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Spatial Analysis of Citizens' Travel Data

The Pollicino Project

Fondazione Transform Transport ETS

Fondazione Transform Transport ETS
Research and Innovation in Mobility
and Transport Planning

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About

Transform Transport is a non-profit research foundation based in Milan (Italy) and focused on innovation in mobility and transport planning. It provides **innovative, inclusive, and sustainable mobility solutions** for shaping the future of society and cities worldwide in line with the UN's SDG 11 (Sustainable cities and communities).

It grounds on 30 years of Systematica's work and explores how **disruptive technologies**, increasingly and rapidly influencing urban mobility, can have a positive impact on cities, neighborhoods, and buildings, collaborating closely with municipalities and companies, and using Big Data for greater insights.

Transform Transport actively participates in lectures, talks, and hackathons in partnership with Universities, mentoring and sharing methodologies with students. It also promotes and develops **research studies**, disseminating them through books, publications, conferences, public talks, and events.

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+ Introduction

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Introduction

The Pollicino Project

- The project is an initiative of Fondazione per lo Sviluppo Sostenibile and Osservatorio Nazionale Sharing Mobility.
 - Transform Transport was engaged in the project Pollicino working group in the data analysis phase.
 - The project is based on the **data altruism** concept, data is provided with the voluntary collaboration of citizens, who agreed to anonymously recording their movements for seven days (GDPR compliant).
 - The project is based on the use of the **loPollicino smartphone application**, an app based travel diary that records citizens transportation habits.
 - The ultimate goal of the project is to **support local government decision-making processes** in the field of sustainable mobility.
- Data collection:
 - 6 weeks between May and June 2022
 - 1827 citizens activated the loPollicino app
 - 955 citizens completed the survey
 - **600 citizens were included in the analyses**, these:
 - Declared they lived in the municipality of Bologna
 - Make up a statistically relevant sample based on gender and age group
 - 13348 trips recorded
 - Participants can recheck, verify, edit/delete trip information detected by the app (path, purpose, mode).
 - Participants can split or merge several recorded trips due to change in mode or purpose.

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Capire la mobilità di Bologna grazie ai suoi cittadini

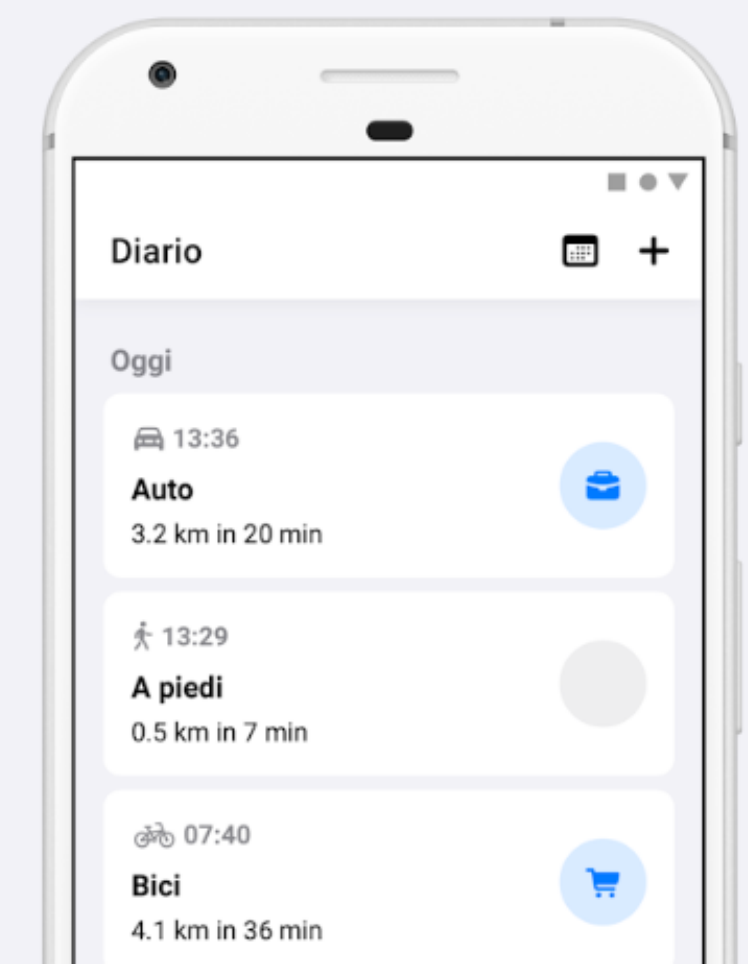
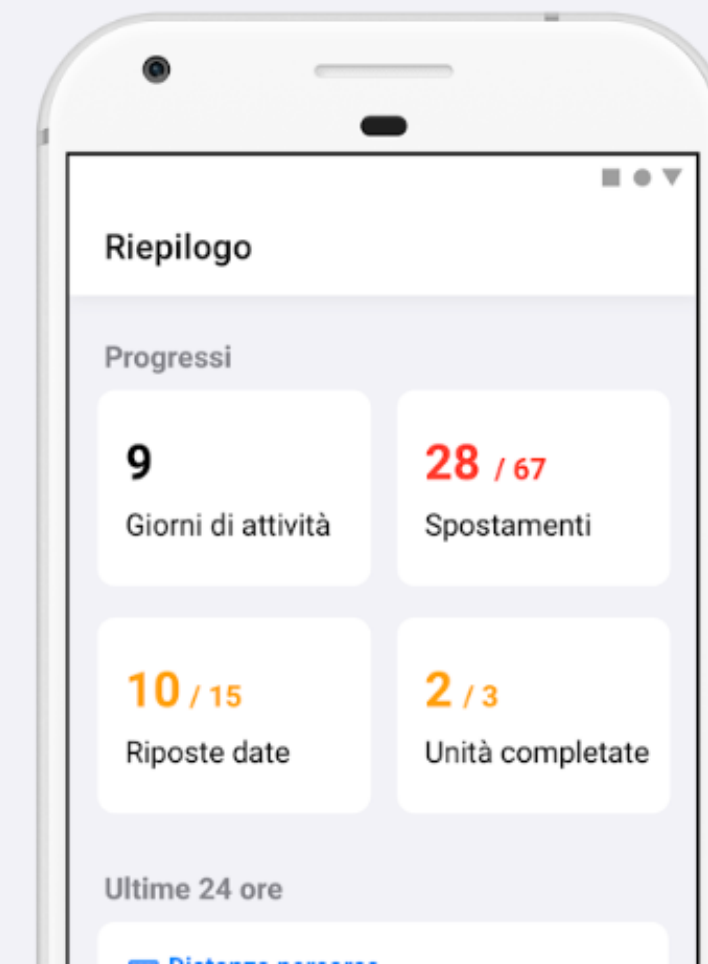
PARTECIPA ALL'INDAGINE E RITIRA I TUOI PREMI

Scarica l'app
loPollicino



Collabora attivamente per capire la mobilità di Bologna.

Consenti la registrazione anonima dei tuoi spostamenti per almeno 7 giorni.



Introduction

Spatial Analysis of Citizens' Travel Data: The Pollicino Project

This study was carried out by Transform Transport, engaged in the project Pollicino working group in the data analysis phase. Results of the analysis are published in the article: Spatial Analysis of Citizens' Travel Data: The Pollicino Project.

Abstract

Shifting mobility paradigms are leading to fragmented and flexible travel patterns in cities, no longer captured by traditional survey methods. Sensor data provided by multiple devices, including smartphones, enables ever more sophisticated analyses, that meet the necessity in understanding our environment. In this context, this research investigated citizens' travel behavior in Bologna, using GPS data collected through the Pollicino project, an app-based mobility survey carried out between May and June 2022. The study is structured in a data cleaning, processing, and mapping methodology, with the objective to identify spatial behaviors of citizens. The proposed analysis uncovered soft modes as predominant and concentrated in central zones of the city. Temporal assessments unveiled peak travel times, while aggregation reveals unique mobility patterns. Leisure emerges as the leading trip purpose. Notably, results highlighted that GPS data sourced through a mobility survey produces important insights to understand granular mobility behaviors, shedding light on key information for city planning and sustainable transportation.

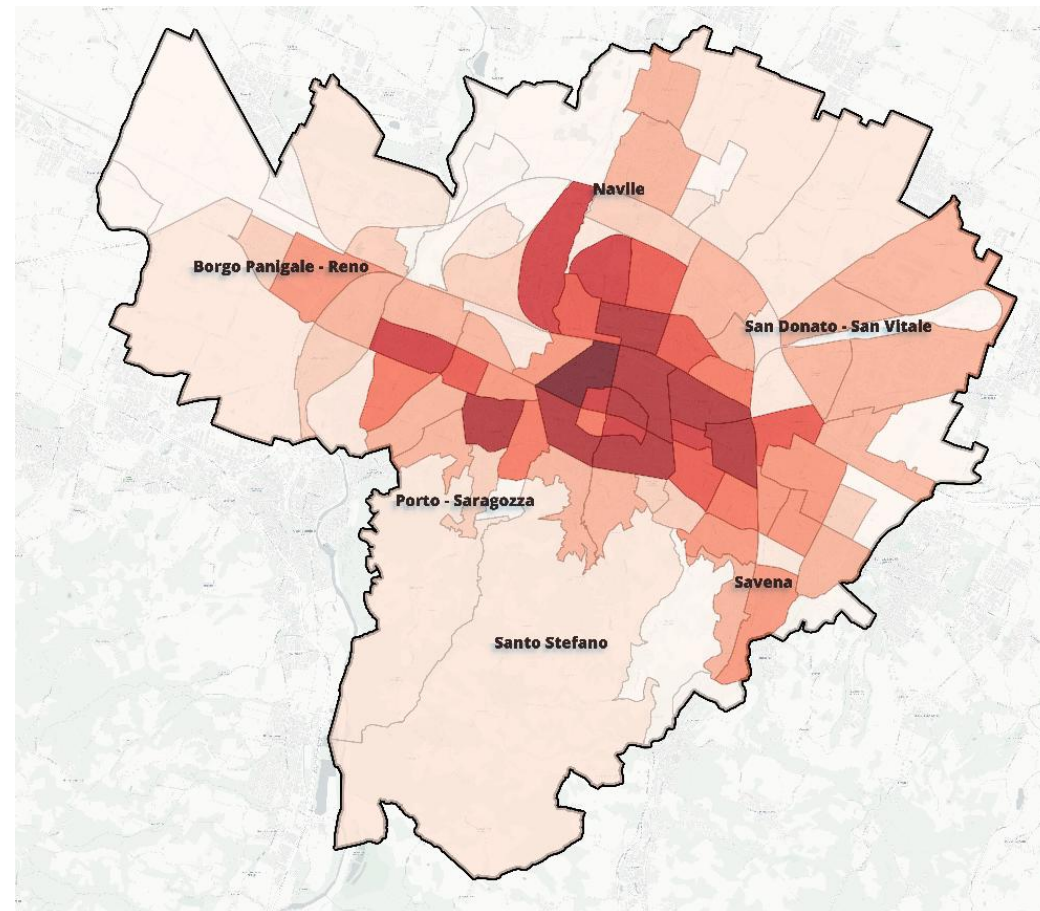
Ceccarelli, G., Albashir, A., Gorrini, A., Ciuffini, M., Refrigeri, L., & Asperti, G. (2023). Spatial Analysis of Citizens' Travel Data: The Pollicino Project. Zenodo. <https://doi.org/10.5281/zenodo.10361489>

Introduction

Objectives

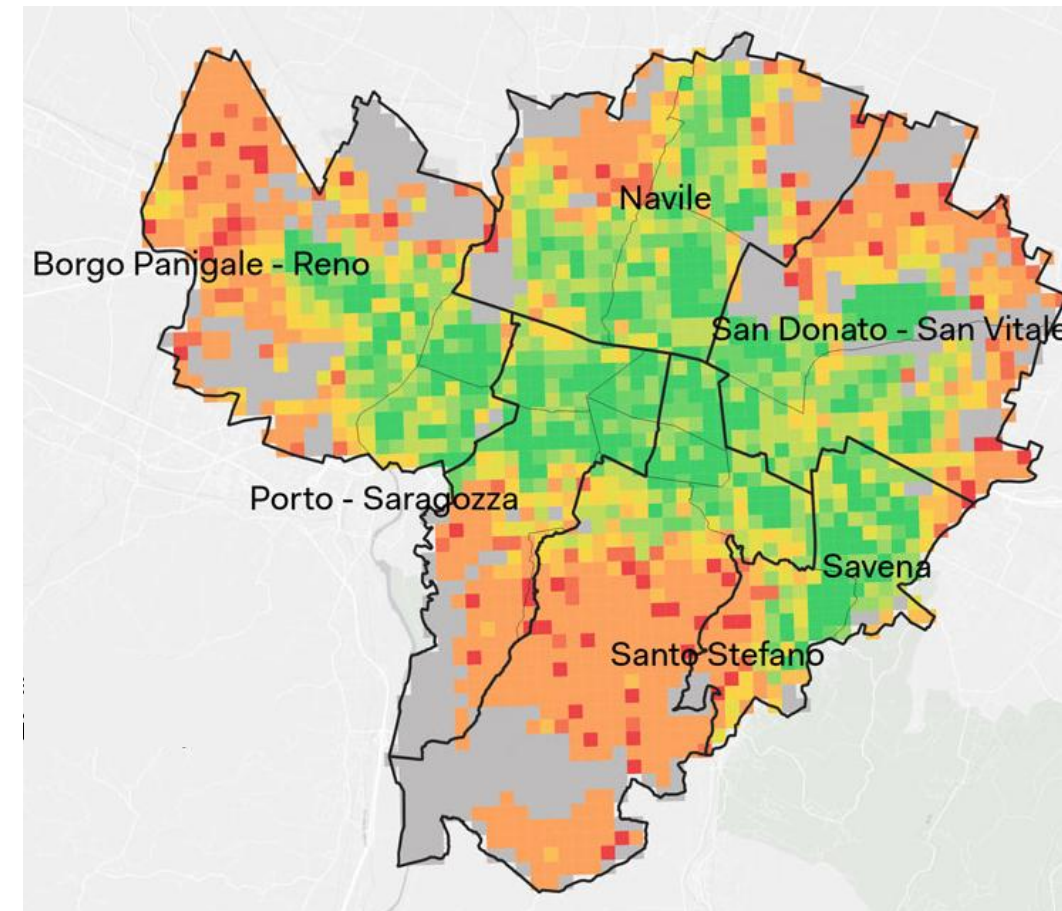
The main objective of this research was to unlock the potential of the **Big Data** collected by the mobile sensors by analyzing its spatial components in order to extract the mobility patterns, citizens' behaviors related to modal choice, and to understand its relation with both the urban characteristics and city infrastructure.

Thematic maps



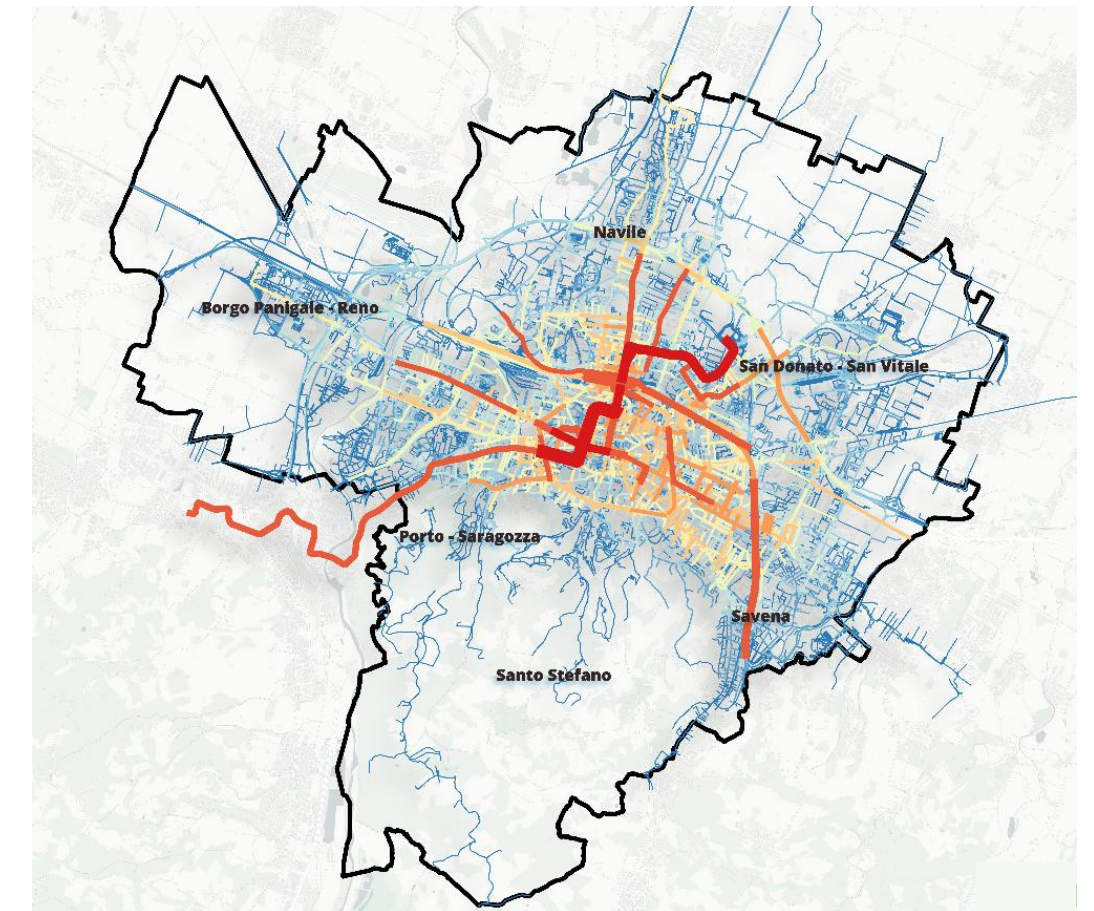
For an overview of the *spatial distribution of trips and mobility patterns* in Bologna

Spatial clustering



For the spatial understanding of *modal choices*

Trajectory analysis



For understanding the influence of *infrastructure and orography*

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+ Data and Methodology

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Data and Methodology

Data Description

The daily movements recorded through the tracking app IoPollicino are structured in three datasets.

The first set of data contains the anonymous **profile of each participant**.

Dataset #1 specifications

- Participant ID (anonymous)
- Socio-demographic (e.g., gender, age group)
- Mobility cluster, describing mobility behaviors of participants (i.e., *Metabolici, Sostenibili, Megamixer, Autonomi, Auto/ moto dipendenti*)

The second dataset includes a series of **descriptive information about the trip**.

Dataset #2 specifications

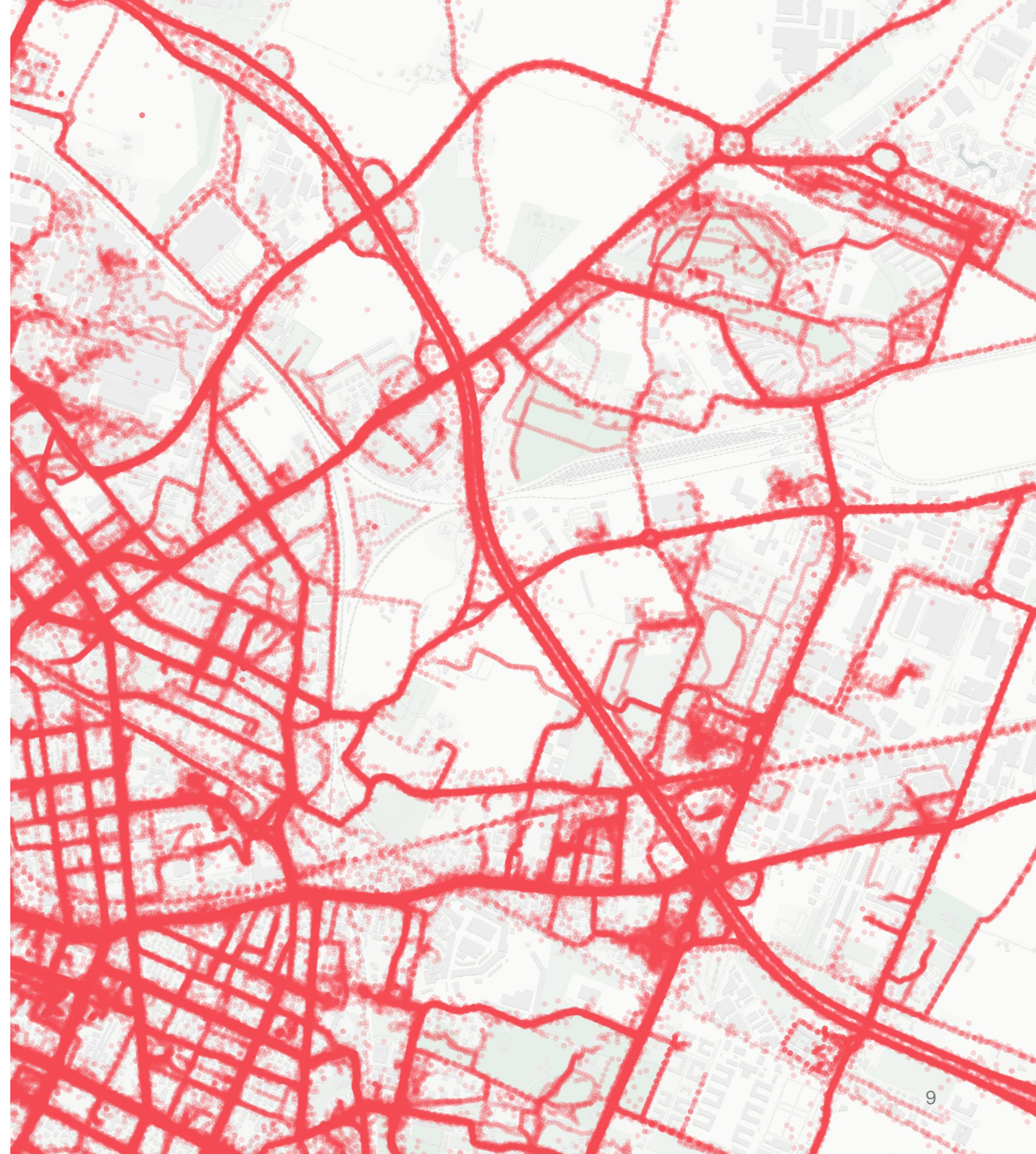
- Trip ID
- Participant ID
- OD matrix

The third dataset consists of the GPS point records between the **origin and the destination of each trip** to describe the full trajectory of the trip.

Dataset #3 specifications

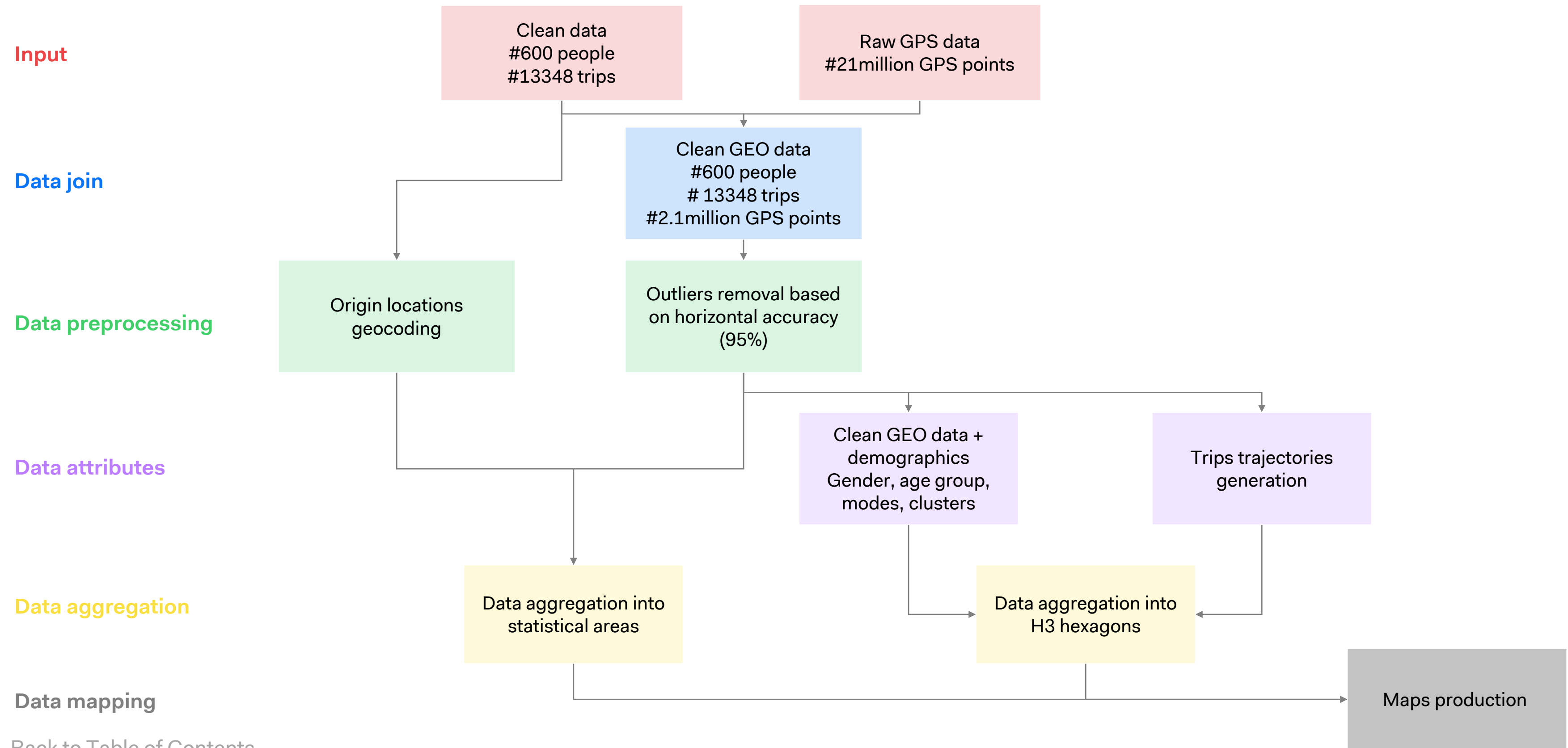
- Point ID
- Trip ID
- Latitude, longitude
- Location accuracy [m]
- Speed [m/s]
- Time [dd/mm/yyyy]
- Travel mode (e.g., car, bus, walking)

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Data and Methodology

Methodology



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+ Preliminary Data Analysis

Preliminary Data Analysis

Zoning Source: Open Data – Comune di Bologna

The municipality of Bologna is divided into **90 statistical areas**. These are used as a base to quantify the coverage of the data sample and the average GPS accuracy.

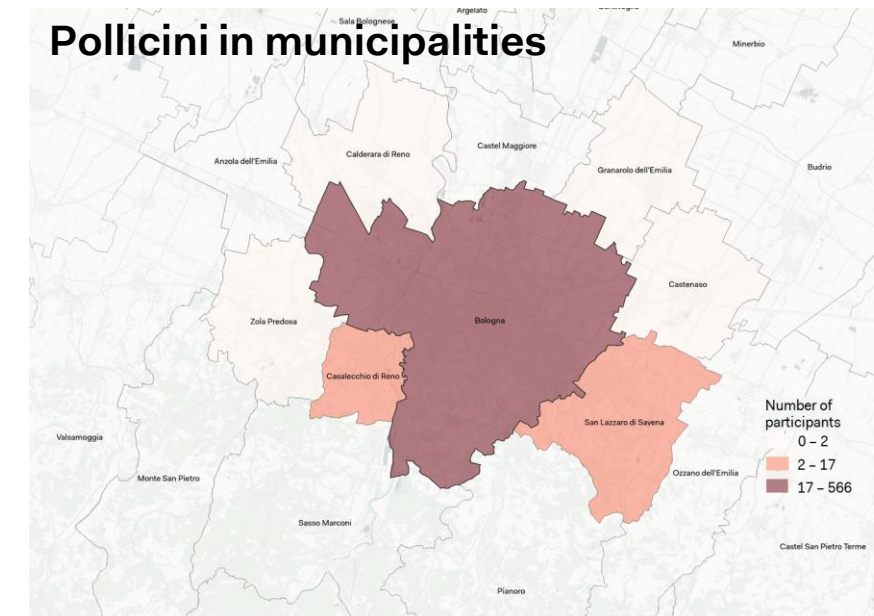
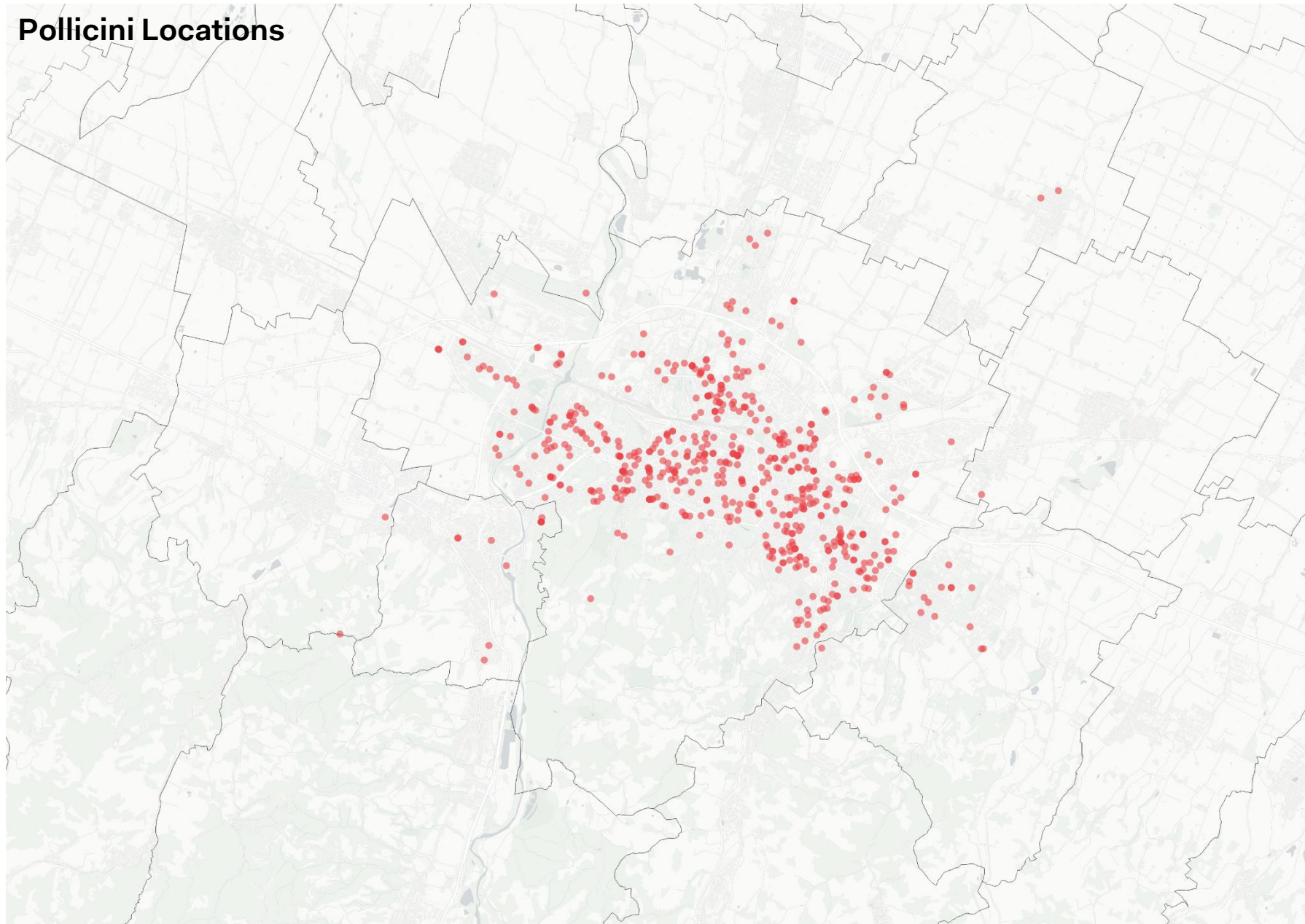
1	Lavino Di Mezzo	46	Scalo Merci San Donato
2	Via Del Vivaio	47	Via Del Lavoro
3	Bargellino	48	Michelino
4	Aeroporto	49	Via Mondo
5	La Birra	50	Osservanza
6	Lungo Reno	51	San Michele In Bosco
7	Ducati-Villaggio Ina	52	Paderno
8	Borgo Centro	53	Galvani-1
9	Triumvirato-Pietra	54	Galvani-2
10	Rigosa	55	Giardini Margherita
11	Casteldebole	56	Mezzofanti
12	Caserme Rosse-Manifattura	57	Siepelunga
13	Cnr	58	Dagnini
14	Arcoveggio	59	Chiesanuova
15	Via Ferrarese	60	Irnerio-1
16	Ex Mercato Ortofrutticolo	61	Irnerio-2
17	Piazza Dell'unita'	62	Cirenaica
18	San Savino	63	Scandellara
19	Savena Abbandonato	64	Via Larga
20	Croce Coperta	65	Roveri
21	Mulino Del Gomito	66	Ospedale Sant'orsola
22	La Dozza	67	Mengoli
23	Laghetti Del Rosario	68	Guelfa
24	La Noce	69	Croce Del Biacco
25	Tiro A Segno	70	Stradelli Guelfi
26	Pescarola	71	Stadio-Meloncello
27	Lazzaretto	72	Xxi Aprile
28	Beverara	73	San Giuseppe
29	Marconi-2	74	Ravone
30	Marconi-1	75	Via Del Genio
31	Prati Di Caprara-Ospedale Maggiore	76	San Luca
32	Scalo Ravone	77	Malpighi-2
33	Zanardi	78	Malpighi-1
34	Velodromo	79	Fossolo
35	Via Vittorio Veneto	80	Due Madonne
36	Villaggio Della Barca	81	Lungo Savena
37	Battindarno	82	Pontevecchio
38	Canale Di Reno	83	Bitone
39	Agucchi	84	Cavedone
40	Emilia Ponente	85	Via Arno
41	Cadriano-Calamosco	86	Ospedale Bellaria
42	Fiera	87	Monte Donato
43	San Donnino	88	Via Toscana
44	Pilastro	89	Corelli
45	Caab	90	Ponte Savena-La Bastia



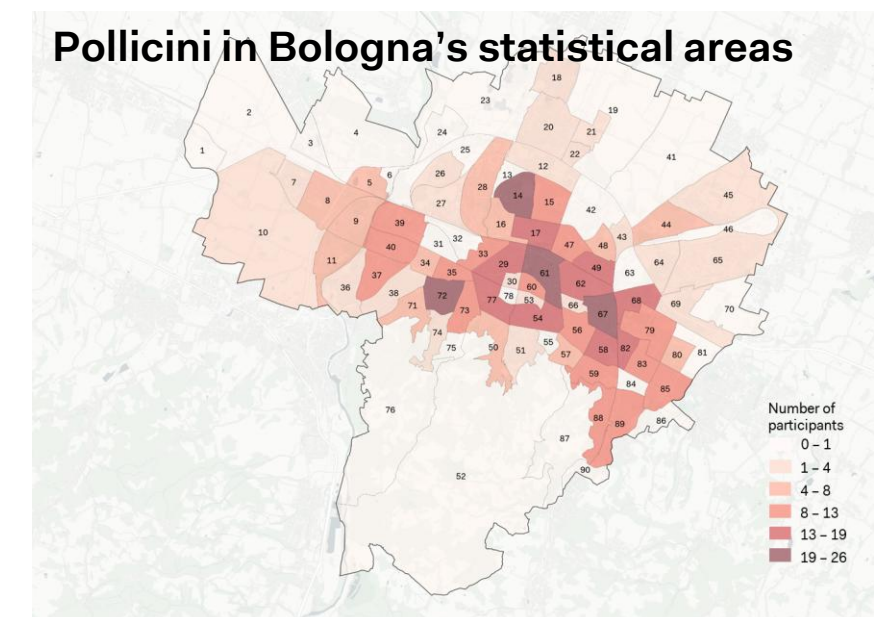
Preliminary Data Analysis

Participants locations

In the preliminary data analysis phase, the first aim was to gain an understanding of the **distribution of participants in Bologna and the surrounding municipalities.**



566 participants in Bologna



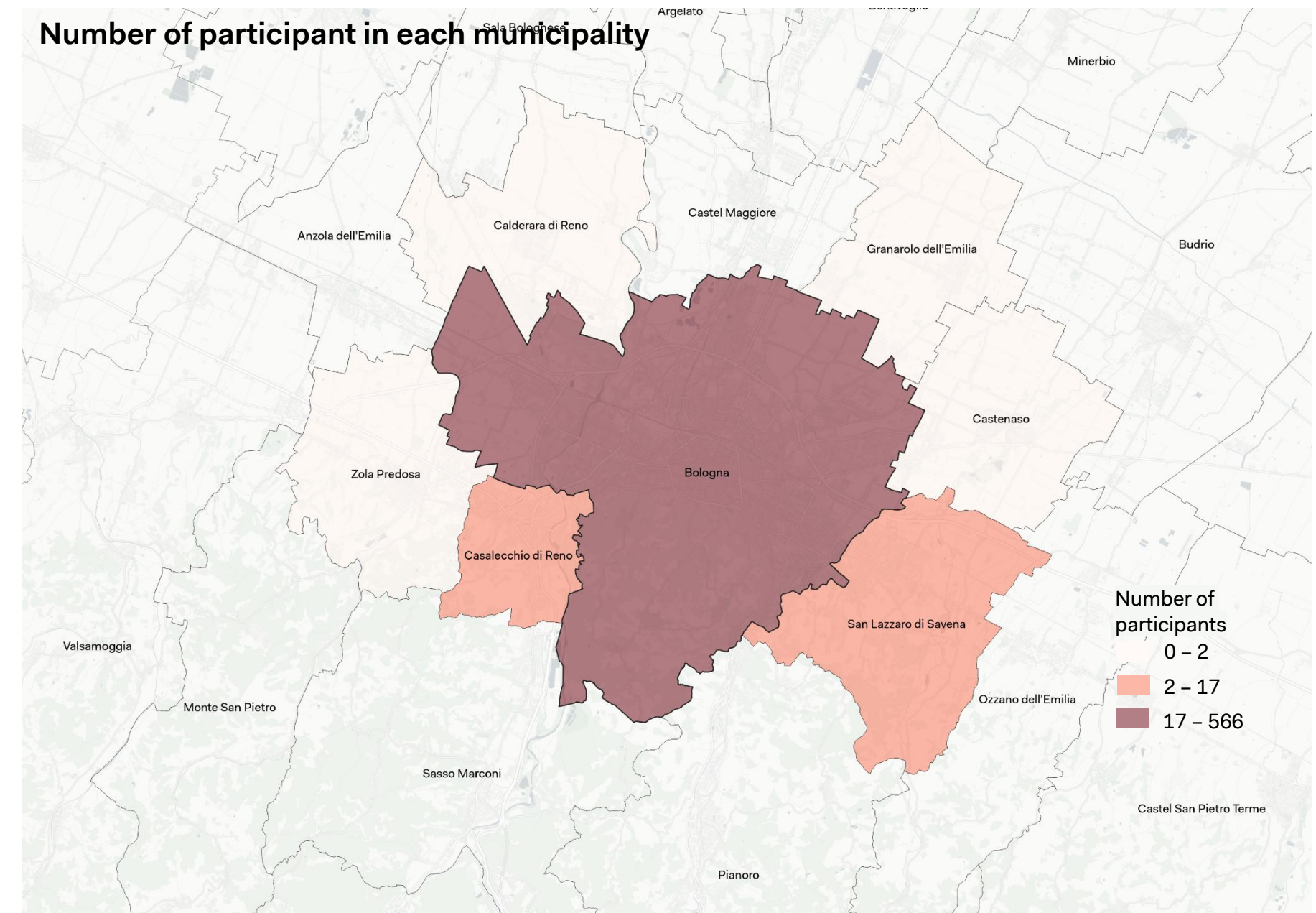
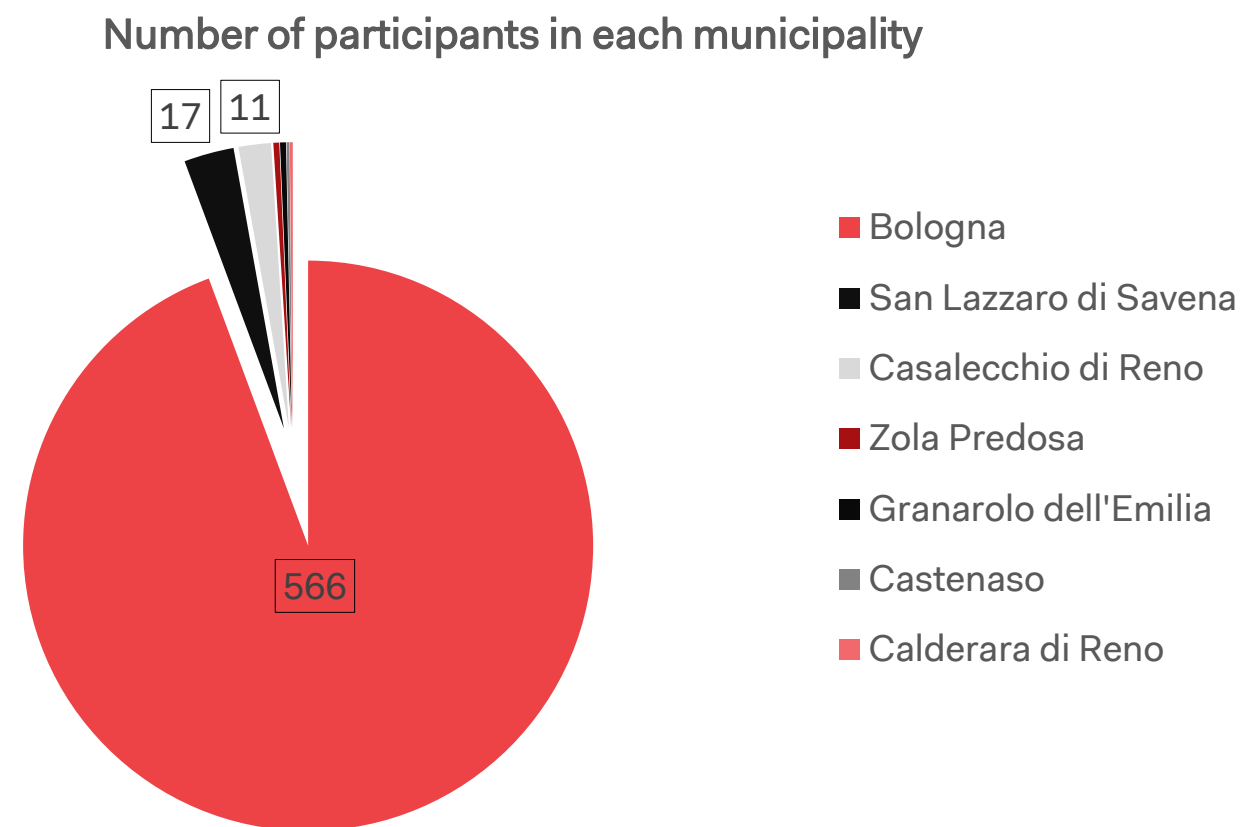
**26 participants in zone 72 (XXV Aprile),
24 participants in zone 14 (Arcoveggio),
21 participants in zone 67 (Mengoli),
20 participants in zone 61 (Irnerio-2)**

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Preliminary Data Analysis

Participants locations

In the preliminary data analysis phase, the first aim was to gain an understanding of the **distribution of participants and their representativity from a spatial perspective**. Results outline that **94%** of participants in the study were living within the municipality of Bologna, while 6% in the surrounding municipalities, in particular San Lazzaro di Savena and Casalecchio di Reno..

