eHUBS - Smart Shared Green Mobility Hubs

Deliverable 2.1

Maps with the indicator of potential locations for eHUBS

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This document describes and explains the quick scan method and presents the heatmaps of shared mobility potential for three pilot cities (for which data is available).

1. Assumptions

As the name implies, quick scan is a quick-and-dirty method for checking the relative potential of different areas; therefore, many factors which can affect the potential of demand are not considered in the method. This section lists the assumptions of the method which shall be taken into account when interpreting and using the results of this method:

- It assumes an empty canvas, meaning no existing shared mobility facilities are taken into account;
- The unit of forecast is zone (e.g. census tract) and does not pin down any specific location;
- It does not consider the effect of supply on demand;
- It does not consider the effect of operational attributes of the shared mobility system (cost, reliability, etc.);
- It does not consider local restrictions for transport modes (car free zone, bike prohibition…) or mobility hub set-up (such as existing chargers).

2. Quick scan method

- Variable selection: collect data of factors which can influence shared mobility demand.
- Calculate potential score: derive a "shared mobility potential score" for each zone by calculating a weighted sum of factors. Factor weights are taken from published academic studies. The potential score is calculated for both EV carsharing and e-bikesharing (different factors and weights).
- Derive indicator for shared mobility potential: derive the relative potential indicator by calculating the percentage rank of the above score.
- Visualization via heatmap: create heatmap according to the potential indicator values.

In the following we will elaborate upon the details of each step.

In order to select the factors which are relevant for our forecast, we reviewed studies on shared mobility demand to find out factors which can influence demand (see state-of-the-art report). For calculating the composite score for potential shared mobility demand, the weights of factor need to be determined. We intend to use results from academic studies which derived weights via applying statistical analysis on real transaction records of existing shared mobility systems. Because shared e-mobility systems are still in the nascent stage of development, we were not able to find many studies based on real transaction records. In the end we decide to use the following two studies which are presented in Table 1:

Table 1 List of studies which provide the models used for the heatmap

	Vehicle type	**Location**	**Time of data collection**	**Number of records**
(Hu et al., 2018)	EV	Shanghai, China	2017	72,648 (8 months)
(Guidon et al., 2019)	E-bike	Zurich, Switzerland	2017	5,790,000 (1 year)

The decision of using these two studies as references results in several limitations. First, the two cities in the studies are quite different in some aspects from some pilot cities in the eHUBS project: Shanghai is a megacity in east Asia while all pilot cities are in the western world and much smaller in size; Zurich is public transport oriented while cities like Manchester are heavily relying on car for transport. These differences can also affect how the included factors influence shared mobility demand. Second, only having one study for each type of shared mobility does not allow us to compare the results between different studies. Third, both studies are based on one-way shared systems, therefore the derived weights may not fully reflect the extent of factor influence in case of roundtrip systems. These limitations have to be taken into account when interpreting the results of quick scan forecast (heatmap).

These two studies did not include all the influential factors we found in the state-of-the-art report, however, we are not able to include factors beyond the models in these two papers because their weights cannot be determined. Table 2 is the list of variables included in our calculation (also depends on the data availability of each city).

Table 2 List of variables used in each city

	Amsterdam	**Manchester**	**Leuven**	**Nijmegen**	**Kempten**	**Dreux**
Socio-demographics						
Population density	√	√	√	√	√	√
Gender	√	√	√	√	√	√
Age	√	√	√	√	√	√
Income	√			√		
Transport connectivity						
Bus stop	√	√	√			√
Metro/tram stop	√	√	NA		NA	NA
Train station	√	√	√	√	√	√
PT passengers	√					
Level of accessibility		√				
Road network	√	√	√	√		√
Bike path network	√	√				√
POI data						
Workplace	√					
Restaurant POI	√	√	√	√		√
University	√	√	√	√		
Shopping center	√			√	√	
Recreational center	√		√		√	
Land use data						
Percentage of residential area			√	√		
Percentage of office area	√		√	√		

Note: NA means the city does not have a metro/tram service.

Table 3 lists some main factors which area expected to influence shared mobility demand but are excluded in the calculation of this heatmap. We also listed the reasons why they are excluded. They can be included in future forecast of shared mobility potential if relevant data or new studies regarding their weights becomes available.

Table 3 Factors excluded and reasons for exclusion

	No data	**No estimated weight**	**Other reasons**
Parking difficulty	√	√	
Parking price	√ (except Amsterdam)	√	
Mixed land use	√		
Vehicle ownership	√ (except Kempten)	√	Ambiguous influence
Bike ownership	√	√	
Carsharing/bikesharing membership	√	√	
Lifestyle	√ (except Nijmegen)	√	

Table 4 lists the coefficients (weights) for each of the factor in the model in the original publication. However, since these models use different basic unit (e.g. Guidon et al. used 300m*300m grid cell as basic unit while we use census tract), their derived factor weights have to be converted in order to be used in calculation based on different unit. Table 5 presents the final weights used in our calculation.

Table 4 Factor coefficients in the original papers

	EV carsharing	**E-bikesharing**
Reference	(Hu et al., 2018)	(Guidon et al., 2019)
Zone area	~2.6km2 (1 km hexagon)	0.09 km2 (300m*300m grid cell)
Population	0.01 (thousand per km2)	13.18 (thousand) 0.0029 (within 0.25 miles radius) (He et al., 2019)
Gender (percentage of male)	5.414	
Age (percentage of 15-65)	1.781	
Age (percentage of older than 65)	-0.476	
Income (median)		0.07 (thousand CHF)
Bus stop	0.097 (number of bus routes)	
Metro/tram stop	0.149 (number of metro lines)	0.82 (Urban rail station within 200m)
Train station		1.69 (train station within 500m)
Transit hub	0.445	1.6455 (He et al., 2019)
PT passengers		0.16
Level of accessibility		1.14 (high level accessibility 22% of zones)
Secondary road length	0.042 (km)	
Local road length	0.473 (km)	
Bike path length		0.89 (km)
Workplace		1.63 (thousands)
Restaurant POI		0.05
University	0.144	
Shopping center	0.226	
Recreational center		1.1484 (He et al., 2019)
Percentage of residential area	0.988	
Percentage of office area	1.416	

Table 5 Factors and coefficients used in calculation

Variable	Operationalization	Unit	EV sharing	E-bike sharing
Population	Population density	Number per 0.01 km2	0.001	0.12
Gender	Percentage of male		5.414	
Age	Percentage of 15-65		1.781	
Age	percentage of older than 65		-0.476	
Income	Average income	Thousand euro		0.047
Bus stop	Bus stop density	Number per km2	0.252	
Metro/tram stop	Metro/tram stop density	Number per km2	0.387	
	Presence of metro/tram station	Dummy variable (1 or 0)		0.82
Train station	Presence of train station	Dummy variable (1 or 0)	0.445	1.69
PT passengers	PT passenger density	Number per km2		0.0144
Level of accessibility	High accessibility area	Dummy variable (1 or 0)		1.14
Secondary road length	Secondary road density	Km per km2	0.109	
Local road length	Local road density	Km per km2	1.23	
Bike path length	Bike path length density	Km per km2		0.08
Workplace	Number of workplaces	Thousands per km2		0.147
Restaurant POI	Restaurant density	Number per km2		0.0045
University	Presence of university	Dummy variable (1 or 0)	0.144	
Shopping center	Presence of shopping center	Dummy variable (1 or 0)	0.226	
Recreational center	Presence of recreation center	Dummy variable (1 or 0)		1.15
Residential area	Percentage of residential area		0.988	
Office area	Percentage of office area		1.416	

3. Results for each city

3.1 Leuven

Table 6 Data source and processing for each variable: Leuven

Variable	Data source	Processing
Population density	NIS data	
Percentage of male	NIS data	
Percentage of 15-65	NIS data	
percentage of older than 65	NIS data	
Bus stop density	Bus stops	GIS calculate
Presence of train station		Mark zones next to train station
High accessibility area	Bus stops	Percentage ranking: top 20%
Secondary road density	Road network	GIS calculate
Local road density	Road network	GIS calculate
Restaurant density	Building plan	GIS calculate
University	Building plan	GIS calculate
Recreational POI Density	Building plan	GIS calculate
Percentage of residential area	Building plan	GIS calculate
Percentage of office area	Building plan	GIS calculate

Table 7 Models used for calculating shared mobility potential score: Leuven

Variable	Operationalization	Unit	EV sharing	E-bike sharing
Population	Population density	Number per 0.01 km2	0.01	0.12
Gender	Percentage of male		5.414	
Age	Percentage of 15-65		1.781	
Age	percentage of older than 65		-0.476	
Bus stop	Bus stop density	Number per km2	0.252	
Train station	Presence of train station	Dummy variable (1 or 0)	0.445	1.69
Level of accessibility	High accessibility area	Dummy variable (1 or 0)		1.14
Secondary road length	Secondary road density	Km per km2	0.109	
Local road length	Local road density	Km per km2	1.23	
Restaurant POI	Restaurant density	Number per km2		0.0045
University	Presence of university	Dummy variable (1 or 0)	0.144	
Recreational	Recreational POI Density	Number per km2		0.013
Residential area	Percentage of residential area		0.988	
Office area	Percentage of office area		1.416	

In the heatmap, the indicator denotes the percentage rank of a zone in terms of shared mobility potential. For example, 83.3333 - 100.0000 indicates that shared mobility potential of the zones with this color are in the 83.3333-100 percentile (in other words, the potential is higher than 83.3333-100 percent of the zones).

