Project number 875022

Smart Mobility Hubs as Game Changers in Transport

WP3. Development of co-creation and participatory planning and design tools
T3.1. Mobility hubs in the urban space

Deliverable D 3.1
Guidelines for the integration of mobility hubs into the urban space

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1. INTRODUCTION

In this report, and as defined for the SmartHubs project, a mobility hub (MH) is a physical location where shared mobility options are offered at permanent, dedicated, and visible locations as well as where public or collective transport can be found within a walking distance (Geurs et al., 2021). Within this definition, we expanded the concept to not only include shared mobility options but also mobility opportunities in general. These mobility opportunities (Figure 1) were categorized into 1) public transport (rail-based, bus, ferry, etc.), 2) shared mobility (e.g., carsharing, bike sharing, etc.), and 3) mobility services (charging stations, parking, facilities, parcel lockers, etc.). Mobility hubs have the potential to create an attractive and competitive alternative to private motorized transportation by including and connecting different mobility opportunities in an area. The attractiveness and convenience can also be leveraged by place-making strategies, and complementary non-transport-related services (Urban Design Studio, 2016).

Figure 1 Mobility opportunities

Based on the previously mentioned characteristics and considering different perspectives, mobility hubs can perform different roles or goals in mobility systems. For this report, and based on the chosen concept of a MH, we defined the following three objectives for mobility hubs:

a) **Connect public transport:** first-mile/last-mile connector to public transport (Aono, 2019., Shaeen and Christensen, 2013., and Urban Design Studio, 2016).

b) **Compliment public transport:** mobility hubs in areas that current public transport is not been entirely supplied, therefore, works as a complement of the provided service Aono, 2019., Shaeen and Christensen, 2013., and Urban Design Studio, 2016).

c) **Promote sustainable mobility:** mobility hubs have the potential to be promotors of low emission transport modes as well as reduce car dependency, traffic congestion, and parking demand (Aono, 2019., CoMoUK, 2019., and Metrolinx, 2011). Social equity and inclusion is another consideration in this field. Mobility hubs may increase accessibility for vulnerable population groups, including those economically disadvantaged, those with physical and cognitive limitations or language and cultural barriers (Aono, 2019., Choe et al., 2021., and Shaeen and Christensen, 2013). However, a limitation could be the reduced accessibility to digital services, a growing component in public transport and shared mobility (Durand et al., 2022).

Smart mobility hubs go beyond the physical connection of mobility opportunities and are distinguished from mobility hubs because they have digital and democratic components, which can be included at different integration levels (Figure 2).

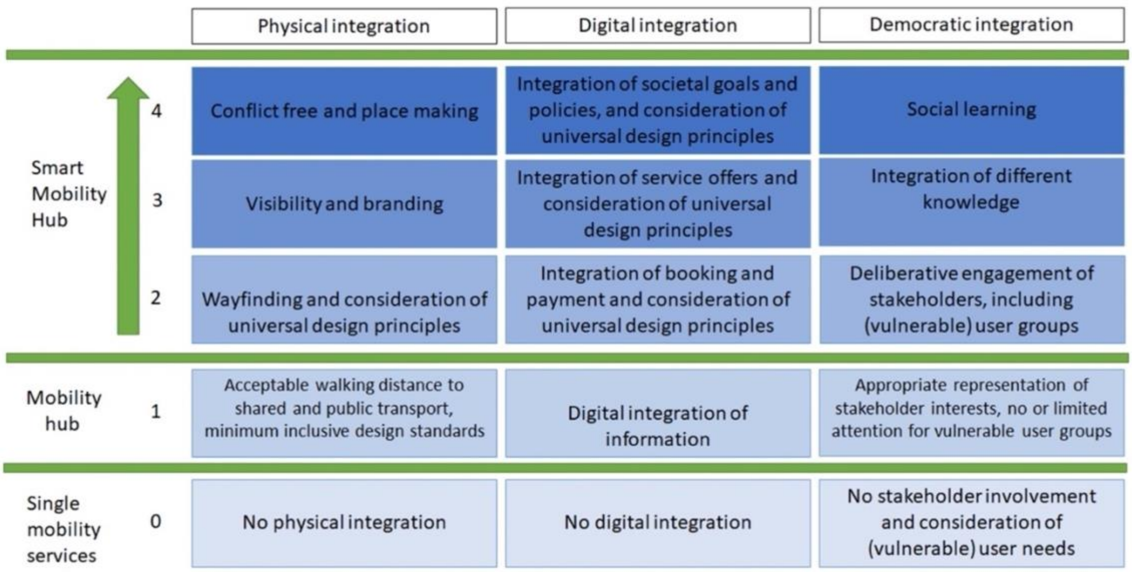


Figure 2 Mobility Hubs' ladder of integration. Source: (Geurs et al., 2021)

1.1. Objectives

Cities are willing to implement mobility hubs because of their advantages. However, given the limited land and resource availability, priorities should be established to define hub locations. Locations of MHs could be determined by considering the role of a particular hub in the mobility system, the desire for the hub, or potential level of integration. Currently, there is a gap of research on spatial factors that might be used to prioritize particular locations for the implementation of mobility hubs. Therefore, the major goal of this report is to develop a methodology for ranking several possible sites for mobility hubs starting at a macro level (e.g. neighborhoods, districts) and searching deeper at a micro level (e.g. street level) (Figure 3). Specifically, the following objectives are considered:

I. **MACRO LEVEL**

- **Rank areas / zones / neighborhoods** in the city where a mobility hub could be allocated. We called this a macro level search. In this macro-approach, the variables used to search for an area in a city to develop a mobility hub are selected according to the three main potential targets for mobility hubs mentioned above. A potential hub should: a) connect public transport, b) compliment public transport, and c) promote sustainable mobility. This approach is based on identifying spatial factors in the literature and a citizen survey. Furthermore, the identified factors could be weighted according to the decision makers' interests.

II. **MICRO LEVEL:**

- **Identify existing mobility hubs, which have not been branded as such**. Based on the MH concept, hubs may already exist within a city's transportation network. Therefore, as an intermediate step to locate hubs, existing hubs could be identified. These hubs will have a different level of physical integration (Figure 2) in terms of an acceptable walking distance, wayfinding & info, visibility, and conflicts between mobility opportunities. Within these four levels, it is possible to enhance the level of physical integration of the existing hub but not the branded hub.

- **Rank potential locations in a micro level.** This refers to the potential locations at the street level. The purpose of this is to identify and rank locations in the previously selected areas in the macro approach to either enhance the identified potential mobility hubs or to implement a new mobility hub.

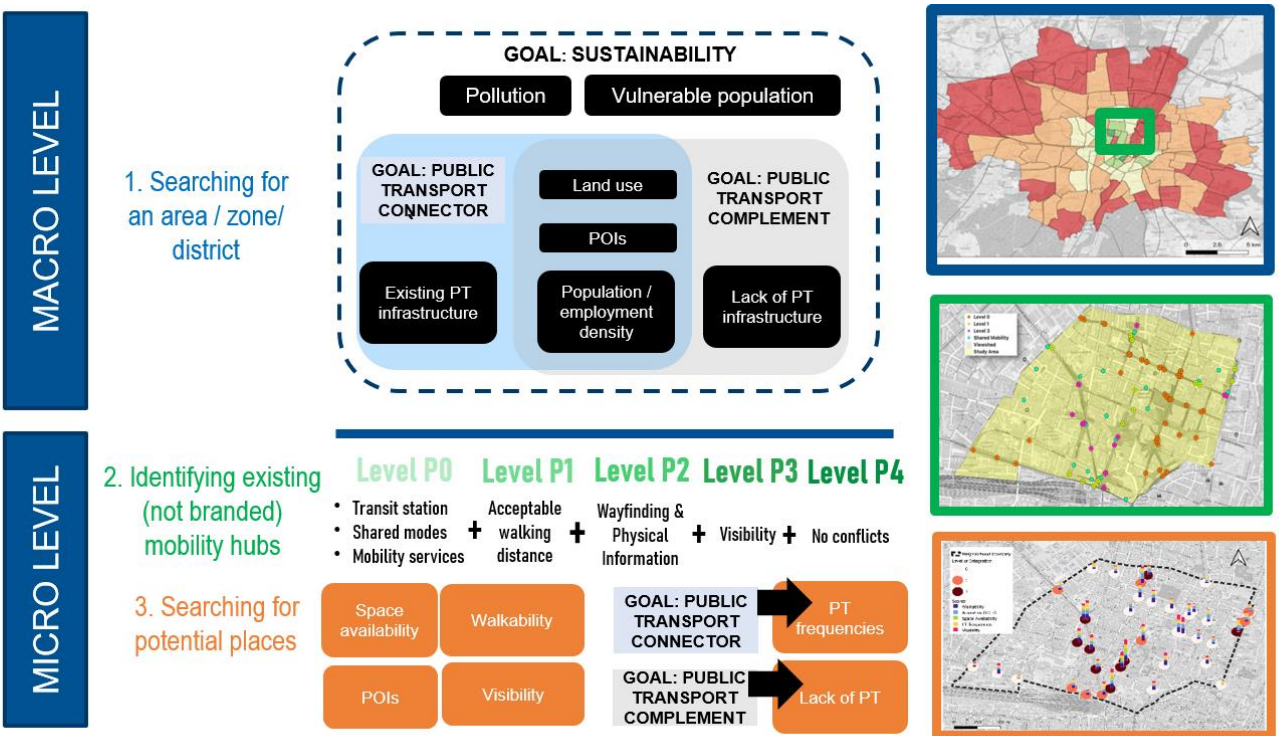


Figure 3 Methodology to rank potential locations for mobility hubs for the micro- and macro-levels.

The purpose of the proposed methodology is to guide planners, developers, and decision-makers through the process of allocating mobility hubs. Although the report considers specific cities to apply the methodology, it can be also be replicated in other contexts, as explained in the following sections. With the first macro-level approach, the report aims to provide a framework for identifying potential locations at a broader (i.e., district, neighborhood, area) level. The subsequent micro-level steps focus on first identifying existing mobility hubs. These are not branded hubs that have the potential to be further developed based on the recognized integration level. Lastly, the third approach is to find potential locations considering five aspects and how well each location can perform considering those aspects.

This report continues as follows: the second chapter of this report includes the methodology to rank neighborhoods suitable for implementing mobility hubs. In the third chapter, a tutorial with online GIS videos has been developed to identify existing mobility hubs, which have not been marked as such. The fourth chapter exemplifies the identification and classification based on selected spatial variables on specific points in the study area (existing unbranded mobility hubs). Finally, the fifth chapter covers the search for potential places, following the third methodological approach.

2. SEARCHING FOR POTENTIAL AREAS / ZONES

This chapter mainly focuses on developing a macro approach to rank areas or zones (e.g., neighborhoods or districts) to determine potential locations for mobility hubs. As a main output of the methodology, different zones in the study area (e.g., a city) will be ranked based on the weights of the selected spatial factors that are in line with the goal desired for the mobility hubs. The first step of the macro approach is to identify spatial factors that would support the ranking of the different zones. The next step is to apply a weight to these spatial factors based on the desired goal of the mobility hubs. Finally, the areas will be ranked using a GIS approach.

2.1. Identification of potential spatial factors to be considered for allocating mobility hubs

We applied four approaches for identifying potential spatial factors that should be considered for choosing areas to locate mobility hubs. The approaches were analyzed in four master theses and study projects of students at the Technical University of Munich:

I. Literature review on spatial factors associated with the allocation of mobility hubs (Ben-Hassine, 2022).
II. Literature review on spatial factors associated with the usage of different transport opportunities (Geipel, 2022).
III. Literature review on spatial factors associated with social equity and transport-related emissions (Navarro, 2022).
IV. Citizens' survey on preferred allocation factors (Klanke, 2022).

The first approach focusses solely on the factors related to mobility hubs. However, as mobility hubs integrate multiple transportation modes, approaches two and three have a broader focus, as literature from different transport modes were consulted. Lastly, the fourth approach addresses civil participation for a collaborative process applying a citizens' survey to determine the factors more highly valued by them.

2.1.1. Literature review on spatial factors associated with the allocation of mobility hubs

There is a lack of studies identifying spatial factors associated with the usage of mobility hubs, however, some studies provided recommendations. Ben-Hassine (2022) compiledthe most common spatial factors considered for implementing mobility hubs from existing literature (see Table 1). Specifically, the most important factors turned out to be a high number of amenities, cycling and pedestrian infrastructure, high population density, and mixed land uses. While the amount of public transport users per day, existence of public spaces, accessibility, and high employment rates were less commonly found in the literature. Moreover, it is worth highlighting that depending on the mobility hub goal, public transport factors can be either high service frequency at a transit station (public transport connector) or low transit coverage (public transport complement).

Table 1 Identified spatial factors commonly mentioned in the literature. Source: (Ben-Hassine, 2022)

Factors		Source																
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**
Population	High population density	✓		✓	✓			✓		✓			✓	✓	✓	✓	✓	✓
	High employment density		✓	✓	✓												✓	
Urban Structure	Accessibility				✓		✓							✓	✓			
	Central locations/ central areas		✓				✓		✓	✓	✓			✓		✓	✓	✓
	Public spaces		✓							✓	✓							
	Mixed-use development		✓	✓	✓			✓			✓				✓	✓	✓	
	High number of amenities (POIS)	✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓
Transport Infrastructure	High frequency transit station			✓	✓		✓	✓	✓					✓				
	Low public transport coverage						✓	✓	✓				✓	✓		✓		
	Cycling and pedestrian infrastructure			✓	✓	✓		✓			✓	✓			✓			
	Number of public transport users/day	✓						✓										
	Existing public transport modes	✓		✓							✓		✓	✓				

Sources: A: (CoMoUK, 2019), B: (Department of City Planning Los Angeles, 2016), C: (Shared-Use Mobility Center, 2021), D: (Aono, 2019), E: (Pfertner and Miramontes, 2017), F: (Miramontes, 2018), G: (Silva and Uhlmann, 2021), H: (Coenegrachts et al., 2021), I: (Cui, 2021), J: (Metrolinx, 2011), K: (Monzón et al., 2016), L: (Mouw, 2020), M: (Frank et al., 2021), N: (Petrović et al.), O: (Anderson et al., 2017), P: (Blad, 2021), Q: (Abd El Gawwad, 2019)

2.1.2. Literature review on spatial factors associated with the usage of different transport opportunities.

Due to the limited information found in the literature regarding spatial factors associated with the usage of the hubs, the second approach that we implemented to identify potential factors to allocate mobility hubs was to review the factors commonly associated with the usage of different mobility opportunities in the literature (e.g., bike-sharing, car-sharing, etc.), therefore not focusing on mobility hubs. The hypothesis was that if we combine the different factors studied from the different mobility opportunities, we can identify the most commonly recurring factors, which, we deduce may be the ones associated with the usage of the hubs.

Geipel (2022) carried out a literature review on spatial factors associated with the usage of different mobility opportunities. In this approach, 116 English-language peer-reviewed studies published between 2011 until March 2022 were selected. Within this literature, bike-sharing (32 studies), scooter-sharing (21 studies), car-sharing (24 studies), ride hailing and taxi services (24 studies), and charging stations for electric vehicles (15 studies) were included. These studies were selected from 324 records after a search in Google Scholar, Web of Science, and Taylor and Francis Online including the keywords *"(locati*) OR (allocati*) OR (position*) OR (distribut*) OR (allotment) OR (assign*) OR (dispersion)"* in addition to the keywords of the different mobility opportunities shown in the Table 2. The preselection was performed based on an abstract screening to identify if the articles have studied potential factors associated with usage or criteria to search for potential locations of the mobility opportunities (Figure 1).

Table 2 Keywords used for searching related studies on different mobility opportunities.

