Interreg
North Sea

Co-funded by
the European Union

ShareDiMobiHub

A guide on using GIS to find suitable locations for mobility hubs: case study on potential shared cargo bike locations in the province of Utrecht.

DELIVERABLE 5.3

04-09-2025

Gido Stoop, Hogeschool Utrecht; Karla Münzel, Hogeschool Utrecht

Summary sheet

Project Name	**ShareDiMobiHub**
Title of the document	A guide on using GIS to find suitable locations for mobility hubs: case study on potential shared cargo bike locations in the province of Utrecht.
Deliverable	D 5.3
Work Package	2
Programme	Interreg NSR
Coordinator	Province of Utrecht
Website	https://www.interregnorthsea.eu/sharedimobihub
Author	
Status	Draft/Public
Dissemination level	Public
Reviewed by	
Submission date	
Starting date	September 2022
Number of months	36

Project partners

Organisation	Abbreviation	Country
Province of Utrecht	ProvU	Netherlands
Capital Region of Denmark	CRD	Denmark
Vestfold county	VTFK	Norway
Subpartner: Statens vegvesen	SVV	Norway
Subpartner: Tønsberg kommune	TK	Norway
Promotion of Operation Links with Integrated Services	POLIS	Belgium
City of Amsterdam	AMS	Netherlands
City of Leuven	LEU	Belgium
University of Antwerp	UAntw	Belgium
Transport Authority for the Amsterdam Region	VRA	Netherlands
Mpact	Mpact	Belgium
Autodelen.net	Auto	Belgium
City of Rotterdam	ROT	Netherlands
Hamburg University of Applied Sciences	HAW	Germany
University of Applied Sciences Utrecht	HU	Netherlands

Document history

Version	Date	Organisation	Main area of changes	Comments
0.1	26-11-2024	Hogeschool Utrecht	First version	
0.2	29-01-2025	Hogeschool Utrecht	Added abstract, added link to webmap, rearranged order of indicator, added section on webmap en physical prototype, other minor changes	Updated after receiving feedback from my Karla Münzel To do: Add section on physical prototype and web-map when done.
0.3	23-06-2025	Hogeschool Utrecht	Added section on Jupiter Notebook and statistics	
0.4	28-07-2025	MPact, Province of Utrecht	Review	
0.5	04-09-2025	Hogeschool Utrecht	Edits based on reviews	

Table of Contents

Abstract

Shared mobility offers a sustainable transportation solution and can optimize urban space usage. This document outlines a GIS-methodology for conducting a location scan to identify suitable locations for shared mobility stations, using a case study on shared cargo bikes in the province of Utrecht. A multi-criteria analysis (MCA) evaluates indicators such as demographics, urban density, and proximity to amenities, providing a suitability score for each location. The methodology combines a literature review and expert input to ensure the right indicators are evaluated. The analysis allows for the adjustment of indicator weights, offering flexibility to tailor the results to specific goals or validate with usage data. The results support policymakers and service providers in finding the most suitable locations, with a flexible, transparent approach that can be applied to other spatial areas as well as other shared mobility types.

All maps in this report can be accessed interactively through this link or by visiting https://webmap.hu.nl/en/app/location_tool_cargobike_provu

1. Introduction

Shared mobility can play a vital role in promoting sustainable transport solutions and optimizing urban space usage. Integrating shared mobility into city planning is a key step toward building an efficient, sustainable mobility system. Analysing potential locations for shared mobility stations and identifying suitable mobility hubs provide a strong foundation for expanding access to these services. A location assessment can pinpoint optimal spots for shared mobility stations, supporting cities, governments and shared mobility providers in their efforts to create a more accessible and eco-friendly transport network. A methodology was developed for identifying the most suitable locations for shared bicycles, shared mopeds and shared cargo bikes by scoring each crossroad in the Netherlands (Figure 1). Additionally, a combined model can predict the most suitable location for shared mobility hubs.

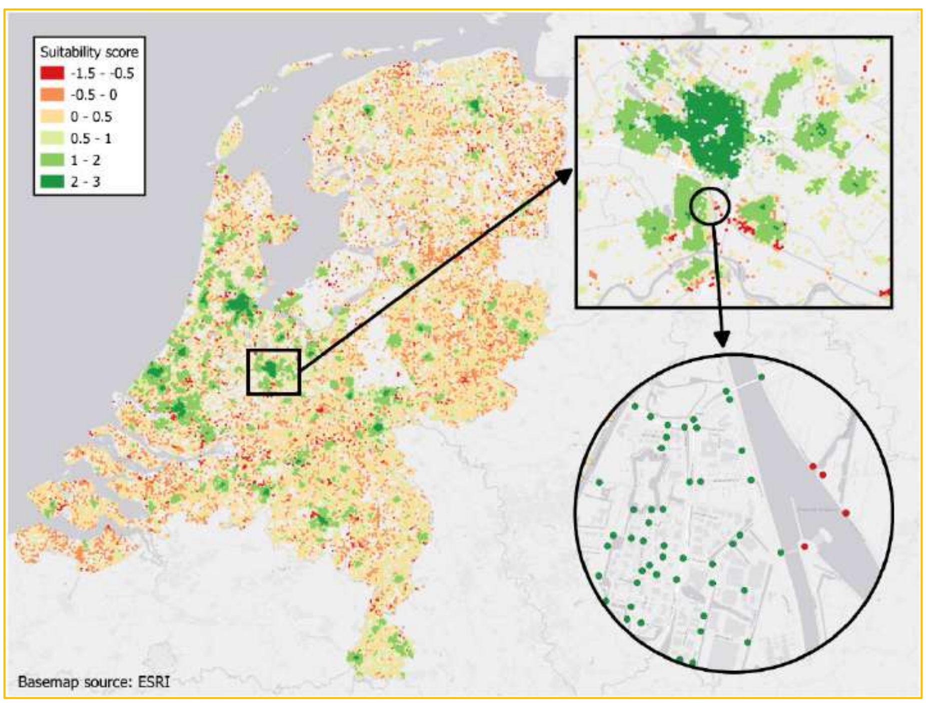


Figure 1: Each crossroad in Netherlands has received a suitability score, example: Cargo Bikes

This document provides an example of a location scan for identifying suitable sites for shared cargo bike services and explains how the scan can be adapted for custom cases through a step-by-step guide. Some basic GIS knowledge is required. However, this document should be sufficient to get started. The example case focuses on potential shared cargo bike service locations in the province of Utrecht. For this analysis, every crossroad in the province has been scored based on its potential as a shared cargo bike location.

The goal of the location scan is to provide insights into the most suitable areas for shared cargo bike stations. The quantifiable indicators used in this location assessment are derived from literature and a workshop with relevant stakeholders. The results, along with options to refine the analysis, establish a data-driven foundation for scaling up shared cargo bike services. Suitability in the context of this method refers to the optimal location for deployment of shared cargo bikes according to the indicators and the weights applied to the indicators by the user of the method.

Each location is scored based on indicators such as resident demographics, urban density, proximity to amenities and access to public transportation. A multi-criteria analysis is performed to calculate the total score of these indicators, resulting in a final suitability score for shared cargo bike services. The importance of the indicators in the multi-criteria analysis can be easily adjusted by modifying the weighting, allowing for scenario testing and refining planning efforts.

The expected results of the analysis should resemble Figure 2, where green areas indicate the most suitable locations, while red areas are less suitable. In this case, the lowest score in the province is 1.2, and the highest is 7. Grey areas represent regions without any evaluated potential locations.

This guide provides instructions on how to create this visualization, though alternative visualizations are also possible.

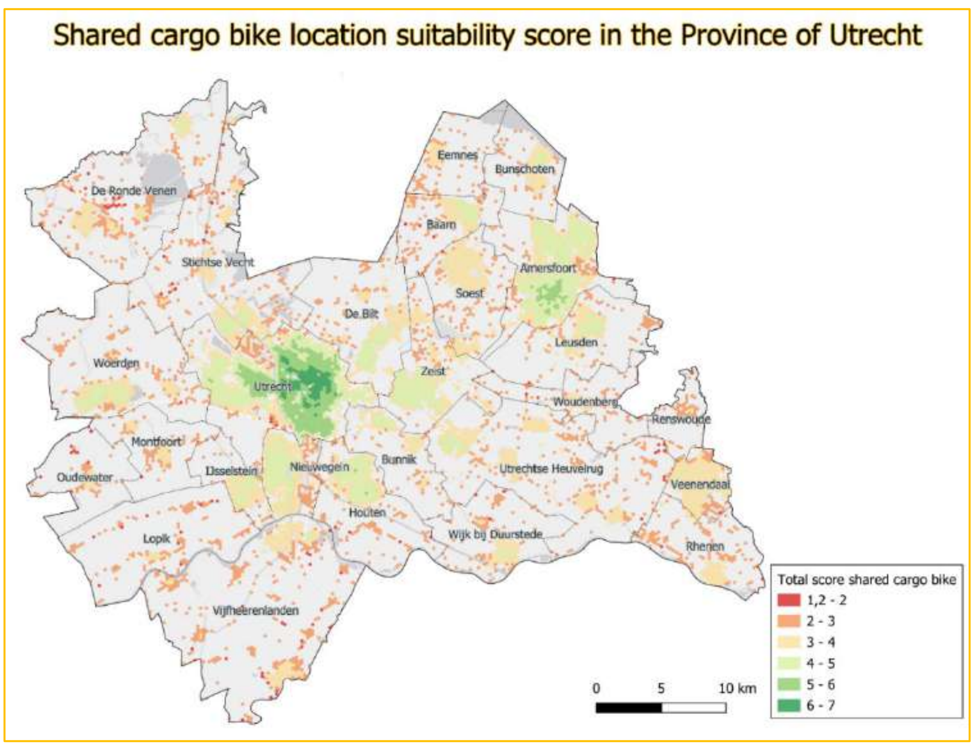


Figure 2: Shared cargo bike location suitability score in the province of Utrecht

One of the alternative visualization is through a physical prototype, that is used for demonstration purposes (Figure 3). Using these types of visualizations can be a strong tool in communicating the importance of certain indicators for shared mobility potential to stakeholders.

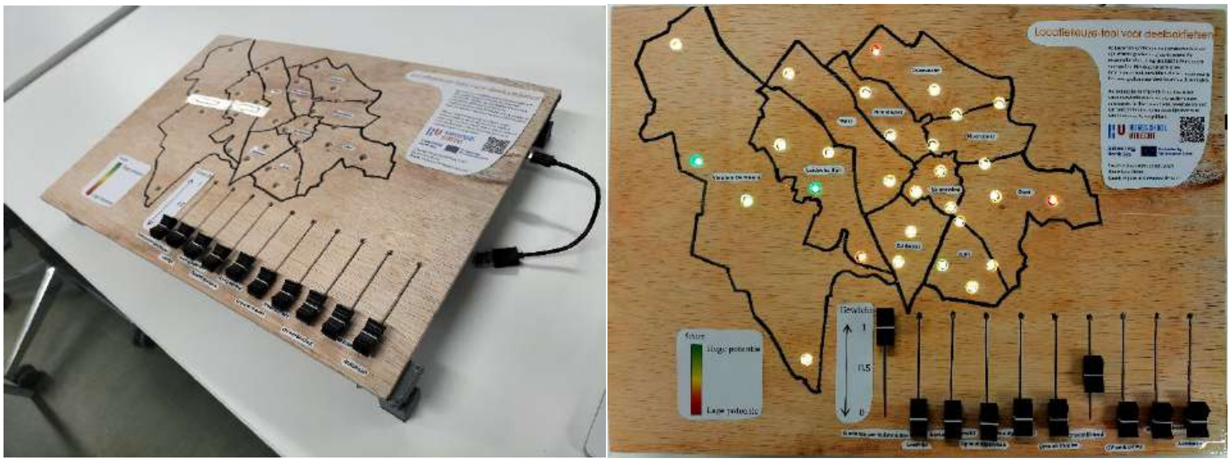


Figure 3: Physical prototype of the Cargo Bike Location tool

2. Identifying indicators through literature and workshop

Since the location scan relies on indicators to assess the success potential for each location, it is essential that the indicators used are well-substantiated. This chapter presents a brief literature review of the limited research available on cargo bikes. To complement the findings from the literature, an expert workshop was also organized. The indicators discussed in the methodology are based on the knowledge presented in this chapter.

2.1 Literature

Cargo bike sharing has the potential to reduce car ownership. Potential users favour shared cargo bikes services over cars due to environmental concerns, health advantage, parking convenience, cost considerations and lack of interest in driving. Cargo bikes can also support car-free living at certain life stages, like when having young children. However, infrastructure improvements, advancements in cargo bike technology, increased visibility, accessibility and positive social norms are necessary to leverage this potential (Bissel & Becker, 2024; Börjesson Rivera & Henriksson, 2014; Dorner & Berger, 2020; Riggs & Schwartz, 2018).

High initial purchase costs, technical issues, and customer complaints, as well as the spread of negative feedback, have been identified as barriers to acceptance (Heinrich, Schulz, & Geis, 2016). Potential users are also put off by complex rental procedures and can find riding cargo bikes intimidating, as handling a cargo bike feels different from a standard bike (Hess & Schubert, 2019; Börjesson Rivera & Henriksson, 2014). To address these barriers, strategies such as free trials, showcasing best practices and sharing positive experiences are recommended (Heinrich, Schulz, & Geis, 2016). Also easy, affordable and accessible car ownership and car infrastructure act as a barrier to convincing a higher population share of shared mobility (de Vries, 2023; Fitschen, Merfeld, Klein, & Henkel, 2024).

Early studies in this scarcely researched field show that cargo bike services are most likely to be used by men, young adults, highly educated individuals, households with low car ownership and active cyclists (Kammerhofer, Pühringer, Kostka, & Berger, 2023; Dorner & Berger, 2020). Car-dependent individuals are less likely to use cargo bike-sharing services as they perceive car use as more flexible, a symbol of freedom, and having higher social recognition. Others simply stated that their current situation meets their mobility need (Bissel & Becker, 2024; Hess & Schubert, 2019).

Most bike rides occur between 8AM and 8PM, with peak activity on Fridays and weekends. The purpose is usually transporting purchases (Kammerhofer, Pühringer, Kostka, & Berger, 2023). Malik, Egan, Dowling & Caulfield (2023) researched small-businesses using cargo bikes and identified significant factors influencing the choice for cargo bike usage, including maximum daily temperature, rainfall, trip timing and seasonality. Their findings suggest that weather and climate play an important role in the decision to use cargo bikes. Dorner & Berger (2020) found similar results.

2.2 Expert-workshop results

Shared cargo bike services are a relatively new phenomenon and the topic has not been extensively researched. Therefore, an expert workshop was organized to gain deeper insights into potential indicators for shared cargo bike success. At the workshop, the participants attended both in person and online. They worked collaboratively in an online environment to share their knowledge about the socio-demographic characteristics of users, the drivers and barriers for adoption, ride destinations, and decision-making regarding location choice (Figure 4). Afterwards, the results were discussed.

The workshop included five municipal officers from four different municipalities, one representative from a shared cargo bike service provider and two representatives from a governmental cooperative programme on shared mobility. A full list of workshop results can be found in the appendix.

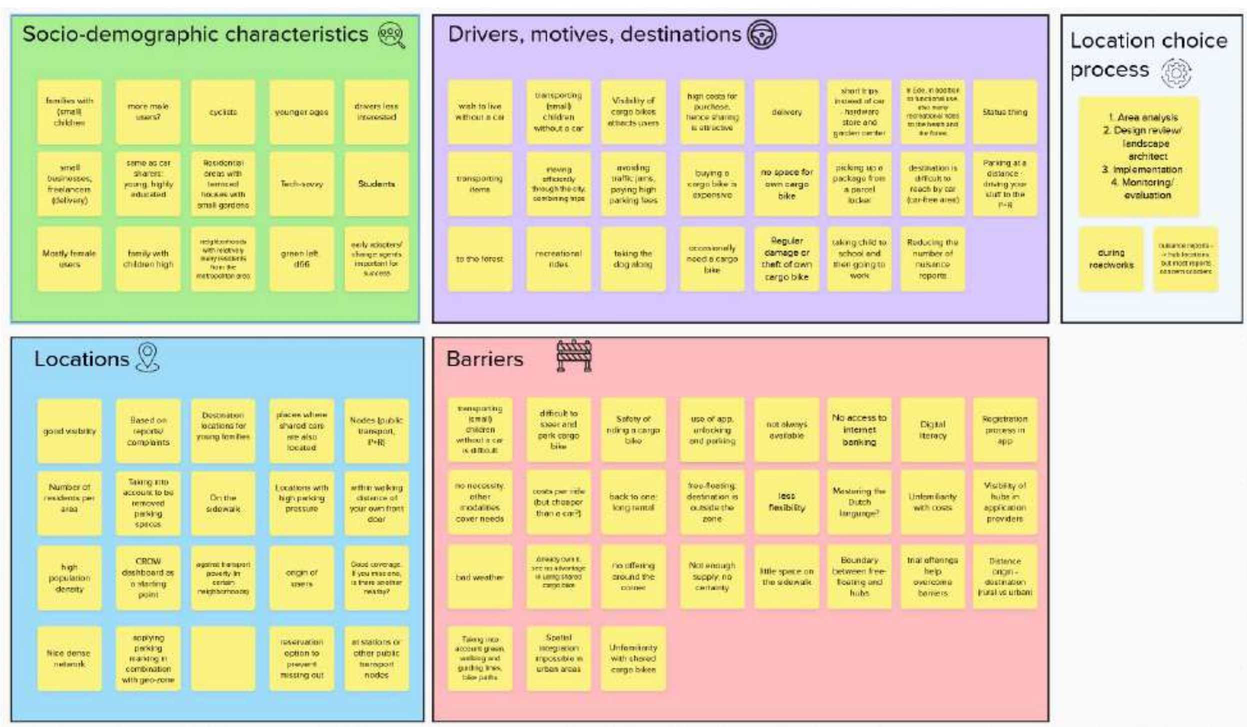


Figure 4: Digital whiteboard used for the expert-workshop

For the socio-demographic characteristics, the experts' knowledge was mostly in line with the literature discussed. Based on their experience-based knowledge, users are mostly young students and highly educated individuals, often with children and are associated with voting for green and progressive political parties such as GroenLinks and D66. The group was considered to be tech-savvy.