Figure 1a. Leuven heatmap for EV carsharing potential

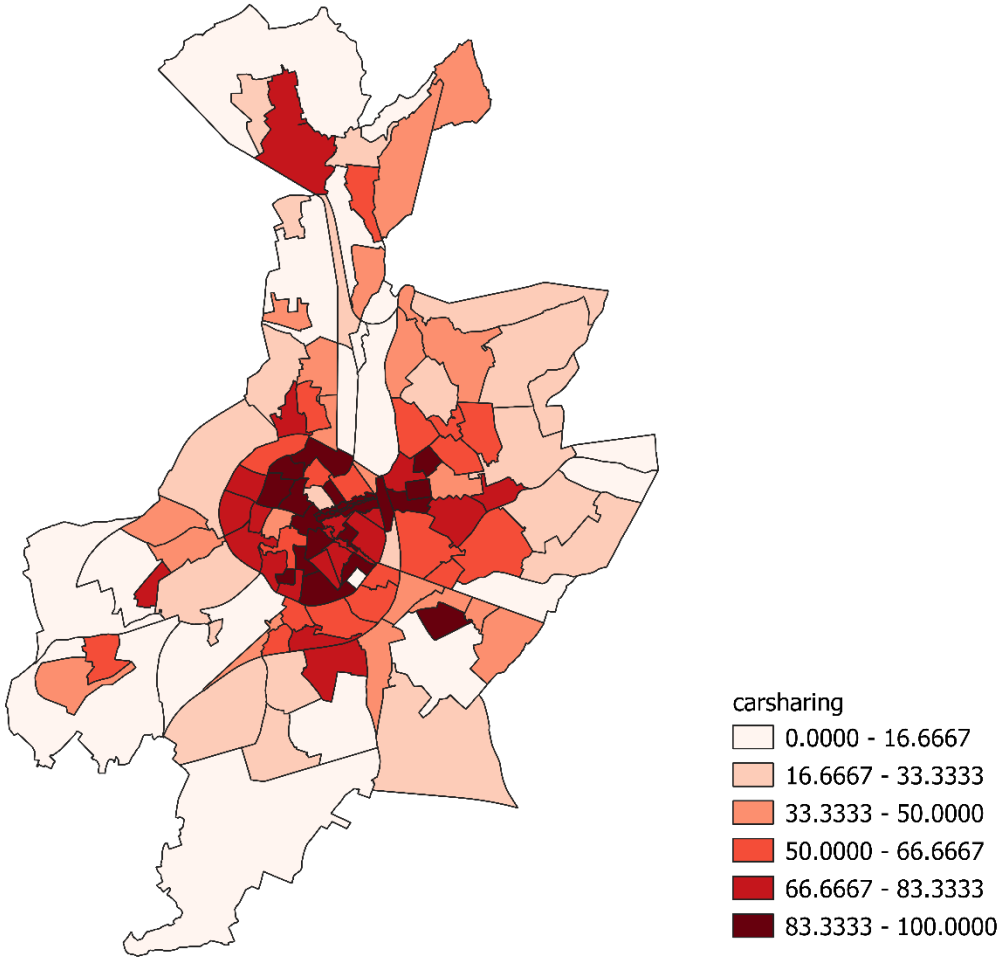


Figure 1b. Leuven heatmap for e-bikesharing potential

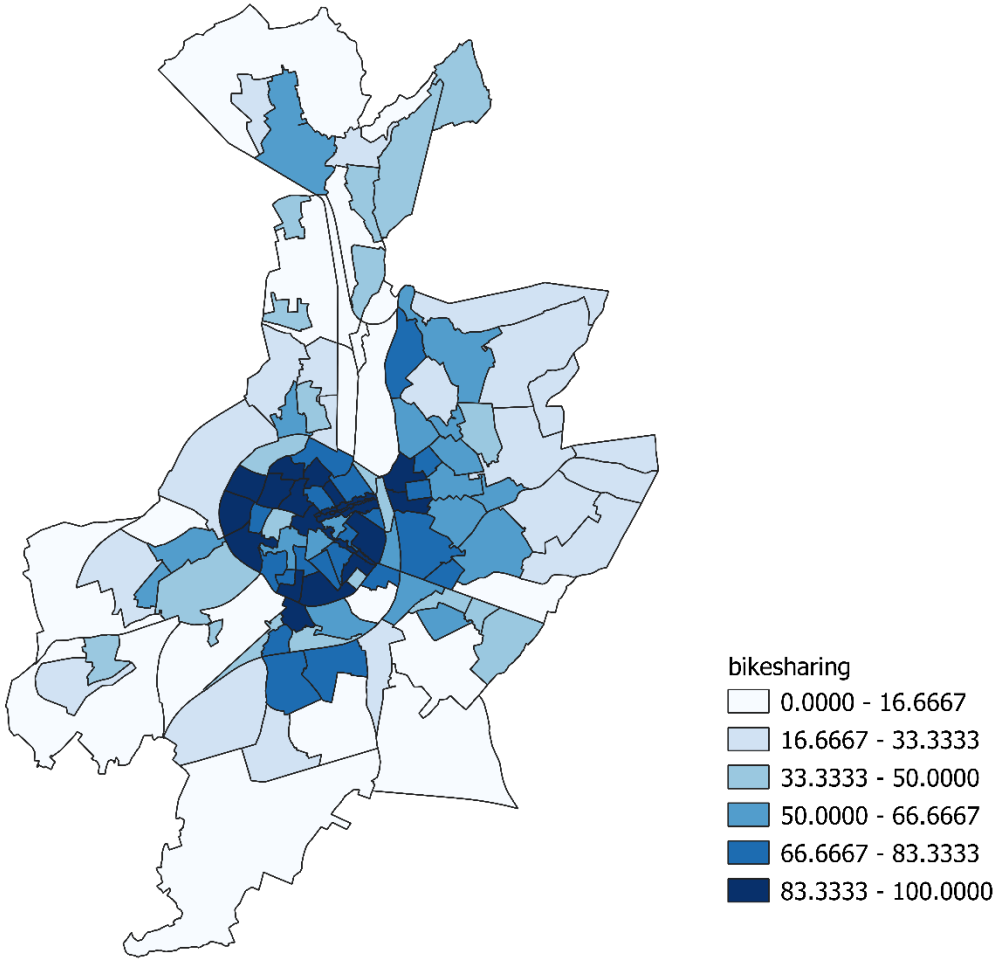
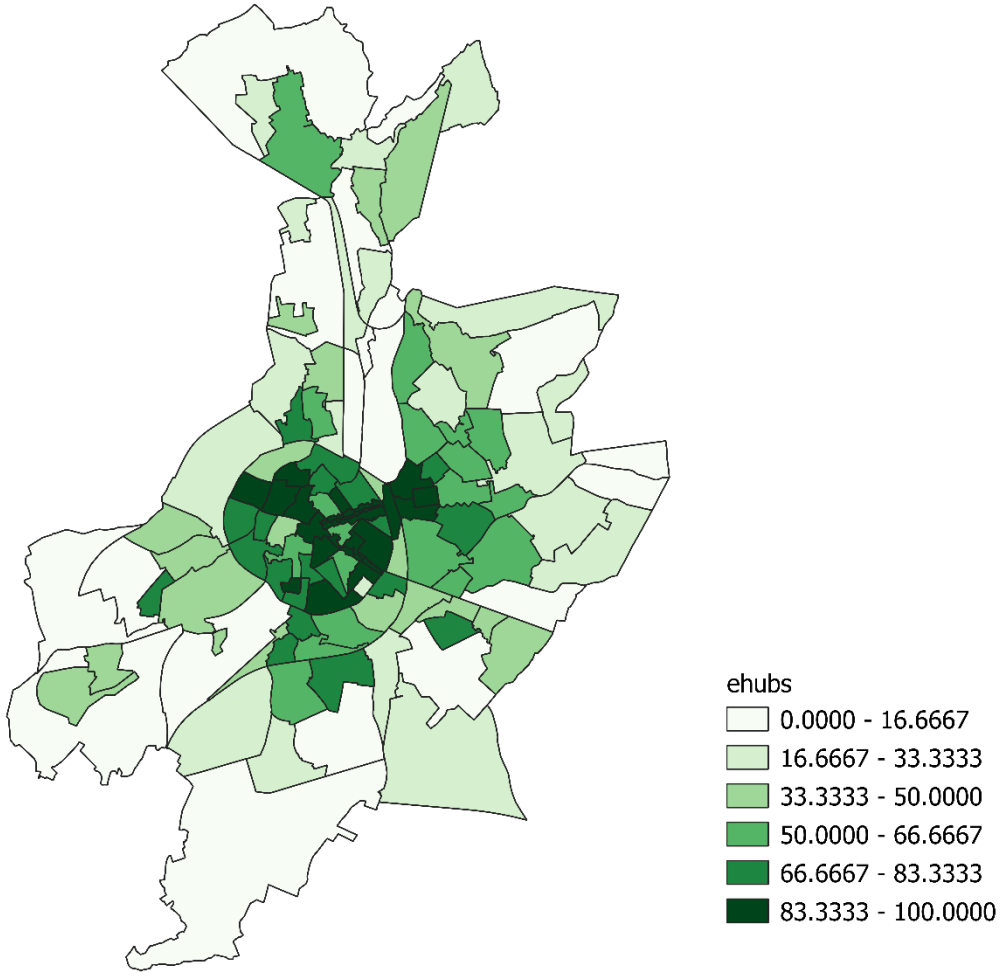


Figure 1c. Leuven heatmap for e-hubs potential



3.2 Manchester

Table 8 Data source and processing for each variable: Manchester

Variable	Data source	Processing
Population density	Census data	
Percentage of male	Census data	
Percentage of 15-65	Census data	
percentage of older than 65	Census data	
Bus stop density	TfGMStoppingPoints	GIS calculation
Metro/tram stop density	TfGMMetroRailStops	GIS calculation
Presence of metro/tram station	TfGMMetroRailStops	Mark zones
Presence of train station	TfGMMetroRailStops	Mark zones
High accessibility area	GMAL_TfGMOpenData Accessibility score of each postcode area	Average score of all postcodes within each OA, assign level
Secondary road density	Road network	GIS calculation
Local road density	Road network	GIS calculation
Bike network density	BeeNetwork CyclePaths	GIS calculation
Restaurant density	UK food hygiene rating data	GIS calculation
University	MappingGM education data	Mark zones

Table 9 Models used for calculating shared mobility potential score: Manchester

Variable	Operationalization	Unit	EV sharing	E-bike sharing
Population	Population density	Number per 0.01 km2	0.001	0.12
Gender	Percentage of male		5.414	
Age	Percentage of 15-65		1.781	
	Percentage of older than 65		-0.476	
Bus stop	Bus stop density	Number per km2	0.252	
Metro/tram stop	Metro/tram stop density	Number per km2	0.387	
	Presence of metro/tram station	Dummy variable (1 or 0)		0.82
Train station	Presence of train station	Dummy variable (1 or 0)	0.445	1.69
Level of accessibility	High accessibility area	Dummy variable (1 or 0)		1.14
Secondary road length	Secondary road density	Km per km2	0.109	
Local road length	Local road density	Km per km2	1.23	
Bike path length	Bike network density	Km per km2		0.08
Restaurant POI	Restaurant density	Number per km2		0.0045
University	Presence of university	Dummy variable (1 or 0)	0.144	