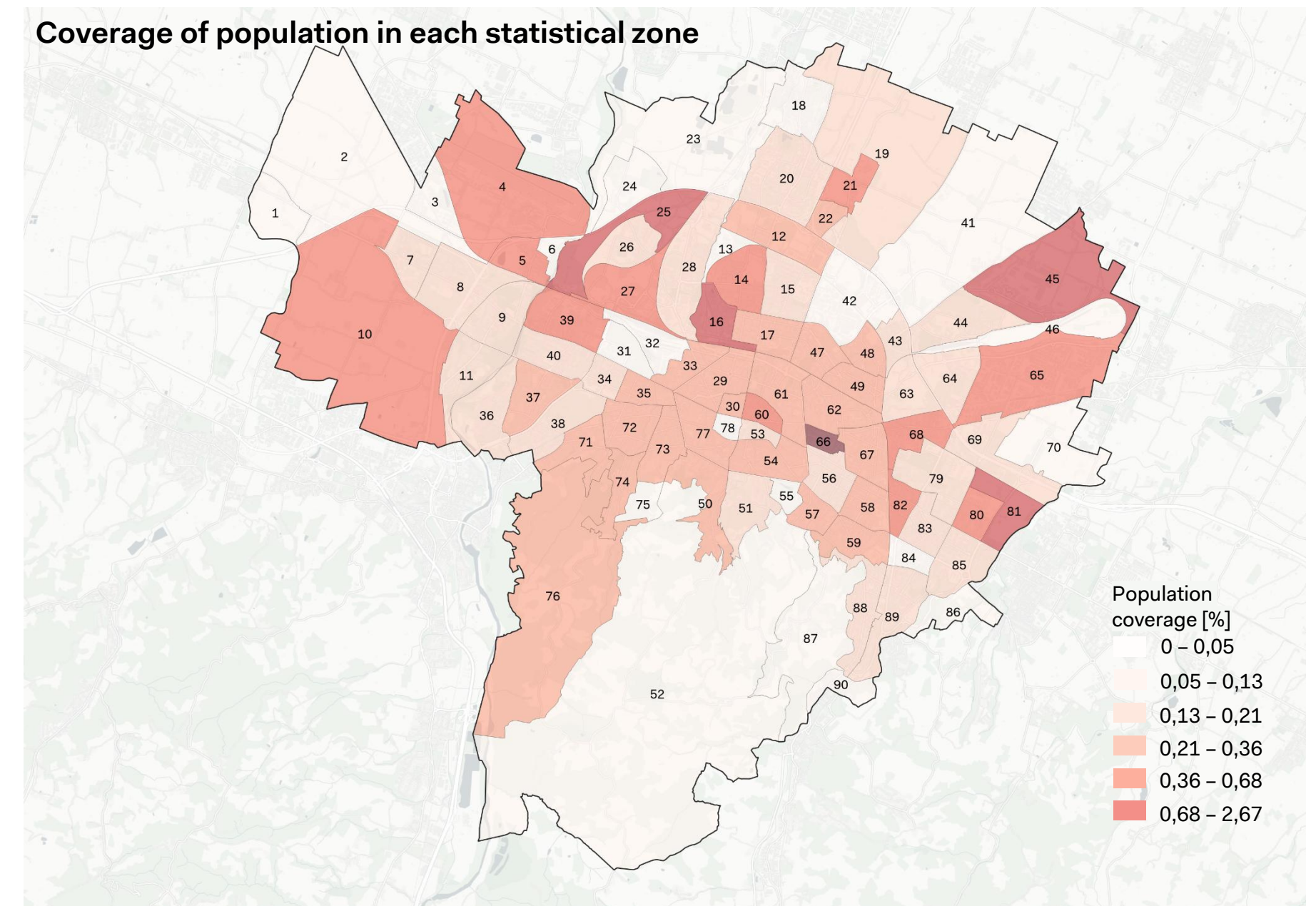
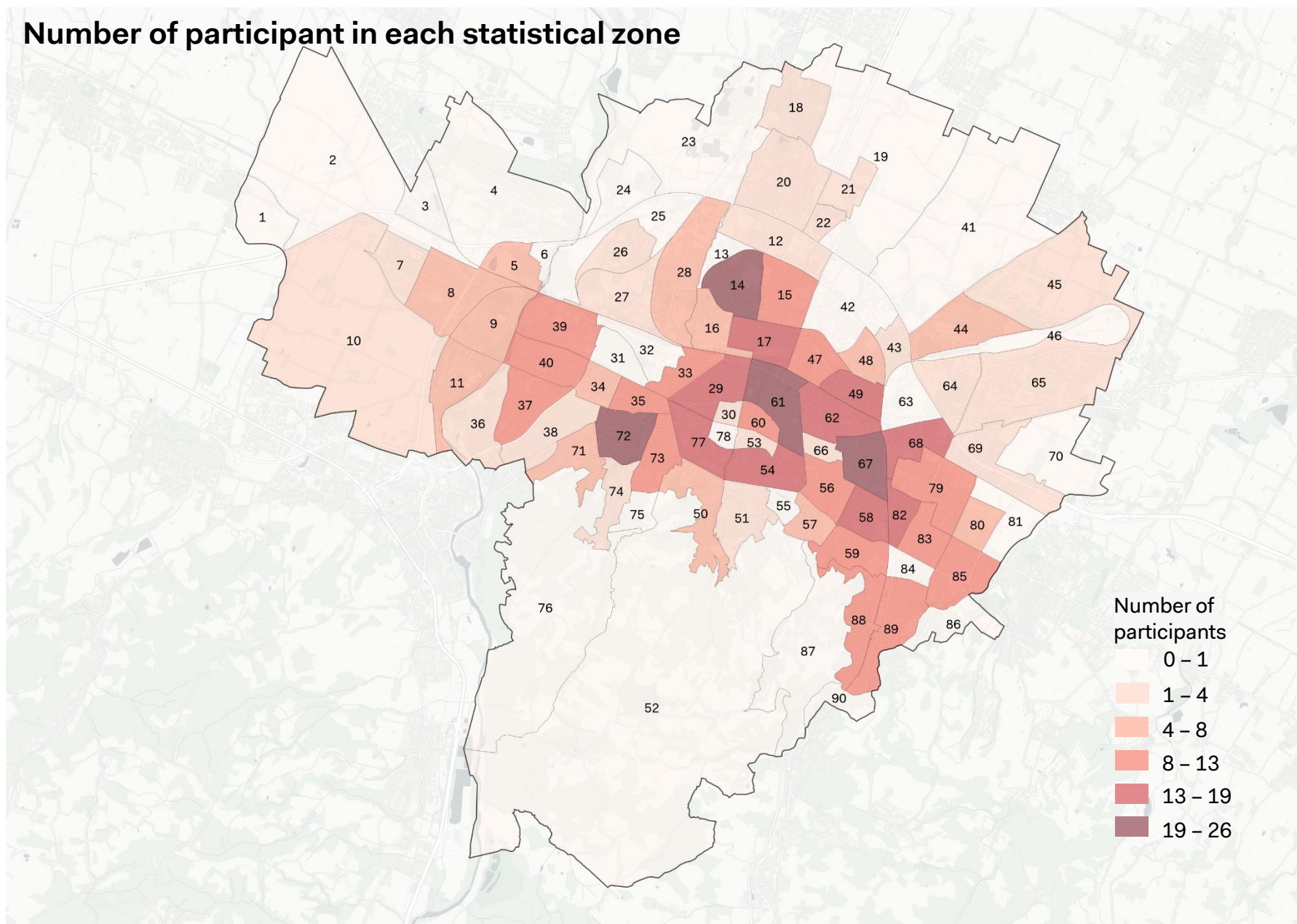


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Preliminary Data Analysis

Participants locations

In the preliminary data analysis phase, the first aim was to gain an understanding of the **distribution of participants and their representivity from a spatial perspective**. Results outline how the population's coverage in the municipality of Bologna is on **average 0.15%**, with several areas that are not represented in the dataset.

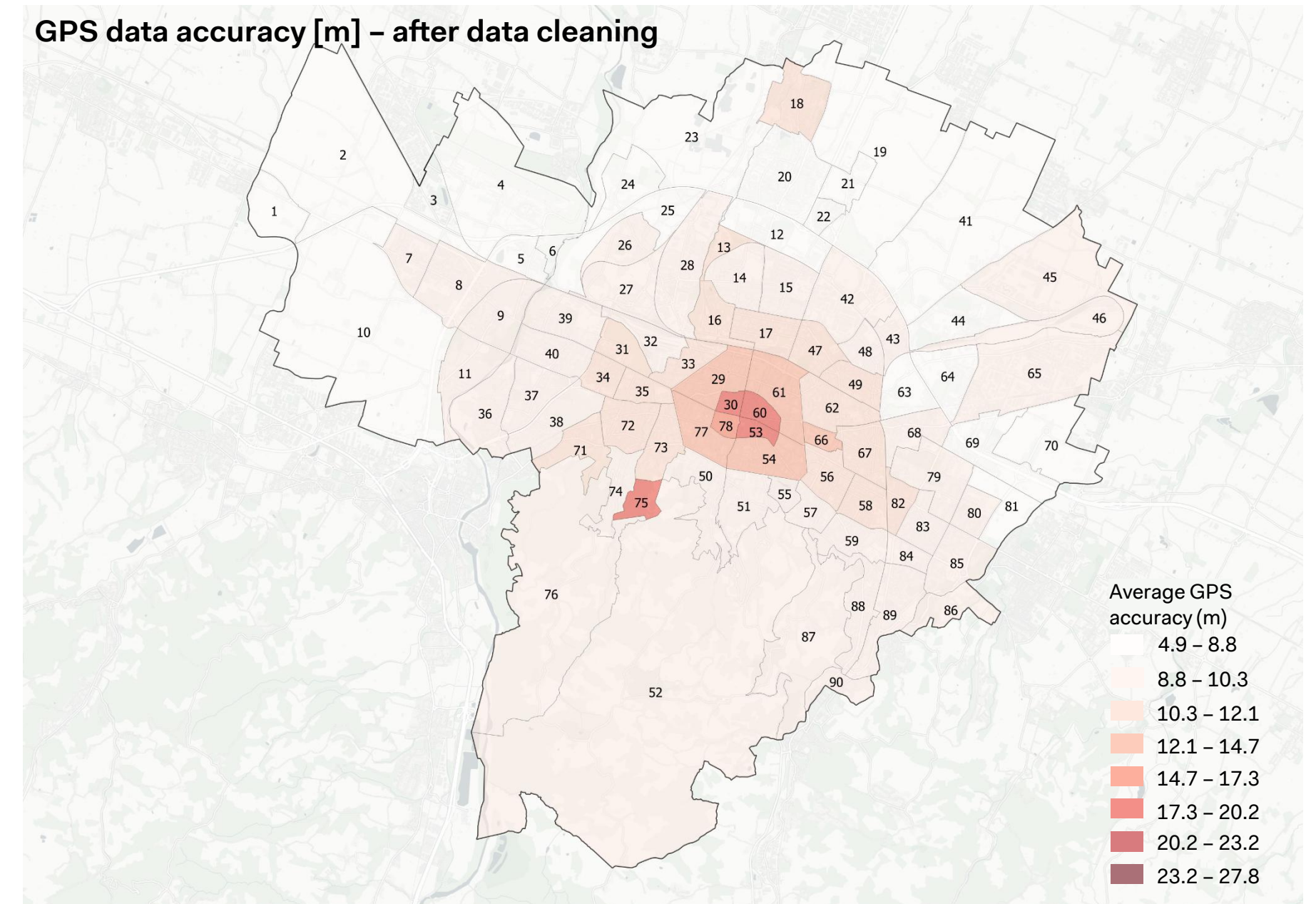
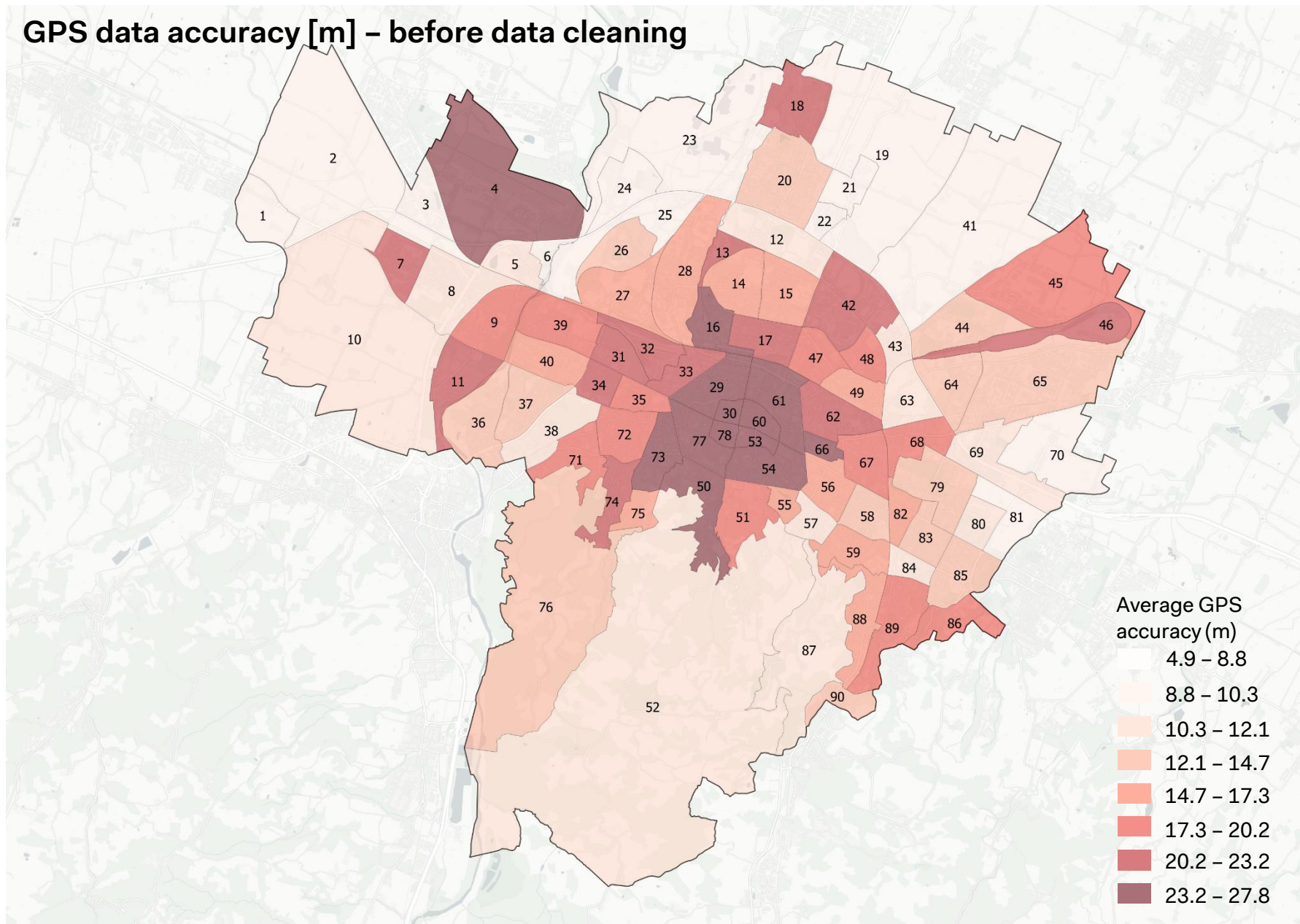


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Preliminary Data Analysis

GPS data accuracy

In the preliminary data analysis phase, the second aim was to **remove outliers from the GPS data**. To this end, the **95th percentile** of the GPS data accuracy was used as a threshold to filter out the outliers, following Kubo et al. (2020). Results outline **significant improvements** in the quality of the dataset, with the mean GPS accuracy shifting from 16m to 10m.



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+ Data Analysis and Mapping

Data Analysis

Modal split

In the data analysis phase, **trajectories** have been structured as a **sequence of connected and cleaned GPS points**. This step allowed for the spatial understanding and classification of movements, into three main modal groups: soft modes, motorized modes and public transport.

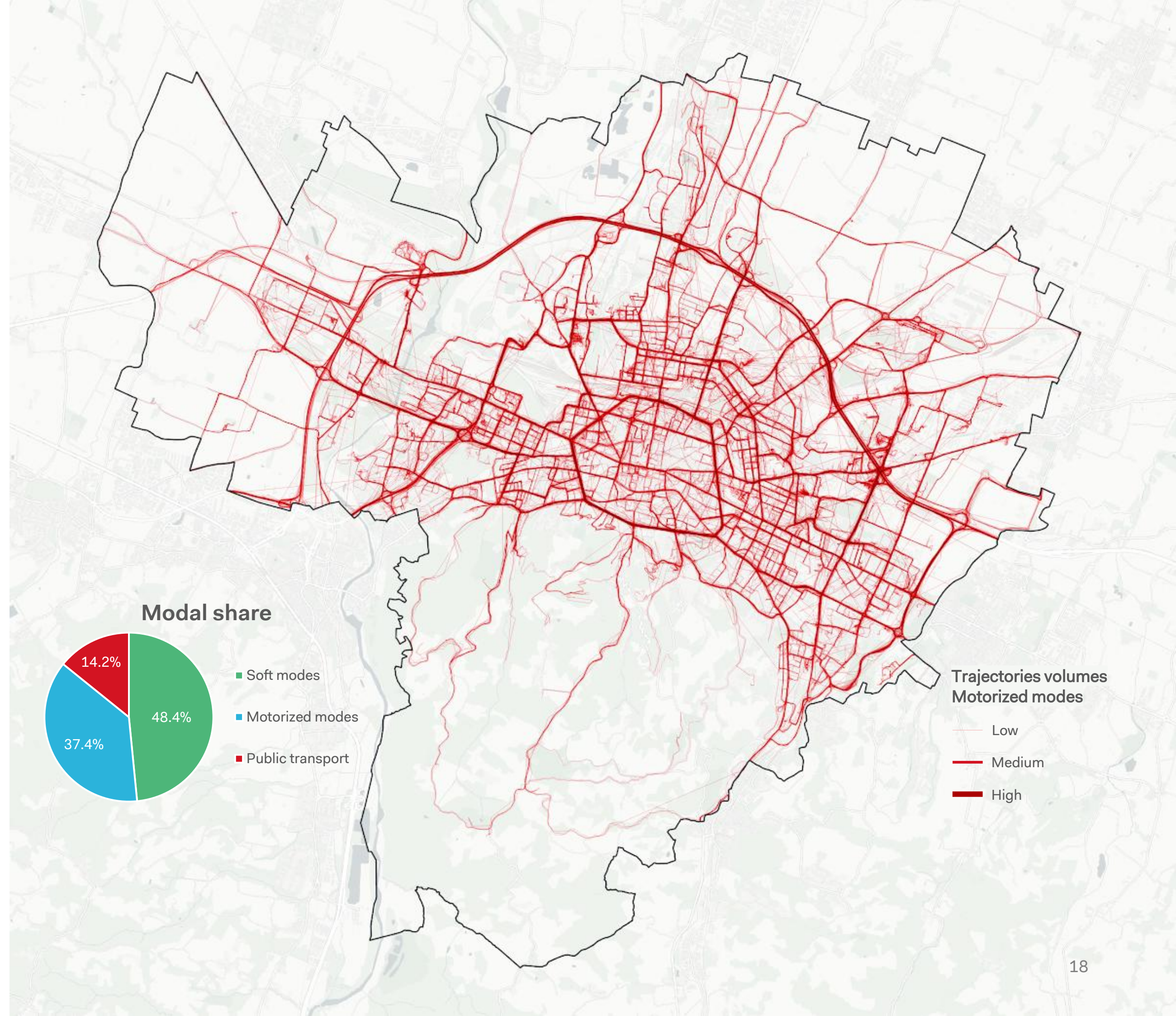
This elaboration represents visually the spatial patterns of **motorized modes trajectories**. These are:

- Car
- Passenger car
- Car sharing
- Motorcycle
- Passenger motorcycle
- Taxi

Trajectories are overlapped spatially on the map, thus **thicker segments** and **darker colors** outline areas where higher number of trips pass by.

In Bologna, motorized modes represent **40%** of the modal share, while soft modes and public transport represent **48%** and **12%** each.

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Data Analysis

Modal split

In the data analysis phase, **trajectories** have been structured as a **sequence of connected and cleaned GPS points**. This step allowed for the spatial understanding and classification of movements, into three main modal groups: soft modes, motorized modes and public transport.

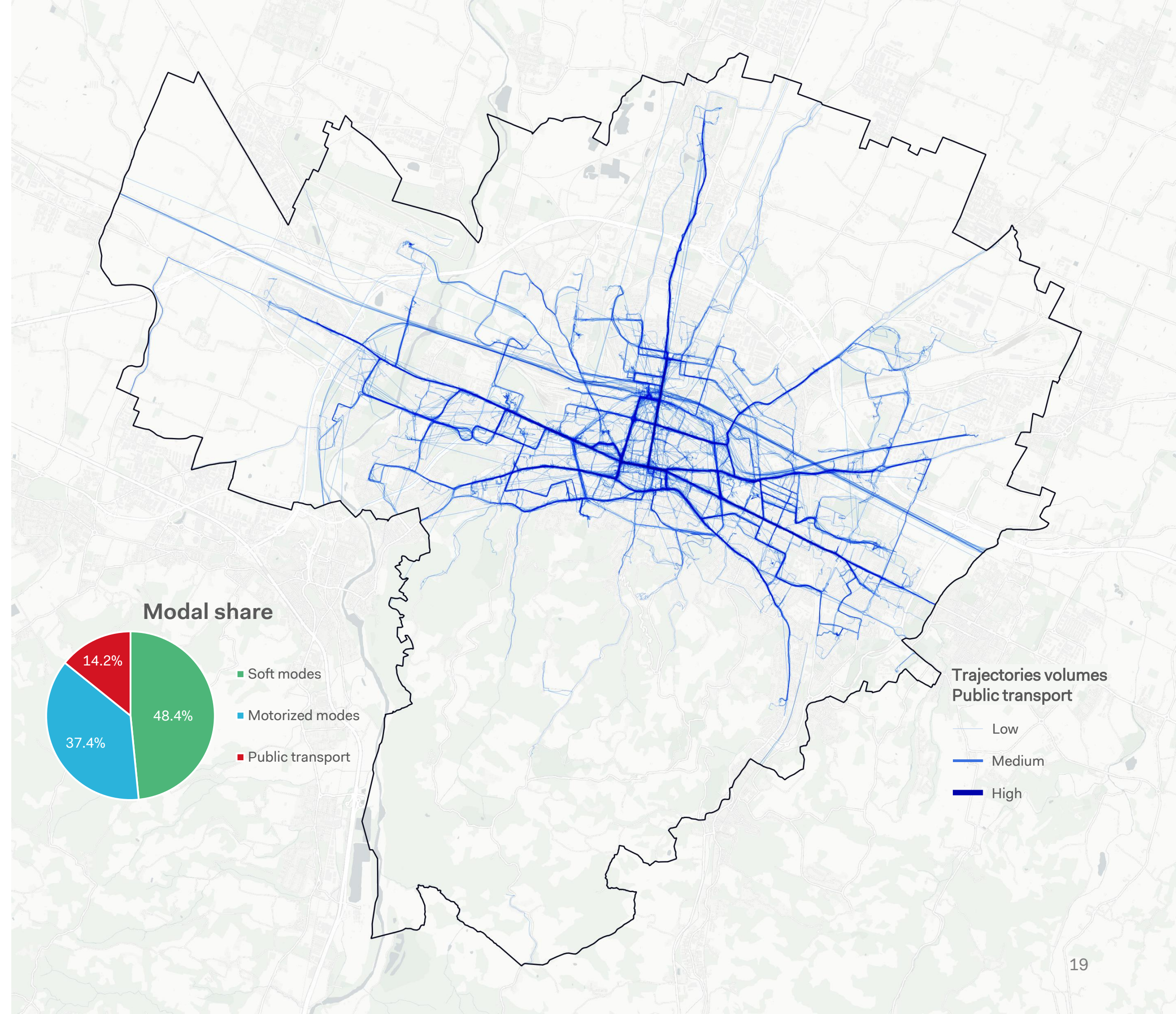
This elaboration represents visually the spatial patterns of **public transport trajectories**. These include:

- Bus
- Train
- People mover

Trajectories are overlapped spatially on the map, thus **thicker segments** and **darker colors** outline areas where higher number of trips pass by.

In Bologna, public transport represent **12%** of the modal share, while motorized modes and soft modes represent **40%** and **48%** each.

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Data Analysis

Modal split

In the data analysis phase, **trajectories** have been structured as a **sequence of connected and cleaned GPS points**. This step allowed for the spatial understanding and classification of movements, into three main modal groups: soft modes, motorized modes and public transport.

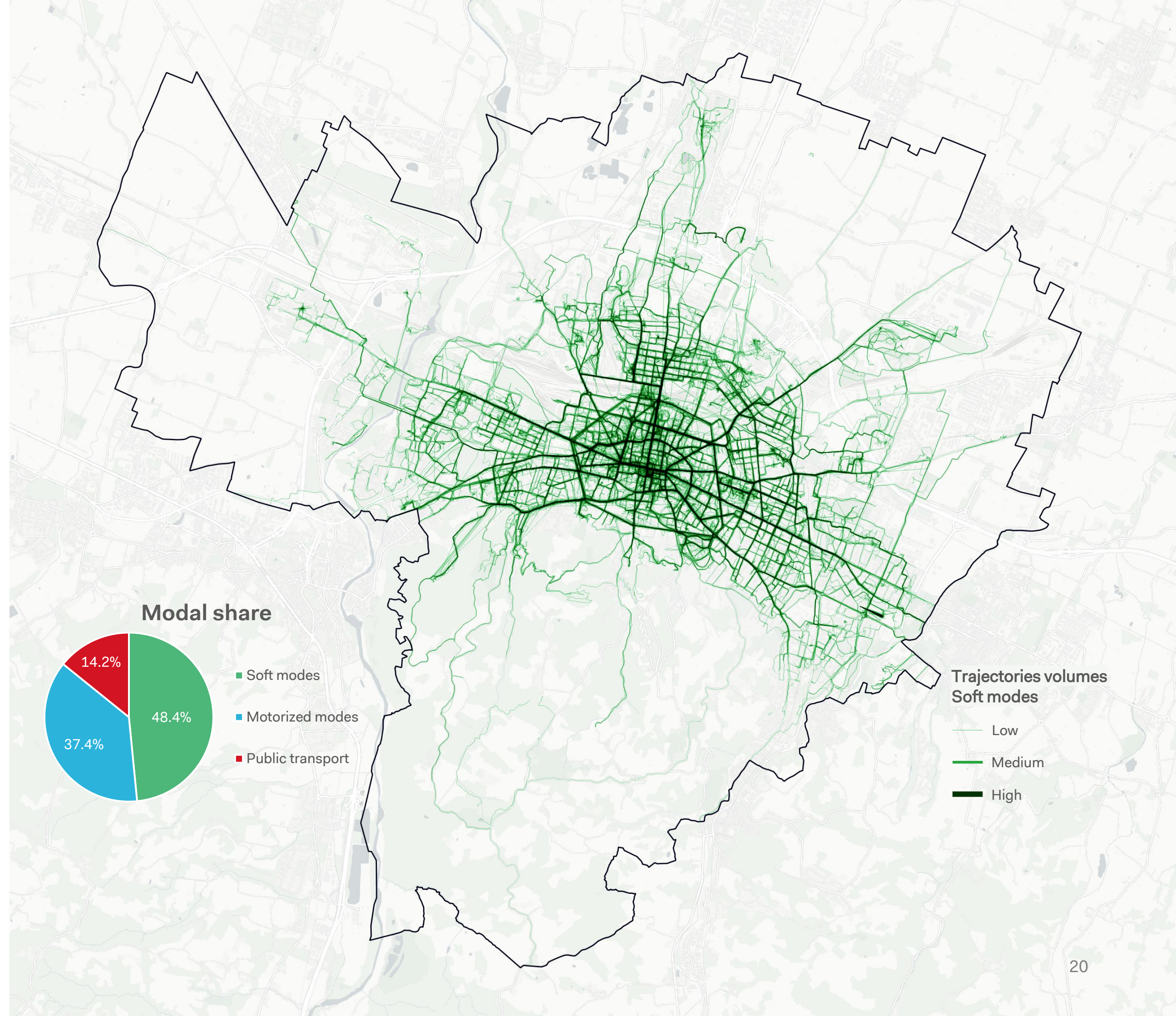
This elaboration represents visually the spatial patterns of **soft modes trajectories**. These include:

- Walking
- Cycling
- Bike sharing
- Scooter

Trajectories are overlapped spatially on the map, thus **thicker segments** and **darker colors** outline areas where higher number of trips pass by.

In Bologna, soft modes represent **48%** of the modal share, while motorized modes and public transport represent **40%** and **12%** each.

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Data Analysis

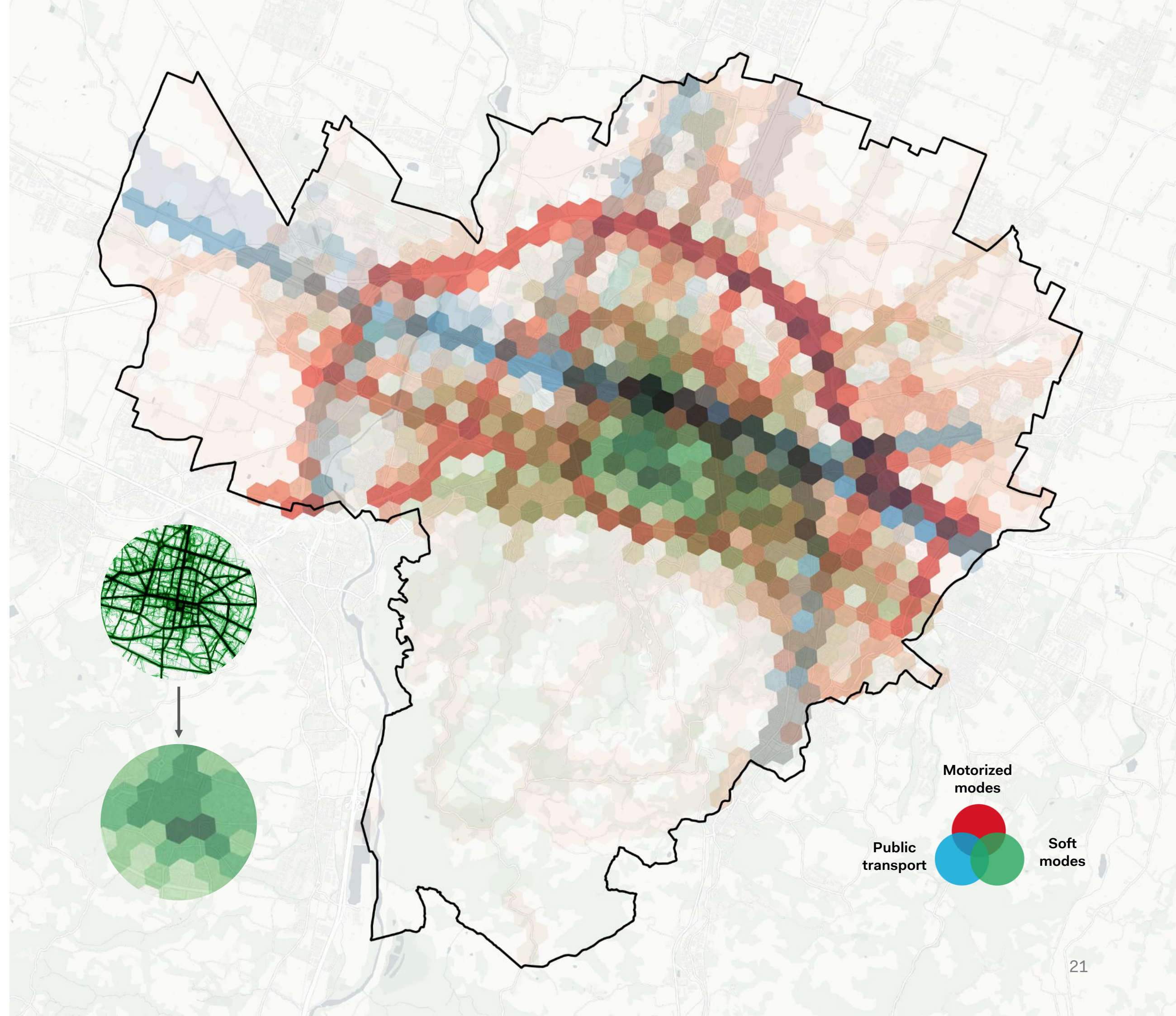
Modal split

In the data analysis phase, following data cleaning processes and the structuring of trajectories, data was aggregated into the **hexagonal H3 grid**, a hierarchical geospatial index based on hexagons developed by Uber. The goal of this step was to **quantify the intensity of trips volumes in Bologna, using a homogeneous spatial unit.**

The map represents **passing-by trips volumes**, quantified as total number of trips passing by each hexagonal area in the H3 grid during the study period, and the spatial distribution of three modal groups in Bologna, **motorized modes trajectories, public transport trajectories and soft modes trajectories.**

Passing-by trips volumes are overlapped spatially on the map, thus **darker colors in three chromatic scales** outline areas where higher number of trips pass by. Furthermore, the three chromatic scales are overlapped, outlining areas where **modal co-presence** occurs.

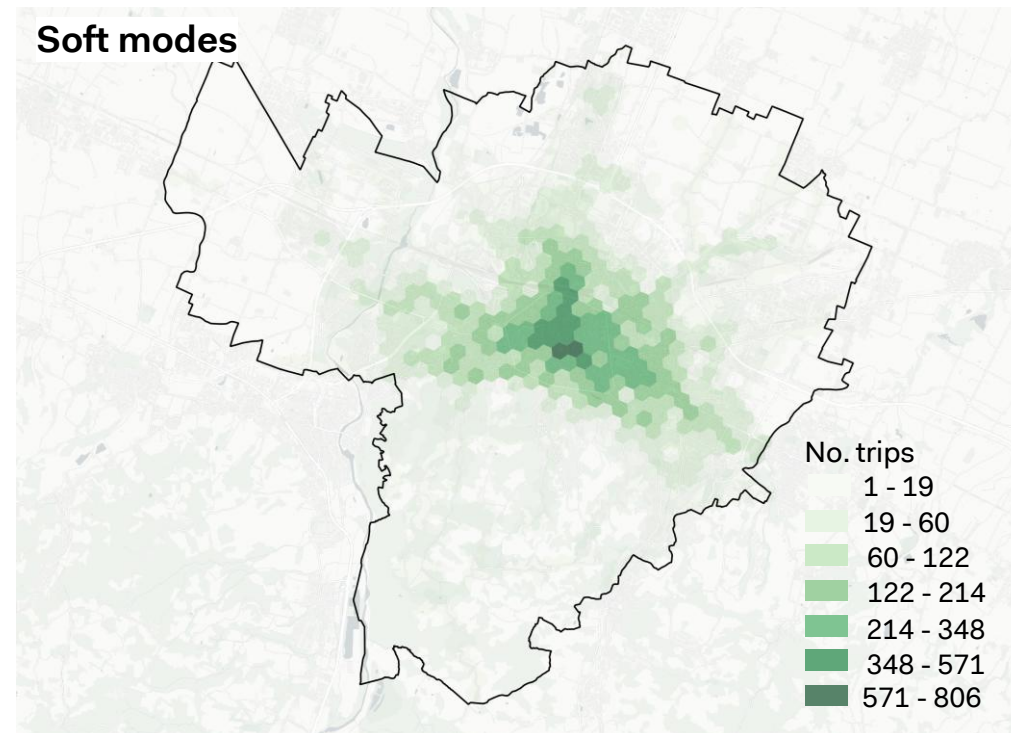
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Data Analysis

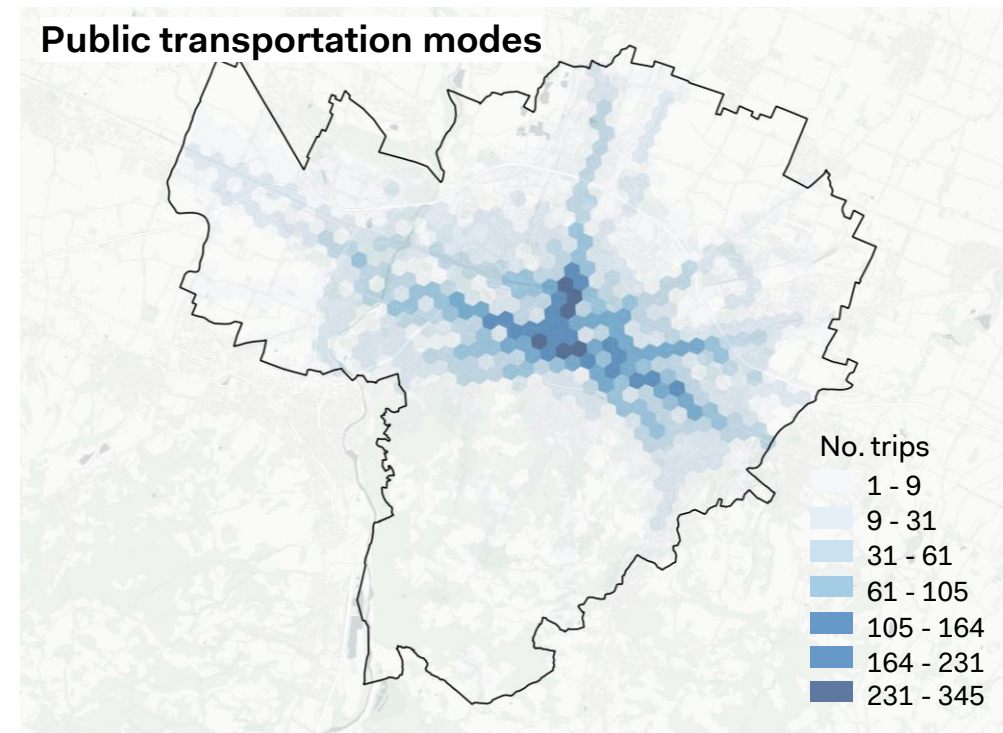
Modal split

In the data analysis and mapping phase, Pollicino's trajectories were aggregated into the **hexagonal H3 grid**, a hierarchical geospatial index based on hexagons developed by Uber, to **quantify and visualize spatial patterns**. Each map represents the number of trips passing by the study area, structured into: soft modes, public transport, motorized modes.



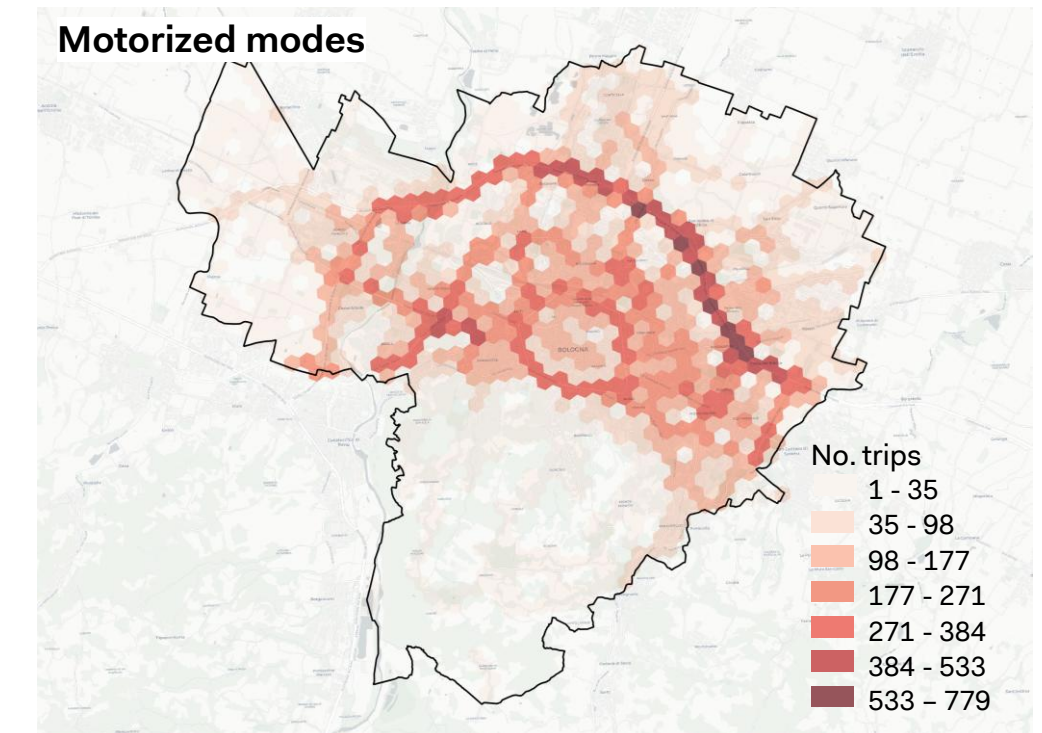
Soft modes trips take place in the city center and spread out to the surrounding areas.

Total number of trips: **5209**
Trip average length: **2039 m**
Percentage of covered area: **56%**



Public transport trips concentrate in the city center but branch out to reach further distances.

Total number of trips: **1394**
Trip average length: **5822 m**
Percentage of covered area: **60%**



Motorized trips main traverse the highway around the city and the inner circular road.

