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BOLOGNA LIVING LAB - Analysis of potential demand and definition of areas with low demand at metropolitan level (in terms of geographical, socio-economic, temporal characteristics and relationships between territories), with identification of a methodology and parameters to define the different degrees of demand and possible implementation/indication of tools to replicate this analysis at different times and in the future

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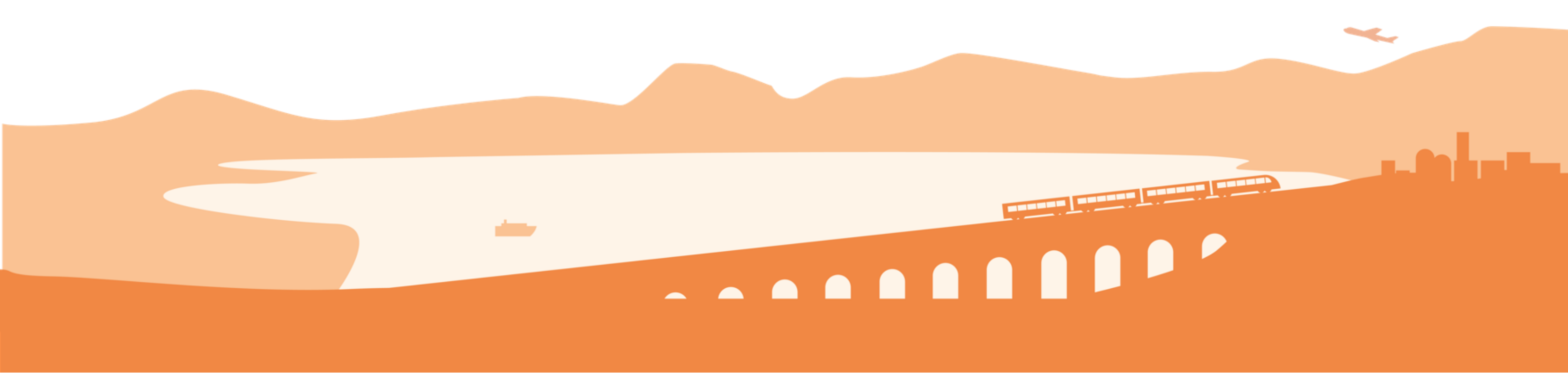

Authors of the document

Partner No.	Partner Acronym	Name of the author	Action	Version
1	SRM and GO-Mobility (subcontracted external expert)	SRM staff: Marco Amadori, Giorgio Fiorillo, Eugenio Margelli GO-Mobility staff: Francesco Ciaffi, Daniele Di Antonio, Daniele Mancuso, Simone Porcacchia	Drafting, refinement and finalization of the document	**Final**

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1. Introduction

Measure 1 of Annex 1 to Resolution No. 48/2023 of the Transport Regulation Authority (ART) represents the technical and methodological basis on which all subsequent functional developments for the structuring of service lots (Measure 6) are based, with particular reference to the definition of the public service area and the related mobility catchment area.

The primary objective of this phase is to define, in a coherent and reasonable manner, the geographical and functional area within which to plan and award local public transport services, while identifying the potential mobility demand to be met. In this perspective, the analysis must go beyond a simple description of observed demand, also including latent, unexpressed needs and the structural and socio-economic characteristics of the territory: morphology, urbanization, demographic profiles, and production system. In the case of the Metropolitan City of Bologna, this application is particularly important due to the ***plurality of territories involved*,** the coexistence of dense urban areas and mountainous or peripheral areas with less intense demand, and the presence of a widespread production system. Correctly defining the public service area therefore means understanding this territorial complexity and orienting the design of the lots according to criteria of efficiency, equity, and contestability.

To meet these needs, the approach adopted in this document sets out a path consistent with the ART guidelines and based on four methodological pillars:

- ***a clear and operational objective***, aimed at building a robust, transparent, and replicable information base capable of supporting the definition of the mobility catchment area and its subsequent division into coherent lots;
- ***the integrated use of heterogeneous data sources***, including:

  - an ad hoc survey on resident mobility conducted to support the updating of the metropolitan SUMP;
  - socio-demographic and employment data (ISTAT and metropolitan atlas);
  - Big Data from mobile radio networks,
  - Floating Car Data (FCD);

- ***a structured data fusion process***, which enhances the specific potential of each source and allows for the reconstruction of the overall mobility dynamics in the territory in a complementary and consistent manner;
- ***a set of clear operational steps*** that progressively guide the definition of service levels in areas with low demand through the construction of analytical zoning and a territorial socioeconomic model and the subsequent combined estimation of trips from various sources.

In light of the above, the approach proposed in the document fully incorporates the ART guidelines, setting out a process that helps to define the Area and the Basin on the basis of objective information sources, primarily through the reconstruction of the main characteristics of potential demand (Measure 1) in order to provide a complete representation of mobility demand in the Bologna basin.

Secondly, this document also forms the basis for the construction of criteria for identifying service lots (Measure 6) through the proposal of a methodology capable of identifying areas characterized by low demand (Measure 2), starting from the intensity of daily trips measured and the related service levels to be guaranteed (Measure 3) with a view to integrated planning consistent with the objectives of the regulatory intervention.

2. Data sources used

The analysis of mobility demand in the metropolitan area of Bologna presented in this document is based on a ***holistic and integrated approach***, which adopts a *data fusion* logic to combine different information sources in a coherent and complementary manner.

The aim is to provide as accurate, detailed, and representative a picture as possible of mobility behavior at the metropolitan level, leveraging the specific strengths of each source while mitigating the shortcomings that each individual dataset may have when used on its own.

The integration process has made it possible to **accurately map the mobility of residents and city users**, **track journeys that** cannot be detected using traditional methods, and associate each journey chain with **comprehensive information on the reason for travel and mode of transport** for different categories of users, thus providing a detailed and innovative insight into mobility demand in the area.

To this end, the following main information sets were used:

- ***Ad hoc mobility survey*** carried out in 2016 and repeated in 2023, designed to provide useful data for updating the metropolitan SUMP, which made it possible to obtain accurate information on the origin, destination, motivation, and mode of transport of residents' journeys, differentiated by macro-area of residence and type category (combination of gender, age, occupation);
- ***Socio-demographic data (ISTAT and metropolitan atlas)***, essential for characterizing the reference populations in terms of density, territorial distribution, and employment levels, in order to correlate mobility behaviors with settlement contexts;
- ***Big Data derived from the mobile radio network***, used to quantify and spatialize mobility flows on a metropolitan scale, distinguishing between residents and city users and analyzing the exchange and crossing components of trips;
- ***Floating Car Data***, used to integrate analyses of vehicle components and enrich the information derived from telephone big data.

This integration has generated a **multi-level knowledge base** never before achieved on a metropolitan scale, capable of comprehensively and dynamically representing the evolution of mobility and effectively supporting the assessments required by Measure 1 of ART Resolution No. 48/2017.

In the rest of this chapter, each source is described based on its main functional characteristics (such as updating, sample size, time and space detail, modal information, and availability of trip motivation) with a brief specification of its role in the data integration process and in the construction of the information base used for demand analysis.

2.1. Socio-economic data

ISTAT data are the main structured and official source of socio-demographic information for the metropolitan area of Bologna. As is well known, their strength lies in **their almost total coverage of the population and workforce**, with a level of detail that allows for disaggregated analysis by socio-demographic profiles such as gender and age, as well as detailed spatial distribution down to the census cell level. In addition, thanks to the Metropolitan Statistical Atlas, it is possible to obtain updated data **on the employment rate by municipality,** which is crucial for defining the potential demand for systematic mobility.

From a functional point of view, however, ISTAT data have some limitations: first, census-based updates are not annual but decennial; annual updates are only carried out at the municipal level, so it is not possible to take into account short-term developments at the sub-municipal level (new residential/productive settlements). In the data fusion process, ISTAT data played a role as a statistical and territorial, providing references for the residents and employed population to help calculate emission indices and, consequently, travel for each territorial area.

Strengths	Need for integration with other sources
- ISTAT census data on population and employees allow for detailed characterization of territories at the municipal and sub-municipal level (census cells). - The annual ISTAT census on a municipal basis provides a constantly updated demographic reference - The territorial structure based on census cells allows for maximum spatial granularity, which is useful for aggregating and correlating with other data sources. - The data allow expansion to the universe of all sample data sources used in data fusion	- The most detailed territorial subdivisions (census cells) are only available for the 2011 and 2021 censuses - Uneven availability (e.g., 2011–2021 for census cells) may limit analysis at the micro-territorial level - No spatially disaggregated information is available on employment type (e.g., Ateco codes)

Table1Strengths and critical elements of socio-economic data within the data fusion process (Source: GO-Mobility analysis)

2.2. PUMS survey

The survey conducted in 2023 to update the PUMS for the Bologna Metropolitan Area is a valuable source of data for the analytical representation of mobility demand. Aimed exclusively at **the resident population aged between 14 and 85,** the survey made it possible to identify daily travel chains in terms of origin, destination, main means of transport used and reason, with a level of detail broken down into 24 hourly bands.