Figure 2a. Manchester heatmap for EV carsharing potential

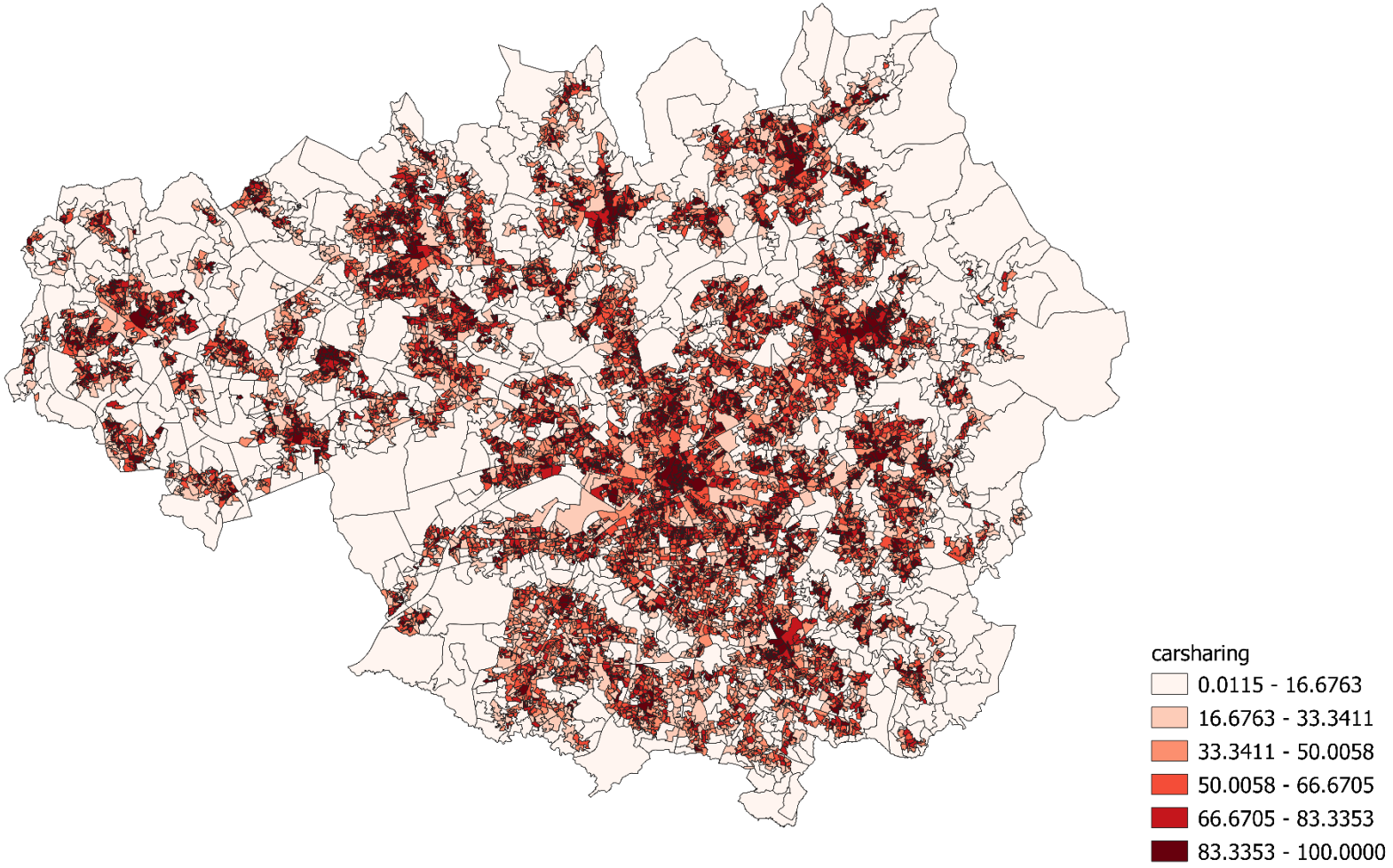


Figure 2b. Manchester heatmap for e-bikesharing potential

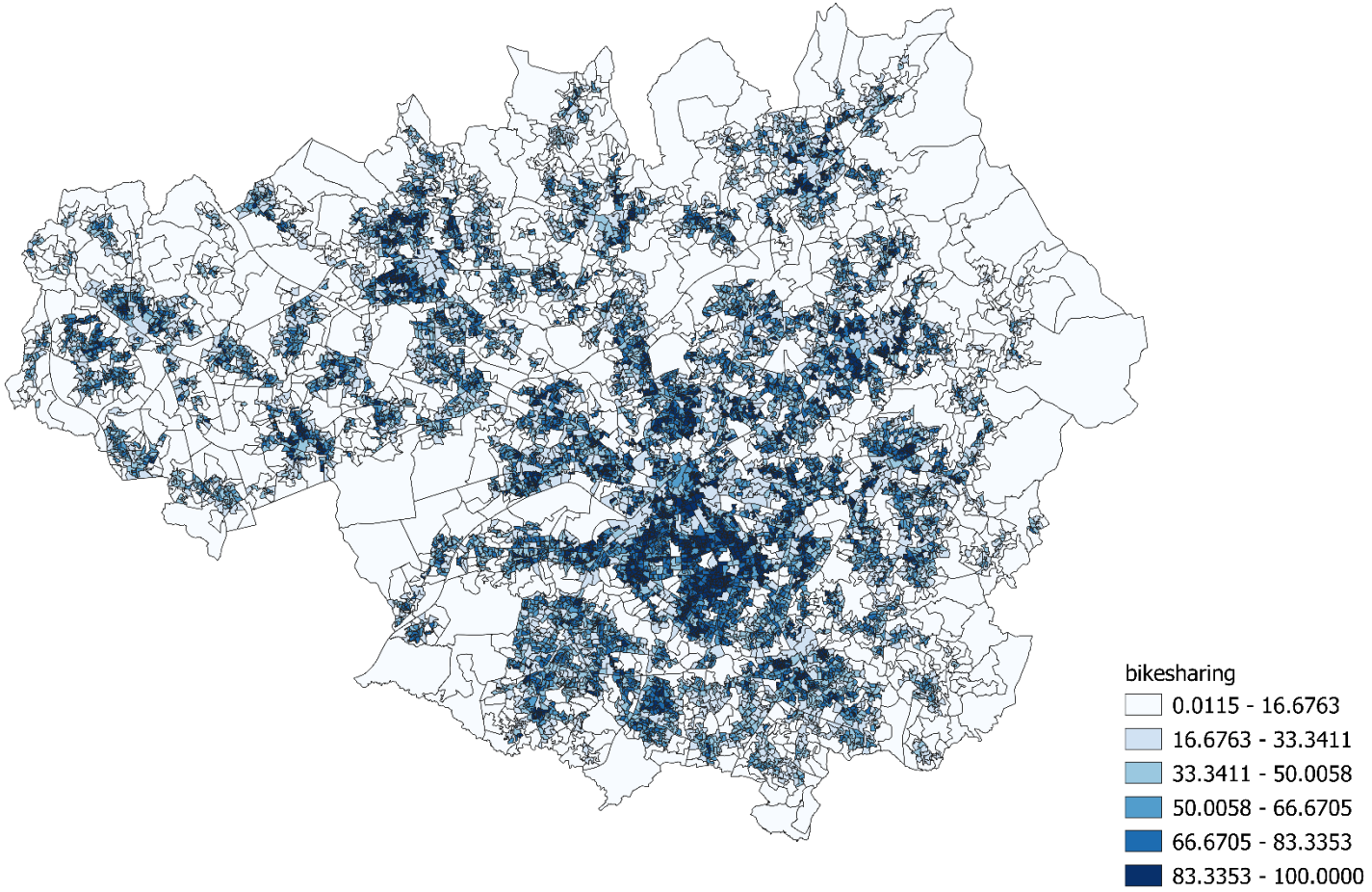
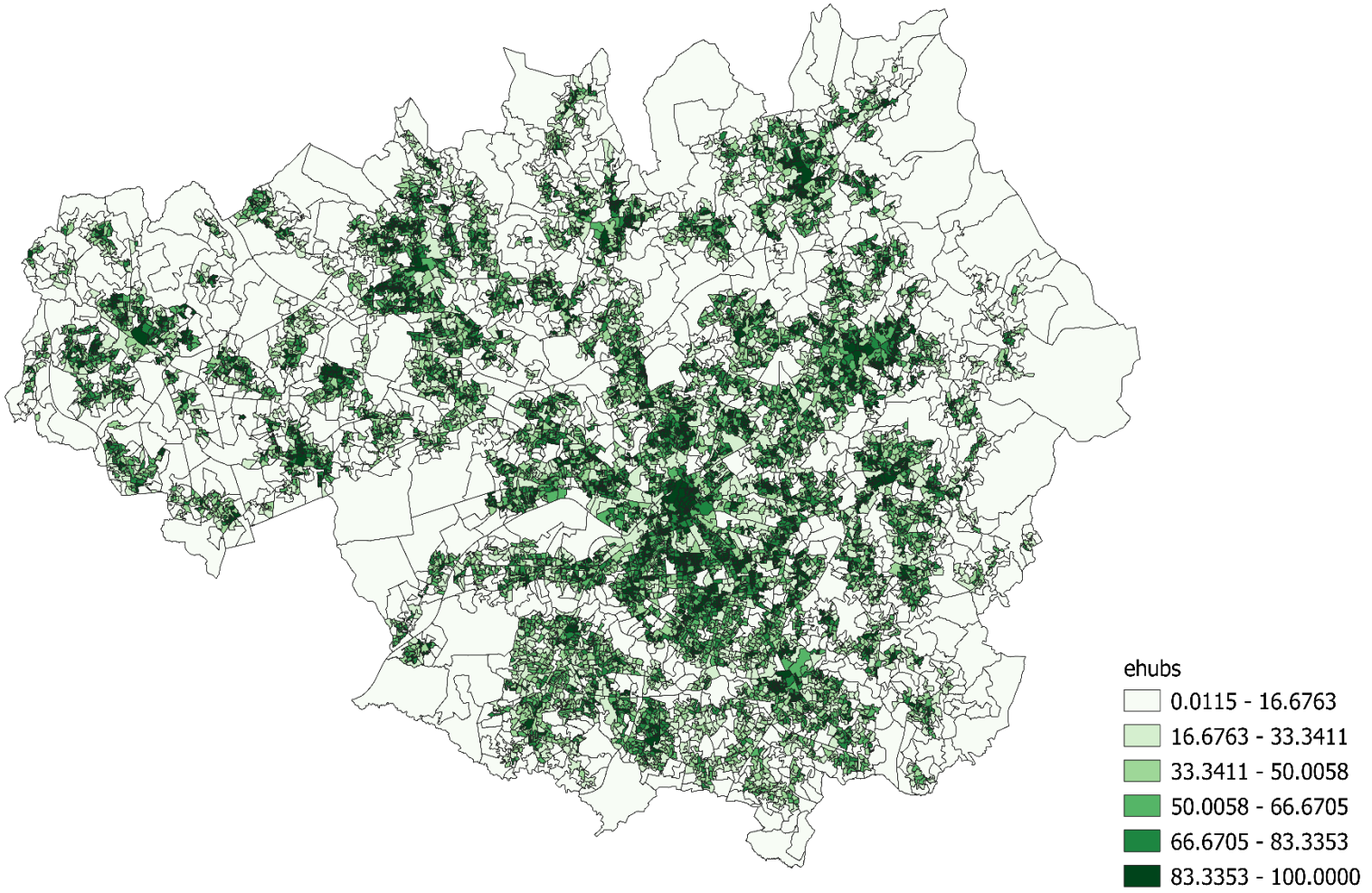