Bike sharing keywords	Scooter sharing keywords	Car sharing keywords	Rail hailing and taxi keywords	Charging stations keywords
("bike shar") OR ("bicycle shar*") OR ("bikeshar*") OR ("bicycle system") OR ("shared bike*") OR ("shared cycl*") OR ("Two-wheeler") OR ("micromobilit* shar*") OR ("shared micromobilit*") OR ("public bicycle") OR ("public bik*")*	*("scooter shar*") OR ("scootershar*") OR ("scooter system") OR ("shared scooter") OR ("Two-wheeler") OR ("micromobilit* shar*") OR ("shared micromobilit*") OR ("public scooter") OR ("shared electric scooter") OR ("shared e-scooter")*	*("car shar*") OR ("carshar*") OR ("car system") OR ("shared car*") OR ("public car") OR ("shared electric car") OR ("shared e-car") OR ("vehicle shar*) OR ("shar* vehicle")*	*"ride hail*") OR ("ridehail*") OR ("ride system") OR (ridesourc*) OR ("ride sourc*") OR ("shared rid*") OR ("taxi") OR ("taxi servic*) OR (uber) OR (lyft) OR ("transport* network company") OR (TNC) OR ("ride pool*") OR (ridepool*))*	*("charg* station") OR (chargingstation) OR ("e-charg* station") OR (electric vehicle charg*) OR ("electric public charg*") OR ("charg* infrastructure")*

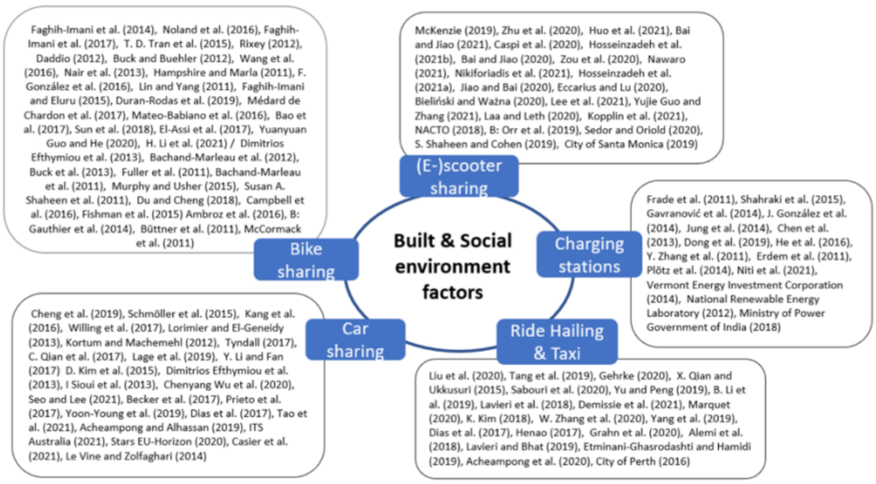


Figure 4 Identified studies classified by the related mobility service. Source: (Geipel, 2022)

The identified factors were categorized by Geipel (2022) into social and built environment characteristics, which were further divided into factors and subfactors. These factors are in line with Cervero's 3 D's: density, design, and diversity (Cervero & Kockelman, 1997). The social environment encompasses sociodemographic characteristics and general population attributes such as population and employment (density). Another category is the built environment which includes topography, activities, a.k.a. POIs (diversity), transport and urban infrastructure (design).

In order to rank the most identified factors, the following process was implemented. First, each factor got a point if it was identified as positively associated with the usage of a mobility opportunity. Second, if the association was negative the factor gets a negative point. Since each mobility opportunity has different number of studies, the sum of points was normalized using min-max normalization, in which the maximum sum has a score of 1 and the minimum a score of 0. Moreover, if a factor was not studied in certain mobility opportunity, it received a score of zero. In the end, we summed all the scores of each mobility opportunity and we ranked them. The factor with the highest sum of scores gets the first ranking position. The lowest ranking positions consist of the factors that were least identified in the literature or those found to have a negative influence.

Results, shown in Table 3, concluded that the top-ranked factors associated with usage of the different mobility opportunities that were most often identified are: population & employment density, public transport infrastructure, recreational POIs, affluent and highly educated households, commercial areas, educational facilities, active modes infrastructure, and car ownership. It is worth highlighting that these factors are not ranked based on the most influential variables, but the variables that were found most often in different studies, and may not necessarily be important/influential for the given dependent variables.

Table 3 Identified studies classified by the related mobility service. Source: (Geipel, 2022)

			Bike Sharing n=32		Scooter Sharing n=21		Car Sharing n=24		Ridehail/Taxi n=24		Charging Station n=15		Total n=116	
Groups	**Factors**	**Sub-Factors**	**Sum**	**Score**	**Sum**	**Score**	**Sum**	**Score**	**Sum**	**Score**	**Sum**	**Score**	**Sum Score**	**Total Rank**
Social Environment	Population	City Population	4	0.36	0	0.00	4	0.42	2	0.23	2	0.29	1.29	14
		Population Density	12	**0.68**	4	0.33	11	**1.00**	12	**1.00**	7	**1.00**	**4.01**	1
		Employment Density	16	**0.84**	7	**0.58**	6	**0.58**	12	**1.00**	6	**0.86**	**3.86**	2
	Socio-Demography	Household Income (Affluence Neighbourhood)	6	0.44	9	**0.75**	8	**0.75**	10	**0.85**	4	**0.57**	**3.36**	5
		Household Size	3	0.32	0	0.00	-1	0.00	-1	0.00	3	0.43	0.75	20
		Household Car Ownership no or Low)	1	0.24	1	0.08	5	**0.50**	6	**0.54**	4	**0.57**	**1.93**	10
		Household/Personal Education Level	3	0.32	4	0.33	7	**0.67**	9	**0.77**	5	**0.71**	**2.80**	6
Built Environment	Topography	Slope (Hilly Terrain)	-5	0.00	1	0.08	0	0.00	0	0.00	0	0.00	0.08	33
	Urban Structure	Distance city center	9	**0.56**	8	**0.67**	3	0.33	0	0.00	2	0.29	**1.85**	11
		Commercial/Retail activity	13	**0.72**	8	**0.67**	6	**0.58**	4	0.38	3	0.43	**2.78**	7
		Mixed Land use	5	0.40	6	**0.50**	3	0.33	2	0.23	1	0.14	**1.61**	12
		Residential Land use	7	0.48	5	0.42	2	0.25	1	0.15	2	0.29	1.59	13
		Institutional Land use	0	0.00	2	0.17	-1	0.00	0	0.00	0	0.00	0.17	31
	Transport Infrastructure	Overall Public Transport	17	**0.88**	7	**0.58**	9	**0.83**	7	**0.62**	5	**0.71**	**3.63**	3
		Metro (Subway)	8	**0.52**	1	0.08	1	0.17	2	0.23	0	0.00	1.00	17
		Railway Station	5	0.40	0	0.00	1	0.17	1	0.15	0	0.00	0.72	22
		Bus Stop	2	0.28	2	0.17	2	0.25	-1	0.00	1	0.14	0.84	19
		Taxi Stop	1	0.24	0	0.00	0	0.00	0	0.00	0	0.00	0.24	32
		Micro Mobility or Car Sharing Stop	1	0.24	0	0.00	0	0.00	0	0.00	0	0.00	0.24	32
		Major Roads	-2	0.12	1	0.08	0	0.00	5	0.46	3	0.43	1.09	16
		Minor Roads	1	0.24	3	0.25	0	0.00	5	0.46	2	0.29	1.24	14
		Intersection Density	-2	0.12	2	0.17	0	0.00	3	0.31	0	0.00	0.59	24
		Embankment Road	1	0.24	1	0.08	0	0.00	0	0.00	0	0.00	0.32	29
		Active-Mode Infrastructure	20	**1.00**	10	**0.83**	2	0.25	3	0.31	0	0.00	**2.39**	9
		Airport Proximity	0	0.00	0	0.00	1	0.17	2	0.23	0	0.00	0.40	26
		Parking Lots	0	0.00	0	0.00	2	0.25	3	0.31	1	0.14	0.70	18
	POIs Recreation	Overall Recreation POIs	4	0.36	12	**1.00**	6	**0.58**	8	**0.69**	6	**0.86**	**3.49**	4
		Cinema	3	0.32	0	0.00	0	0.00	0	0.00	0	0.00	0.32	28
		Hotel	0	0.00	0	0.00	1	0.17	3	0.31	0	0.00	0.47	23
		Food Businesses	9	**0.56**	4	0.33	2	0.25	1	0.15	0	0.00	1.30	15
		Tourist Attractions	0	0.00	3	0.25	0	0.00	0	0.00	0	0.00	0.25	27
		Parks	6	0.44	1	0.08	-1	0.00	2	0.23	0	0.00	0.75	21
		Public Squares	0	0.00	0	0.00	0	0.00	1	0.15	0	0.00	0.15	30
		Sports Centers	1	0.24	0	0.00	0	0.00	1	0.15	0	0.00	0.39	28
	POIs Business	Financial Institutions	-1	0.16	0	0.00	0	0.00	2	0.23	0	0.00	0.39	28
		Educational Facilitis	7	0.48	6	**0.50**	5	**0.50**	7	**0.62**	2	0.29	**2.38**	8
		Medical Instituitions	-1	0.16	0	0.00	1	0.17	3	0.31	0	0.00	0.63	25

2.1.3. Literature review on spatial factors associated with social equity and transport-related emissions.

The third approach was to review social and environmental factors in order to meet the potential sustainable mobility goal of mobility hubs. Navarro (2022) performed a literature review on spatial factors commonly studies in relation to social equity (Table 4) and environmental issues (Table 5). Given the limited literature on those topics, the study took into account literature sources from transport studies and not exclusevely to those referring to mobility hubs. The most common factors considered in social equity approaches correspond to low income, elderly population, unemployed populations, low accessibility, and low car ownership. For the environmental category, emissions, air pollution (e.g., traffic emissions such as CO2, NOx, and PM), and noise were the factors most frequently found on the consulted literature.

Table 4 Identified social equity factors from spatial studies.

Category	**Criteria**	**Sources**												
		a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**m**
Socio demographics	Low income			X	X	X	X	X	X	X	X		X	X
	Elderly population		X				X	X		X	X		X	X
	Migrant population & minority ethnic groups		X										X	
	Unemployed population		X					X	X		X		X	
	Low education level							X					X	
	Gender						X						X	
Social conditions	Public/affordable housing				X									
	Population with disabilities		X				X				X		X	
	Population not able to drive a car						X							
	Low public transport affordability						X							
	Housing conditions (quality & tenure security)		X										X	
	Health and well-being status												X	
	Single parents' households		X							X	X		X	
	Population dependent on public transport											X		
Spatial location	Low accessibility	X	X	X				X	X		X	X	X	X
	Low economic participation								X					X
	Low political participation								X					X
	Rural communities	X									X		X	
Transport related	High traffic fatalities rate													
	Low car ownership (zero-car households)	X		X	X				X		X			X

Sources: a: *(Frank et al., 2021),* b: *(Zakowska & Pulawska, 2014),* c: *(Allen and Farber, 2020),* d: *(Anderson et al., 2017),* e: *(Tran and C. Draeger, 2021),* f: *(Litman, 2007), g: (Caggiani, 2020),* h: *(Currie et al., 2010), i: (Páez et al., 2009),* j: *(Lucas et al., 2018),* k: *(Yodan Rofé et al., 2015),* l: *(Lucas et al., 2016a),* and m: *(van Wee, 2011).*

Table 5 Identified environmental factors from mobility spatial studies.

Criteria	Sources							
	a	b	c	d	e	f	g	h
Air pollution	X	X	X	X	X	X		X
Noise	X	X	X					X
Traffic volume/flow and congestion				X			X	
Vehicle traveled distance					X	X		
Mode share						X		

Sources: a: *(Litman, 2017),* b: *(Martens, 2016),* c: *(*Manaugh et al., 2015*),* d: *(Lucas,2016b),* e: *((Making Equity in Mobility Pilots, 2019),* f: *(Kinigadner and Büttner, 2021),* g: *(Blad, 2021),* h: *(Anderluh et al., 2020).*

2.1.4. Citizens' survey on preferred allocation factors

Finally, as a fourth approach, Klanke (2022) conducted a short online survey (n=159) in December 2021. In this survey, citizens in Munich, Germany were asked about their preferred location for potential mobility hubs. Table 6 shows the different sociodemographic characteristics of the sample, which mostly includes people younger than 34 years old, highly educated, students, and full-time workers. In this survey, one of the questions was that the participants had to decide which of the spatial factors they would like to have in a mobility hub close to them. The most important spatial factors (Figure 5) for the sampled citizens were related with mobility hubs being close to people's residency & workplace, public transport stops, university, public squares and leisure activities (Klanke, 2022).

It is worth mentioning, as the author also points out, the limitations of the conducted survey. This survey does not reflect the interests of the general population and vulnerable groups. Furthermore, the survey was available only online, consequently, people without access to such resources and people with no digital abilities could not take part. Another limitation of the methodology is the underrepresentation of certain minorities, such as gender diverse people or the elderly, who were not represented within the survey respondents.

Table 6 Characteristics of the survey participants. Source: (Klanke, 2022).

Variable	Characteristic	n	%	Variable	Characteristic	n	%
Gender	Female	82	51.6	**Education**	No university degree	23	14.5
	Male	76	47.8		Bachelor	56	35.2
	Diverse	1	0.6		Master	69	43.4
					Doctor	11	6.9
Age	18-24	32	20.1	**Occupation**	Student	64	40.2
	25-34	84	52.8		Full time job	62	39.0
	35-50	22	13.8		Retired	4	2.5
	51-65	16	10.0		Part-time job	14	8.8
	>65	5	3.1		Other	10	9.5

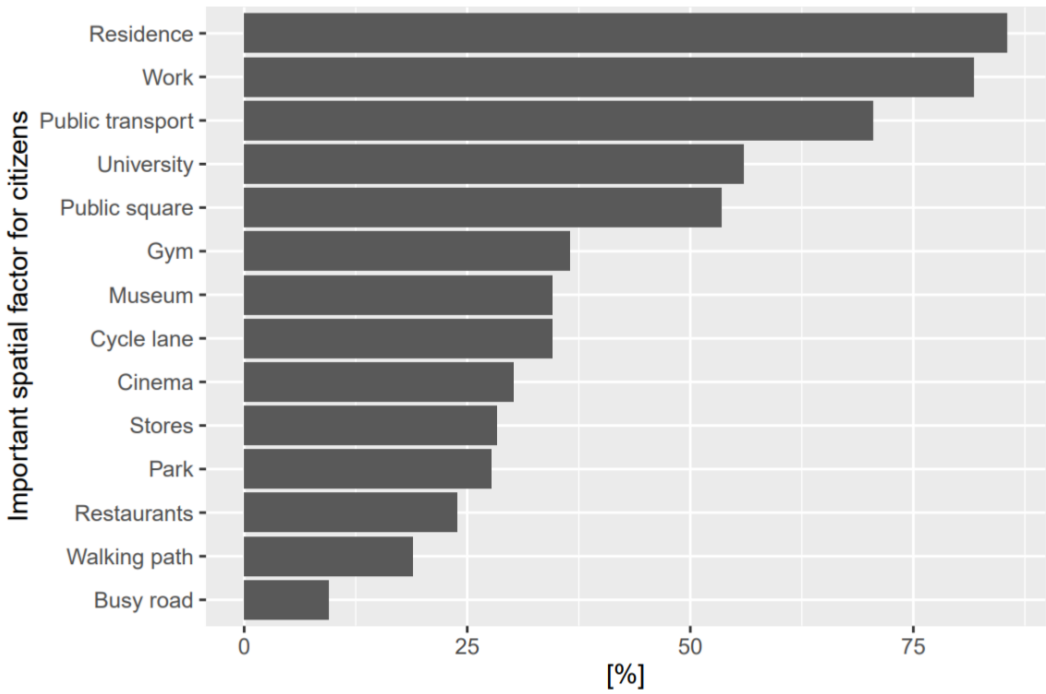


Figure 5 Spatial factors influencing the location preferences of the survey participants. Source: (Klanke, 2022)