The main motives for using a shared cargo bike service are the high cost of purchasing a cargo bike and the risk of theft. Additionally, users may not have space to store a privately owned cargo bike. Shared cargo bikes are often used for transporting children to school. They are also frequently used for occasional recreational trips, such as visiting hardware stores, garden centres or taking a dog to nature areas.

Locations for shared cargo bike services are primarily in dense urban areas with high parking pressure. Currently, the cargo bikes are placed on sidewalks, preferably at locations where other shared mobility services are also available and in close proximity to public transport hubs. Data from the CROW dashboard[1] on various shared mobility services can serve as a starting point, along with filed reports and complaints related to shared mobility. Socio-demographic characteristics are also considered to ensure placement among residents with the highest likelihood to use the service. However, shared cargo bike services may also be specifically introduced in certain neighbourhoods to address transportation poverty. Another key consideration is ensuring a wide coverage of shared cargo bikes across different areas.

Finding enough available space on the sidewalk can be a barrier to implementation. For users, barriers include the cost per ride and long rental periods due to a back-to-one system. In free-floating systems, the destinations may fall outside of the designated zone. Another barrier is unfamiliarity with cargo bikes, as well as a lack of digital skills required for renting one. Finally, individuals who already own cargo bikes see no benefit in using shared cargo bike services.

2.3 Identified Indicators

Based on a literature analysis and the expert workshop ten indicators were identified to have an impact on the success potential of shared cargo bike locations and are included in the analysis:

- Age
- Education level
- Households with children
- Green ideals
- Cars per household
- Urbanization
- Point of interest
- Walkability
- Public transport
- Current offer of shared mobility

These indicators are explained in more detail in section 4.2.

3. Methodology

The method used to assess the suitability of locations for shared mobility should serve as the foundation for a decision-support tool for policymakers. A multi-criteria analysis (MCA) has been chosen for this

[1] CROW (https://www.crow.nl/) is a Dutch knowledge institute for infrastructure, public space, traffic and transport, and work and safety. It has developed a real-time dashboard on shared mobility supply in the Netherlands: https://dashboarddeelmobiliteit.nl/

purpose, valued for its flexibility and transparency. This method can analyse spatial data and allows the importance (or weighting) of various indicators to be adjusted according to different scenarios. The analysis results generate a ranked list of locations, which are then visualized on maps using GIS. In an MCA, multiple criteria are evaluated and assigned a score. By weighting these criteria, their relative importance can be adjusted to accommodate different scenarios (Malczewski, 2006).

To ensure that the absolute values of indicators do not impact their influence, all values are normalized using min-max normalization. This preprocessing technique rescales each criterion to a fixed range, in this case from 0 to 1, by subtracting the minimum value and dividing by the range of the criterion. This ensures comparability across indicators and prevents one criterion from dominating others. The final suitability score for each location is obtained by summing all normalized and weighted criterion scores (Figure 5).

The potential locations for shared mobility analysed here include all intersections in the province of Utrecht, which are a total of 27,779 points. Analysing such a dense network of points allows for reliable insights into spatial patterns regarding suitability for shared mobility.

For the case study presented in this report, the weight for each criteria will be assigned based on the outcome of a spatial linear regression analysis with shared cargo bike user data. The criteria with insignificant P-values were disregarded in the MCA. The criteria with significant P-values were used in the MCA and weight was determined by its coefficient in the spatial linear regression analysis. This method will forge a more robust model, but does require user data. Performing this step is optional.

In this report, an analysis on shared cargo bikes in the province of Utrecht has been described. The method can was also conducted for several shared modes and research areas, but is not described in this report for practical purposes.

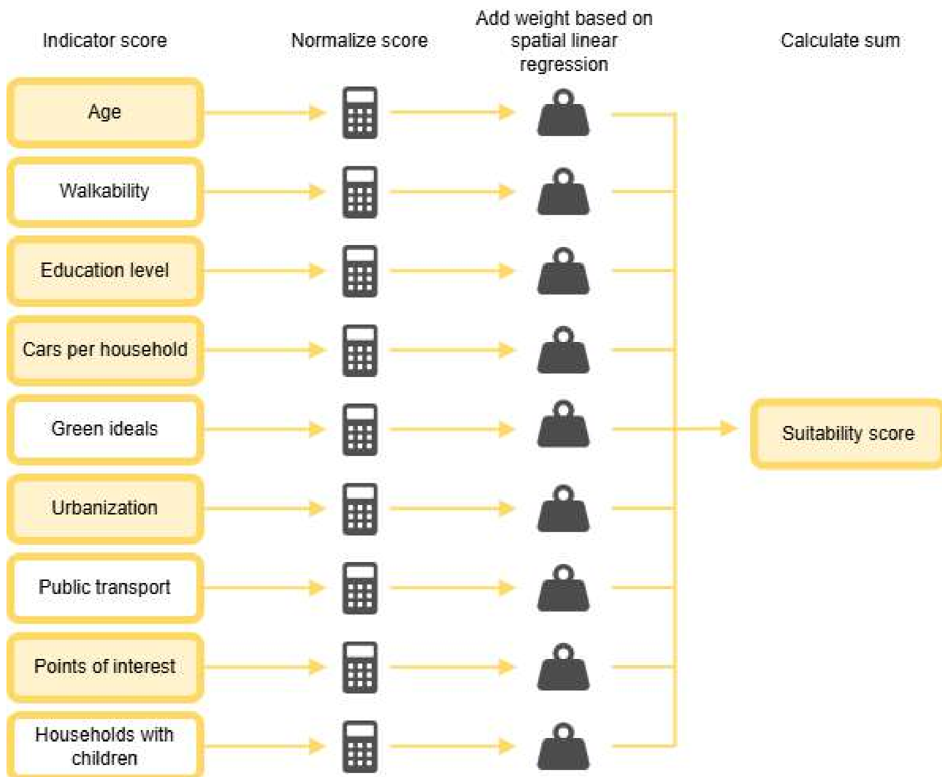


Figure 5: Multi-criteria analysis

4. Step-by-step guide for analysis

The analysis was first performed and tested in QGIS. In the next phase, the steps were established in a Jupiter Notebook to enhance upscaling and increase transparency and reproducibility. A Jupiter Notebook is a file which combines the Python-programming language used for data-science with a notebook function for further elaboration on the code. If you are familiar with the Python-programming language, we encourage you to use the Jupiter Notebook on Github (GitHub, 2025) for your location selection process. Otherwise, you can choose any GIS application of your liking and follow the steps in the remainder of this paragraph to perform your own analysis.

The remainder of this chapter provides a step-by-step guide on how to perform the location scan for shared mobility. The analysis was originally carried out in QGIS, and it is therefore recommended to use the same software. However, it should be perfectly possible to carry out the analysis in ArcGIS Pro as well. Below are some important concepts to keep in mind while working through the step-by-step guide.

- **Potential locations** – Throughout the guide, the term ‘potential locations’ will be used. These are the locations that will be evaluated in the analysis. In the example case of the province of Utrecht, these include all the crossroads in the study area. However, it is up to the user to decide where the potential locations will be located and how they will be defined. To provide support, a method for acquiring all the crossroad points is discussed in this guide.
- **Indicator** – The indicators are the criteria that will be evaluated for our multi-criteria analysis. The indicators are based on literature and an expert workshop and will each have a score between 1 and 0, where 1 represents the highest suitability for shared mobility services and 0 represents the

lowest suitability. In this guide, indicators from the example case of the province of Utrecht will be used, specifically focused on shared cargo bike services.

- **Weight** – The weights influence the importance of each indicator score in the final result. These weights are assigned after all the indicators are calculated and can be decided upon by policymakers based on their knowledge and goals. The weights are easily adjustable. A weight of 0 means that the indicator will not be counted toward the final score. There is no upper limit for the weights given to each indicator. In chapter 6, an optional statistical method is described for assigning weights to the indicators.

4.1 Potential locations

The potential locations are the locations evaluated for suitability for shared cargo bike services. This analysis is performed on the province of Utrecht. Due to the nature of the indicators, the analysis can only be conducted on points within the street and road network. However, this is not necessarily a limitation, as most shared mobility services are provided on the street and road network. Ideally, the analysis would be performed at fixed intervals on the network (for instance, every meter). In practice, this is very resource-intensive at the provincial scale. Therefore, this analysis has limited the number of points by evaluating only the crossroads in the province of Utrecht. To obtain the crossroads, perform the following steps. Small roads can be removed to obtain a lower number of total crossroads. For practical purposes, all footpaths have been removed from the network in this analysis. Alternatively, a custom set of points can be used.

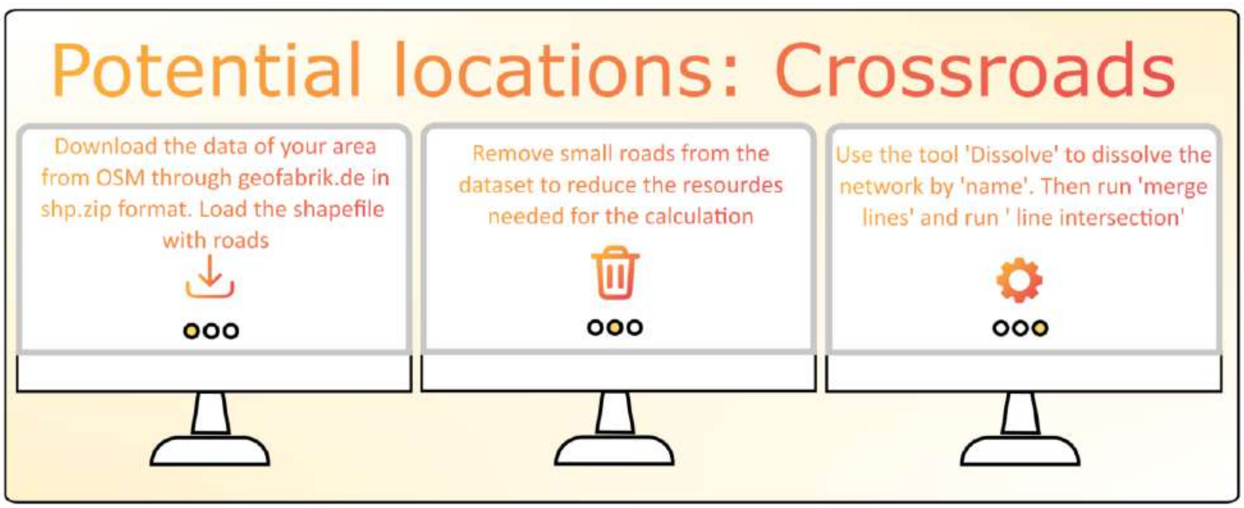


Figure 6: How to calculate the potential locations

4.2 Calculating indicator scores

For the analysis of the example case of the province of Utrecht, a set of 10 indicators is used to calculate the final score. Table 1 describes the data sources and includes remarks on the data used for this case study. For other cases, the sources may differ and the data will be structured differently. For this reason, the step-by-step description of each indicator in sections 4.2.1 to 4.2.10 is described in more general terms. Some of these indicators have been calculated using a methodology similar to that described in earlier research on mobility hubs in Munich (Geurs, et al., 2023).

Indicator	Source	Remarks
Age	(CBS Statline, 2023a)	• Aggregated at postcode-4 level. • Categories are percentages of 0-14, 15-24, 25-44, 45-64, 65 and above.
Education level	(CBS Statline, 2022)	• Aggregated at neighbourhood-level • Categories are percentages of low, medium and highly educated.
Households with Children	(CBS Statline, 2023a)	• Aggregated at postcode-4 level. • Number is the percentage of households in the postcode-4 area with children.
Green ideals	European Parliament Elections 2024 from (Kiesraad, 2024)	• Result per voting booth, aggregated to postcode-4 level. • Percentage of votes towards the parties in the Greens/EFA coalition
Cars per household	(CBS Statline, 2022)	• Aggregated at neighbourhood-level • Number is an average of all the households in the neighbourhood
Urbanization	(CBS Statline, 2023b)	• Per grid cell an address density is given categorized from 0 (least dense) to 5 (most dense)
Points of Interest	(PDOK, n.d.)	• Dataset has all buildings and addresses. For this purpose, it is filtered on industry-, office-, healthcare-, accommodation-, shopping-, sports- and education-function. • Score is based on total number of Points within 250 meters
Walkability	Streets and roads OSM from (Geofabrik, n.d.)	• Service area of 250 meters is calculated over the entire street and road network.
Public Transport	(University of Groningen Geodienst, 2022)	• Has a description of all public transportation lines per stop • Based on OpenOV data • Score is based on unique public transportation lines within 250 meters of walking
Current offer of shared mobility	(CROW, n.d.), (GreenWheels, n.d.), (MyWheels, n.d.), (SnappCar, n.d.) and more	• Scraped from the websites of providers. • CROW data is on free-floating vehicles.

Table 1: Indicator and sources used for the example case of the province of Utrecht

4.2.1 Age

The indicator 'age' provides a score based on the age groups that live in the area of the location. In the literature, it is found that shared mobility is mostly used by age groups between 18 and 45 and by parents of young children (van Kuijk, de Almeida Correia, van Oort, & van Arem, 2022; Kammerhofer, Pühringer, Kostka, & Berger, 2023), which was also confirmed during the expert workshop. For the analysis, the statistics of the area of the potential location are used to calculate a score (Geurs, et al., 2023).

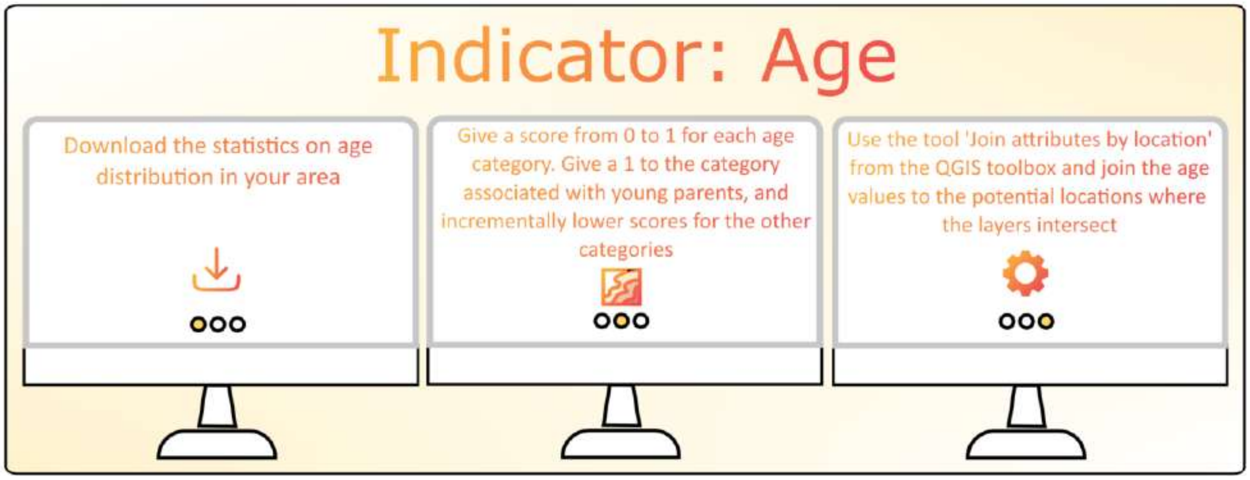


Figure 7: Steps to calculate the 'age' indicator

4.2.2 Education level

The use of shared mobility services is more prevalent among people with higher education levels. This has been described in both the literature and during the expert workshop (Mouratidis, 2022; Dorner & Berger, 2020). Therefore, this indicator has a score based on the percentage of highly educated residents in the area of the potential location.

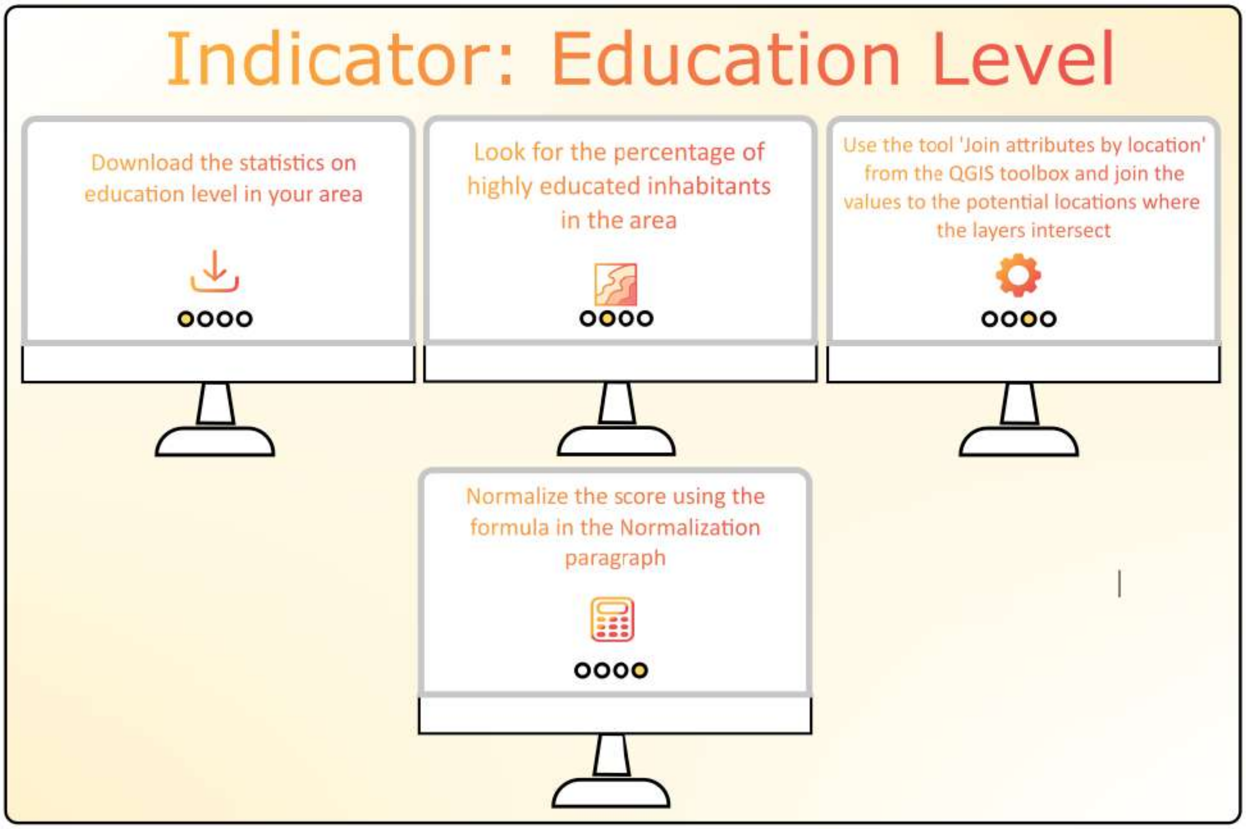


Figure 8: Steps to calculate the 'education level' indicator

4.2.3 Households with children

Households with children are associated with higher levels of shared cargo bike usage, since these bikes are often used for transporting children (Dorner & Berger, 2020). Therefore, the indicator 'households with children' provides a score based on the percentage of households with children in the area of the potential location. **Note**: If you are not able to calculate the walkability, a buffer can also be used instead.

