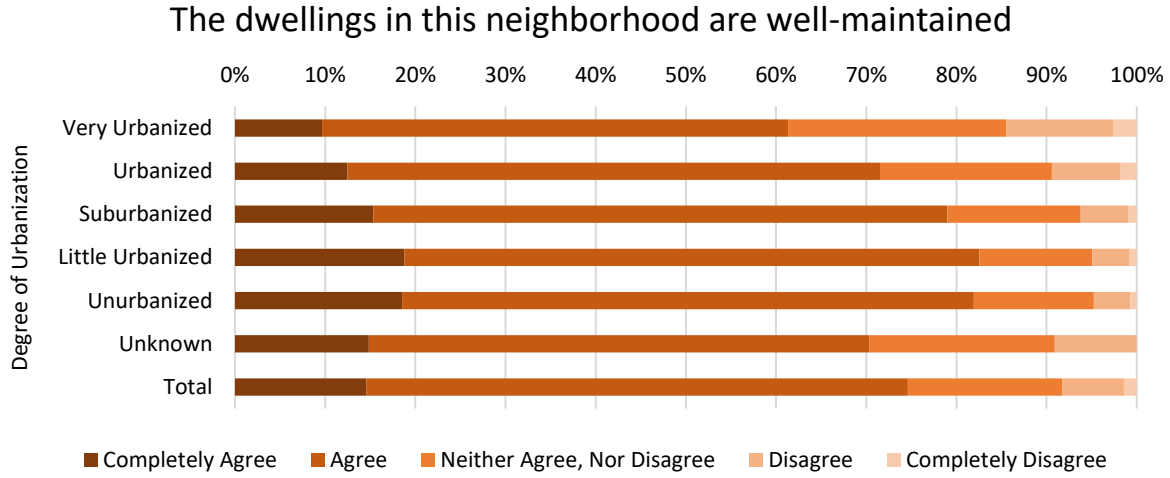


Figure 68: Relation between degree of urbanization and perception of neighborhood dwelling maintenance

Household composition

Figure 69 shows the relation between the respondent's household composition and their perception on neighborhood dwelling maintenance, it has a chi-square value of 1,222.1, with an asymptotic significance of 0.000 (99% confidence).

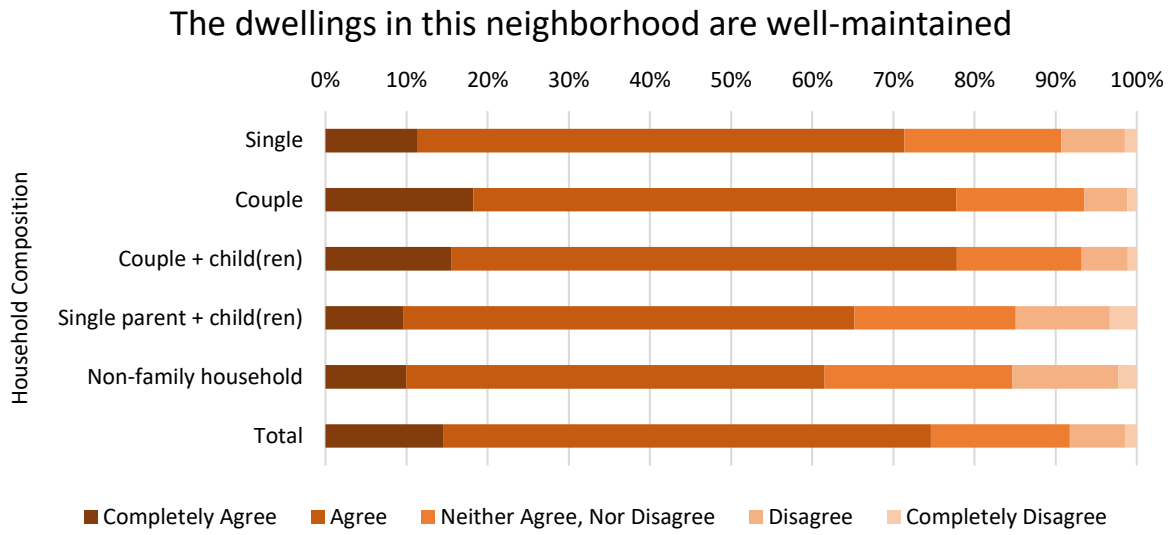


Figure 69: Relation between household composition and perception of neighborhood dwelling maintenance

Level of education

Figure 70 shows the relation between the respondent's level of education and their perception on neighborhood dwelling maintenance, it has a Spearman correlation value of -0.028, with an approximate significance of 0.000 (99% confidence).

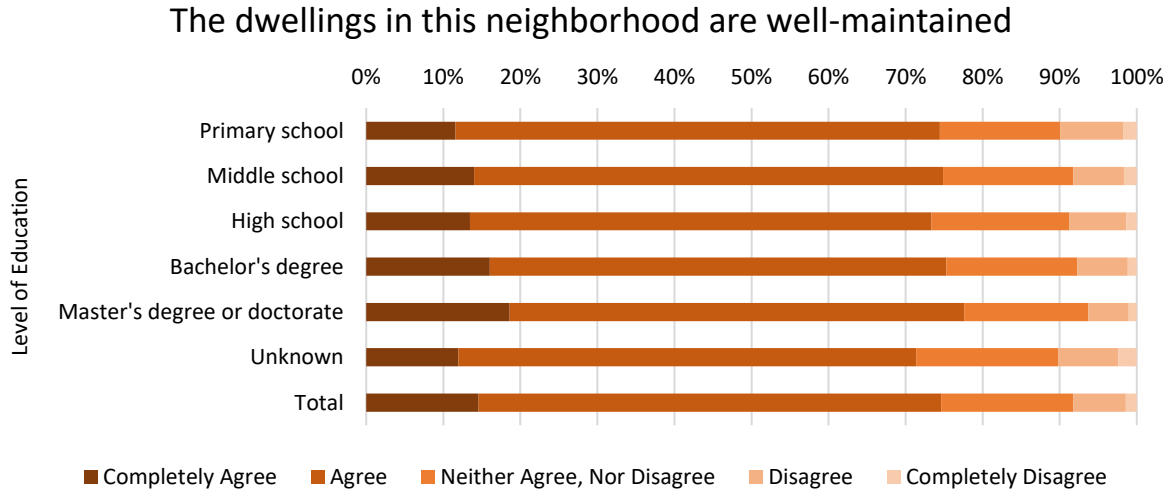


Figure 70: Relation between level of education and perception of neighborhood dwelling maintenance

Ethnicity

Figure 71 shows the relation between the respondent's ethnicity and their perception on neighborhood dwelling maintenance, it has a chi-square value of 816.0, with an asymptotic significance of 0.000 (99% confidence).

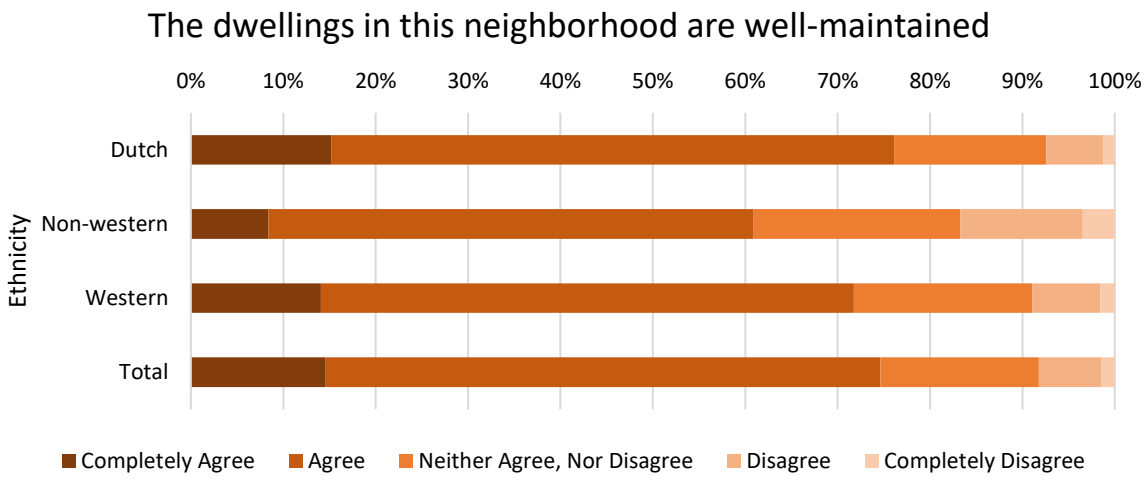


Figure 71: Relation between ethnicity and perception of neighborhood dwelling maintenance

Neighborhood Satisfaction

Figure 72 shows the relation between the respondent's general neighborhood satisfaction and their perception on neighborhood dwelling maintenance, it has a Spearman correlation value of 0.391, with an approximate significance of 0.000 (99% confidence).

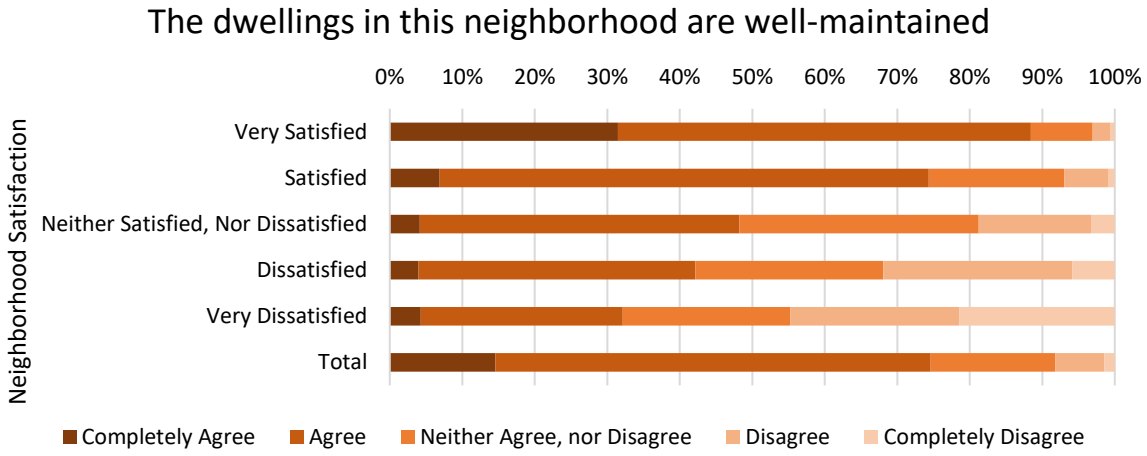


Figure 72: Relation between neighborhood satisfaction and perception of neighborhood dwelling maintenance

V.VIII Variable Interdependencies

Table 44: Spearman correlation coefficients for variable interdependencies (all 99% confidence)

Variable	Maintenance	Primary Schools	Daily Groceries	Safety	Social	Scenic / Aesthetic
Scenic / Aesthetic	0.576	0.166	0.133	-0.214	0.300	X
Social	0.267	0.162	0.085	-0.167	X	
Safety	-0.248	-0.134	-0.089	X		
Daily Groceries	0.109	0.312	X			
Primary Schools	0.159	X				
Maintenance	X					

Appendix VI: Pilot Study

VI.I: Invitation letter

Dutch Version

Dear mister/miss,

For my thesis at the Technical University Eindhoven I research how municipalities can better involve neighborhood residents in making plans for neighborhood improvements.

You can help me with my thesis by filling in a questionnaire. Please scan the QR-code, or use the link below.

https://tueindhoven.limequery.com/736931?lang=en

Filling in the survey takes about 10 minutes. This research is not conducted for the municipality Eindhoven. To my knowledge, the municipality has no short term plans regarding Limbeek.

Thanks in advance,

Mark Geelhoed

English Version

Dear mister/miss,

For my thesis at the Technical University Eindhoven I research how municipalities can better involve neighborhood residents in making plans for neighborhood improvements.