Figure 2c. Manchester heatmap for e-hubs potential



3.3 Amsterdam

Table 10 Data source and processing for each variable: Amsterdam

Variable	Data source	Processing
Population density	VMA Socio-demographics	
Percentage of male	VMA Socio-demographics	
Percentage of 15-65	VMA Socio-demographics	
Percentage of older than 65	VMA Socio-demographics	
Average income	VMA Socio-demographics	
Bus stop density	VMA stops	GIS calculation
Metro/tram stop density	VMA stops	GIS calculation
Presence of metro/tram station	VMA stops	GIS calculation
Presence of train station	VMA stops	GIS calculation
PT passenger density	VMA PT OD matrix	
Secondary road density	VMA link	GIS calculation
Local road density	VMA link	GIS calculation
Bike network density	VMA link	GIS calculation
Number of jobs	VMA Socio-demographics	
Restaurant density	Building plan	GIS calculation
University	Number of students	HBM/WO students>5000
Shopping center	Main POI list	Mark zones
Recreational center	Main POI list	Mark zones
Percentage of office area	Building plan	GIS calculate

Table 11 Models used for calculating shared mobility potential score: Amsterdam

Variable	Operationalization	Unit	EV sharing	E-bike sharing
Population	Population density	Number per 0.01 km2	0.001	0.12
Gender	Percentage of male		5.414	
Age	Percentage of 15-65		1.781	
	percentage of older than 65		-0.476	
Income	Average income	Thousand euro		0.047
Bus stop	Bus stop density	Number per km2	0.252	
Metro/tram stop	Metro/tram stop density	Number per km2	0.387	
	Presence of metro/tram stop	Dummy variable (1 or 0)		0.82
Train station	Presence of train station	Dummy variable (1 or 0)	0.445	1.69
PT passengers	PT passenger density	Number per km2		0.0144
Secondary road length	Secondary road density	Km per km2	0.109	
Local road length	Local road density	Km per km2	1.23	
Bike path length	Bike network density	Km per km2		0.08
Workplace	Job density	Thousands per km2		0.03
Restaurant POI	Restaurant density	Number per km2		0.0045
University	Presence of university	Dummy variable (1 or 0)	0.144	
Shopping center	Presence of shopping center	Dummy variable (1 or 0)	0.226	
Recreational center	Presence of recreational center	Dummy variable (1 or 0)		1.15
Office area	Percentage of office area		1.416	