Strengths	Need for integration with other sources
- Provides a representative estimate of mobility on an average weekday - Includes time details of trips for each time slot - Allows analysis of users' socio-demographic profiles - Collects information on the reason for the trip (work, study, shopping, etc.) - Provides the mode of transport used (car, bus, train, bicycle, etc.) - Allows for a distinction between trips within the municipality and between different municipalities	- Territorial granularity limited to only 16 macro-zones of the metropolitan area - Refers exclusively to residents of the metropolitan city aged over 14 - Sample data declared via questionnaire, not measured directly on actual behavior

Table2Strengths and weaknesses of the PUMS survey within the data fusion process (Source: GO-Mobility analysis)

The reasons for travel were grouped into five categories: ***work*, *shopping*, *social activities*, *study*, *and other reasons***, thus providing a detailed and qualitative overview of mobility needs.

From a territorial point of view, the segmentation of the survey into **16 aggregate zones** of the Metropolitan City of Bologna allows for refined municipal or supra-municipal analysis. This level of granularity was particularly useful for estimating **self-contained flows at the municipal level**, which are not fully represented in the data from the mobile radio network due to the intrinsic characteristics of the data.

For this reason, the survey played a fundamental role in the **data fusion** process, contributing to **the construction of origin-destination matrices** and **the modal and motivational attribution** of trips, compensating for the typical shortcomings of big data on these qualitative aspects.

2.3. Mobile network data (telephone big data)

Big data from mobile networks is the quantitative core of mobility analysis in metropolitan areas, constituting the most extensive and representative source of observation, thanks to a **sample covering approximately 30% of the population**. This type of data makes it possible to detect not only the movements of residents, but also those of temporary residents (e.g., university students) and city users, i.e., those who gravitate towards the area for work, study, or other services without officially and/or permanently residing there.

Strengths	Need for integration with other sources
- Includes non-residents, domiciled persons, and city users in the mapping, providing a comprehensive representation of mobility - The only source capable of detecting and quantifying movements across the territory - Offers a particularly accurate estimate of inter-municipal and exchange movements - Represents all city users, even outside the main metropolitan centers (airport, stations, trade fair, etc.) - Guarantees extended time coverage over 3 months (May, July, November) and 4 types of days (weekdays, Saturdays, Sundays, events) - It allows specific analyses to be carried out during special events (stadium, concerts) - Territorial subdivision into approximately 200 zones, constructed in line with analytical objectives - Hourly details available - Provides socio-demographic characterization of users (residence, age, citizenship) and travel (type, regularity, cardinality, AV)	- Does not provide information on the reason for and mode of transport - Does not detect movements within the individual zones of the territorial subdivision adopted

Table3Strengths and critical elements of mobile network data within the data fusion process (Source: GO-Mobility analysis)

The added value of mobile radio data lies in its ability to represent all *city users'* movements, not only those observable through access points such as stations, airports, or exhibition centers, but across the entire territory, contributing to a robust and integrated reconstruction of the actual movement chain of this rather significant component of demand in a key area of the country such as the metropolitan city of Bologna.

Another strength of this source is its **high temporal resolution**, which allows **mobility** to **be observed on an hourly and daily basis**, providing a dynamic snapshot of travel behavior and travel patterns. Among other things, this makes it possible to **measure seasonal fluctuations** by continuously monitoring monthly changes in demand and ensuring an up-to-date representation of mobility needs throughout the year (see paragraph §3.3.1).

Compared to other sources, mobile radio data is irreplaceable for observing all extraterritorial exchanges between the metropolitan city and the rest of the country, and for mapping crossings (i.e., flows that affect the metropolitan city without originating or terminating within its territory). Furthermore, thanks to the high degree of representativeness of the sample, it is particularly accurate in providing a detailed view of dynamics at the municipal or sub-municipal level, with a level of spatial aggregation of approximately 200 zones, consistent with the functional logic of mobility. On the other hand, by its very nature, it does not allow for the analysis of mobility within each of the zones defined for data extraction.

In the data fusion process, mobile radio data therefore provided the main basis for quantifying the origin/destination matrices of non-residents, with a degree of granularity and representativeness that is essential for calibrating and integrating other sources with reference to the mobility of residents in the metropolitan city.

2.4. Floating Car Data

Floating Car Data (FCD) is a valuable source for the dynamic analysis of the mobility system, particularly in relation to private car travel, as it consists of anonymized GPS data from connected vehicle fleets (including taxis, commercial vehicles, and shared vehicles), which track the routes actually traveled on the road network and provide granular information on travel times, average speeds, and hourly congestion profiles. shared vehicles), which track the routes actually taken on the road network and provide granular information on travel times, average speeds, and hourly congestion profiles.

Strengths	Need for integration with other sources
- Detects all types of vehicle movements passing through the metropolitan area of Bologna (including interchanges and crossings) - They offer high spatial granularity, down to GPS coordinates, which is useful for road infrastructure analysis - They provide data with minute-by-minute granularity, enabling dynamic analysis in near real time - Enables accurate measurement of average speeds, distances traveled, and travel times, which are key indicators for evaluating network performance - They provide information on the vehicle's area of residence (based on the place of overnight stay), which is useful for statistical expansion to the reference universe	- They cover only car travel, excluding other forms of mobility - They do not provide information about the user, the driver, or any passengers - It is not possible to associate the reasons for the trip with the movements

Table4Strengths and weaknesses of Floating Car Data within the data fusion process (Source: GO-Mobility analysis)

One of the strengths of this source lies in its ability to accurately measure private transport mobility dynamics. This level of detail is otherwise difficult to obtain through surveys based on traditional methods. Thanks to this spatial and temporal granularity, it is possible to calculate key indicators such as average travel times, average speeds along road sections, and hourly, daily, or seasonal variations in network performance. Furthermore, compared to traditional sources, this type of data offers a broader sampling in terms of both quantity and statistical reliability.

In the data fusion process, FCDs were used to enrich and refine the interpretation of data from other sources, especially with regard to metrics of mutual exchange between adjacent areas, which is crucial for maximizing potential and compensating for the inherent shortcomings of telephone data in the case of continuous residential settlements or areas with poor coverage.

2.5. Data fusion process

As mentioned above, in order to ensure that the analysis was as robust, consistent, and representative as possible of mobility demand in the metropolitan city of Bologna, a *data fusion* approach was adopted based on the structured and methodological integration of the aforementioned data sources. This process made it possible to **combine the strengths of the different information bases, while compensating for the inherent limitations of** each and creating a common knowledge base.

The aim was to harmonize the spatial, temporal, and conceptual dimensions of the different sources, ensuring a cross-sectional and layered reading of mobility phenomena, capable of representing the main components of urban and metropolitan mobility: internal, exchange, and crossing trips. This section summarizes the main activities that make up this process.

Phase 1: definition of the territorial basis for analysis

The first phase of the data fusion process involved defining a coherent and sufficiently granular territorial basis to support integration between heterogeneous sources. The construction of an ad hoc zoning system ensured the **spatial standardization necessary to make data from different sources, with different structures and resolutions, comparable**.

1. ***Construction of an ad hoc zoning system with over 1,000 territorial zones within the metropolitan city***

The first step in the integration process was to define a coherent, detailed, and homogeneous territorial zoning, necessary to ensure spatial compatibility between the different data sources. To this end, the territory of the metropolitan city of Bologna was divided into 1,050 zones, constituting the basic unit for subsequent analyses.

2. ***Aggregation and standardization of socioeconomic data on a zonal basis***

The relevant socioeconomic indicators were calculated for each of the identified zones, based on data provided by ISTAT (population census) and the Metropolitan Atlas. This work required the harmonization of sources with different resolutions and structures.

3. ***Recomposition by cross-sociodemographic profiles***

For each area, the resident population was broken down by age group, gender, and employment status, so as to allow for a detailed and multifactorial reading of mobility behaviors. This level of detail proved particularly useful for comparing user characteristics with the data observed on trips and for subsequent sample expansion and user segmentation exercises.

Phase 2: calculation of trips from different data sources

The second phase of the data fusion process is dedicated to reconstructing trips from different sources and is divided into two parallel macro-activities, each focusing on a different subset of the population and a different analytical perspective. On the one hand, trips leaving home and returning home are estimated for residents only, integrating PUMS (sample) survey data with socio-demographic data. On the other hand, the overall movements of all users, residents and non-residents, are calculated from telephone big data, integrated and refined thanks to the contribution of FCD data.

This dual approach allows us to make the most of the wealth of information available, balancing behavioral detail and sample size.

Calculation of trips leaving home and returning home for residents only

1. ***Calculation of movements based on the PUMS survey and socio-demographic data:***

The survey carried out in 2023, targeting residents of the metropolitan city, is used to estimate the average number of inter-municipal and intra-municipal trips made by each user category, broken down by gender, age group, employment status, and origin/destination relationships in the 16 survey areas.

2. ***Normalization with respect to the actual population of each zone:***

The mobility indicators derived from the survey are compared to the resident population at the time of the survey to obtain '*mobility* rates' that can also be used in time projections.