You can help me with my thesis by filling in a questionnaire. Please scan the QR-code, or use the link below.

https://tueindhoven.limequery.com/736931?lang=en

Filling in the survey takes about 10 minutes. This research is not conducted for the municipality Eindhoven. To my knowledge, the municipality has no short term plans regarding Limbeek.

Thanks in advance,

Mark Geelhoed

VI.II Introduction text

Welcome, thank you for participating in my research.

This survey will contain questions regarding your satisfaction with different properties of your neighborhood and which locations you are satisfied or dissatisfied with. These are followed by some question regarding your personal situation.

I am conducting this research to find out whether this questionnaire is a suitable method for a municipality to involve residents in improving their neighborhood. Your participation is of great importance to the completion of my thesis.

The questionnaire takes about 10 minutes.

For more information, email: m.w.geelhoed@student.tue.nl

Table 45: Survey neighborhood research Limbeek

Step	Variable	Question	Level of Measurement	Options
2	Consent participation	Do you agree with the statement below? By signing this form, I consent to the following: I am 17 years or older. I am sufficiently informed regarding the research by use of a separate information form. I have read the form and have had the opportunity to ask questions, these have been sufficiently answered. I participate voluntarily to this research. There is no explicit or implicit pressure for me to participate to this research. It is clear to me that I can stop my participation to this research at any moment, without providing any reason. I know that I do not have to answer questions if I do not want to.	Nominal	1 = Yes 2 = No
	Processing	I give permission to process the personal data that is gathered during the survey, as described in the information form.	Nominal	1 = Yes 2 = No
3	Neighborhood Satisfaction	How satisfied are you with your neighborhood in general?	Ordinal	1 = Very satisfied 2 = Satisfied 3 = Neutral 4 = Dissatisfied 5 = Very dissatisfied` 6 = No opinion
	Variable valuation	Which characteristics contribute most to your satisfaction with your neighborhood? Please select 5 characteristics and rank them in order of importance, which the highest on the top right.	Nominal	1 = The aesthetic properties of the buildings in my neighborhood. 2 = The aesthetic properties of the public space in my neighborhood 3 = The maintenance of my neighborhood. 4 = The ease to make contact with other residents in my neighborhood. 5 = The (lack of) noise disturbance in my neighborhood. 6 = The personal safety in my neighborhood. 7 = The traffic safety in my neighborhood. 8 = The opportunities for recreation and relaxation in my neighborhood. 9 = The accessibility of public transport in my neighborhood. 10 = The impact of my neighborhood on my mental health.
4	How satisfied are you with:			
	Scenic / Aesthetic	The aesthetic properties of the buildings in your neighborhood?	Ordinal	1 = Very satisfied 2 = Satisfied 3 = Neutral 4 = Dissatisfied 5 = Very dissatisfied` 6 = No opinion
		The aesthetic properties of the public space in the neighborhood?	Ordinal	1 = Very satisfied 2 = Satisfied 3 = Neutral 4 = Dissatisfied 5 = Very dissatisfied` 6 = No opinion

	Maintenance	The maintenance of your neighborhood?	Ordinal	1 = Very satisfied 2 = Satisfied 3 = Neutral 4 = Dissatisfied 5 = Very dissatisfied` 6 = No opinion
	Social	The ease to have contact with other residents in your neighborhood?	Ordinal	1 = Very satisfied 2 = Satisfied 3 = Neutral 4 = Dissatisfied 5 = Very dissatisfied` 6 = No opinion
	Noise	The (lack of) noise disturbance in your neighborhood?	Ordinal	1 = Very satisfied 2 = Satisfied 3 = Neutral 4 = Dissatisfied 5 = Very dissatisfied` 6 = No opinion
	Personal Safety	The personal safety in your neighborhood?	Ordinal	1 = Very satisfied 2 = Satisfied 3 = Neutral 4 = Dissatisfied 5 = Very dissatisfied` 6 = No opinion
	Traffic Safety	The traffic safety in your neighborhood?	Ordinal	1 = Very satisfied 2 = Satisfied 3 = Neutral 4 = Dissatisfied 5 = Very dissatisfied` 6 = No opinion
	Recreation	The opportunities for recreation and relaxation in your neighborhood?	Ordinal	1 = Very satisfied 2 = Satisfied 3 = Neutral 4 = Dissatisfied 5 = Very dissatisfied` 6 = No opinion
	Public Transport	The accessibility of public transport in your neighborhood?	Ordinal	1 = Very satisfied 2 = Satisfied 3 = Neutral 4 = Dissatisfied 5 = Very dissatisfied` 6 = No opinion
	Mental health	The impact of your neighborhood on your mental health?	Ordinal	1 = Very satisfied 2 = Satisfied 3 = Neutral 4 = Dissatisfied 5 = Very dissatisfied` 6 = No opinion
5	Preferred PT stop	If you would make use of public transport, which public transport stop would you use? Please select the location of this stop on the map.	Nominal	GPS location
	PT stop frequency	How often do you use this stop?	Ordinal	1 = Daily 2 = Weekly 3 = Monthly 4 = Annually 5 = Never
6	Positive locations (3X)	Please select the first/second/third location or object you are satisfied with.	Nominal	GPS location
		Which characteristic(s) cause you to be satisfied with this location/object and why?	Nominal	1 = Aesthetic, pleasant to look at 2 = Maintenance 3 = Social 4 = Noise level 5 = Personal safety 6 = Traffic safety 7 = Recreation / Relaxation 8 = Public Transport 9 = Mental Health 10 = Other: [Fill in]

	Negative locations (3X)	Please select the first/second/third location or object you are dissatisfied with.	Nominal	GPS location
		Which characteristic(s) cause you to be dissatisfied with this location/object and why?	Nominal	1 = Aesthetic, unpleasant to look at 2 = Maintenance 3 = Social 4 = Noise level 5 = Personal safety 6 = Traffic safety 7 = Recreation / Relaxation 8 = Public Transport 9 = Mental Health 10 = Other: [Fill in]
7	Age	What age group do you belong to?	Interval	1 = 17-24 years 2 = 25-34 years 3 = 35-44 years 4 = 45-54 years 5 = 55-64 years 6 = 65-74 years 7 = 75 years or older 8 = Prefer not to say
	Gender	What is your gender?	Nominal	1 = Female 2 = Male 3 = Other / Prefer not to say
	Household composition	What is the composition of your household?	Nominal	1 = One-person household 2 = Couple without children 3 = Couple with child(ren) 4 = Single Parent with child(ren) 5 = Student house 6 = Non-family household / Other 7 = Prefer not to say
	Level of education	What is your highest completed education?	Ordinal	1 = Primary Education 2 = VMBO, HAVO-, VWO-year 3, MBO1 3 = HAVO, VWO, MBO 2-4 4 = HBO-, WO bachelor's degree 5 = HBO-, WO master's degree, Doctorate 6 = Other 7 = Refused
	ZIP-Code	What is the ZIP-code of the house you live in?	Nominal	Open answer
8	In case the municipality would be making plans for the improvement of your neighborhood:			
	Opinion	Would you like it if the municipality asked for your opinion?	Nominal	1 = Yes 2 = Uncertain 3 = No
	Questionnaire	Would you be willing to fill in a questionnaire?	Nominal	1 = Yes 2 = Uncertain 3 = No
	Public Gathering	Would you go to an information evening in your neighborhood?	Nominal	1 = Yes 2 = Uncertain 3 = No
		If you wish to receive the results of this research, then please fill in your e-mail address.		Open answer
	Feedback	Do you have feedback regarding this survey or the research?		Open answer

Screenshots

Which characteristics contribute most to your satisfaction with your neighborhood?

Double-click or drag-and-drop characteristics in the left list to move them to the right. Please select 5 characteristics and rank them in order of importance, with the highest on the top right.

Your choices	Your ranking
The aesthetic properties of the buildings in my neighborhood.	
The aesthetic properties of the public space in my neighborhood.	
The maintenance of my neighborhood.	
The ease to make contact with other residents in my neighborhood	
The (lack of) noise distrubance in my neighborhood.	
The personal safety in my neighborhood.	
The traffic safety in my neighborhood.	
The opportunities for recreation and relaxation in my neighborhood.	
The accessibility of public transport in my neighborhood.	
The impact of my neighborhood on my mental health.	

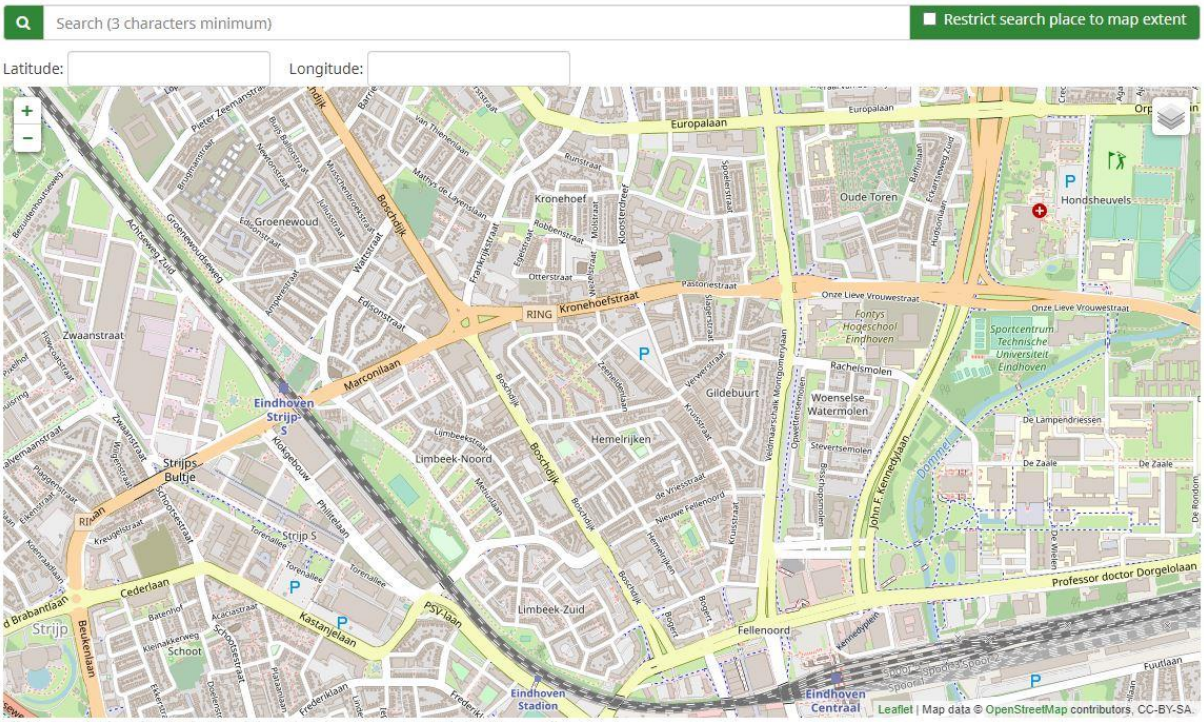
Figure 73: Ranking most contributing neighborhood characteristics

*How satisfied are you with:

	Very satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied	No opinion
The aesthetic properties of the buildings in your neighborhood?	○	○	○	○	○	○
The aesthetic properties of the public space in your neighborhood?	○	○	○	○	○	○
The maintenance of your neighborhood?	○	○	○	○	○	○
The ease to have contacts with other residents in your neighborhood?	○	○	○	○	○	○
The (lack of) noise distrubance in your neighborhood?	○	○	○	○	○	○
The personal safety in your neighborhood?	○	○	○	○	○	○
The traffic safety in your neighborhood?	○	○	○	○	○	○
The opportunities for recreation and relaxation in your neighborhood?	○	○	○	○	○	○
The accessibility of public transport in your neighborhood?	○	○	○	○	○	○
The impact of your neighborhood on your mental health?	○	○	○	○	○	○

Figure 74: Satisfaction with individual neighborhood characteristics

Please select the **first** location you are satisfied with.