Figure 3a. Amsterdam heatmap for EV carsharing potential

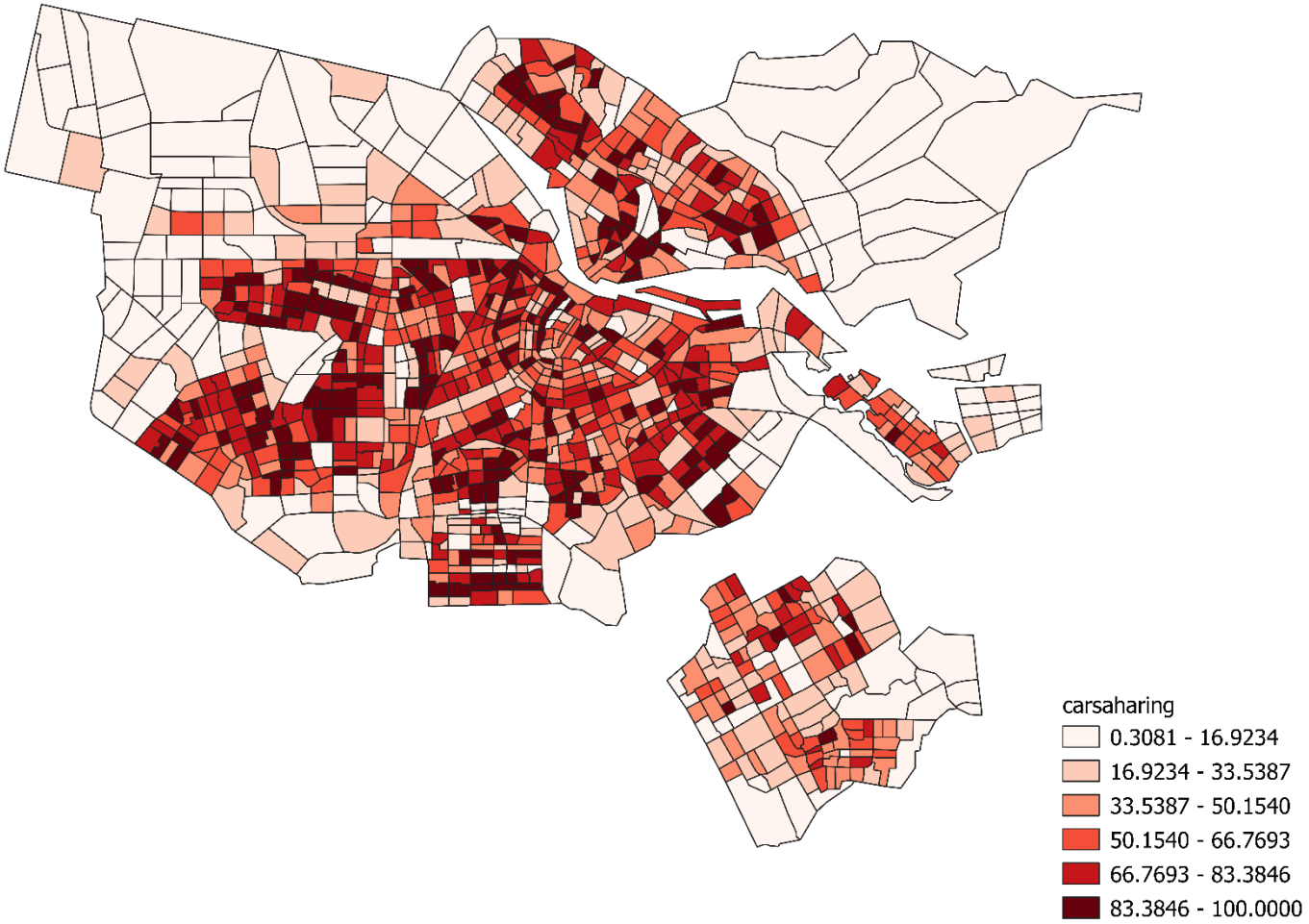


Figure 3b. Amsterdam heatmap for e-bikesharing potential

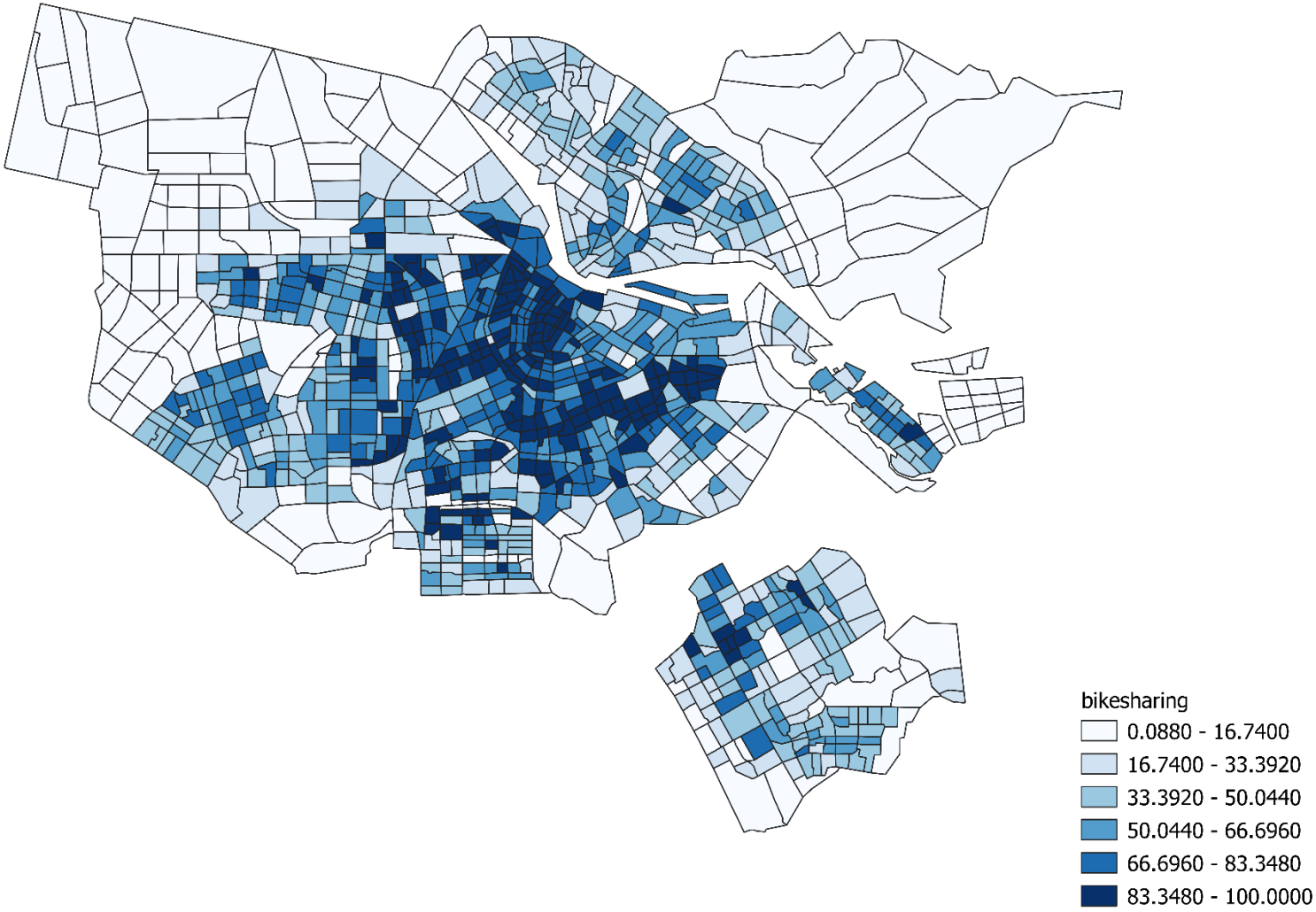
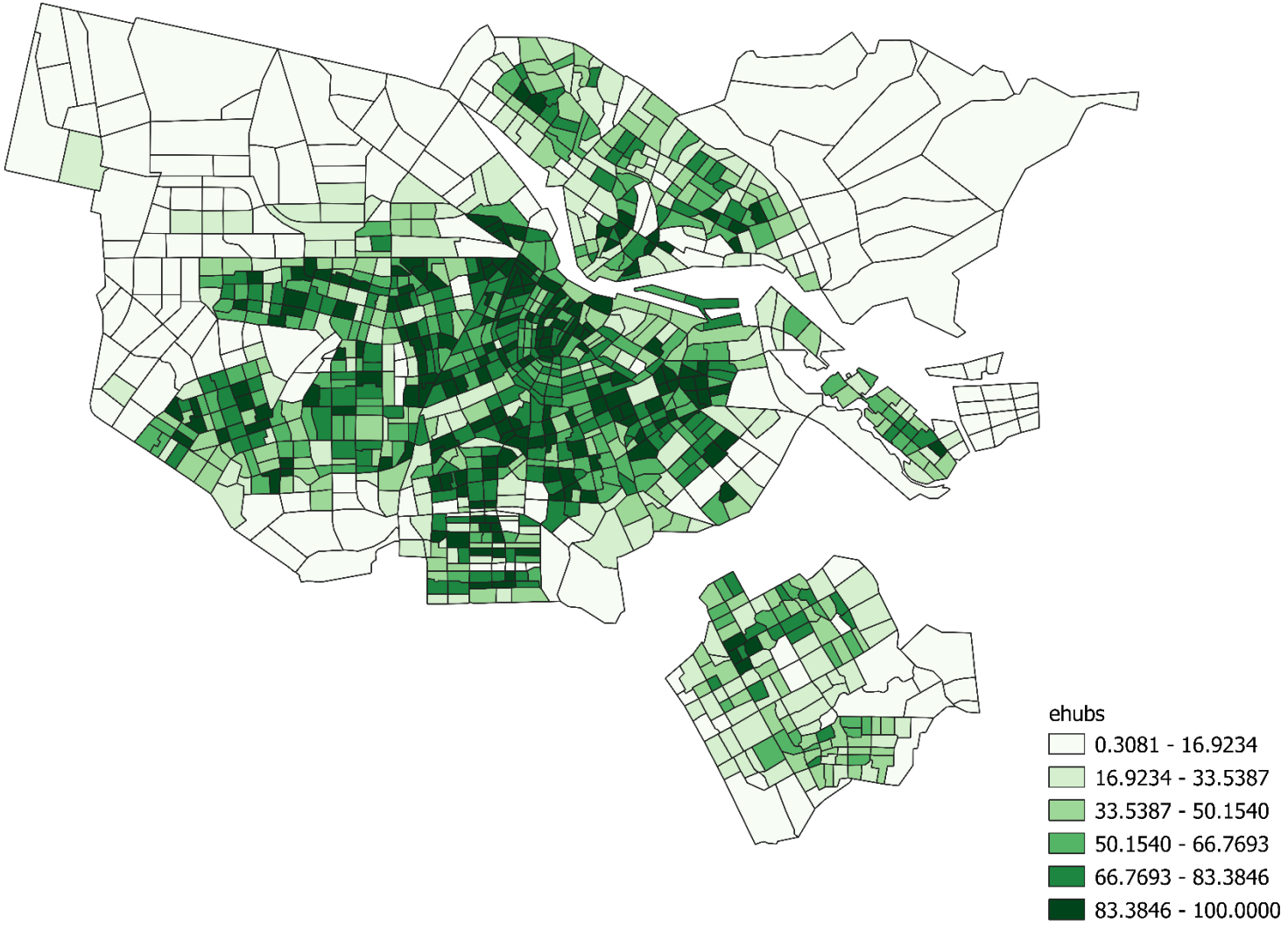


Figure 3c. Amsterdam heatmap for e-hubs potential



3.4Nijmegen

Table 12 Data source and processing for each variable: Nijmegen

Variable	Data source	Processing
Population density	CBS data	
Percentage of male	CBS data	
Percentage of 15-65	CBS data	
percentage of older than 65	CBS data	
Income	Excel file	
Presence of train and rail station		Mark zones with train station
Secondary road density	Road network	GIS calculate
Local road density	Road network	GIS calculate
Restaurant density	CBS data	
Shopping center	CBS data	
University		Mark zones with train station
Percentage of residential area	CBS data	
Percentage of office area	CBS data	

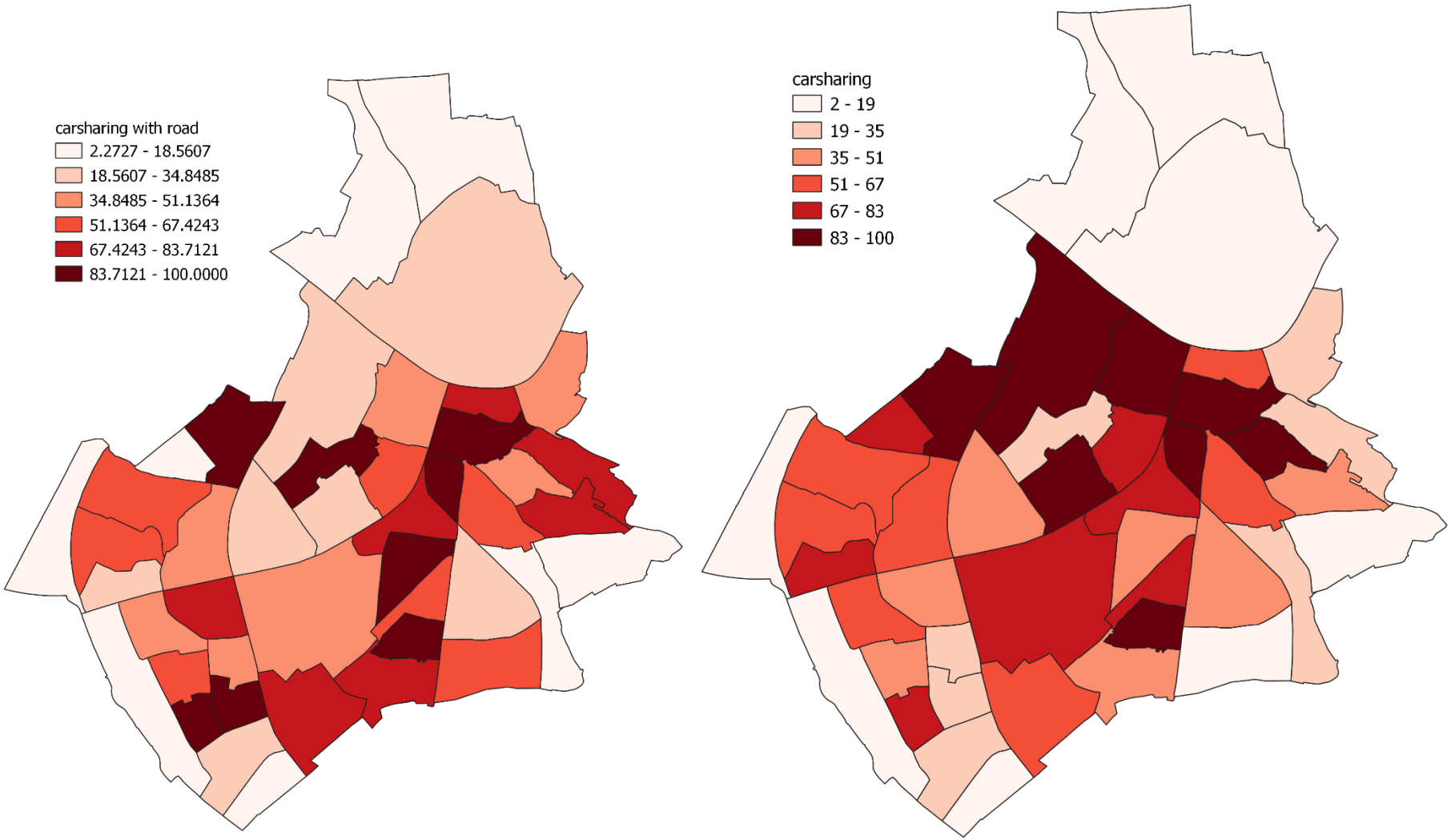
Table 13 Models used for calculating shared mobility potential score: Nijmegen

Variable	Operationalization	Unit	EV sharing	E-bike sharing
Population	Population density	Number per 0.01 km2	0.001	0.12
Gender	Percentage of male		5.414	
Age	Percentage of 15-65		1.781	
Age	percentage of older than 65		-0.476	
Income	Average income	Thousand euro		0.047
Train station	Presence of train station		0.445	1.69
	Presence of rail station			0.82
Secondary road length	Density	Km per km2	0.109	
Local road length	Density	Km per km2	1.23	
Restaurant POI	Density	Number per km2		0.0045
University			0.144	
Shopping center			0.226	
Residential area*	Percentage of residential area		0.988	
Office area*	Percentage of office area		1.416	

*: Discounted by percentage of total built area.