3. ***Disaggregation by mode and reason for travel:***

Once the total volume of trips for each 'key' user profile combination has been defined, the trips are further broken down by reason (work, study, shopping, etc.) and main mode of transport, based on the distributions observed in the survey.

4. ***Estimation of trips with detailed zoning:***

The mobility rates are finally applied to the updated resident population, reconstructed for each of the 1,050 analysis zones. The result is a travel matrix that combines high spatial granularity and socio-demographic detail.

It is important to note that the matrix obtained has asymmetrical zoning, with greater spatial detail on the origin (1,050 zones) for departures from home and on the destination for returns.

Calculation of total movements from telephone big data and FCD

1. ***Extraction of movements measured by the mobile network for all user profiles:***

Telephone data is used to quantify the total number of daily movements across the entire metropolitan area, distinguishing between residents, city users, and non-residents, and classifying users according to age, origin, and mobility components (internal, exchange, crossing).

2. ***Verification and enrichment of data using Floating Car Data:***

FCD data is used to correct any distortions, such as "bounces" due to accuracy and coverage limitations of data from the mobile network. This eliminates false trips that do not correspond to actual routes, improving the quality and consistency of the information flow, particularly on short inter-municipal routes and in high-density urban areas.

Phase 3: production of two integrated outputs for different analysis purposes

The third phase involved the construction of the outputs resulting from the integration process between the sources, obtained for different analytical purposes, differentiating the level of territorial and informational detail and thus allowing a two-pronged approach: one broader and more systemic, the other focused on areas with less intense demand.

Creation of a database for comprehensive mobility analysis

This first output aims to provide an overview of mobility behaviors affecting the metropolitan city of Bologna and is designed to support general assessments of the structure and intensity of mobility demand, regardless of user residence:

- ***Broad spectrum of population covered***: the database includes trips made by all types of users, residents and non-residents, including city users and through traffic, as detected by the mobile radio network;

- ***Zoning consistent with telephone data***: the information is aggregated into approximately 200 areas, consistent with the zoning used for extracting data from the mobile network;
- ***Focus on volumes***: the dataset does not contain details on the reason for or mode of transport, but focuses on quantities, distribution, and the socio-demographic profiles of users.

Creation of a database for specific analyses of areas with low demand

The second output was designed to enable targeted analysis of areas characterized by more discontinuous or dispersed mobility demand, such as peripheral areas, and was created to support the definition of the level of public transport service in these areas, providing a more granular reading of residents' mobility behavior:

- ***Disaggregated information on origin and return***: the database focuses on the home-based movements of residents only, with the possibility of clearly distinguishing between departures and returns for each socio-demographic profile;
- ***Highly detailed zoning for a detailed understanding of the territory***: the territorial basis consists of the 1,050 socioeconomic zones defined in the first phase, making it possible to achieve a high level of spatial granularity;
- ***Details on modes of transport and reasons for*** travel: the dataset includes information on the reason for travel (work, study, shopping, etc.) and the mode used (car, public transport, bicycle, etc.), which is essential for assessing service needs and the effectiveness of the existing offer.

The overall result is an integrated knowledge system that, in a way that is unprecedented on a metropolitan scale, allows for a coherent and flexible reading of the different components of mobility demand: from the most systematic to the occasional, from local to cross-city trips, from the dynamics of residents to those of city users.

2.5.1. Estimation of the intra-zone travel component

A crucial step that cut across the entire methodological process was the ***estimation of the intra-zone component of mobility***, i.e., the part of travel that takes place within the same zone. As these are internal movements that cannot be directly detected from telephone data, this component would risk remaining "invisible" if not adequately estimated, compromising the robustness and representativeness of the final analyses. To fill this gap and ensure a complete and reliable picture of mobility, a specific methodological process was developed, structured in several stages:

- firstly, a transcoding matrix was constructed between the two main zoning systems adopted: telephone zoning (approximately 200 zones), used to extract data from the mobile network, and more granular zoning (1,050 zones), used for socio-economic analyses related to the territory and potential demand. This operation made information from different sources compatible with each other.
- subsequently, based on PUMS mobility survey data, a gravitational model was calibrated to estimate the share of *self-contained* trips for each municipality, distinguishing appropriately between trips within Bologna and those within other municipalities in the metropolitan area, to take into account the different dynamics;
- the model was then applied to the zoning of 1,050 zones to reconstruct internal origin/destination relationships with the highest possible level of detail;
- Finally, the percentage share of intra-zone trips for each zone of the telephone zoning was estimated, maintaining the average proportion of trips starting and ending in the same area relative to the total generated and attracted by each zone.

3. Analysis of actual, potential, and low demand

The analysis of mobility demand is a key step in defining the public service area and the mobility catchment area, in accordance with Measure 1 of Resolution No. 48/2023 of the Transport Regulation Authority (ART). This analysis provides the technical and methodological basis for the subsequent identification of the services to be included in the service contract, the identification of areas with low demand (Measure 2) and, finally, the structuring of the lots to be awarded on an exclusive basis (Measure 6).

This chapter aims to reconstruct, in an integrated and coherent manner, the potential demand for mobility, i.e., the set of citizens' travel needs that can be identified through a process of data fusion between statistical sources, mobility surveys, mobile network data, and socio-demographic indicators (see chapter §2). Through an integrated reading of these, the chapter aims to provide a complete and up-to-date picture of mobility demand in the metropolitan area of Bologna, which is useful for planning an efficient, accessible, and sustainable public transport system.

3.1. Territorial framework and reference zoning system

The metropolitan city of Bologna covers an area of approximately 3,700 km² and has an extremely diverse territorial morphology, which **significantly influences population distribution, settlement dynamics, and mobility needs**.

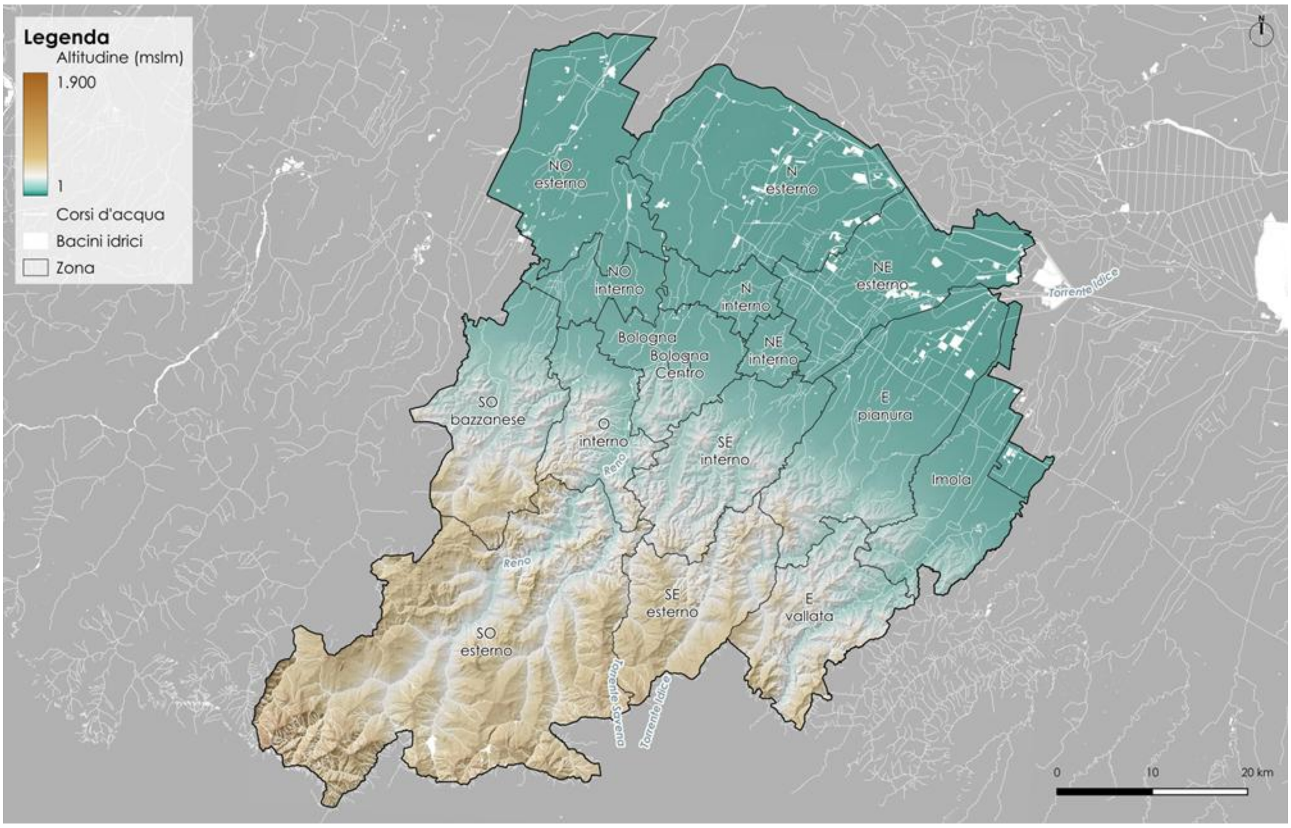

Figure 1 Location of the main urban centers at the provincial level (Source: GO-Mobility analysis based on TINITALY 1.1 data)

The territory is divided along an altitudinal and functional gradient that stretches from the Po Valley in the north to the Tuscan-Emilian Apennines in the south, passing through a central hilly belt that forms an environmental and settlement hinge (Figure 1). From an orographic point of view, three large areas can be distinguished:

- ***the plain***, which occupies about 40% of the territory, historically linked to agriculture and now also home to important production centers. The main towns include Imola, San Lazzaro di Savena, Castel San Pietro Terme, and San Giovanni in Persiceto;
- ***the hilly area***, located south of the Via Emilia, includes municipalities such as Casalecchio di Reno, Sasso Marconi, and Valsamoggia, which are examples of mixed territories with widespread residential areas and strong ties to the provincial capital;
- ***The Bolognese Apennines***, covering about 35% of the area, are characterized by peaks over 1,000 meters and low population density; the main municipalities, such as Porretta Terme, Vergato, and Loiano, are distributed along the main valleys (Reno, Setta, Santerno).