Click to set the location or drag and drop the pin. You may may also enter coordinates

Which characteristic(s) cause you to be satisfied with this location/object and why?

- [ ] Aesthetic, pleasant to look at
- [ ] Maintenance
- [ ] Social
- [ ] Noise Level
- [ ] Personal Safety
- [ ] Traffic Safety
- [ ] Recreation / Relaxation
- [ ] Public Transport
- [ ] Mental Health
- [ ] Other:

Figure 75: Association mapping tool

VI.IV Limbeek ZIP-codes and respondent density

Figure 76: ZIP-code areas Limbeek

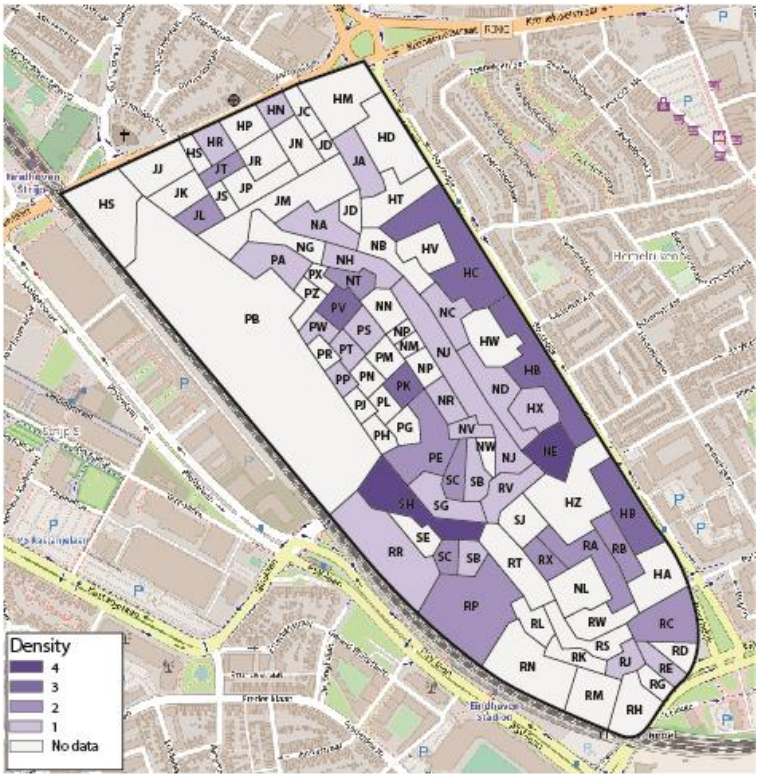


Figure 77: Density of respondents per ZIP-code area

VI.V Sample Description

Table 46 shows the composition of the sample of the pilot study. In order: age group, gender, household composition and level of education.

Table 46: Sample composition

Age Group			
Category	Frequency	Percent	Valid Percent
17-24 years	4	4.2	5.6
25-34 years	23	24.2	32.4
35-44 years	8	8.4	11.3
45-54 years	10	10.5	14.1
55-64 years	14	14.7	19.7
65-75 years	12	12.6	16.9
Valid Total	71	74.7	100.0
Missing System	24	25.3	
Total	95	100.0	
Gender			
Female	30	31.6	42.3
Male	39	41.1	54.9
Other / Prefer not to say	2	2.1	2.8
Valid Total	71	74.7	100.0
Missing System	24	25.3	
Total	95	100.0	
Household Composition			
One-person household	26	27.4	36.6
Couple without children	32	33.7	45.1
Couple with child(ren)	4	4.2	5.6
Single parent with child(ren)	1	1.1	1.4
Non-family household / Other	1	1.1	1.4
Student house	4	4.2	5.6
Prefer not to say	3	3.2	4.2
Valid Total	71	74.7	100.0
Missing System	24	25.3	
Total	95	100.0	
Highest Completed Education			
Primary Education	1	1.1	1.4
VMBO, HAVO-, VWO-year 3, MBO1	8	8.4	11.3
HAVO, VWO, MBO2-4	11	11.6	15.5
HBO-, WO Bachelor's degree	26	27.4	36.6
HBO-, WO Master's degree, Doctorate	24	25.3	33.8
Other	1	1.1	1.4
Valid Total	71	74.7	100.0
Missing System	24	25.3	
Total	95	100.0	

VI.VI Sample Representativeness

The potential number of respondents in Table 47 is calculated by subtracting the number of neighborhood residents who are below the age of 17 from the total number of residents in the research area (3,810), as they are not allowed to participate in the survey. First, the residents in Limbeek below the age of 15 (315), according to (Statistics Netherlands (CBS), 2021), have been removed. Second, as specific data about Limbeek is unavailable, the number or residents aged 15 and 16 is calculated by multiplying the average percentage of residents in Eindhoven aged 15 (0.92%) and 16 (0.93%) years-old by the total number or Limbeek residents. So, the number of potential respondents in the age category 15-24 (835) is reduced by (1.84% * 3,810 =) 70 to 765. Then, the number of respondents who completed the survey (71) is divided by the total number of potential participants (3,425) to calculate the respondent rate per eligible resident (2.07%). The expected count of respondents per category is then calculated by multiplying the respondent rate by the number of residents per category. For gender, it is assumed that the percentage of males and females in the 1-16 age group is 50-50. And so, 192 is subtracted from the total number of both gender categories. For household composition, the potential number of respondents per category is calculated by multiplying the number of households without children (490) by two and the household with children (330) by three but is then subtracted by the number of children (315). The remaining 65 residents are categorized as: 'other'.

Table 47: Sample expected count calculation

Respondents	71	Eligible respondent rate		2.07%		
Personal Characteristics	**Category**	**Eligible Residents**			**Count**	
		Limbeek-South	Limbeek-North	Total	Expected	Observed
	Total Residents	1,380	2,430	3,810		
	Potential participants (17+)	1,190	2,235	3,425		
Age	0-14	165	150	315	0	0
	15-16	25	45	70	0	0
	17-24	160	605	`765	15.9	4
	25-44	450	1,105	1,555	32.2	31
	45-65	390	360	750	15.5	24
	65+	190	165	355	7.4	12
Gender	Female	577	841	1,418	28.6	30
	Male	662	1,341	2,003	40.4	39
	Other				0.0	2
Household Composition	One person household	475	1,300	1,775	34.7	26
	Household without Children	330	650	980	19.1	36
	Household with children	375	300	675	13.2	5
	Other				0.0	4
Education Level	Low	420	440	860	17.6	9
	Medium	370	820	1,190	24.3	11
	High	410	970	1,380	28.2	50
	Other				0.0	1
					1.63%	
Zip-Code	Limbeek-Zuid			1,190	19.5	22
	Limbeek-Noord			2,235	36.5	34

VI.VII Limbeek Neighborhood Satisfaction comparison

Table 48 lists the distributions of the respondent's satisfactions with the neighborhood in general and the individual characteristics.

Table 48: Limbeek Neighborhood Satisfaction

Satisfaction with:	General Neighborhood Satisfaction			Building Aesthetics			Public Space Aesthetics	
	N	Limbeek	WoON2018	N	Limbeek	WoON2018	N	Limbeek
Very satisfied	6	6.4%	33.0%	1	1.1%	16.8%	4	4.5%
Satisfied	40	42.6%	51.8%	26	28.3%	53.5%	35	39.3%
Neutral	28	29.8%	10.6%	30	32.6%	19.9%	25	28.1%
Dissatisfied	17	18.1%	3.5%	27	29.3%	8.2%	22	24.7%
Very dissatisfied	3	3.2%	1.1%	8	8.7%	1.5%	3	3.4%
Total	94	100.0%	100.0%	92	100.0%	100.0%	89	100.0%

Satisfaction with:	Maintenance			Social			Noise	
	N	Limbeek	WoON2018	N	Limbeek	WoON2018	N	Limbeek
Very satisfied	1	1.1%	14.6%	5	5.7%	8.1%	12	13.2%
Satisfied	39	41.5%	60.0%	39	44.3%	39.2%	29	31.9%
Neutral	25	26.6%	17.1%	28	31.8%	32.3%	24	26.4%
Dissatisfied	21	22.3%	6.8%	9	10.2%	16.6%	15	16.5%
Very dissatisfied	8	8.5%	1.4%	7	8.0%	3.8%	11	12.1%
Total	94	100.0%	100.0%	88	100.0%	100.0%	91	100.0%

Satisfaction with:	Personal Safety			Traffic Safety		Recreation	
	N	Limbeek	WoON2018	N	Limbeek	N	Limbeek
Very satisfied	4	4.4%	37.9%	5	5.4%	7	8.0%
Satisfied	38	41.8%	47.2%	35	37.6%	23	26.1%
Neutral	19	20.9%	9.4%	23	24.7%	36	40.9%
Dissatisfied	22	24.2%	4.3%	24	25.8%	20	22.7%
Very dissatisfied	8	8.8%	1.2%	6	6.5%	2	2.3%
Total	91	100.0%	100.0%	93	100.0%	88	100.0%

Satisfaction with:	Public Transport		Mental Health	
	Frequency	Limbeek	Frequency	Limbeek
Very satisfied	33	37.1%	5	5.7%
Satisfied	40	44.9%	25	28.7%
Neutral	11	12.4%	44	50.6%
Dissatisfied	2	2.2%	12	13.8%
Very dissatisfied	3	3.4%	1	1.1%
Total	88	100.0%	87	100.0%

VI.VIII Selected locations and heatmaps

All selected locations

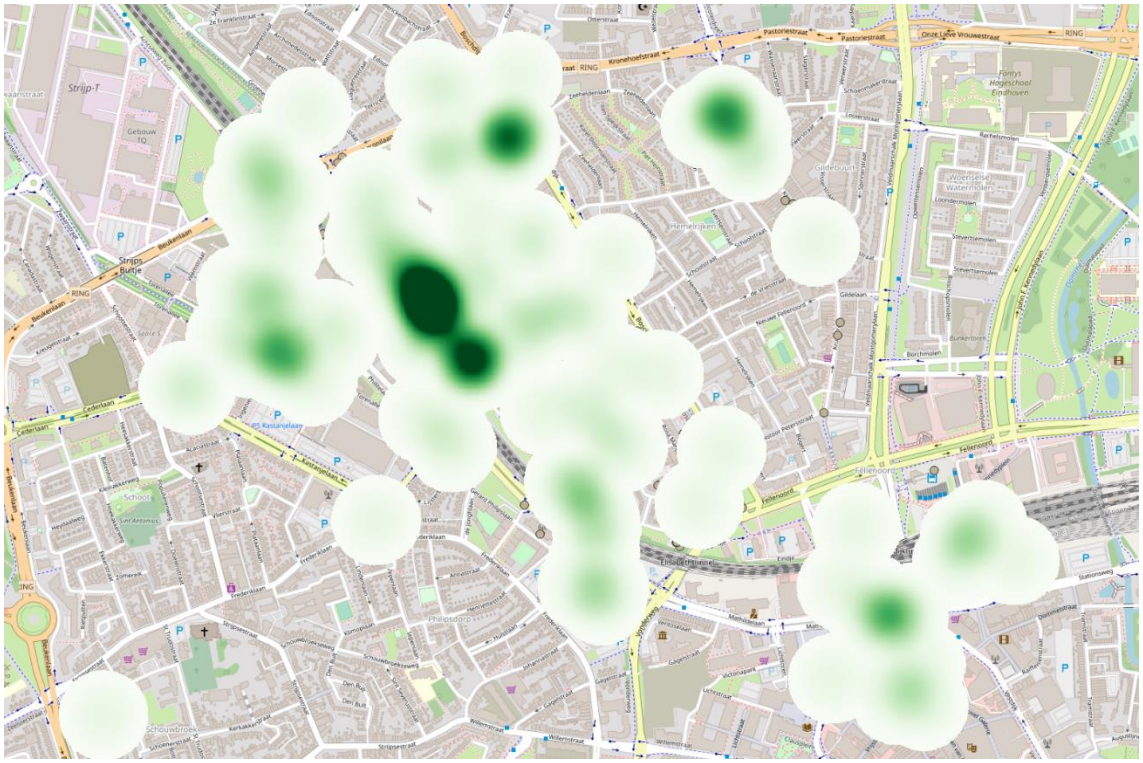


Figure 78: All positive heatmap (range 0-10)