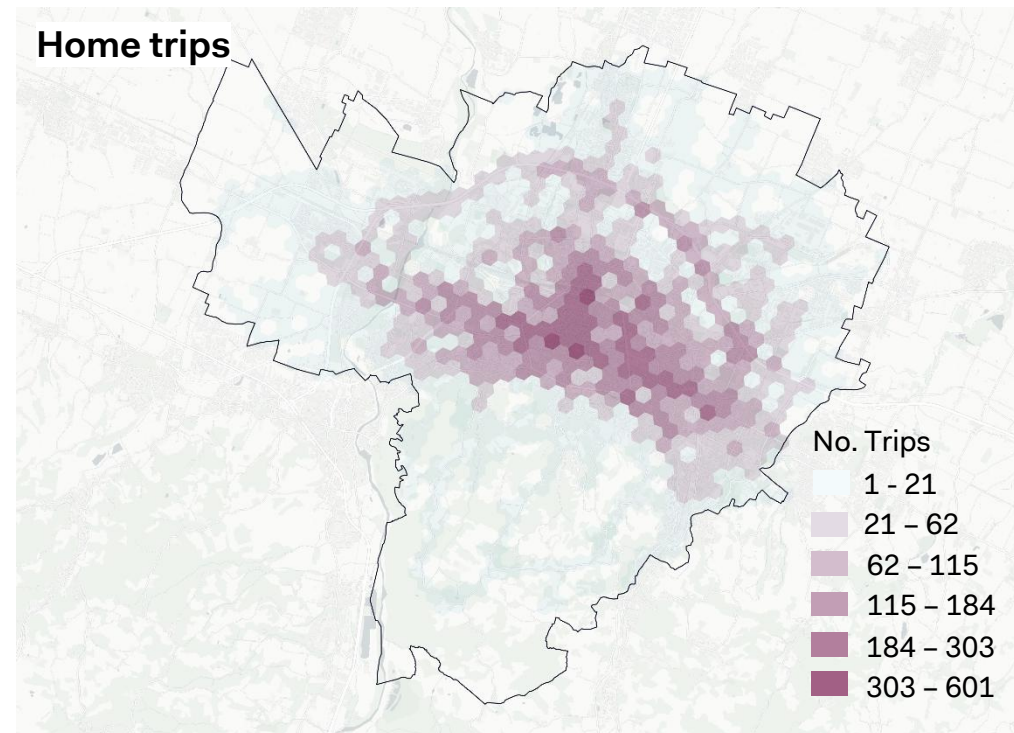
Total number of trips: **4216**
Trip average length: **9722 m**
Percentage of covered area: **81%**

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Data Analysis

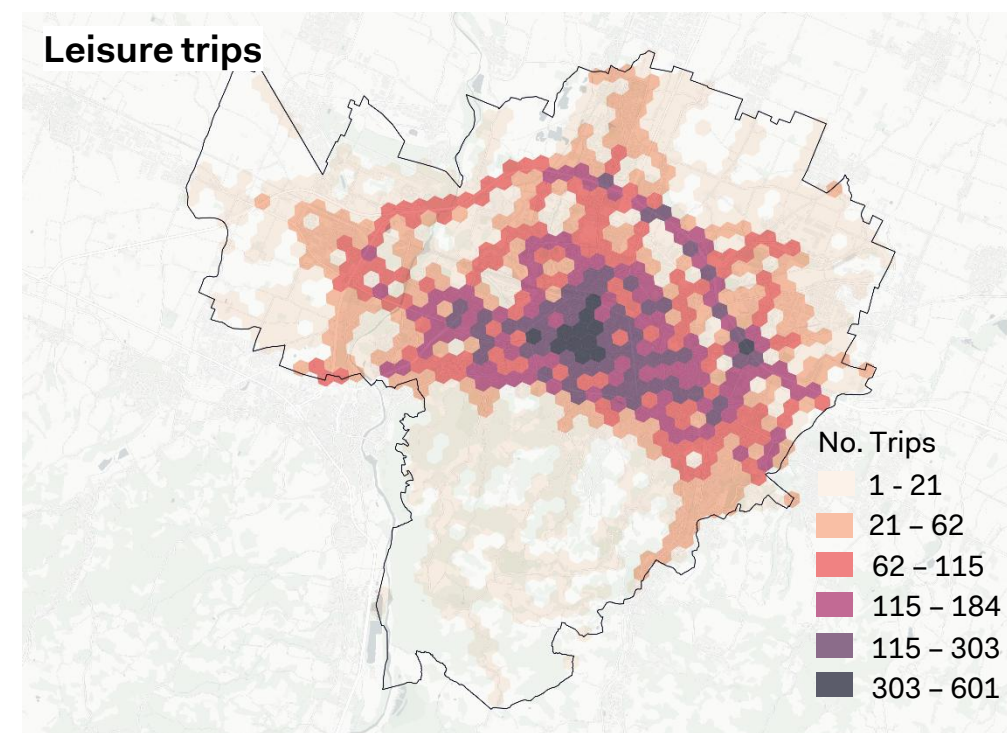
Trip purpose

In the data analysis and mapping phase, Pollicino's trajectories were aggregated into the **hexagonal H3 grid**, a hierarchical geospatial index based on hexagons developed by Uber, to **quantify and visualize spatial patterns**. Each map represents the number of trips passing by the study area, structured into: home trips, leisure trips, work trips.



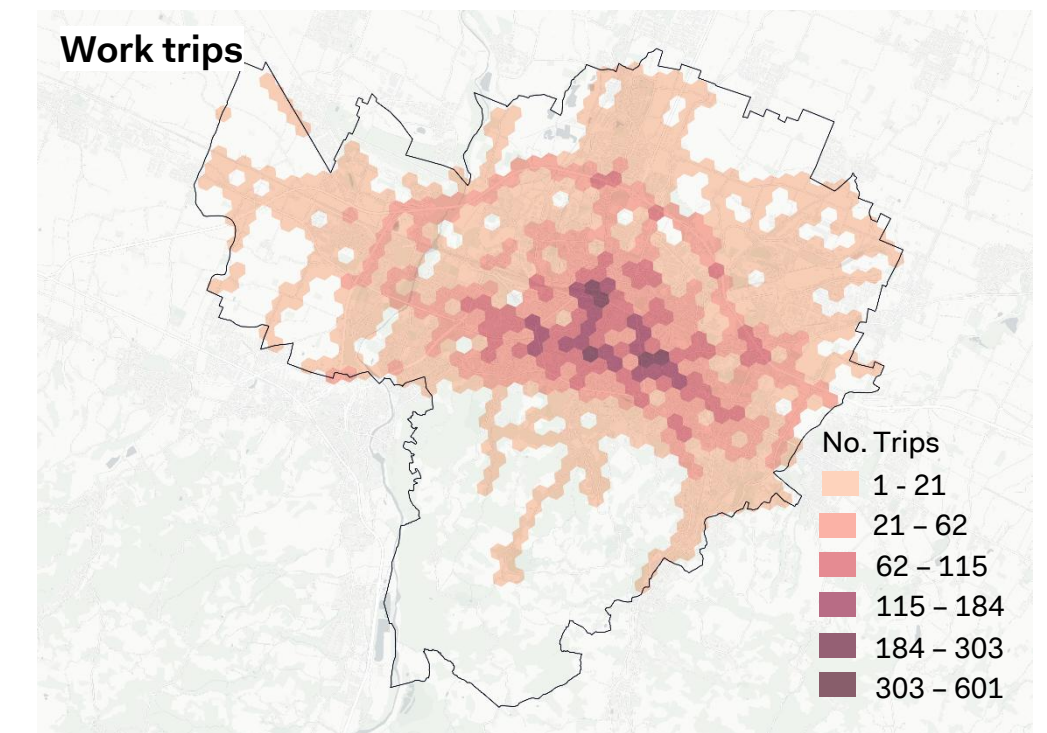
Travel to and from home is concentrated in the city center and spread out to the surrounding areas.

Total number of trips: **3249**
Trip average length: **3978 m**
Percentage of covered area: **66%**



Leisure is the main motivation for travel, trips are distributed throughout the territory, with a high density in the city center.

Total number of trips: **5354**
Trip average length: **6083 m**
Percentage of covered area: **75%**



Commuting trips are few and scattered, with most trips in the central areas of the city and a low density around the highways.

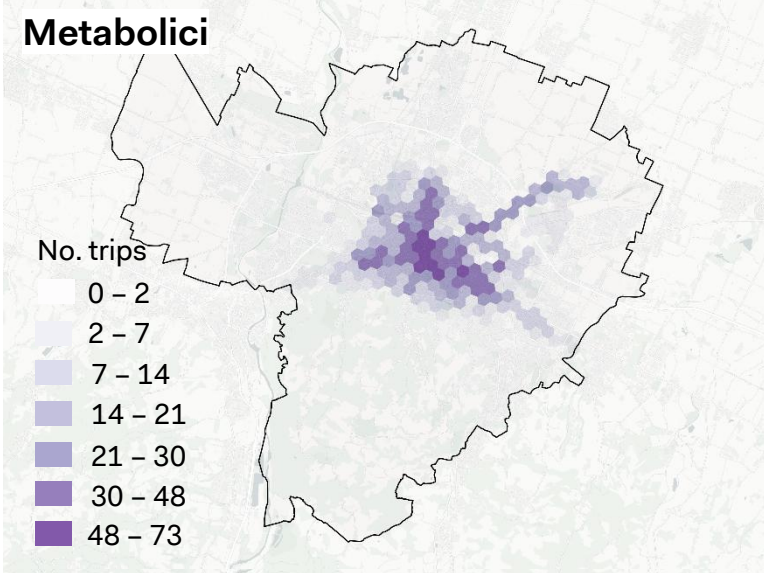
Total number of trips: **1462**
Trip average length: **5653 m**
Percentage of covered area: **59%**

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Data Analysis

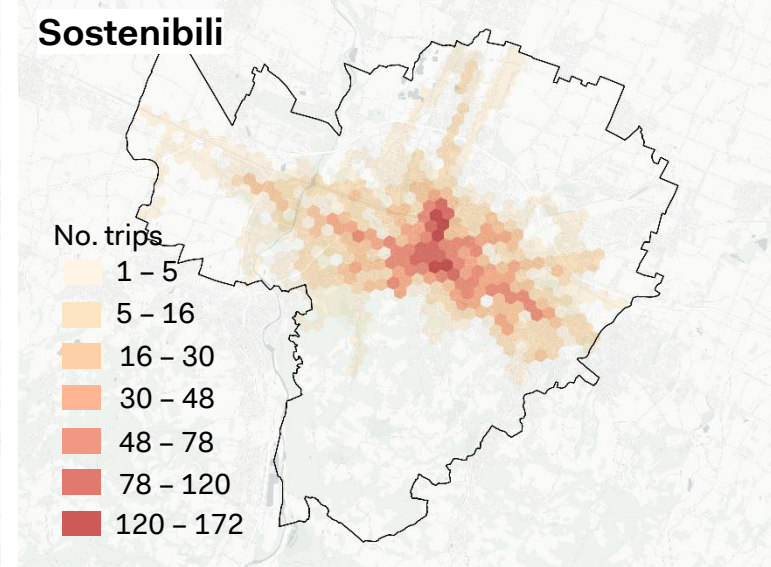
Mobility clusters

In the data analysis and mapping phase, Pollicino's trajectories were aggregated into the **hexagonal H3 grid**, a hierarchical geospatial index based on hexagons developed by Uber, to **quantify and visualize spatial patterns**. Each map represents the number of trips passing by the study area, describing spatial patterns of citizens grouped into five mobility clusters, based on their mobility behaviors and profiles. *



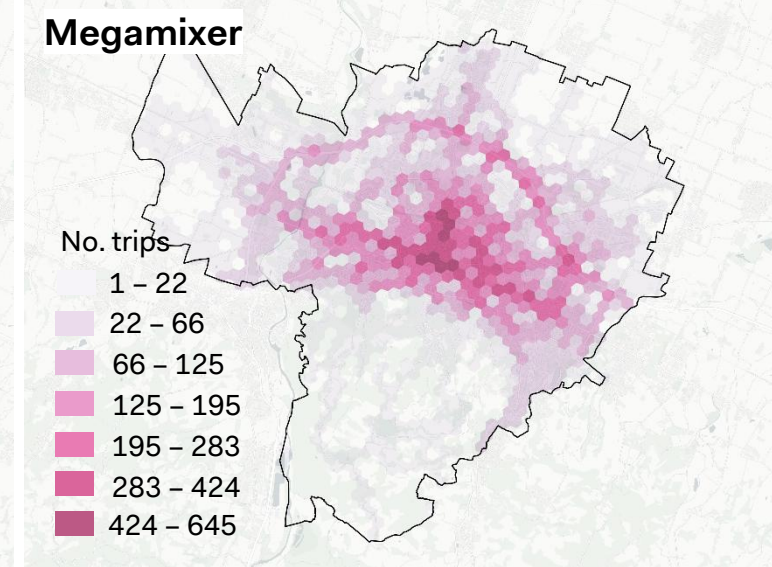
Metabolici trips concentrate around the city center.

Total number of trips: **458**
Trip average length: **2511 m**
Percentage of covered area: **23%**



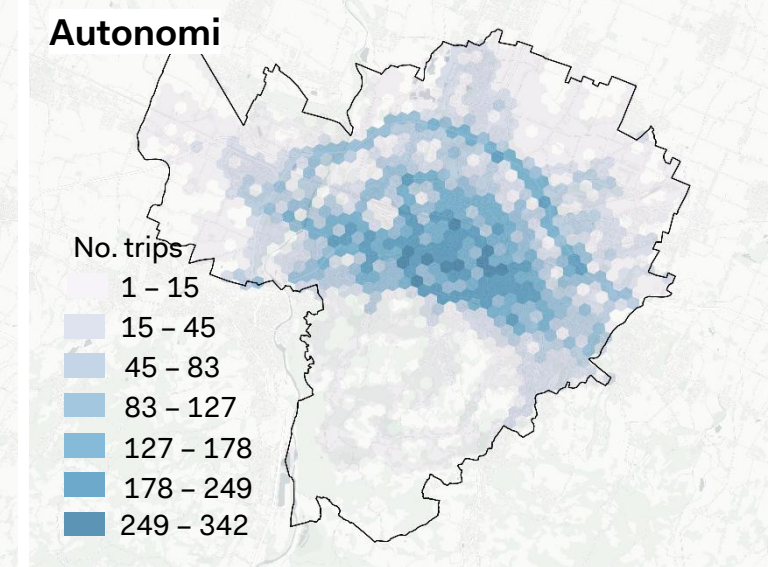
Sostenibili trips revolve around the center, the east-west and north city axis.

Total number of trips: **880**
Trip average length: **3093 m**
Percentage of covered area: **37%**



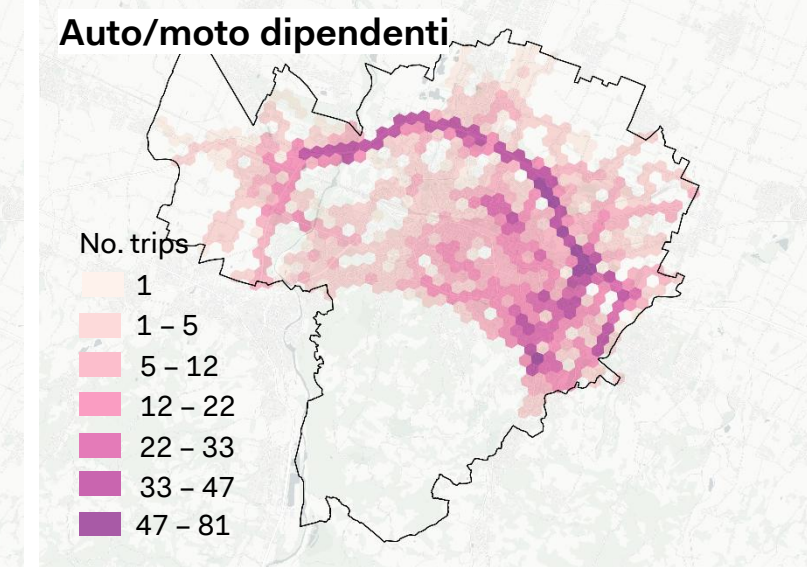
Megamixer trips are spread out the whole territory.

Total number of trips: **4847**
Trip average length: **5702 m**
Percentage of covered area: **77%**



Autonomi trips present a similar distribution than the Megamixer ones.

Total number of trips: **4314**
Trip average length: **5650 m**
Percentage of covered area: **76%**



Auto/moto dipendenti trips present a high concentration around the highway.

Total number of trips: **320**
Trip average length: **5416 m**
Percentage of covered area: **50%**

* [Go to Annex C](#) for further information

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+ Interactive mapping

Interactive mapping

Movements matrix – *Sostenibili*

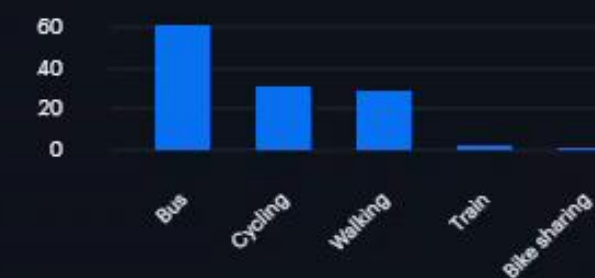
The map outlines how the *Sostenibili* mobility cluster travels in the city of Bologna during an average daily period, their preferred transport modes and trip purposes

Spatial Analysis of Citizens' Travel Data: The Pollicino Project

The research investigates citizens' travel data in Bologna using GPS traces collected through the Pollicino project. The research has been conducted by Transform Transport in collaboration with Osservatorio Nazionale Sharing Mobility and Fondazione per lo Sviluppo Sostenibile. The map outlines how the *Sostenibili* mobility cluster travels in the city of Bologna during an average daily period, their preferred transport modes and trip purposes. The complete research description is available at: <https://transformtransport.org/research/urban-mobility-metrics/spatial-analysis-of-citizens-travel-data-the-pollicino-project>



Transportation mode



Gender



09/27/2023
5:08:10 AM – 9:03:18 AM

Count of Rows over Time



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+ Conclusion

Conclusions

The objective of the research was to investigate the reliability of GPS data for building **mobility models to support local government decision-making process** in the field of sustainable mobility.

From the perspective of **modal split**:

- Soft mode trips have the highest volumes during the study period;
- Motorized mode trips cover the largest area of the city;
- Walking trips had most volumes among soft mobility modes;
- The majority of public transportation trips were made by bus;
- Most motorized trips were made by car;

From the perspective of **spatial analysis**:

- The central areas of the city have the highest density of overall travel, where most soft travel is concentrated;
- Motorized trips are often distributed on the highway and inner ring road;
- Daily trips have a similar spatial distribution in the morning hours and lunchtime;

From the perspective of **travel purposes**:

- The dominant reason for travel is leisure, followed by travel to home, while travel to work accounts for the smallest share of total travel;
- The analysis reveals a high correlation between walking trips and grocery stores, bicycle parking, and pedestrian areas;
- Bicycle trips were found to be highly correlated with urban fabric density.

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References

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- Saki, S., & Hagen, T. (2022). A practical guide to an open-source map-matching approach for big GPS data. *SN Computer Science*, 3(5), 415. <https://doi.org/10.1007/s42979-022-01340-5>
- Wang, D., Miwa, T., & Morikawa, T. (2020). Big trajectory data mining: a survey of methods, applications, and services. *Sensors*, 20(16), 4571. <https://doi.org/10.3390/s20164571>
- Yang, X., Stewart, K., Tang, L., Xie, Z., & Li, Q. (2018). A review of GPS trajectories classification based on transportation mode. *Sensors*, 18(11), 3741. <https://www.mdpi.com/1424-8220/18/11/3741>

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+ Annex

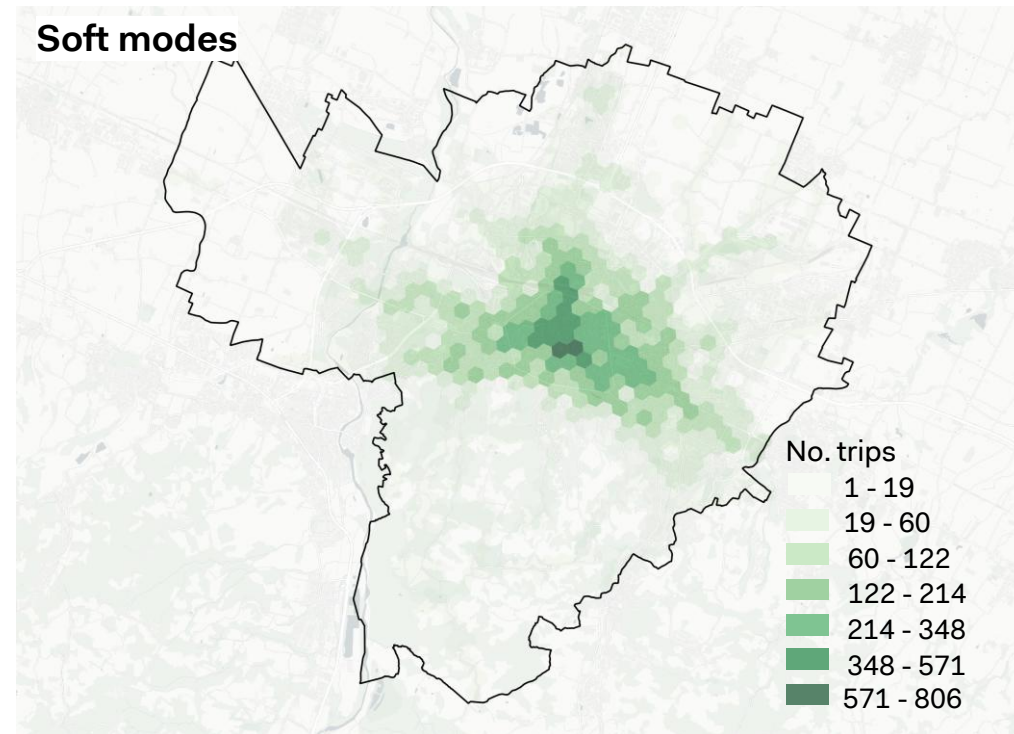
+ Annex A Modal Split

Annex A gathers analyses and mapping results describing spatial patterns of different modes in Bologna. Three main modal groups (*i.e.*, *soft modes*, *public transport modes* and *motorized modes*) are further disaggregated into single modes, showing specific spatial patterns in each group.

Maps represent **passing-by trips volumes**, quantified as total number of trips passing by each hexagonal area in the H3 grid during the study period.

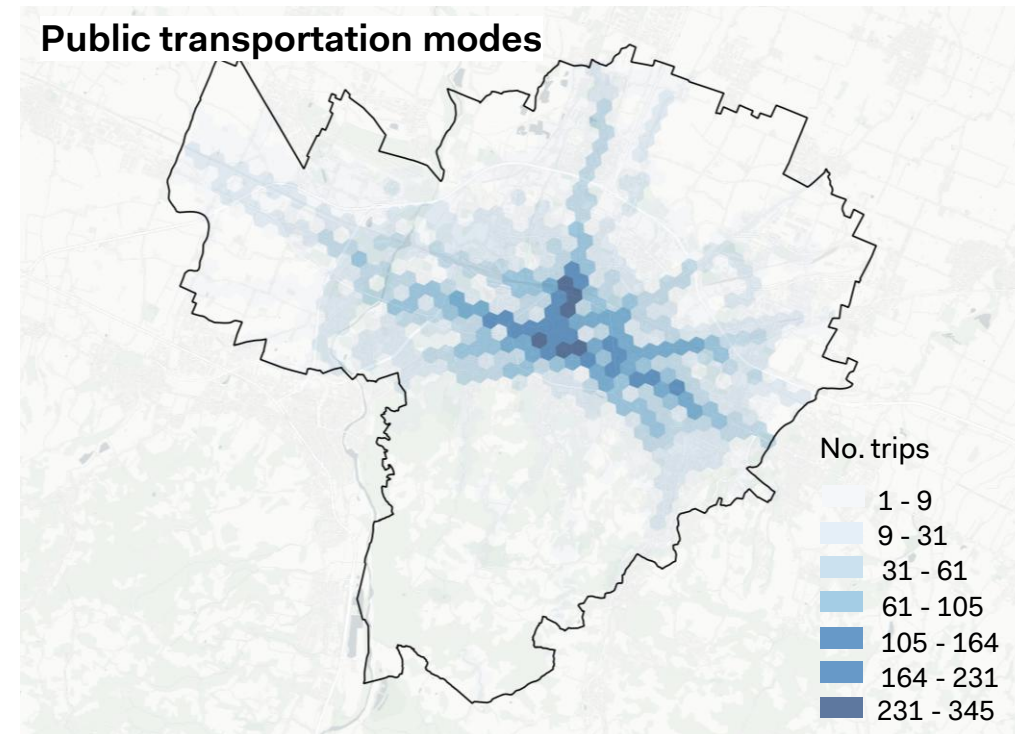
Annex A

Modal split



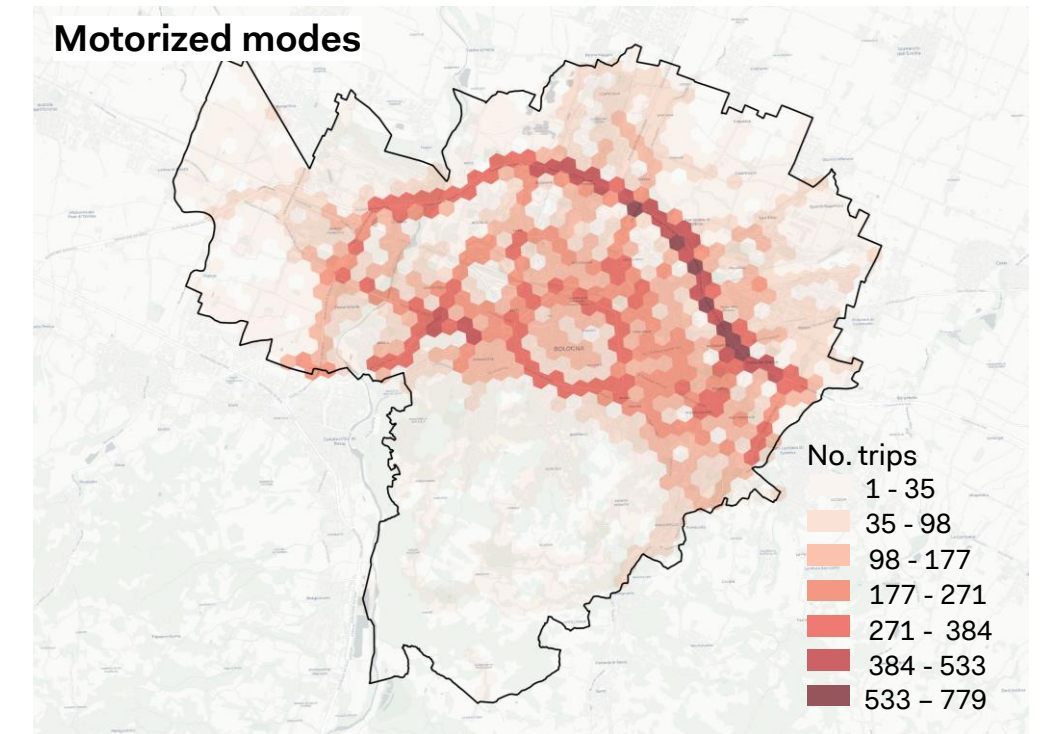
Soft modes trips take place in the city center and spread out to the surrounding areas.

Total number of trips: **5209**
Trip average length: **2039 m**
Percentage of covered area: **56%**



Public transport trips concentrate in the city center but branch out to reach further distances.

Total number of trips: **1394**
Trip average length: **5822 m**
Percentage of covered area: **60%**



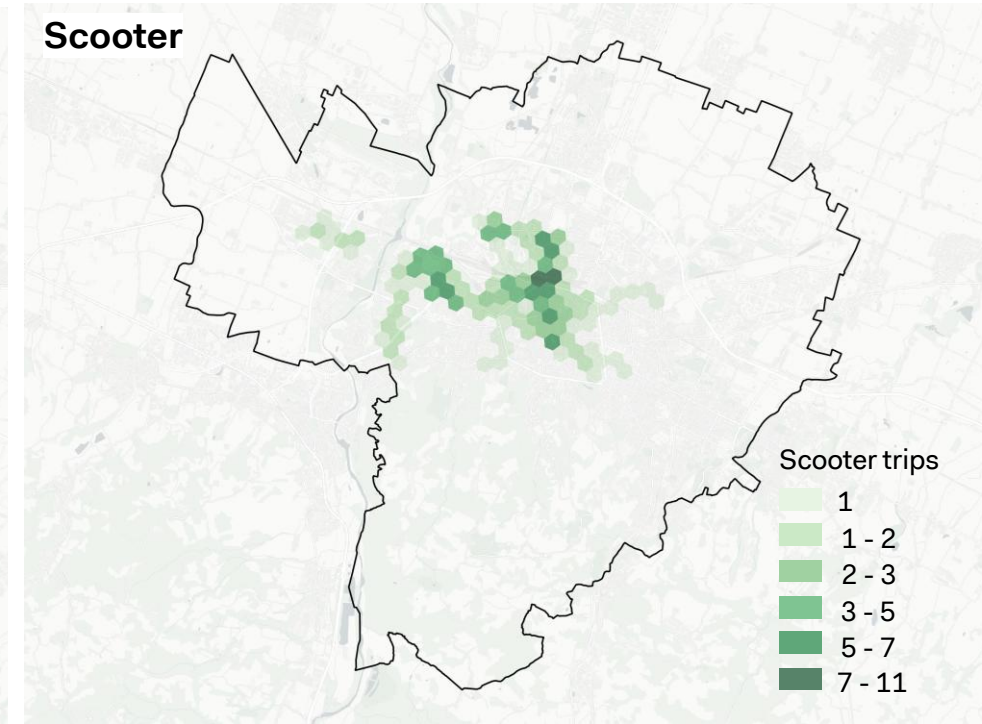
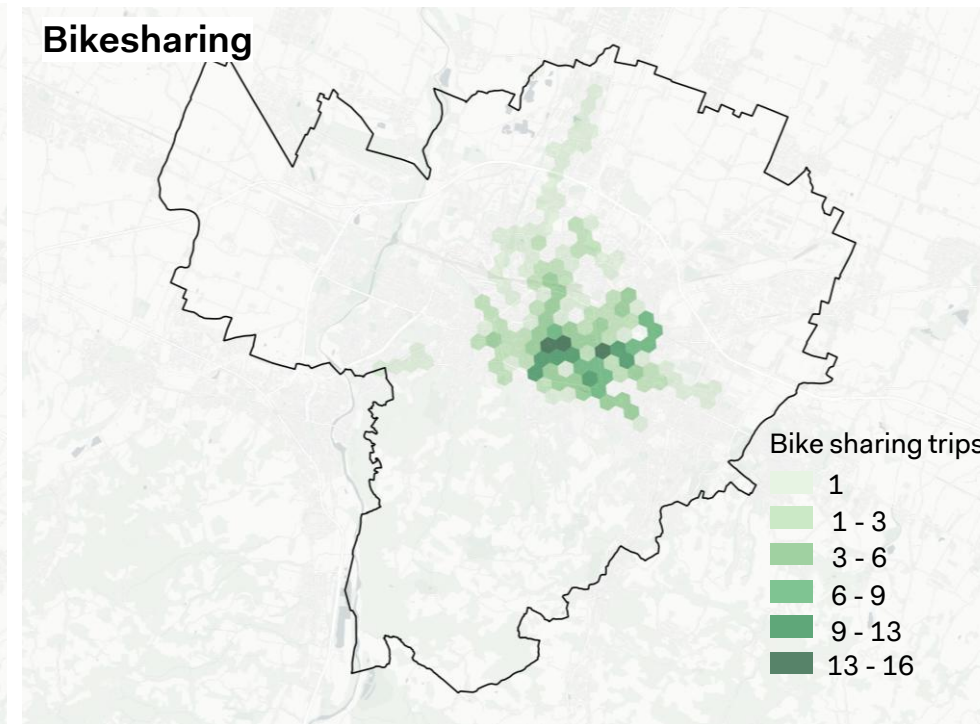
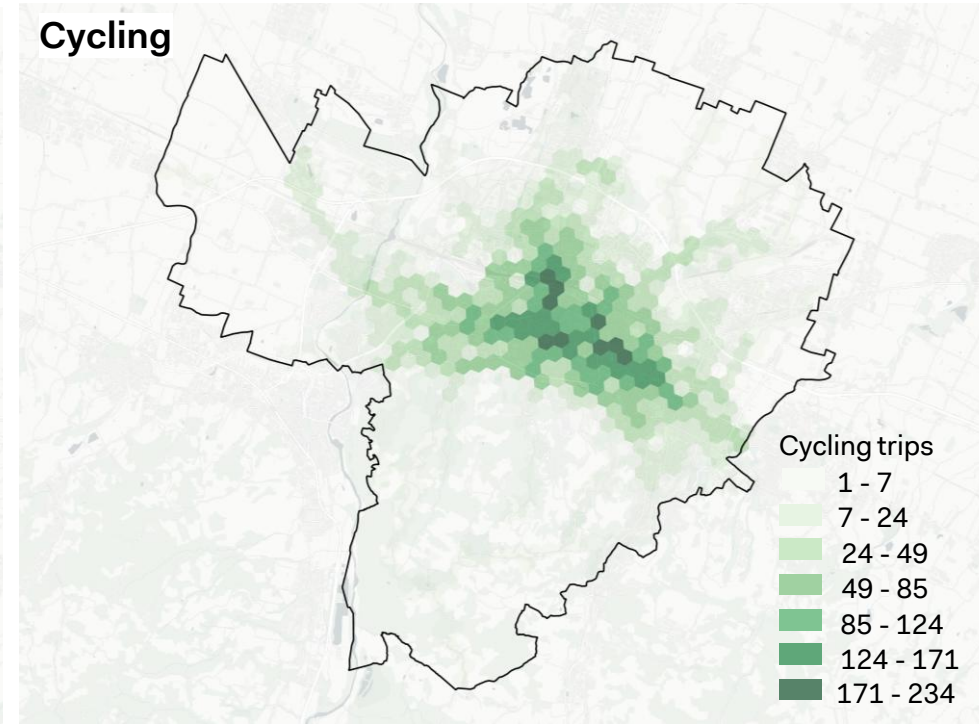
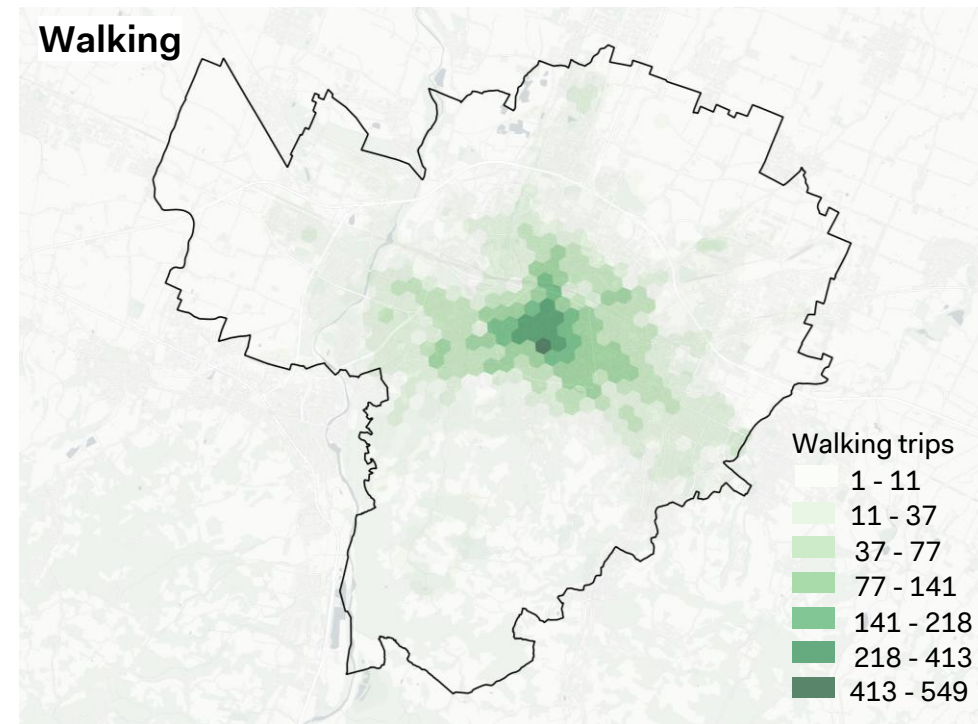
Motorized trips main traverse the highway around the city and the inner circular road.

Total number of trips: **4216**
Trip average length: **9722 m**
Percentage of covered area: **81%**

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Annex A

Soft modes



Total number of trips: **3501**
Trip average length: **1529 m**
Percentage of covered area: **44%**

Total number of trips: **1617**
Trip average length: **3132 m**
Percentage of covered area: **49%**

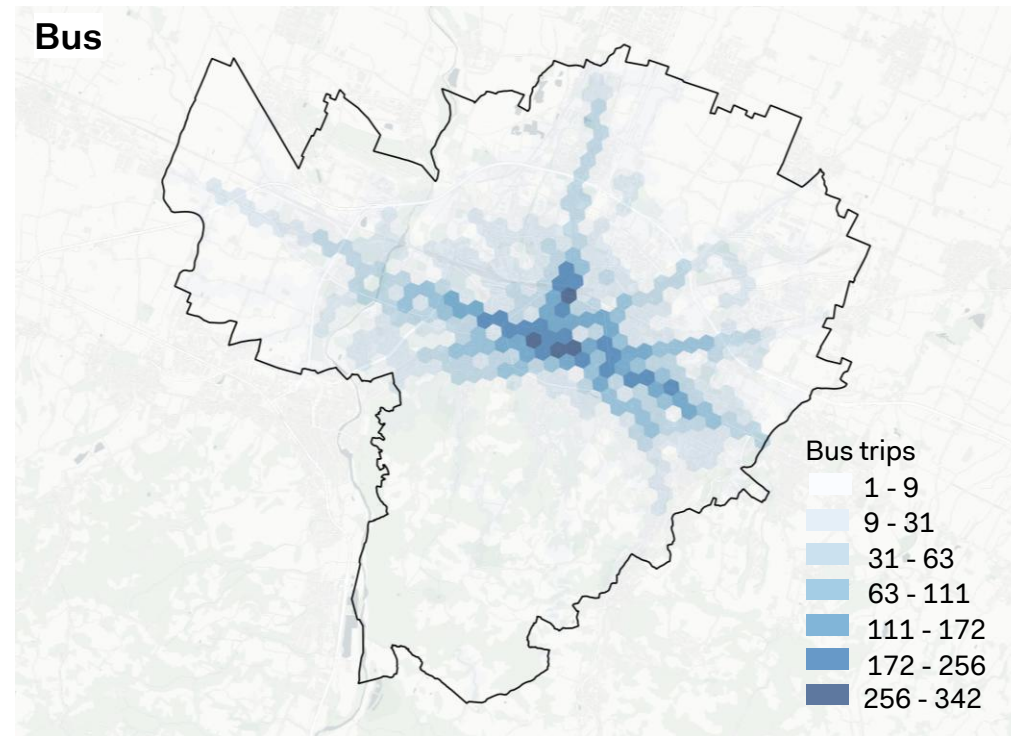
Total number of trips: **49**
Trip average length: **2662 m**
Percentage of covered area: **10%**

Total number of trips: **42**
Trip average length: **1742 m**
Percentage of covered area: **8%**

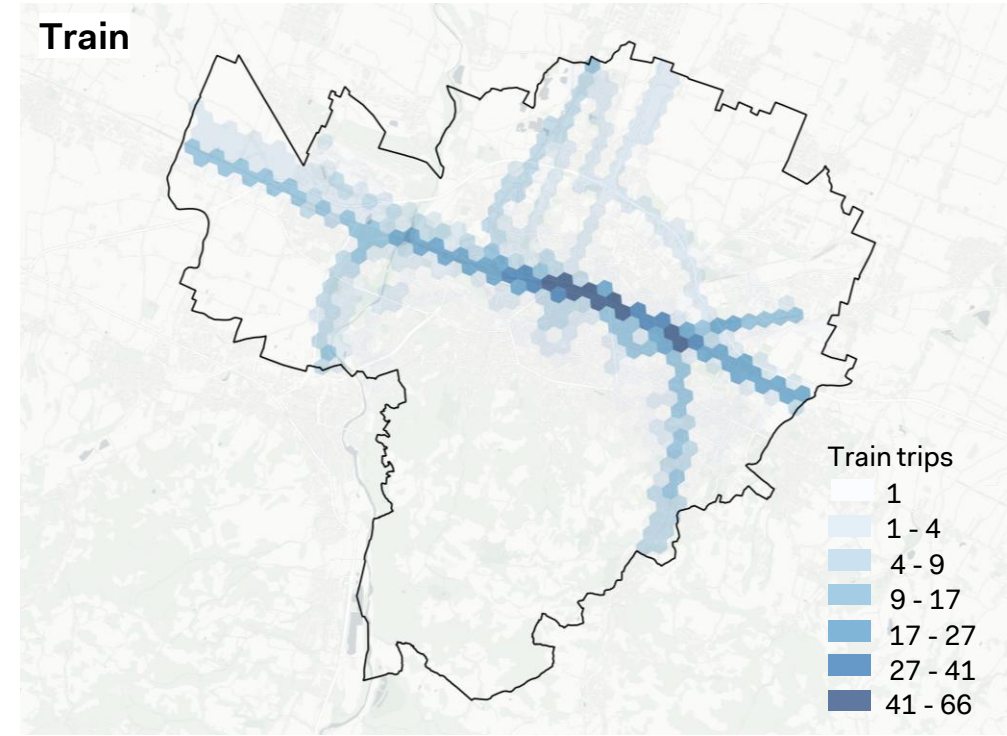
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Annex A

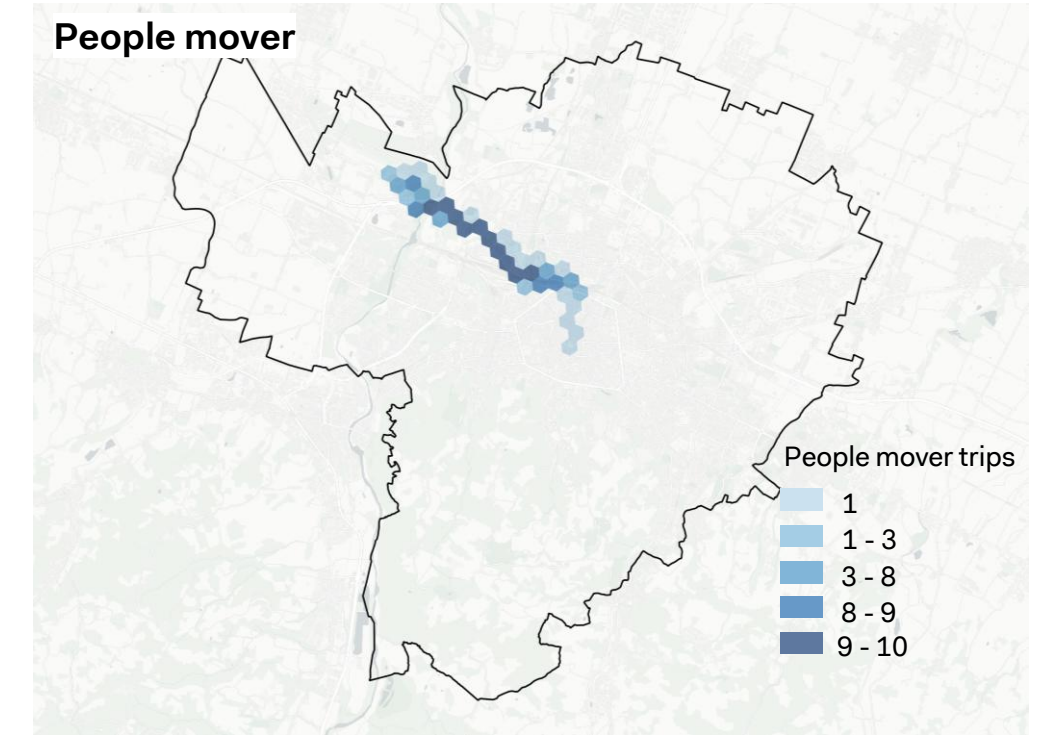
Public transport modes



Total number of trips: **1289**
Trip average length: **4780 m**
Percentage of covered area: **55%**