The settlement system reflects this territorial structure and can be divided into several main categories:

- the metropolitan urban center of Bologna, the economic, demographic, and infrastructural hub;
- the centers along the Via Emilia, with linear development and continuous settlement;
- the small hill towns, distributed along ridges and mountain ranges;
- the mountain settlements in the valley bottoms, which are more isolated and less densely populated.

Bologna, with its approximately 400,000 inhabitants, is therefore the hub of the basin's socio-economic relations and generates an urban polarization effect along the east-west axis of the Via Emilia. This urban and territorial structure defines **a complex polycentric system, with strong functional interdependencies and different mobility needs between the various areas,** thus constituting a complex operational context for the planning and regulation of local public services.

3.2. Socio-economic characterization

The socio-economic characterization of the metropolitan area of Bologna is a **key factor in understanding the potential demand for mobility**, in line with the provisions of Measure 1 of Resolution 48/2023 ART, since the demographic and productive structure of the territory influences both the expected volumes of travel and the related modes and reasons for travel.

This section analyzes two fundamental components: the resident population and the economic structure, with the aim of providing a concise but robust overview of the socio-economic conditions that influence daily and systematic mobility needs in the territory, to support planning decisions and the identification of areas with low demand.

3.2.1. Population and demographic structure

Over the last thirty years, the resident population in the metropolitan city of Bologna has seen **steady growth** (+11.5%), in line with the regional trend in Emilia-Romagna. This growth has been largely fueled by positive net migration—both internal and international—which, at least until 2011, offset the gradual decline in the natural population balance. However, this demographic development has taken on different characteristics across the territory, profoundly influencing the distribution of the population and, consequently, the demand for mobility.

In particular, the **municipality of Bologna** experienced a significant decline in population in the 1990s, attributable to **suburbanization phenomena** that encouraged people to move to neighboring municipalities. In the following years, there was a gradual recovery, although without reaching previous levels. The areas of **the inner metropolitan belt,** on the other hand, benefited most **from demographic expansion,** thanks to greater accessibility, more affordable housing, and infrastructure development. In contrast, the **hilly and mountainous areas** have maintained a **more sparse and dispersed settlement structure,** with an often-elderly population distributed in villages in the valley bottoms or on poorly urbanized ridges.

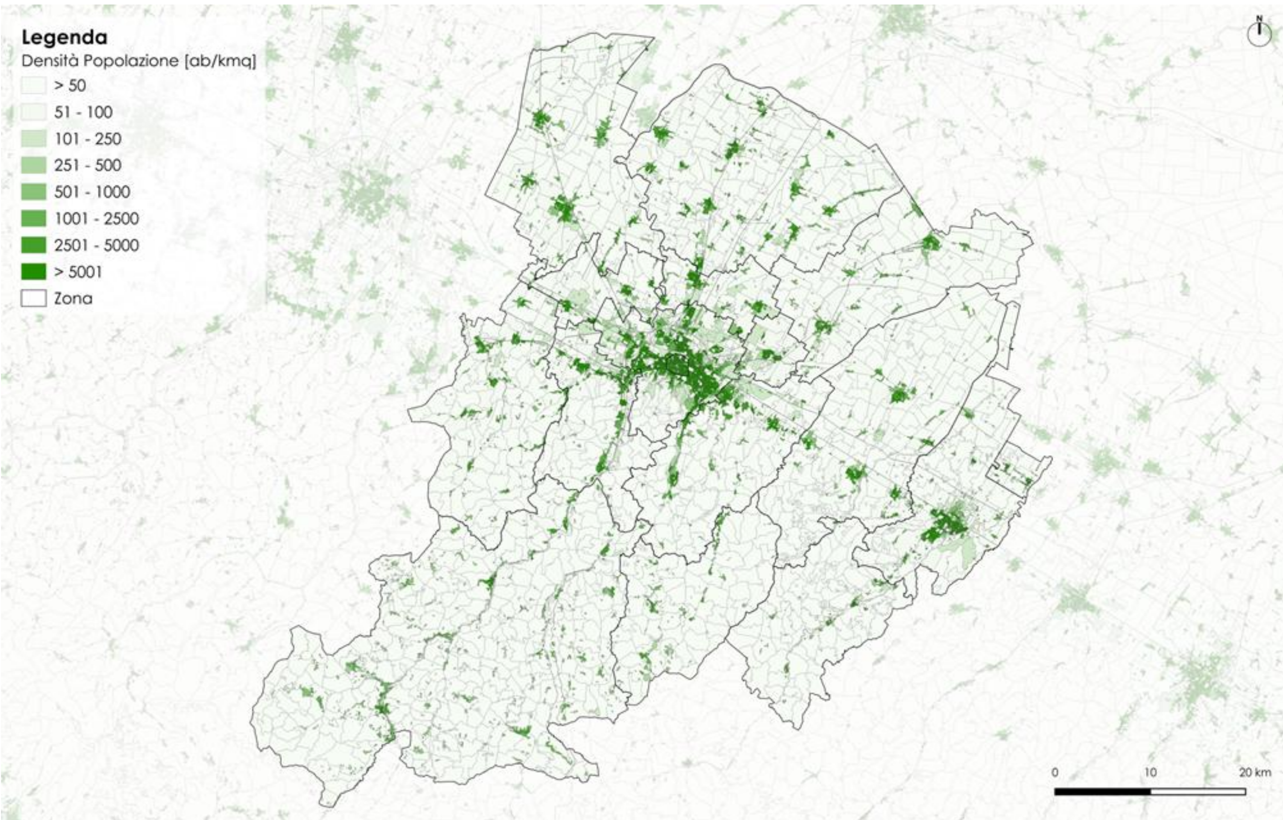

Figure 2 Population density per census cell in the study area in 2021 (Source: GO-Mobility analysis of ISTAT data)

These dynamics are clearly reflected in the population density (Figure 2): while Bologna exceeds 2,750 inhabitants per km² and Imola stands at around 340 inhabitants per km², the Apennine areas show much lower values, often below 300 inhabitants per km². These thresholds identify the so-called "rural *areas*" according to the Eurostat definition, which in the province affect a significant proportion of the population; this **scattered settlement pattern leads to a less concentrated demand for mobility,** with a need for more flexible, accessible, and widespread services, often incompatible with the traditional public transport offer.

It is important to note, however, **that these density values are calculated on a municipal basis** and reflect the entire administrative area, not just urbanized areas. For example, the low average density of Imola is influenced by its large territorial extension and the presence of rural hamlets and does not fully represent the density of the compact urban area, which is significantly higher. The difference between Bologna and Imola, therefore, although real, is accentuated by the calculation method and should be interpreted taking into account these morphological and administrative specificities.

Demographic trends in the decade 2011–2021 confirm the vitality of intermediate areas (+10 on average), while the Apennine areas have experienced a further slight contraction. The rest of the territory shows more modest but still positive growth rates, contributing to overall relative stability. Specifically, expanding areas require a strengthening of systematic transport services, while areas in decline pose challenges in terms of service sustainability and universal accessibility.

Another important factor is the **transformation of family structure**: throughout the province, there has been an increase in the number of families, even where the population is stable or slightly declining. This phenomenon is linked to the reduction in average family size, with smaller households and a growing number of people living alone, particularly in central areas such as the historic center of Bologna. Finally, in terms **of age structure,** there is a general aging of the population, with a higher average age in hilly and mountainous areas (over 47 years). In these areas, old-age and dependency ratios are high, indicating a reduction in independent mobility and a growing demand for accessible, often non-systematic, transport by users with reduced mobility. At the same time, the capital is experiencing slighter rejuvenation and a reduction in dependency indices, which is reflected in more structured and regular mobility patterns at the urban level.