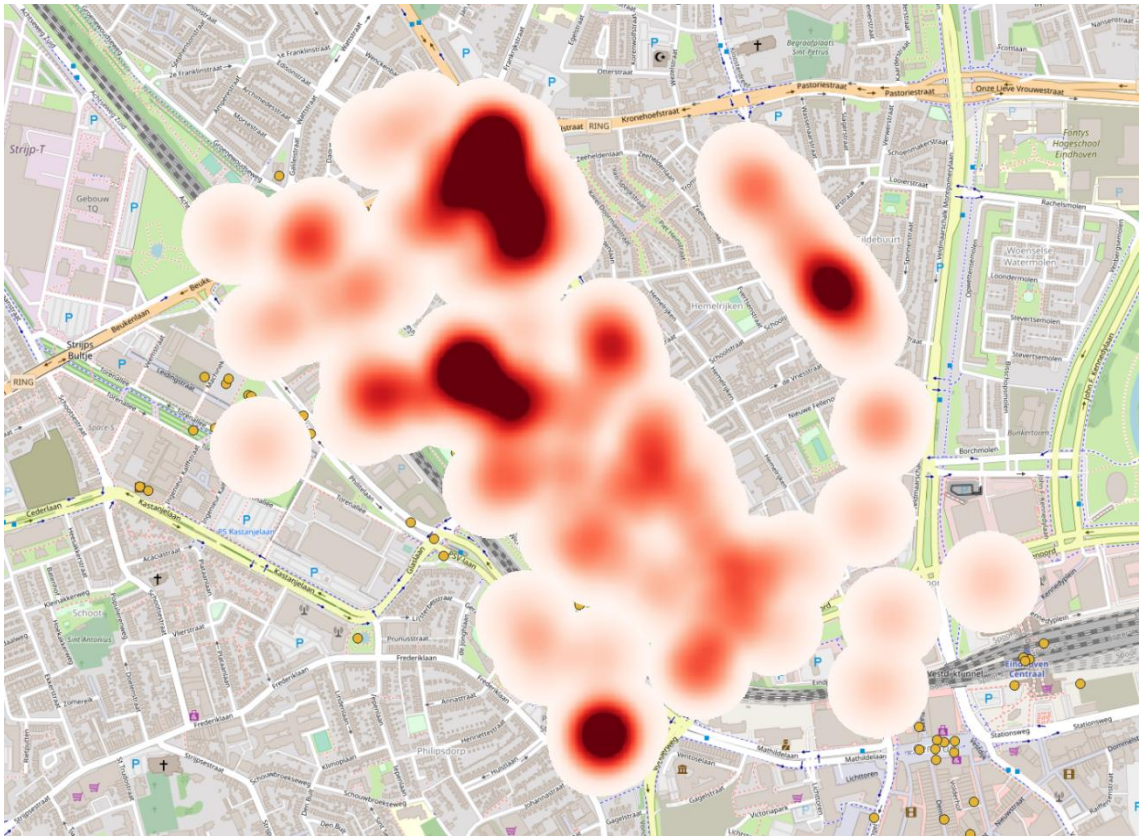


Figure 79: All negative heatmap (range 0-10)