2.2. Weighting spatial factors

Different factors may be more or less relevant when searching for hub locations in different contexts, cities, or areas. Therefore, the previously identified factors could be weighted in relation to the goal of the mobility hub and interest of users and decisions makers. As shown in Equation 1, an overall ranking score (RS) for a "j" spatial unit of study (e.g., neighborhood, district, cells, analysis zones) can be achieved by summing the different "i" factors "F" multiplied by the "i" weights "W". Since different factors have different measurement units, these variables should be normalized, for example, by using a min-max or a z-score approach. The overall sum of the weights should be 1 (or 100%).

$$RS_j = \sum_{i}^{n} normalized(F_i) * W_i \qquad \text{where} \sum_{i}^{n} W_i = 1 \qquad (1)$$

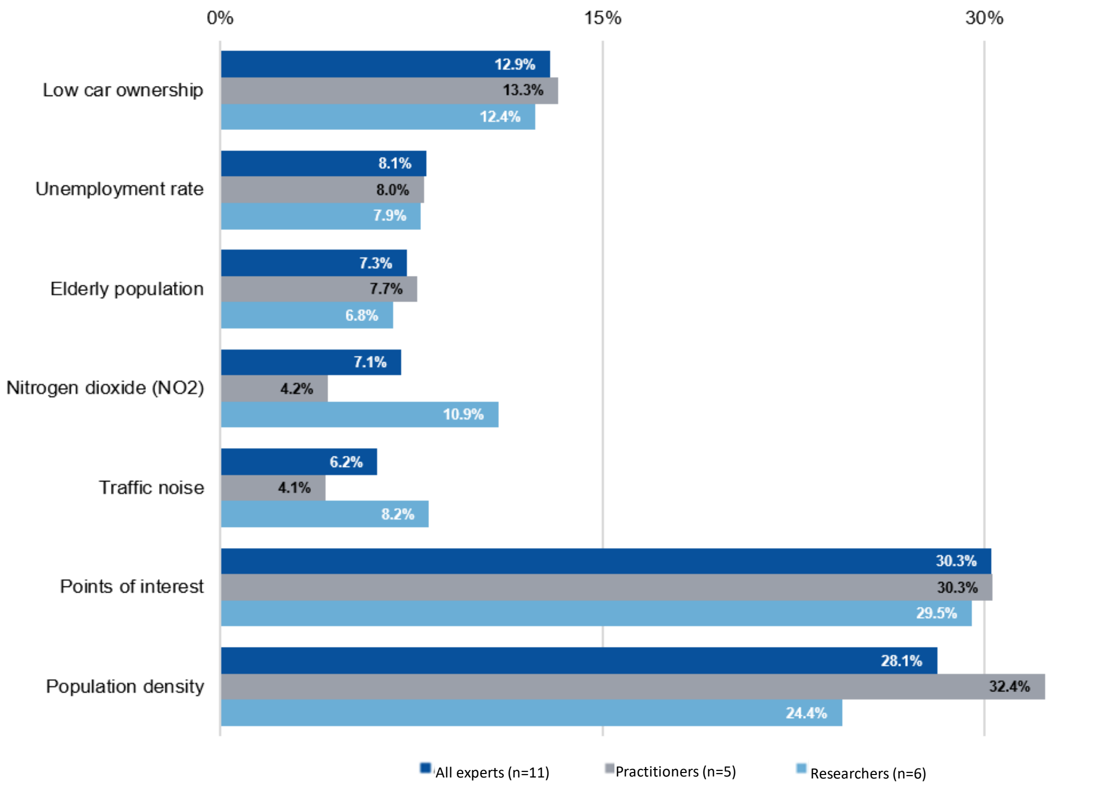
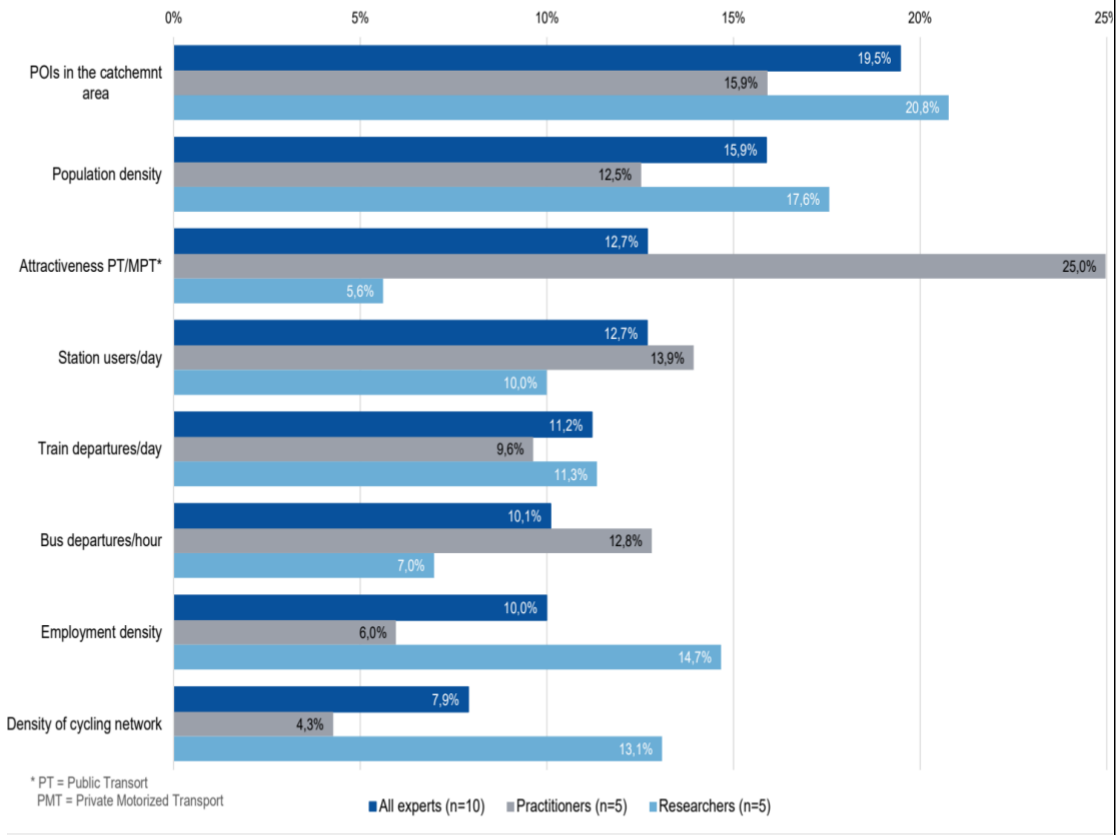
The weights are based on the importance of each spatial factor and could be chosen and set according to mobility policies, mobility hubs' goals, citizens and other stakeholders involved in the planning process (planners, developers, mobility providers, decision-makers). In this latter case, the importance of the involved variables can be assigned by the stakeholders themselves. Alternative

ways of choosing the weights can be based in the most common factors found in the literature or also the preferred location found from the citizens' survey, as explained in the previous sections.
Moreover, as an alternative to reduce subjectivity by choosing the different weights, a third approach is to use the Analytical Hierarchical Process (AHP). This method has been frequently used in multi-criteria analysis to allocate resources considering the interests of involved stakeholders (Saaty, 1987 and Goepel, 2018). The weights in this approach are obtained through pairwise comparisons of all the spatial factors. In these comparisons, the participants (or stakeholders) assign a value from 1-9 based on their judgement on the relevance of each factor compared to the others remaining to reach a specific goal; in this case, it should be to allocate mobility hubs. The numbers are arranged in a matrix nxn, where n is the number of factors, to calculate the individual weights (Saaty, 1987, Goepel, 2018, Brunner et al., 2011).
The individual judgements are then aggregated to calculate the final weights (Goepel, 2018., Aguarón et al., 2019., and Aull-Hyde et al., 2006). A particular characteristic of the method is the need to calculate the consistency of the results. For this, using the maximum eigenvalue of the comparison matrix the consistency ratio is calculated; consistent values should be below 0.1 (for more details on the method see Saaty, 1987., Goepel, 2018., and Brunner et al., 2011). It is worth highlighting that AHP has been widely used in the transportation planning field (Anderluh et al., 2020; Anderson et al., 2017; Blad, 2021; Brunner et al., 2011). One limitation of the method is that, according to Goepel (2018) and as Anderluh et al., (2020) mentioned, the number of considered factors should not be more than 9 to keep an adequate consistency ratio.
To exemplify, we conducted two AHP approaches including the perspectives of practitioners and academic researchers with two different goals: a) sustainable mobility, b) public transport connector at railway stations (see Table 7). The factors selected were those most frequently cited in the literature (see Table 1, Table 4, Table 5). Finally, Table 8 shows the results of the different weights of the AHP approach.

Table 7 Practitioners and researchers surveyed for the AHP approach

Experts group	Number of consulted experts	Local context	Represented institution
Academic researchers	2	Belgium, Brussels.	Vrije Universiteit Brussel.
	1	Münster, Germany.	University of Münster.
	2	Wien, Austria.	University of Natural Resources and Life Sciences. Technical University of Wien.
	1	Munich, Germany.	Technical University of Munich.
Practitioners	1	Fürstenfeldbruck, Germany.	City of Fürstenfeldbruck.
	1	Hamburg, Germany.	Hamburger Hochbahn AG.
	1	Offenburg, Germany.	City of Offenburg.
	2	Munich, Germany.	City of Munich.

Table 8 AHP results with two different goals: Sustainability and Public transport connector

<table>
<tr><th>GOAL</th><th>AHP Results</th></tr>
<tr><td>Sustainability</td><td>
</td></tr>
<tr><td>Public transport connector at railway stations</td><td>
</td></tr>
</table>

2.3. GIS approach for ranking areas to implement mobility hubs

Now, after having identified the different factors and established the respective weights, the next step is to identify or rank the zones of a city for implementing a mobility hub. The method starts with establishing the desired target for the mobility hub, i.e., connect public transport, compliment public transport, promote sustainable mobility (as explained in the in the introductory section of this report). Second, the spatial factors associated with the target are collected for each specific case and aggregated into a spatial level of study (e.g., traffic analysis zones, postal areas, districts, neighborhoods, etc.). We recommend choosing the factors shown in Table 9, which is a summary of the resulting factors identified using the different approaches in the previous section. Third, we apply Equation 1 to obtain a ranking score for each zone of analysis. Finally, decision-makers should choose one or several areas to implement mobility hubs based on those results. In this step, it is recommended to choose the highest-ranking scores. The results could be used to explore different scenarios with various factors and weightings to have a wider range for decision making. Some examples of these different scenarios are explained in the following paragraphs.

Table 9 Identified potential spatial factors for selecting an area for implementing mobility hubs

Literature on mobility hubs	Usage Literature on mobility hubs components	Citizens' survey	Social Equity	Environmental

• Population density,
• POIs
• cycling and pedestrian infrastructure,
• mixed land use.
• public transport:
  o transit station with high service frequency
  o low transit coverage
	• Population & employment density,
	• public transport infrastructure,
	• leisure POIs,
	• household income
	• commercial areas,
	• educational facilities,
	• cycling and pedestrian infrastructure,
	• car ownership.
		• People's residency & work location,
		• public transport infrastructure,
		• university,
		• public squares
		• leisure POIS
			• low income,
			• elderly,
			• unemployed,
			• low accessibility,
			• low car ownership.
				• air pollution
				• noise

To exemplify how various scenarios could look, we considered seven different weighting alternatives of spatial factors. Three of the scenarios considered the results (weights) from the AHP approach, explained in the previous section (section 3.2). Specifically, scenario one considers the weights from the practitioners, based on the AHP approach (Figure 6), another one deals with the results from the academic experts (Figure 7), and the third AHP approach considers the combined results from the two groups of experts (Figure 8). The four remaining ranking scenarios aim to convey the special focus on only one of the sustainability elements, i.e., efficiency (Figure 9), social equity (Figure 10), or environment (Figure 11). Lastly, the final focus is given equal weights to all the considered factors (Figure 12). The following figures (Figures 6-12) represent the ranking scores for each of the previously described cases.

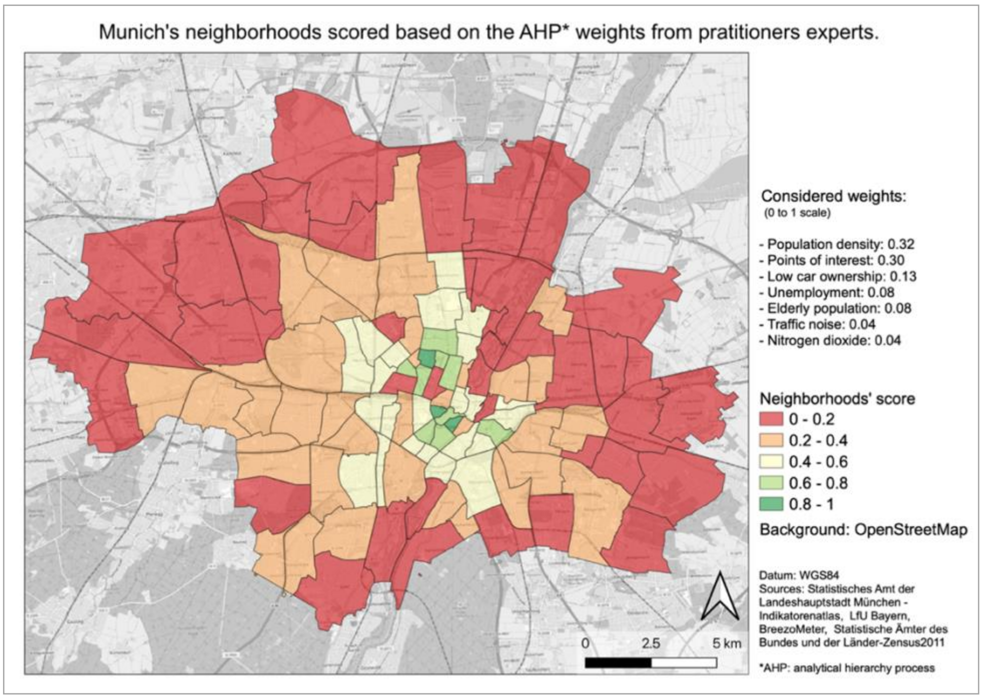


Figure 6 Ranking score based on assigned weights by practitioners using the AHP approach

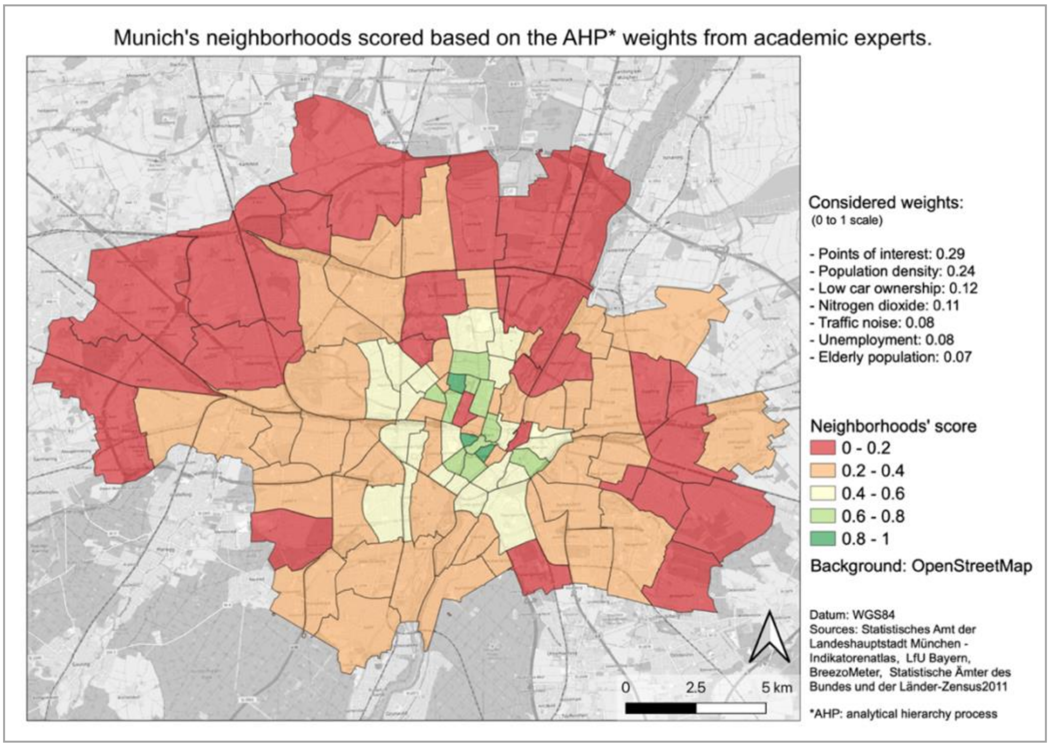


Figure 7 Ranking score based on assigned weights by experts from academia using the AHP approach