3.2.2. Employees and economic structure

The evolution of the economic structure of the metropolitan city of Bologna is also reflected in the sectoral composition of the workforce, which over the last two decades has shown different dynamics between **the capital**, **the metropolitan belt**, and **the peripheral areas**. The total number of employees in the region grew steadily between 1991 and 2011, with a more marked expansion in the first decade (+6.3% at the provincial level between 1991 and 2001); however, in the subsequent period 2001–2011, **growth stabilized,** with a slight decline in the number of employees in the province (-0.4%) and a more significant decline in the municipality of Bologna (-6%).

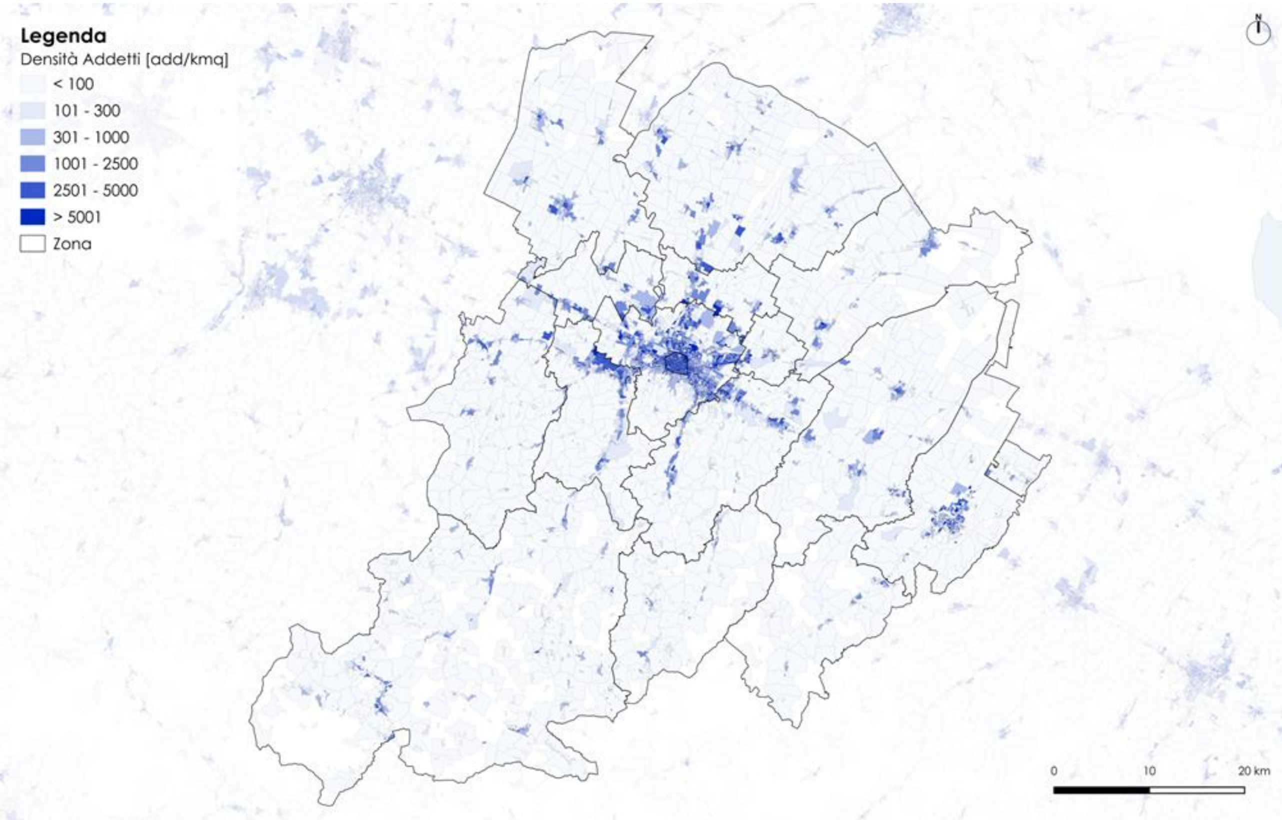

Figure1Density of employees per census cell in the study area in 2011 (Source: GO-Mobility analysis of ISTAT data)

The agricultural sector has suffered the most marked and widespread decline, in line with the structural downsizing that has affected the entire sector at national level. As for the industrial sector, although it has shown a slight decline over time, it still has a significant weight in the flat and suburban areas of the province, especially north of Via Emilia. In these areas—including Calderara di Reno, Anzola dell'Emilia, San Lazzaro di Savena, and Castenaso—industry is developed along the main infrastructure axes (road and rail), benefiting from good accessibility and adequate production space. The **Bologna Interport hub and the industrial area of Zola Predosa** are also important production hubs: the concentration of employees in these areas generates significant demand for systematic and commuter mobility, both for the resident workforce and for flows from neighboring areas.

At the same time, in the capital and particularly in the Bologna city center, there is a **gradual expansion of the tertiary sector**: the commerce, transport, and services sectors are showing significant growth, driven by digitalization, logistical developments, and growing demand for urban services related to mobility, cul-ture, education, and healthcare. This transition has direct and us impacts on the configuration of urban mobility: there is an increasing need for accessible, frequent, and widely distributed public transport to serve both service workers and users generated by these activities.

Finally, intermediate areas have experienced the most dynamic changes, with significant growth in the commerce and services sectors at the expense of agriculture and, to some extent, industry. This heterogeneity requires ***demand-driven*** planning of mobility services capable of responding to evolving economic contexts and the increasing dispersion of workplaces.

Commercial areas (Figure 4) are much more concentrated than industrial areas, located mainly in the urban center of Bologna and in the main neighboring municipalities, often **close to strategic interchange nodes or high-traffic axes**. Although more compact, this distribution generates complex mobility demand, consisting of short but intense journeys spread over a long period of time, typical of mobility linked to services, commerce, and urban use.

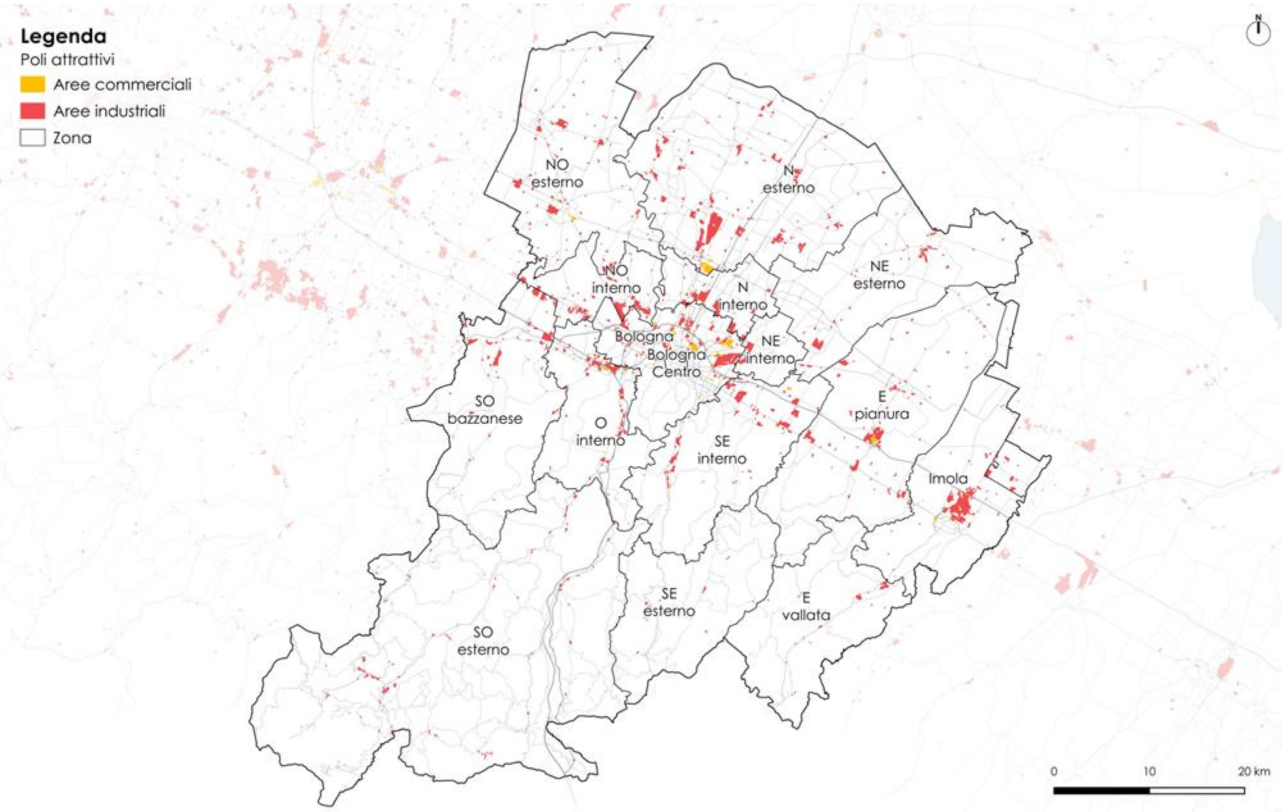

Figure 4 Distribution of commercial and industrial areas at the provincial level (Source: GO-Mobility analysis based on OpenStreetMap data)

Overall, the sectoral distribution of employees confirms a hybrid and functionally differentiated territorial model, in which production hubs, tertiary centers, and rural areas coexist. To respond to this complexity, it is crucial that public transport planning balances the need for efficiency in high-demand corridors with flexible and targeted mobility solutions for peripheral and less well-served areas, thus ensuring accessibility, competitiveness, and social inclusion on a metropolitan scale.