Aesthetic

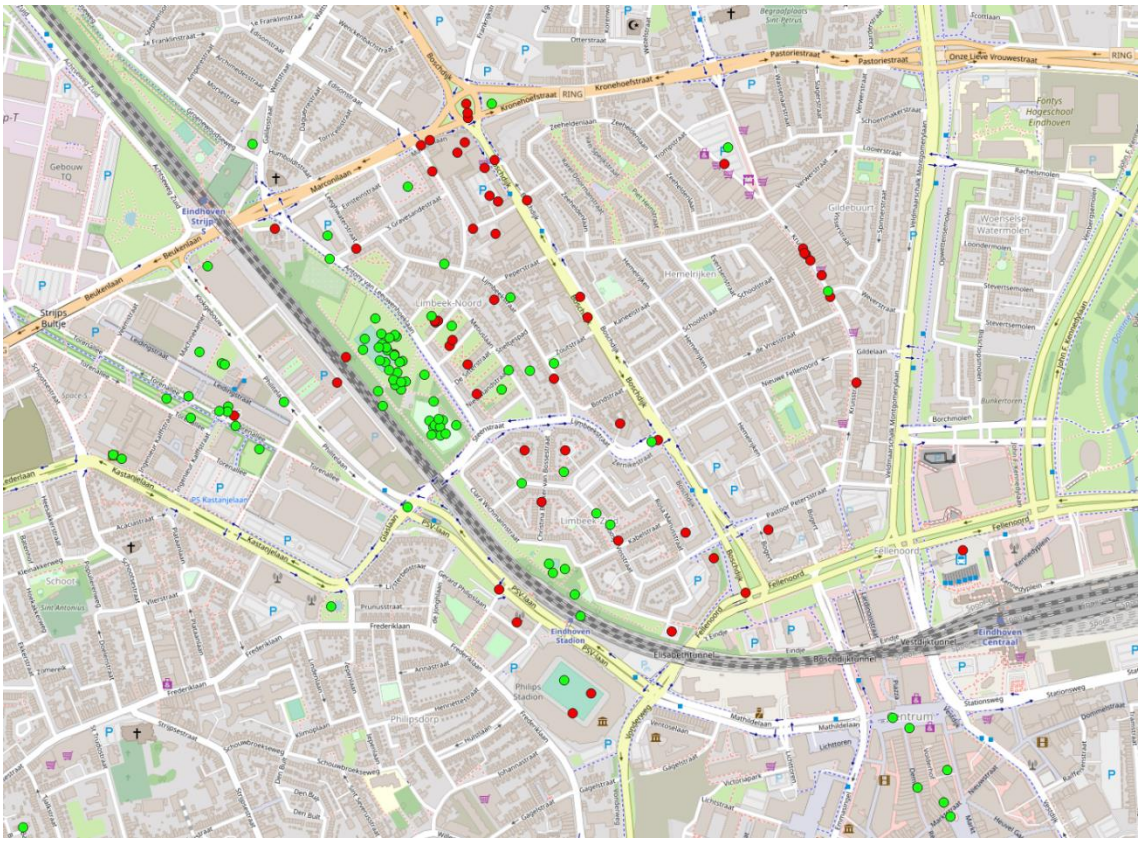


Figure 80: Selected locations with an aesthetic association

Maintenance

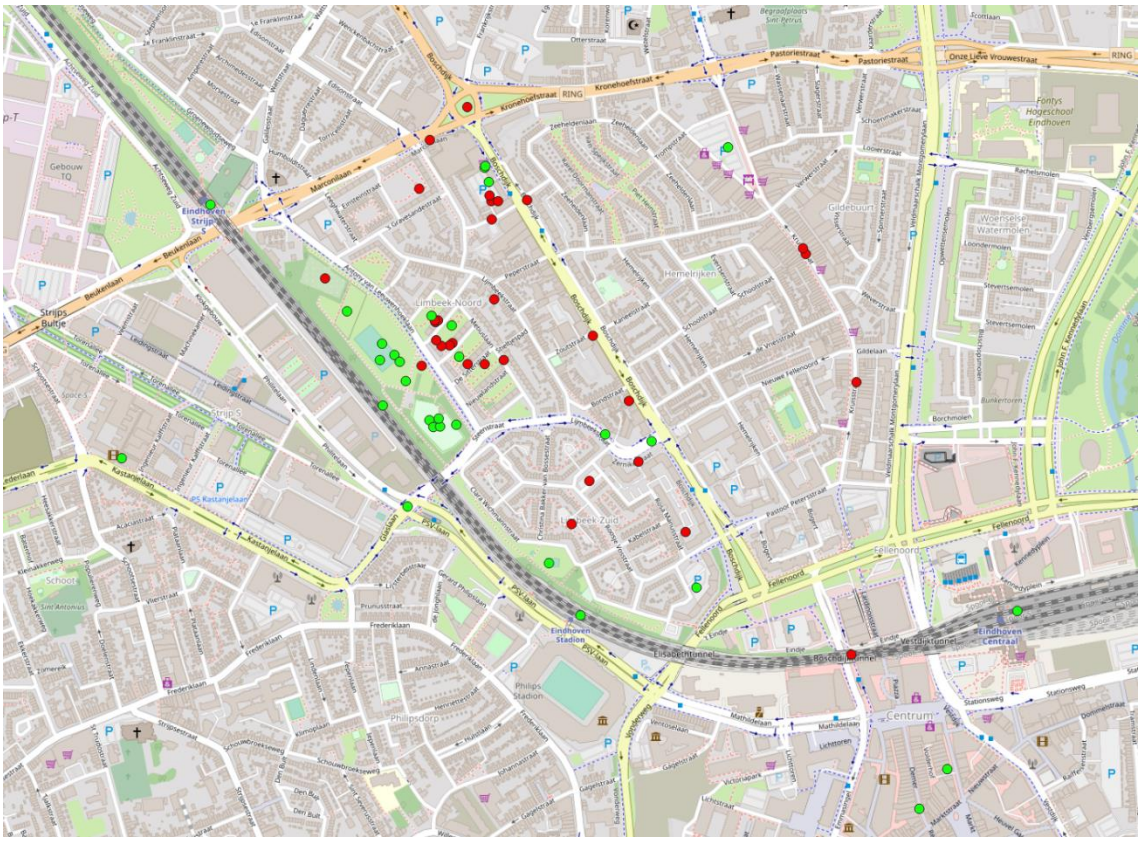


Figure 81: Selected locations with a maintenance association

Social

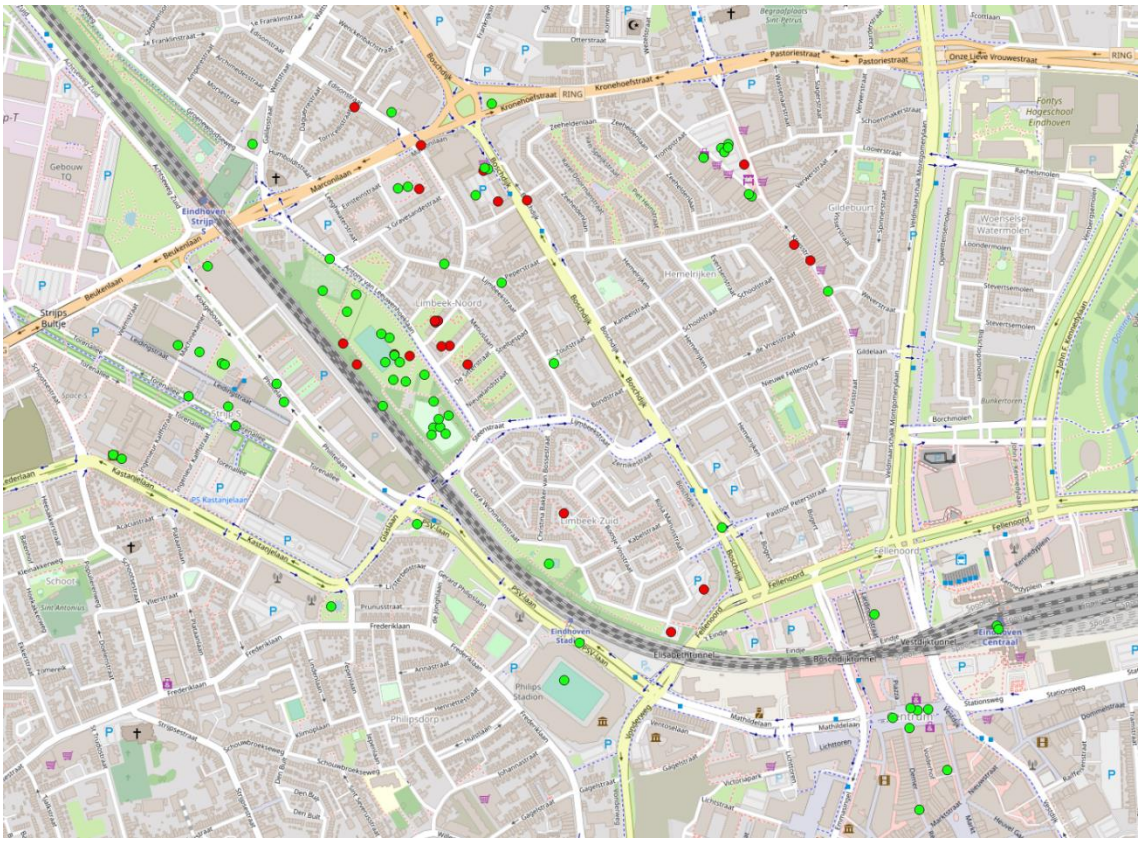


Figure 82: Selected locations with a social association

Noise

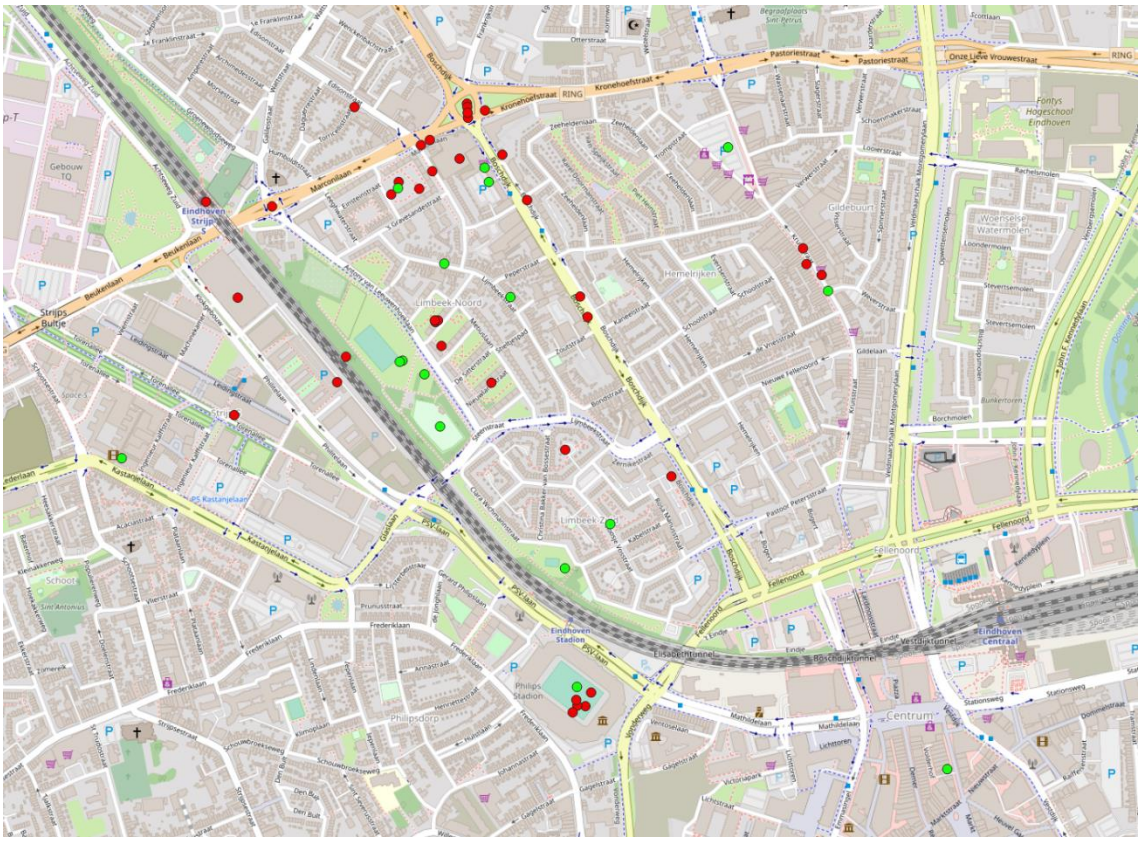


Figure 83: Selected locations with a noise association

Personal Safety

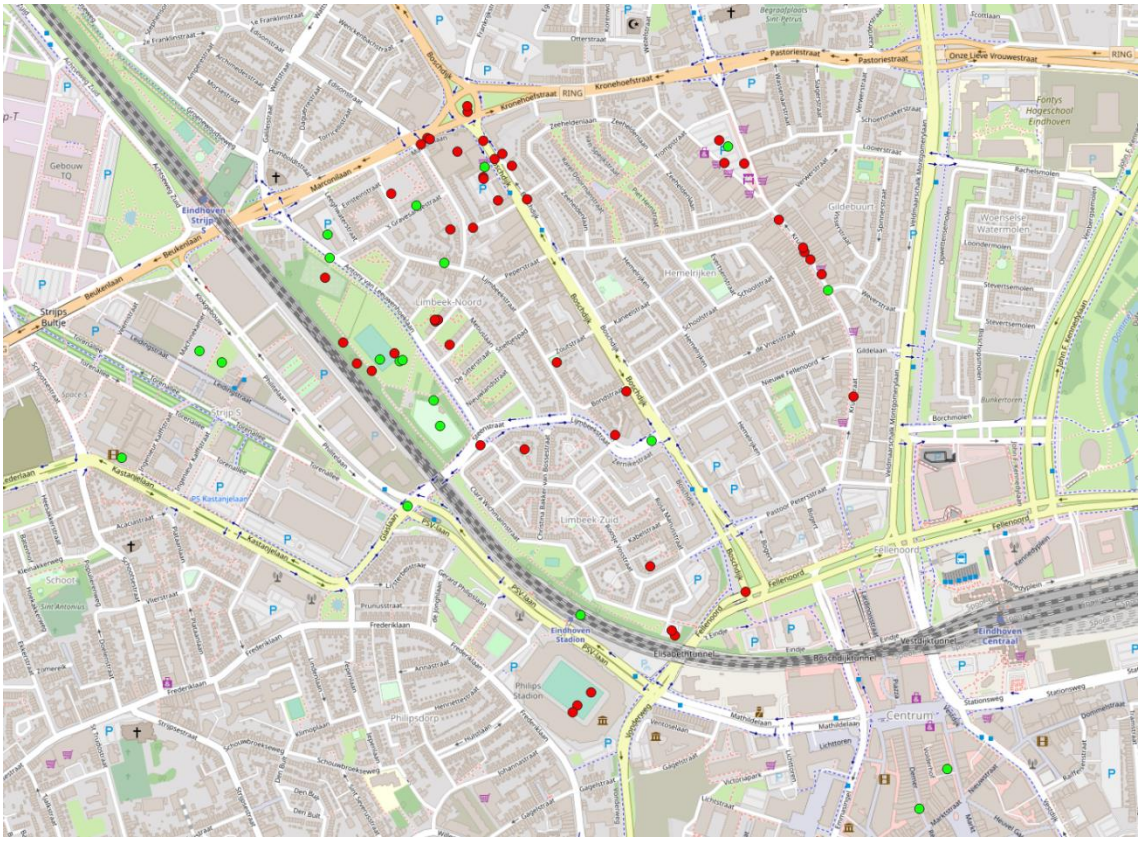


Figure 84: Selected locations with a personal safety association

Traffic Safety

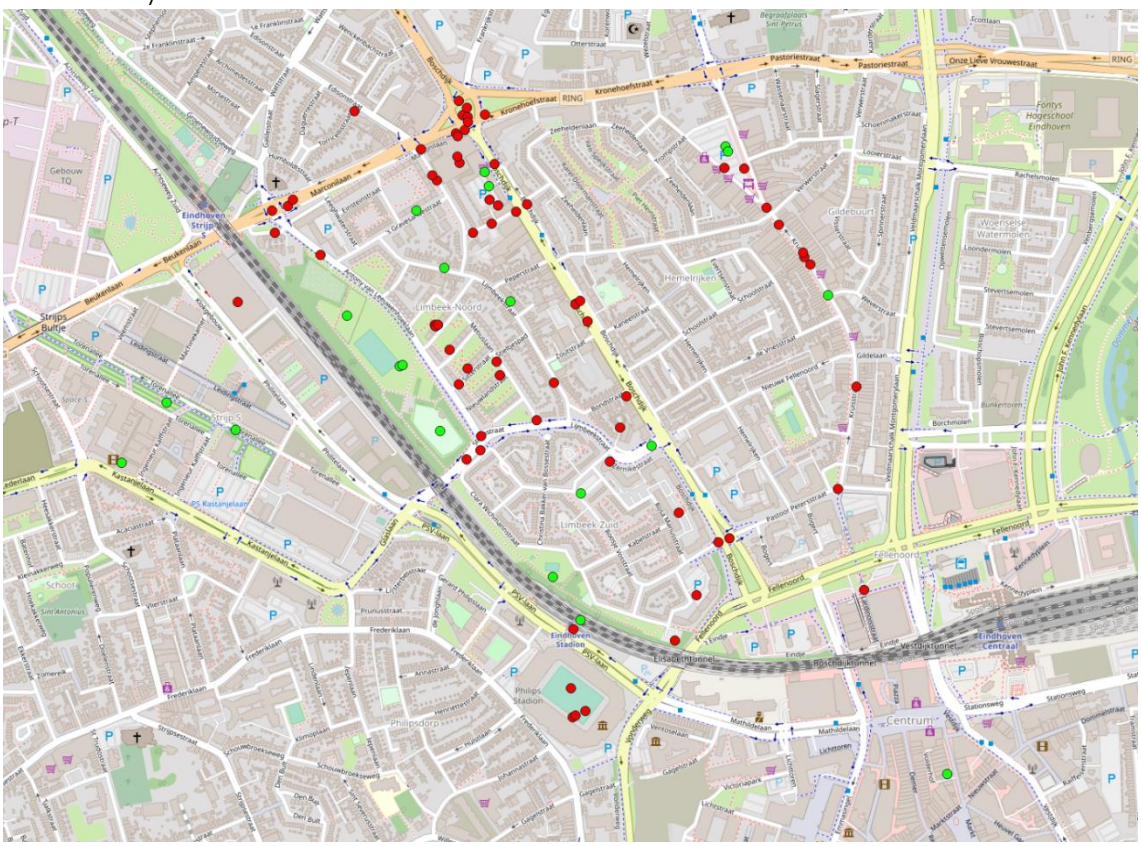


Figure 85: Selected locations with a traffic safety association

Recreation

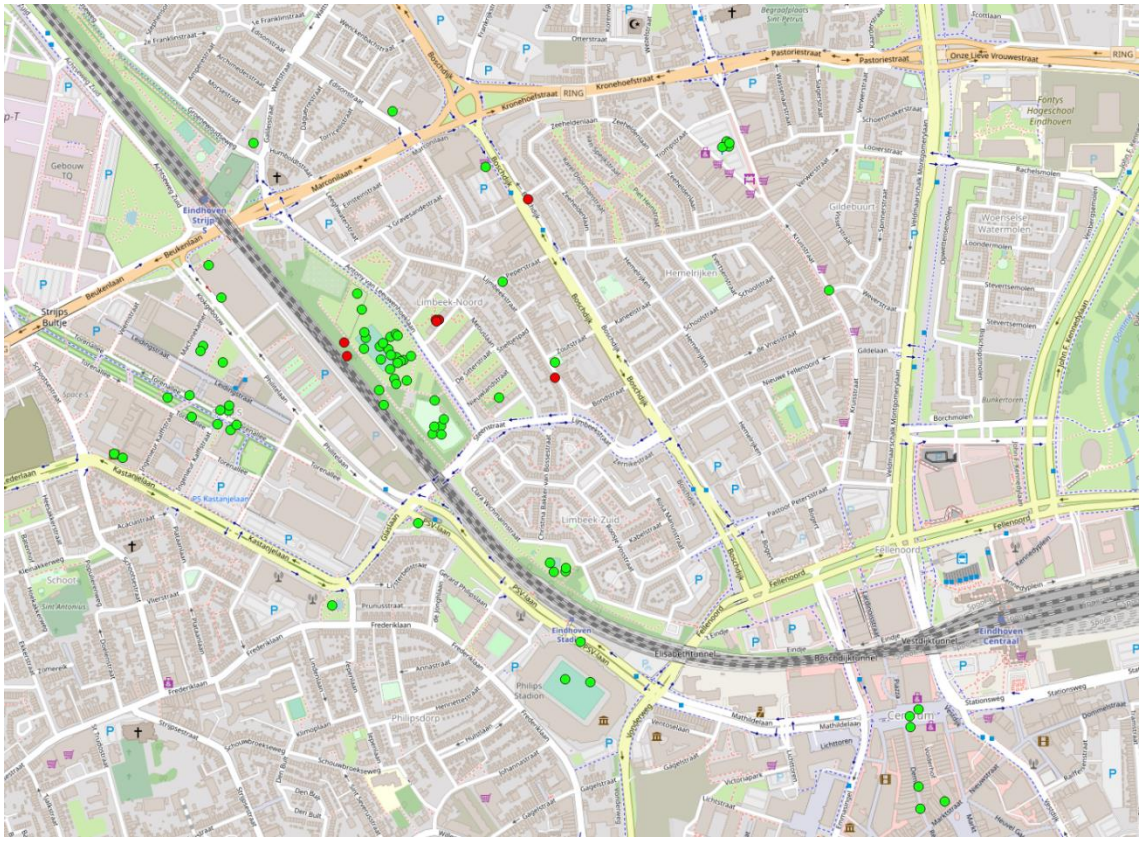


Figure 86: Selected locations with a recreation association

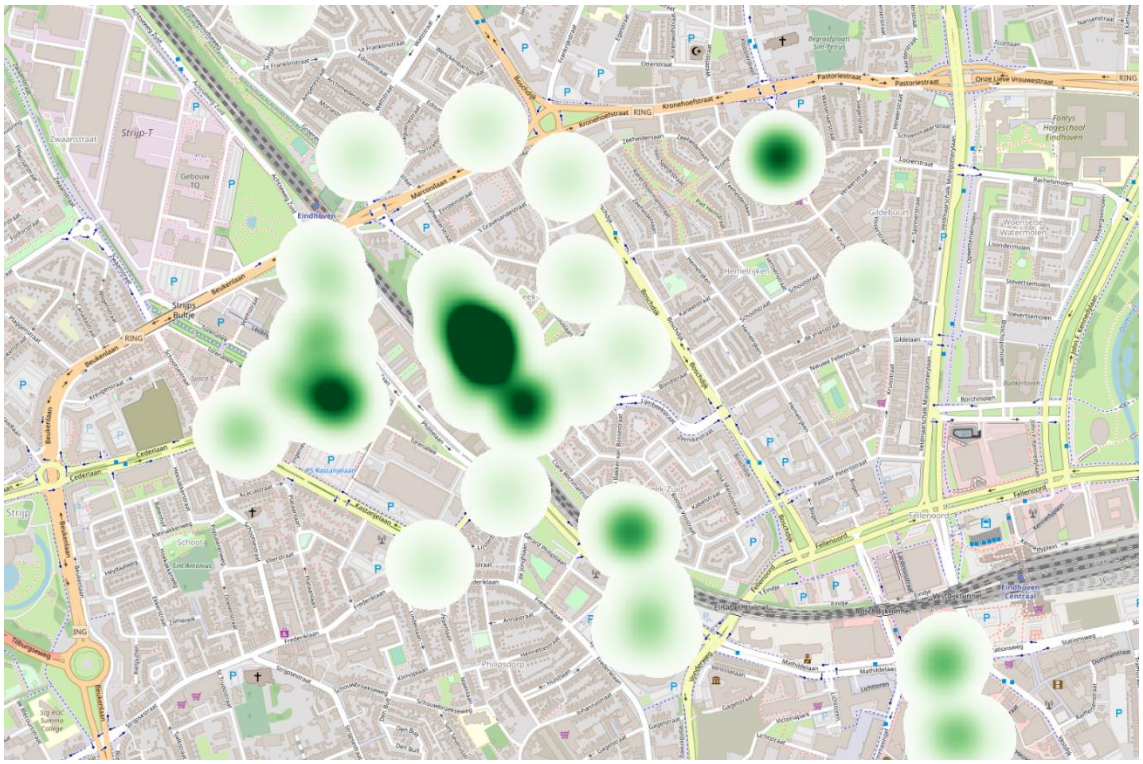


Figure 87: Positive recreation heatmap

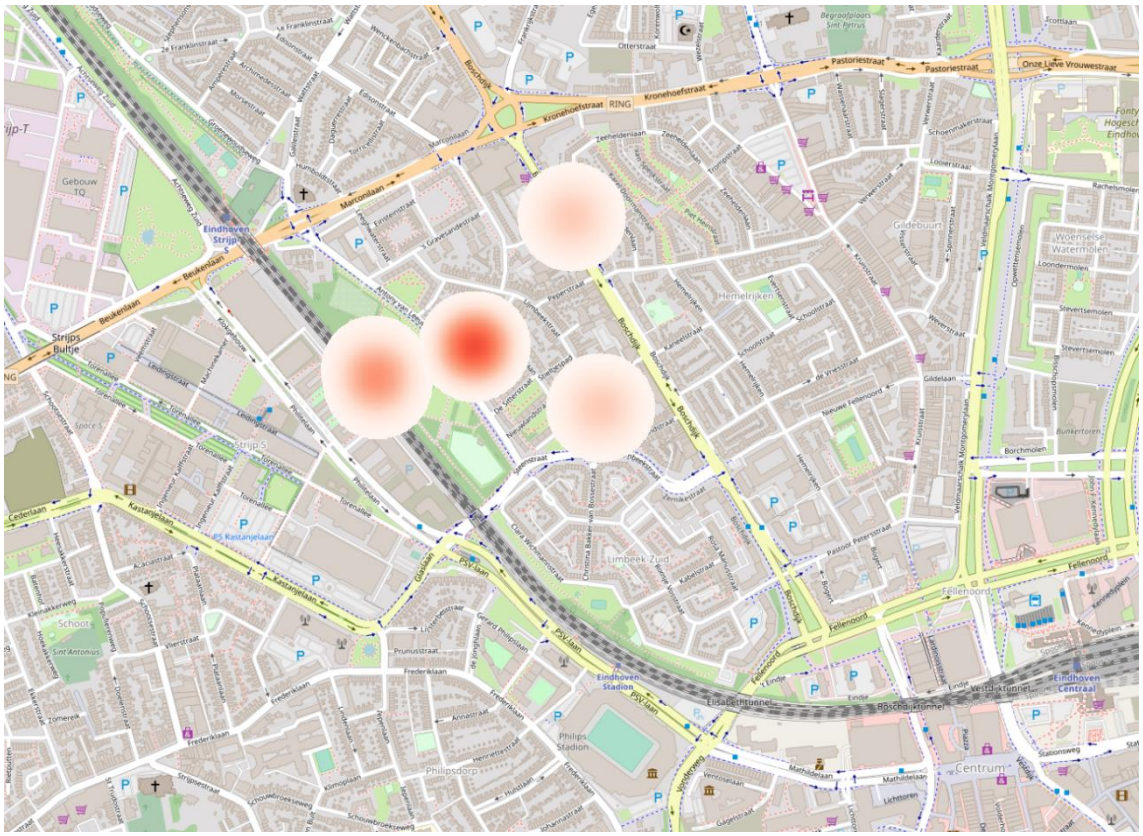


Figure 88: Negative recreation heatmap

Public Transport

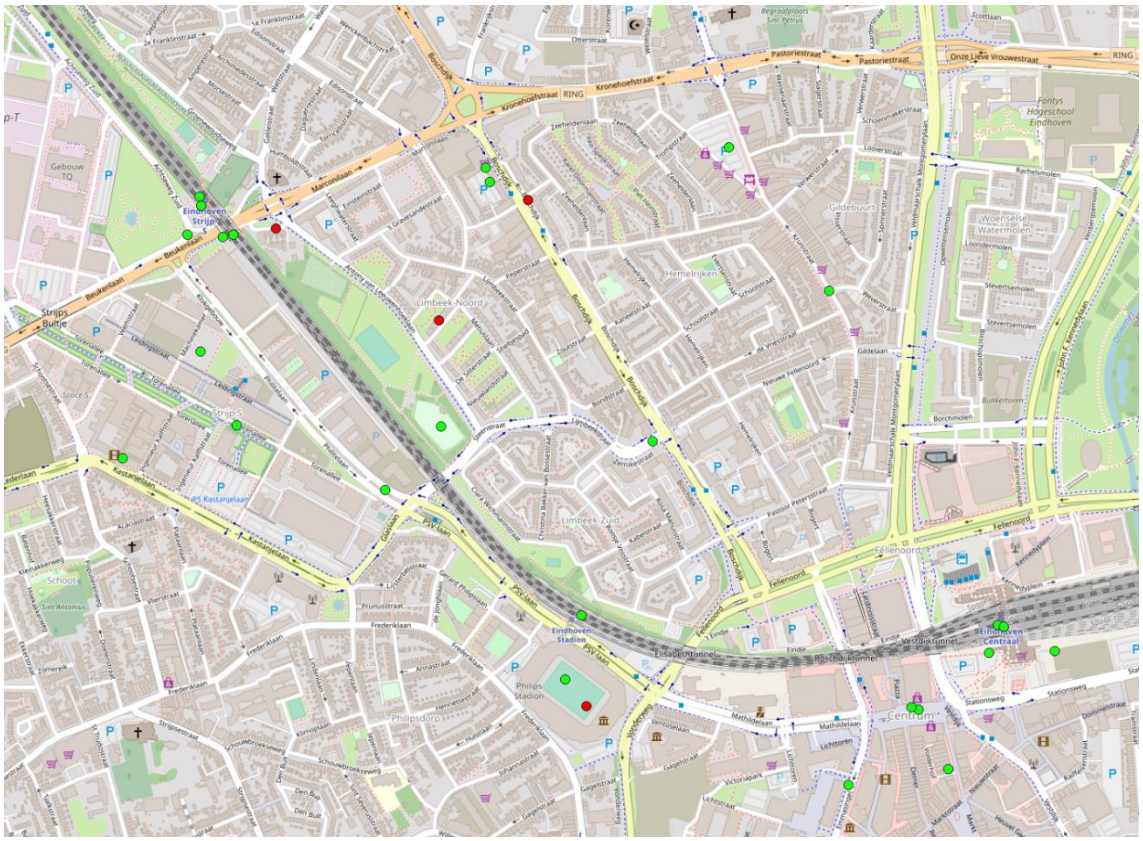


Figure 89: Selected locations with a public transport association

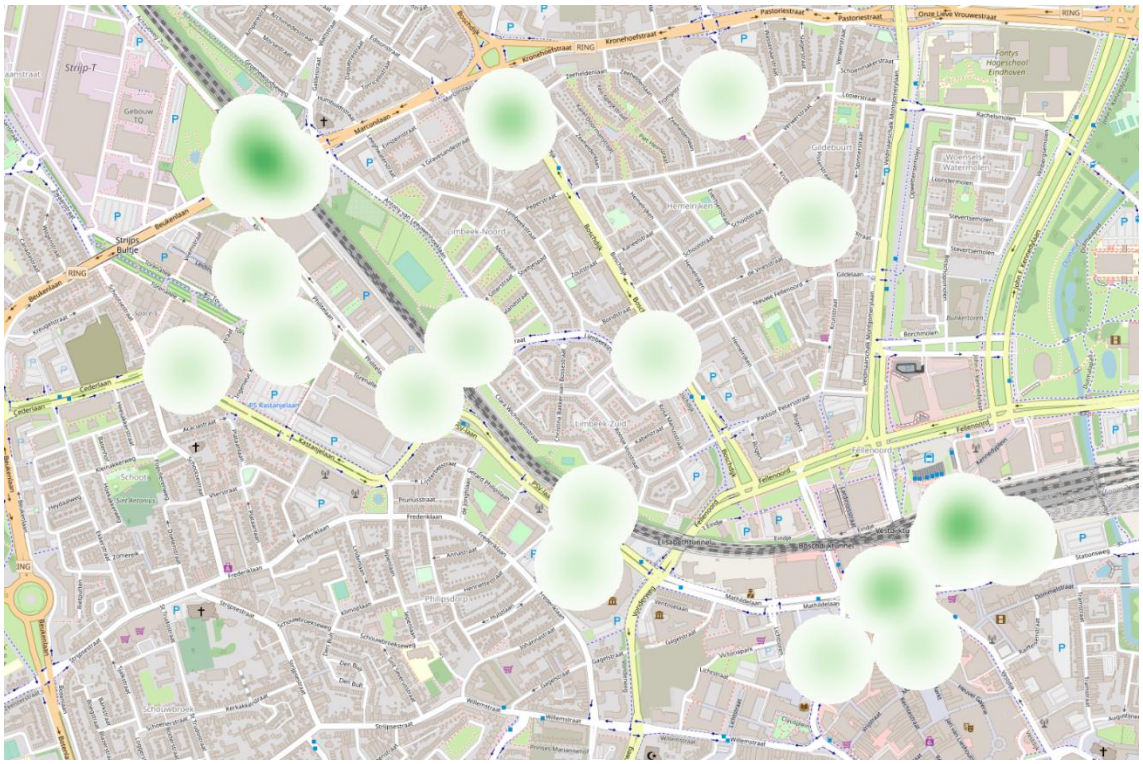


Figure 90: Positive public transport heatmap

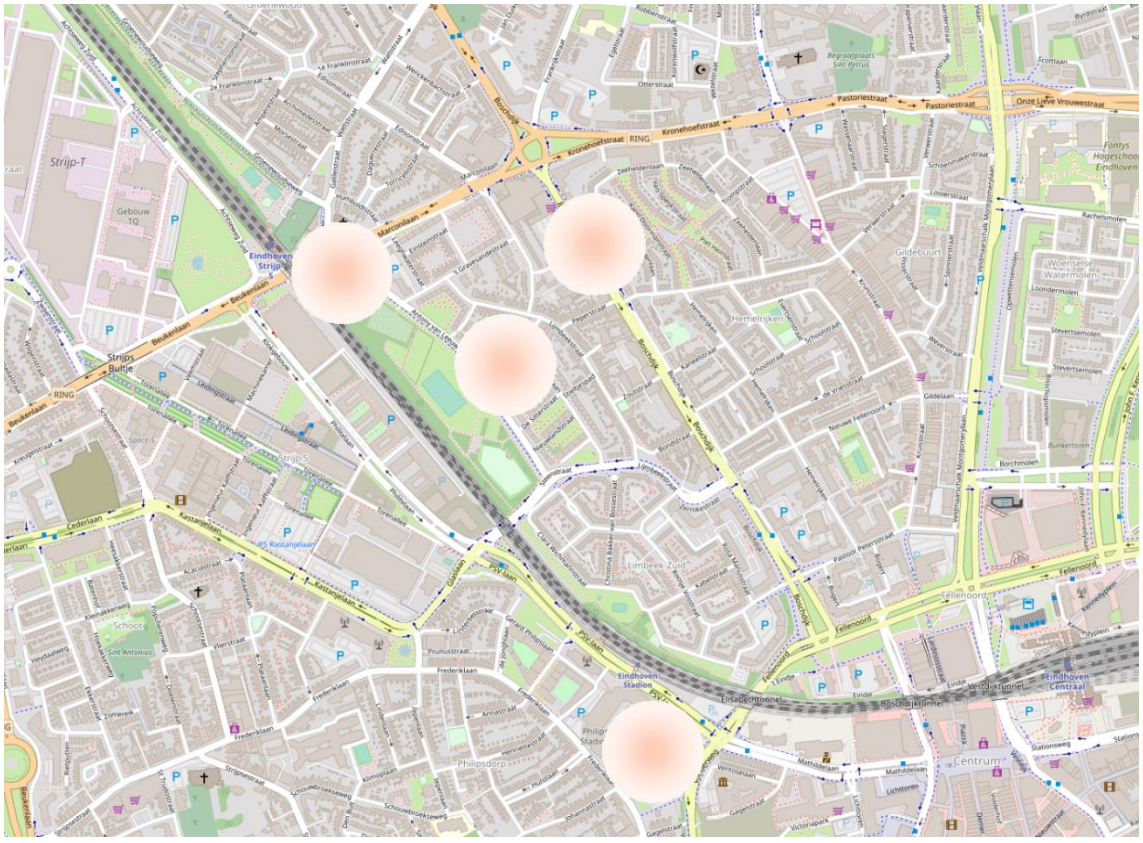


Figure 91: Negative public transport heatmap

Mental Health

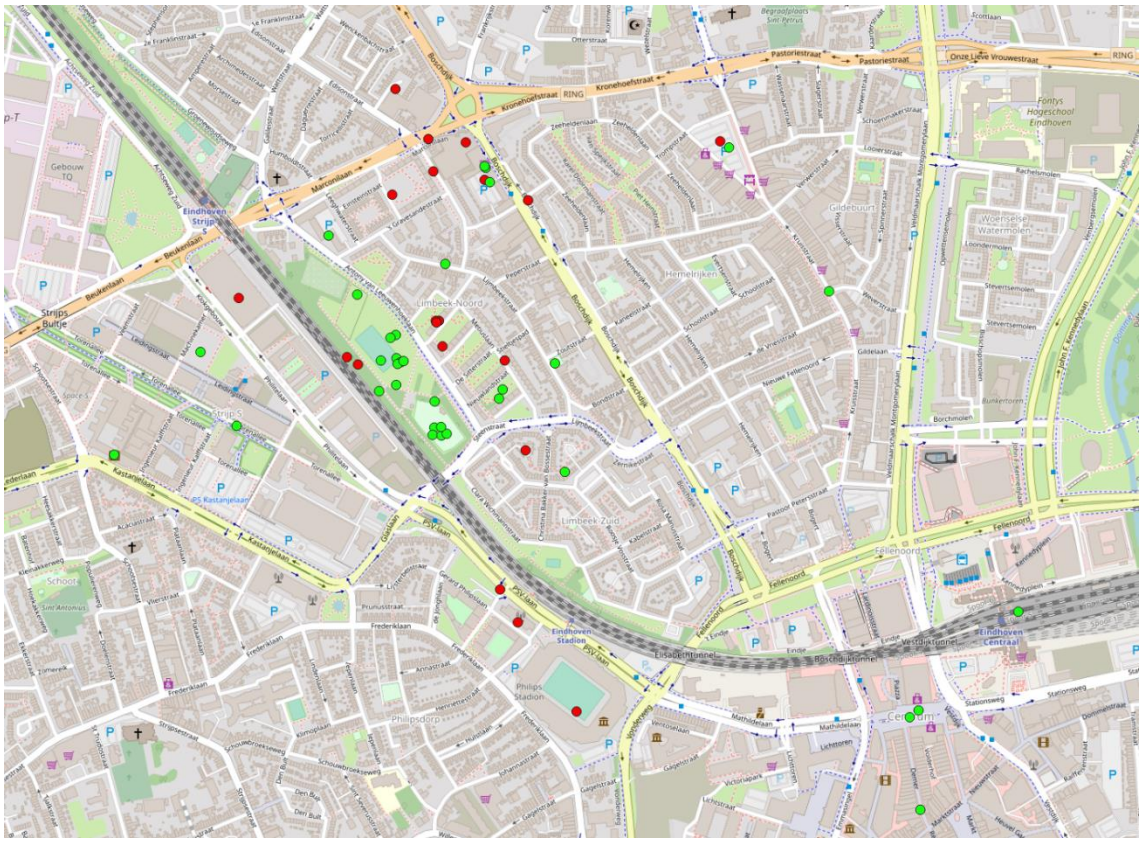


Figure 92: Selected locations with a mental health association

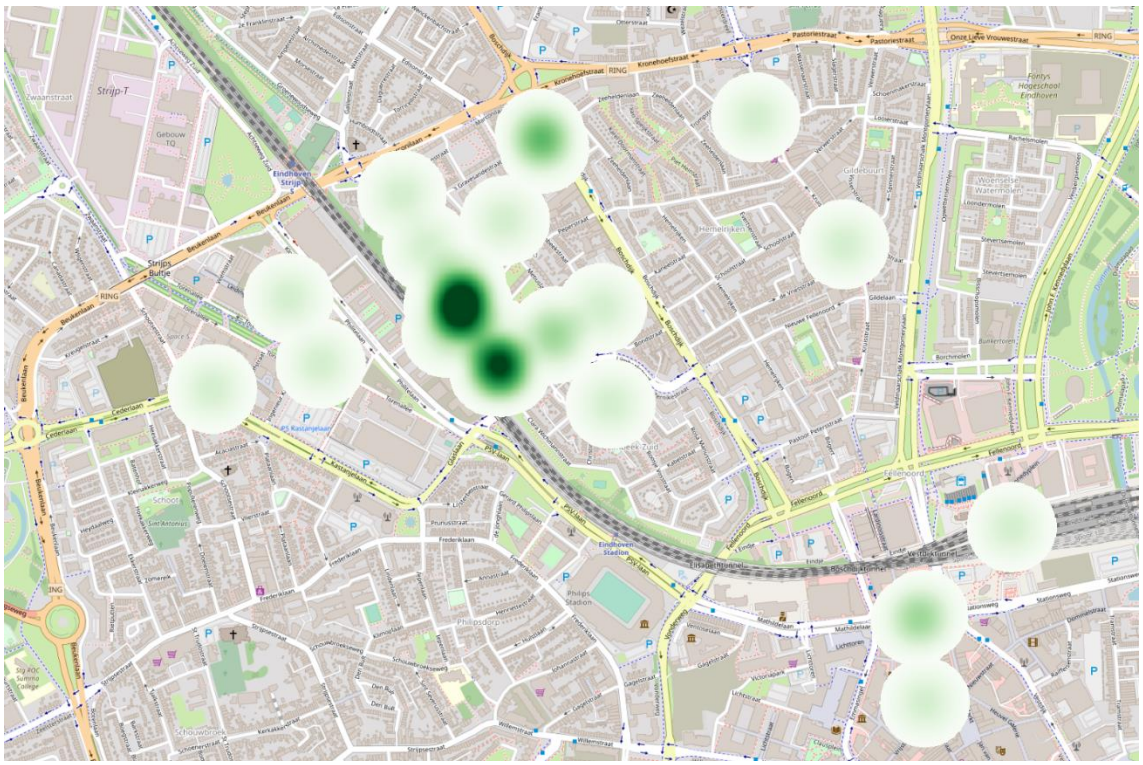


Figure 93: Positive mental health heatmap

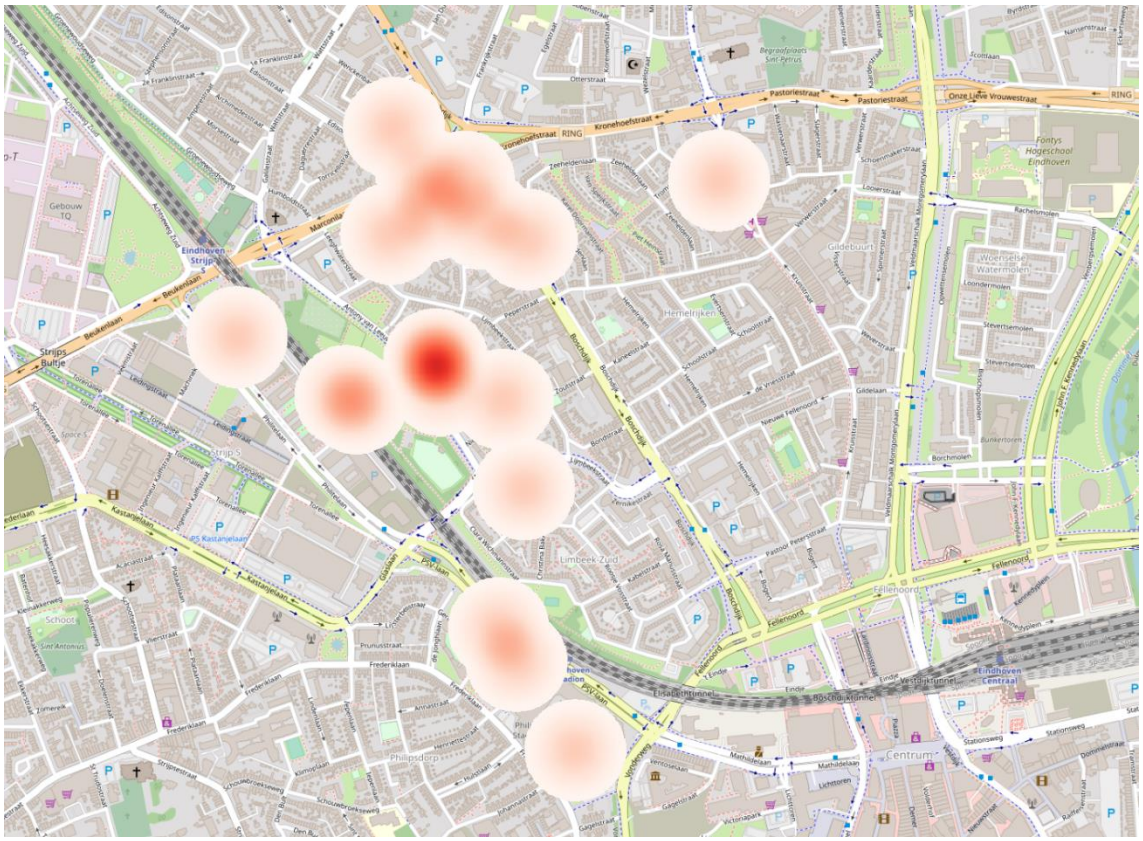