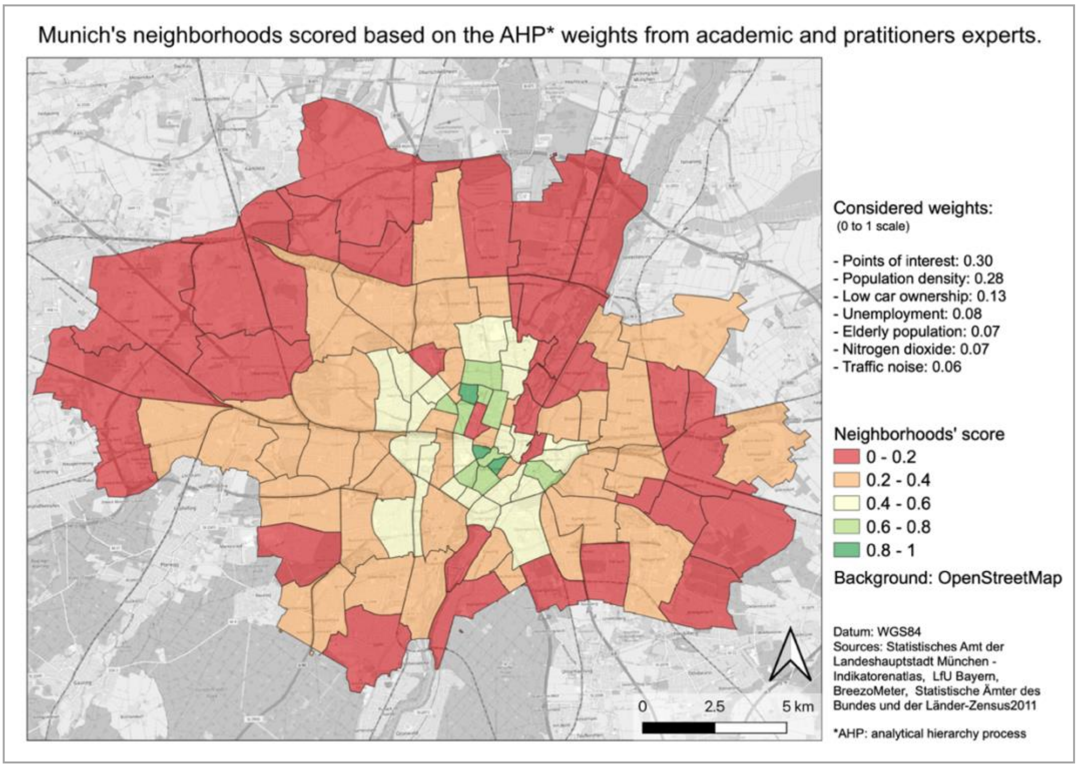


Figure 8 Ranking score based on the combined weights assigned using the AHP approach

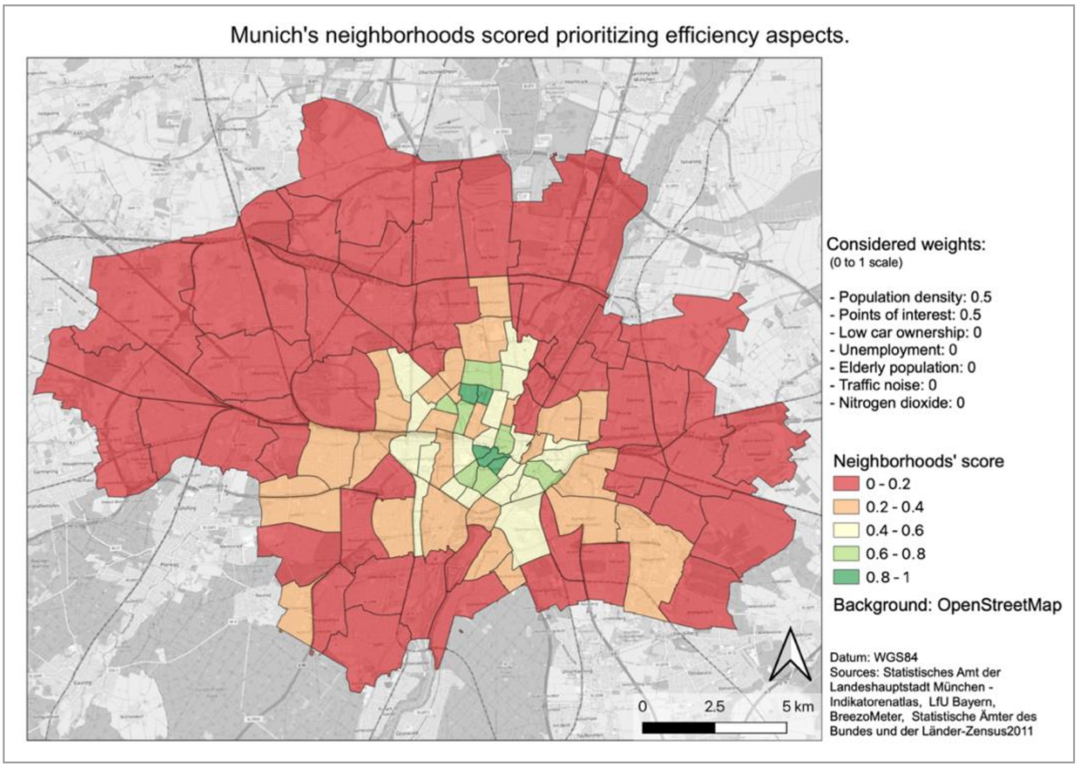


Figure 9 Ranking score prioritizing only the considered efficiency aspects

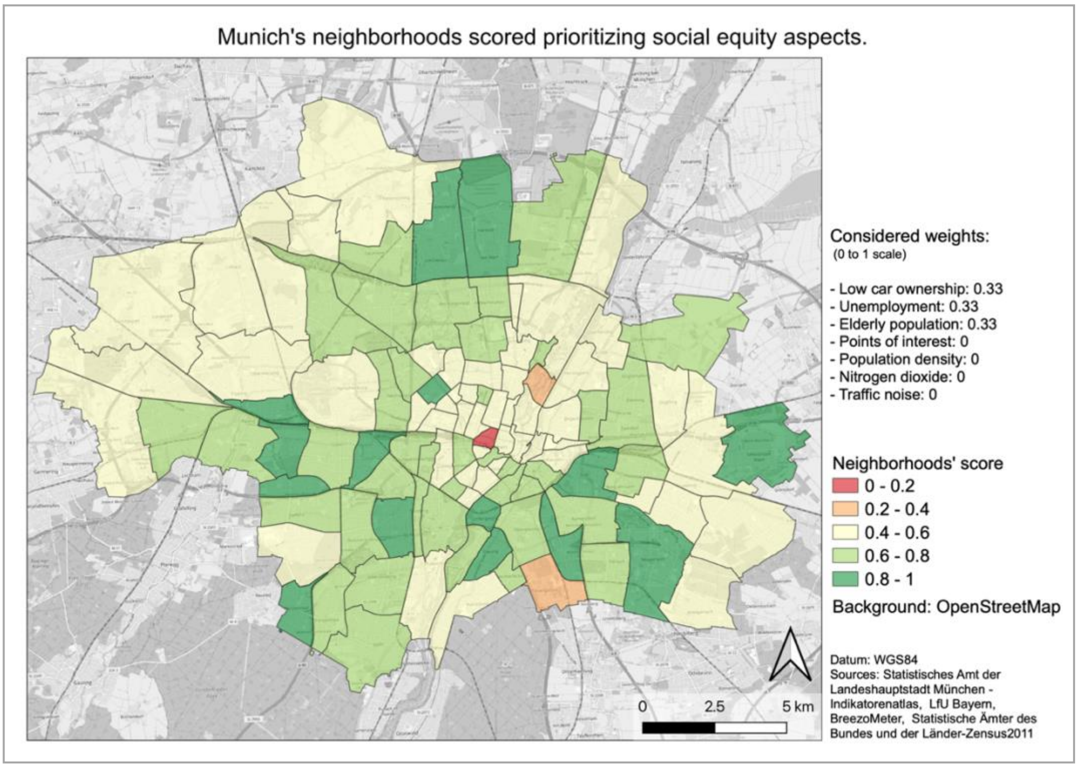


Figure 10 Ranking score prioritizing only the considered social equity aspects

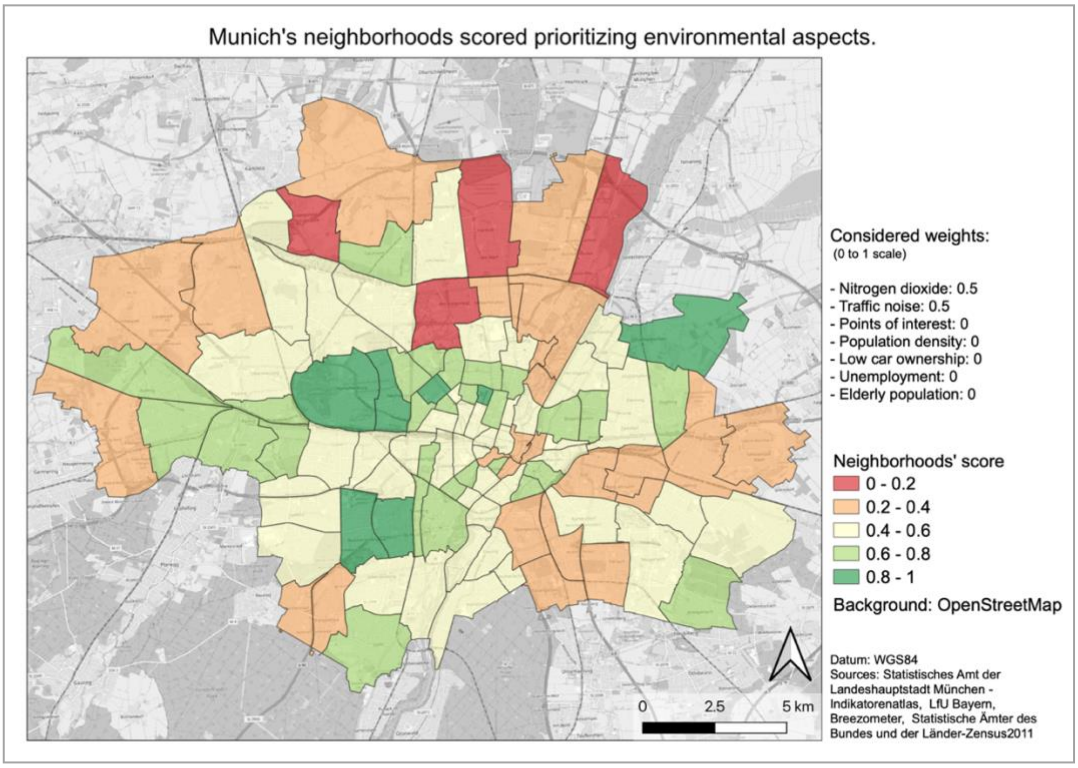


Figure 11 Ranking score prioritizing only the considered environmental aspects

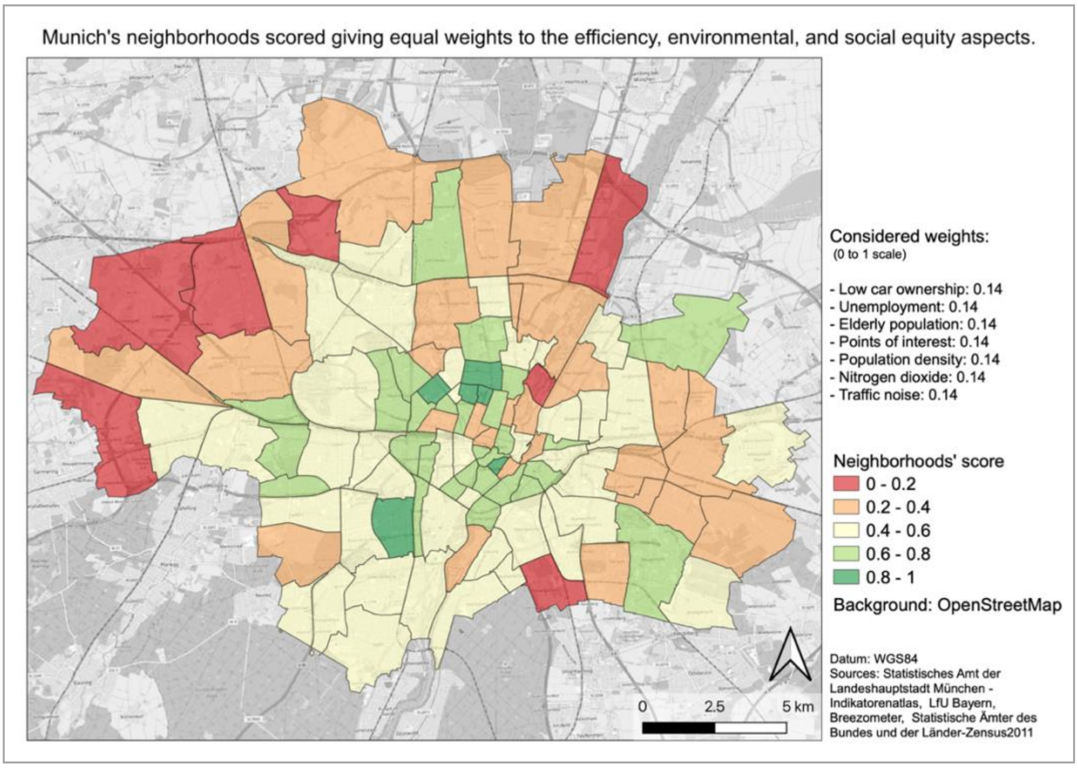


Figure 12 Ranking score giving equal weights to the considered sustainability aspects

3. IDENTIFYING EXISTING (NOT BRANDED) MOBILITY HUBS

According to the previously used definition of mobility hubs, physically connected mobility opportunities already exist in the urban space. The objective of this step is to identify where in the urban space mobility hubs exist but are not branded as such. Thus, the planner has two options: a) to implement a mobility hub where there are no physically integrated mobility opportunities or b) to improve the physical integration of existing integrated mobility opportunities.

The prerequisites of the next step on finding a location of mobility hubs are based on:

- The selected area or zone from the previous chapter.
- Goal of the mobility hub.
- Existing mobility opportunities.
- The new hub should be implemented from level zero or an upgrade of existing infrastructure.

3.1. Physical levels of integration

Smart Mobility have can have different levels of integration: physical, digital, and democratic (Figure 2)(Geurs et al., 2022). In terms of physical levels of integration, five levels (P0, P1, P2, P3, P4) were identified with the objective that a user feels that mobility opportunities (see Figure 1) are physically integrated. Each level is linked with a different variable: presence of mobility opportunities (P0), acceptable walking distance between mobility opportunities (P1), wayfinding & info between mobility opportunities (P2), visibility between mobility opportunities (P3), few conflicts between mobility opportunities (P4) (Figure 13).