Total number of trips: **94**
Trip average length: **20159 m**
Percentage of covered area: **30%**

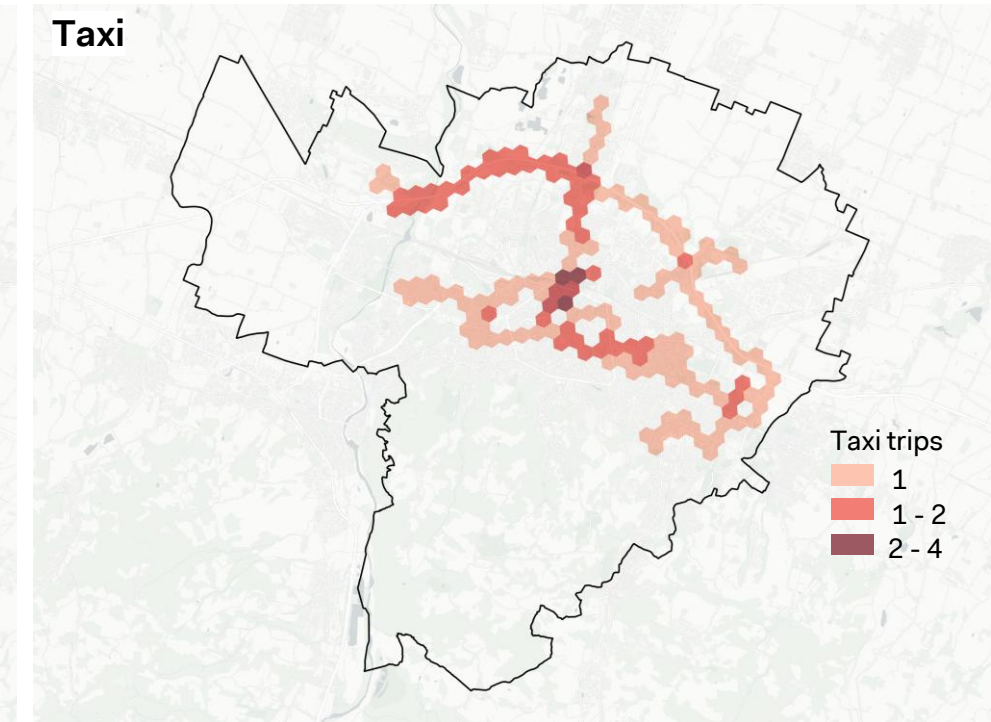
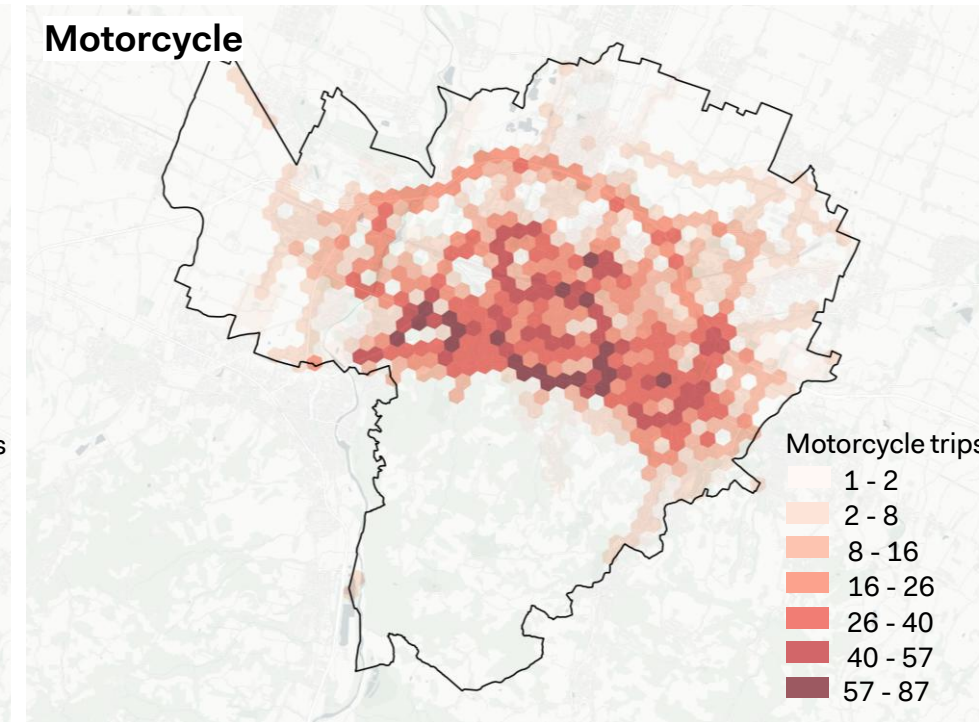
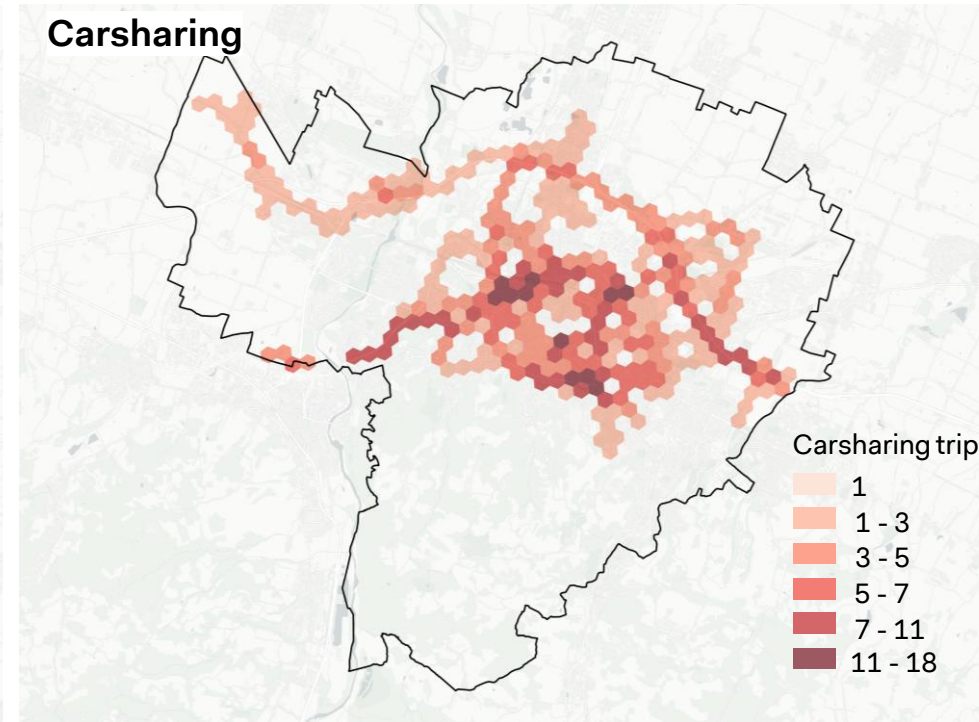
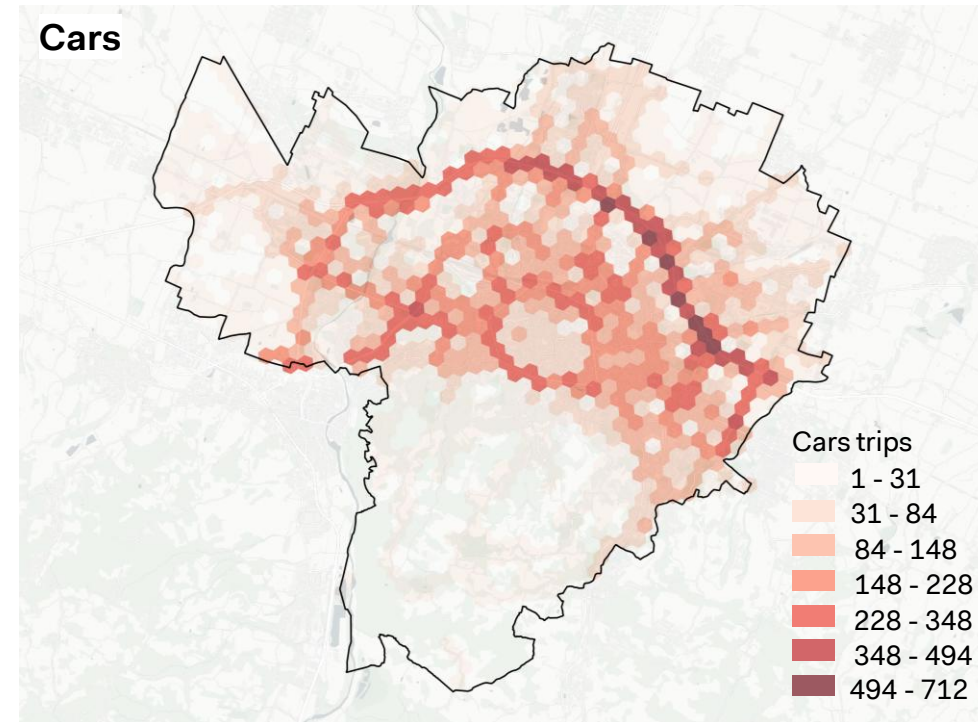


Total number of trips: **11**
Trip average length: **5374 m**
Percentage of covered area: **3%**

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Annex A

Motorized modes



Total number of trips: **3502**
Trip average length: **10533 m**
Percentage of covered area: **81%**

Total number of trips: **75**
Trip average length: **7403 m**
Percentage of covered area: **30%**

Total number of trips: **624**
Trip average length: **5556 m**
Percentage of covered area: **50%**

Total number of trips: **13**
Trip average length: **4802 m**
Percentage of covered area: **12%**

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+ Annex B

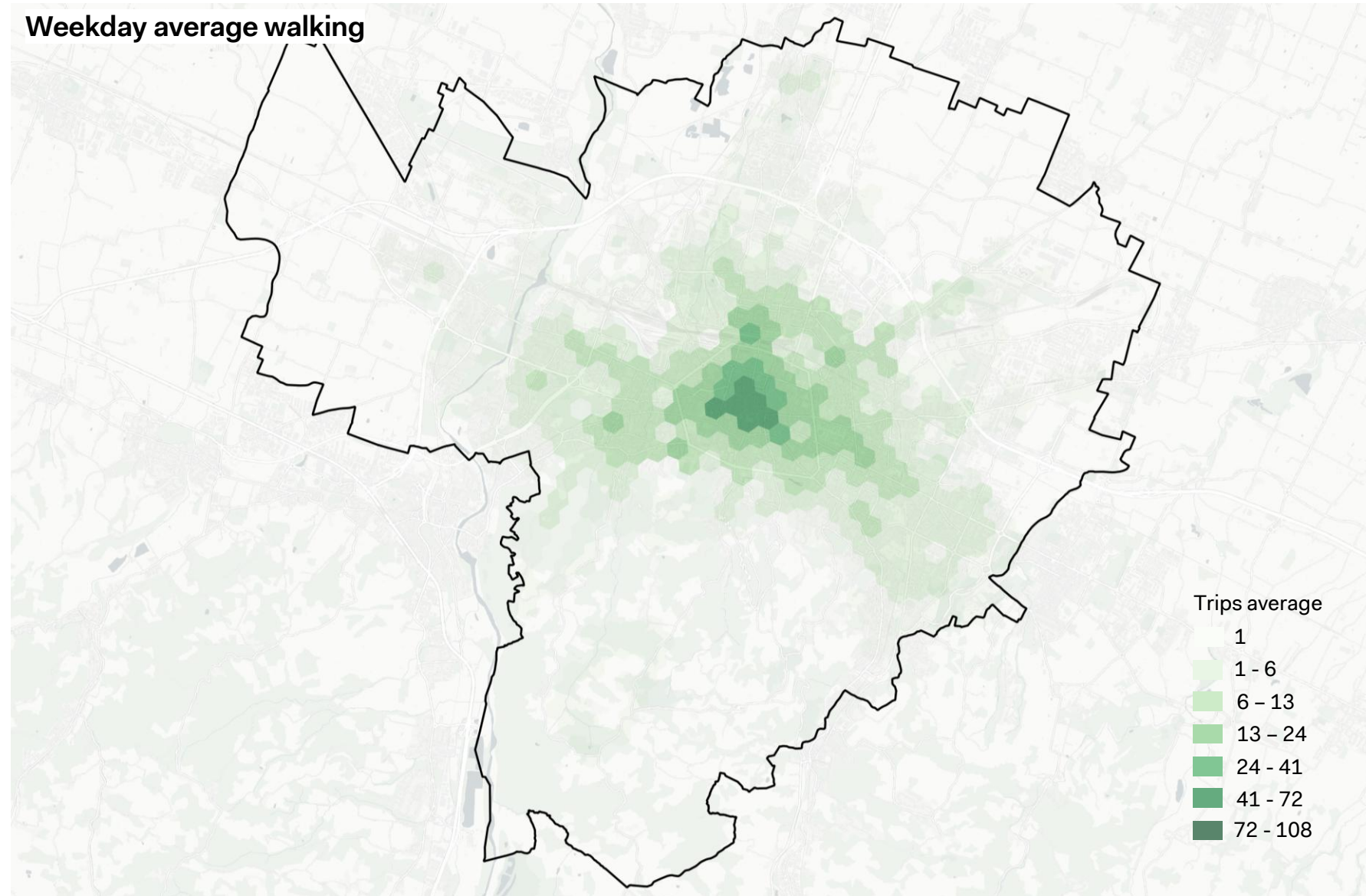
Weekdays and Weekends

Annex B gathers analyses and mapping results describing spatial patterns of different modes in Bologna, structured in weekdays (WD) and weekends (WE). Three main modal groups (*i.e.*, *soft modes*, *public transport modes* and *motorized modes*) are further disaggregated into single modes, showing specific spatial patterns in each group.

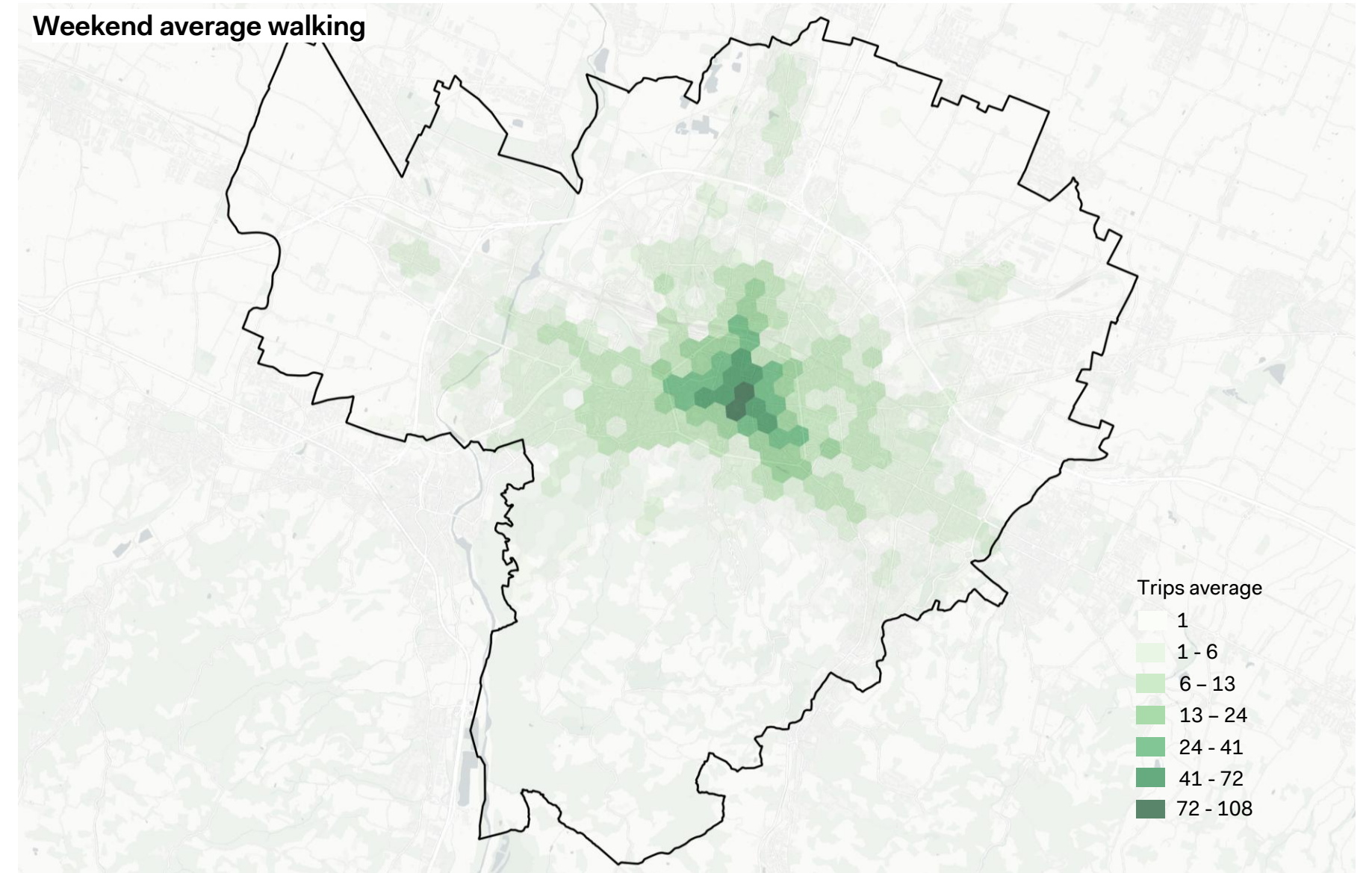
Maps represent **passing-by trips averages**, quantified as the average number of trips passing by each hexagonal area in the H3 grid during an average weekday and weekend day.

Annex B

Walking – weekday/weekend comparison



Total number of trips (average day): **494**
Trip average length: **1432 m**
Percentage of covered area: **41%**

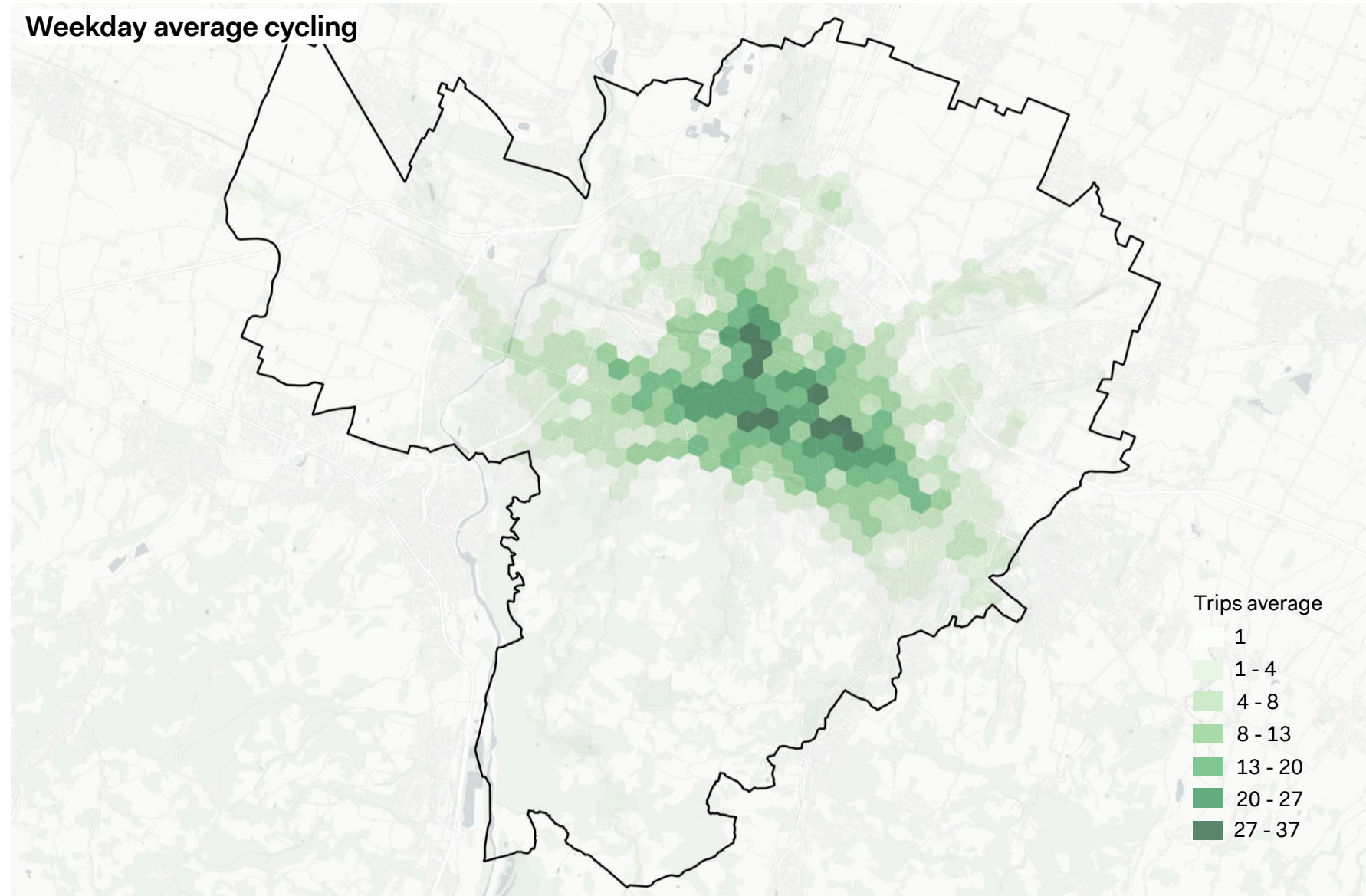


Total number of trips (average day): **515**
Trip average length: **1762 m**
Percentage of covered area: **37%**

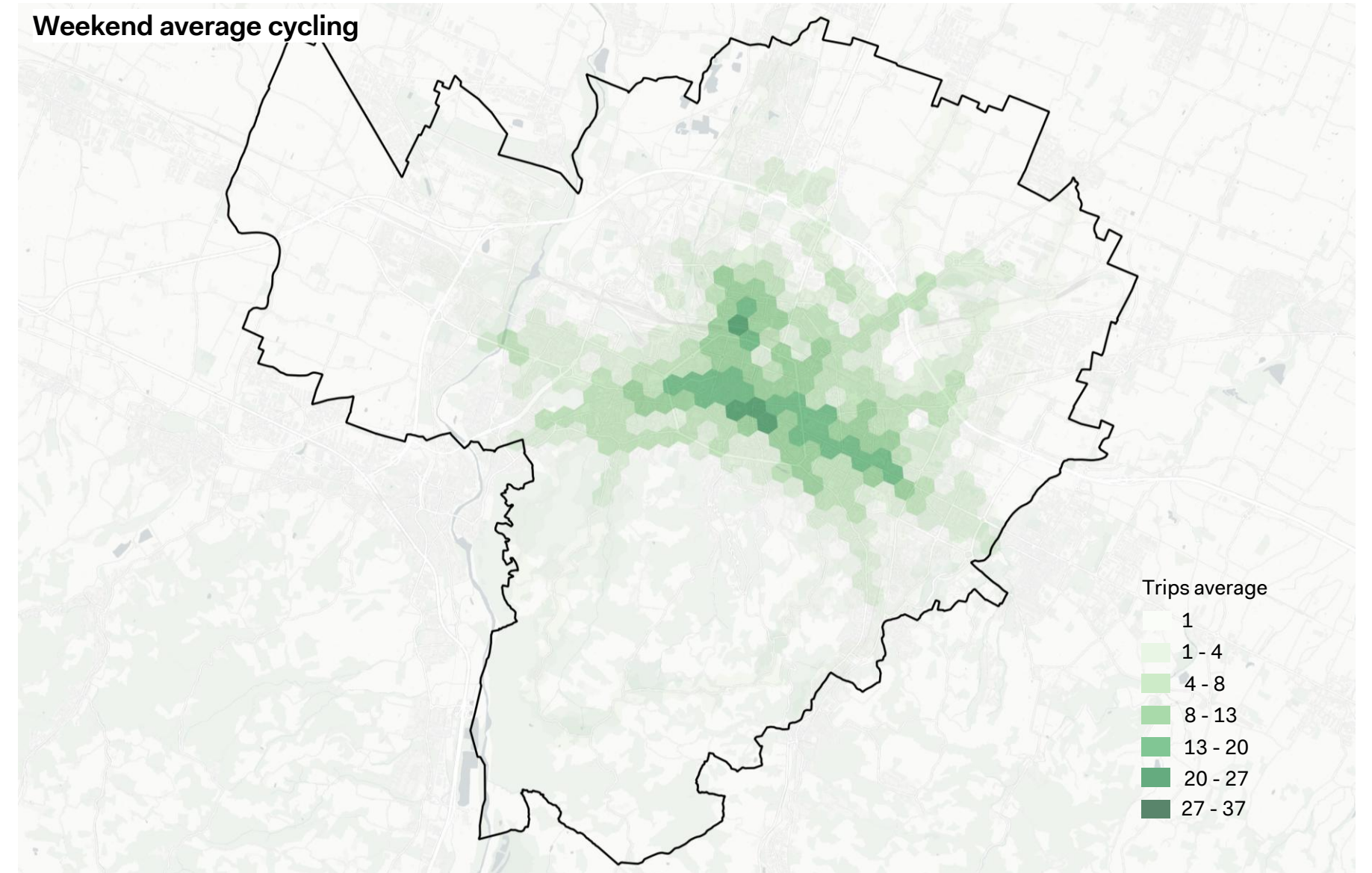
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Annex B

Cycling – weekday/weekend comparison



Total number of trips (average day): **258**
Trip average length: **3130 m**
Percentage of covered area: **41%**

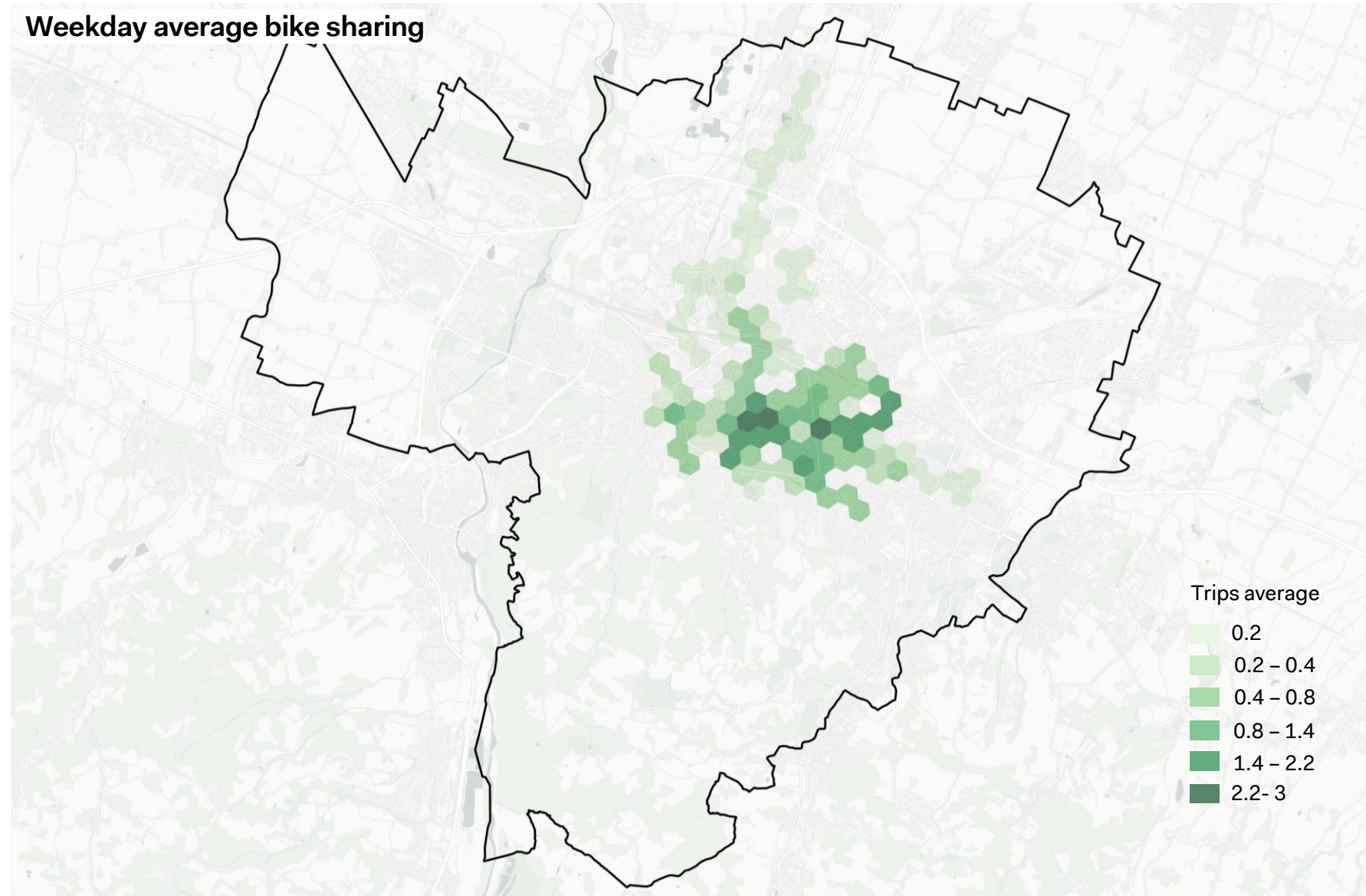


Total number of trips (average day): **165**
Trip average length: **3138 m**
Percentage of covered area: **37%**

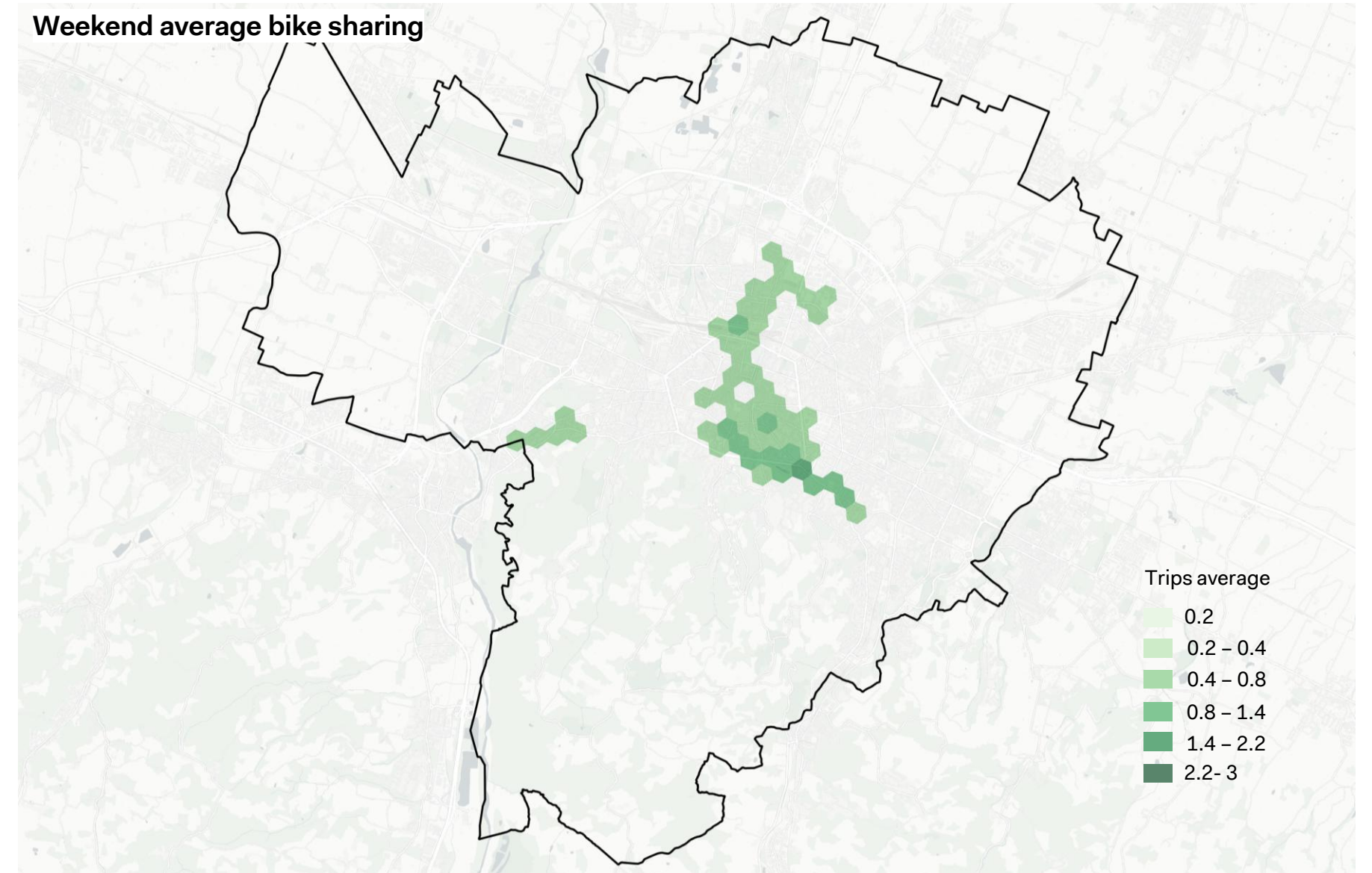
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Annex B

Bike sharing – weekday/weekend comparison



Total number of trips (average day): **8**
Trip average length: **2725 m**
Percentage of covered area: **9%**

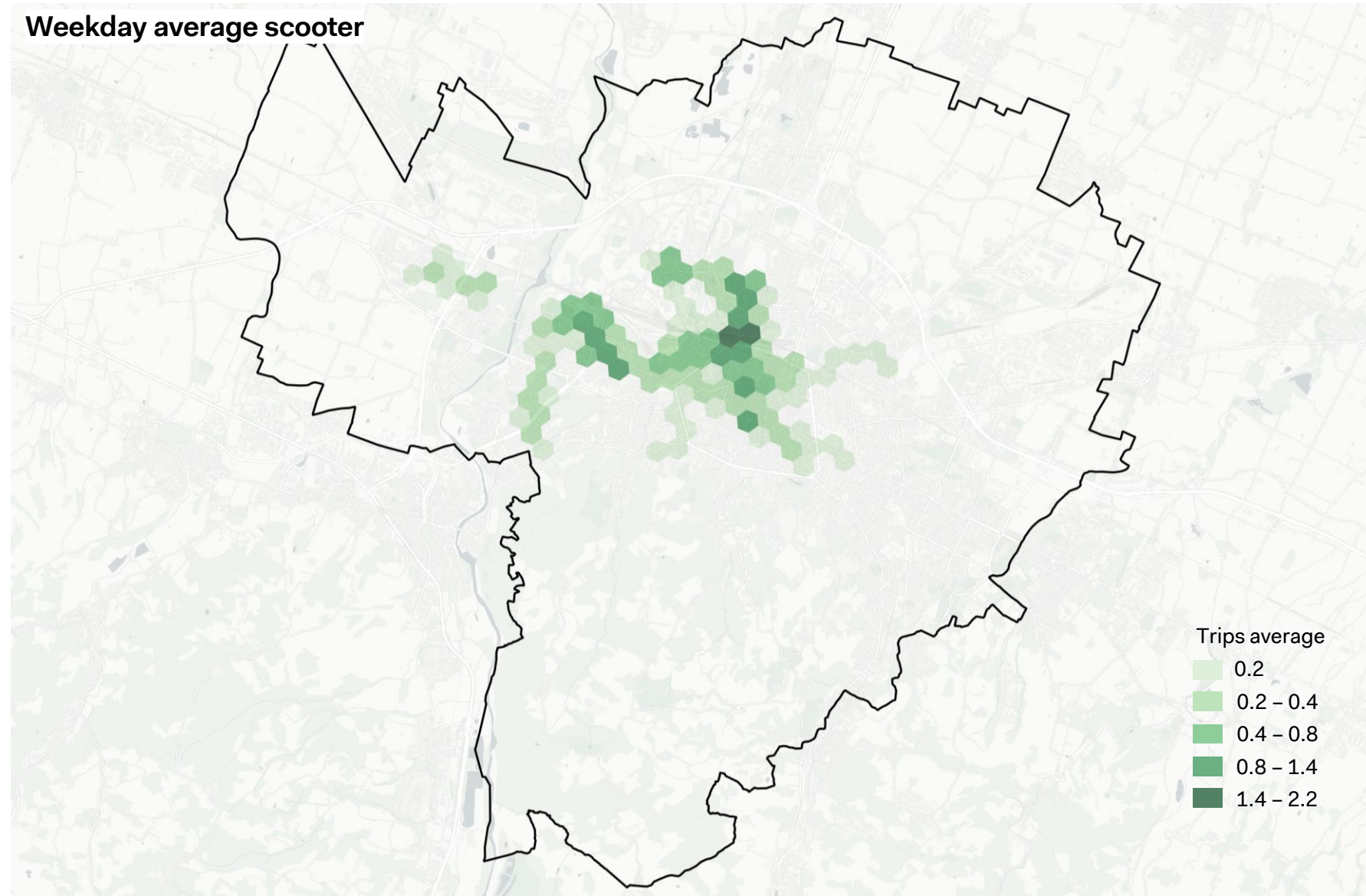


Total number of trips (average day): **4**
Trip average length: **2337 m**
Percentage of covered area: **4%**

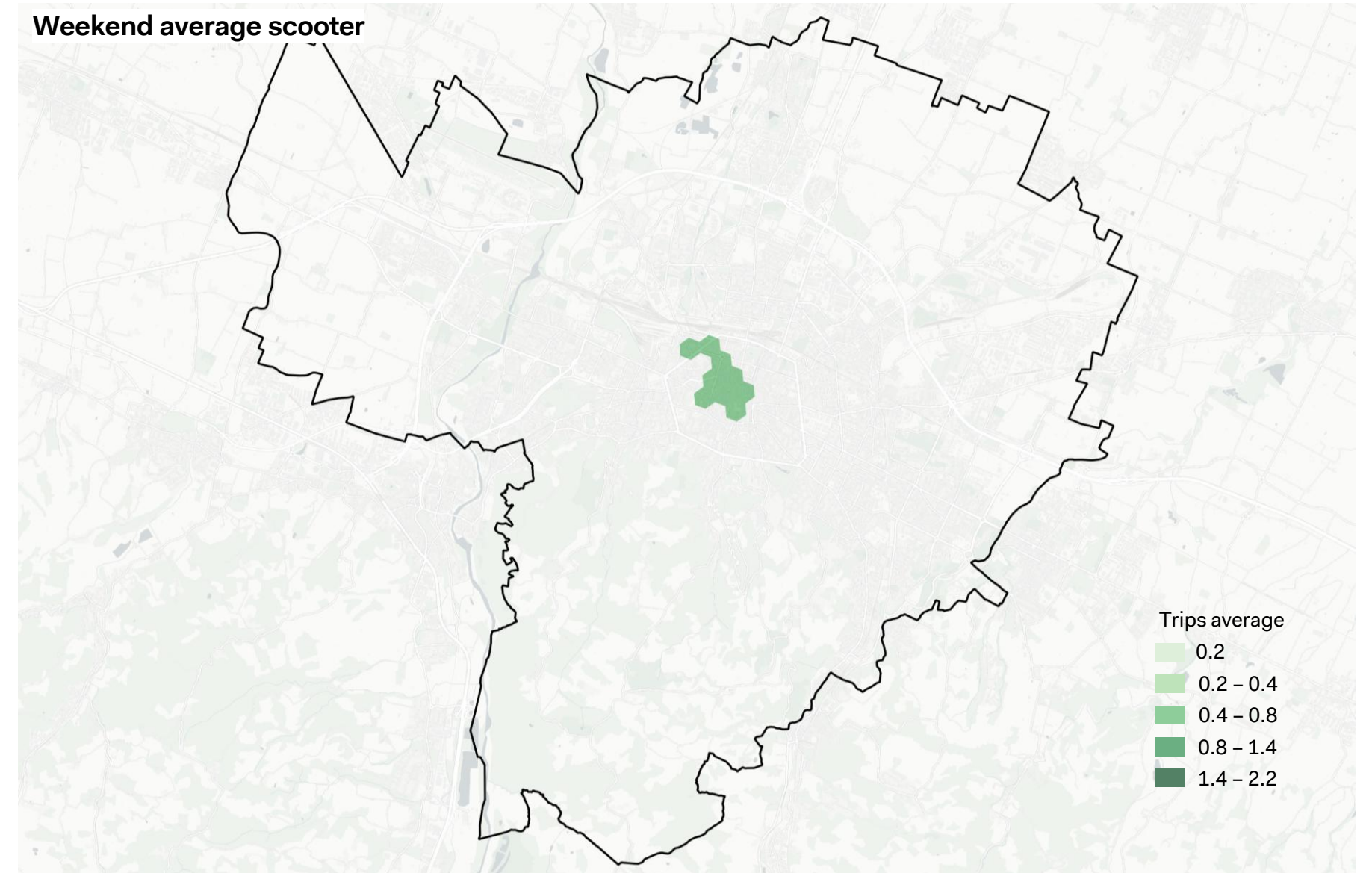
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Annex B

Scooter – weekday/weekend comparison



Total number of trips (average day): **8**
Trip average length: **1742 m**
Percentage of covered area: **8%**