Note for Nijmegen:
The road network density variable is calculated from the supplied shapefile. However, it is not clear whether the file covers the entire road network. Therefore we included two heatmaps in case of EV carsharing and eHUBS: one with road network density as a predictor and the other one without. (Only one map is created for e-bike sharing because road network is not relevant for the potential of e-bike sharing)

Figure 4a. Nijmegen heatmap for EV carsharing potential



(1) EV carsharing potential (with road density as predictor)

(2) EV carsharing potential (without road density as predictor)

Figure 4b. Nijmegen heatmap for e-bikesharing potential

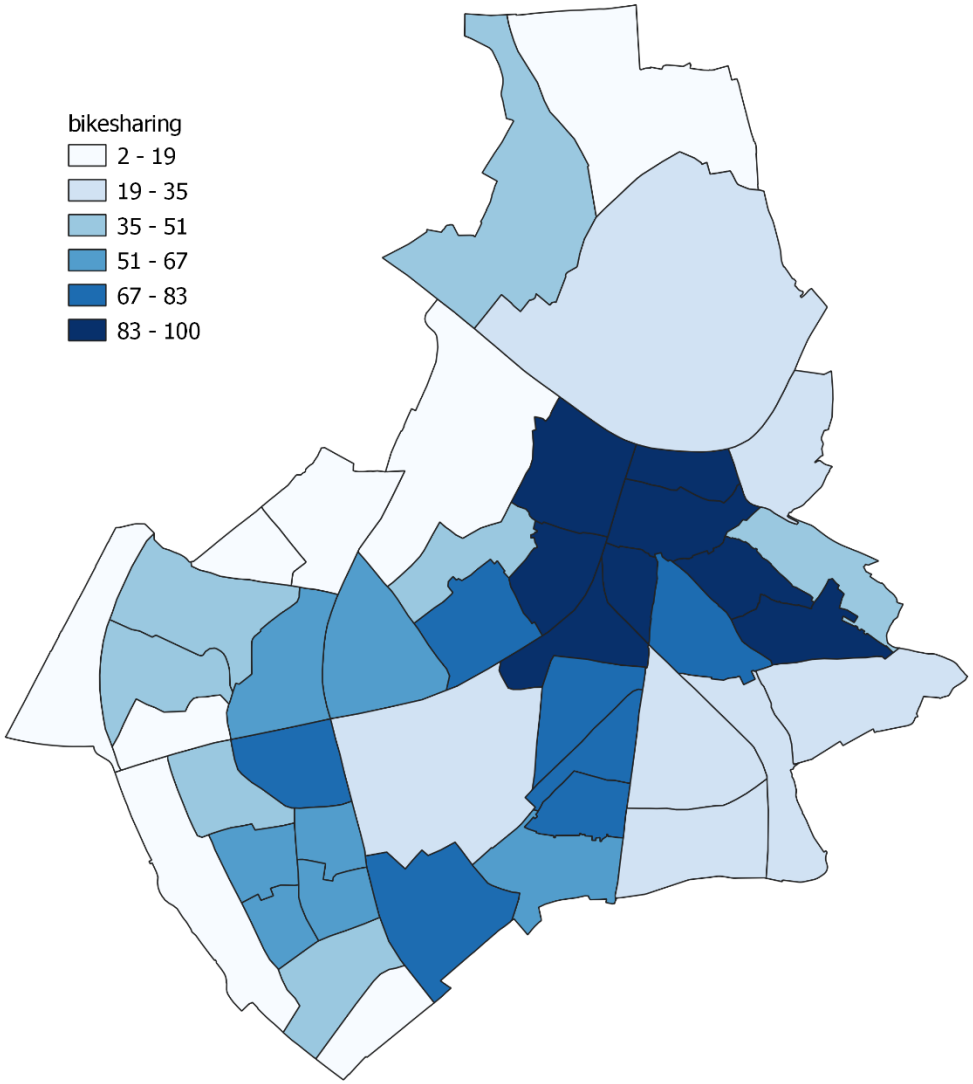
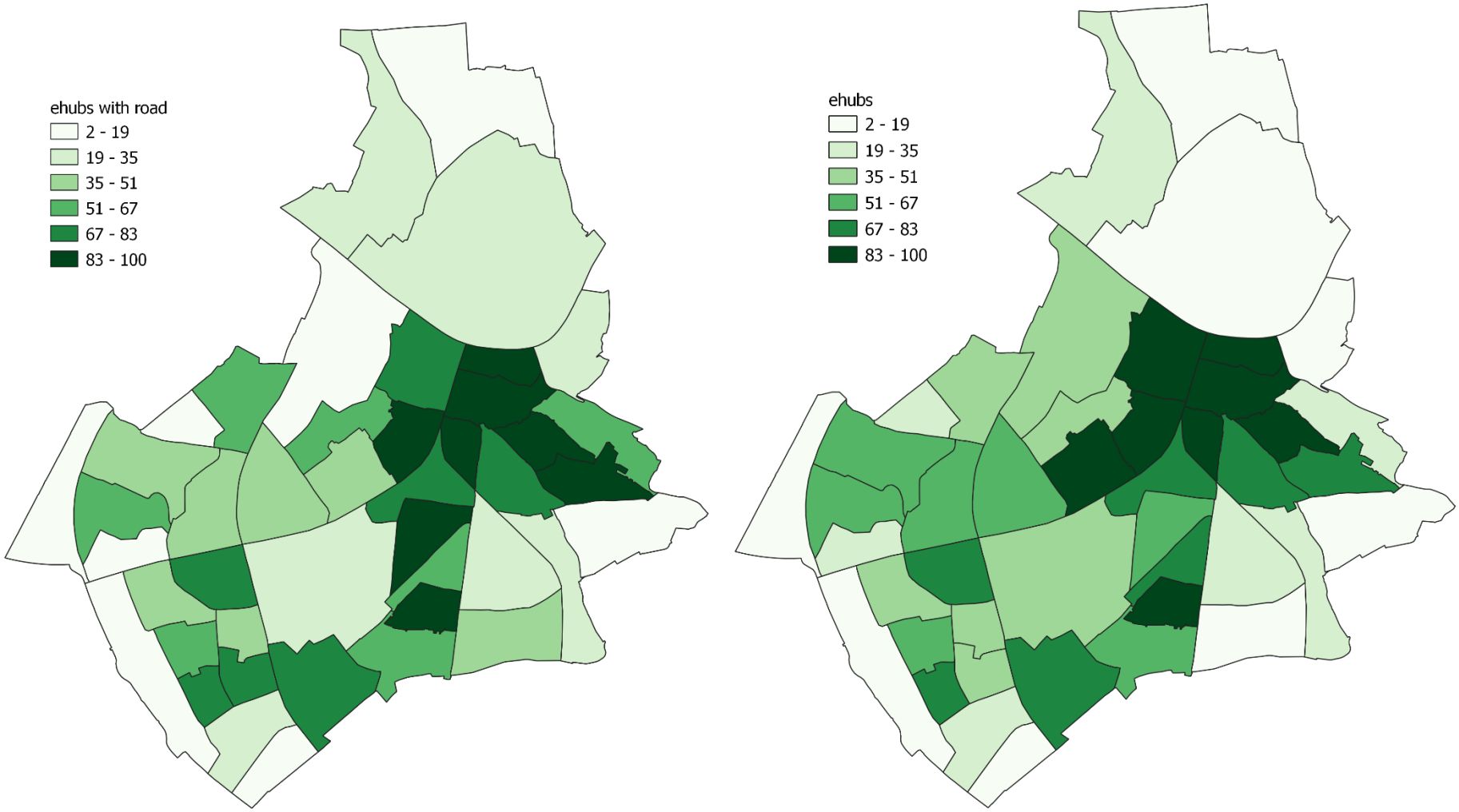


Figure 4c. Nijmegen heatmap for e-hubs potential



(1) eHUBS potential (with road density as predictor)

(2) eHUBS potential (without road density as predictor)

3.5 Kempten

Table 14 Data source and processing for each variable: Kempten

Variable	Data source	Processing
Population density	Excel file provided by Kempten	
Percentage of male	Excel file provided by Kempten	
Percentage of 15-65	Excel file provided by Kempten	
Percentage of older than 65	Excel file provided by Kempten	
Presence of train station	Excel file provided by Kempten	
Shopping POI	Excel file provided by Kempten	
Recreational POI density	Excel file provided by Kempten	

Table 15 Models used for calculating shared mobility potential score: Kempten

Variable	Operationalization	Unit	EV sharing	E-bike sharing
Population	Population density	Number per 0.01 km2	0.001	0.12
Gender	Percentage of male		5.414	
Age	Percentage of 15-65		1.781	
	Percentage of older than 65		-0.476	
Train station	Presence of train station	Dummy variable (1 or 0)	0.445	1.69
Shopping center	Presence of shopping center	Dummy variable (1 or 0)	0.226	
Recreational POI	Recreational POI Density	Number per km2		0.013