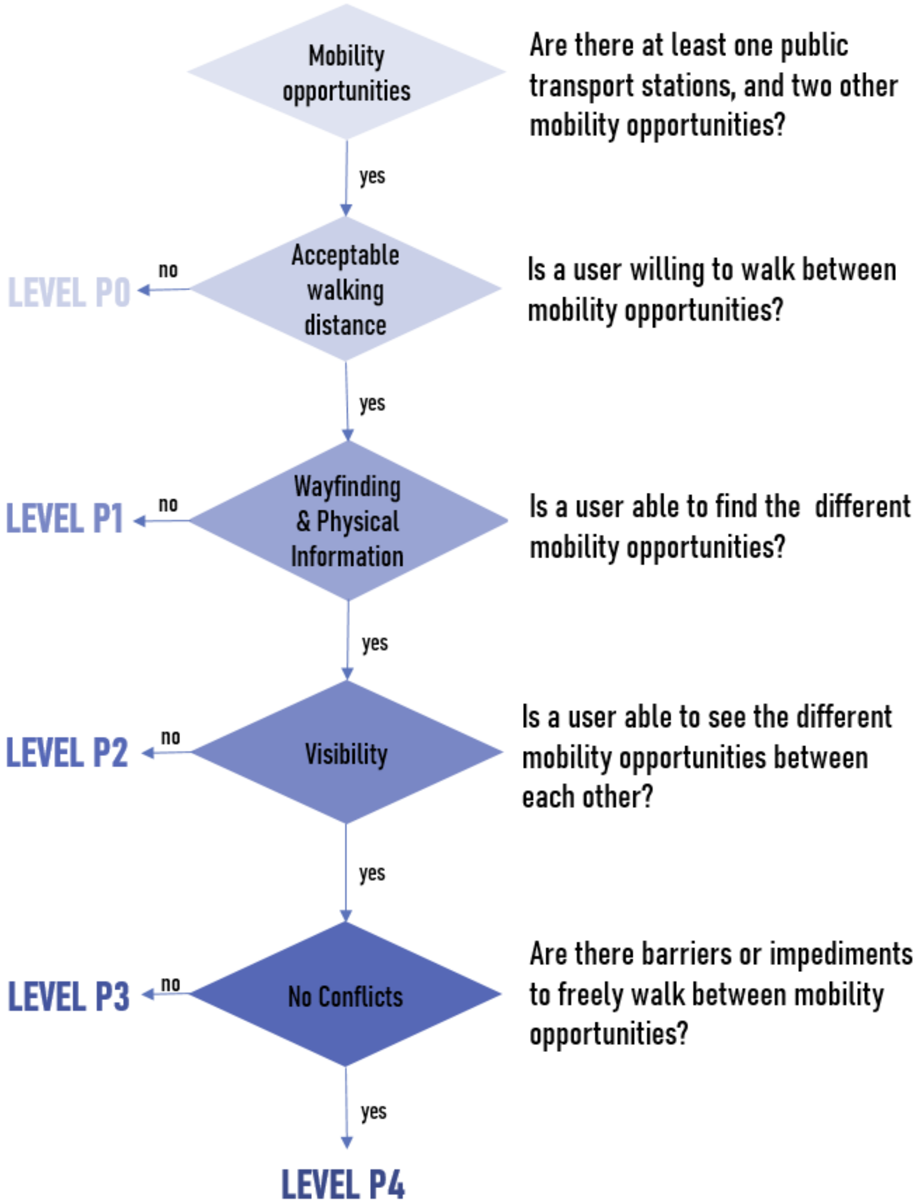


Figure 13 Theoretical framework to estimate the level of physical integration

3.1.1. Acceptable walking distance

The first questions to be asked for the assessment of the levels of integration are:

- Is a public transport stop and at least two mobility opportunities with a dedicated spot (e.g. shared mobility) within an acceptable walking distance available?
- Is a user is willing to walk (or move) between these options?

A P1 level (Figure 14) would match the positive answer to these questions, otherwise it would be a P0 level (Figure 15). The acceptable walking distance or time that a user is willing to walk between mobility opportunities is usually between 250-500m meters or between 3-5 minutes walking time (see Table 10).

Table 10 Acceptable walking distance and time to mobility opportunities. Source: (Geurs et al, 2021)

Reference	Max. walking time	Reference	Max. walking distance
Indrakesuma, 2018	5 min	Bolger et al., 1992	250m
I Luo et al., 2021	5 min	Mouw, 2020	300-500m
Nielsen, 2005	3 - 5 min	Wright & Hook, 2007	500m
Blad, 2021	5 min	Nielsen, 2005	300-400m
		Blad, 2021	400m
		CoMoUK, 2019	400-800m

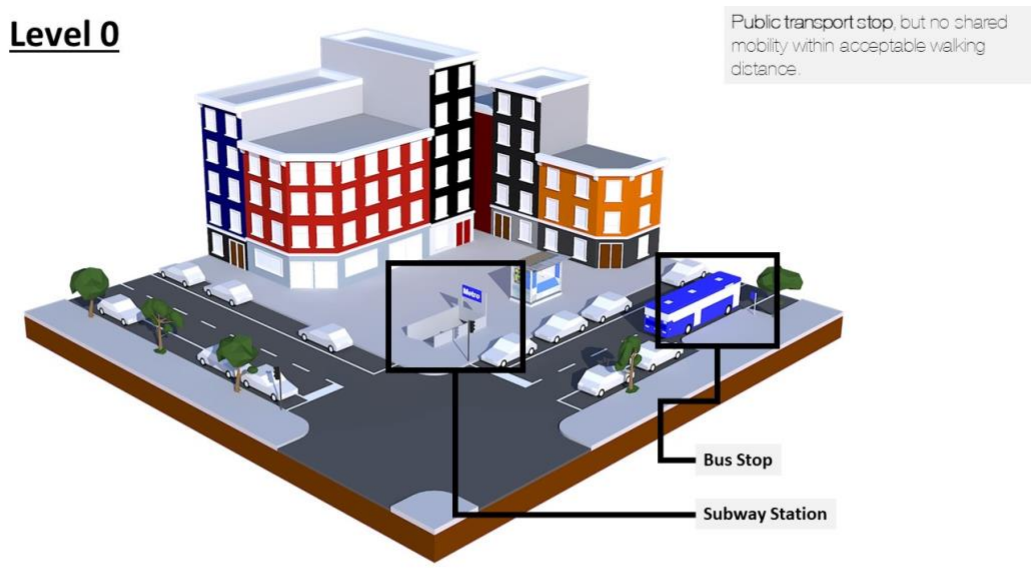


Figure 14 Level P0: no acceptable walking distance between mobility opportunities

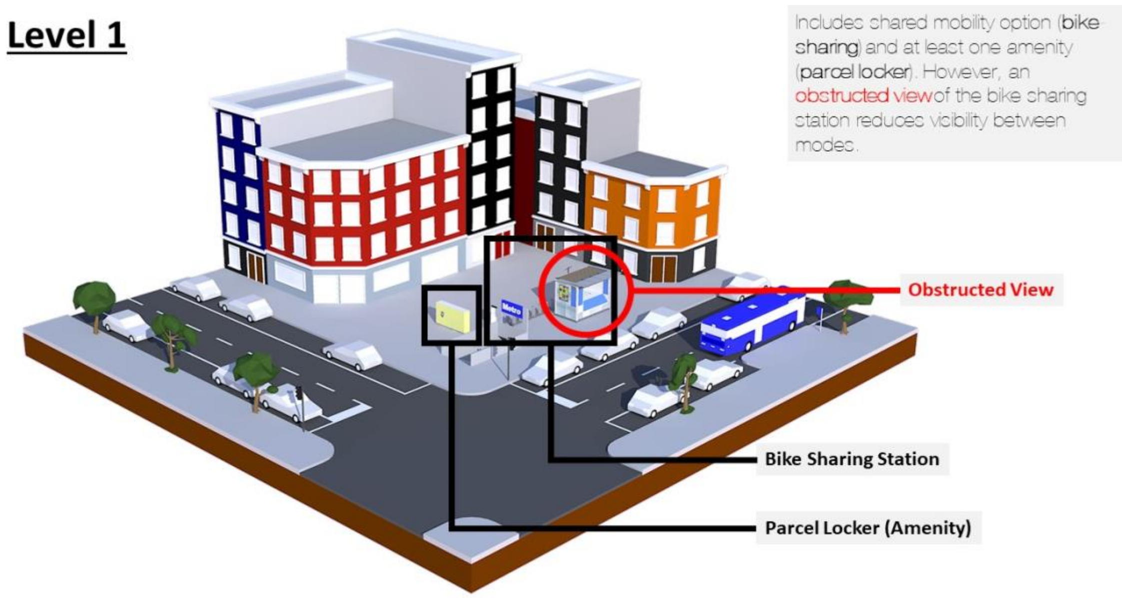


Figure 15 Level P1: acceptable walking distance between mobility opportunities

3.1.2. Wayfinding and info

A P2 level of integration is achieved when users can find the different mobility opportunities even though they are not next to each other (Figure 16). Wayfinding information may work as a guide to provide seamless connection between different transport modes and the surrounding environment in such a way that the (potential) traveler is guided to make use of the mobility hub. A clear, uniform design of the wayfinding and information displays is required, especially at the larger hubs or the hubs where different transport and additional services are not located next to each other. In this section, a brief overview on the type of elements and their importance is given. The information compiled below has been covered on previous mobility hubs guidelines that have been consulted during the development of this project, including: Aono, 2019; CoMoUK, 2019, 2021; Johansson, Bramryd, et al., 2021; Miramontes, 2018; Monzón et al., 2016. However, the SmartHubs deliverable D3.3. will elaborate this topic in more detail.

Efficient wayfinding starts even before one arrives at the mobility hub. From a user's perspective, it is useful to communicate not only information about the transfer options offered by one operator, but also to include information about transport services provided by other operators. For example, this can be done by using maps that give information about different operators. Once one has arrived at the mobility hub, it is important that all services are located in close proximity of each other. When services are not located in close proximity of each other, three types of physical wayfinding and info might guide the user: 1) horizontal marks, 2) vertical signs, and 3) informative maps.

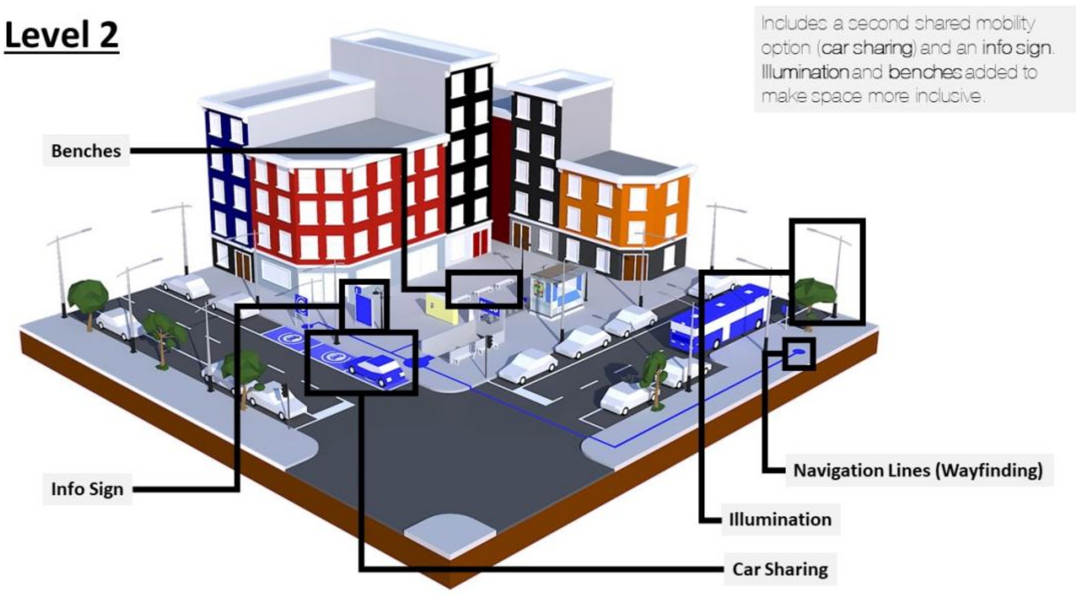


Figure 16 Level P2: wayfinding and info between mobility opportunities

Horizontal marks are distinctive and visually recognizable elements at the ground level that direct the user towards the different transport modes and services. Examples of horizontal marks are pavement textures, guiding lights, and guidance paintings. Pavement textures make it possible to differentiate the transport modes and transition areas, as well as provide guidance for visually impaired users. Guiding lights or floor-level lights improve visibility and safety, especially for pedestrians. This could be a group of aligned elements or a continuous light strip. Additionally, users can be guided to the transport option they need by means of specific painting or sticker placement on the ground. Guidance paintings can be color-coded painting on the floor, as well as textures that can be used to distinguished between the various modes and services. Sticker placement or ground painting can provide a cheap, yet efficient, solution to provide directions to both transport and other services and can also provide an estimated transfer time on foot. It is recommended that icons are integrated to the sticker placement for instance, for travelers that are not familiar with the local language.

Vertical signs could be signposting or digital pillars. Signposting may be needed at the hub to physically integrate the different services by indicating direction, distance, and time. A (digital) pillar or information board can serve as an easy-to-recognize landmark for travelers. Not only does such a pillar increase visibility of the mobility hub and allow users to orient themselves, it can also allow users to use this pillar if any further information on the location of the different services, on departure times, prices, etc. is required. Ideally, the (digital) pillar or information board is located in close proximity to at least one of the mobility services. An example of a good practice can be found at Leibnizplatz in Bremen, Germany; the pillar that indicates the 'Mobil.Punkt' is located next to the bike racks and cambio-carsharing station (Figure 17). Optionally, the placement of stickers or arrows on the ground can be used to guide travelers and residents to the information board or pillar as well as to the other services. Ideally, all modes of transportation and additional services should be visible from the centrally placed information board or pillar (Aono, 2019; CoMoUK, 2019, 2021; Johansson, Bramryd, et al., 2021; Miramontes, 2018; Monzón et al., 2016).

To help travelers find their way around the mobility hub and location of the elements of the hub, (digital) maps have to be included on the pillar as well. If users do not know where a mobility service is located, they can walk towards the pillar, which serves as a landmark, and consult the (digital) map to find where the service they need is located.

Figure 17 Mobility point in Bremen. Source: M. Glotz-Richter, 'Der Verkehr, Die Stadt und die "mobil.punkte" - wie Carsharing das Klima schützt.' in: Klimaschutz und Mobilität. Beispiele aus der kommunalen Praxis und Forschung - so lässt sich was bewegen (Cologne, 2013) pp. 76-87, there p. 82.

To increase visual identity of the network of mobility hubs, uniform branding of the network of hubs is valuable and useful. In other words, the authorities have to make sure that the branding of the hubs in a city or region are the same.

To make sure that people who do not speak the local language can make use of the mobility hub in an optimal fashion, it is important to prioritize symbols over text and to provide travel information on the wayfinding and information in multiple languages. For example, for people with a visual impairment, the pillar should include basic tactile information and should, ideally, provide audible information as well. To ensure that the visually impaired can transfer easily from A to B, physical interventions should be made when developing the hub. Physical interventions might involve using bubble pavements, adding short poles or lighting/colored contrasts at a crosswalk, adding tactile pavements to ensure safer guiding, avoiding overly curvy paths, creating barriers/fencing between footpaths and roads, and utilizing sounds at traffic lights. To make sure that people in wheelchairs can use the mobility hub as smoothly as possible, it can be useful to use a moveable screen at the digital pillar that can be adapted to the height of the person in a wheelchair, or to make sure that the information on the (analogue or digital) pillar is not placed too high. To ensure a smooth transfer between modes, it is recommended to make use of lowered footpaths.