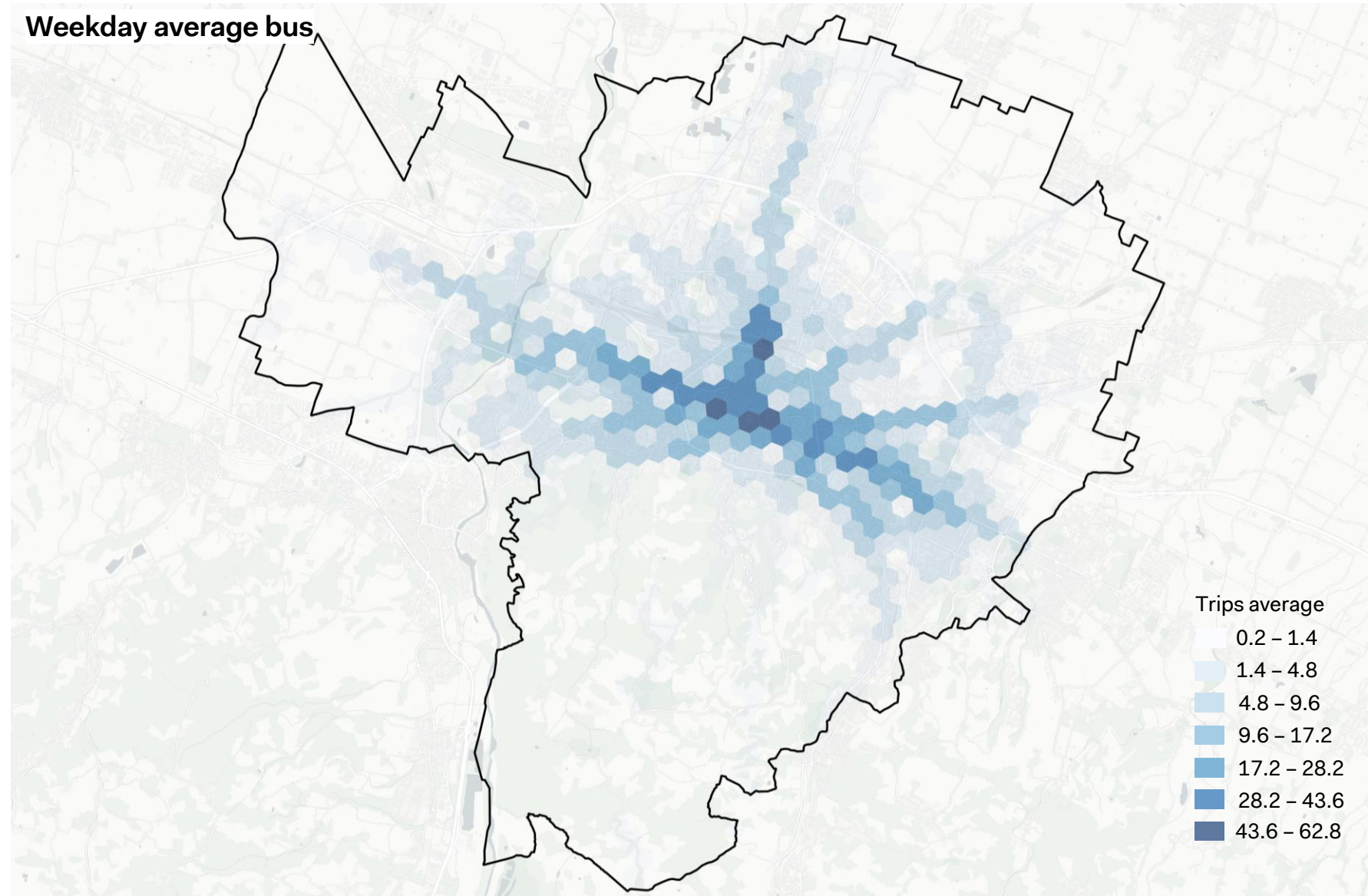


Total number of trips (average day): **1**
Trip average length: **2063 m**
Percentage of covered area: **1%**

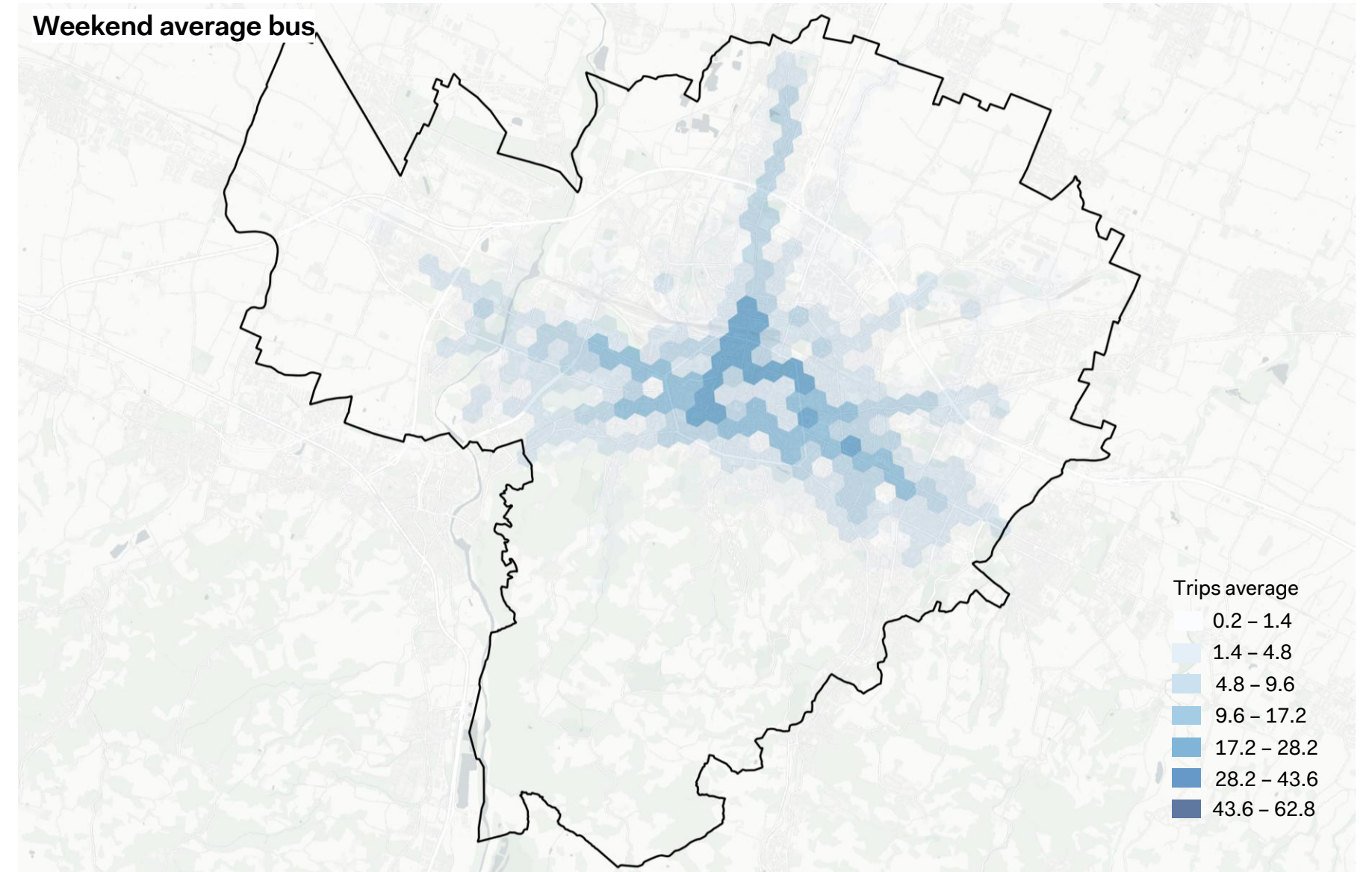
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Annex B

Bus – weekday/weekend comparison



Total number of trips (average day): **214**
Trip average length: **4775 m**
Percentage of covered area: **48%**

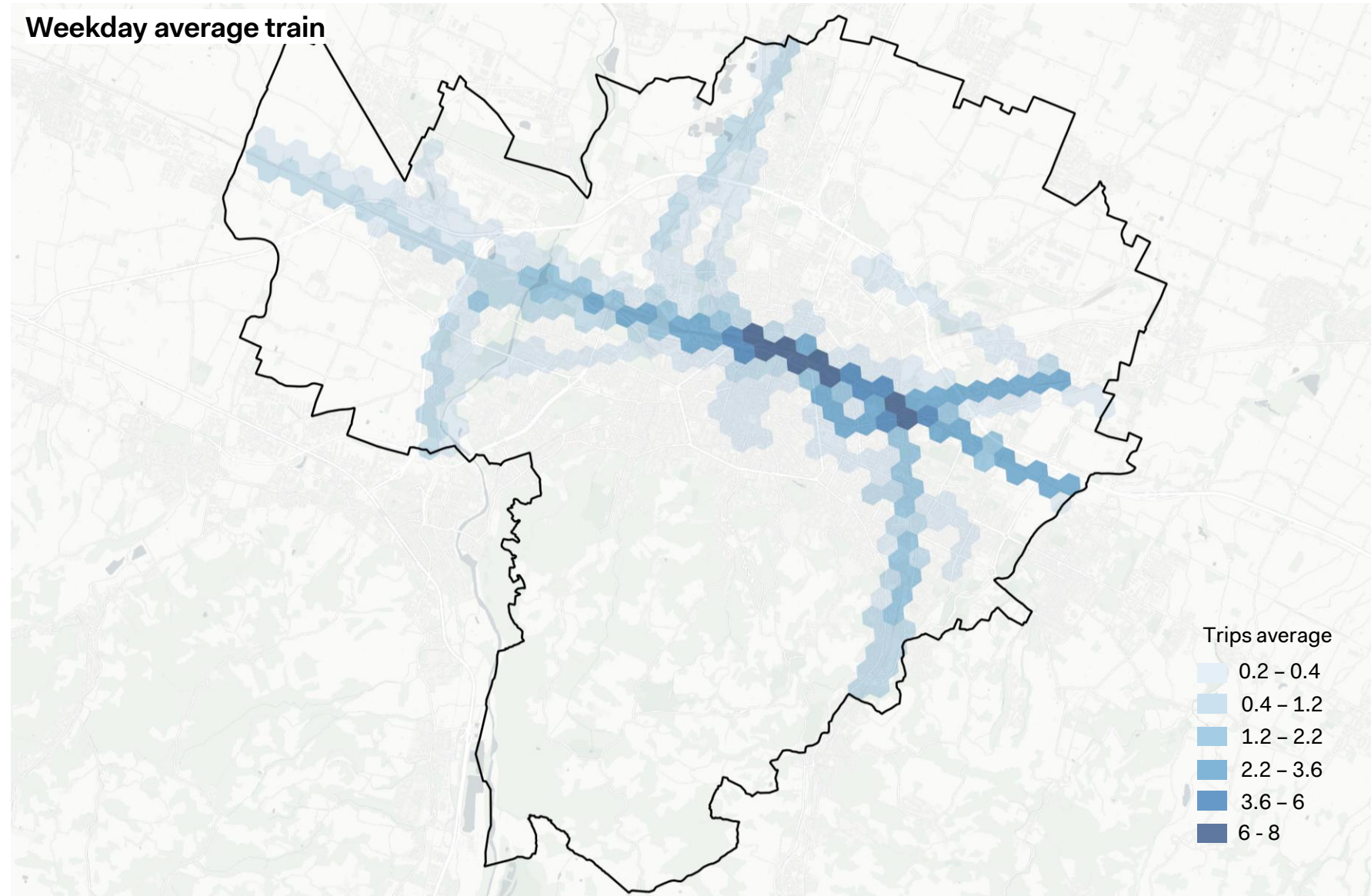


Total number of trips (average day): **109**
Trip average length: **4806 m**
Percentage of covered area: **30% of the study area**

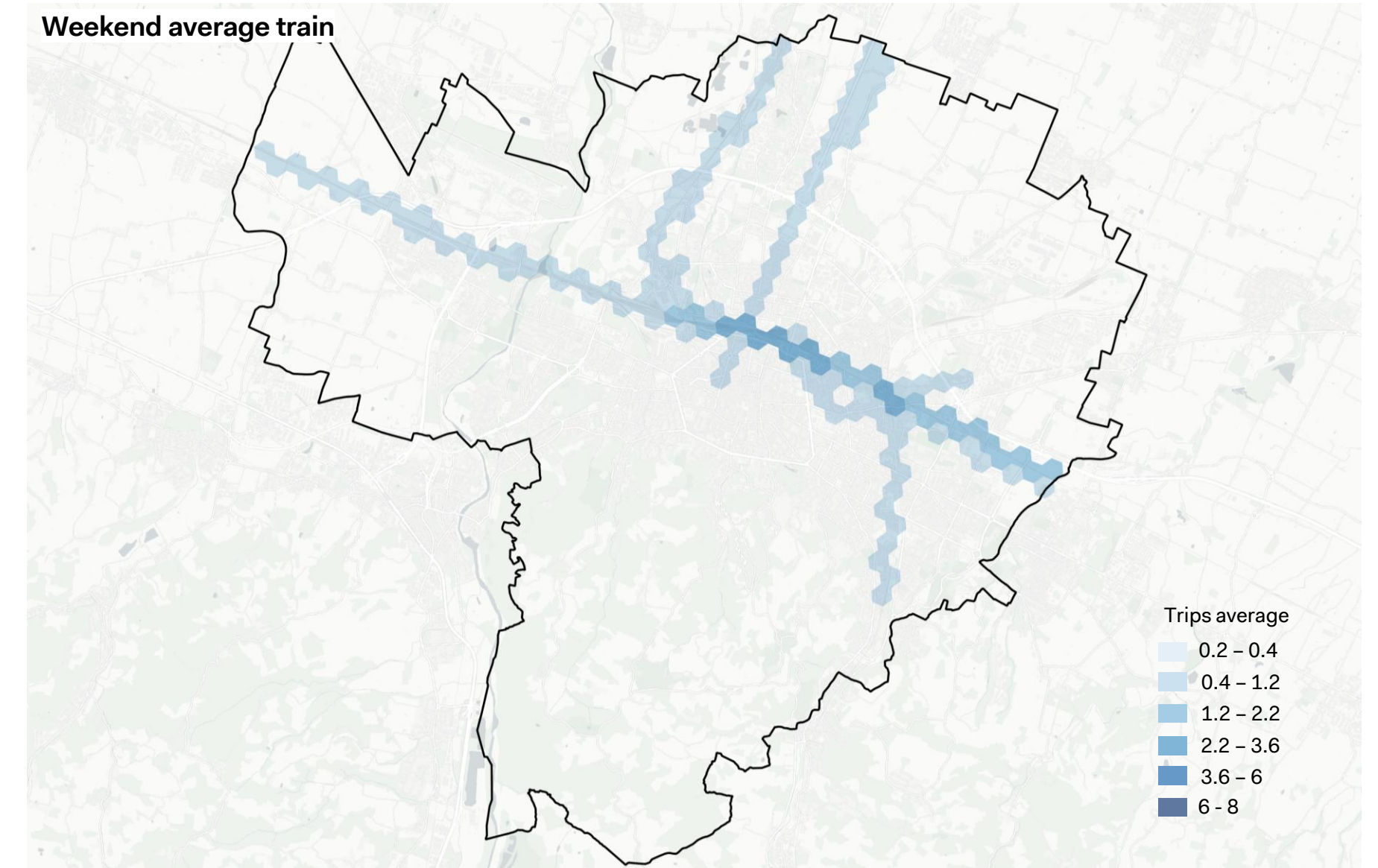
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Annex B

Train – weekday/weekend comparison



Total number of trips (average day): **17**
Trip average Length: **16753 m**
Percentage of covered area: **22%**

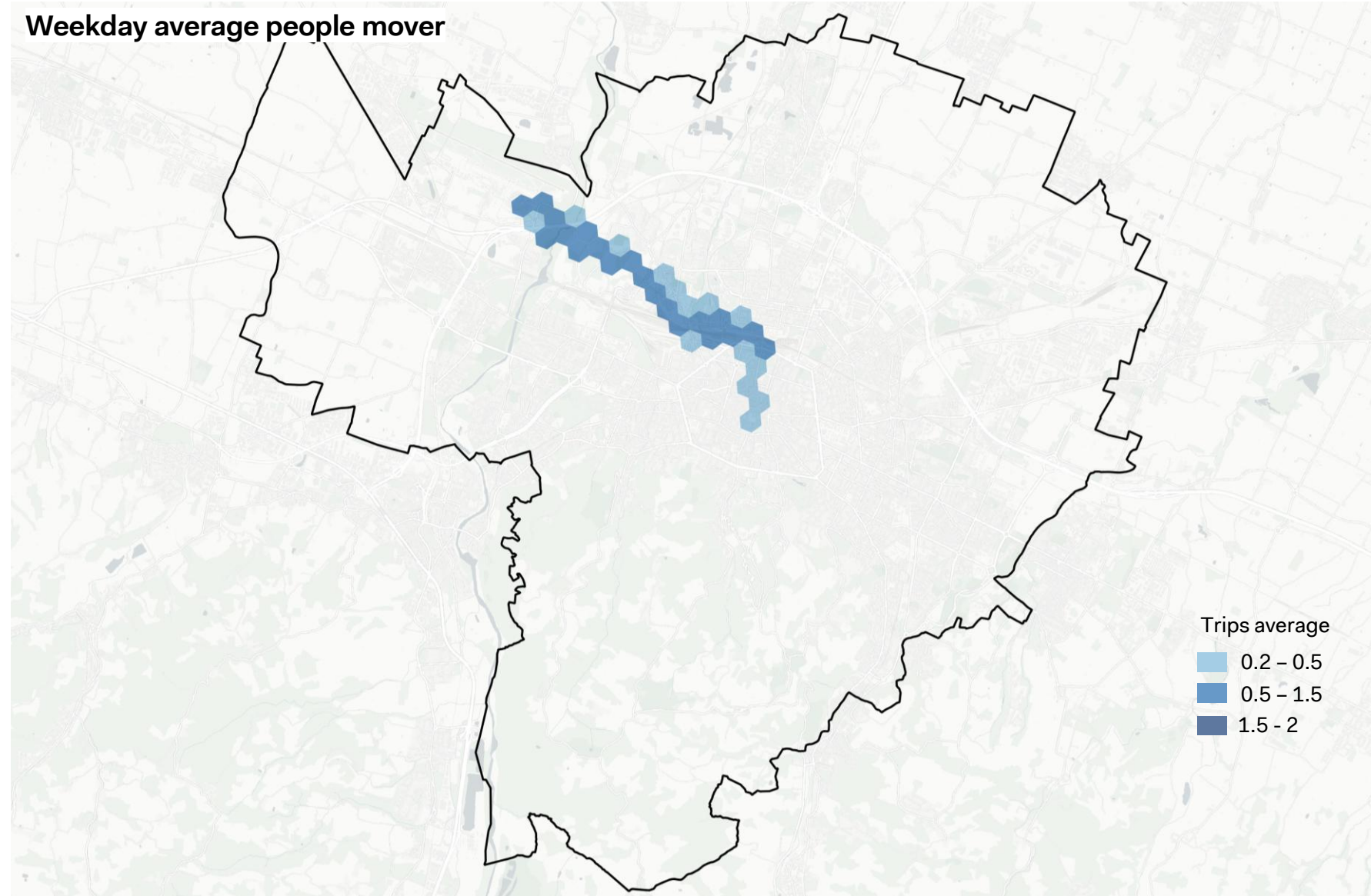


Total number of trips (average day): **5**
Trip average Length: **45860 m**
Percentage of covered area: **10%**

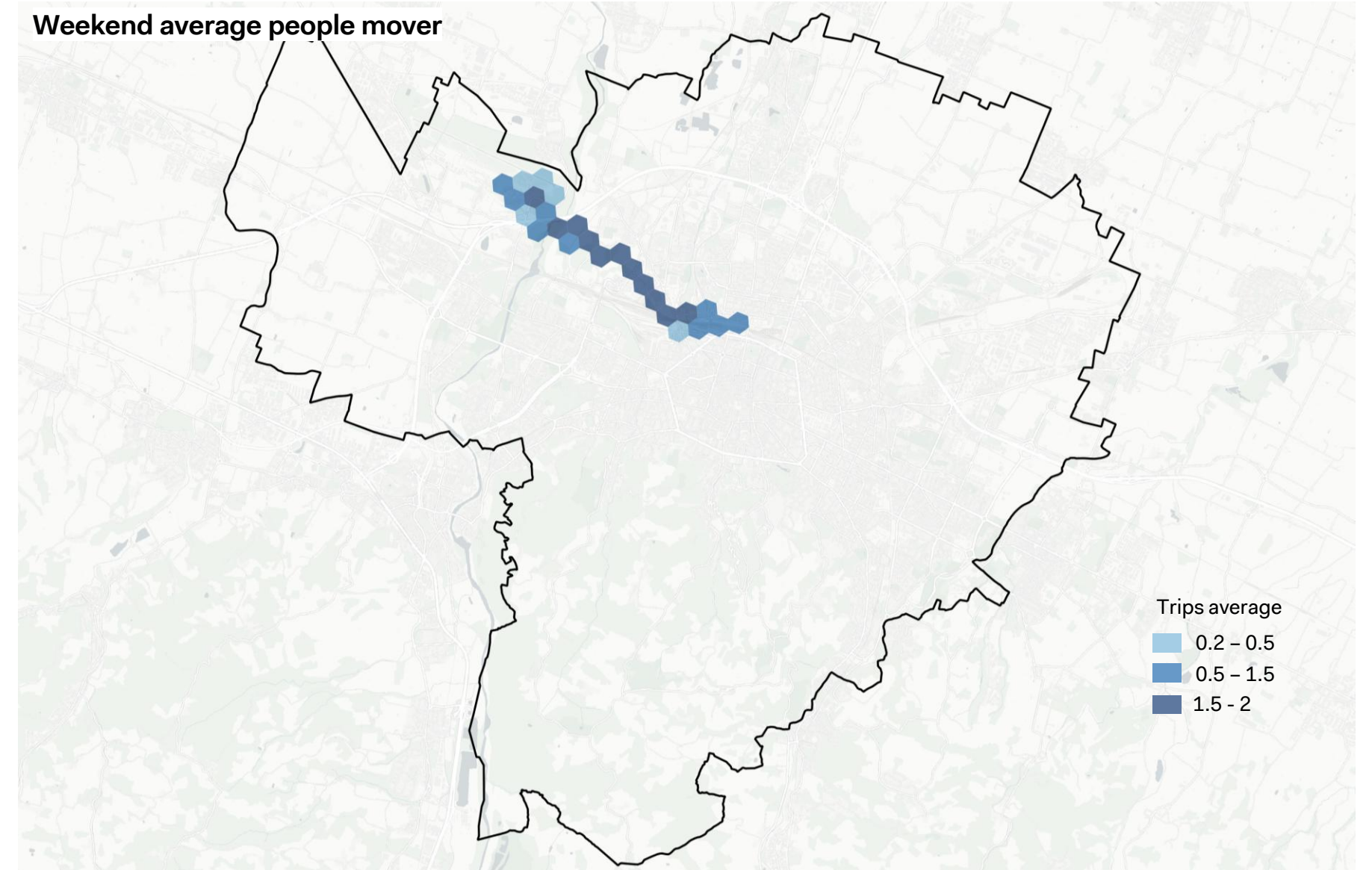
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Annex B

People mover – weekday/weekend comparison



Total number of trips (average day): **1**
Trip average length: **6637 m**
Percentage of covered area: **3%**

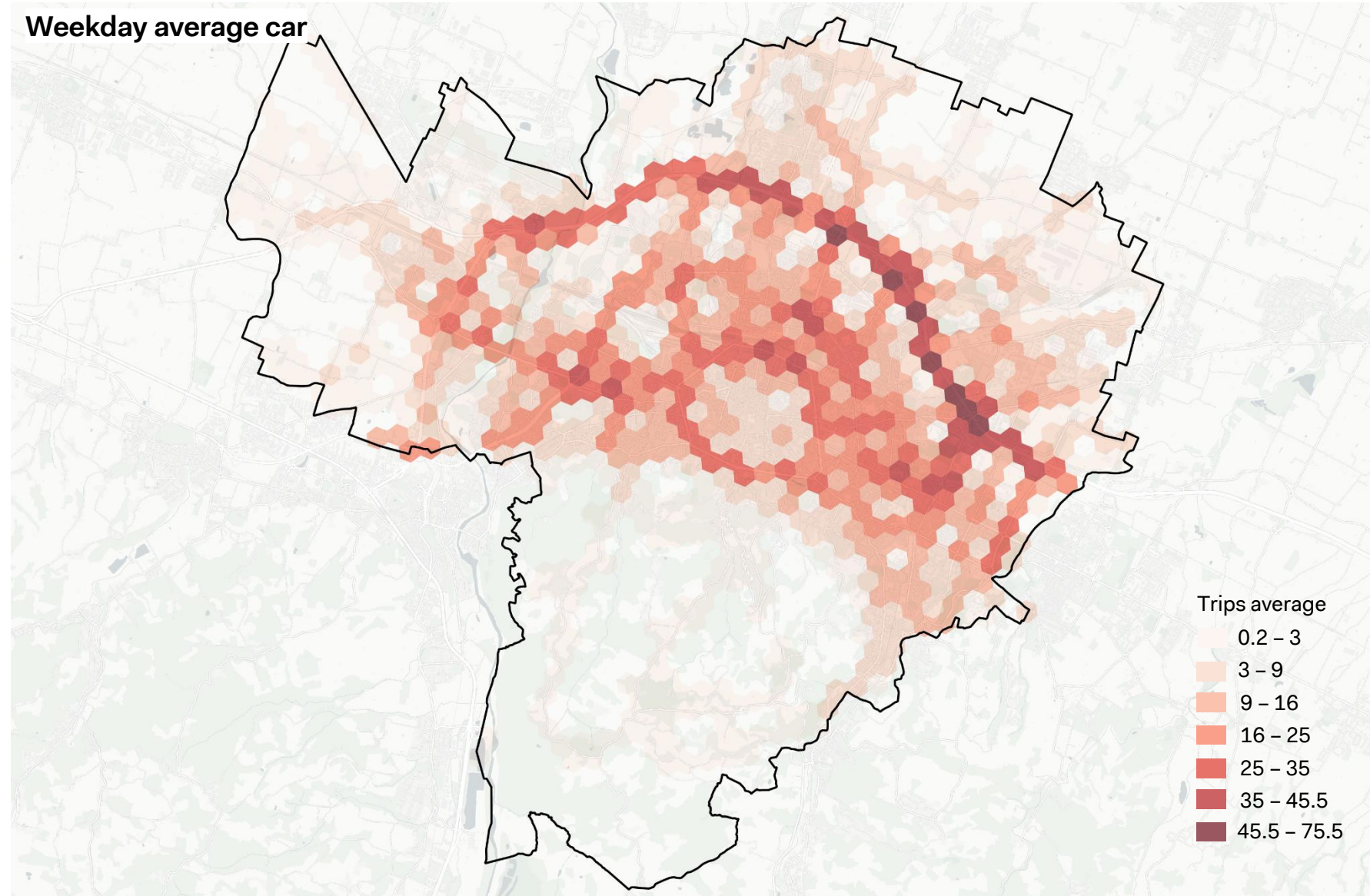


Total number of trips (average day): **3**
Trip average length: **3857 m**
Percentage of covered area: **2%**

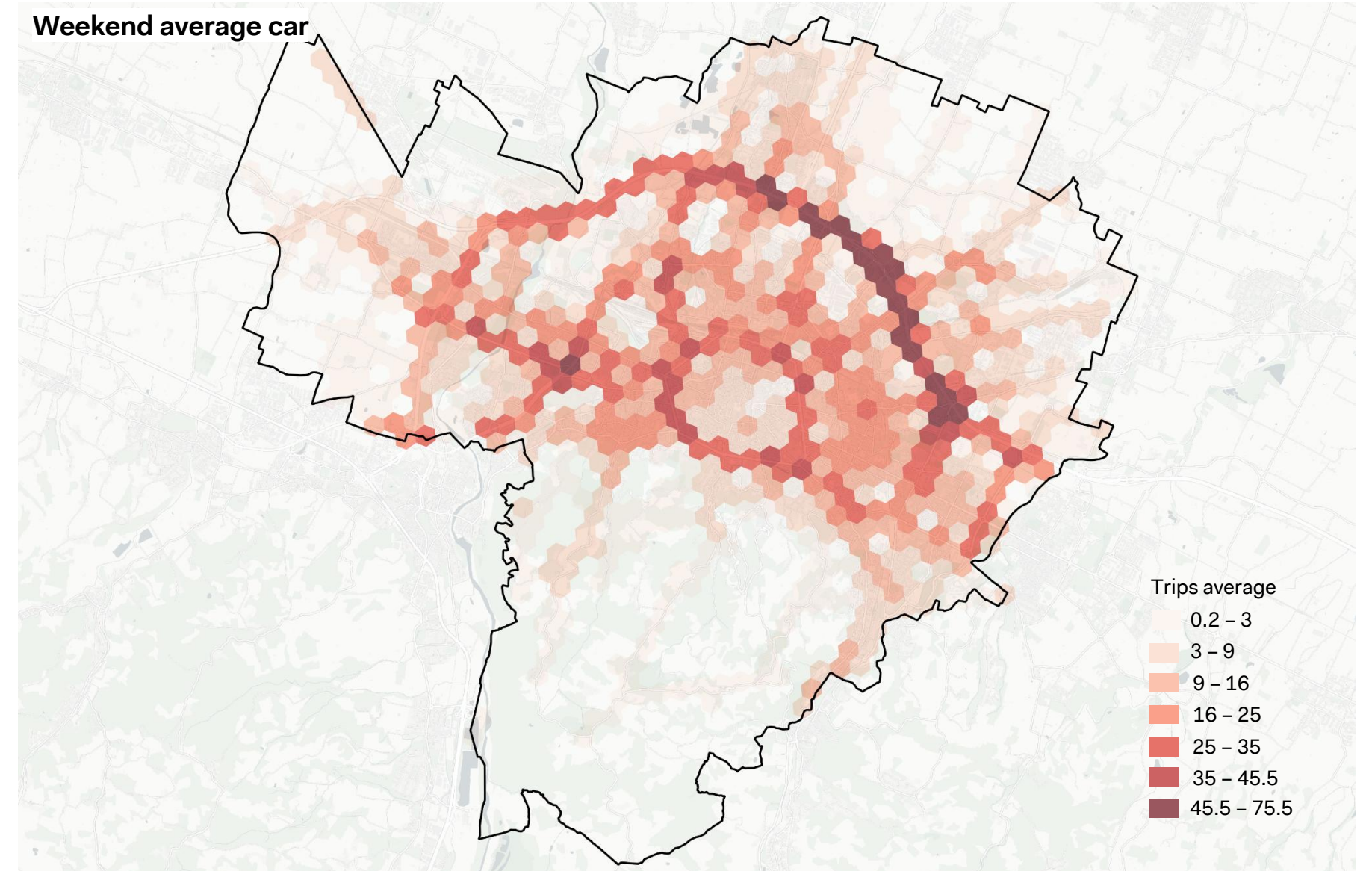
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Annex B

Car – weekday/weekend comparison



Total number of trips (average day): **499**
Trip average length: **9679 m**
Percentage of covered area: **74%**

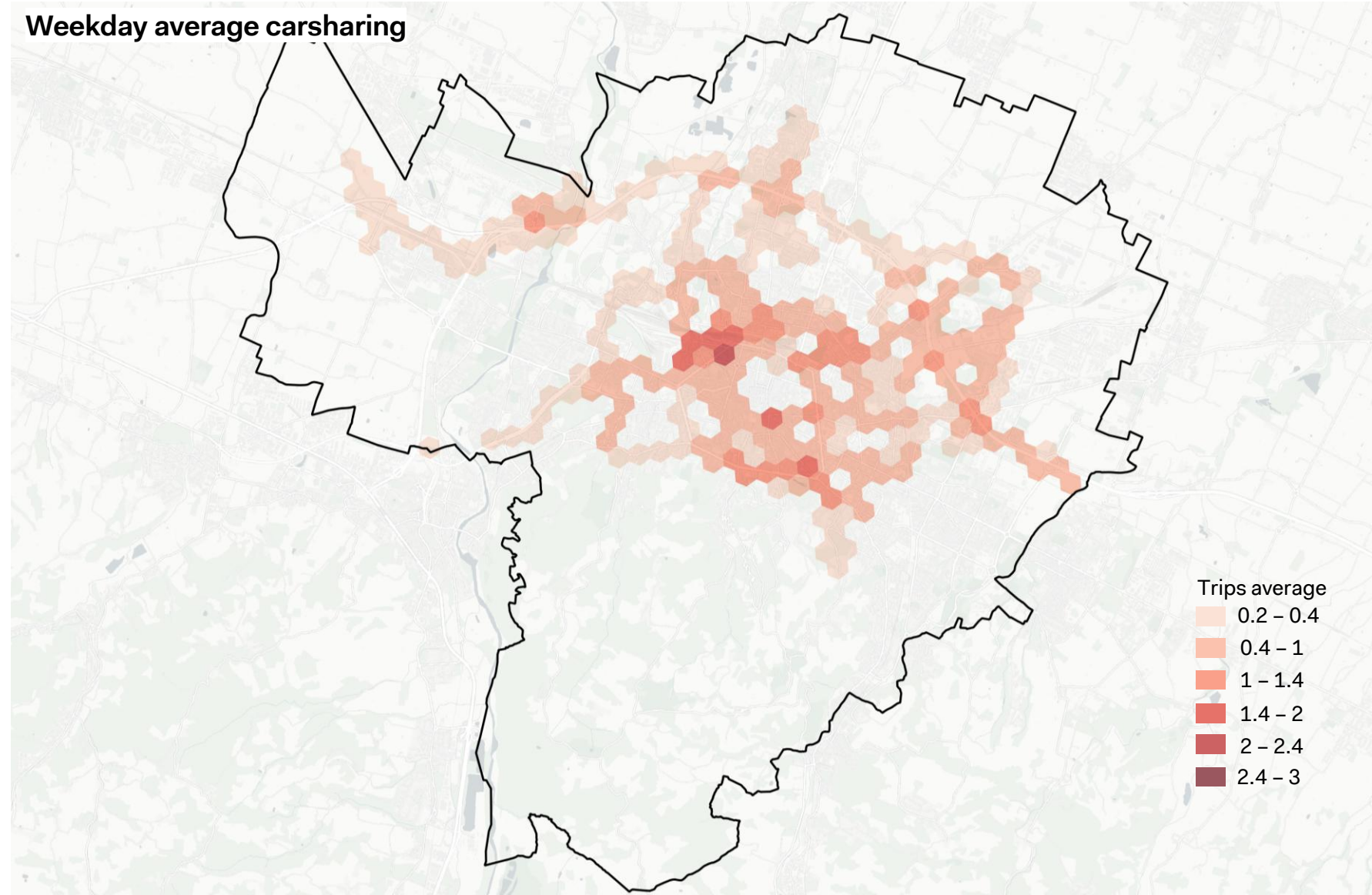


Total number of trips (average day): **504**
Trip average length: **12648 m**
Percentage of covered area: **68%** of the study area

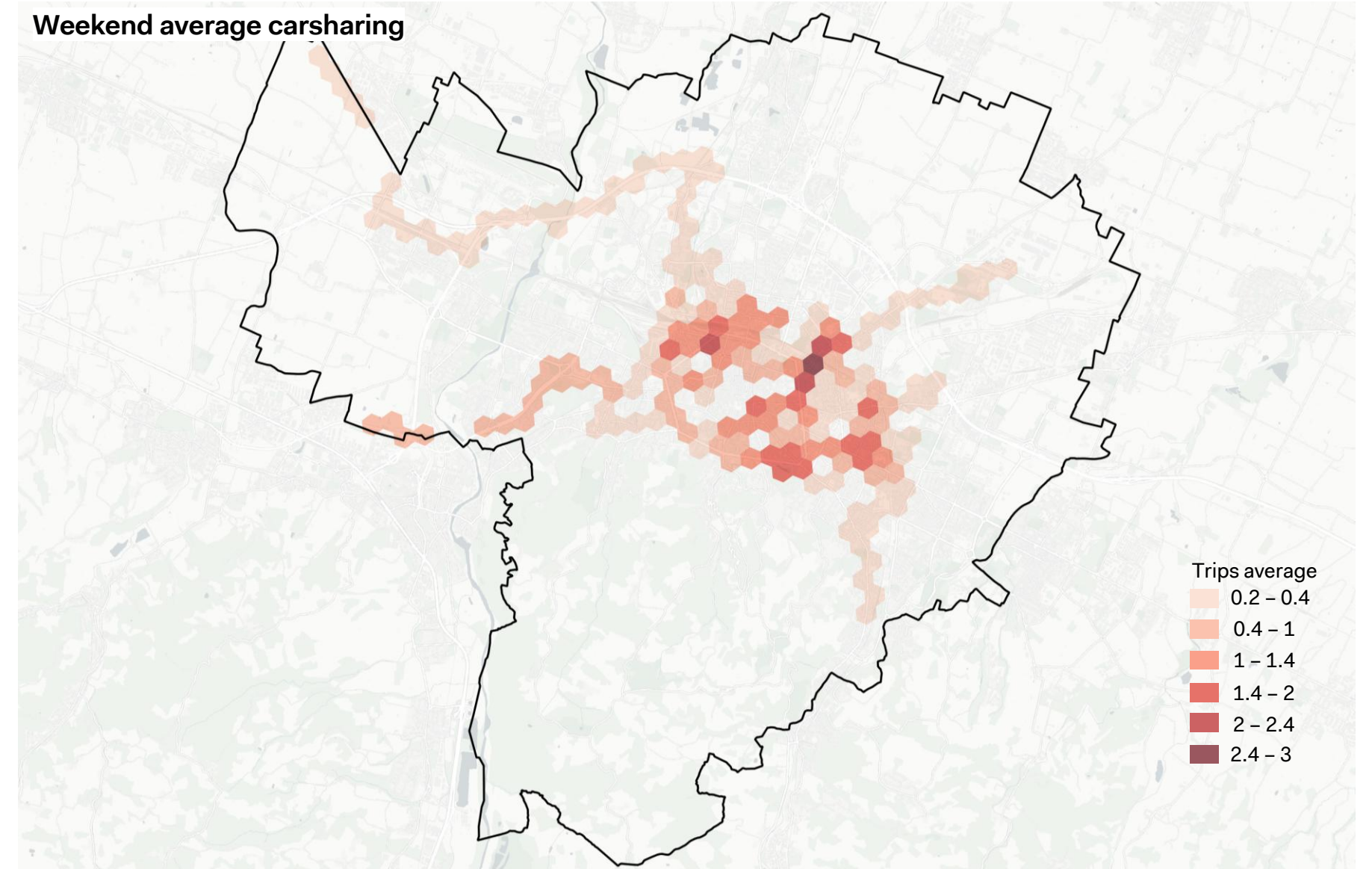
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Annex B

Carsharing – weekday/weekend comparison



Total number of trips (average day): **11**
Trip average length: **7526 m**
Percentage of covered area: **2%**

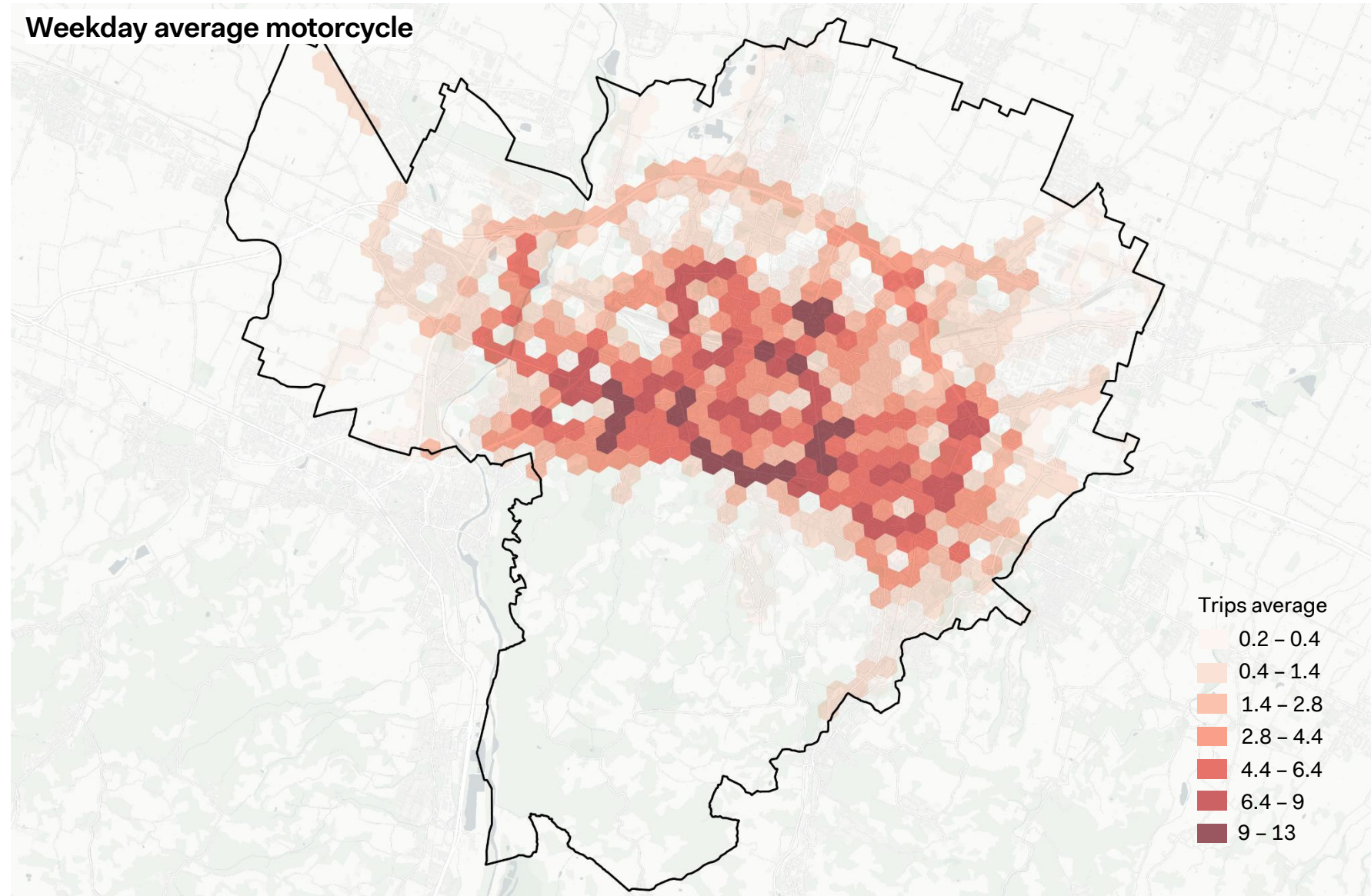


Total number of trips (average day): **10**
Trip average length: **7066 m**
Percentage of covered area: **2%**