Figure 5a. Kempten heatmap for EV carsharing potential

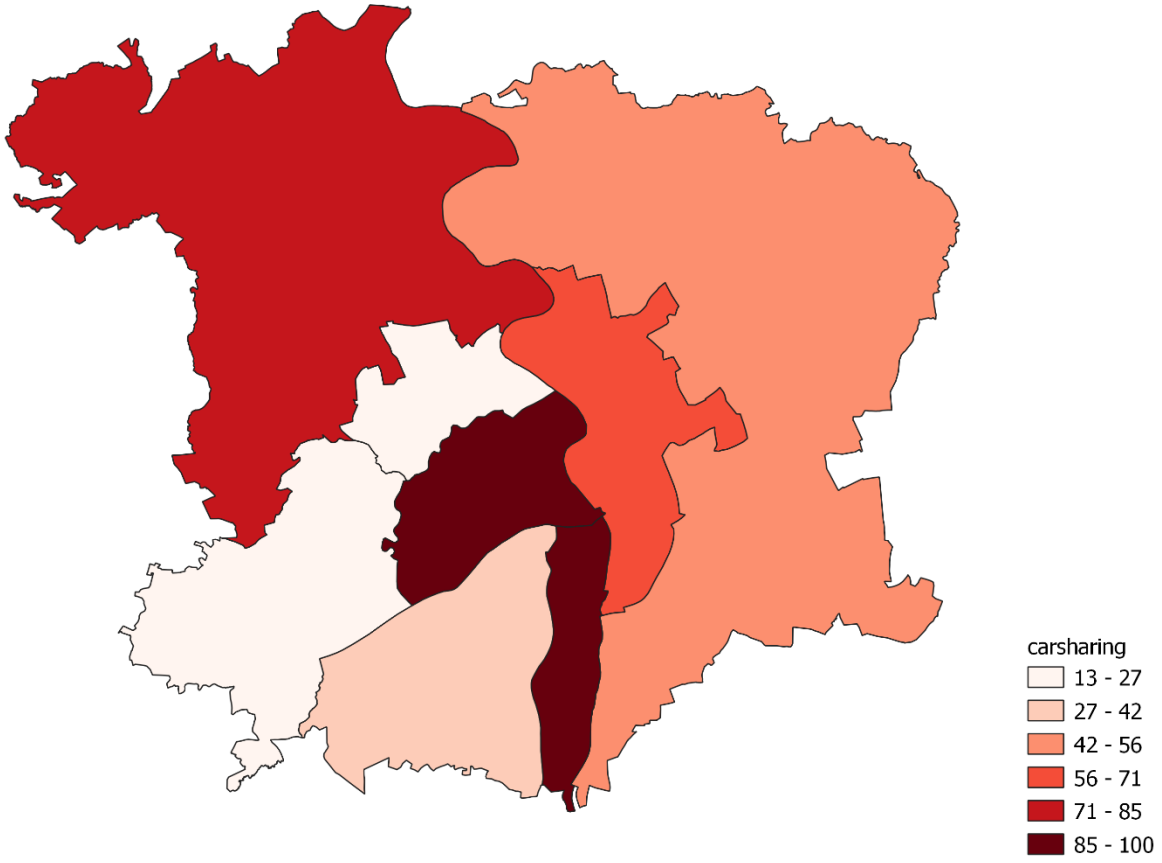
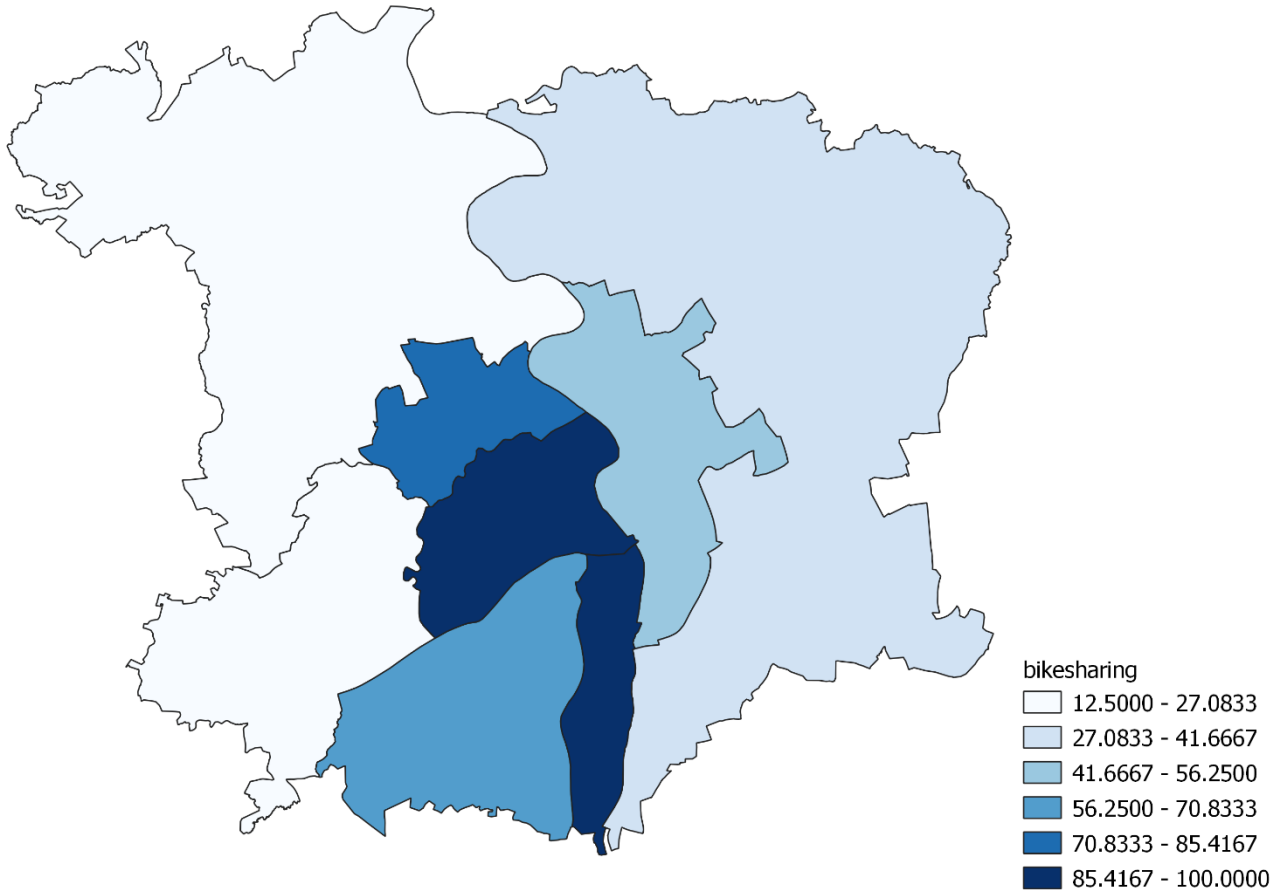
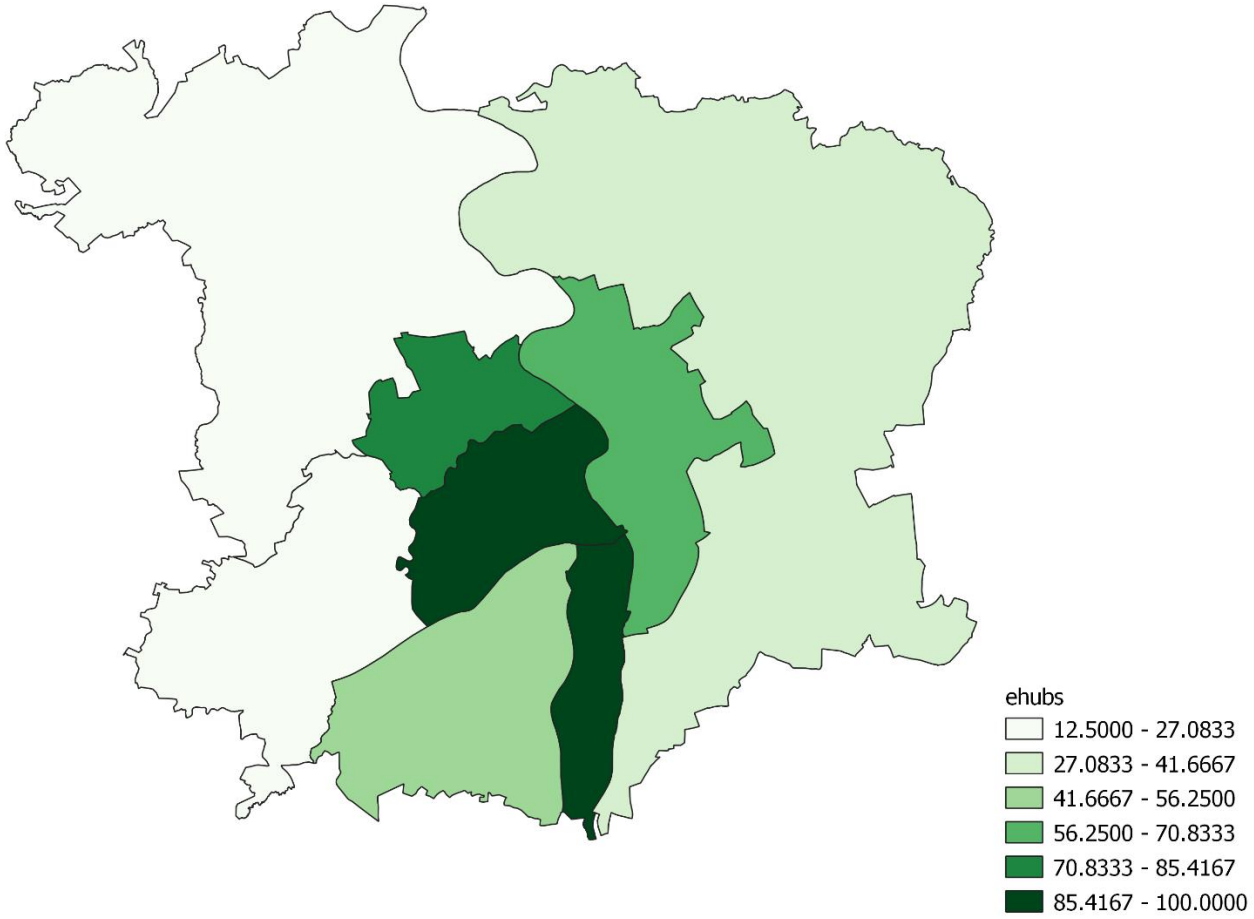


Figure 5b. Kempten heatmap for e-bikesharing potential




ehubs
12.5000 - 27.0833
27.0833 - 41.6667
41.6667 - 56.2500
56.2500 - 70.8333
70.8333 - 85.4167
85.4167 - 100.0000

3.6 Dreux

Table 16 Data source and processing for each variable

Variable	Data source	Processing
Population density	Census data	
Percentage of male	Census data	
Percentage of 15-65	Census data	
percentage of older than 65	Census data	
Bus stop density	Bus stops	GIS calculate
Presence of train station		Mark zones next to train station
Secondary road density	Road network	GIS calculate
Local road density	Road network	GIS calculate
Bike path density	Bike path network	GIS calculate
Restaurant density	Restaurant	GIS calculate

Table 17 Models used for calculating shared mobility potential score

Variable	Operationalization	Unit	EV sharing	E-bike sharing
Population	Population density	Number per 0.01 km2	0.001	0.12
Gender	Percentage of male		5.414	
Age	Percentage of 15-65		1.781	
Age	percentage of older than 65		-0.476	
Bus stop	Bus stop density	Number per km2	0.252	
Train station	Presence of train station		0.445	1.69
Secondary road length	Density	Km per km2	0.109	
Local road length	Density	Km per km2	1.23	
Bike path length	Density	Km per km2		0.08
Restaurant POI	Density	Number per km2		0.0045