3.1.3. Visibility

If a user can see the different elements of the hubs between each other, a P3 level of integration is achieved (Figure 18). In this level there are no visual barriers between the different elements.

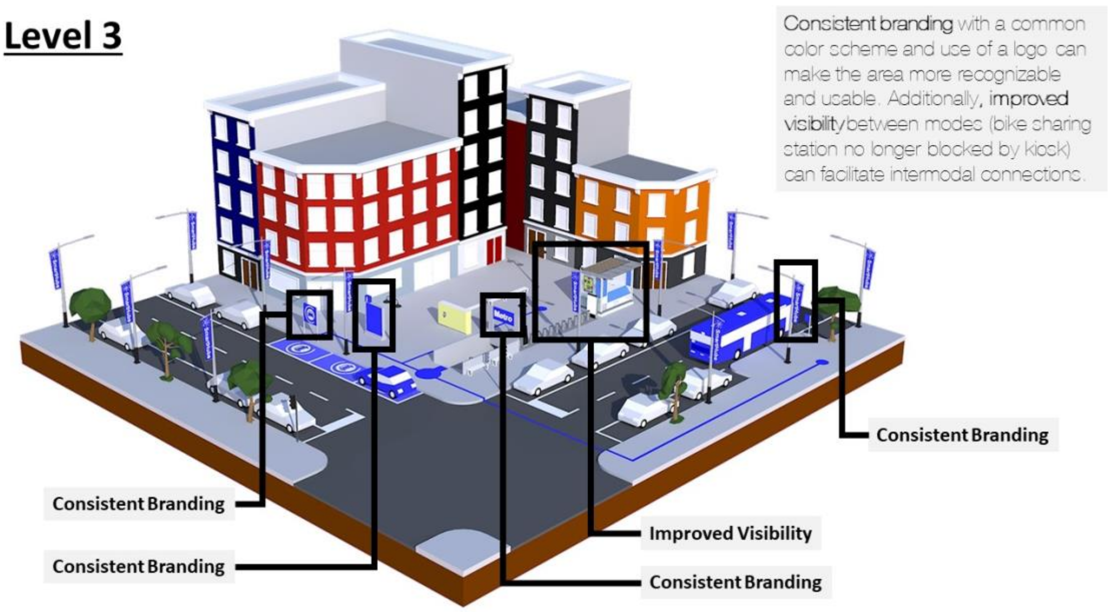


Figure 18 Level P3: All mobility opportunities are visible to each other

3.1.4. Conflicts

P4 level of integration (Figure 19) is achieved where there are no conflicts between the opportunities. Conflicts might arise when multiple transport modes converge, especially with high flows, and in highly dense and mixed urban areas mainly due to a lack of space (Bertolini, 2008). Various sources indicate the most typical conflicts occur between motorized vehicles, pedestrians, and cyclists (Choe et al., 2021., and Petrović et al., 2019). Some examples are conflicts between cyclists who ride in the bike lane and cars parked on the street, bikes outside the parking racks blocking the way of the pedestrians (Miramontes, 2018), and waiting or crossing passengers hindering free flow of other users (Conway et al., 2013; and Urban Design Studio, 2016).

For this reason, the consideration of the design and distribution of the space designated to each mode and service in a mobility hub is essential to reduce potential conflicts. For instance, misplacing bike parking infrastructure, cycling lanes, and points of access to public transport might interfere with the flow of users of other modes. Another important, related aspect is the design and location of the entrances to the hub. Those should be designed in order to avoid potential detours and difficult turns to enter the mobility hub, which might be problematic and inconvenient for the users as documented by Miramontes (2018). This is particularly applicable for users of the parking spaces or Park&Ride, Kiss&Ride, etc. (Petrović et al., 2019; Urban Design Studio, 2016).

Based on the previous information, we categorized conflicts mainly in two types: a) Conflicts between modes and users, and b) Conflicts related to access and connections (Figure 20). Porter et al. (2016) described 6 guiding principles for minimization of conflicts on multimodal networks:

- Safety: design a place to minimize potential crashes.
- Accommodation and comfort: provide access to all type of users and ensure all related modes are properly included in the design.
- Coherence and predictability: design each the facilities for each mode in a consistent and recognizable way. This includes right of way and wayfinding.
- Context sensitivity: the design is consistent and supports the surrounding land uses.
- Experimentation: try innovative solutions and configurations to solve multimodal conflicts.

To complement this information to reduce these potential conflicts, we have listed in

Figure 21 potential questions that could be asked to identify them. Additionally, a pedestrian and cyclist flow analysis in the area can always be useful to identify specific potential conflicts (Porter et al., 2016).

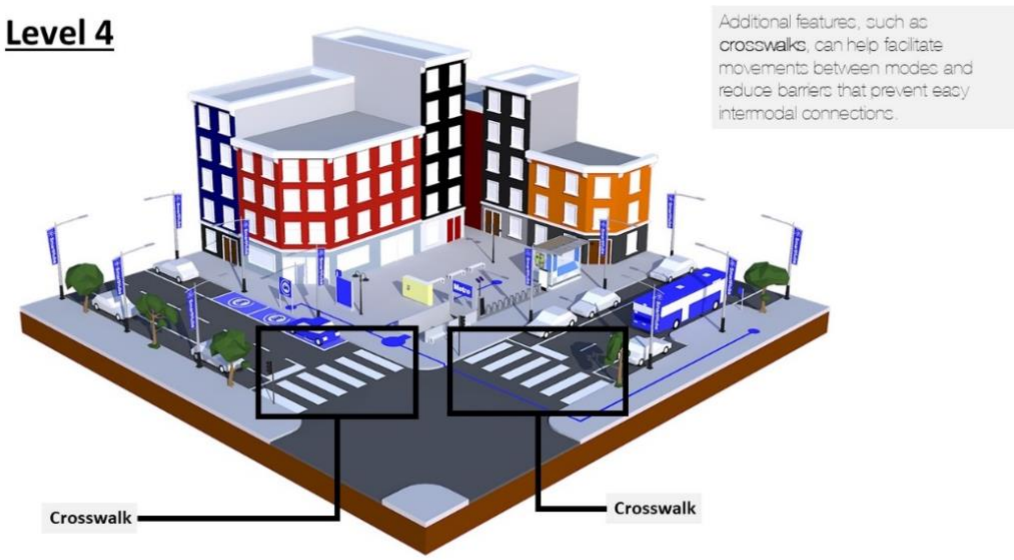


Figure 19 Level P4: no conflicts between the mobility opportunities

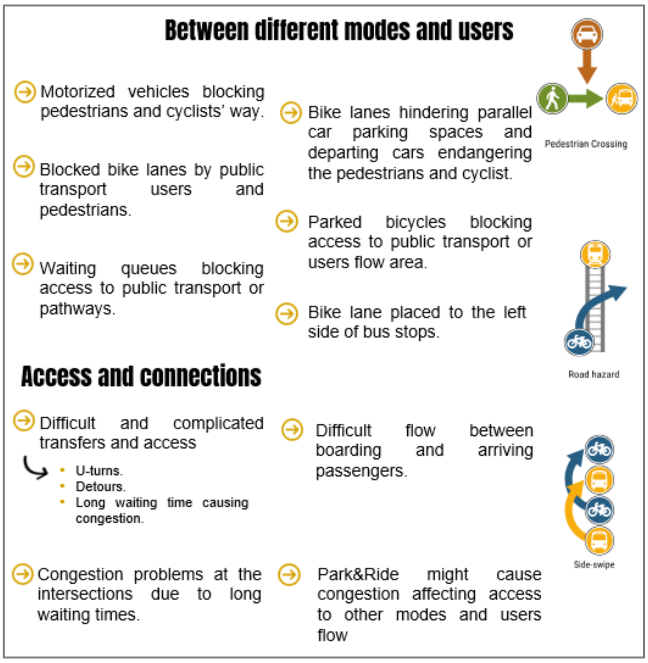


Figure 20 Potential types of conflicts

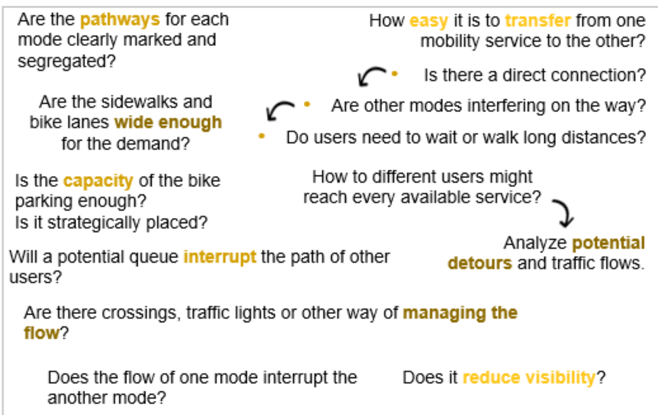


Figure 21 Questions to identify potential conflicts that may affect seamless and intermodal multimodal connection

3.2. Method for identifying the different physical integration levels

Based on the factors identified above and the chosen study area, we can look for existing mobility opportunities that have formed mobility hubs, however, they have not been branded as such. Therefore, to search for a potential location of a mobility hub, we will first identify the existing mobility hubs which have not been branded as such at different integrations levels: P0, P1, P2, P3, and P4.

For this purpose, we have prepared a GIS (Geographic Information System) tutorial using the QGIS-software (open source software) to identify transit stations at levels P0, P1, and P3. The levels P2 and P4 are not identified in the analysis due to limited or nonexistent spatial data on wayfinding, mode orientation, and mode conflicts. Therefore, when we identify in the methodology a level P1, it can be P1 or P2 and also if we identify a level P3, it can be P3 or P4, as the missing information on the previously addressed topics may or may not upgrade the level (Figure 22). Figure 23 shows an outcome of the QGIS analysis of potential P0, P1, and P3 (levels) locations within the Maxvorstadt neighborhood in Munich, Germany. However, our step-by-step instruction should be replicable in most cities with the necessary data and software.

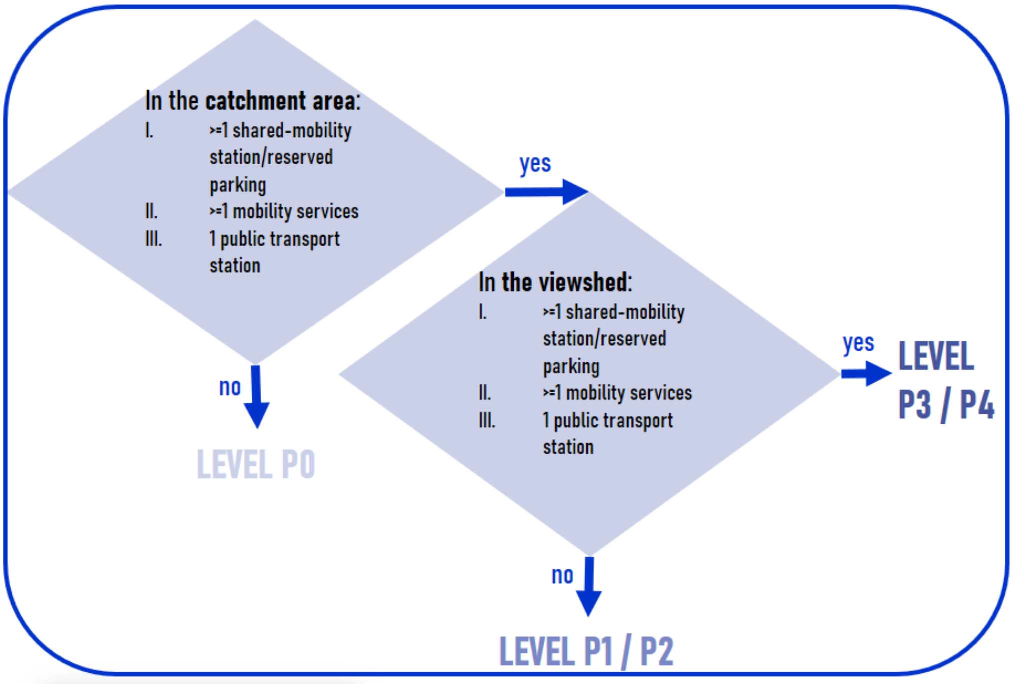


Figure 22 Summary of the GIS method for identifying the level of physical integration

The main four parts of the tutorial are as follows: first, we prepare the analysis by collecting spatial data and updating software settings. Second, we create catchment areas from transit stops to analyze which mobility opportunities are in the proximity of the transit stop. Third, we define a visibility area form transit stops, where we can count the mobility opportunities visible from the transit stops. Finally, if mobility opportunities exist in the visibility area of a transit stop, we label it as Level P3. Otherwise, if mobility opportunities exist only in the catchment area of the transit stop, we label it as Level P1. Again, we refrain from identifying P2 and P4 due to above-mentioned reasons. If a transit stop is not labelled as Level P1 or Level P3, we label it as Level P0, meaning there are no mobility opportunities close to the transit stop (Figure 22).

Figure 23 Identified existing mobility hubs and shared mobility opportunities in the study area.

3.2.1. Video tutorials

Video tutorials demonstrate this using the software QGIS (Figure 25, Figure 24) to show a step-by-step process. In addition, if the user of this guideline does not have previous knowledge of GIS, Figure 24 shows tutorials for learning the basics of QGIS.

Figure 24 Video tutorials for identifying levels of integration of mobility hubs

Figure 25 QGIS basics video tutorials

3.2.2. Analysis Definitions

Catchment Areas

In our analysis, we use the terms "acceptable walking distances", "catchment areas", and "convex hulls" interchangeably. They are all defined by the acceptable walking distance of 250 meters as discussed in in Section 4.1.1. However, to create a layer of this on a map, we must create a catchment area, which is the area that is serviced around each transit stop. In QGIS, the term convex hull is used to represent a "catchment area". A convex hull in QGIS is essentially the minimum coverage area from a point or set of points. In our case, we set the distance to 250m, providing irregular diamond shapes around transit stops. However, as demonstrated in Figure 26, other distances can be set.

Viewpoints and Viewsheds

Another important concept to understand is viewpoints and viewsheds. Viewpoints are essentially points at a transit stop from which a pedestrian enters or exits a transit mode. From there, a viewshed can be calculated. A viewshed is a visibility boundary from an observer's point of view of the area. In our case, we take into the account the height of buildings (at a uniform 50m) as obstructing vision. An example of this is in Figure 27, which demonstrates the extent to which a pedestrian can see other service options from a transit station.

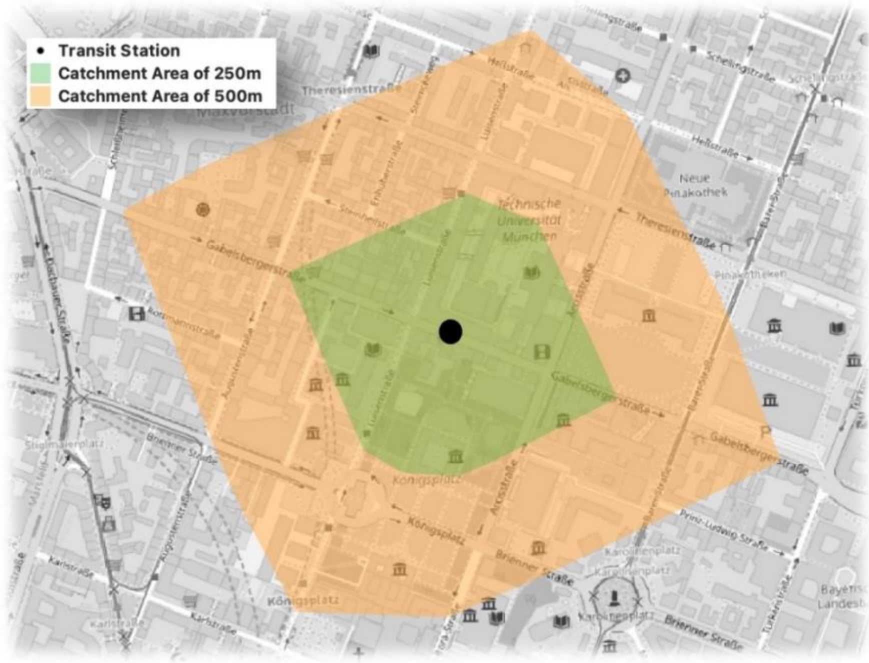


Figure 26 Catchment Areas of 250m and 500m from a Transit Station in Maxvorstadt, Munich

Figure 27 Viewshed of a pedestrian from a transit station in Maxvorstadt, Munich

3.2.3. Pre-Analysis Steps

This QGIS tutorial aims to identify the level of physical integration of potential or existing mobility hubs. We will start by carrying out some pre-analysis steps which include updating the plugins, setting the correct projections, adding a base-map, downloading existing open-source spatial data information, and finally, projecting each individual layer. The example takes place within the

Maxvorstadt district of Munich. However, the steps can be replicated for any city. The steps are summarized in Figure 28.