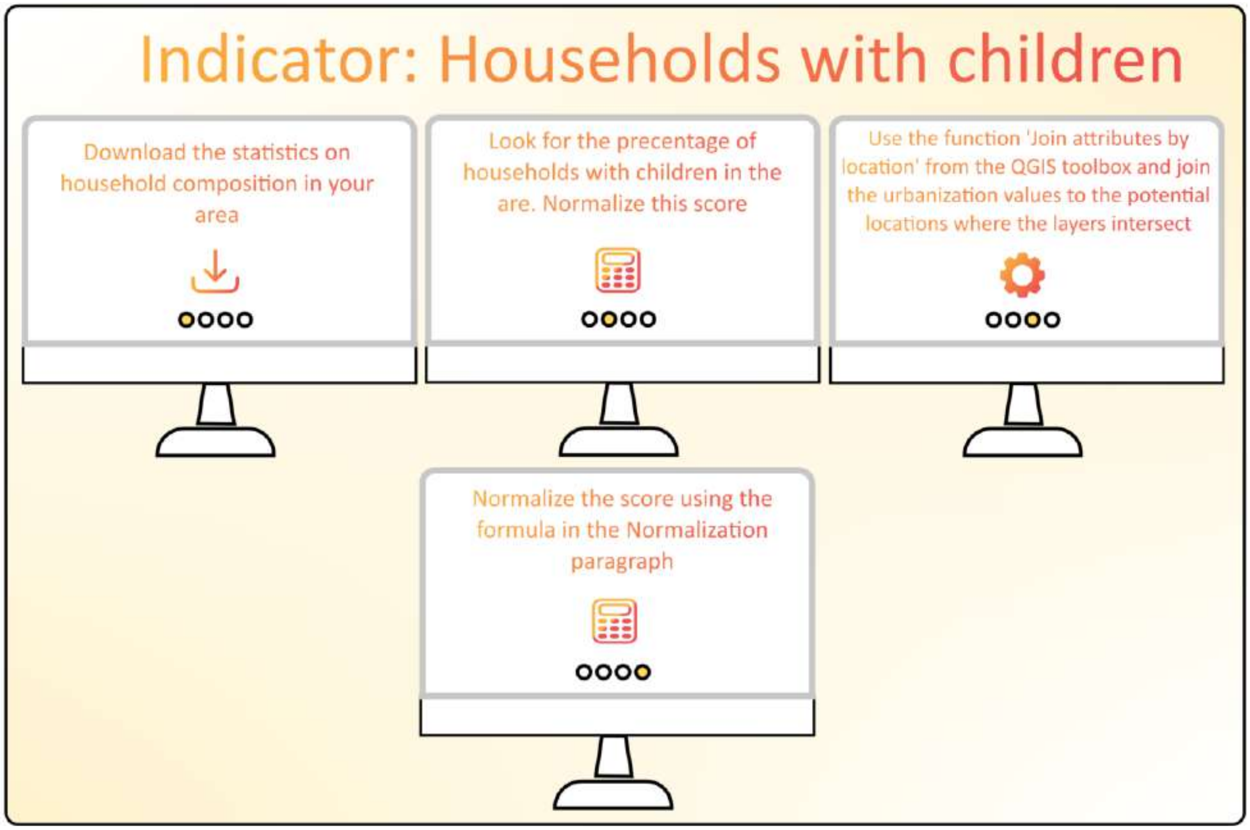


Figure 9: Steps to calculate the 'Households with children' indicator

4.2.4 Green ideals

Demographic groups with green ideals have been associated with higher usage of carsharing (Münzel, Boon, Frenken, Blomme, & van der Linden, 2020). It is assumed that this group is also more inclined to use shared cargo bike services when they are offered. Green ideals at a location can be quantified using data on election results in the area surrounding the potential location.

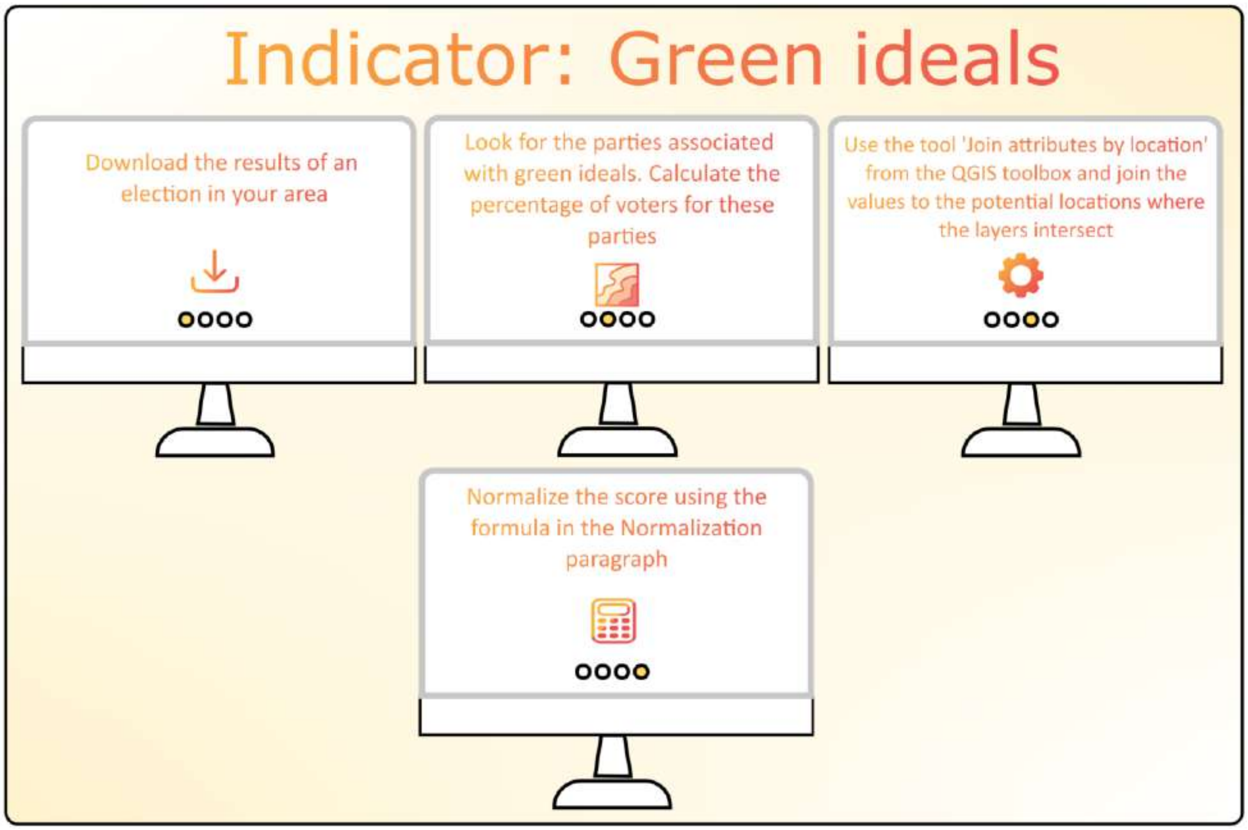


Figure 10: Steps to calculate the 'green ideals' indicator

4.2.5 Cars per household

The number of cars per household can influence the usage of (shared) cargo bikes (Bissel & Becker, 2024). Households with a higher number of cars are less likely to use shared cargo bike services, as they already have alternative modes of transportation for moving goods and people. The score for this indicator depends on the average number of cars per household in the area of the potential location. It is important to invert the score in the final step, as higher car ownership is associated with lower potential for shared cargo bike service usage.

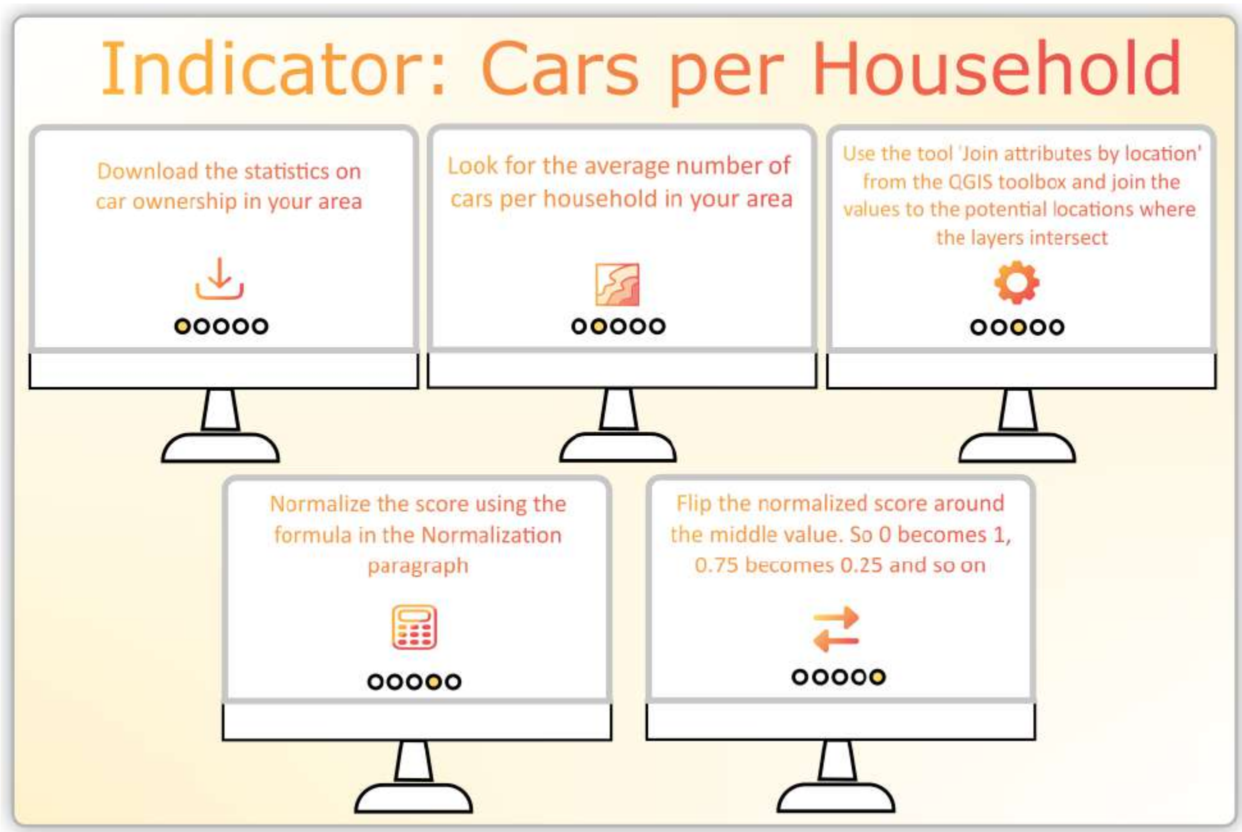


Figure 11: Steps to calculate the 'cars per household' indicator

4.2.6 Urbanization

The urbanization indicator provides a score based on the number of addresses per square kilometre at each potential location, also known as address density. Address density is closely related to population density, so in the absence of data on address density, population density data can also be used. The address (or population) density influences the number of potential users near the potential location.

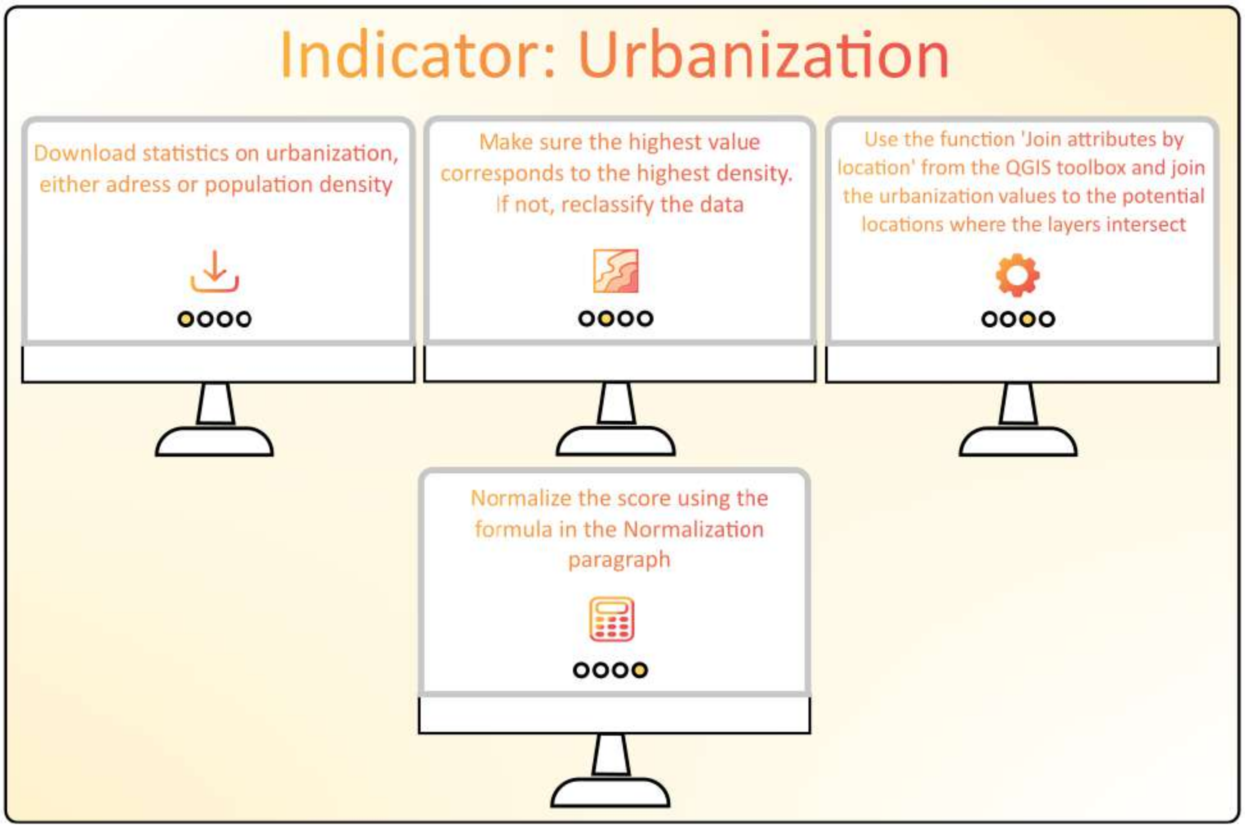


Figure 12: Steps to calculate the 'urbanization' indicator

4.2.7 Point of interest

The ‘Points of Interest’ (POI) indicator provides a score based on the number of destinations users are likely to visit within the service area of the potential location. These locations could be stores, offices, schools, sports facilities and so forth. It is assumed that more POIs in the service area make the location more attractive.