3.2.3. General considerations

The analysis conducted on the population, economic structure, and territorial distribution of the metropolitan city of Bologna highlights ***a highly heterogeneous context, marked by growing polarization between dense and dynamic central areas and peripheral or mountainous areas with less intense demand.***

In urban and suburban areas, particularly along the Via Emilia axis and in the inner suburbs, the combination of high population density, an active workforce, and a tertiary-based economy generates **systematic demand for mobility**, which must be met by high-frequency, widespread services throughout the day. In contrast, hilly and Apennine areas are characterized by low density, high aging indices, and poor infrastructure accessibility, resulting **in low demand in quantitative terms but with a high social impact.** In these areas, the adoption of flexible solutions such as DRT can be essential to ensure equitable access to mobility and territorial inclusion.

The distribution of employees by economic sector also reinforces this interpretation: **the urban center and the most densely-populated areas are characterized by a high concentration in** the **advanced tertiary**, commerce, and services sectors, while the outlying areas maintain a greater presence of industrial or agricultural activities, often associated with **less regular and more fragmented travel needs**. In this context, potential demand cannot be understood solely in terms of absolute volumes, but must be interpreted in relation to spatial distribution, the socio-demographic characteristics of users, and the nature of travel.

The integration of these elements with a *data-driven* approach consistent with the guidelines of the metropolitan PUMS is key to structuring a public service that is both **efficient and accessible**. This approach makes it possible to design a mobility system that is more in line with the specific characteristics of the territories, capable of adapting to actual and potential demand and of recognizing and protecting situations of low demand in a targeted manner, as required by the ART regulatory framework. The analyses carried out are therefore a fundamental building block for the construction of a service based on territorial evidence and on principles of equity and effectiveness.

3.3. Transport demand analysis

As mentioned above, the analysis of mobility demand in the metropolitan area of Bologna is a fundamental step in understanding **actual and potential travel needs** and allows the territorial and socio-demographic dimensions previously analyzed to be integrated with direct observation of travel behavior, in order to provide a dynamic and temporally articulated picture of actual mobility.

The survey was structured by examining three months of the year—May, July, and November—chosen to **represent different seasons** and conditions of use of the transport system. For each month, demand was analyzed in two distinct time contexts: average weekday and public holiday, in order to capture both the regularity of systematic mobility and variations related to leisure, tourism, and other non-recurring behaviors.

The observation focused on a set of functional macro-components of demand, reflecting the main types of spatial relationships in the catchment area:

- ***Movements within Bologna***, indicative of intra-municipal urban mobility in the capital;
- ***Movements within other municipalities***, indicative of intra-municipal urban mobility in the rest of the metropolitan area;
- ***Exchanges between Bologna and other municipalities***, i.e., metropolitan flows to and from the capital;
- ***Inter-municipal movements***, between municipalities in the metropolitan area excluding the capital;
- ***Exchanges with the outside***, i.e., flows to and from the metropolitan city of Bologna;
- ***Crossing movements***, with no origin or destination in the basin but which affect it in transit.

For each of these components, the analysis is divided into various levels, including:

- *Reason for travel*, which breaks down the relative weight of the reasons for travel (work, study, other, etc.);
- *Modal split*, which shows the relative weight of the different modes of transport (public transport, private cars, active mobility, other systems);
- *User profiling*, distinguishing between residents, city users (non-residents who gravitate towards the area) and regular users, with recurring behavior for work or study reasons.

The objective of the analysis is twofold: on the one hand, to reconstruct the geography of travel and usage profiles in the metropolitan area; on the other hand, to identify temporal variations and functional differences useful for defining service levels, calibrating timetables, and assessing weak and/or potentially unserved demand.

3.3.1. Seasonality

Firstly, a comparison between the months of May, July, and November highlights the effects of seasonality on transport demand, highlighting variations in travel volumes, modal split, and user profiles.

November

An analysis of the distribution of **journeys by macro-component** over three typical days (weekday, Saturday, and Sunday) reveals a complex but generally stable demand pattern, with absolute values remaining high even at the weekend (Table 5). The highest volume is recorded on weekdays, with over 3.6 million trips, but Saturdays (3.39 million) and Sundays (2.93 million) also show significant levels, confirming that holiday mobility is a structural component of the system.

Component	Weekdays	Saturday	Sunday
Within Bologna	1,043,711	940,141	749,551
Other municipalities	954,130	854,186	684,572
Rest of CM from/to Bologna	461,499	422,683	327,304
Exchange between other municipalities	478,288	443,860	356,257
Exchange with external parties	486,641	495,188	495,448
Crossing	254,821	234,715	320,847
Total	**3,679,090**	**3,390,773**	**2,933,979**

Table 5 Absolute value of journeys within the metropolitan city of Bologna by macro-component and typical day - November 2024 (Source: GO-Mobility analysis)

Among the individual components (Figure 5), journeys within Bologna are predominant on all typical days, with a peak of over 1 million journeys on weekdays, gradually decreasing over the weekend. travel within other municipalities follows a similar pattern, while travel between the rest of the metropolitan area and Bologna is particularly intense on weekdays (around 461,000), falling by around 30% on Sundays. Travel between other municipalities remains stable but decreases at the weekend, while travel to and from outside the metropolitan area is remarkably consistent across the three days, with almost identical values, suggesting a more structural component of mobility or one linked to interprovincial networks.

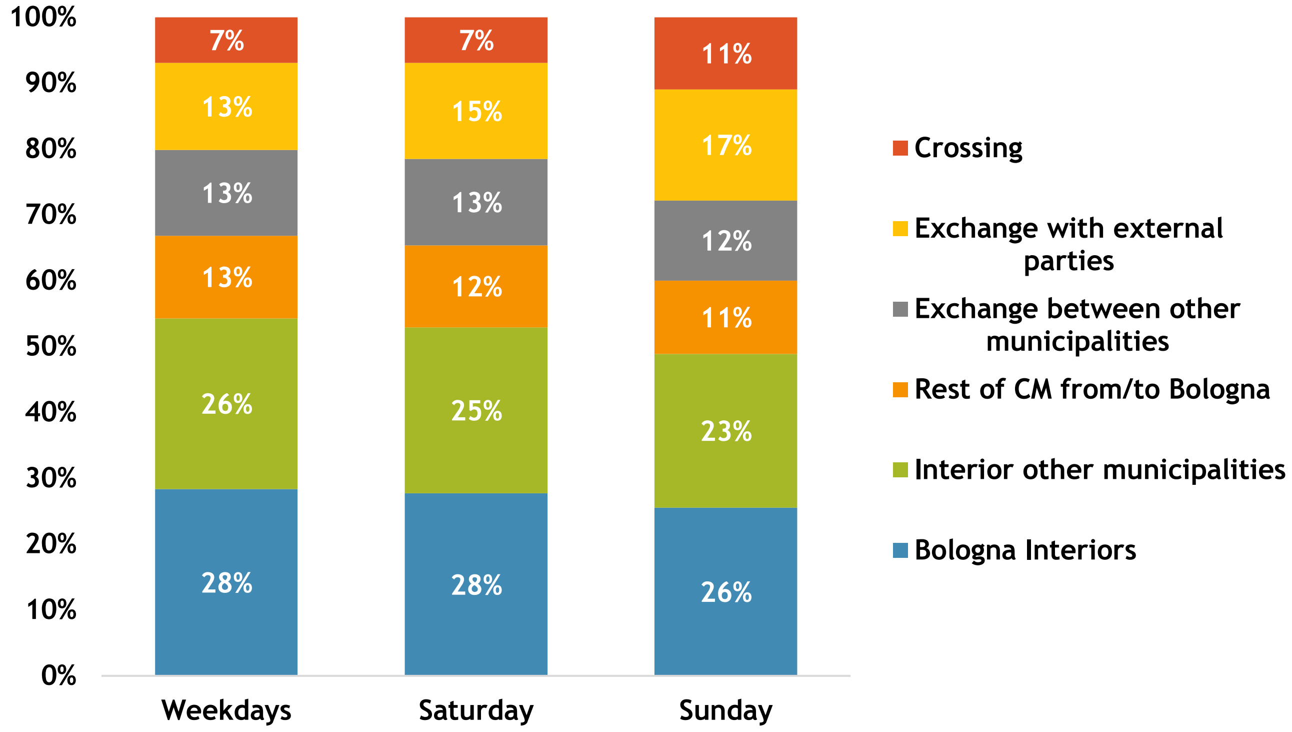

Figure 5 Percentage weight of the various macro-components of travel in the metropolitan city of Bologna per typical day - November 2024 (Source: GO-Mobility analysis)