Figure 94: Negative mental health heatmap

Other

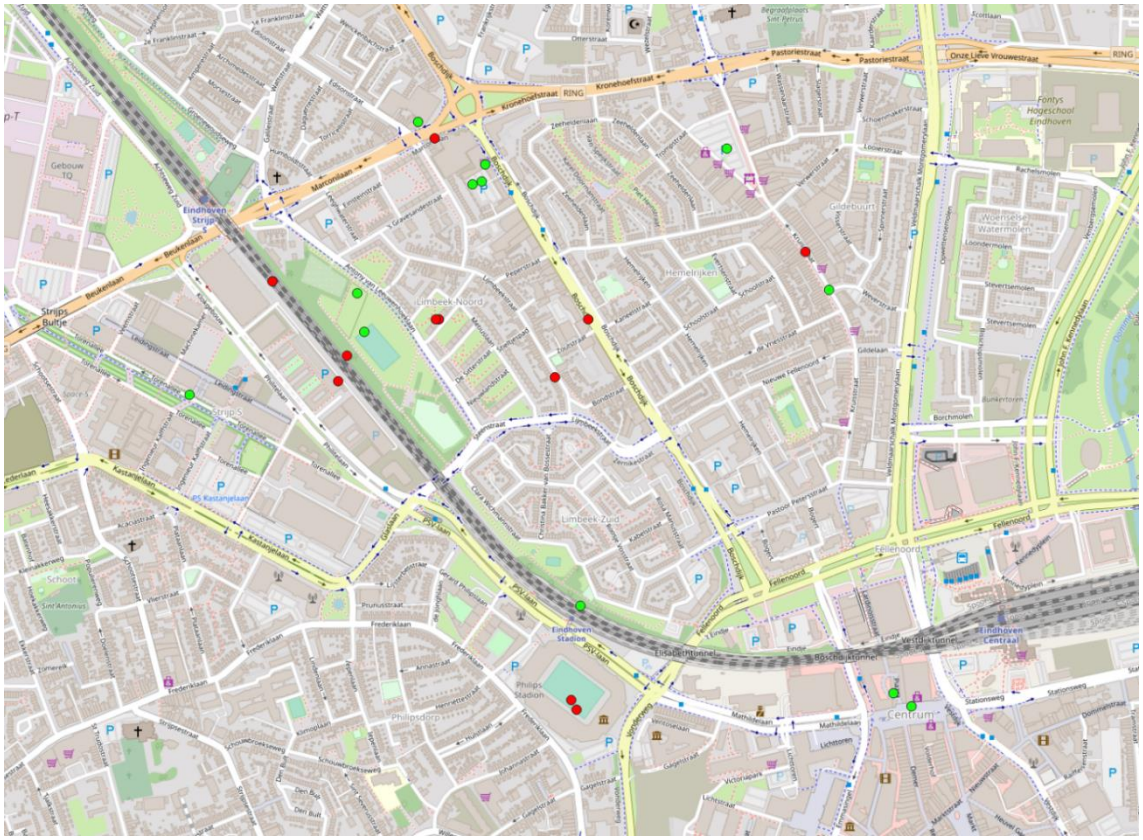


Figure 95: Selected locations with an 'other' association

VI.IX Willingness to participate

Table 49: Combined Crosstabulation willingness to participate

Personal	Would you go to an information meeting?						Would you be willing to fill in a questionnaire						
Characteristics	Yes	%	No	%	Uncertain	%	Yes	%	No	%	Uncertain	%	Total
Age													
17-24 years	1	25.0	2	50.0	1	25.0	4	100.0	0	0.0	0	0.0	4
25-34 years	4	17.4	10	43.5	9	39.1	18	78.3	0	0.0	5	21.7	23
35-44 years	3	37.5	0	0.0	5	62.5	8	100.0	0	0.00	0	0.0	8
45-54 years	4	40.0	1	10.0	5	50.0	8	80.0	0	0.0	2	20.0	10
55-64 years	7	50.0	2	14.3	5	35.7	11	78.6	2	14.3	1	7.1	14
65-74 years	8	66.7	2	16.7	2	16.7	11	91.7	0	0.0	1	8.3	12
Gender													
Female	10	33.3	7	23.3	13	43.3	28	93.3	1	3.3	1	3.3	30
Male	15	38.5	10	25.6	14	35.9	30	76.9	1	2.6	8	20.5	39
Other/No answer	2	100.0	0	0.0	0	0.0	2	100.0	0	0.0	0	0.0	2
Household composition													
One-person household	11	42.3	4	15.4	11	42.3	22	84.6	0	0.0	4	15.4	26
Household without child(ren)	14	38.9	12	33.3	10	27.8	32	88.9	1	2.8	3	8.3	36
Household with child(ren)	1	20.0	1	20.0	3	60.0	4	80.0	0	0.0	1	20.0	5
Other	1	25.0	0	0.0	3	75.0	2	50.0	1	25.0	1	25.0	4
Education Level													
Lower Education	2	22.2	4	44.4	3	33.3	8	88.9	0	0.0	1	11.1	9
Medium Education	5	45.5	0	0.0	6	54.5	11	100.0	0	0.0	0	0.0	11
High Education	19	38.0	13	26.0	18	36.0	40	80.0	2	4.0	8	16.0	50
Other	1	100.0	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1