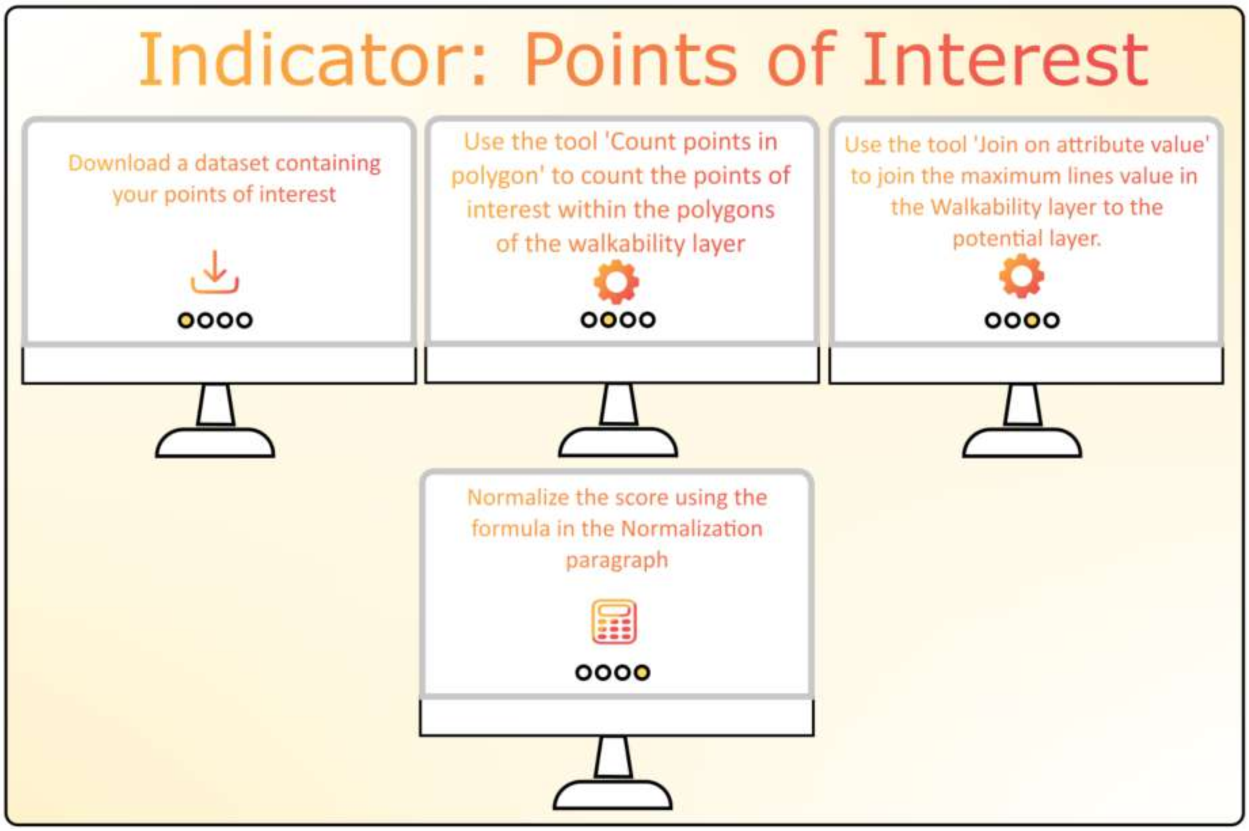


Figure 13: Steps to calculate the 'points of interest' indicator

4.2.8 Walkability

The indicator ‘walkability’ provides a score for the service area of the potential location. The service area can also be described as the area from which the location is accessible within a reasonable walking distance. The larger this service area, the higher the score. To calculate walkability, the road and pedestrian network was taken into account, ensuring that only feasible routes were considered. The acceptable walking distance for the service area for the example case of the province of Utrecht was set at 250 meters (Geurs, et al., 2023).

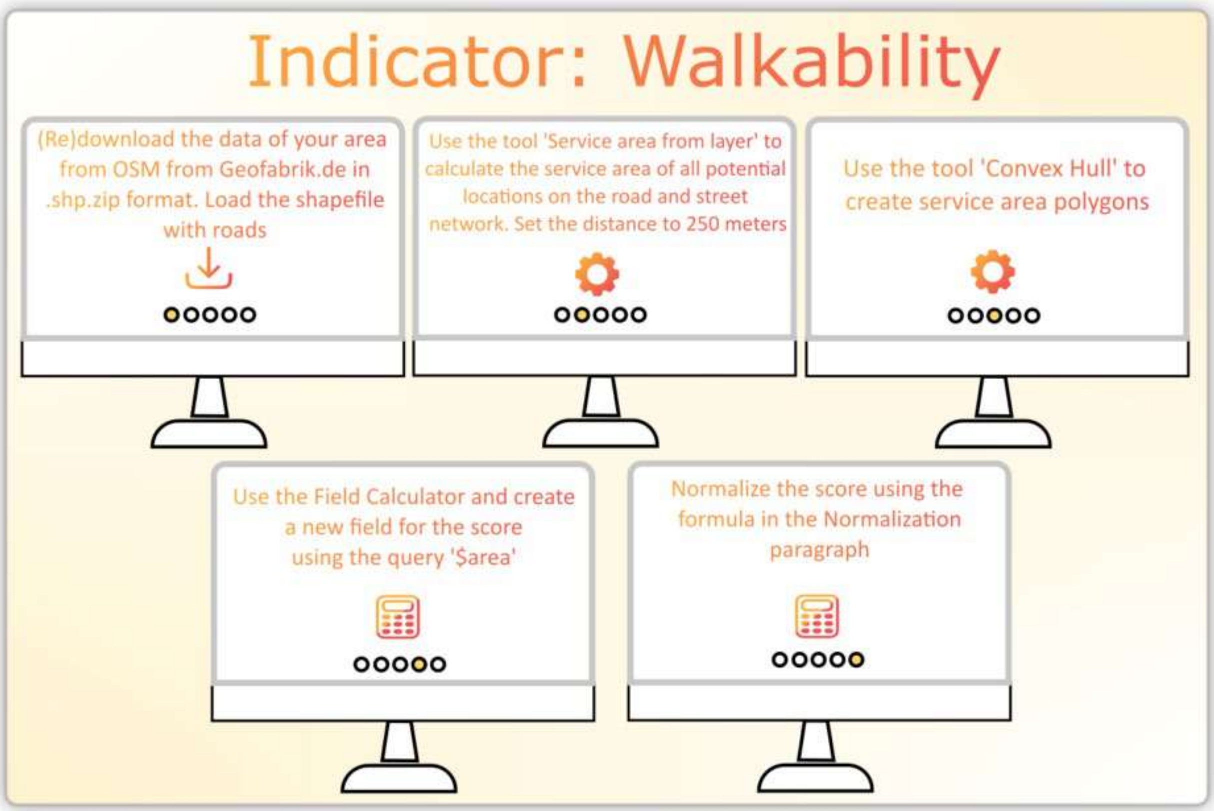


Figure 14: Steps to calculate the ‘walkability’ indicator

4.2.9 Public transport

The ‘Public transport’ indicator provides a score based on the number of train-, bus- and other public transportation lines departing within the service area of the location. The connection between shared mobility services and public transportation remains underexplored in the literature (van Kuijk, de Almeida Correia, van Oort, & van Arem, 2022). However, in the expert workshop, a preference for public transport stops was mentioned and it is assumed that a higher number of available public transportation lines within walking distance enhances the connection between shared mobility and the public transport network.

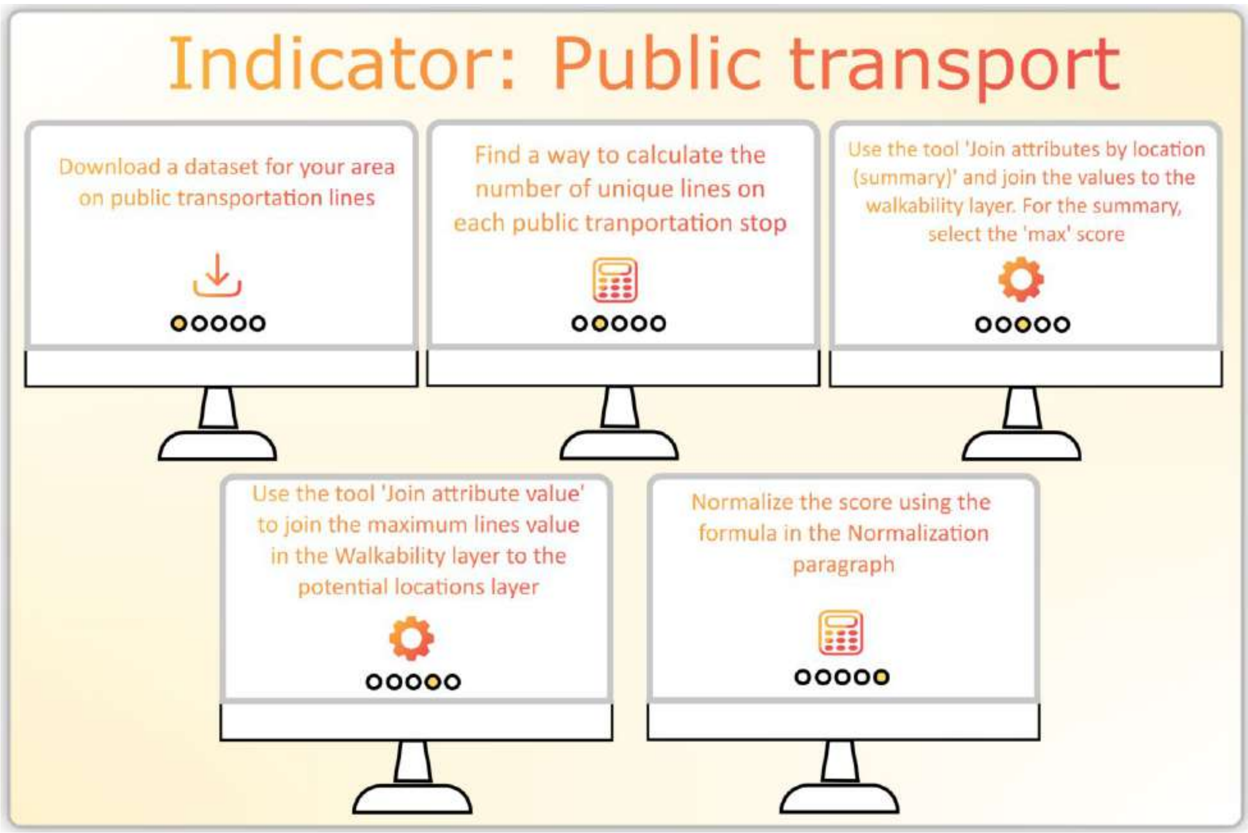


Figure 15: Steps to calculate the 'Public transport' indicator

4.2.10 Current offer of shared mobility

The indicator 'Current offer of shared mobility' provides a score for the currently available shared mobility options within the service area of the location. The current availability of shared mobility can be used as an indication of the potential success of new shared mobility (hubs).

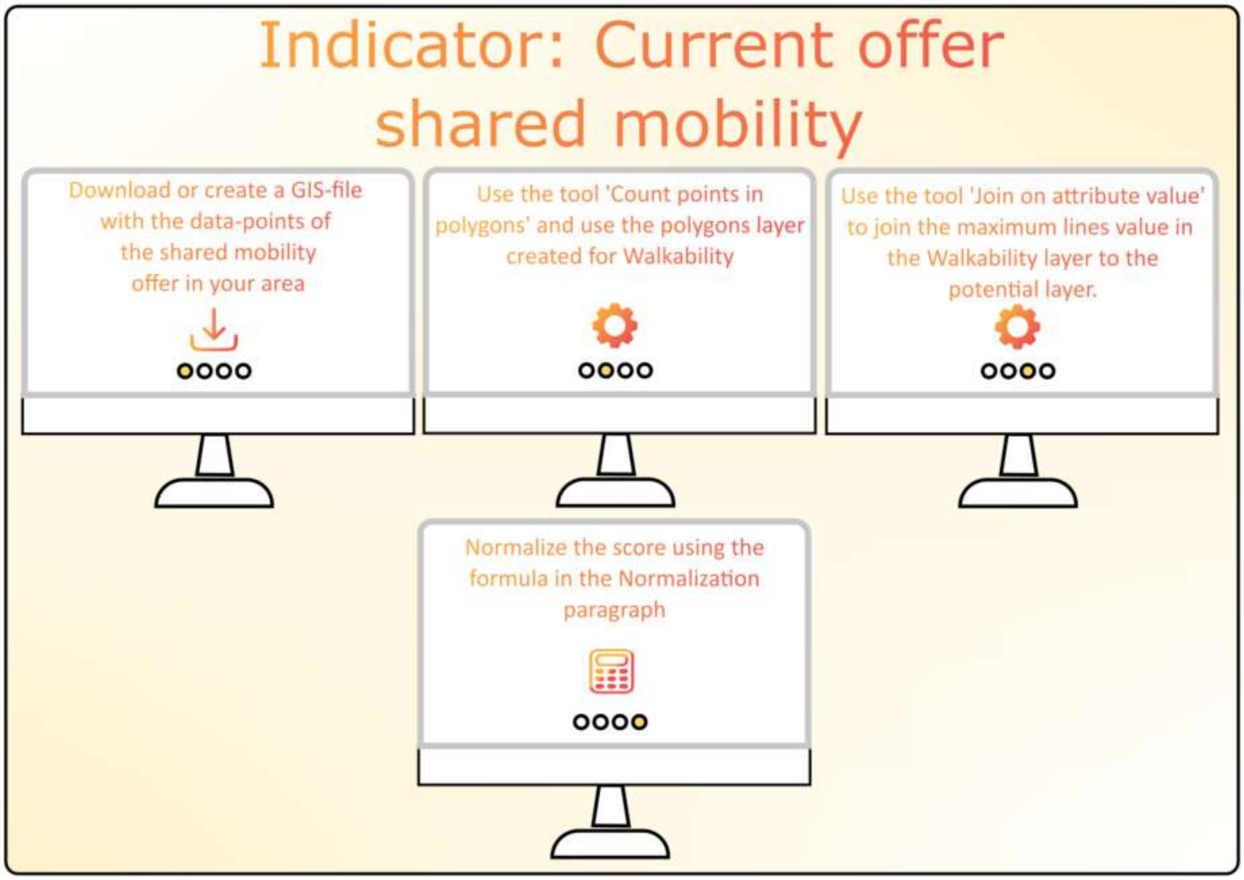


Figure 16: Steps to calculate the 'Current offer of shared mobility' indicator

4.3 Calculating the total score

To ensure that the absolute values of indicators do not impact their influence, all values are normalized as described in section 3. Then, the simplest way to calculate the total score for the suitability of a location for shared cargo bike services is by calculating the sum of all the normalized values of the indicator scores without adding any weights. To make the analysis more suitable to your area and goals, weights can be added to the various indicators. These weights will influence the importance of an indicator to the final score. The higher the weight, the greater the importance of this indicator will be to the final score.

Calculating without weights:

Suitable location score = A + B + C + D + E + F + G + H

Where A to H are the normalized scores for the indicators.

Calculating with weights:

Suitable location score = A*1.5 + B*0.4 + C + D*0.1 + E*0 + F*2 + G + H

Where A to H are the normalized scores for the indicators, and the values after the multiplication sign are the assigned weights.

4.4 Visualization of the scores – Creating a hexagon grid

A grid of hexagons is used to visualize the scores of each crossroad within the hexagon. This increases the readability of the results through an alternative visualization. The score of the hexagon is based on the average scores of all the potential locations within the hexagon shape. The hexagons do not cover the full extent of the province of Utrecht, since many hexagon areas do not have any potential locations within their boundaries and therefore do not have any associated score. The hexagon grid cells are spaced with an interval of 250 meters between the adjacent hexagons. In other words, if a hexagon has the vertices 1 to 6, the distance between vertex 1 and 3 is 250 meters. Figure 17 depicts all the steps to create a hexagonal grid.

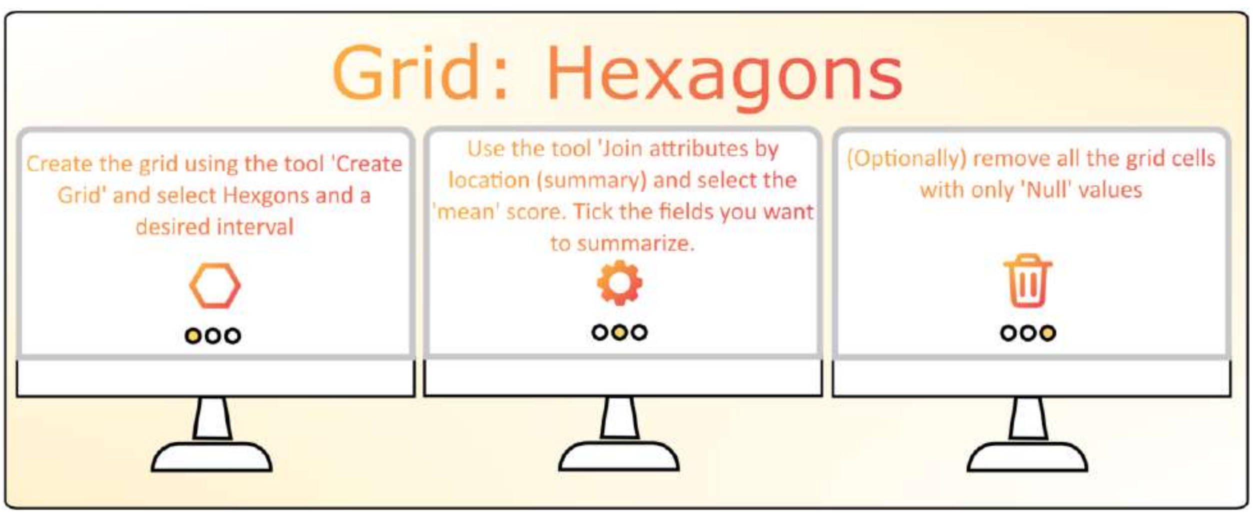


Figure 17: Steps to create a hexagonal grid

5. Results

The score for the shared cargo bike location suitability was made up of 10 different indicators. In this chapter, a few of these indicator scores are plotted on a map and discussed. This is discussed to provide some context as to how the location scan produces its results. The other indicators' scores can be found in the Appendix.

5.1 Indicator: Age

Figure 18 shows the results for the indicator 'Age'. In general, the two biggest cities in the province of Utrecht seem to have the most inhabitants in the age group associated with shared cargo bike usage, with Nieuwegein, south of the city of Utrecht, as an outlier in this regard.