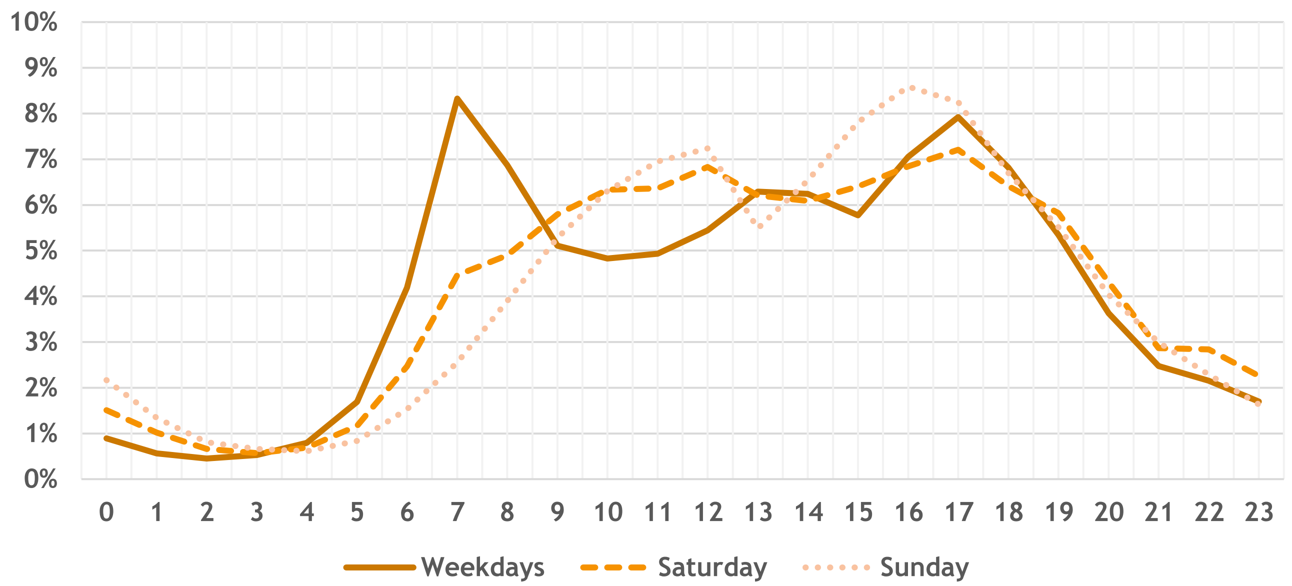

Figure 6 Hourly distribution of trips in the metropolitan city of Bologna on a typical day - November 2024 (Source: GO-Mobility analysis)

An interesting fact concerns the cross-town flow, which peaks on Sundays (over 320,000 trips), exceeding both Saturdays and weekdays. This behavior seems to reflect mobility linked to long-distance flows, tourism, or non-systematic trips that cross the metropolitan area without an internal origin or destination. Overall, **the picture shows broad demand spread throughout the week, with a functional reshaping of the components rather than a net contraction in mobility.**

The analysis of the hourly distribution of trips carried out for the month of November (Figure 6) highlights, however, distinct patterns between weekdays and holidays, with direct implications for the temporal organization of transport services and the calibration of supply.

On weekdays, there are two main peaks: one in the morning between 7:00 and 8:00, typical of systematic mobility linked to work and school, and one in the afternoon between 5:00 and 6:00, which has a peak value slightly lower than in the morning in terms of percentage weight but spread over a wider time slot. This latter aspect suggests diluted pressure on the metropolitan transport system in the second half of the day, consistent with greater heterogeneity in the reasons for and times of return. There is also a small midday peak around 1:00 p.m., mainly attributable to students leaving school and a share of light midday mobility.

At **the weekend**, behavior changes significantly. Saturday and Sunday show a morning peak delayed to around 12:00 and an afternoon peak brought forward to around 16:00 and 17:00. Saturdays are characterized by a more uniform distribution of movements between 9:00 a.m. and 7:00 p.m., with substantial continuity in activities, while Sundays show a marked reduction in mobility around lunchtime, with a sharp drop around 1:00 p.m., indicating a day characterized by more concentrated movements in specific time slots.

May

In May, mobility demand in the metropolitan city of Bologna remained **high and stable throughout the week**. Unlike other seasons, the volume of travel peaked on Saturdays (over 3.6 million) but remained at comparable levels, albeit lower, on weekdays and Sundays, indicating active and distributed mobility, even at weekends. (Table 6 andFigure2). The most significant figure is represented by the *Bologna Internal* component, which records substantially constant volumes between weekdays and Saturdays (over 950,000 trips), with a physiological decline on Sundays, confirming the central role of the capital city in non-work and leisure mobility. A similar pattern can be observed in *the other municipalities* component, with a slight increase on Saturdays and overall stability even on public holidays, reflecting widespread local vitality throughout the area.

Component	Weekdays	Saturday	Sunday
Internal Bologna	952,539	957,686	799,550
Other municipalities	929,559	968,800	827,133
Rest of CM from/to Bologna	428,006	433,545	364,787
Exchange between other municipalities	447,759	464,962	397,292
Exchange with external parties	457,648	527,585	579,865
Crossing	262,077	303,475	385,480
Total	**3,477,588**	**3,656,053**	**3,354,106**

Table 6 Absolute value of journeys within the Metropolitan City of Bologna by macro-component and typical day - May 2024 (Source: GO-Mobility analysis)

The *exchange* components *between municipalities* in the metropolitan area and *between the rest of the metropolitan city and Bologna* show a stable trend, with limited variations between days, but a slight decline on Sundays. More significant is the trend in the *'Exchange with outside'* component, which grows progressively from weekdays to reaching almost 580,000 trips: a clear sign of the metropolitan area's openness to the outside world, especially for non-systematic activities and opportunities to enjoy the area at the weekend.

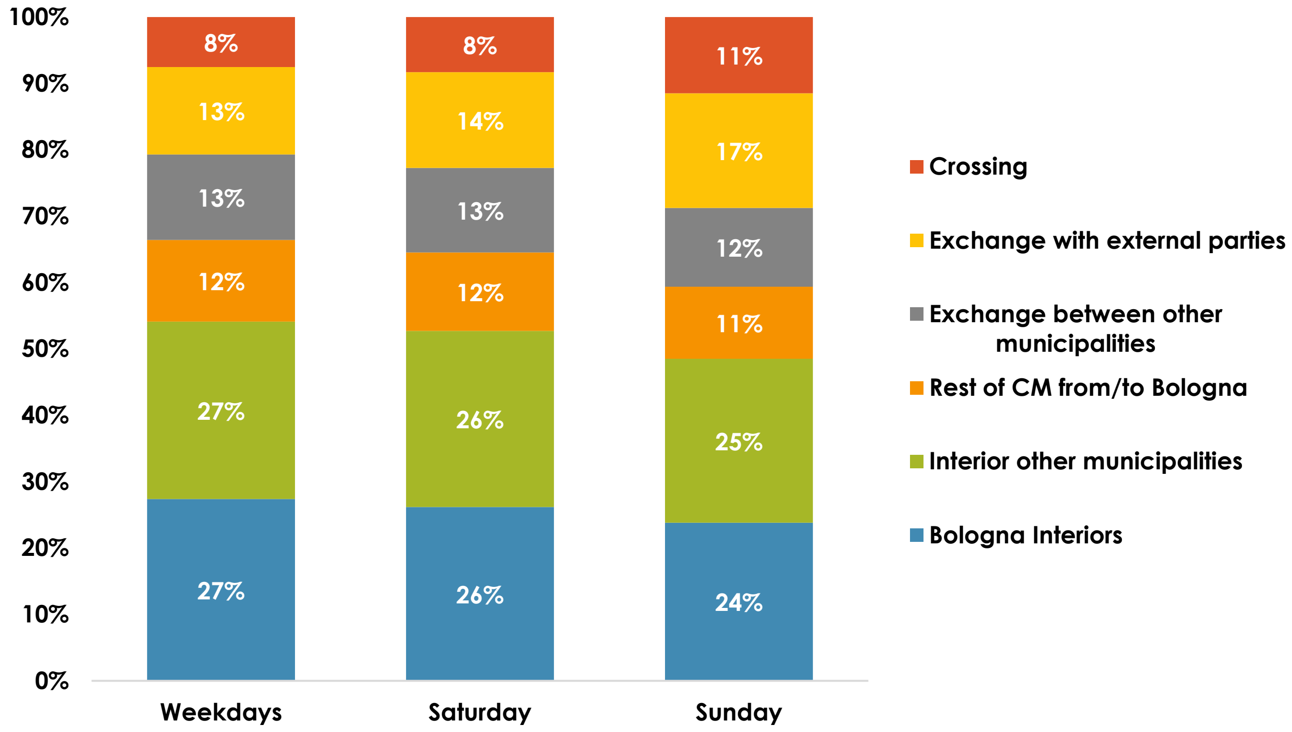

Figure2 Percentage weight of the various macro-components of trips in the metropolitan city of Bologna per typical day - May 2024 (Source: GO-Mobility analysis)

Finally, the crossing component shows a steady increase at the weekend, rising from 262,000 trips on weekdays to over 385,000 on Sundays, indicating heavier transit traffic, probably linked to tourism, leisure, or interregional travel. Overall, therefore, the May data paints a picture of **extensive, continuous, and multifunctional mobility that extends well beyond the traditional boundaries of systematic mobility**.