Language													
Dutch	25	38.5	15	23.1	25	38.5	54	83.1	2	3.1	9	13.8	65
English	2	33.3	2	33.3	2	33.3	6	100.0	0	0.0	0	0.0	6
Total	27	38.0	17	23.9	27	38.0	60	84.5	2	2.8	9	12.7	71

Appendix VII: Study area pictures

The map in Figure 96 shows an overview of the locations where the pictures of the study area were taken. A larger map is available in Figure 21.

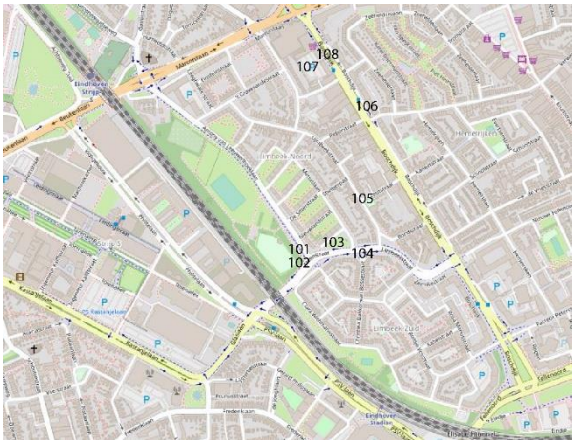


Figure 96; Map with picture locations

Figure 97: picture from the south-east corner of the Anthony van Leeuwenhoeklaan Park in north-eastern direction. On the right, the two-way bicycle lane and pedestrian path along the Anthony van Leeuwenhoek-laan. In the center, the entrance building to the playground, with behind it the football field (Dutch: Trapveldje). On the left, part of the playground, with in the background the high-rise buildings of Strijp-S.

Figure 97: Anthony van Leeuwenhoeklaan Park, Limbeek-North

Figure 98: picture from the south-east corner of the Anthony van Leeuwenhoeklaan Park facing east towards the fenced playground. Behind the playground, the Eindhoven-Boxtel railway and the north-eastern façade of the Strijp-S high-rise buildings, some of which are still under construction.

Figure 98: Playground at the Anthony van Leeuwenhoeklaan Park, Limbeek-North