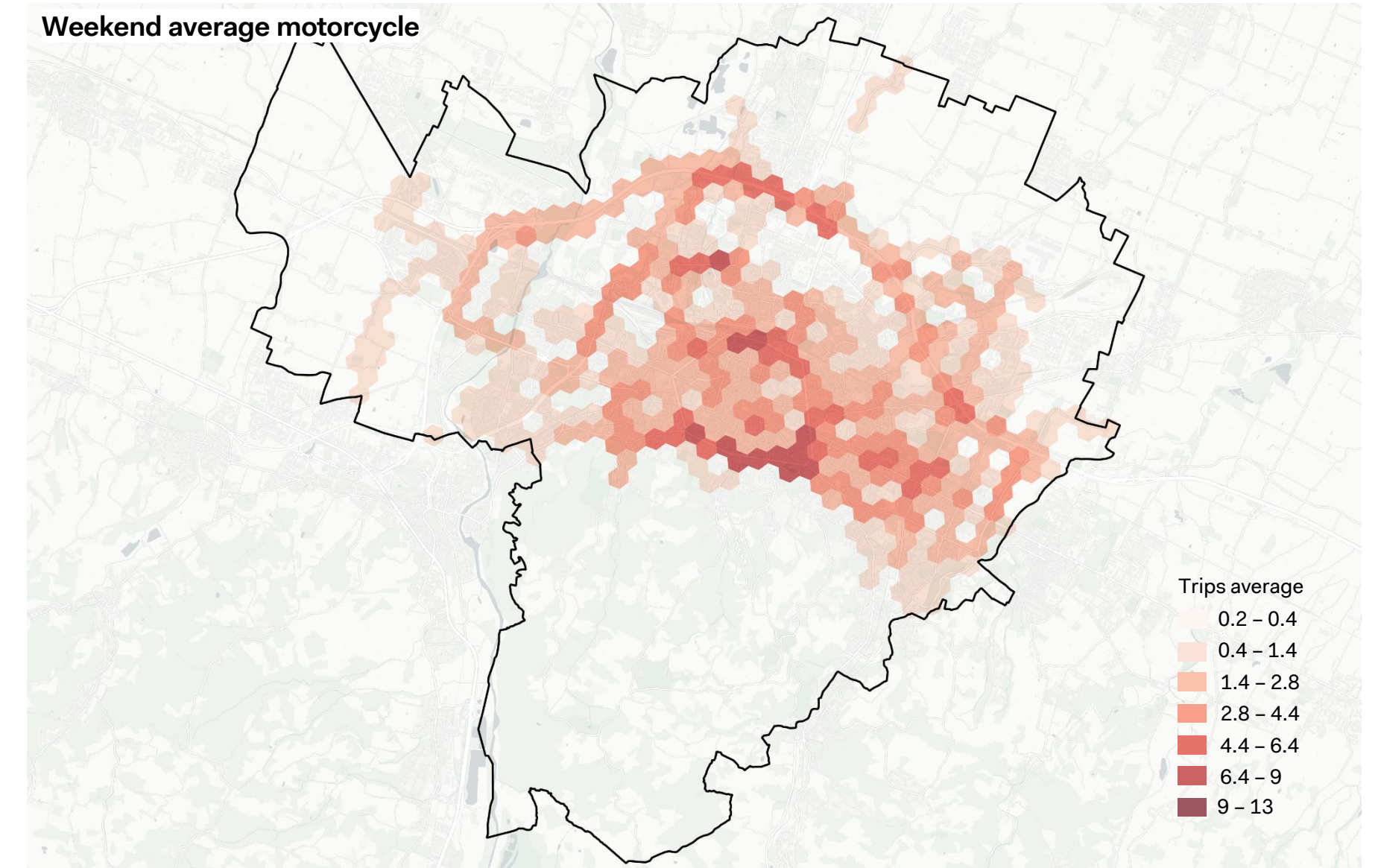
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Annex B

Motorcycle – weekday/weekend comparison



Total number of trips (average day): **104**
Trip average length: **5071 m**
Percentage of covered area: **46%**

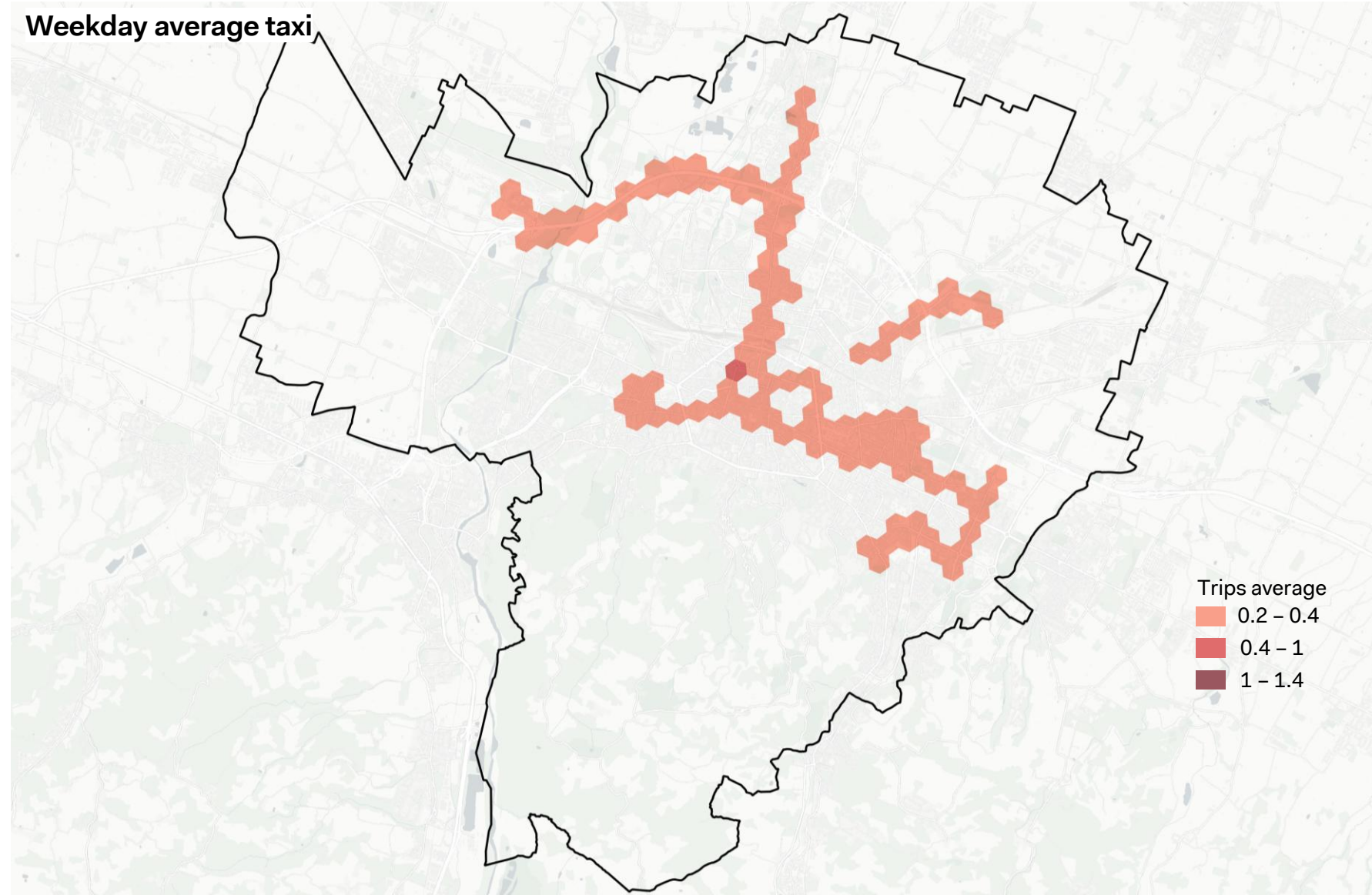


Total number of trips (average day): **51**
Trip average length: **8040 m**
Percentage of covered area: **35%**

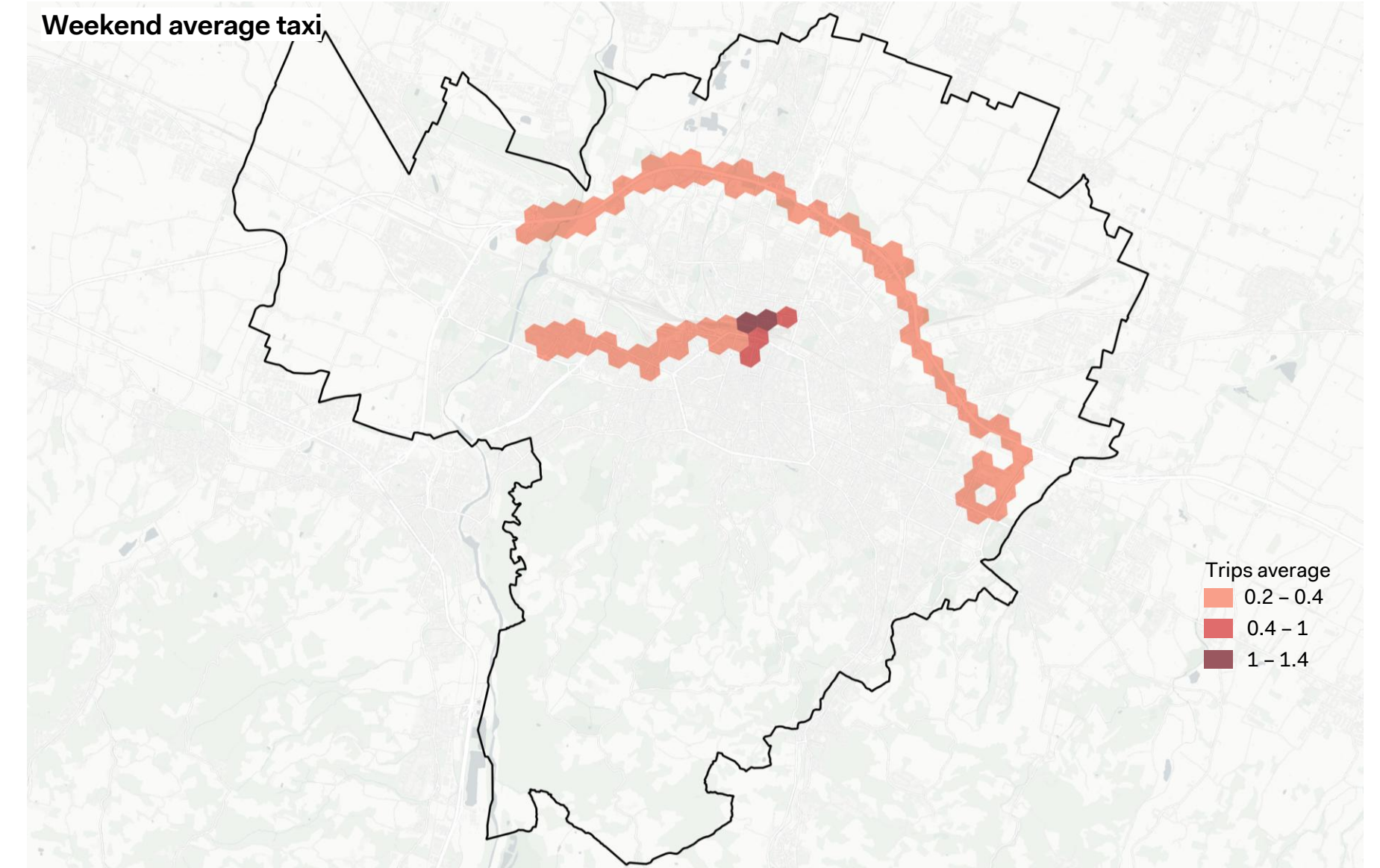
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Annex B

Taxi – weekday/weekend comparison



Total number of trips (average day): **2**
Trip average length: **4718 m**
Percentage of covered area: **9%**



Total number of trips (average day): **3**
Trip average length: **4935 m**
Percentage of covered area: **6%**

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+ Annex C

Mobility Clusters Analysis

Annex C gathers analyses and mapping results describing spatial patterns of citizens grouped into five mobility clusters, based on their mobility behaviors and profiles:

1. *Metabolici*; namely participants using mainly soft mobility modes;
2. *Sostenibili*: participants mainly using soft and shared mobility modes;
3. *Megamixer*: participants using all transport modes;
4. *Autonomi*: participants mainly using private vehicles and soft mobility modes;
5. *Auto/ moto Dipendenti*: participants using private motorized transport modes only.

Analyses aim at uncovering spatial patterns of trips structured by:

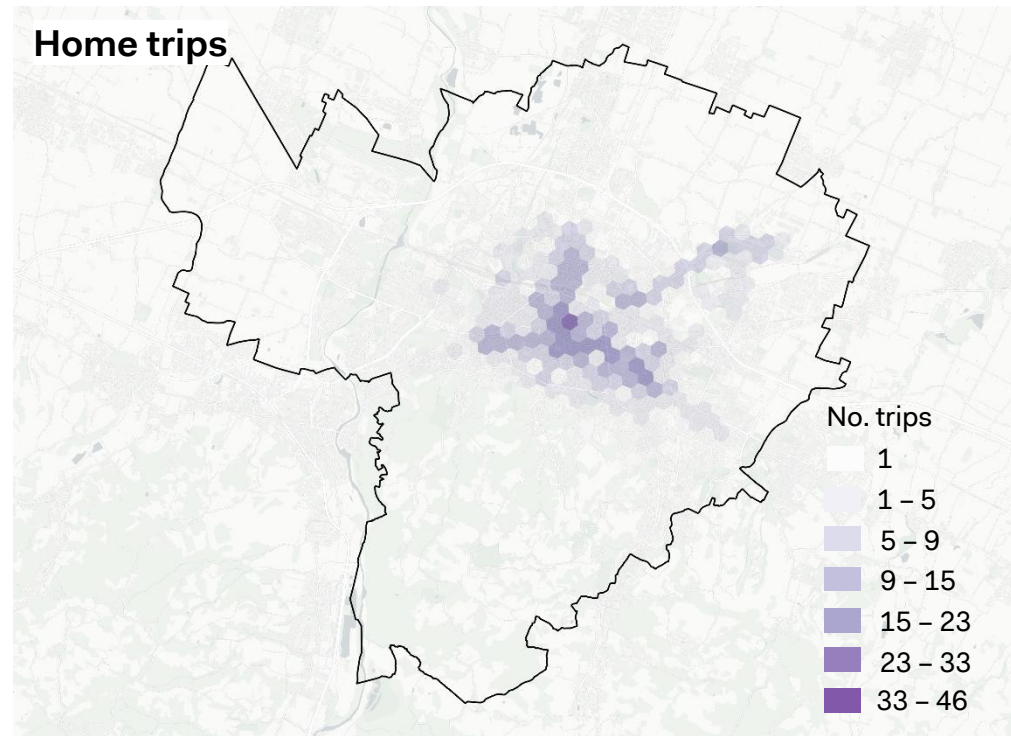
- Trips purposes (Annex C.1)
- Temporal profiles (Annex C.2)
- Modal split (Annex C.3)

Maps represent **passing-by trips volumes**, quantified as total number of trips passing by each hexagonal area in the H3 grid during the study period.

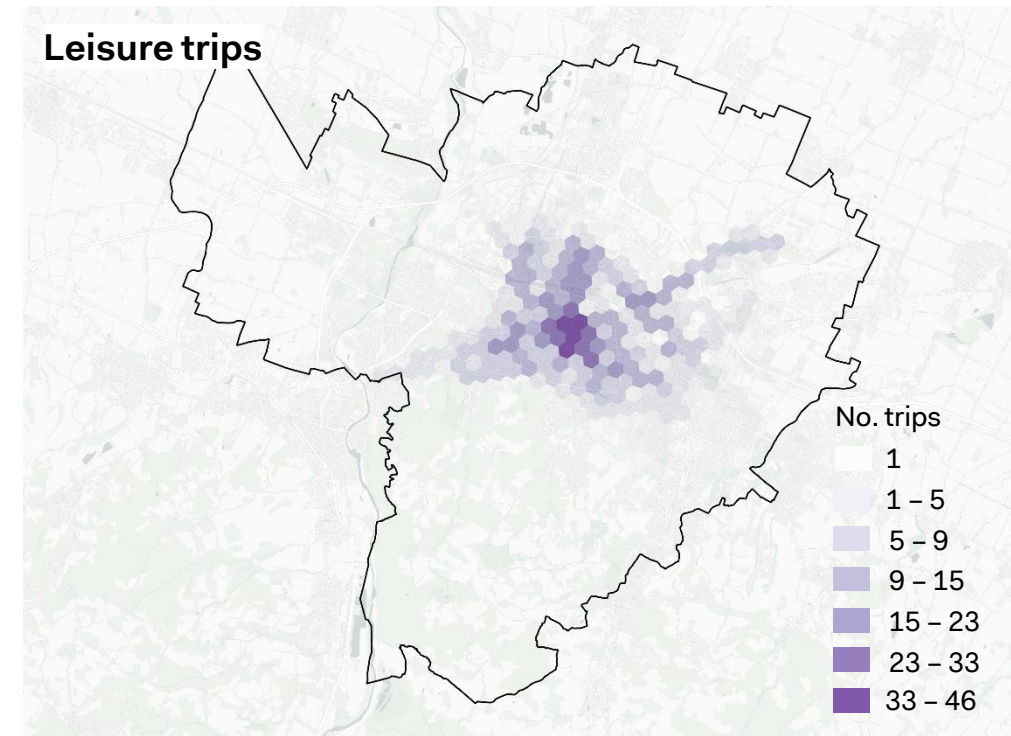
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Annex C.1

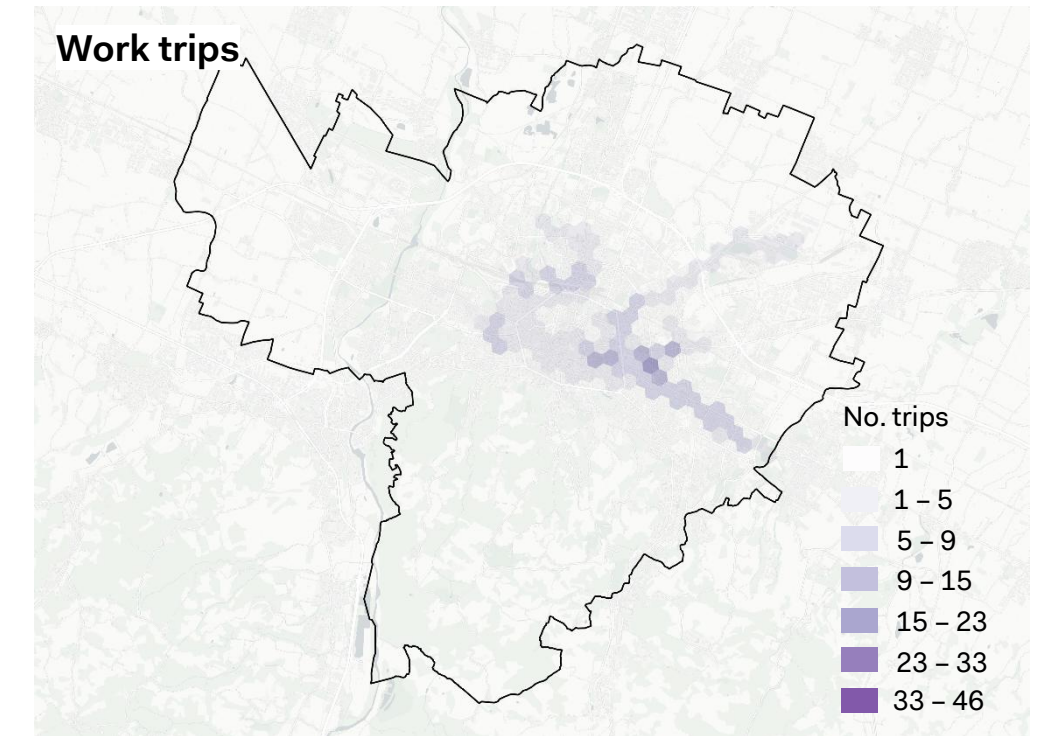
Metabolici – trip purpose



Total number of trips: **144**
Trip average length: **2309 m**
Percentage of covered area: **17%**



Total number of trips: **233**
Trip average length: **2537 m**
Percentage of covered area: **20%**

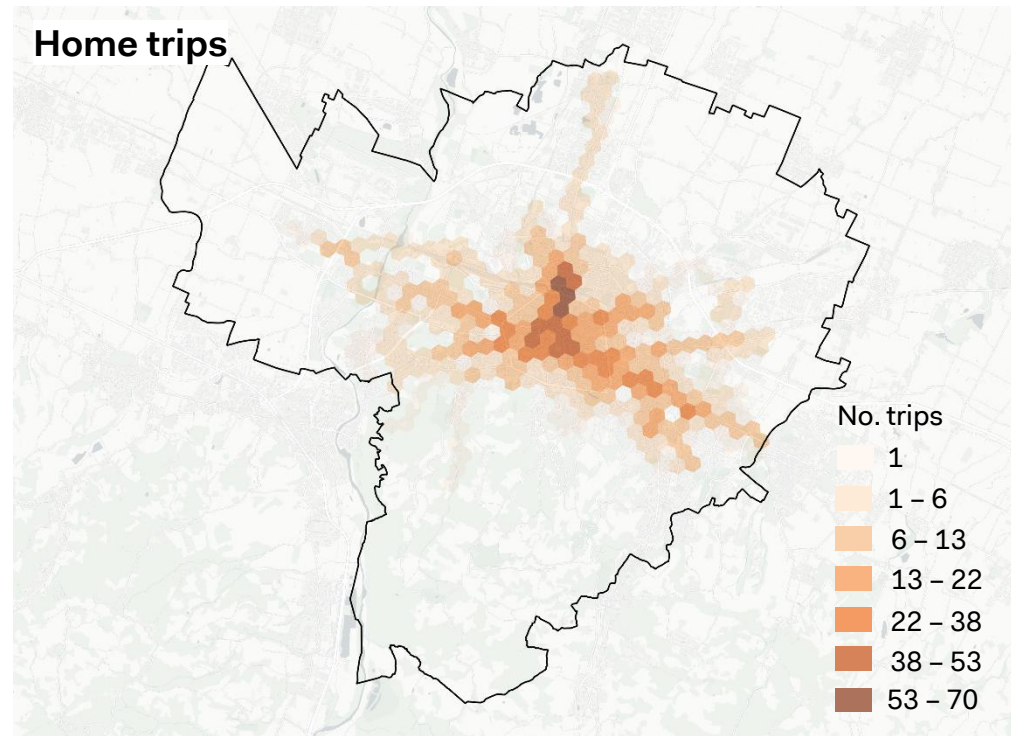


Total number of trips: **58**
Trip average length: **2957 m**
Percentage of covered area: **10%**

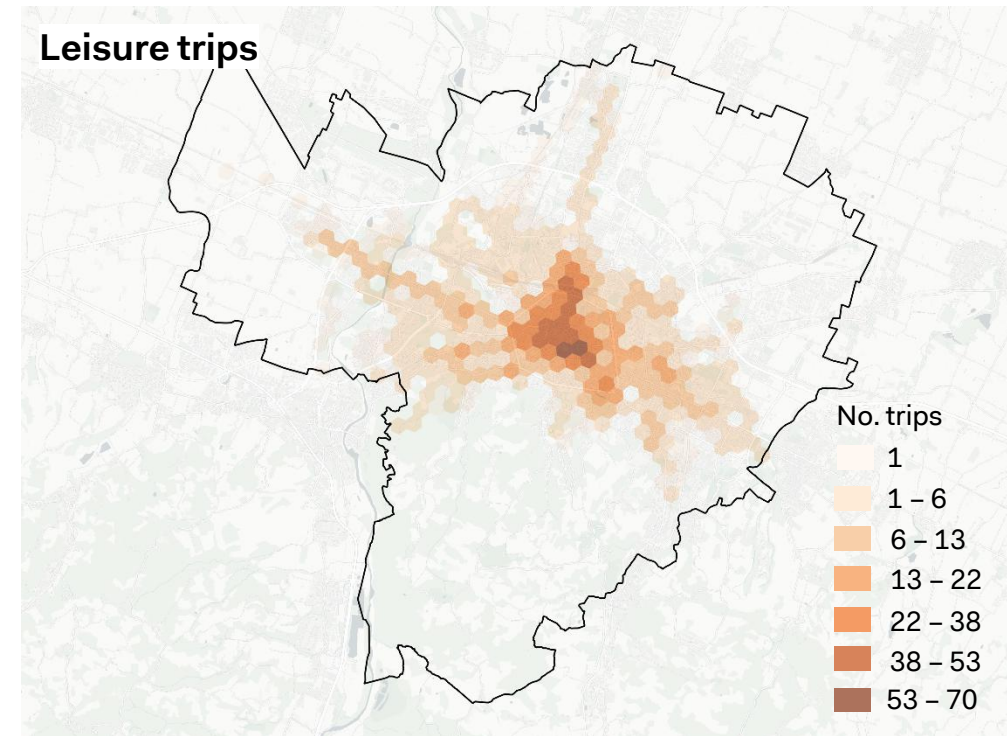
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Annex C.1

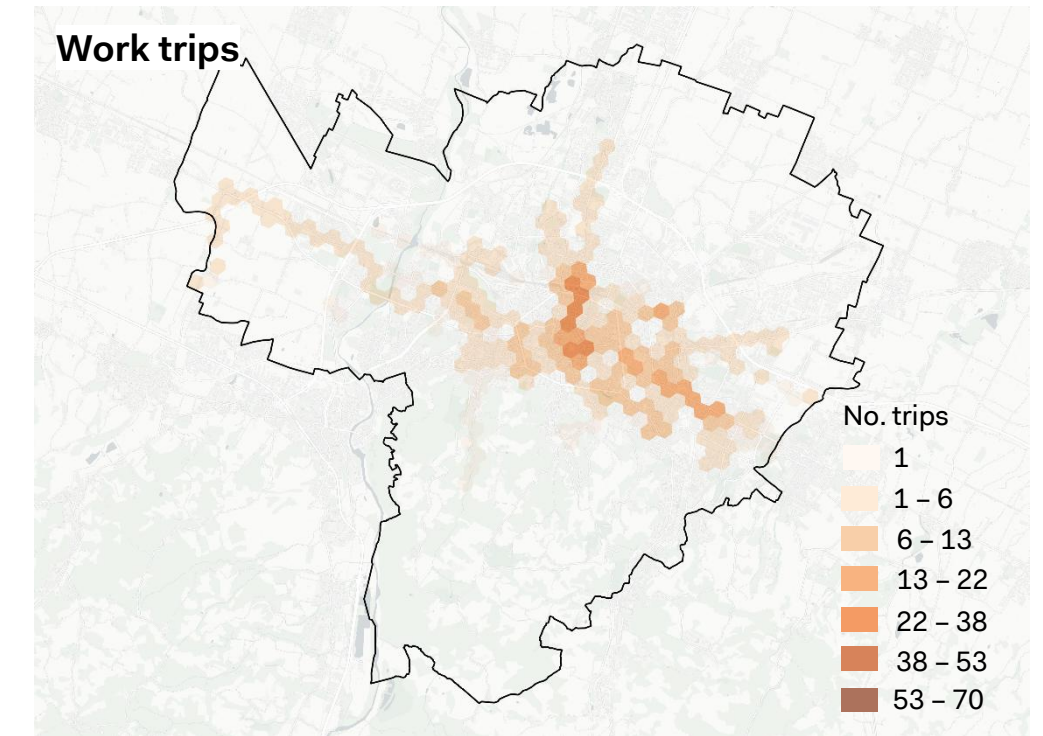
Sostenibili – trip purpose



Total number of trips: **298**
Trip average length: **2953 m**
Percentage of covered area: **25%**



Total number of trips: **377**
Trip average length: **2581 m**
Percentage of covered area: **27%**

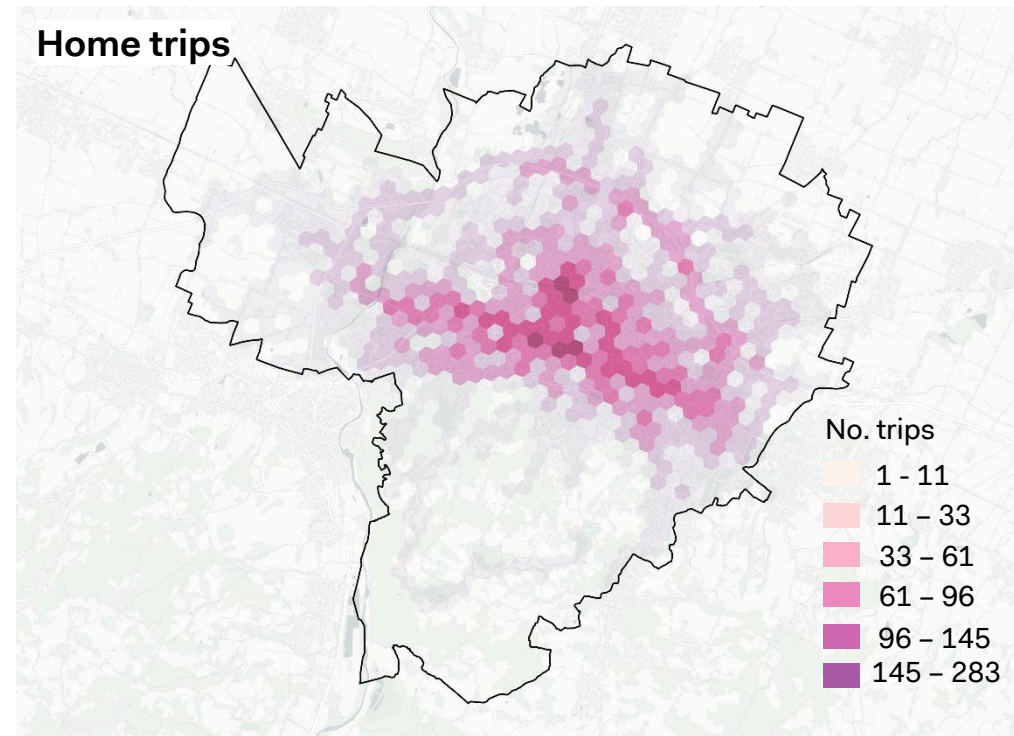


Total number of trips: **121**
Trip average length: **4757 m**
Percentage of covered area: **17%**

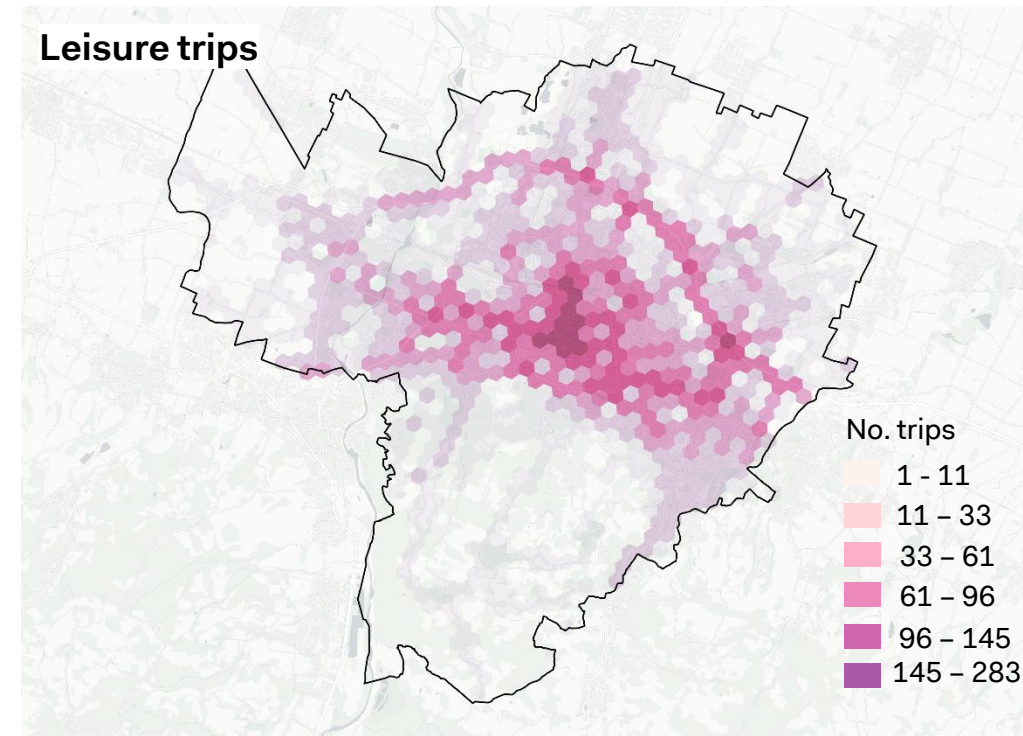
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Annex C.1

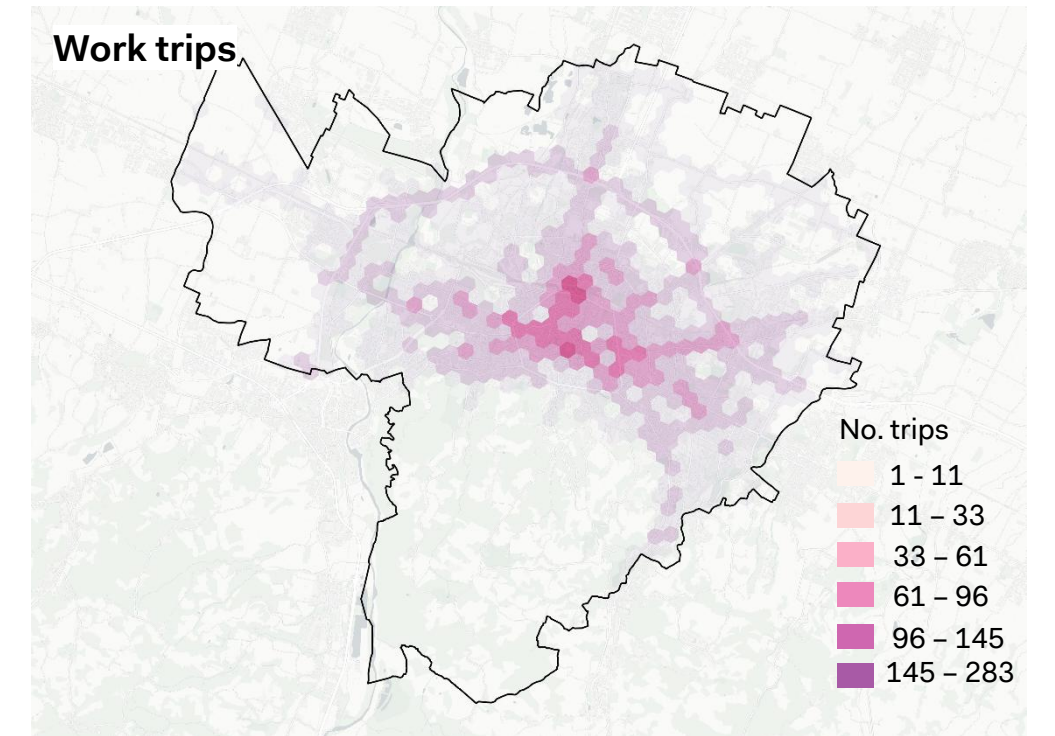
Megamixer – trip purpose



Total number of trips: **1489**
Trip average length: **2993 m**
Percentage of covered area: **60%**



Total number of trips: **2268**
Trip average length: **6277 m**
Percentage of covered area: **68%**

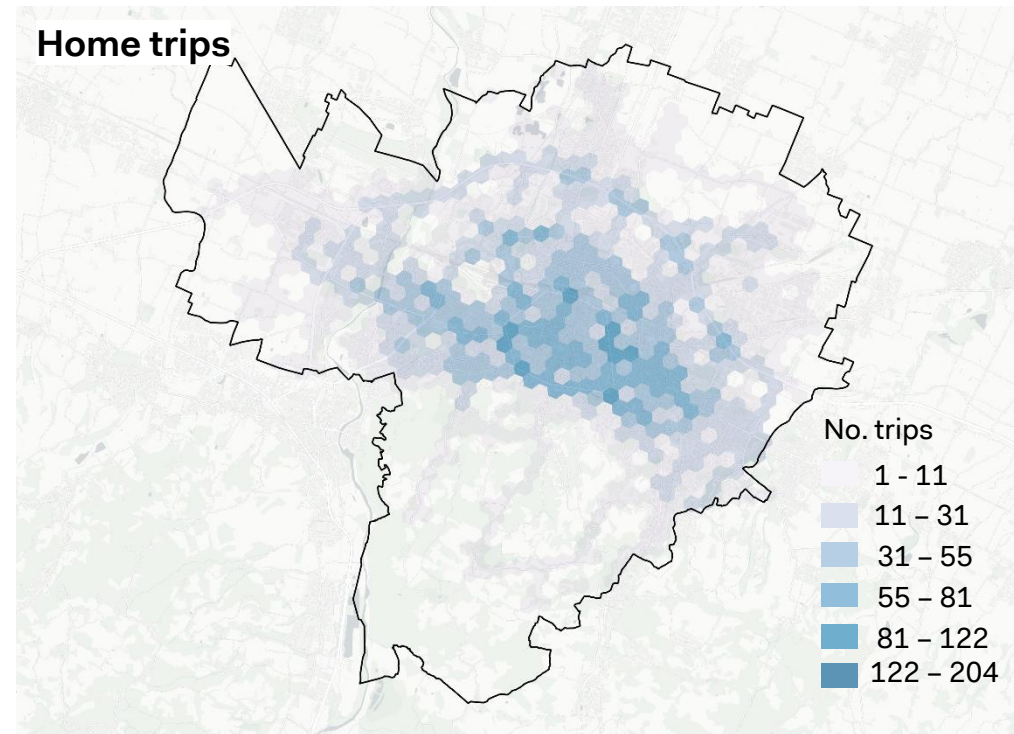


Total number of trips: **697**
Trip average length: **5466 m**
Percentage of covered area: **48%**

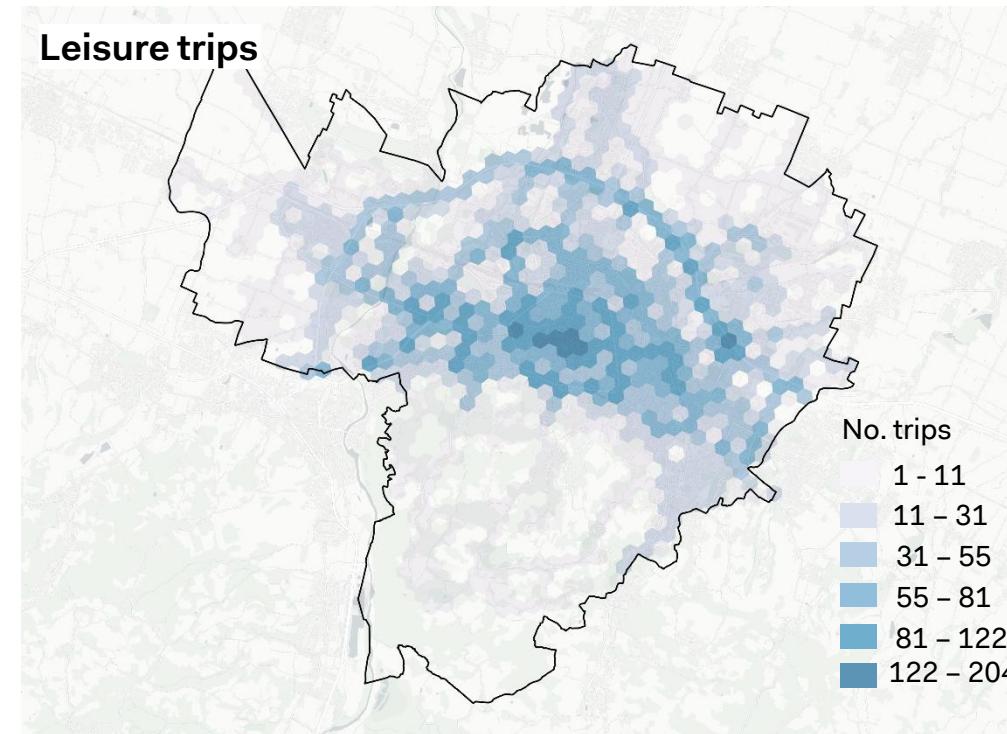
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Annex C.1

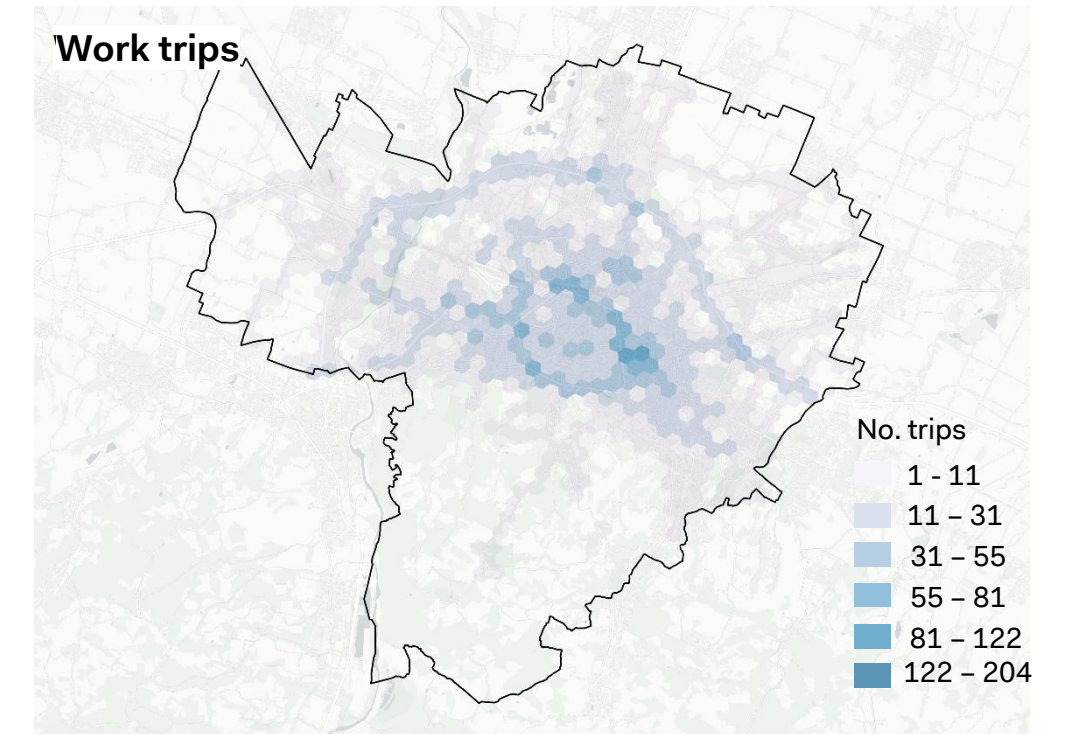
Autonomi – trip purpose



Total number of trips: **1220**
Trip average length: **3793 m**
Percentage of covered area: **56%**



Total number of trips: **2313**
Trip average length: **2211 m**
Percentage of covered area: **69%**