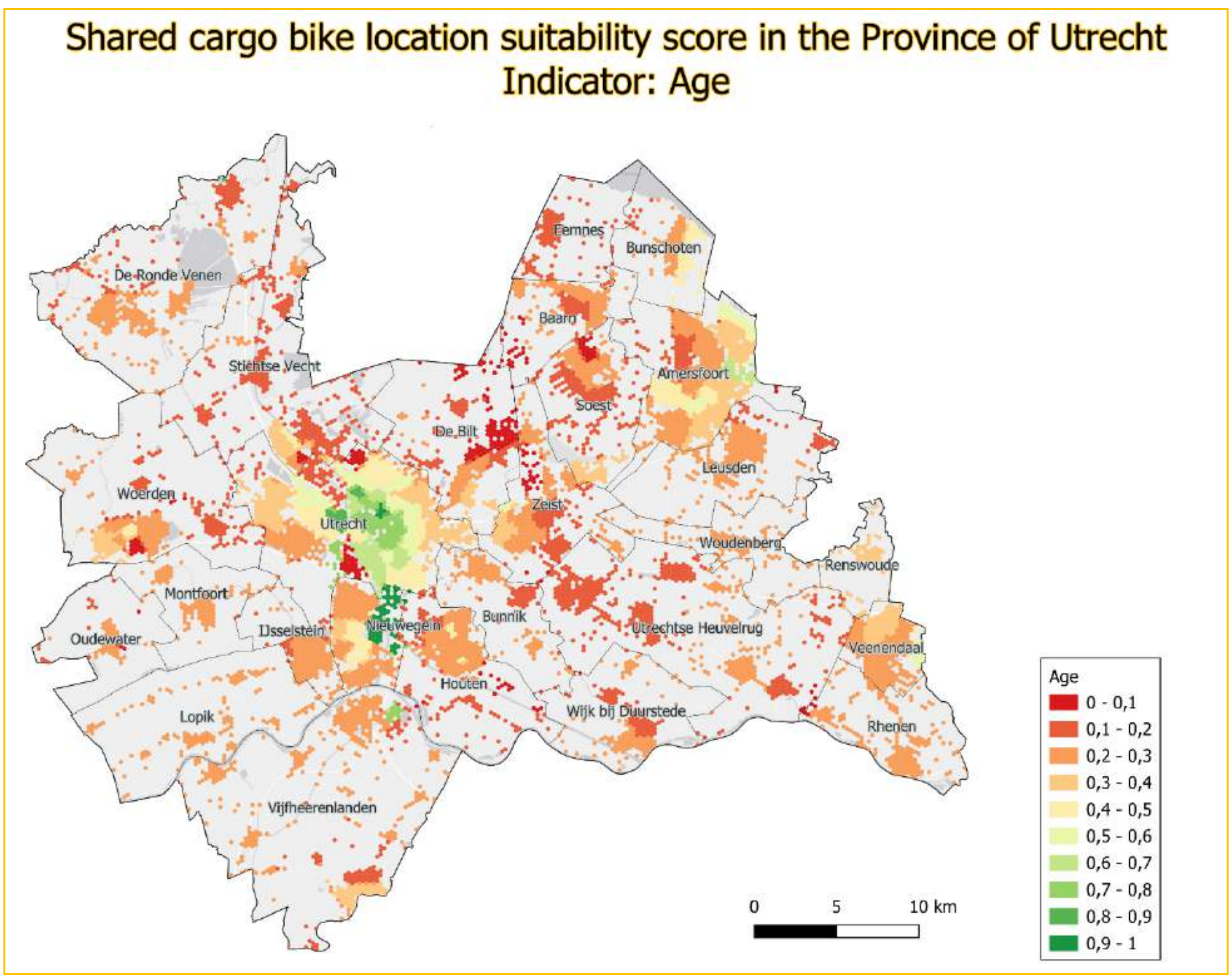


Figure 18: Shared cargo bike location suitability score in the province of Utrecht, Indicator: Age

5.2 Indicator: Green voters

Figure 19 shows the results for the indicator 'Green voters' which is used as a proxy indicator for ecological consciousness. It can be seen that the highest scores for these indicators can be found in the two biggest cities in the province. The area in between these two cities is also greener than the rest of the province.

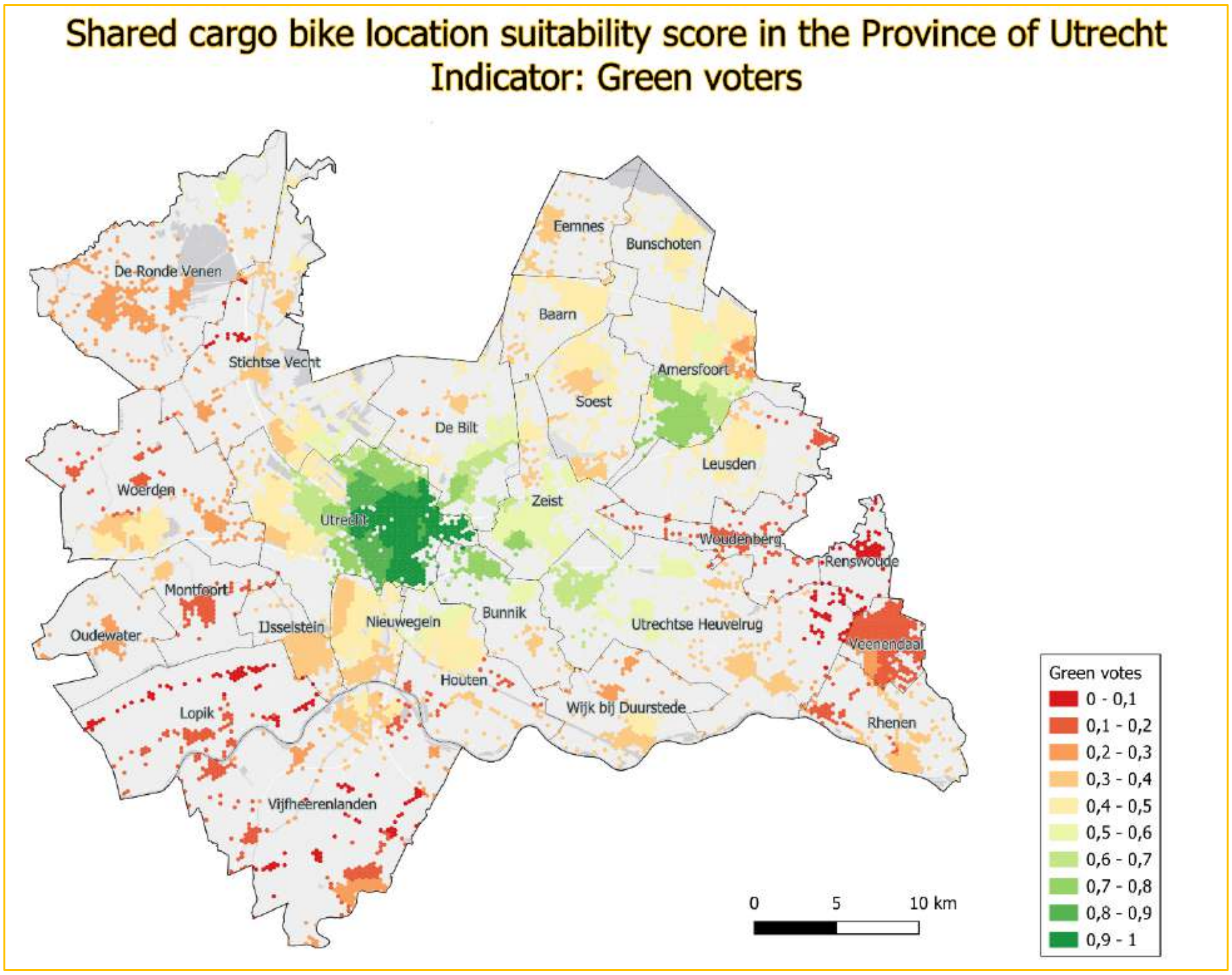


Figure 19: Shared cargo bike location suitability score in the province of Utrecht, Indicator: Green ideals

5.3 Indicator: Points of Interest

Figure 20 shows the results for the indicator 'Points of Interest'. For this indicator, the results are far more localized, and can vary much, even within built-up areas. Most of the built-up areas have one or more areas with many points of interest. Usually, these are located around shopping centers.

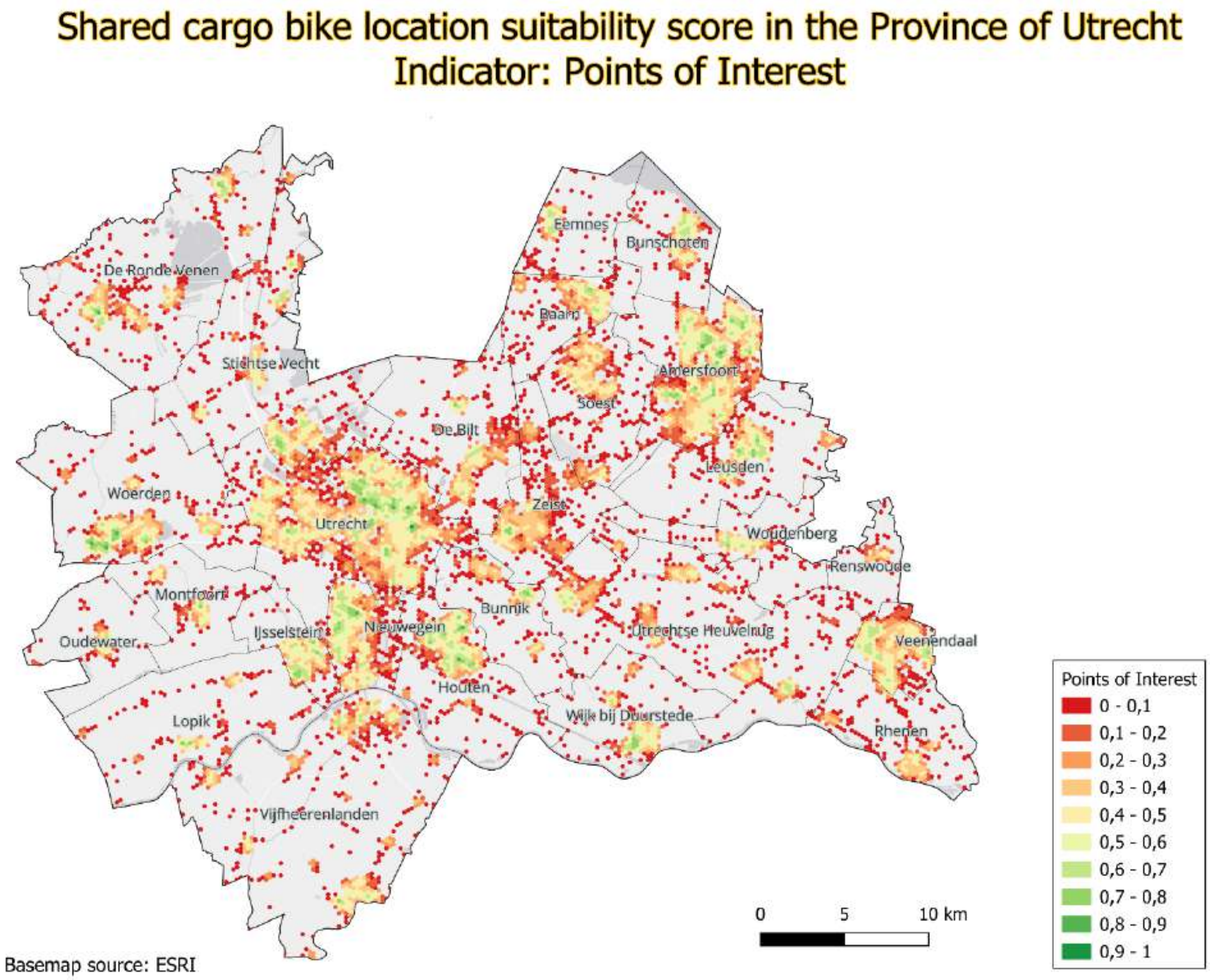


Figure 20: Shared cargo bike location suitability score in the province of Utrecht, Indicator: Points of Interest

5.4 Total score

Figure 21 shows the total score of all ten indicators combined. In this case, all indicators have received an equal weighting. This figure shows which areas are the most suitable for implementation of shared cargo bike services. The results are to be expected, namely the more urban areas are more suitable. However, it becomes interesting when looking at the differences within urban areas.

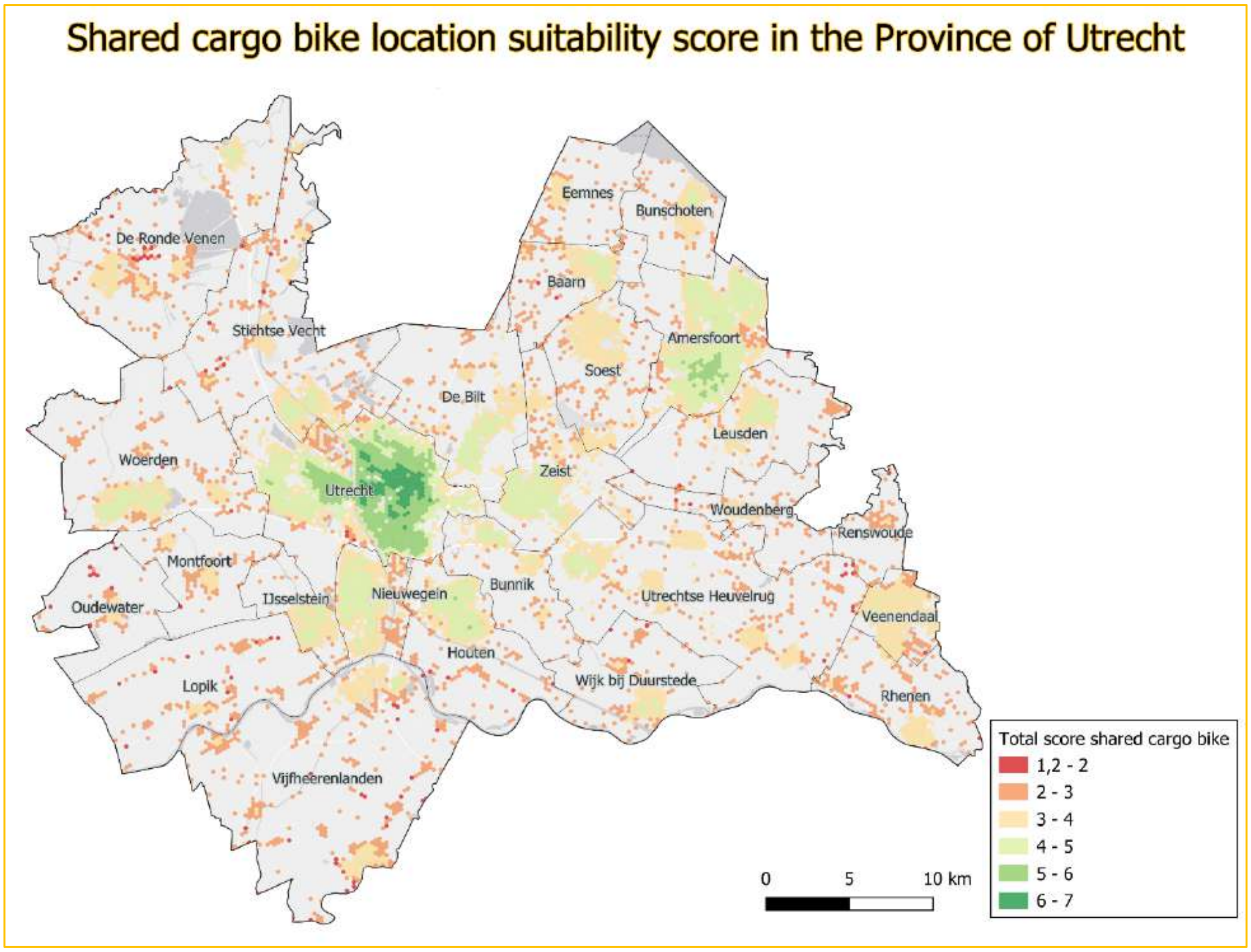


Figure 21: Shared cargo bike location suitability score in the province of Utrecht

Figure 22 shows the scores for every crossroad in the area of a neighborhood in one of the provinces more rural municipalities. This 'zoomed-in' perspective allows for more precise evaluation of an area and can be used to choose locations on a neighbourhood level. Whereas Figure 21 is more suitable for deciding locations on a municipal or even provincial level.