Figure 99: Picture of the 4-floor portico flat at the Steenstraat and the 3-floor row houses at the Metiuslaan, taken from the bike lane along the Steenstraat in north-eastern direction. The portico flat is similar in lay-out, appearance and size as those along the Nieuwlandstraat, De Sitterstraat, Swammerdamstraat, Van Swindenstraat and Kraijenhofstraat. The other porticoflats on the northern side of Limbeek-North have a comparable lay-out and appearance.

Figure 99: Portico flats at Steenstraat, Limbeek-North

Figure 100: picture of the row-houses along the Christina Bakker-van Bossestraat, taken from the bicycle path along the Kramerstaat in southern direction. In the background, constructive elements of the Philips Stadium are visible.

Figure 100: Row-houses at Christina Bakker-van Bossestraat, Limbeek-South

Figure 101: picture of the small playground at the Zoutstraat, taken from the Zoutstraat-Lijmbeekstraat crossing in south-eastern direction.

Figure 101: Playground at Zoutstraat and Lijmbeekstraat

Figure 102: Picture of the Boschdijk road in northern direction, taken from the Boschdijk-Van Kinsbergen-straat crossing. The picture shows the apartment flats and the stores in the plinth of the Boschdijk. In the background, the new apartment flat in the north-east of Limbeek, which is under construction at the time of data collection.

Figure 102: Boschdijk road in northern direction.

Figure 103: Picture of the car park behind Limbeek's grocery store, taken from the store's exit in south-western direction.

Figure 103: Grocery store carpark

Figure 104: Picture of the entrance of the grocery store car park from the Boschdijk. Taken from the car park in eastern direction.

Figure 104: Carpark entrance from Boschdijk