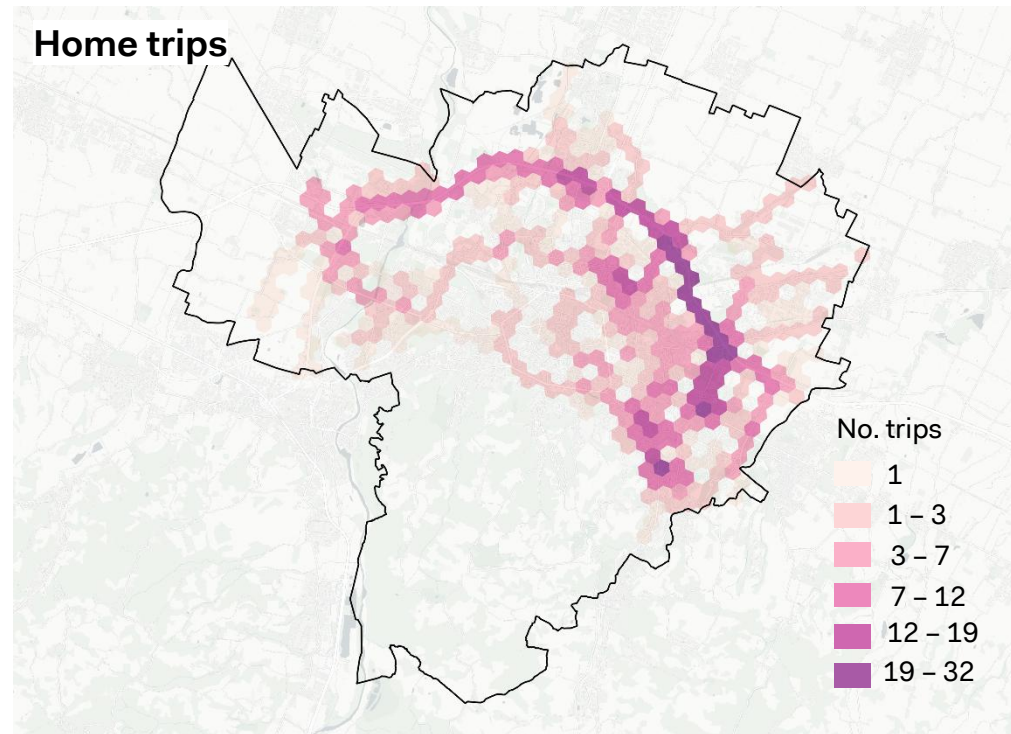


Total number of trips: **541**
Trip average length: **6171 m**
Percentage of covered area: **51%**

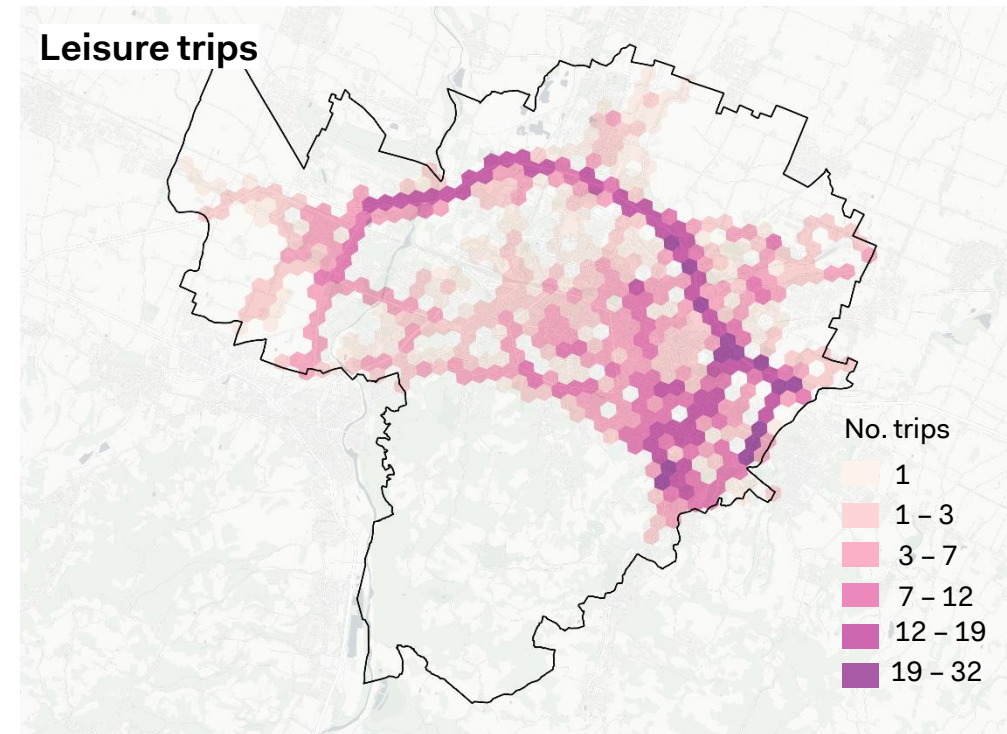
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Annex C.1

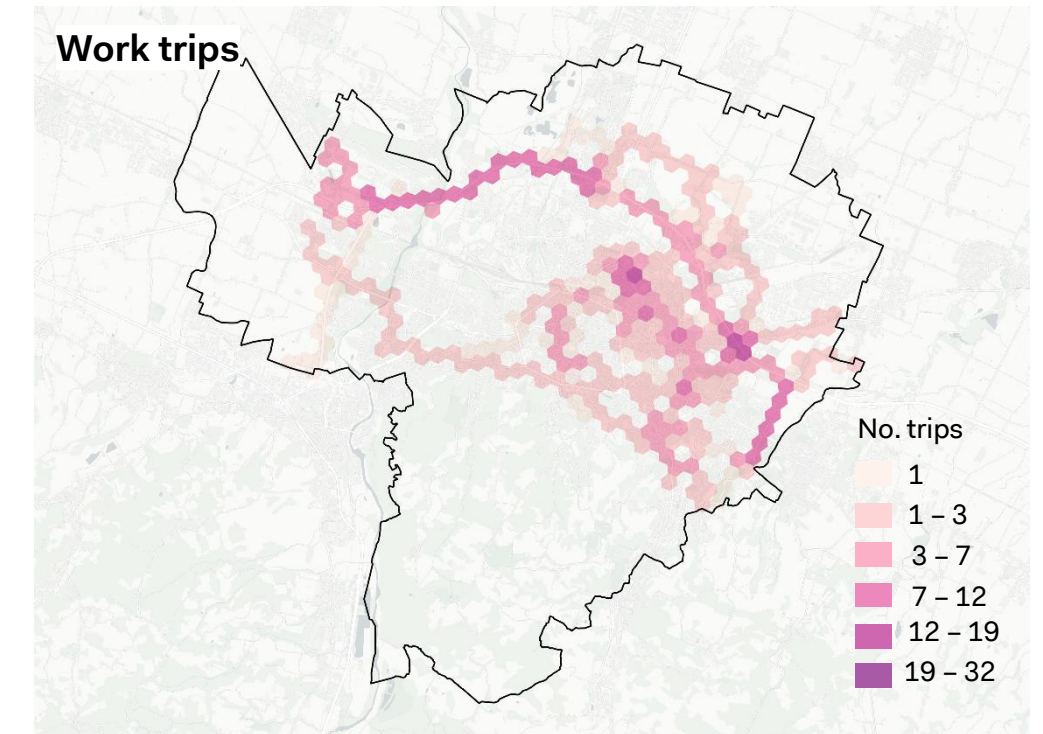
Auto/ moto dipendenti – trip purpose



Total number of trips: **98**
Trip average length: **6726 m**
Percentage of covered area: **33%**



Total number of trips: **154**
Trip average length: **5589 m**
Percentage of covered area: **41%**

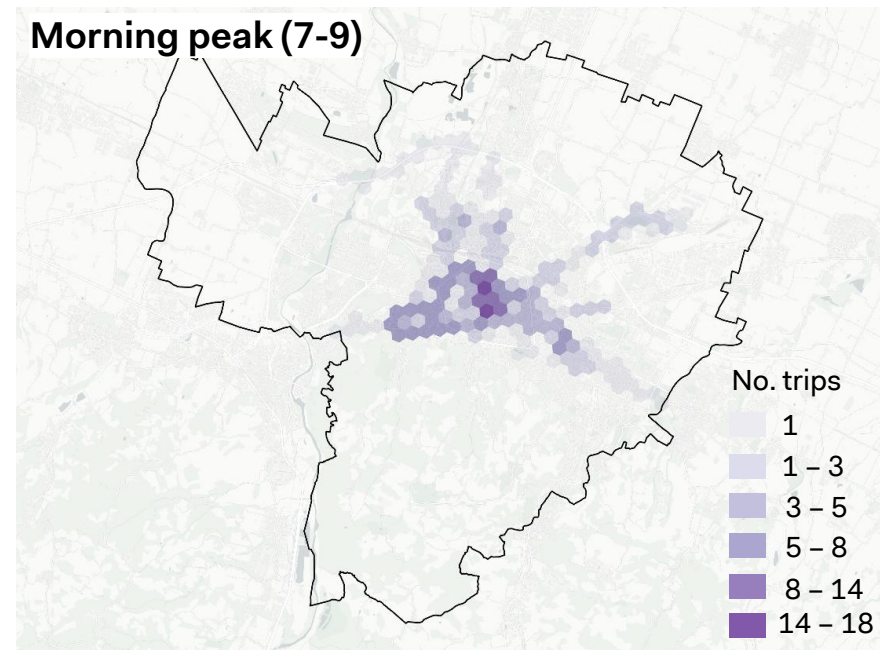


Total number of trips: **45**
Trip average length: **8223 m**
Percentage of covered area: **24%**

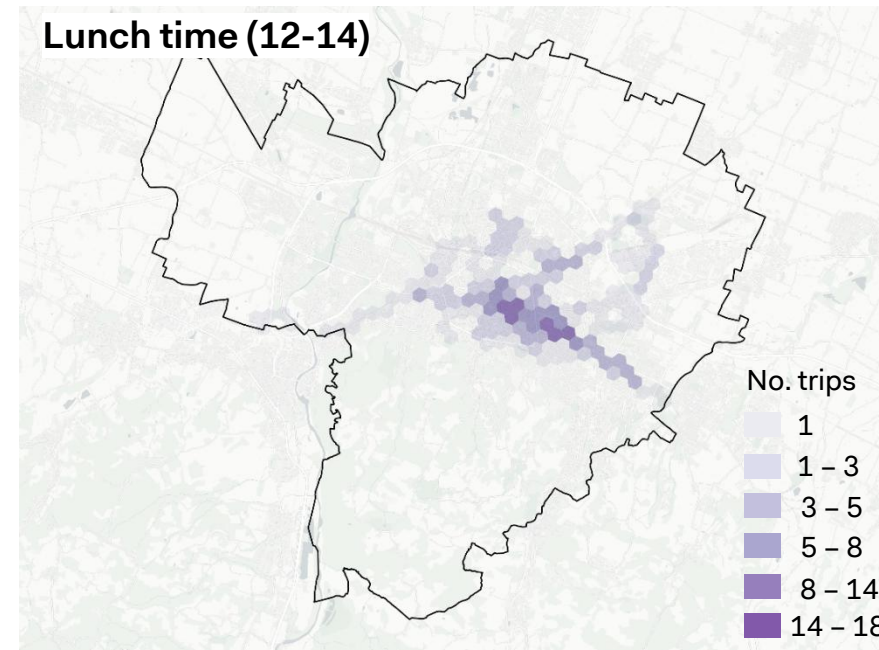
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Annex C.2

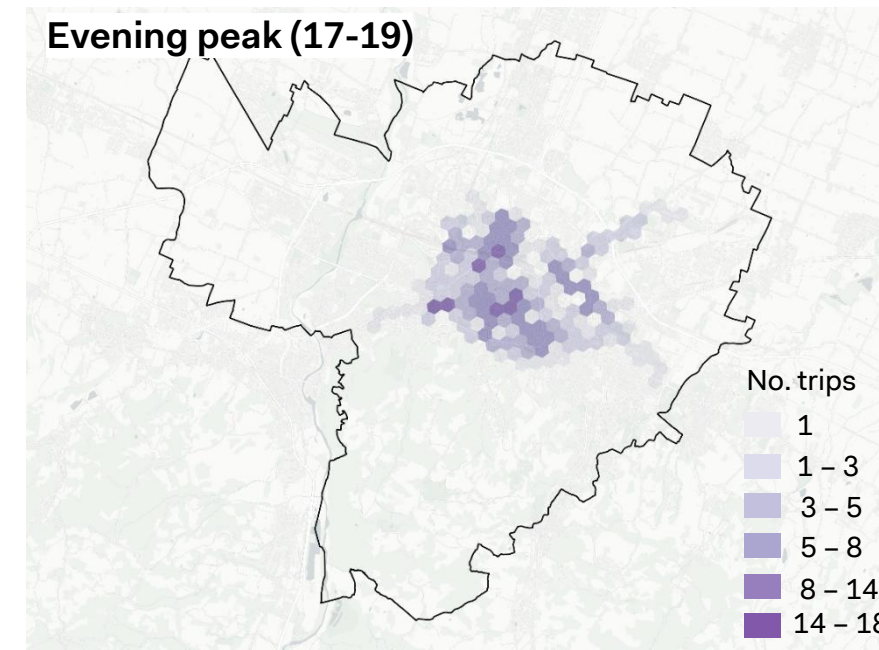
Metabolici – temporal profile



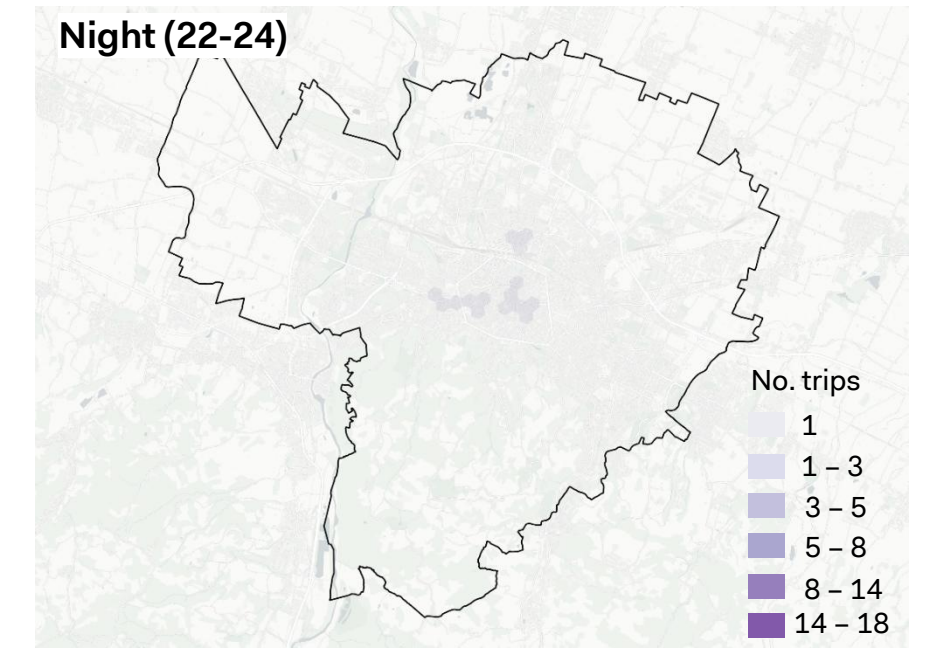
Total number of trips: **57**
Trip average length: **2900 m**
Percentage of covered area: **13%**



Total number of trips: **45**
Trip average length: **2427 m**
Percentage of covered area: **11%**



Total number of trips: **68**
Trip average length: **2577 m**
Percentage of covered area: **12%**

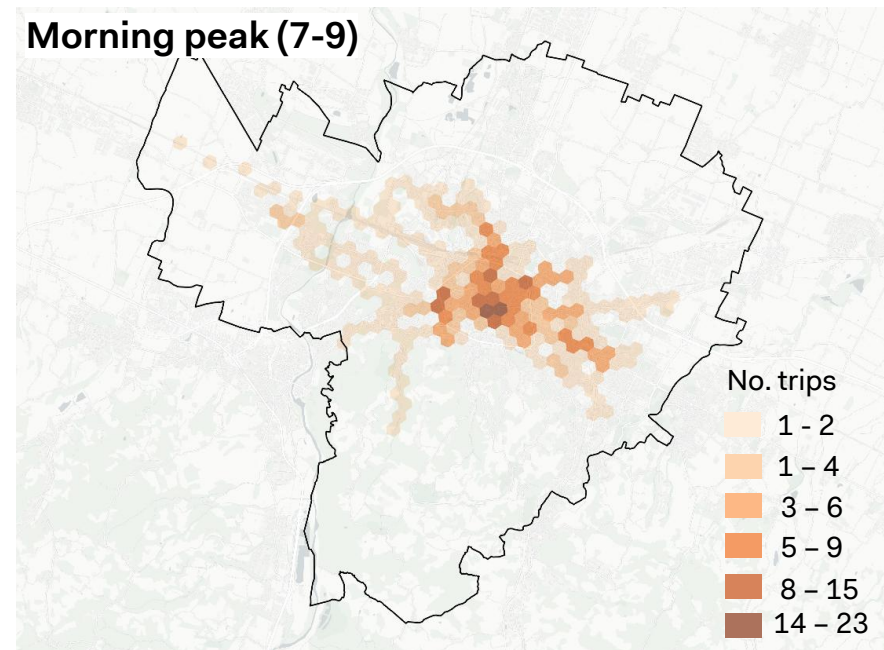


Total number of trips: **4**
Trip average length: **998 m**
Percentage of covered area: **1%**

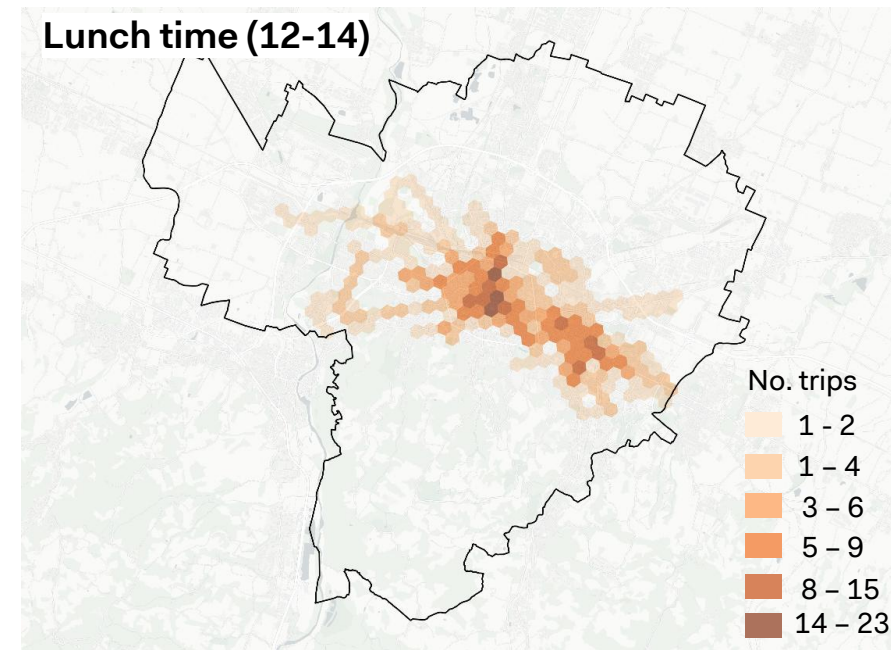
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Annex C.2

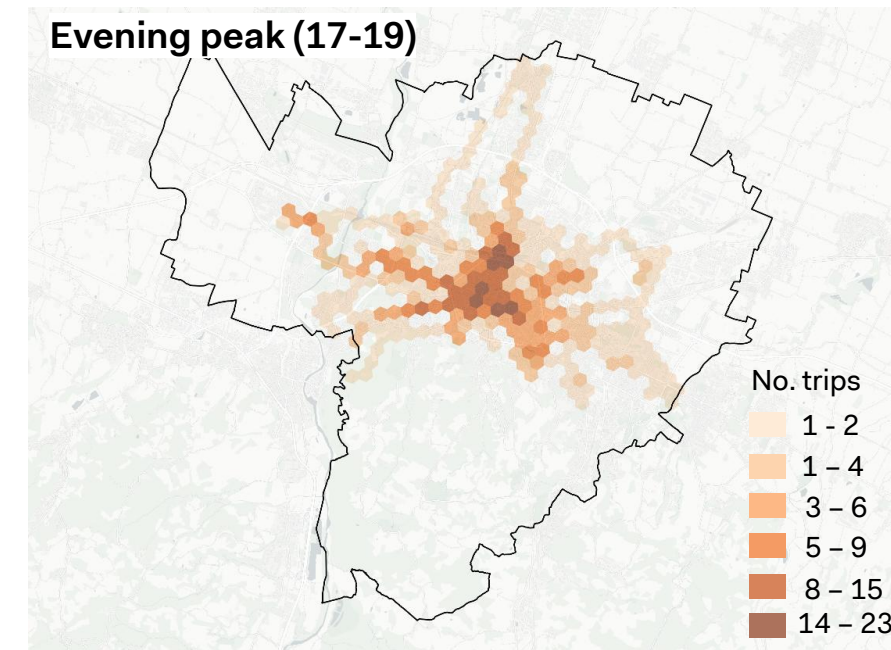
Sostenibili – temporal profile



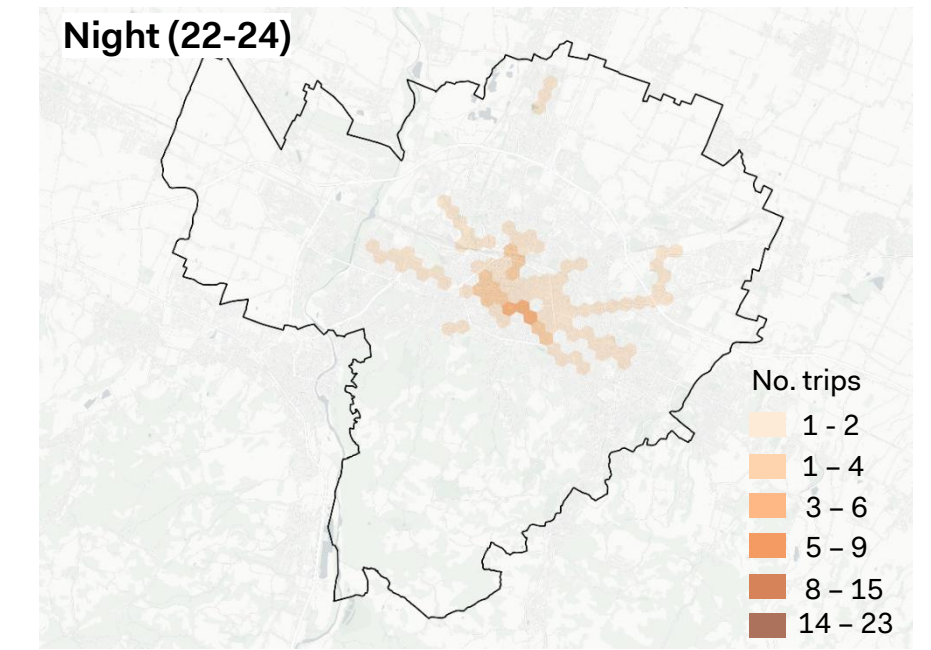
Total number of trips: **65**
Trip average length: **3510 m**
Percentage of covered area: **16%**



Total number of trips: **85**
Trip average length: **2946 m**
Percentage of covered area: **17%**



Total number of trips: **129**
Trip average length: **3380 m**
Percentage of covered area: **21%**

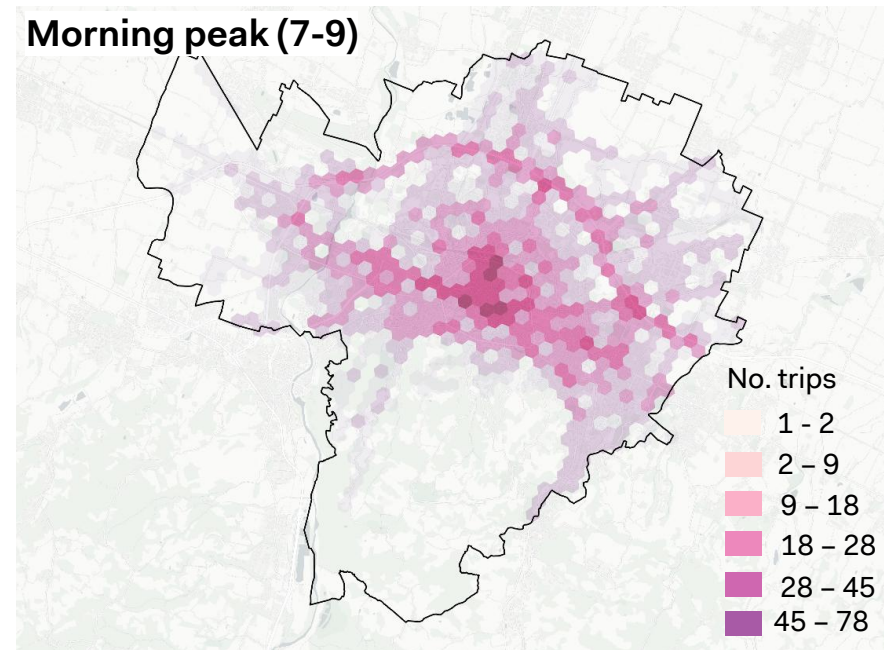


Total number of trips: **18**
Trip average length: **2616 m**
Percentage of covered area: **7%**

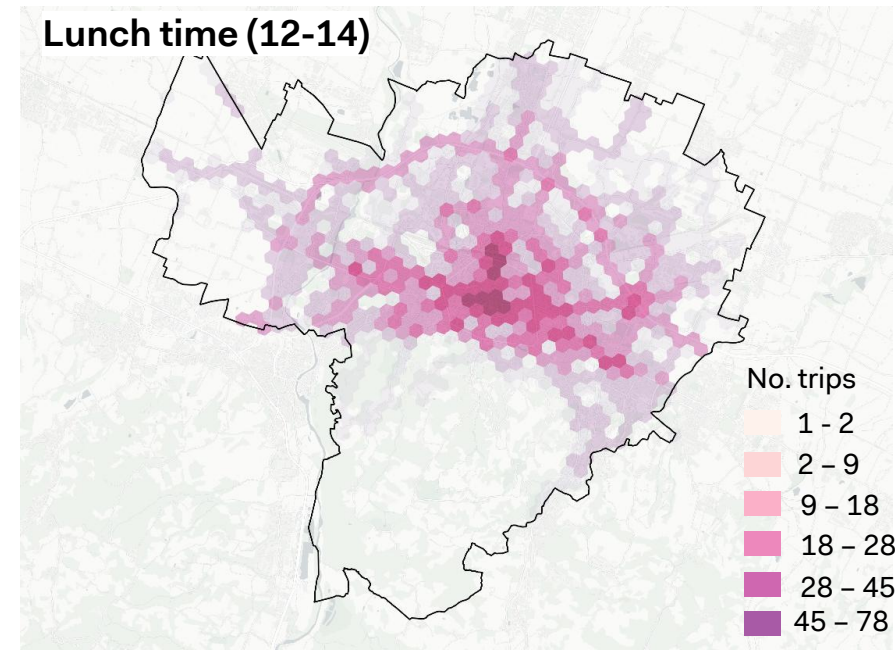
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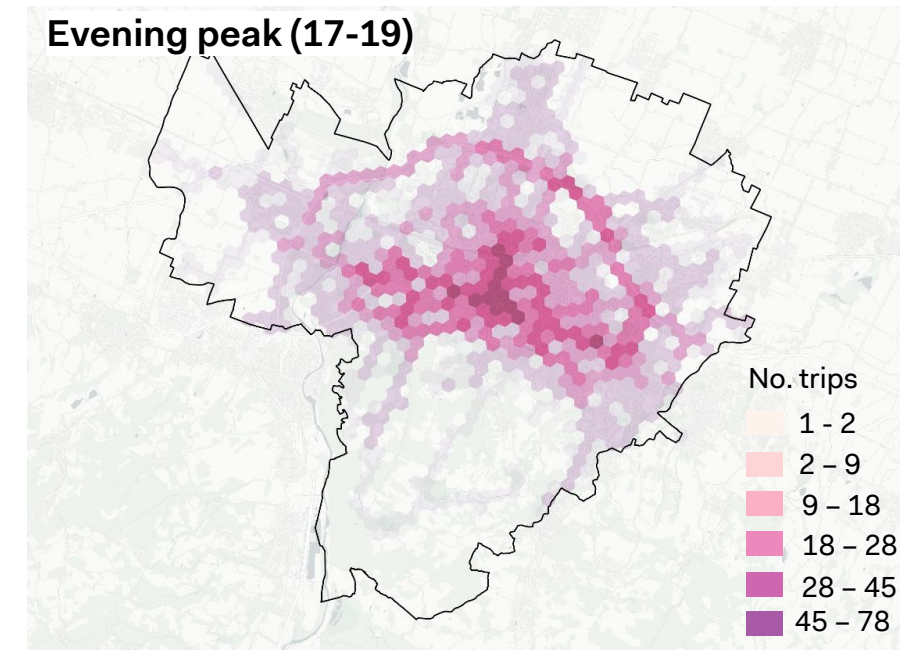
Megamixer – temporal profile



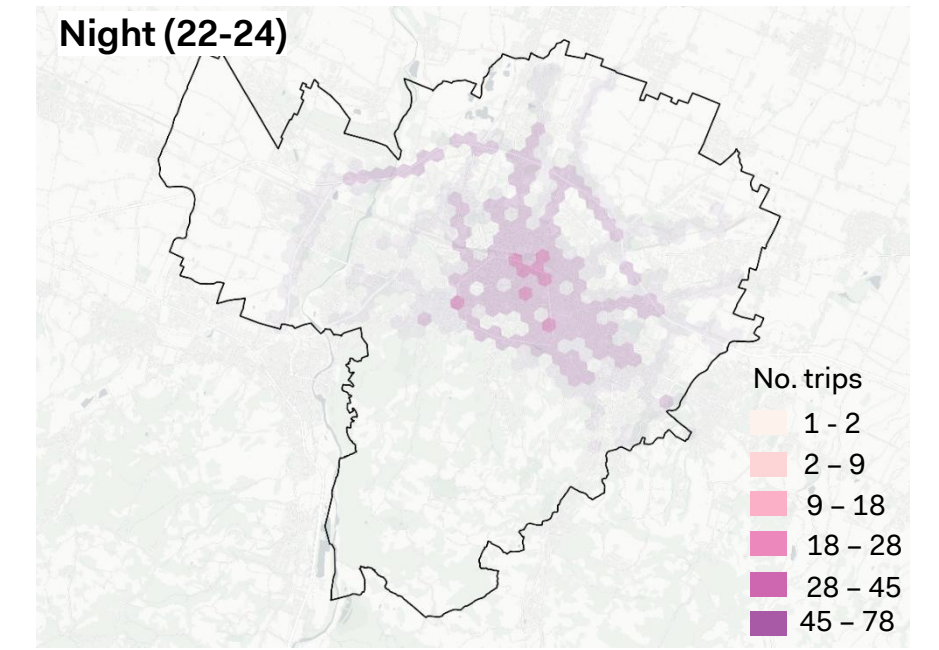
Total number of trips: **513**
Trip average length: **6392 m**
Percentage of covered area: **56%**



Total number of trips: **571**
Trip average length: **6154 m**
Percentage of covered area: **54%**



Total number of trips: **591**
Trip average length: **5105 m**
Percentage of covered area: **56%**

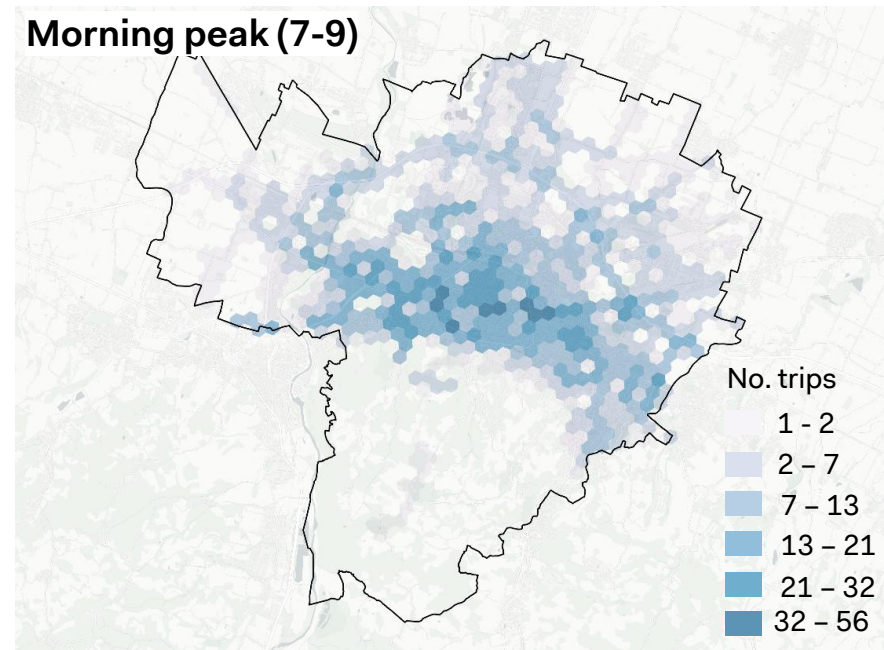


Total number of trips: **76**
Trip average length: **4470 m**
Percentage of covered area: **27%**

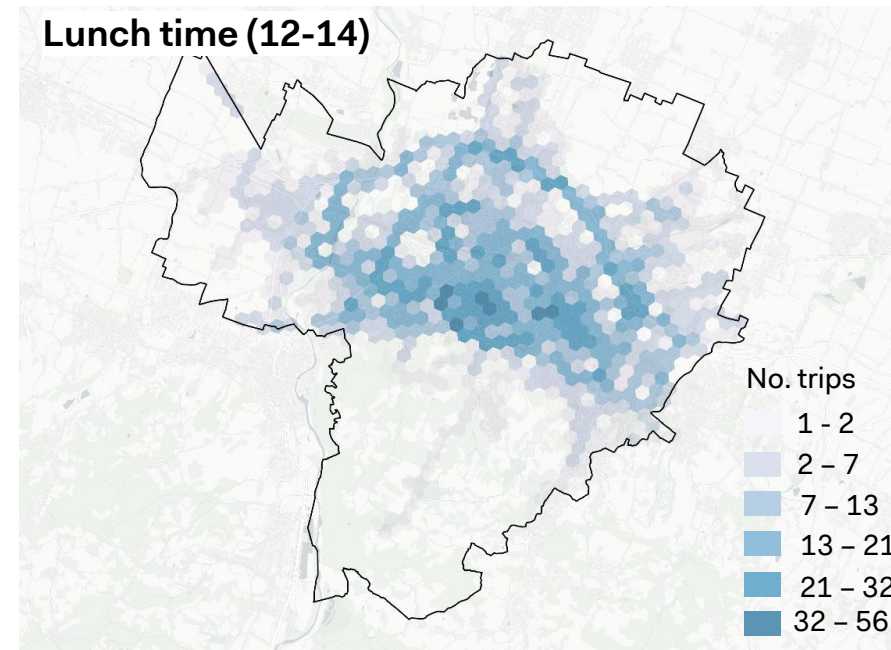
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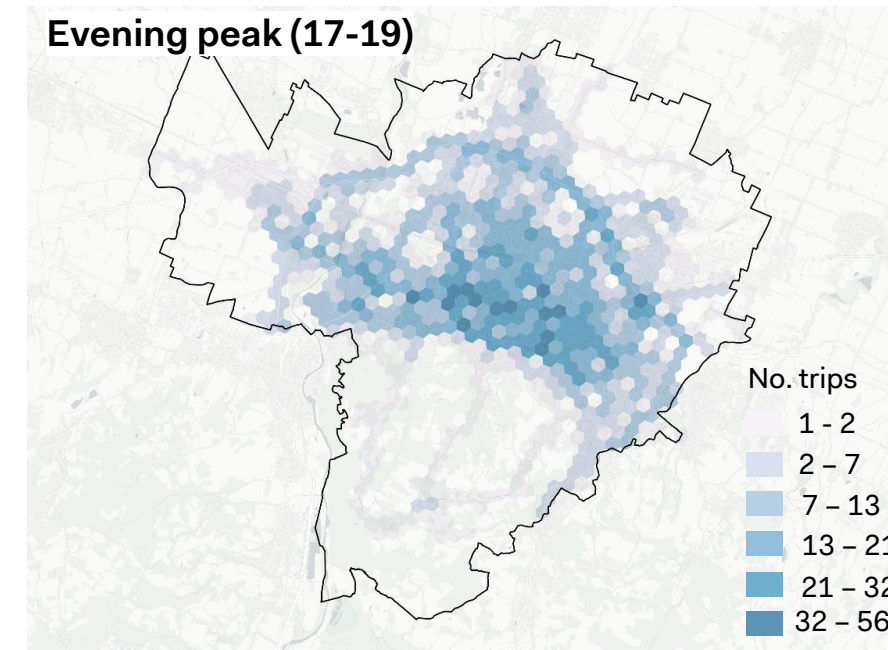
Autonomi – temporal profile



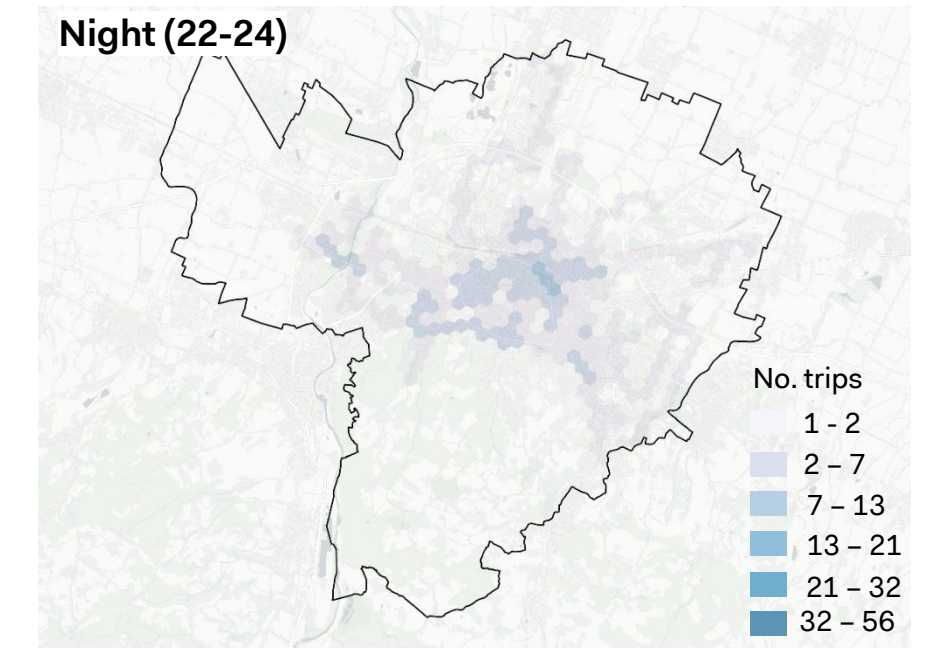
Total number of trips: **499**
Trip average length: **6651 m**
Percentage of covered area: **53%**



Total number of trips: **476**
Trip average length: **5038 m**
Percentage of covered area: **51%**



Total number of trips: **568**
Trip average length: **4092 m**
Percentage of covered area: **53%**

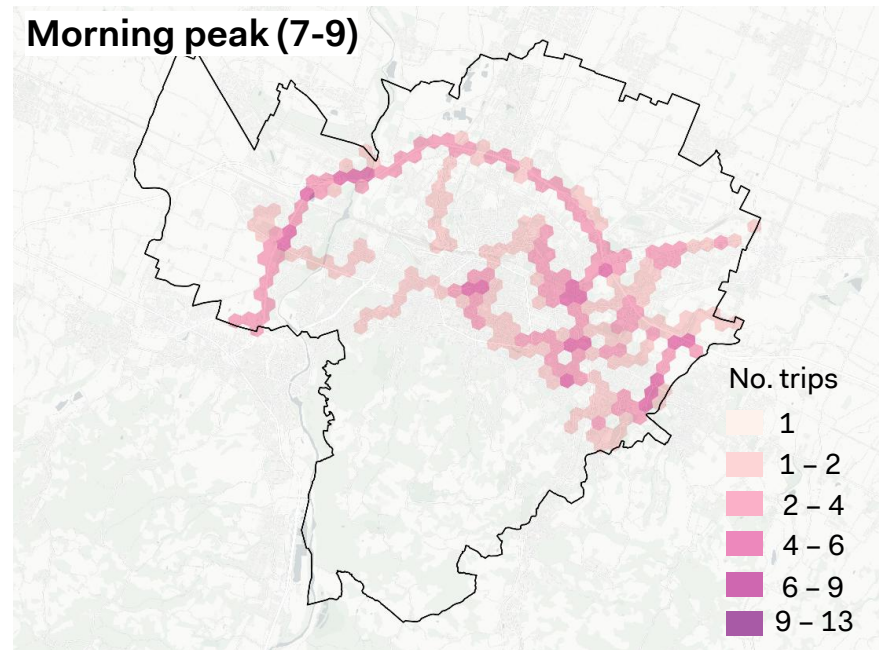


Total number of trips: **42**
Trip average length: **4604 m**
Percentage of covered area: **22%**

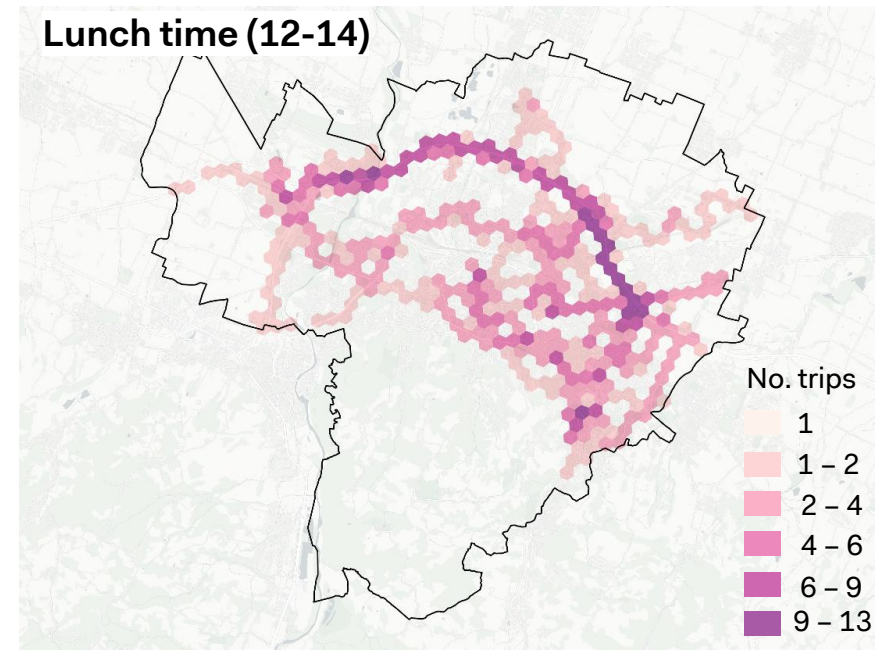
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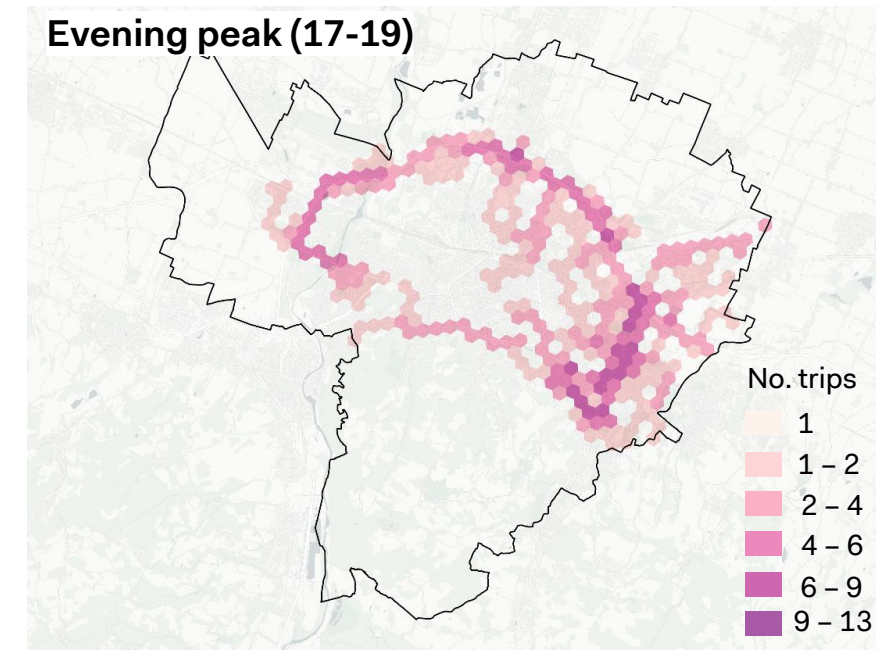
Auto/moto dipendenti – temporal profile