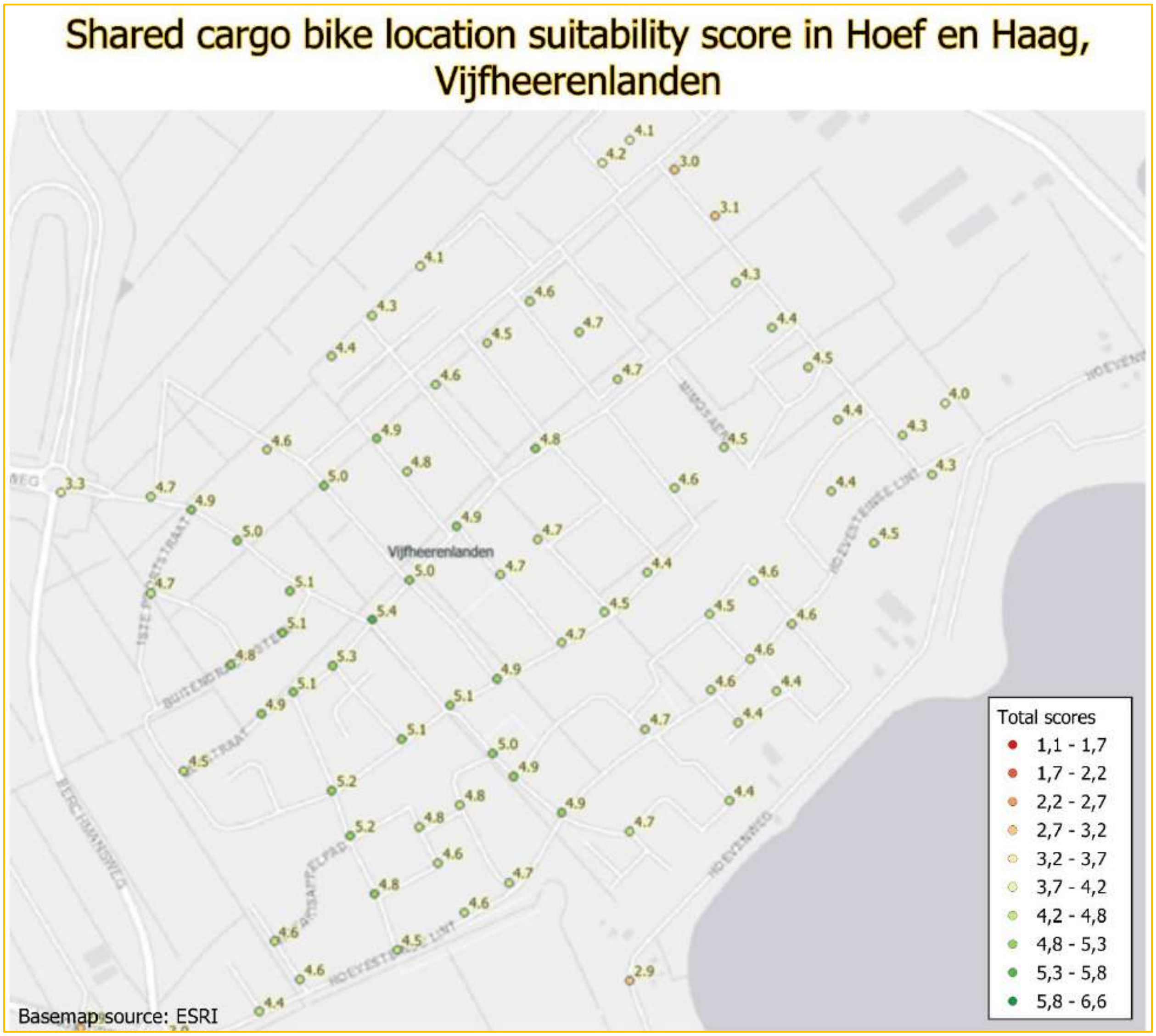


Figure 22: Shared cargo bike location suitability score in Hoef en Haag, Vijfheerenlanden

6. Validation and calibration

To validate and calibrate the model result, some statistical analysis must be performed. In this case, linear regression has been performed. The normalized indicator scores are the independent variables. The dependent variable has to be based on real usage data of shared mobility vehicles. A provider of shared cargo bikes services has shared its free-floating cargo bike usage data for the purposes of this statistical analysis. The data points only contained the start and end locations of the shared cargo bike rides. To get a value for each crossroad, the sum of the 50 nearest data-points to the crossroads was computed. This value is the dependent variable. The lower the value, the more popular the location is for shared cargo bike users and vice versa.

Table 2 shows the outcomes of the linear regression model, which explains 50% of the variance (R^2 = 0.50). Urbanization exhibits the strongest influence, with a large negative coefficient (-22,670), suggesting a significant inverse relationship with the dependent variable. The result has an inverse relationship, because a lower score is more favourable for the dependent variable, while this is not the case for the independent variables. Walkability (-7,250), car ownership (-7,789), and age (-12,170) also show statistically significant negative associations ($p < 0.01$). Education level (-3,755), green ideals (-4,814), and points of interest (-4,200) further contribute to the model with smaller but significant effects. In contrast, the presence of children and public transport in the area do not show significant effects ($p = 0.362$ and $p = 0.132$, respectively).

To calibrate the model, the weights are then based on the coefficient value of each of the indicators, with no weights applied for the indicators that were not statistically significant. The final score for each crossroad is therefore the sum of normalized indicator scores, multiplied by the weight for each indicator.

Indicator	Coefficient	P-value	Weights
Walkability	-7250	0.000	0.31
Urbanization	-22670	0.000	1.00
Car ownership	-7789	0.008	0.37
Children in area	1853	0.362	0.00
Age	-12170	0.000	0.56
Education level	-3755	0.006	0.18
Public transport	-3658	0.132	0.00
Green ideals	-4814	0.000	0.19
Points of interest	-4200	0.007	0.21

Table 2: Linear regression results

The correlation matrix of the independent variables (Figure 23) reveals some notable positive correlations. Urbanization, car ownership, and age are strongly correlated with each other, suggesting they may have some multicollinearity. Furthermore, green ideals correlate positively with age ($r = 0.64$) and urbanization ($r = 0.48$), suggesting that populations in the age associated with shared mobility usage and more urban populations may hold stronger environmental values. Overall, most correlations are moderate.

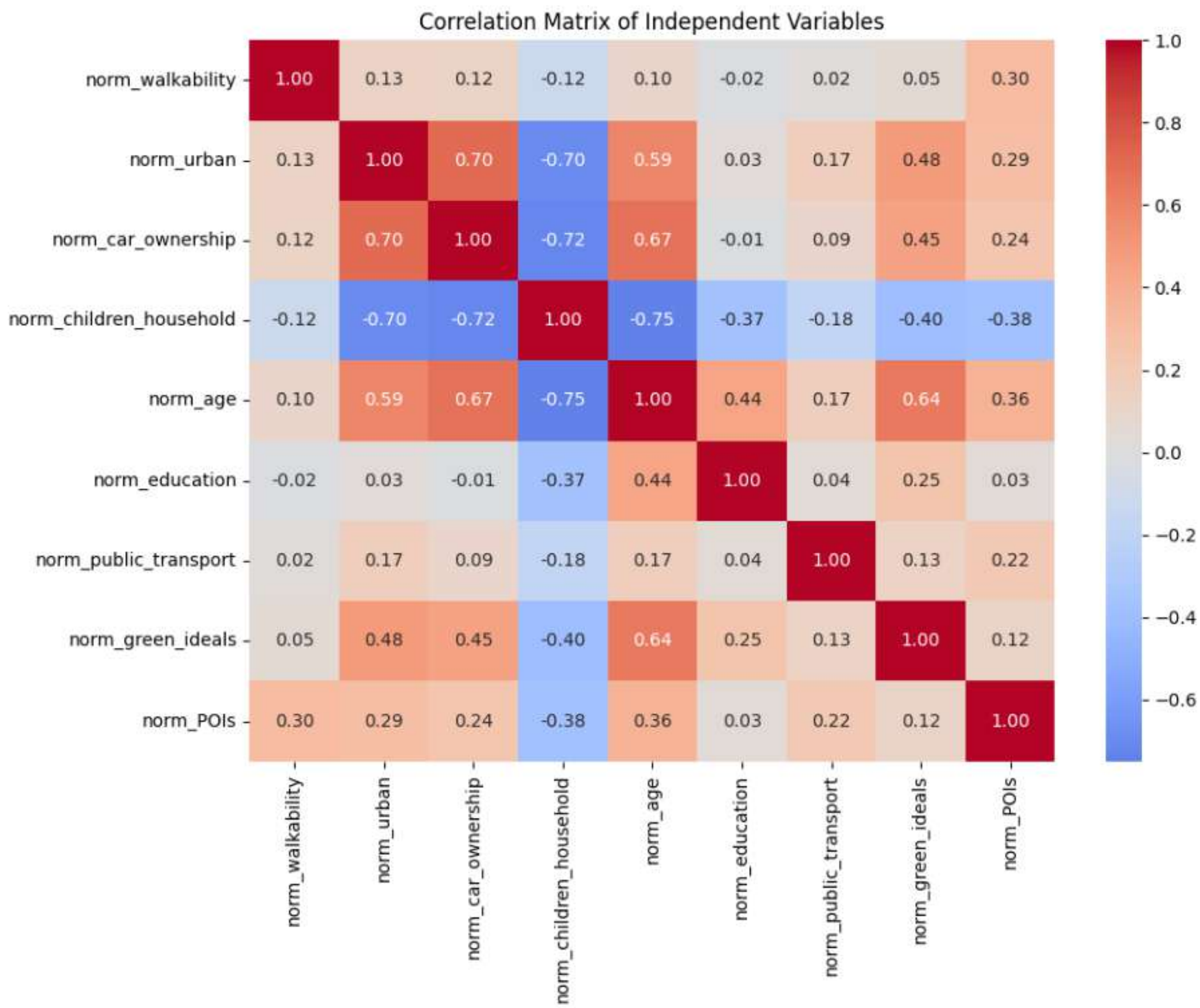


Figure 23: Correlation Matrix of Independent Variables

7. Conclusion and Recommendations

This application of the Multi-Criteria Analysis provides an easy-to-execute method for finding suitable locations for shared mobility locations. It is also flexible in the sense that the weights can be tailored to the context and the goals of the policymaker who will consult the analysis results. The indicators can also be modified, based on the knowledge from literature and experts in the field, to be more suitable for different shared mobility modes. Finding the importance of each indicator, and thus the weights, can be done using linear regression if there is user data available.

The findings of these assessments aid in selecting ideal locations for shared mobility and potential hubs, providing a foundation for data-driven policy development. The location scan can also be used as a starting point for discussion with policymakers and support them in understanding the important indicators for shared mobility success.

The flexibility of this model also allows it to be executed across different regions and this is also highly encouraged. Researchers wishing to use this step-by-step guide could also think about developing user-friendly software or interfaces for the location scan, to facilitate policymakers in using the tool. Furthermore, other indicators can be tested to see whether it will increase the explained variance of the model.

References

Bissel, M., & Becker, S. (2024). Can cargo bikes compete with cars? Cargo bike sharing users rate cargo bikes superior on most motives – Especially if they reduced car ownership. *101*, 218-235. doi:10.1016/j.trf.2023.12.018

Börjesson Rivera, M., & Henriksson, G. (2014). Cargo Bike Pool: A way to facilitate a car-free life? *Resilience – the new research frontier. Proceedings of the 20th Annual International Sustainable Development Research Conference (ISDRC 2014) Trondheim 18-20 June 2014*, 273-280.

CBS Statline. (2022). *Wijk- en buurtkaart 2022*. Retrieved from https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische-data/wijk-en-buurtkaart-2022

CBS Statline. (2023a). *Kerncijfers per Postcode*. Retrieved from https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische-data/gegevens-per-postcode

CBS Statline. (2023b). *Kaart van 500 meter bij 500 meter met statistieken*. Retrieved from https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische-data/kaart-van-500-meter-bij-500-meter-met-statistieken

CROW. (n.d.). *Dashboard Deelmobiliteit*. Retrieved from https://dashboarddeelmobiliteit.nl/

Dorner, F., & Berger, M. (2020). Peer-to-Peer Cargo Bike Sharing: Findings from LARA Share project. *Proceedings of 8th Transport Research Arena TRA 2020*.

Geofabrik. (n.d.). *OpenStreetMap Data Extracts*. Retrieved from https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische-data/wijk-en-buurtkaart-2022

Geurs, K., Grigolon, A., Münzel, K., Gkiotsalitis, K., Duran-Rodas, D., Büttner, B., . . . Klementschitz, R. (2023). The Smarthubs integration ladder: a conceptual model for the categorisation of shared mobility hubs. *Transport Reviews, 44*(1), 112-139. doi:10.1080/01441647.2023.2239499

GitHub. (2025). *Shared-Mobility-Location-Suitability-Model.* Retrieved from https://github.com/GidoStoop/Shared-Mobility-Location-Suitability-Model

GreenWheels. (n.d.). *Reserveer*. Retrieved from https://www.greenwheels.com/nl/book

Heinrich, L., Schulz, W., & Geis, I. (2016). The Impact of Product Failure on Innovation Diffusion: The Example of the Cargo Bike as Alternative Vehicle for Urban Transport. *Transportation Research Procedia, 19*, 269-271. doi:10.1016/j.trpro.2016.12.086

Hess, A., & Schubert, I. (2019). Functional perceptions, barriers, and demographics concerning e-cargo bike sharing in Switzerland. *Transportation Research Part D: Transport and Environment, 71*, 153-168. doi:10.1016/j.trd.2018.12.013

Kammerhofer, A., Pühringer, F., Kostka, L., & Berger, M. (2023). Understanding Spatio-Temporal Usage Patterns of Cargo Bike Sharing to Foster Market Diffusion. *Nature-based Solutions for Sustainable Resilient Smart Green and Blue Cities. Proceedings of REAL CORP 2023, 28th International Conference on Urban Development, Regional Planning and Information Society*, 881-892.

Kiesraad. (2024). *Overzicht uitslagen per gemeente Europees Parlementsverkiezing 2024*. Retrieved from https://www.kiesraad.nl/verkiezingen/europees-parlement/uitslagen/uitslagen-per-gemeente

Malczewski, J. (2006). GIS-based multicriteria decision analysis: a survey of the literature. *International Journal of Geographical Information Science, 20*(7), 703-726. doi:10.1080/13658810600661508

Malik, F., Egan, R., Dowling, C., & Caulfield, B. (2023). Factors influencing e-cargo bike mode choice for small businesses. *Renewable and Sustainable Energy Reviews, 178*(113253). doi:10.1016/j.rser.2023.113253

Mouratidis, K. (2022). Bike-sharing, car-sharing, e-scooters, and Uber: Who are the shared mobility users and where do they live? *Sustainable Cities and Society, 86*, 2022. doi:10.1016/j.scs.2022.104161

Münzel, K., Boon, W., Frenken, K., Blomme, J., & van der Linden, D. (2020). Explaining carsharing supply across Western European cities. *International Journal of Sustainable Transportation, 14*(4), 243-254. doi:10.1080/15568318.2018.1542756

MyWheels. (n.d.). *Altijd een deelauto in jouw buurt*. Retrieved from https://mywheels.nl/auto-huren

PDOK. (n.d.). *Dataset: Basisregistratie Adressen en Gebouwen (BAG)*. Retrieved from https://www.pdok.nl/introductie/-/article/basisregistratie-adressen-en-gebouwen-ba-1

SnappCar. (n.d.). *Rent a car in your neighborhood*. Retrieved from https://www.snappcar.nl/

University of Groningen Geodienst. (2022). *Openbaar Vervoer Nederland*. Retrieved from https://hub.arcgis.com/maps/9c7f791fb35e4eaab465e342fdf944e1/about

van Kuijk, R. J., de Almeida Correia, G. H., van Oort, N., & van Arem, B. (2022). Preferences for first and last mile shared mobility between stops and activity locations: A case study of local public transport users in Utrecht, the Netherlands. *Transportation Research Part A: Policy and Practice, 166*, 285-306. doi:10.1016/j.tra.2022.10.008

Appendix

Appendix A: Results from the workshop on shared cargo bike services

Socio demographic characteristics associated with shared cargo bike services

- Residential areas with terraced houses and small gardens
- Neighborhoods with relatively many residents from the Randstad
- Tech-savvy
- Students
- Same goes for car-sharers, young and highly educated
- Families with children
- GreenLeft, D66

Drivers, motives and destinations

- Moving efficiently through the city, combining trips - Sven
- Avoiding traffic jams, expensive paid parking
- Parking at a distance – driving with your belongings to the P+R (desired effect)
- Short trips instead of by car, to hardware stores and garden centers (Shopping function)
- No space for a personal cargo bike
- A bit of a status symbol
- Frequent damage or theft of personal cargo bike
- In Ede, lots of recreational trips to the heath and forest, in addition to functional use
- Reducing the number of nuisance complaints
- Transporting goods
- Buying a cargo bike is expensive
- Picking up a package from a package locker
- Destination is hard to reach by car (car-free area)
- Going to the forest
- Recreational trips
- Taking the dog along
- Occasionally needing a cargo bike
- Bringing the child to school and then heading to work

Locations for shared cargo bike services

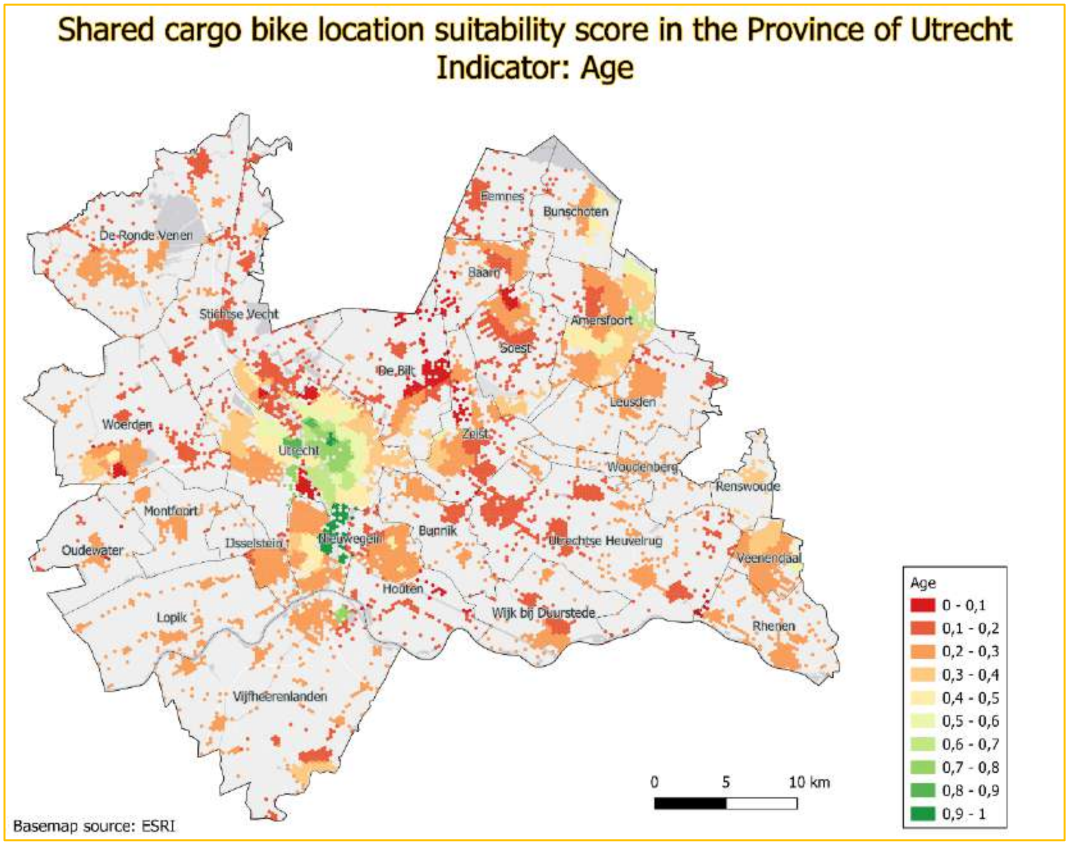
- Based on reports/complaints
- Using the CROW dashboard as a starting point
- On sidewalks
- Destination locations for young families
- Taking into account parking spaces to be removed
- Locations with high parking pressure
- Number of residents per area
- Dense network
- Use parking bay markings combined with geo-zones