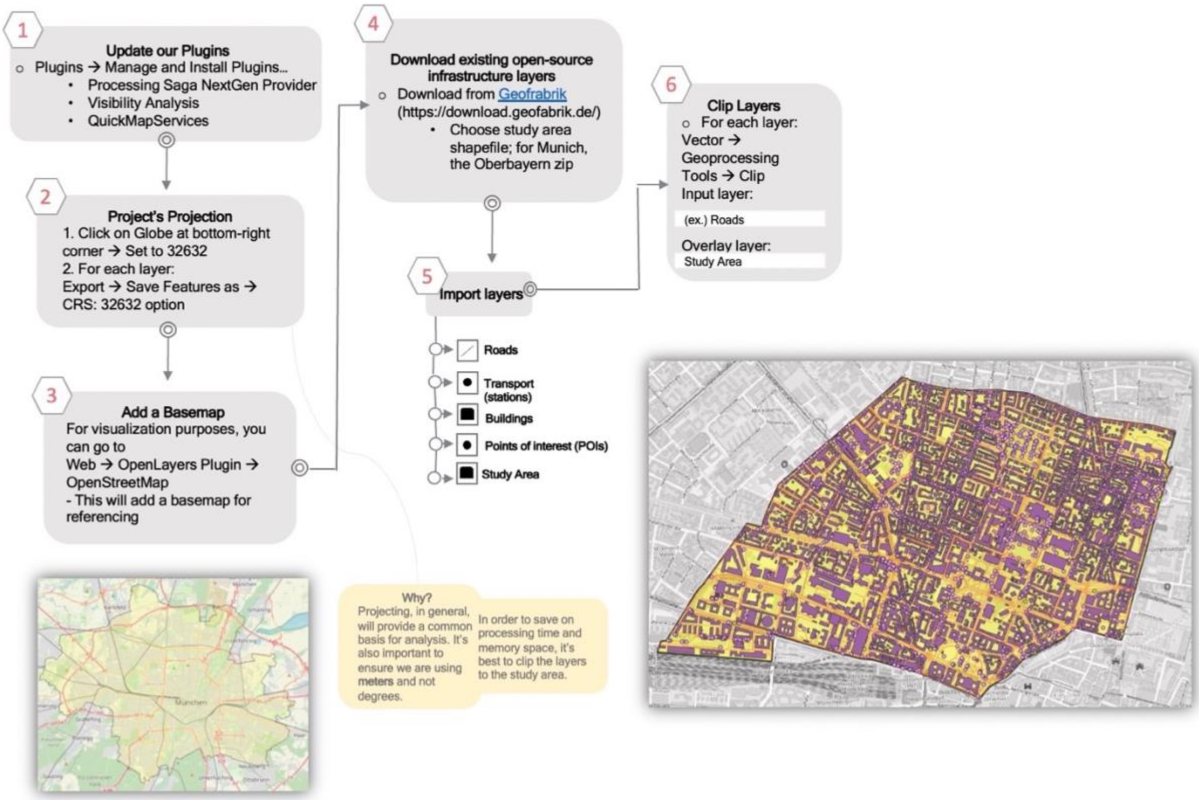


Figure 28 Pre analysis steps

1) *Update the plugins.* To begin, we will install the plugins "QuickMapServices" for access to OpenStreetMap basemaps, "Visibility Analysis" for the ability to conduct an analysis on pedestrian viewpoints, and "Processing Saga NextGen Provider" to be able to rasterize layers.
2) *Project's projection.* We need to set the correct projection. Specifically, this needs to happen in order to conduct the analysis in meters instead of the default setting of degrees.
3) *Add a basemap to the project.* In this step, we add a background map to orient ourselves in the analysis and better understand the locations.
4) *Download existing open-source infrastructure layers.* In our example, we obtain spatial data information from the open-source data project "*Geofrabrik*" (download.geofrabrik.de). You can find open-source spatial data for most cities in the world on this site. The data comes from OpenStreetMap.
5) *Import our layers into QGIS.* In this step, we need to import all of the layers into QGIS to be able to analyze them.
6) *Clip each layer to the study area shapefile.* To finalize our pre-analysis steps, we crop all the layers to the specific study area boundary.

3.2.4. Catchment areas from transit stops

In this section, we will create catchment areas from transit stops. These catchment areas are essentially acceptable walking distances from transit stops (see Table 10). We will begin by creating a layer of mobility opportunities, and then creating a catchment area layer (Figure 29).

7) *Create a mobility opportunities layer (e.g., shared mobility layer)*. We will conduct this step by creating a shared mobility opportunities layer, using extracted car sharing and bike sharing features from the points of interest layer. By extracting and then combining these features, we will have our mobility opportunity layer.
8) and 9) *Create catchment areas.* The catchment areas we will be creating are considered "convex hulls" within QGIS, however, it still represents the acceptable walking distance we would like to consider (discussed in Section 4.2.1). The result is often in the form of irregular diamonds, demonstrated in Figure 29

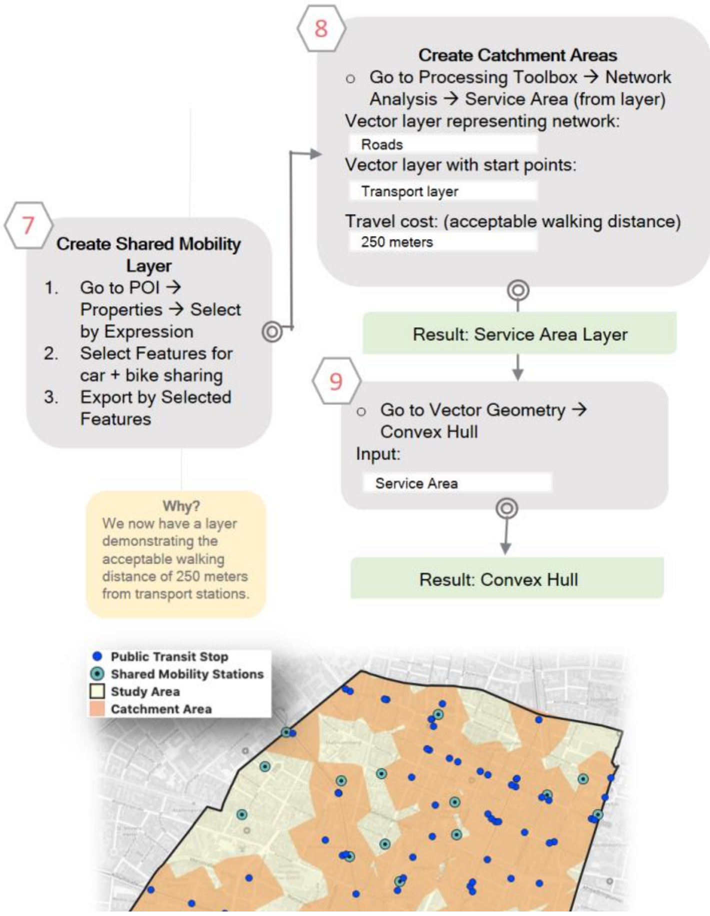


Figure 29 Catchment areas from transit stop

3.2.5. Viewpoint within mobility services

In this section, we will be working on the visibility analysis from the pedestrians' point of view at a public transit stop. The outcome of this analysis will be a boundary layer of a pedestrian's free and unobstructed view. The main viewpoint will begin from a pedestrian's location at a public transit stop and include other options that can be viewed within a user-chosen distance (discussed in Section 4.2.1).

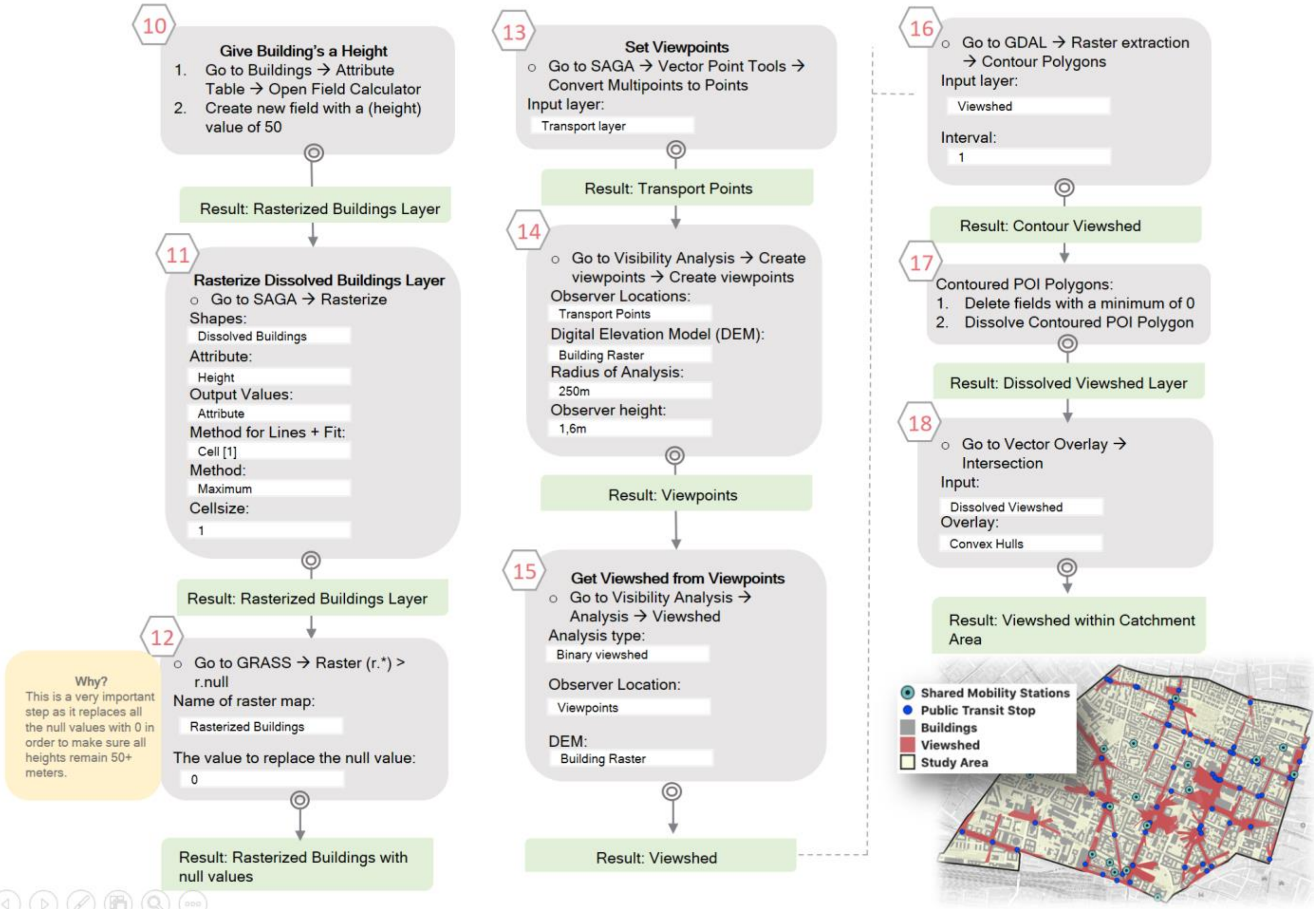


Figure 30 Viewshed area form transit stops

10) *Give buildings a height*. In this step, we will need to assign a height of 50 meters to the buildings layer. This will essentially create a viewing obstruction and attempt to simulate the reality of a pedestrian's experience. It will also allow us to capture the areas on the street which are visible to pedestrians.
11) *Rasterize dissolved buildings.* This will transform a vector layer into a raster layer, with a value for 0 as the street level and 50 as the height of the building. This will allow us to perform the viewshed analysis later (Step 14-16).
12) *Check that the height values are numerical.* Since some of the results may be 'null' values and not 0, the analysis may not be able to compute that null is the street level. For that, we will have to convert the null values into 0's.
13) *and 14) Set Viewpoints.* The viewpoints are essentially created from the transit stations. They will be the same point but will represent an observer instead of a transit station. Moreover, a height is given to the observer height (e.g. 1.6 meters). This is simply an average height. It is then analyzed against the height of the buildings within a radius of 250 meters, which is our acceptable walking distance.
15) and 16) *Get Viewsheds from Viewpoints.* The viewshed analysis is the maximum boundary of visibility for a pedestrian. The result is a constellation pattern along the streets (Figure 27).
17) and 18) In order to better visualize the viewsheds, we will remove the parts of the layer with a value of 0. This will ensure we can see the relevant viewsheds. Next, we will overlap it with

the catchment areas to keep only the viewshed sections that are within an acceptable walking distance.

3.2.6. Identification of Level P0, P1, or P3

In this section, we will finally identify which transit areas fall under different mobility hub integration levels. We will do this by identifying which mobility opportunities can be found within the catchment area and then the pedestrian viewshed (Figure 31).