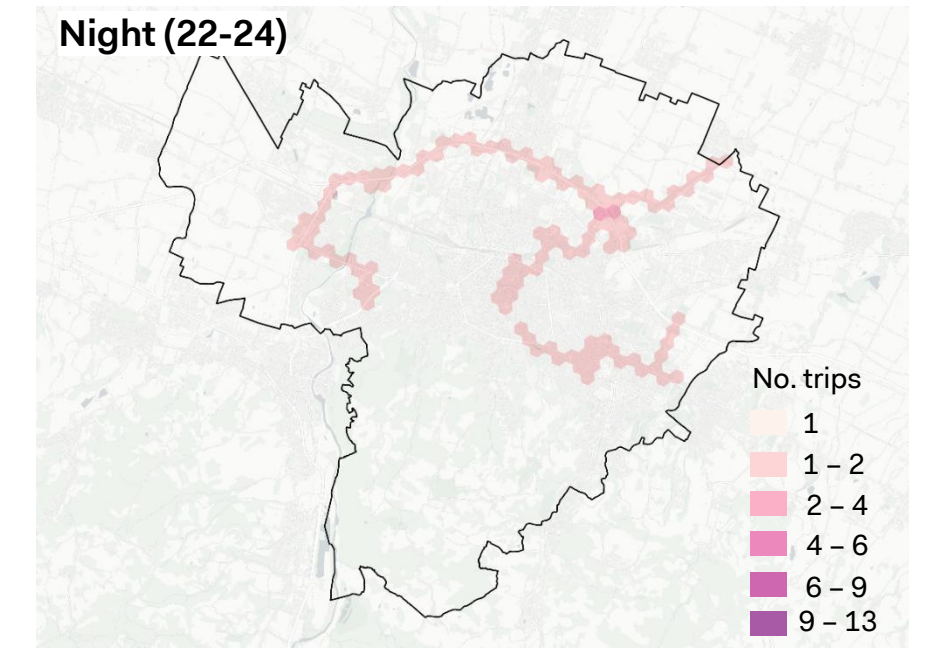
Total number of trips: **24**
Trip average length: **24713 m**
Percentage of covered area: **18%**



Total number of trips: **45**
Trip average length: **12405 m**
Percentage of covered area: **28%**



Total number of trips: **38**
Trip average length: **6179 m**
Percentage of covered area: **22%**

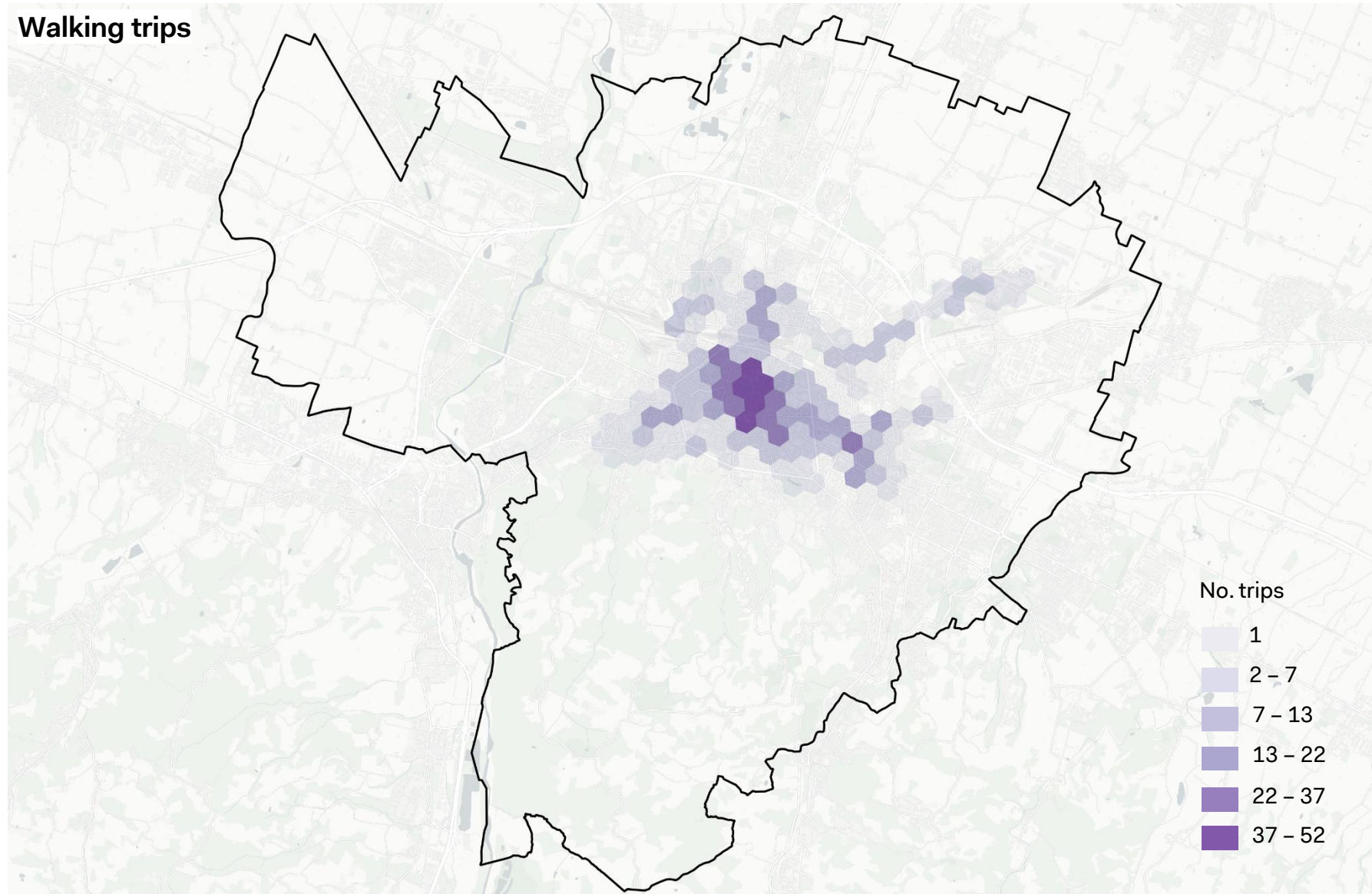


Total number of trips: **3**
Trip average length: **16221 m**
Percentage of covered area: **8%**

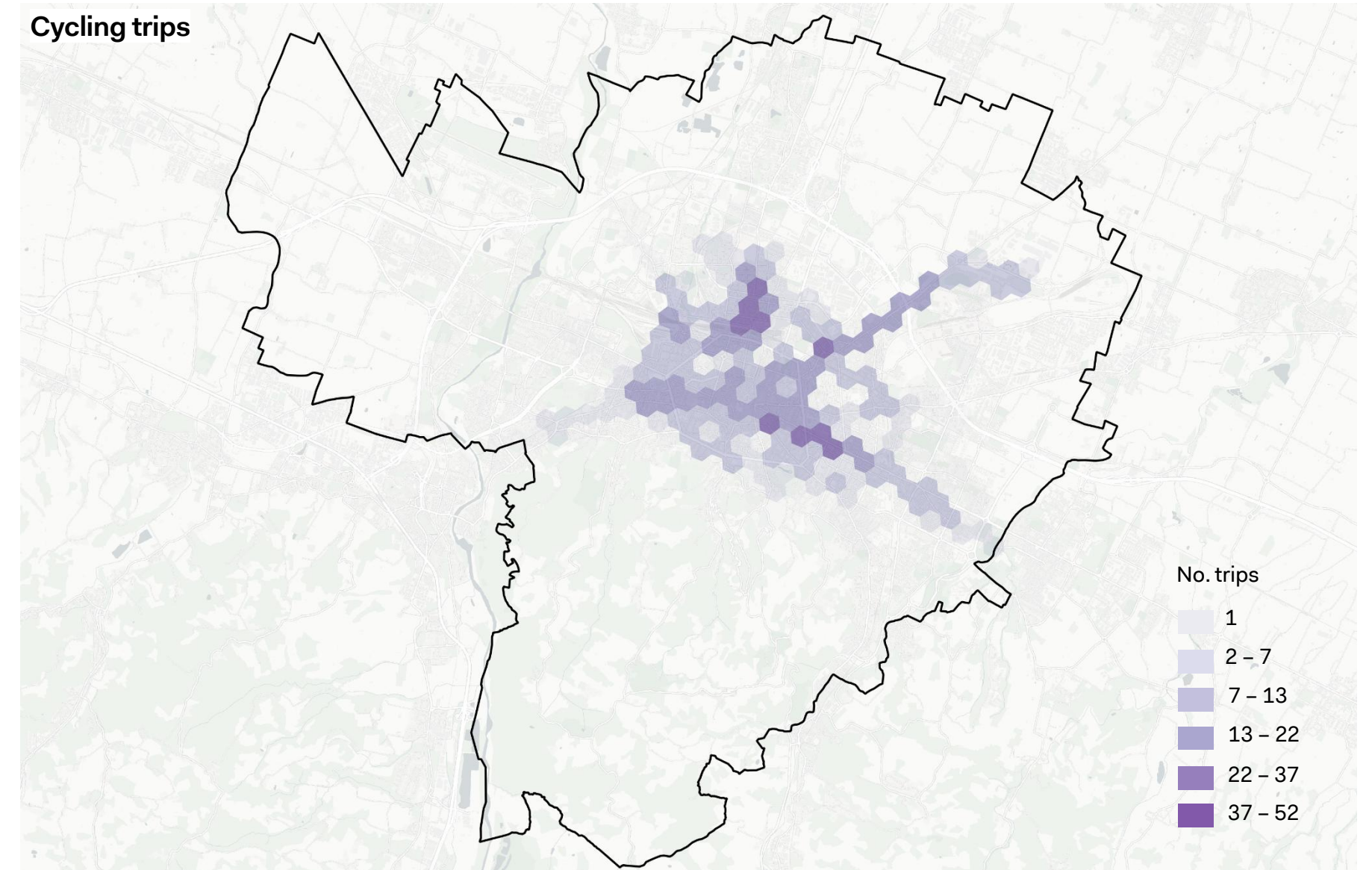
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Annex C.3

Metabolici – modal split



Total number of trips: **285**
Trip average length: **1627 m**
Percentage of covered area: **14%**

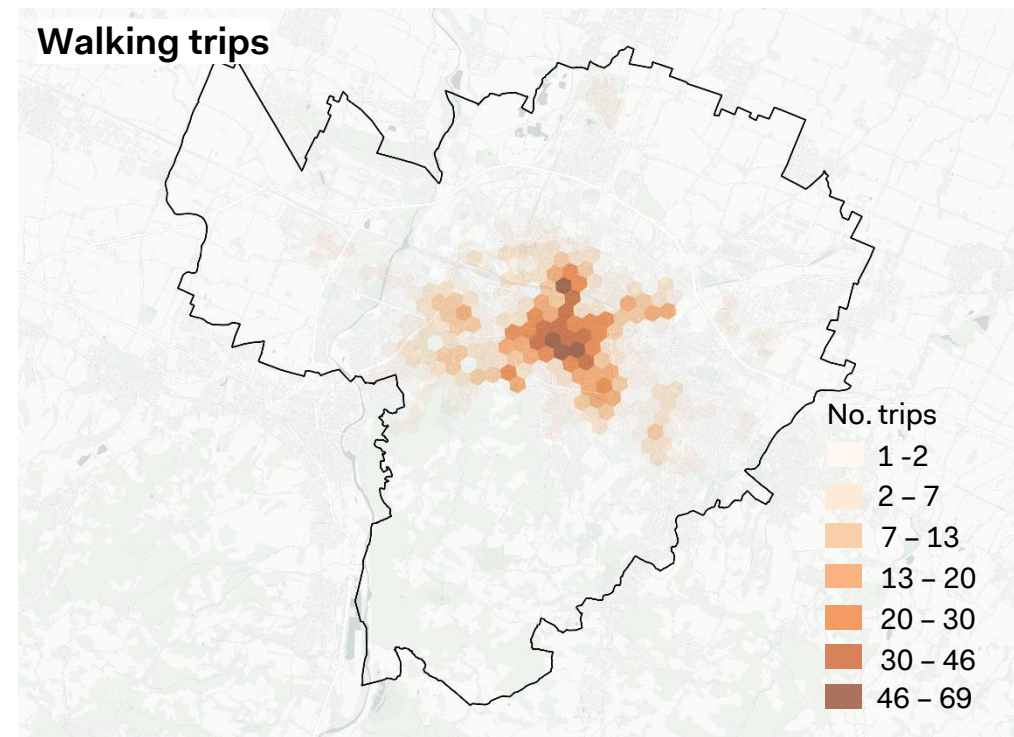


Total number of trips: **141**
Trip average length: **3908 m**
Percentage of covered area: **18%**

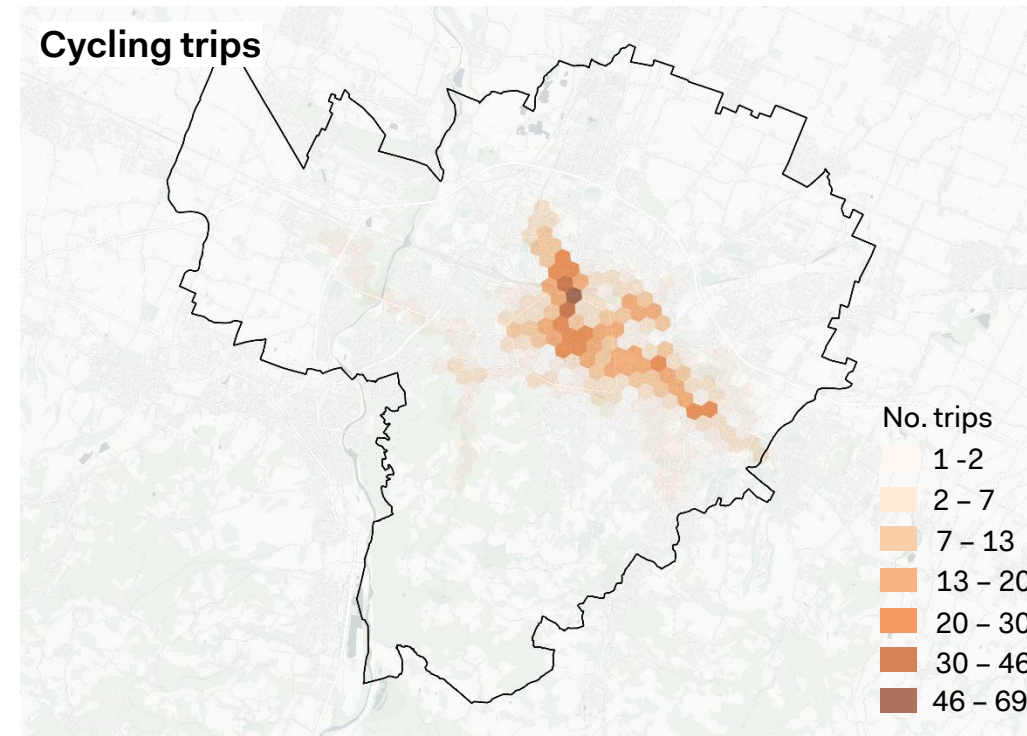
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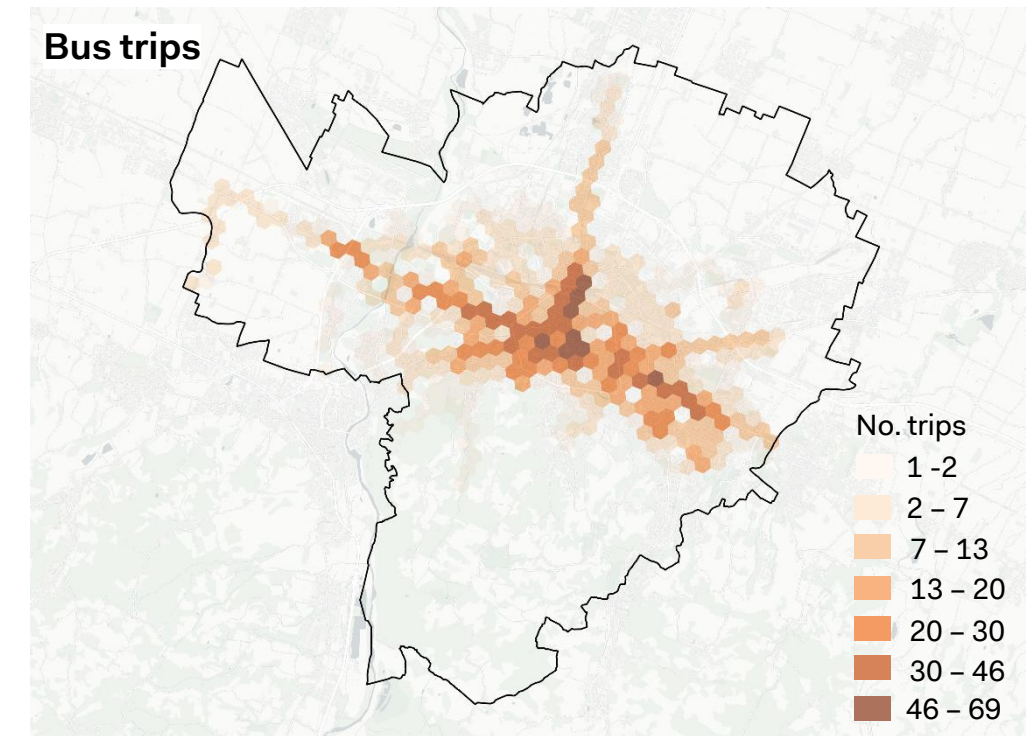
Sostenibili – modal split



Total number of trips: **381**
Trip average length: **1480 m**
Percentage of covered area: **17%**



Total number of trips: **168**
Trip average length: **2253 m**
Percentage of covered area: **14%**

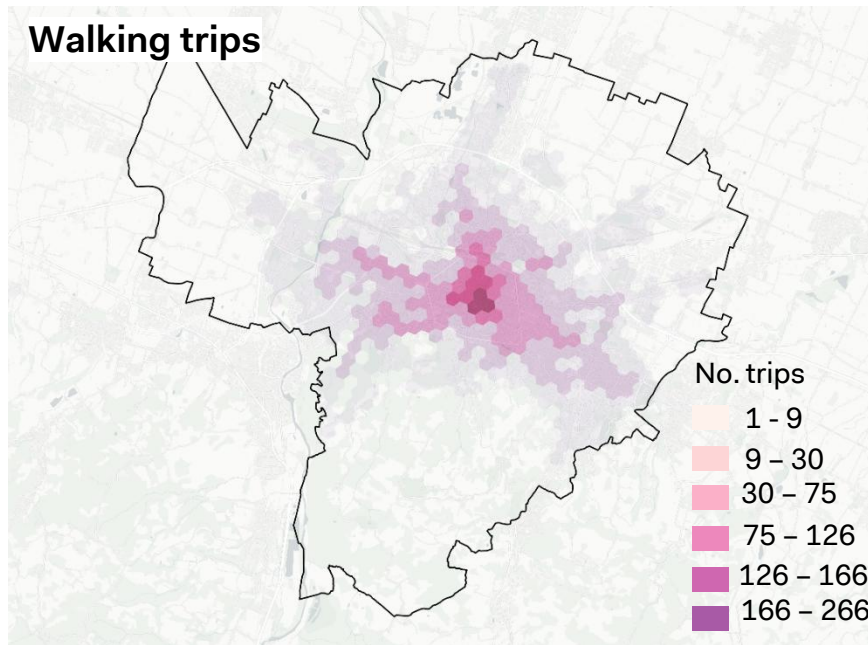


Total number of trips: **286**
Trip average length: **4609 m**
Percentage of covered area: **28%**

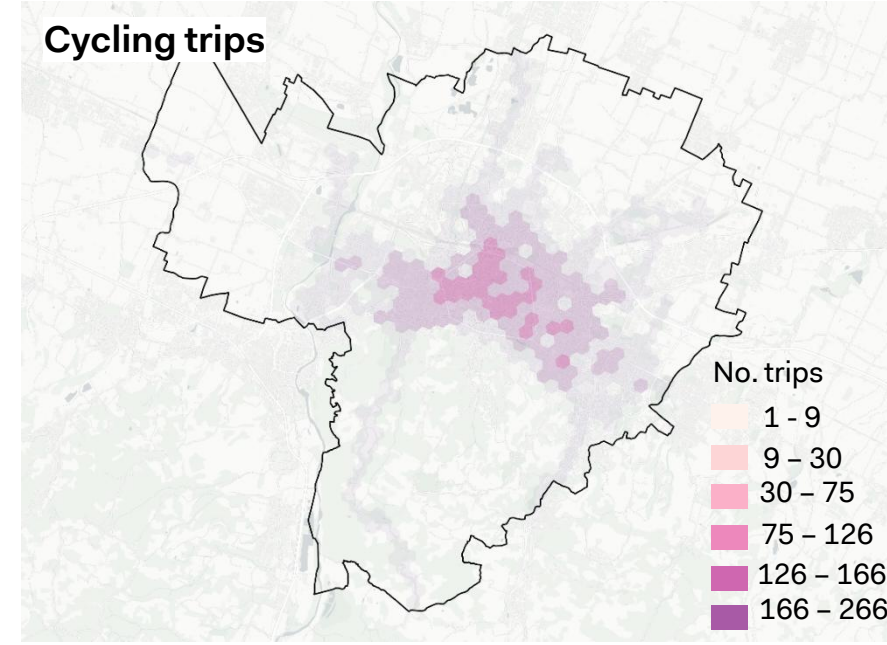
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Annex C.3

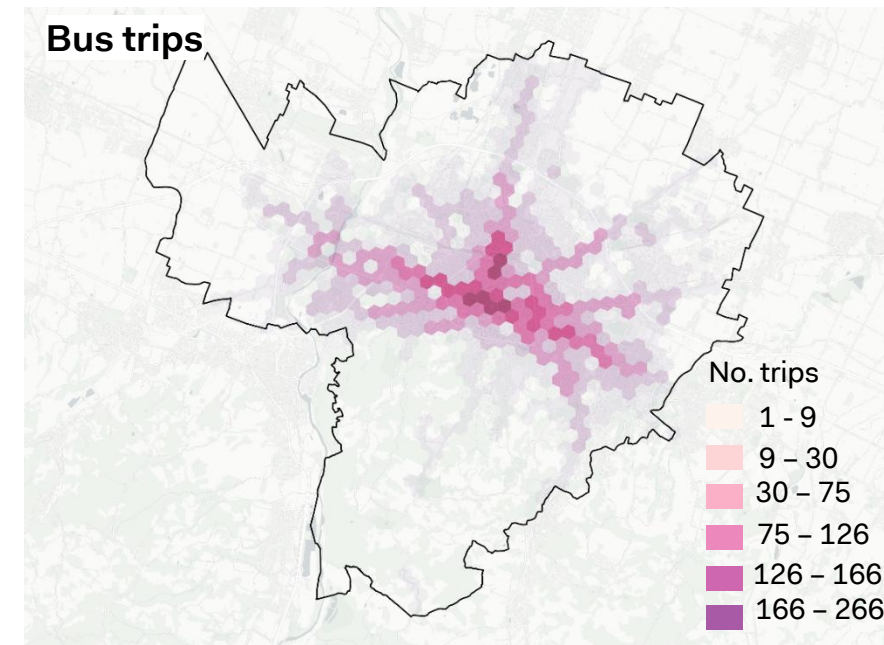
Megamixer – modal split



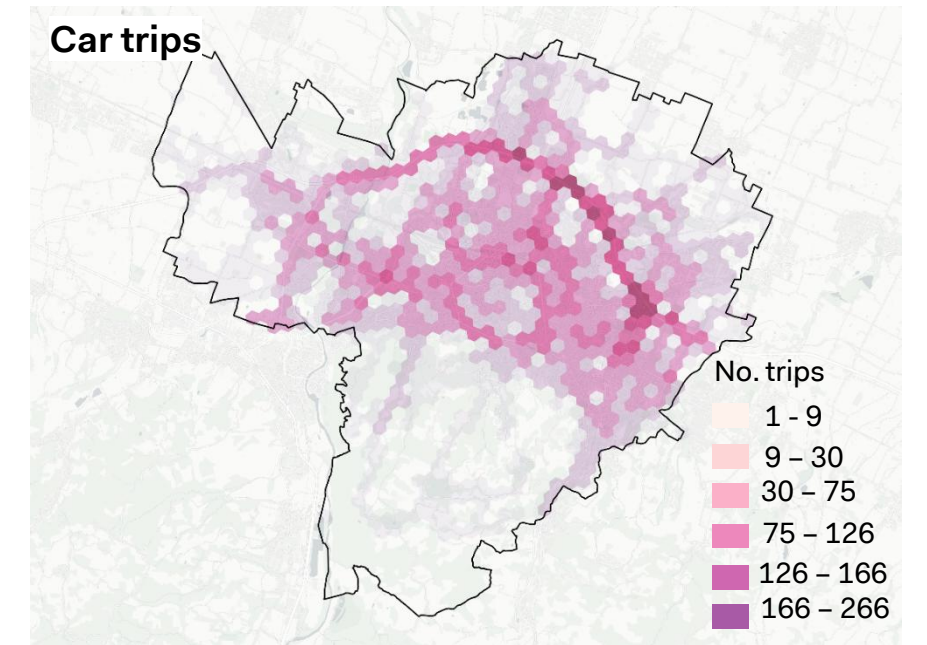
Total number of trips: **24**
Trip average length: **24713 m**
Percentage of covered area: **18%**



Total number of trips: **45**
Trip average length: **12405 m**
Percentage of covered area: **28%**



Total number of trips: **1003**
Trip average length: **4829 m**
Percentage of covered area: **43%**

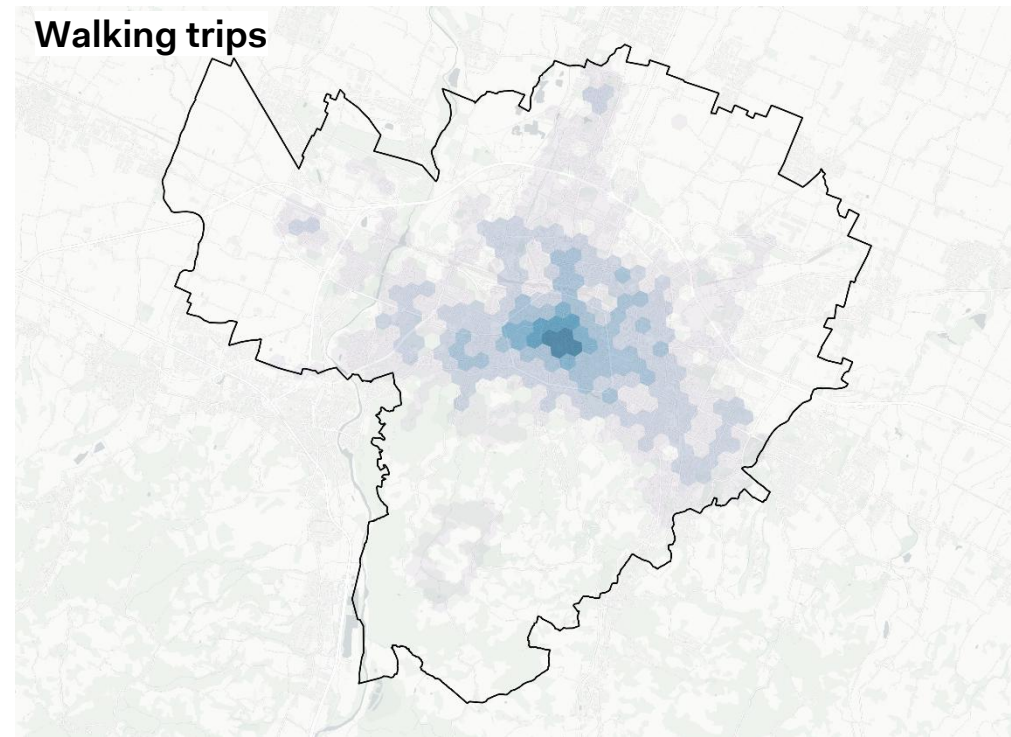


Total number of trips: **1595**
Trip average length: **10215 m**
Percentage of covered area: **68%**

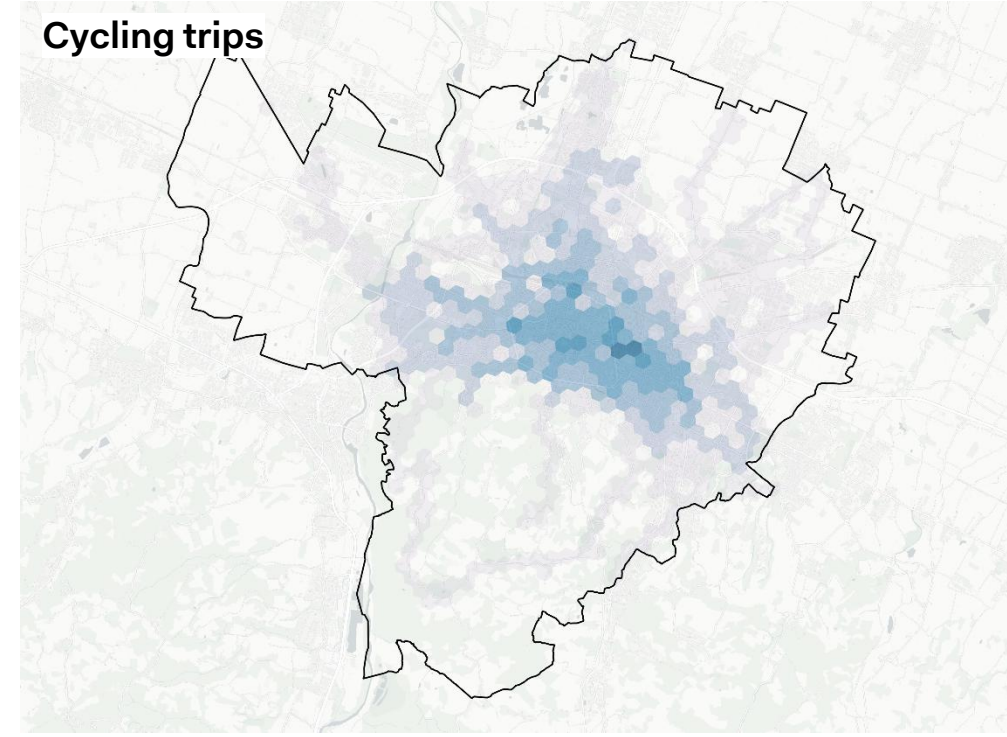
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Annex C.3

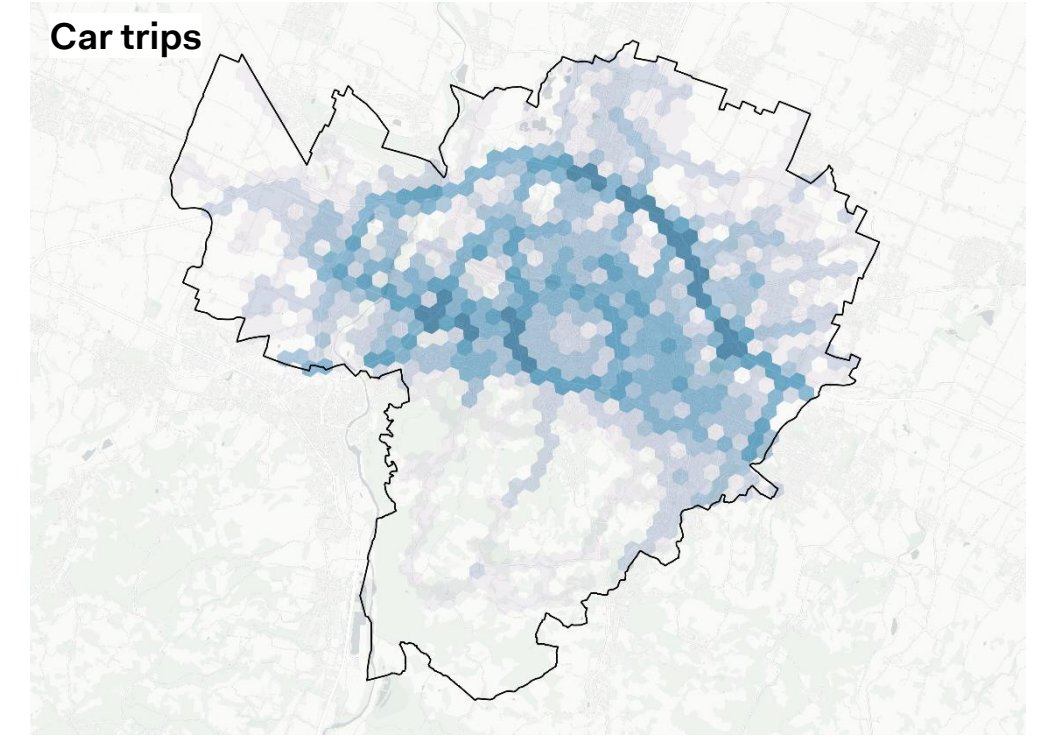
Autonomi – modal split



Total number of trips: **1258**
Trip average length: **1425 m**
Percentage of covered area: **35%**



Total number of trips: **946**
Trip average length: **3147 m**
Percentage of covered area: **43%**

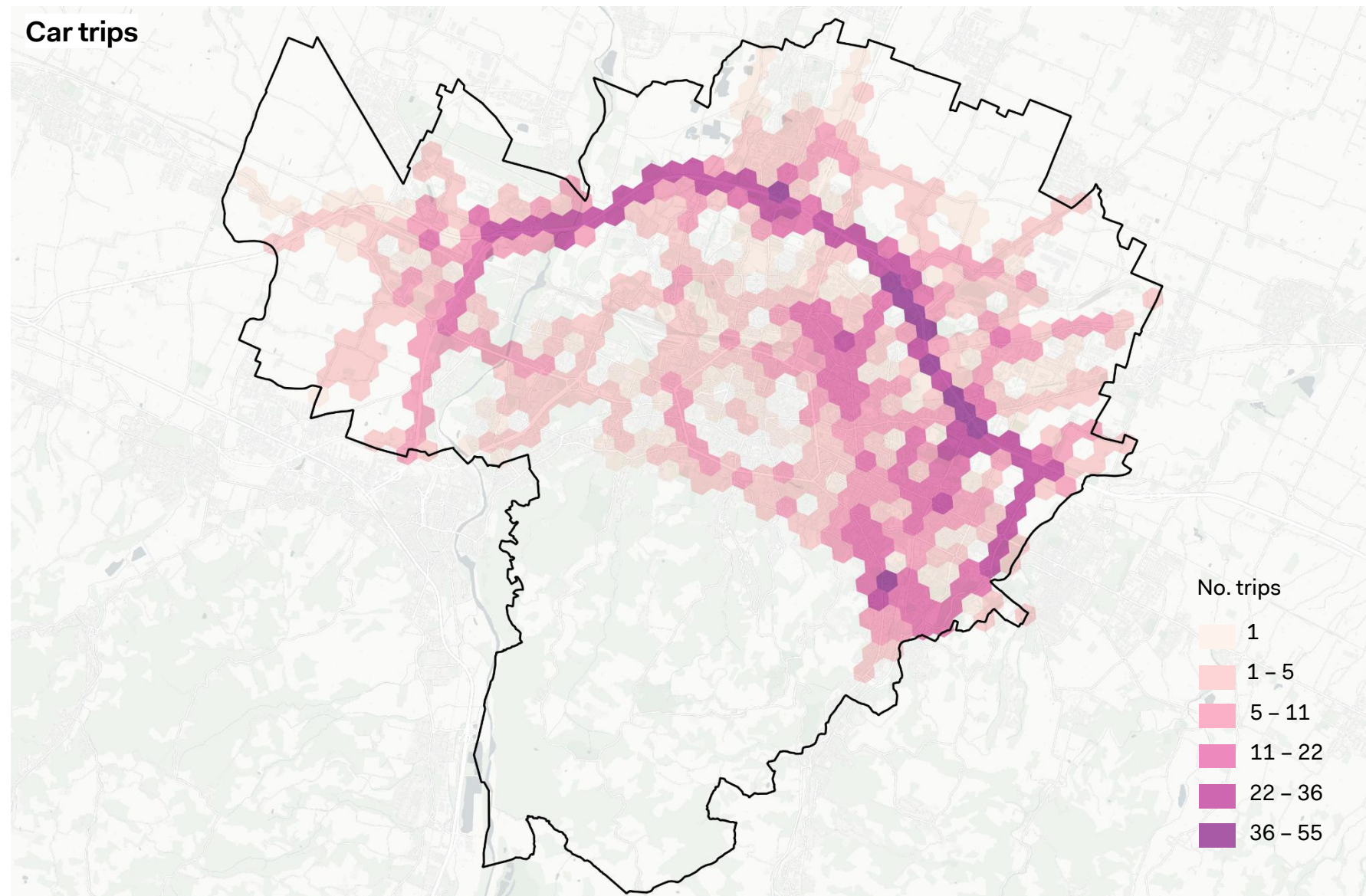


Total number of trips: **1697**
Trip average length: **10353 m**
Percentage of covered area: **67%**

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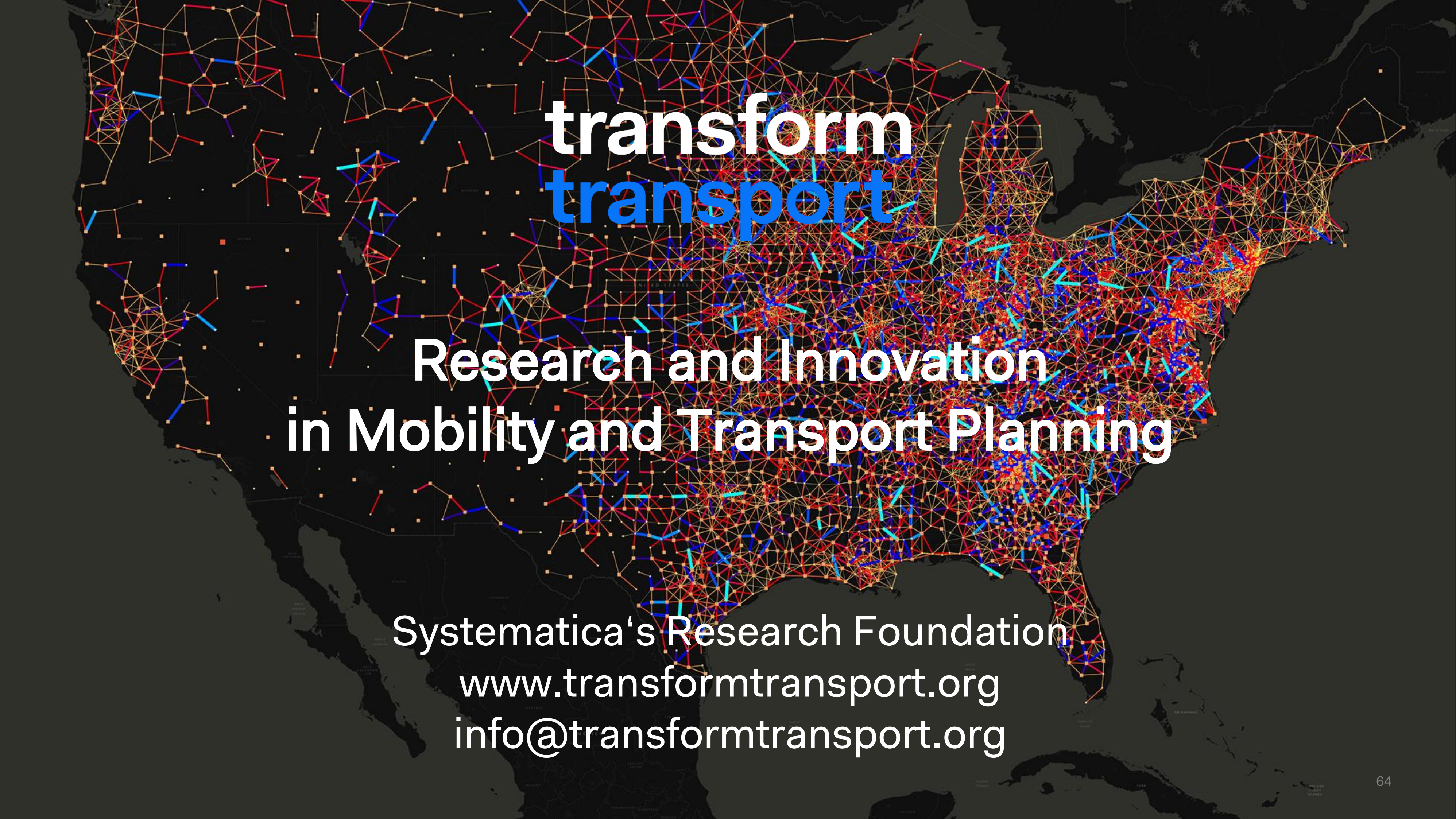
Annex C.3

Auto/ moto dipendenti – modal split



Total movements: **417**
Trip average Length: **14360 m**
Percentage of covered area: **44%**

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Research and Innovation in Mobility and Transport Planning

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