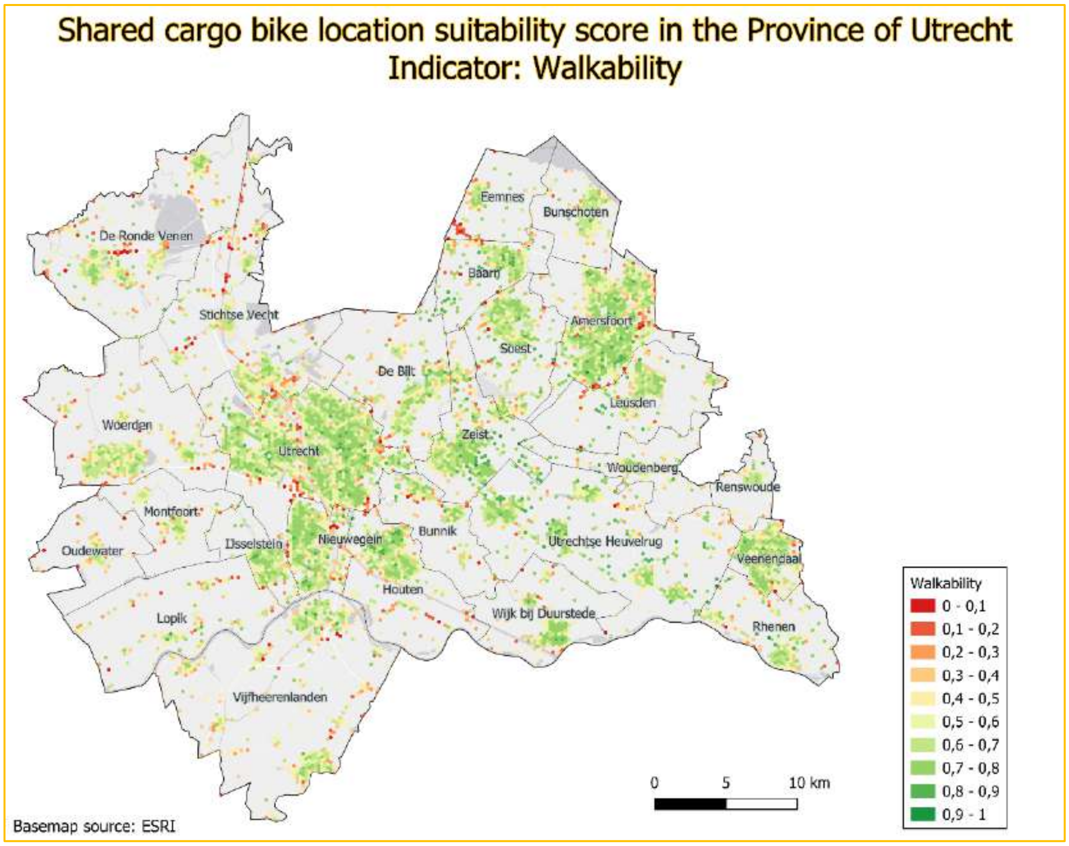
- Reservation option to prevent unavailability
- Within short walking distance from one's front door
- Addressing transportation poverty (in certain neighborhoods)
- User demographics
- Good coverage: if you miss one, there’s another nearby
- Hubs (public transport, P+R)
- Places where shared cars (and shared cargo bikes) are also located
- High population density
- Near stations or other public transport hubs
- Locations with roadside contruction
- Smaller houses with less storage space

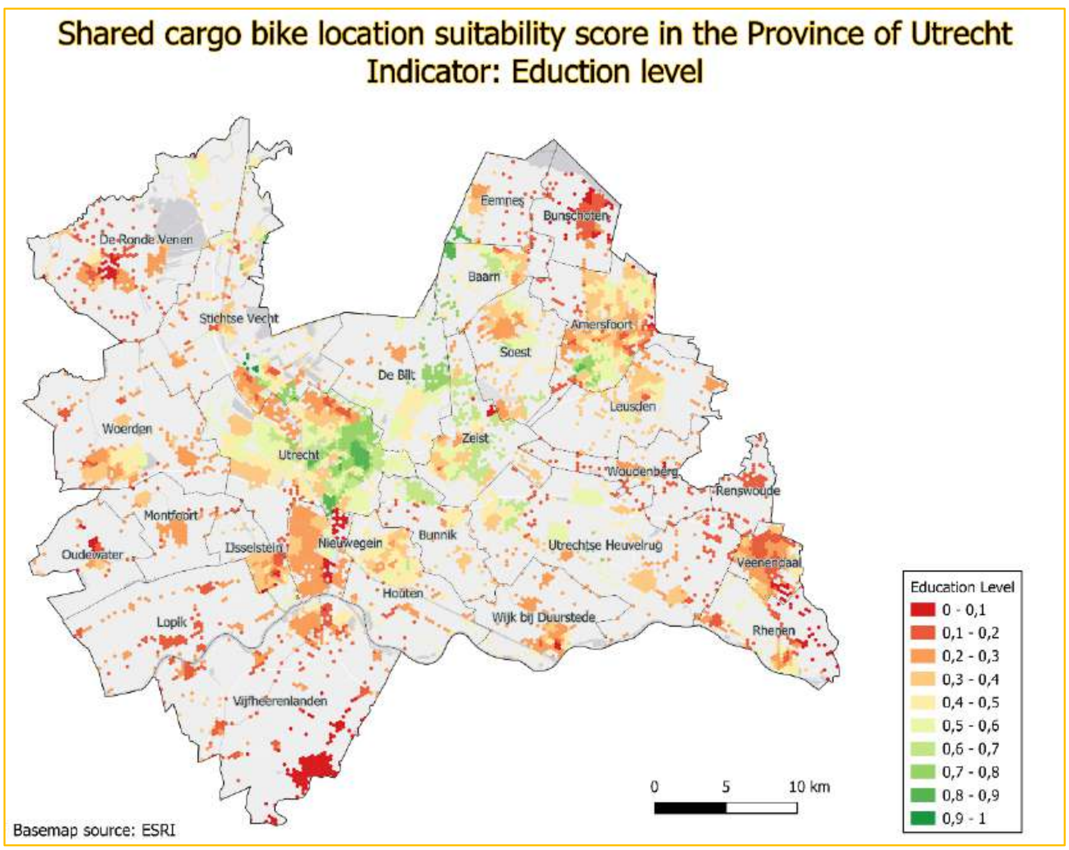
Barriers for using shared cargo bike services

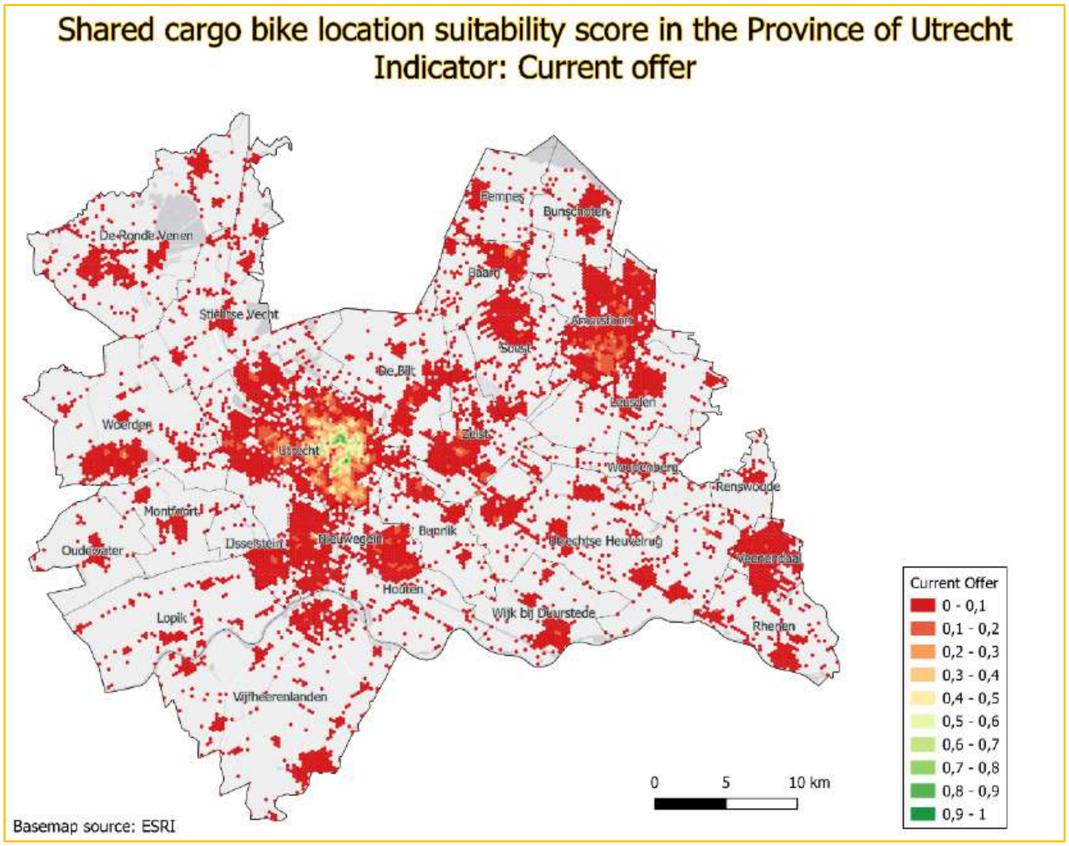
- Cost per ride (but cheaper than a car?)
- Back-to-one: long rental periods
- Free-floating: destinations lie outside the zone
- No availability around the corner
- Already own a cargo bike, see no benefit in using a shared cargo bike
- Unfamiliarity with costs
- Unfamiliarity with shared cargo bikes
- Spatial integration impossible in urban areas
- Not enough availability, lack of certainty
- No access to online banking
- Consider green spaces, walking and guiding lines, and bike racks
- Visibility of hubs in provider applications
- Distinction between free-floating and hubs
- Limited space on sidewalks
- Registration process in the app
- Digital skills (what factors influence this?)
- Distance between origin and destination (rural vs. urban)
- Proficiency in Dutch/English? (non-Western migrant background)
- Trial offers help to overcome barriers

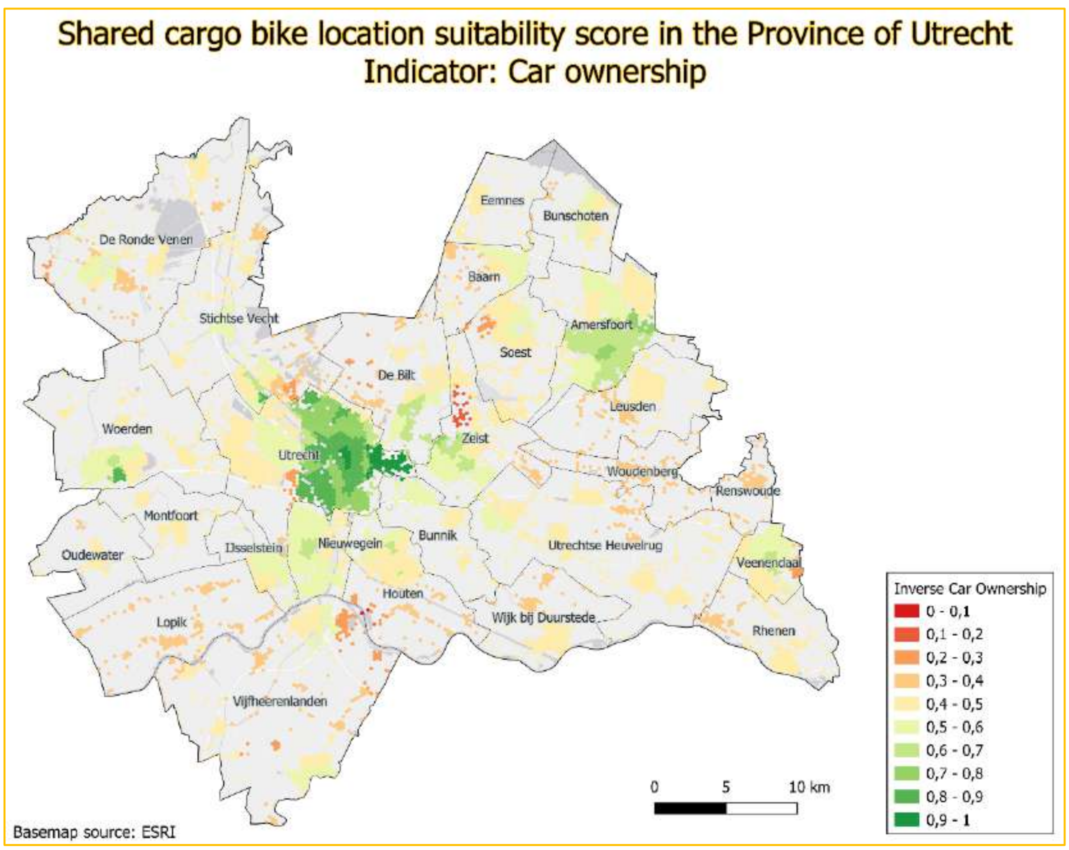
Appendix B: Maps of the results per indicator

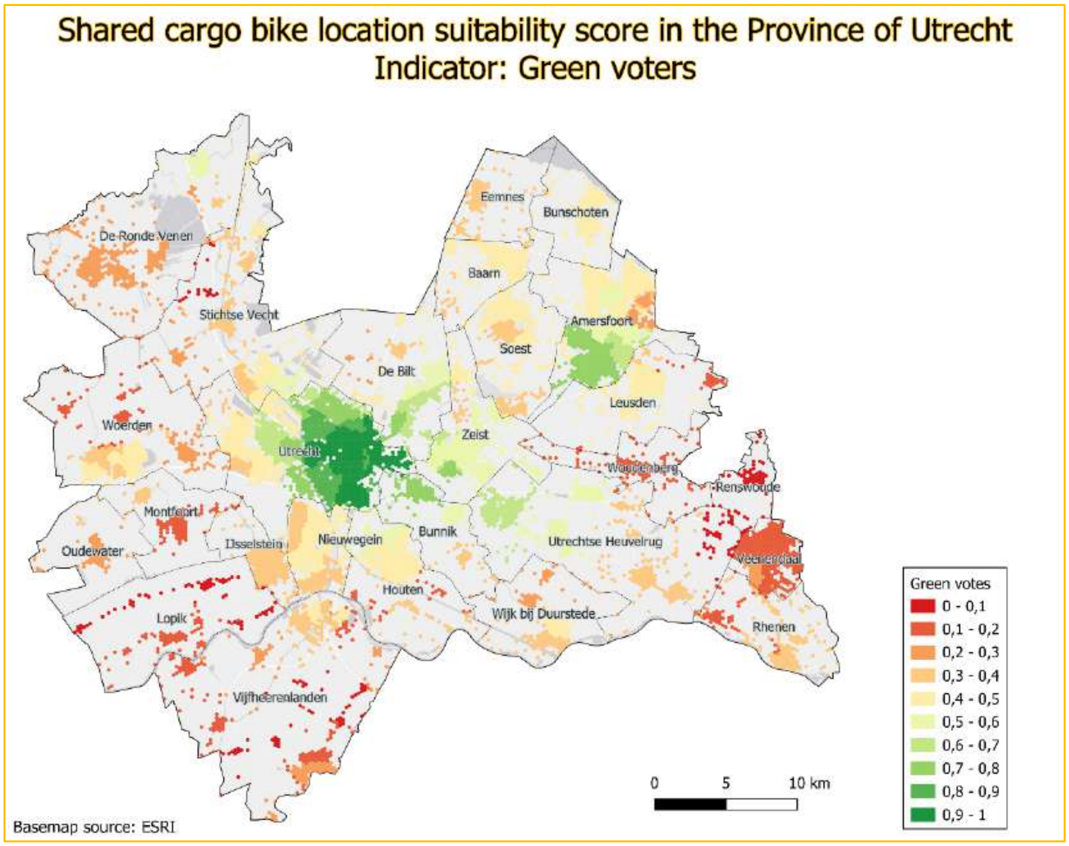


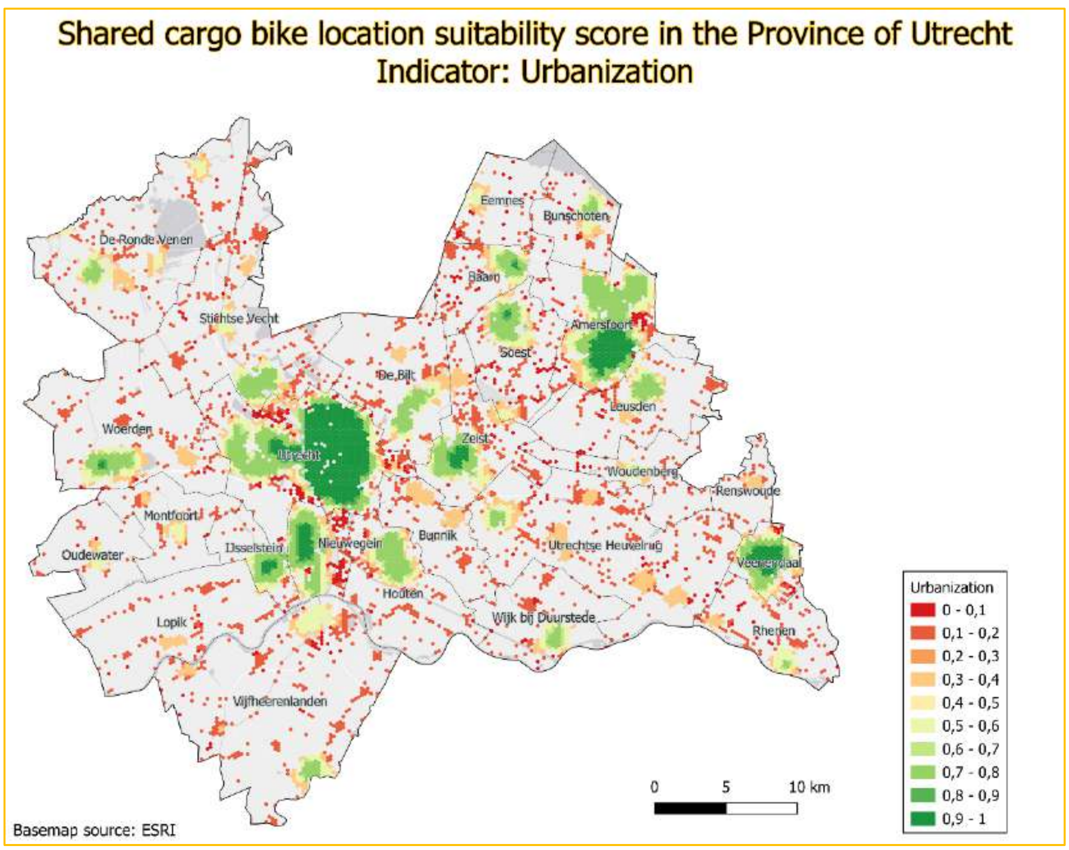

Shared cargo bike location suitability score in the Province of Utrecht
Indicator: Walkability
De Ronde Venen
Stichtse Vecht
Eemnes
Bunschoten
Baarn
Amersfoort
Soest
De Bilt
Leusden
Woerden
Utrecht
Zeist
Woudenberg
Renswoude
Montfoort
IJsselstein
Nieuwegein
Bunnik
Utrechtse Heuvelrug
Veenendaal
Oudewater
Houten
Lopik
Wijk bij Duurstede
Rhenen
Vijfheerenlanden
0
5
10 km
Walkability
0 - 0,1
0,1 - 0,2
0,2 - 0,3
0,3 - 0,4
0,4 - 0,5
0,5 - 0,6
0,6 - 0,7
0,7 - 0,8
0,8 - 0,9
0,9 - 1
Basemap source: ESRI