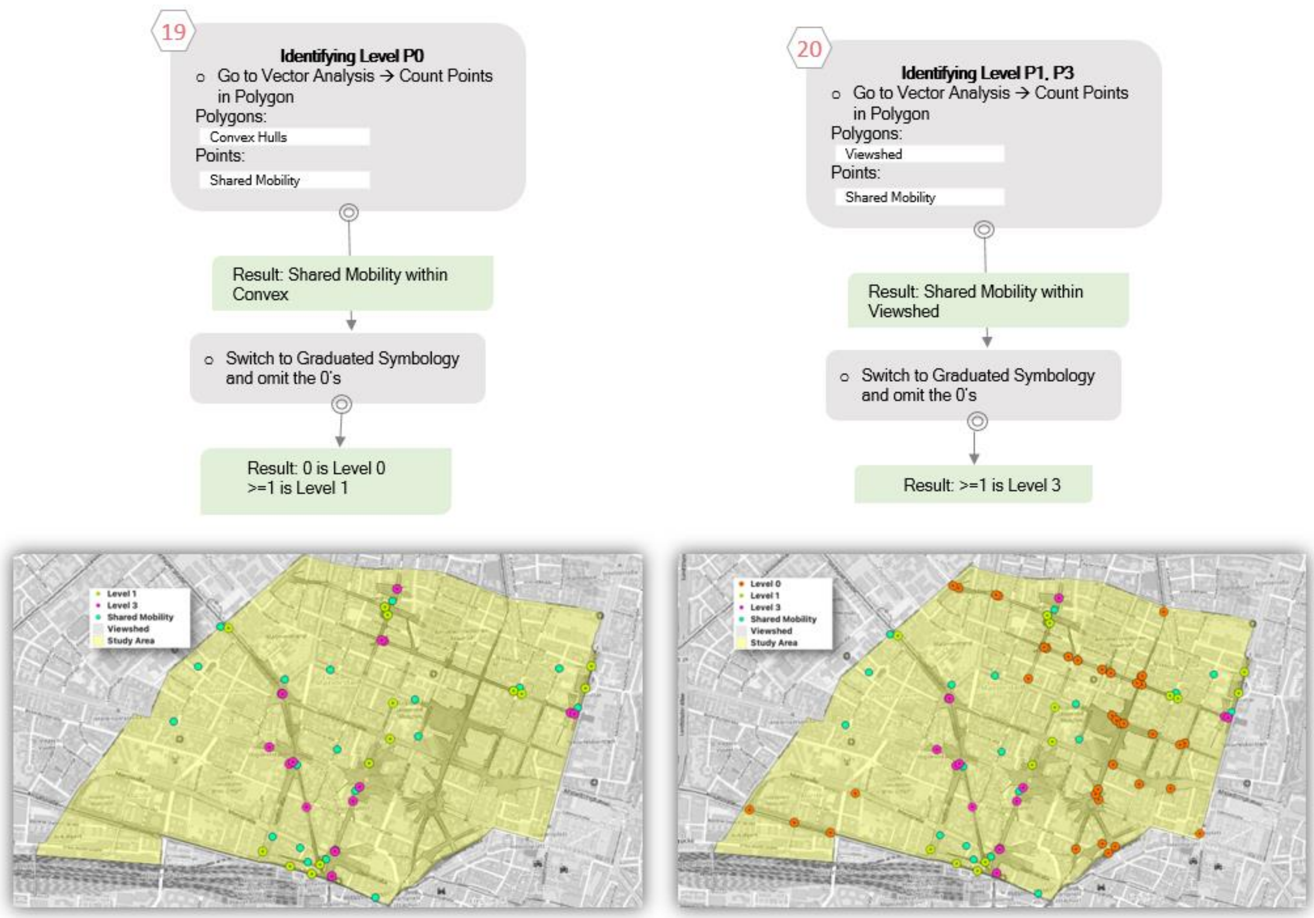


Figure 31 Identified level P0, P1 and P3 in Maxvorstadt, Munich, Germany

19) *Identifying Level P0 – Mobility opportunities within catchment area*. For this step, we will count out how many shared mobility services can be found within the catchment area of a public transit stop. Again, a Level P0 is a public transit stop which does not have at least one mobility opportunity within an acceptable walking distance (also referred to as catchment area). In our example, we consider that the mobility opportunities are the shared mobility stations, such as bike and car rentals. Essentially, any public transit stop that does not have a shared mobility option within the catchment area is considered a Level P0 in physical integration.
20) *Identifying Level P1, P3 – Mobility opportunities within the viewshed*. After finding a Level P0, we can better identify Level P1 and Level P3. Level P1 is a public transit stop which has at least one mobility opportunity within an acceptable walking distance but remains outside

of the pedestrian viewshed. Level P3 is then the public transit area that contains mobility opportunities within the pedestrian viewshed. In this step, we will essentially repeat the same step from before, except this time, analyze the layers within the viewshed.

In order to showcase the transferability of the method, we applied the same process in Anderlecht, Belgium (Figure 32). Although it is a larger area than the Maxvorstadt case study, it is meant to demonstrate that bigger districts can also be analyzed. Likewise, whole cities can be analyzed, however, greater computational power may be required.

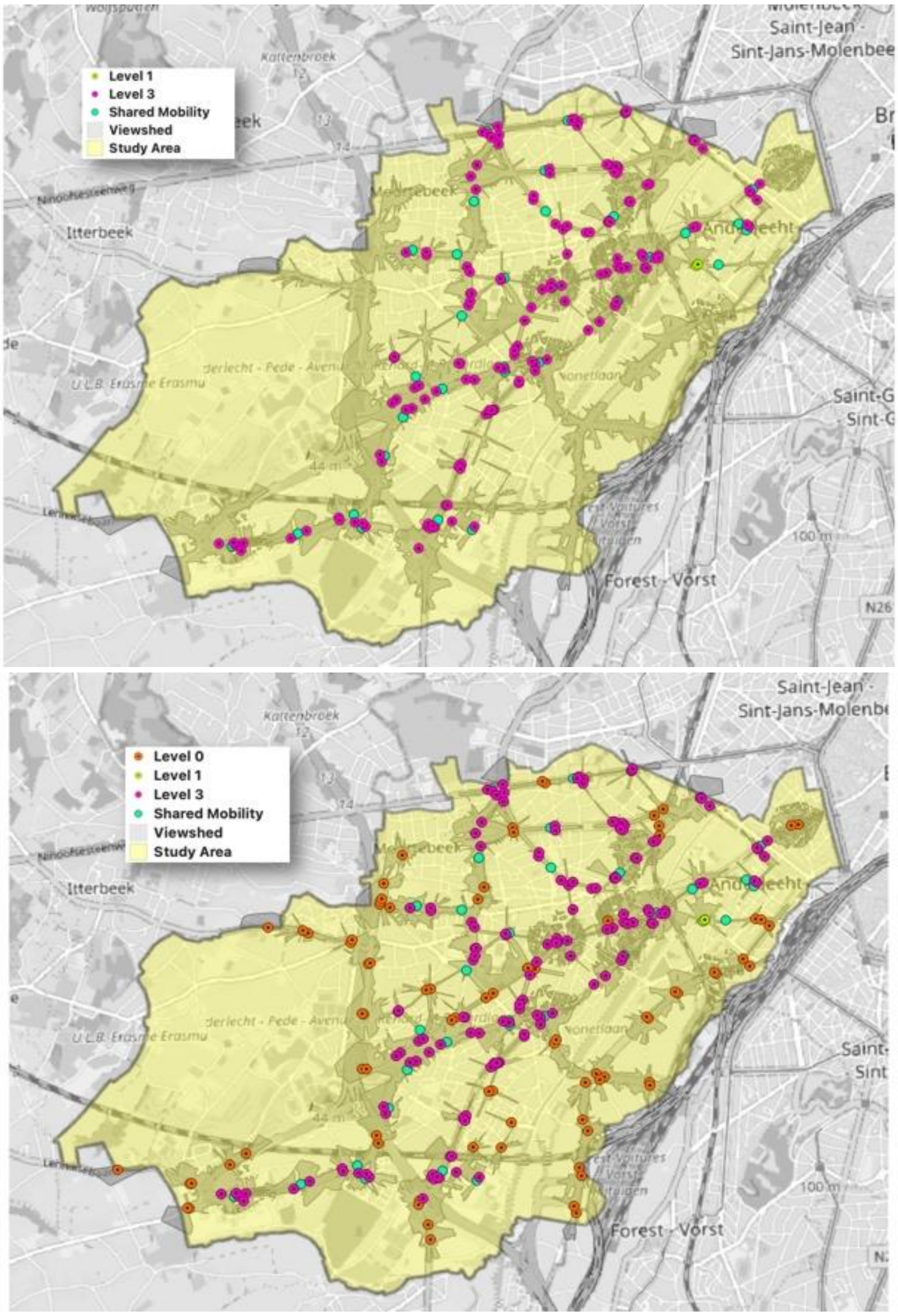


Figure 32 Identified level P0, P1 and P3 in Anderlecht, Brussels, Belgium

4. SEARCHING FOR POTENTIAL PLACES

In the previous steps, we identified an area to implement mobility hubs and identified existing mobility hubs in the urban space which have not been branded as such. Now, in the chosen area for implementation, the next step is a micro level approach aiming to score different potential locations of mobility hubs. The parameters to build the scoring are based on the goal of the hubs: connect public transport or compliment public transport. We neglected “sustainability goal” because social and environmental factors are usually gathered in macro scales (e.g. district, neighborhood). As a final step, these parameters are min-max normalized (values from 0 to 1) in order to make them comparable to each other.

If the goal is to be a public transport connector the transit stops will be evaluated with local parameters (based on Table 9):

- Main hub: Public transport station.
- Walkability: Area of the catchment area.
- Visibility: Area of the viewshed.
- POIs: density of POIs in the catchment area.
- PT Frequencies: number of departures of public transport.
- Space availability: public space without building in the catchment area.

An example of the application process was carried out in the neighborhood of Maxvorstadt (Figure 33) in Munich and Anderlecht (Figure 34) in Brussels aiming to have hubs as public transport connectors. Results show different scores and levels of integration, which decision makers may analyze and select the most suitable options for the neighborhood. As mentioned before, this method can be replicated following the same steps to identify potential locations in other areas of analysis.

Figure 33 and Figure 34 show the identified (not branded) existing mobility hubs. These are classified based on the integration levels (level 0, level 1, or level 3). Moreover, the bars in each potential hubs summarize their scores based on walkability, amenities, space availability, PT frequencies, and visibility. The figures can help decision makers prioritize the establishment of a mobility hub, either based on specific interests or as an overall ranking, i.e. the higher the bar, the better the option for establishing a mobility hub. As mentioned before, this method can be replicated following the same steps to identify potential locations in other areas of analysis.

Figure 33 PT stations: level of physical integration and normalized scores in Maxvorstadt, Munich, Germany

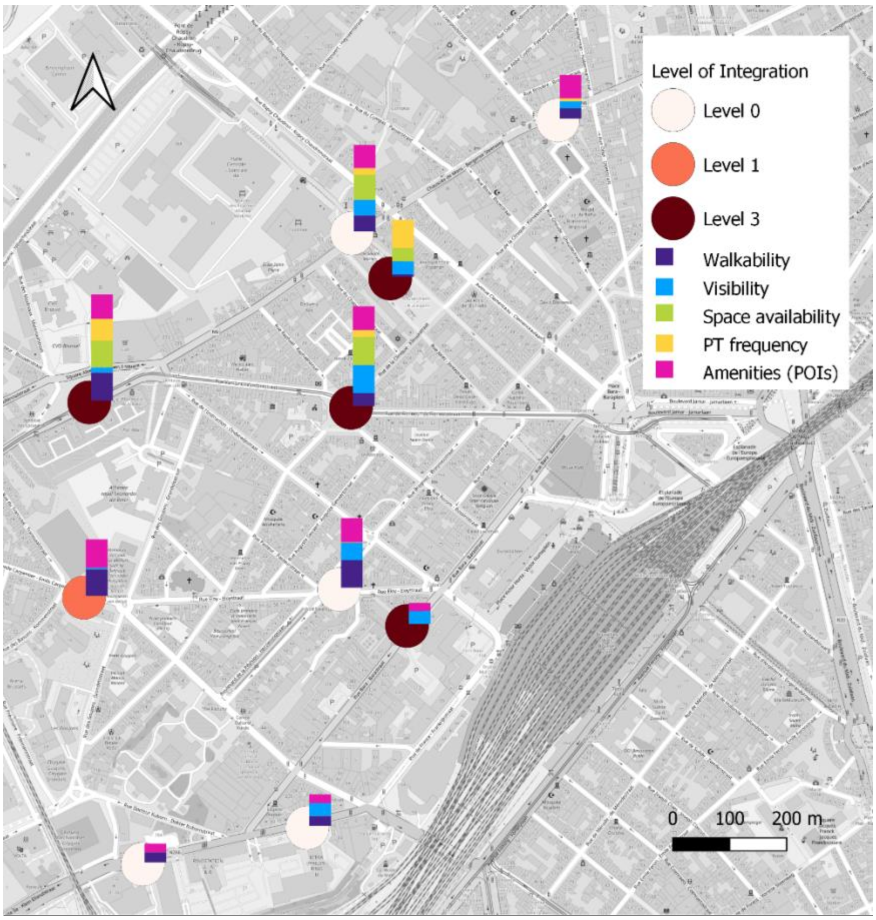


Figure 34 PT stations: level of physical integration and normalized scores in Anderlecht, Brussels, Belgium

If the goal is to compliment public transport, the local parameters (based on Table 9) will be identified in areas with low proximity to public transport:

- Main hub: low proximity to public transport.
- Walkability: Area of the catchment area.
- Visibility: Area of the viewshed.
- POIs: density of POIs in the catchment area.
- Space availability: public space without building in the catchment area.

Figure 35 shows an application in Maxvorstadt, Munich where the potential locations are in the spots with lower access to PT stops. Similarly, with this visual representation, decision-makers can make more informed decisions regarding the allocation of mobility hubs considering the proximity to public transport. If the bar is higher, a potential location would have a higher overall score based on walkability, surrounding amenities, visibility, and space availability.

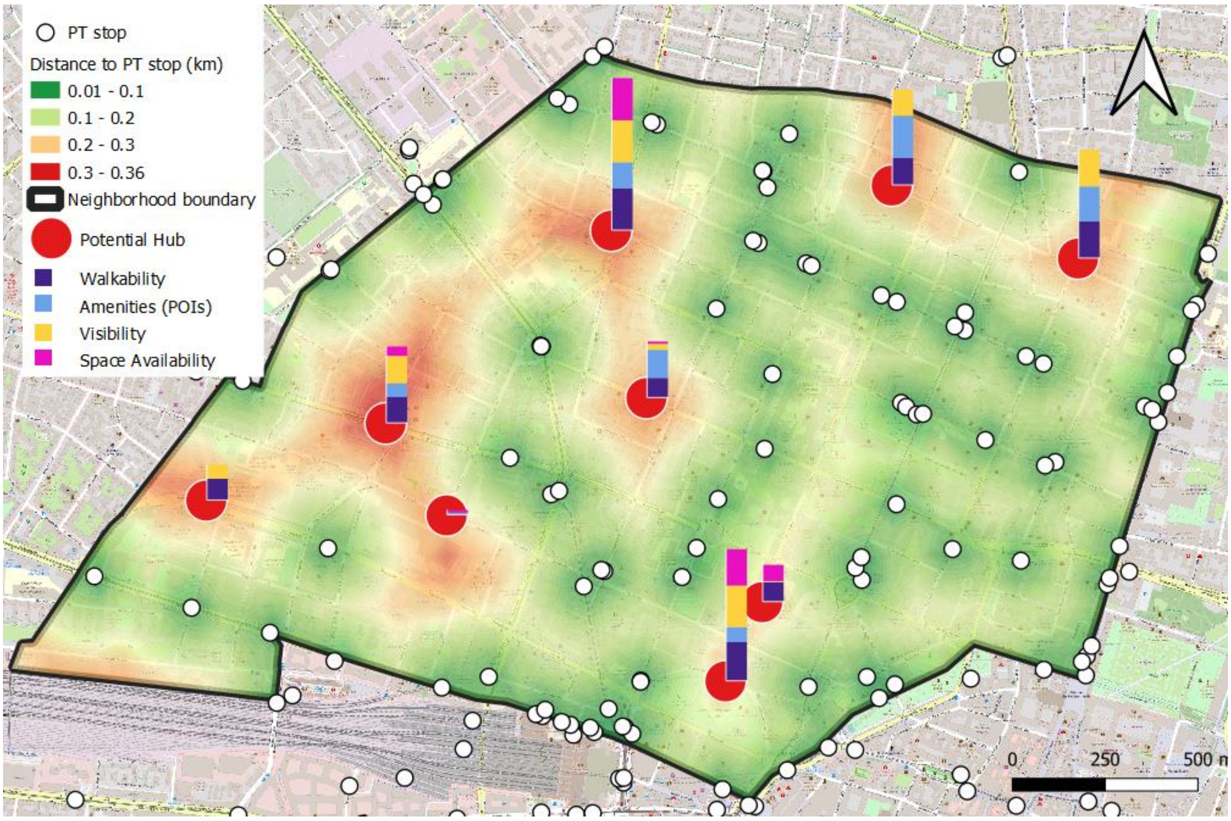


Figure 35 Potential hubs and scores in areas with low proximity to PT stops

5. CONCLUSION

In this deliverable of the SmartHubs project, we developed a process to search for potential locations of mobility hubs. After developing different weighting processes and selecting spatial factors, neighborhoods or areas can be selected for the implantation of a hub. Furthermore, if the goal of the hub is to be a PT connector, the actual level of physical integration in the selected area or neighborhood can be assessed as well as potential performance parameters. Similarly, if the hubs aim to compliment PT, their locations may be where there currently is a lack of them and they can be assessed with the performance indicator.

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