Figure 6a. Dreux heatmap for EV carsharing potential

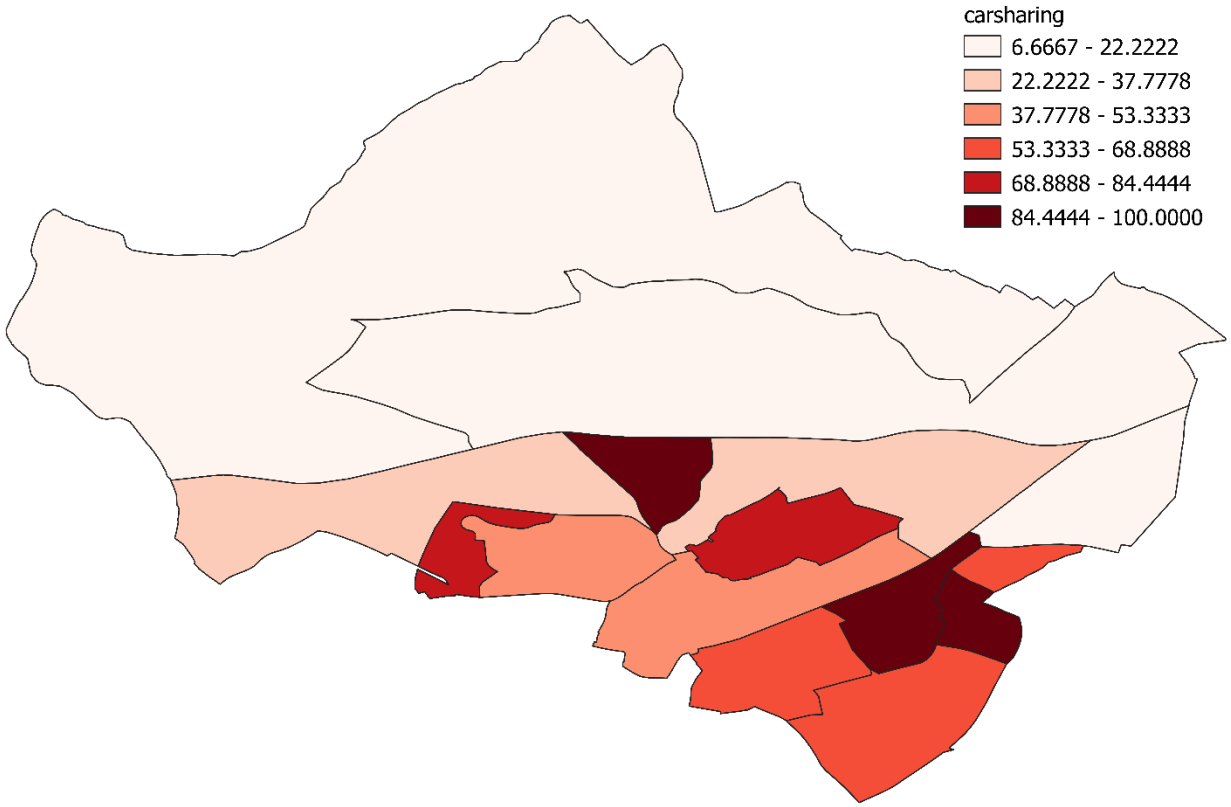


Figure 6b. Dreux heatmap for e-bikesharing potential

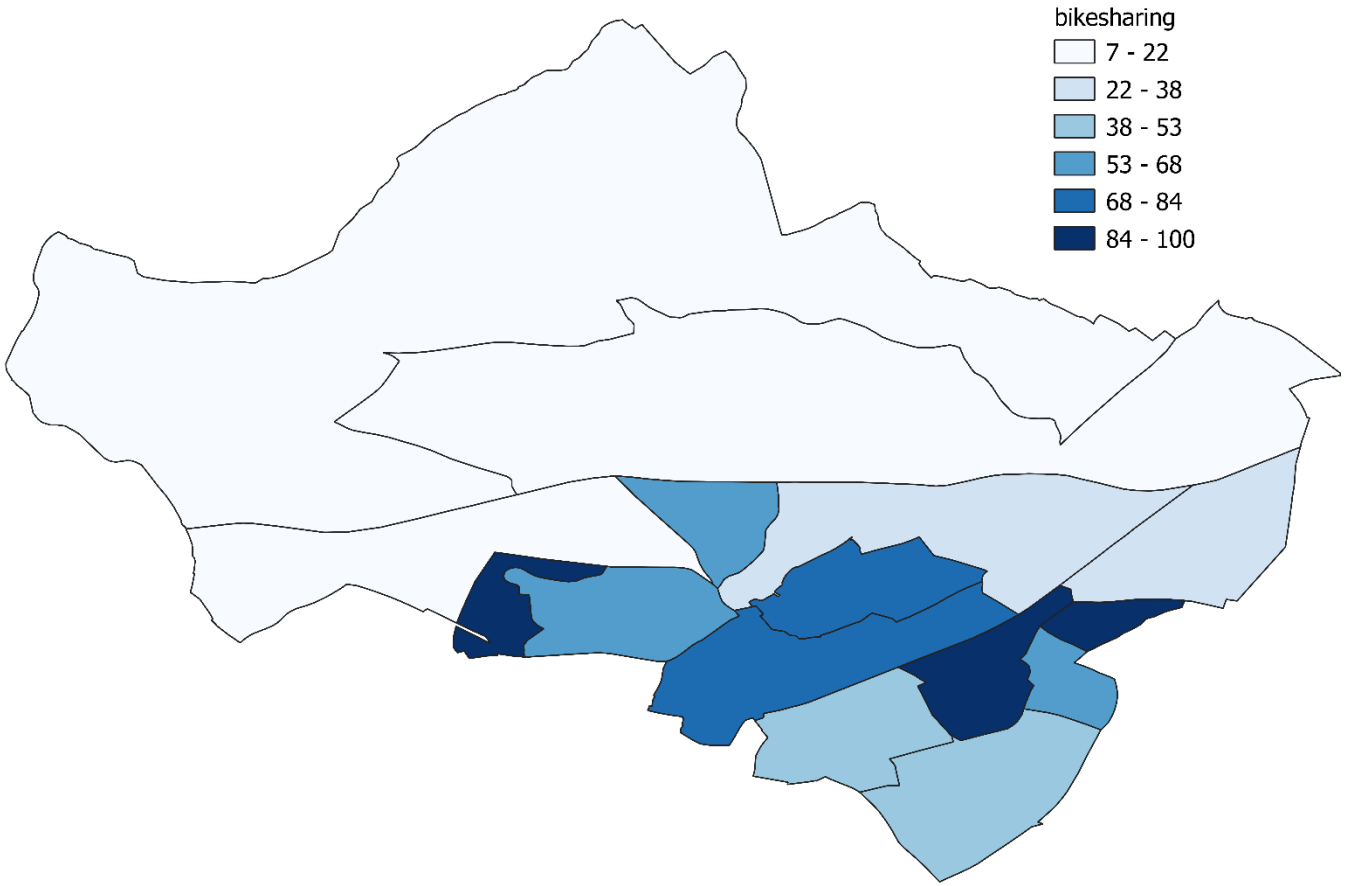
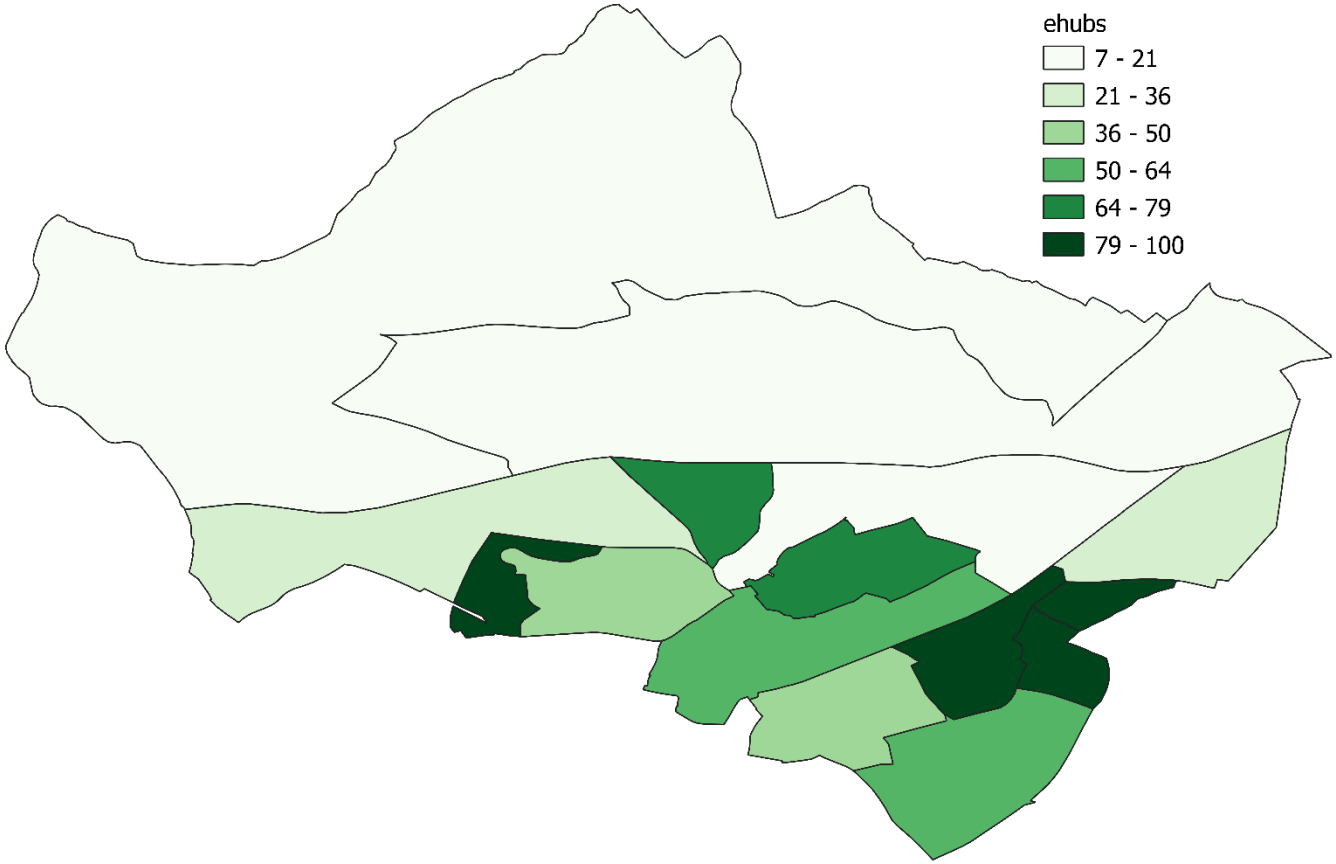


Figure 6c. Dreux heatmap for e-hubs potential



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