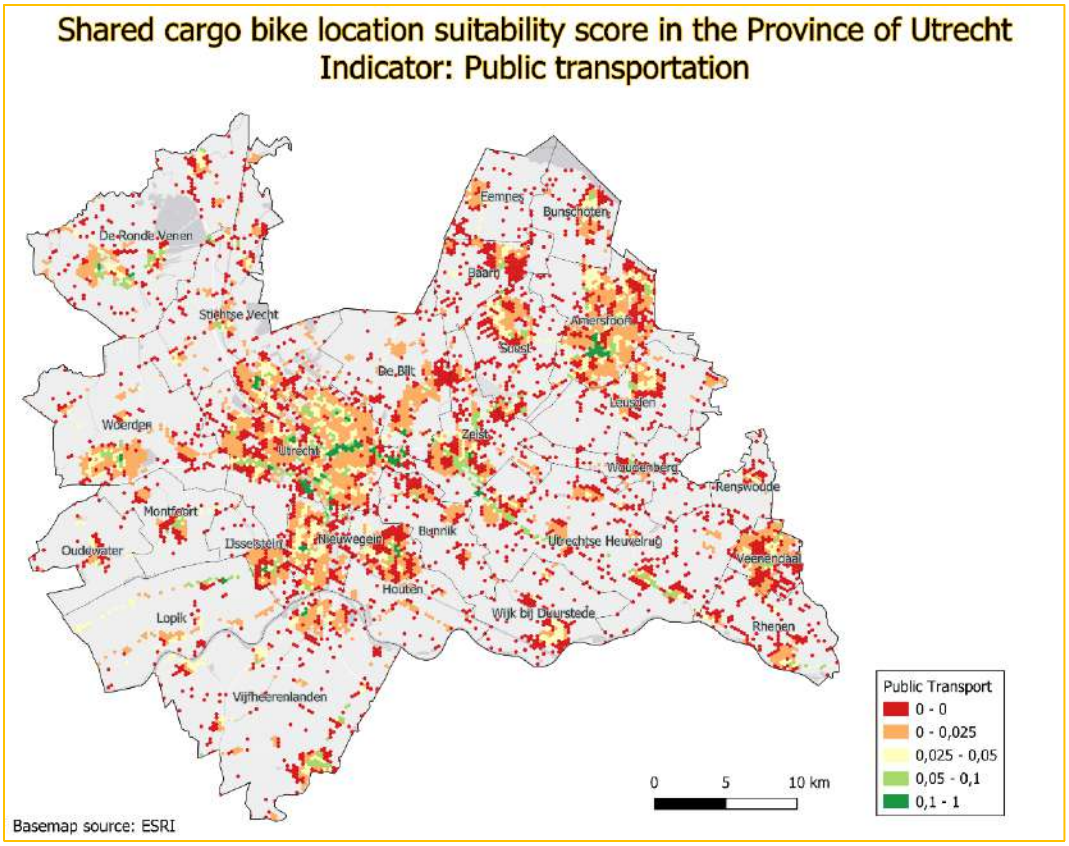

Shared cargo bike location suitability score in the Province of Utrecht
Indicator: Eduction level
De Ronde Venen
Stichtse Vecht
Eemnes
Bunschoten
Baarn
Amersfoort
Soest
De Bilt
Leusden
Woerden
Utrecht
Zeist
Woudenberg
Renswoude
Montfoort
IJsselstein
Nieuwegein
Bunnik
Utrechtse Heuvelrug
Veenendaal
Oudewater
Houten
Lopik
Wijk bij Duurstede
Rhenen
Vijfheerenlanden
0
5
10 km
Education Level
0 - 0,1
0,1 - 0,2
0,2 - 0,3
0,3 - 0,4
0,4 - 0,5
0,5 - 0,6
0,6 - 0,7
0,7 - 0,8
0,8 - 0,9
0,9 - 1
Basemap source: ESRI

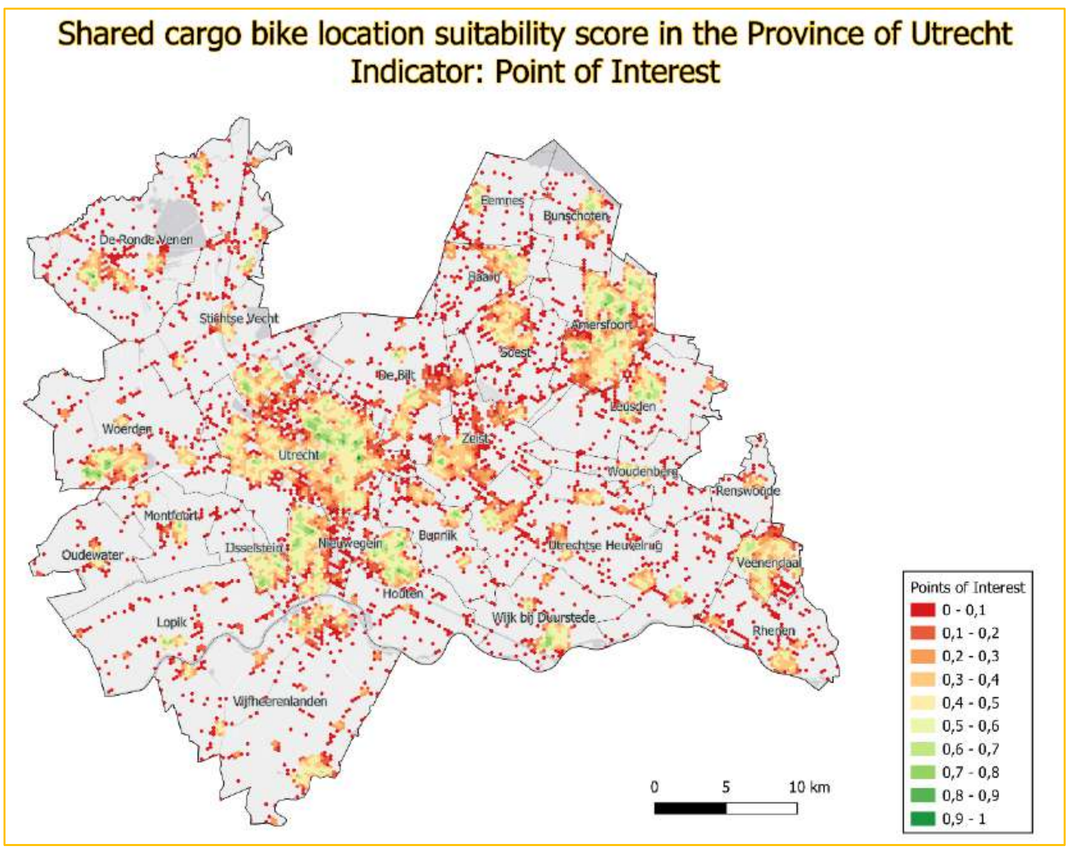

Shared cargo bike location suitability score in the Province of Utrecht
Indicator: Current offer
Eemnes
Bunschoten
De Ronde Venen
Baarn
Stichtse Vecht
Amersfoort
Soest
De Bilt
Leusden
Woerden
Utrecht
Zeist
Woudenberg
Renswoude
Montfoort
Nieuwegein
Bunnik
Utrechtse Heuvelrug
Oudewater
IJsselstein
Veenendaal
Houten
Lopik
Wijk bij Duurstede
Rhenen
Vijfheerenlanden
0
5
10 km
Current Offer
0 - 0,1
0,1 - 0,2
0,2 - 0,3
0,3 - 0,4
0,4 - 0,5
0,5 - 0,6
0,6 - 0,7
0,7 - 0,8
0,8 - 0,9
0,9 - 1
Basemap source: ESRI

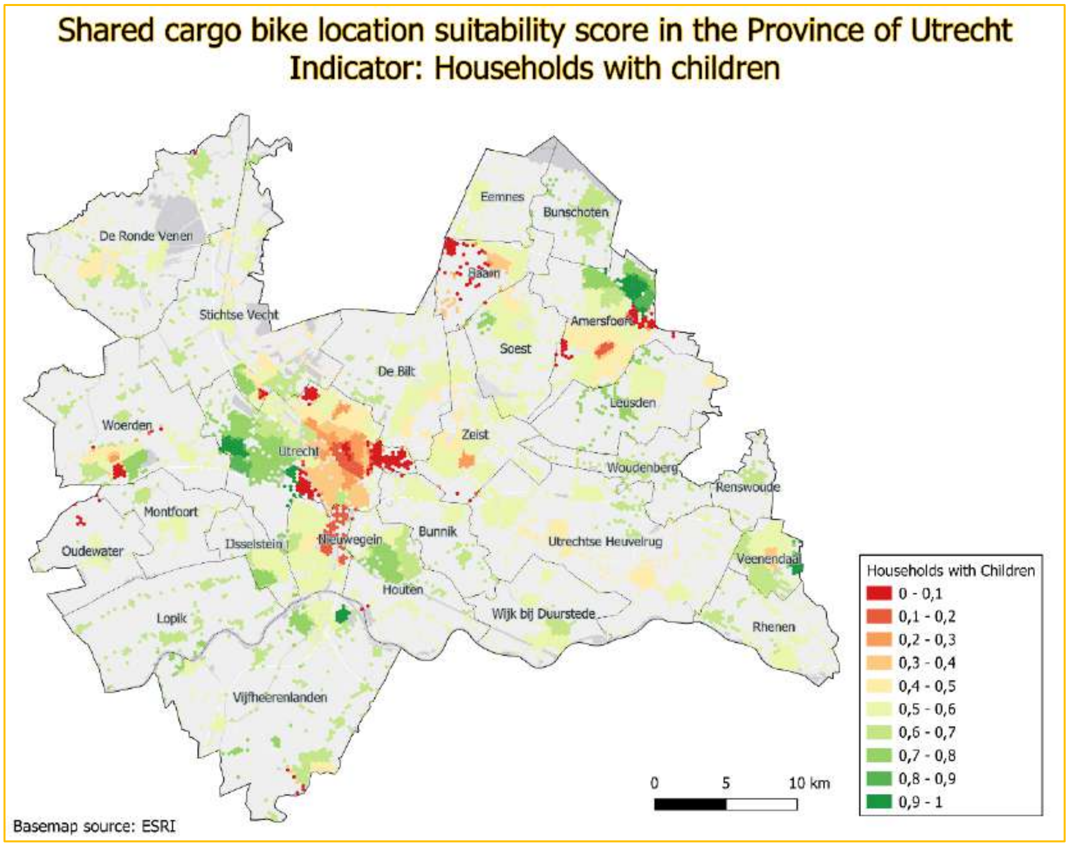

Shared cargo bike location suitability score in the Province of Utrecht
Indicator: Car ownership
Eemnes
Bunschoten
De Ronde Venen
Baarn
Stichtse Vecht
Amersfoort
Soest
De Bilt
Leusden
Woerden
Utrecht
Zeist
Woudenberg
Renswoude
Montfoort
Nieuwegein
Bunnik
Utrechtse Heuvelrug
Oudewater
IJsselstein
Veenendaal
Houten
Lopik
Wijk bij Duurstede
Rhenen
Vijfheerenlanden
0
5
10 km
Inverse Car Ownership
0 - 0,1
0,1 - 0,2
0,2 - 0,3
0,3 - 0,4
0,4 - 0,5
0,5 - 0,6
0,6 - 0,7
0,7 - 0,8
0,8 - 0,9
0,9 - 1
Basemap source: ESRI


Shared cargo bike location suitability score in the Province of Utrecht
Indicator: Green voters
Eemnes
Bunschoten
De Ronde Venen
Baarn
Stichtse Vecht
Amersfoort
Soest
De Bilt
Leusden
Woerden
Zeist
Utrecht
Woudenberg
Renswoude
Montfoort
Oudewater
IJsselstein
Nieuwegein
Bunnik
Utrechtse Heuvelrug
Veenendaal
Houten
Lopik
Wijk bij Duurstede
Rhenen
Vijfheerenlanden
0
5
10 km
Green votes
0 - 0,1
0,1 - 0,2
0,2 - 0,3
0,3 - 0,4
0,4 - 0,5
0,5 - 0,6
0,6 - 0,7
0,7 - 0,8
0,8 - 0,9
0,9 - 1
Basemap source: ESRI


Shared cargo bike location suitability score in the Province of Utrecht
Indicator: Urbanization
Eemnes
Bunschoten
De Ronde Venen
Baarn
Stichtse Vecht
Amersfoort
Soest
De Bilt
Leusden
Woerden
Zeist
Utrecht
Woudenberg
Renswoude
Montfoort
Oudewater
IJsselstein
Nieuwegein
Bunnik
Utrechtse Heuvelrug
Veenendaal
Houten
Lopik
Wijk bij Duurstede
Rhenen
Vijfheerenlanden
0
5
10 km
Urbanization
0 - 0,1
0,1 - 0,2
0,2 - 0,3
0,3 - 0,4
0,4 - 0,5
0,5 - 0,6
0,6 - 0,7
0,7 - 0,8
0,8 - 0,9
0,9 - 1
Basemap source: ESRI


Shared cargo bike location suitability score in the Province of Utrecht
Indicator: Public transportation
Eemnes
Bunschoten
De Ronde Venen
Baarn
Stichtse Vecht
Amersfoort
Soest
De Bilt
Leusden
Woerden
Zeist
Utrecht
Woudenberg
Renswoude
Montfoort
Bunnik
Oudewater
IJsselstein
Nieuwegein
Utrechtse Heuvelrug
Veenendaal
Houten
Wijk bij Duurstede
Lopik
Rhenen
Vijfheerenlanden
Public Transport
0 - 0
0 - 0,025
0,025 - 0,05
0,05 - 0,1
0,1 - 1
0
5
10 km
Basemap source: ESRI


Shared cargo bike location suitability score in the Province of Utrecht
Indicator: Point of Interest
Eemnes
Bunschoten
De Ronde Venen
Baarn
Stichtse Vecht
Amersfoort
Soest
De Bilt
Leusden
Woerden
Zeist
Utrecht
Woudenberg
Renswoude
Montfoort
Bunnik
Oudewater
IJsselstein
Nieuwegein
Utrechtse Heuvelrug
Veenendaal
Houten
Wijk bij Duurstede
Lopik
Rhenen
Vijfheerenlanden
Points of Interest
0 - 0,1
0,1 - 0,2
0,2 - 0,3
0,3 - 0,4
0,4 - 0,5
0,5 - 0,6
0,6 - 0,7
0,7 - 0,8
0,8 - 0,9
0,9 - 1
0
5
10 km


Shared cargo bike location suitability score in the Province of Utrecht
Indicator: Households with children
De Ronde Venen
Stichtse Vecht
Eemnes
Bunschoten
Baarn
Amersfoort
Soest
De Bilt
Leusden
Woerden
Utrecht
Zeist
Woudenberg
Renswoude
Montfoort
Oudewater
IJsselstein
Nieuwegein
Bunnik
Utrechtse Heuvelrug
Veenendaal
Houten
Wijk bij Duurstede
Rhenen
Lopik
Vijfheerenlanden
Households with Children
0 - 0,1
0,1 - 0,2
0,2 - 0,3
0,3 - 0,4
0,4 - 0,5
0,5 - 0,6
0,6 - 0,7
0,7 - 0,8
0,8 - 0,9
0,9 - 1
0
5
10 km
Basemap source: ESRI

The ShareDiMobiHub Consortium

The consortium of ShareDiMobiHub consists of 13 partners and 4 subpartners with multidisciplinary and complementary competencies. This includes European cities and regions, universities, network partners and transport operators.

For further information please visit https://www.interregnorthsea.eu/sharedimobihub