Furthermore, in May, the hourly distribution of trips (Figure 8) largely confirmed the behavior observed in the autumn period, while highlighting some seasonal differences that reflect the adaptation of mobility patterns to the greater social and climatic liveliness of the spring period.

During **weekdays**, there are two established peaks in systematic mobility: one in the morning between 7:00 and 8:00 a.m. and one in the afternoon between 5:00 and 6:00 p.m., which are entirely comparable to those observed in November. However, there is a more pronounced and longer lunch peak, extending from 1:00 p.m. to 3:00 p.m., indicating greater use of transportation in the middle of the day. This trend can be interpreted as an effect of the greater outdoor and social activity typical of the spring season, which broadens the range of reasons for travel (e.g., extended school trips, recreational activities).

On **Saturdays and Sundays**, the general behavior remains consistent with that observed in November, with a fairly constant distribution of trips on Saturdays and peaks concentrated in the midday and afternoon hours. In particular, there is an increase in the intensity of the Sunday afternoon peak, which is more pronounced than in the fall, consistent with greater mobility for leisure, family activities, or events.

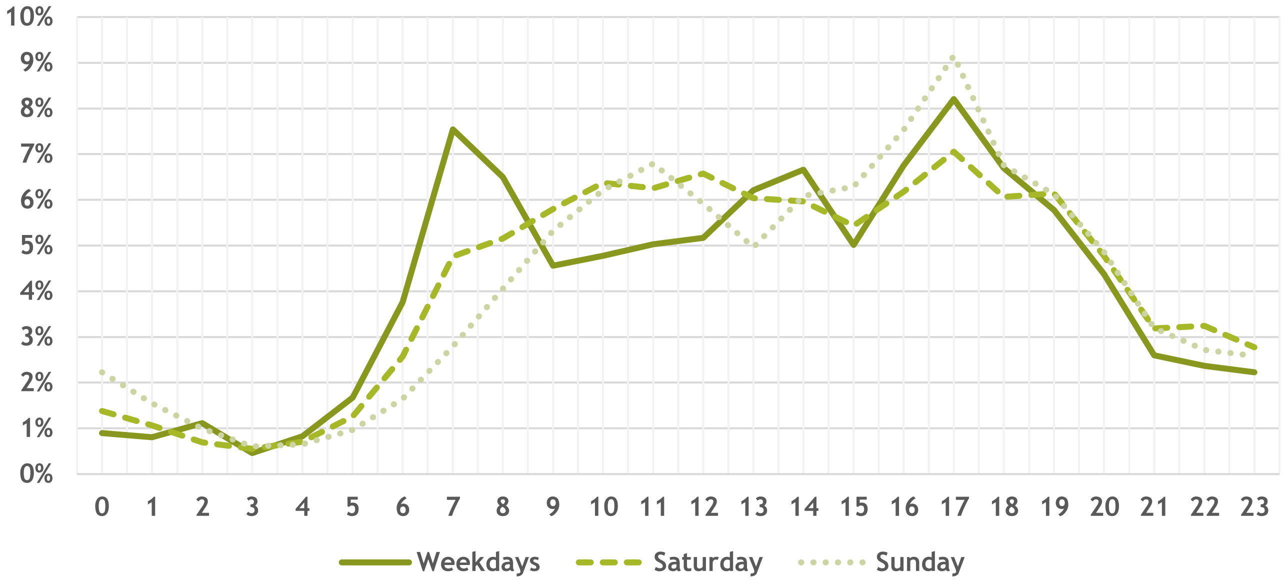

Figure 8 Hourly distribution of trips in the metropolitan city of Bologna by typical day – May 2024 (Source: GO-Mobility analysis)

July

In July, mobility demand in the metropolitan city of Bologna showed a **trend consistent with the summer season, marked by a slight progressive decline from weekdays to weekends**, but with travel levels remaining high: over 3.5 million on weekdays, almost 3.2 million on Saturdays, and 2.8 million on Sundays (Table 7). This confirms that, even in summer, mobility in the metropolitan area remains extensive and varied, albeit with different functions compared to the months when schools and work are in full swing.

Component	Weekdays	Saturday	Sunday
Bologna	1,061,351	851,699	674,837
Other municipalities	671,172	540,649	464,472
Rest of CM from/to Bologna	424,034	328,667	271,534
Exchange between other municipalities	486,412	418,361	357,600
Exchange with external parties	536,960	568,583	549,235
Crossing	352,810	478,110	491,954
Total	**3,532,738**	**3,186,069**	**2,809,632**

Table 7 Absolute value of trips within the Metropolitan City of Bologna by macro-component and typical day - July 2024 (Source: GO-Mobility analysis)

Travel *within the municipality of Bologna* remains in first place in terms of volume on all typical days, but with a marked decrease at weekends, indicating a reduction in systematic mobility and a partial emptying of the capital on public holidays. A similar pattern can be observed for *travel within other municipalities*, which falls significantly at weekends, particularly on Sundays.

The decline is more marked in *the component connecting the rest of the metropolitan city to Bologna*, confirming the predominant role of the city-suburb relationship on working days and its attenuation during the summer weekend. *Travel between municipalities within the metropolitan area* also decreases at weekends, but to a lesser extent, suggesting a widespread and local share of mobility that remains active even outside the systematic circuits.

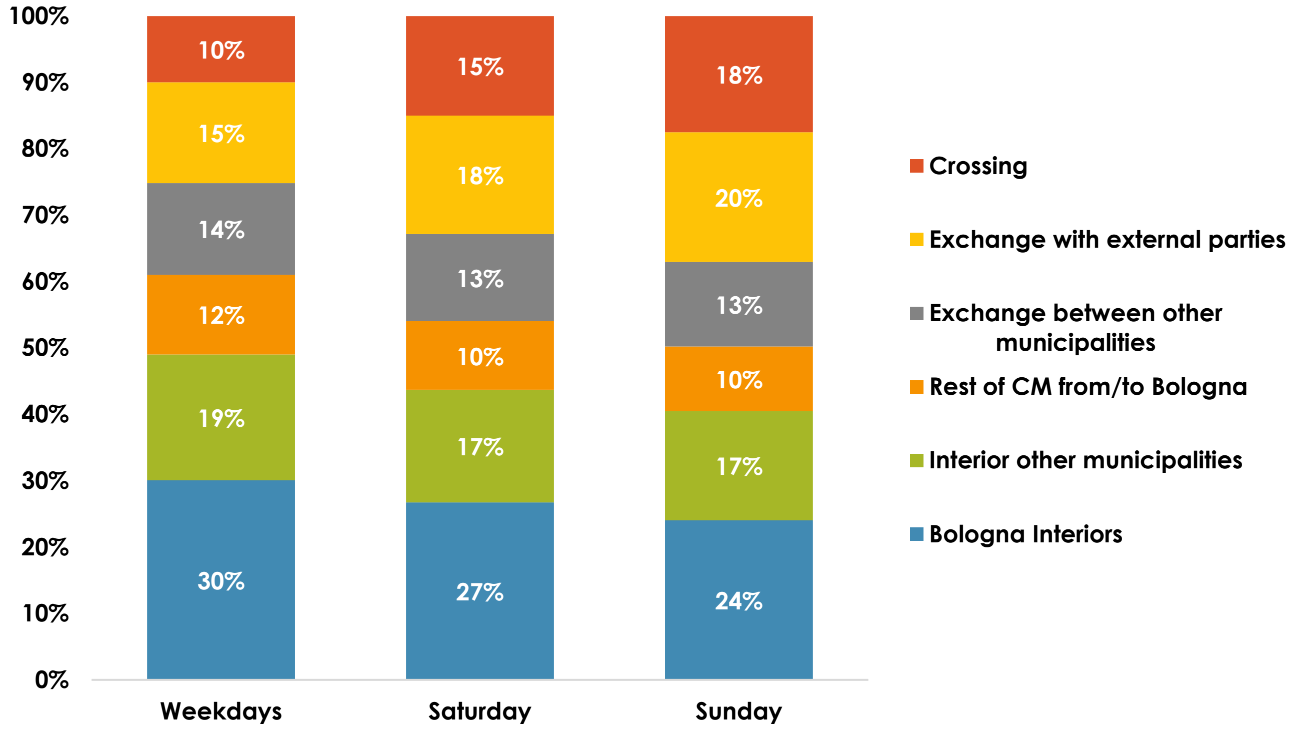

Figure3Percentage weight of the various macro-components of travel in the metropolitan city of Bologna per typical day - July 2024 (Source: GO-Mobility analysis)

The opposite behavior is observed for *exchanges with the outside*, which increase on holidays, reaching their peak on Saturdays. This indicates a mixed component of systematic and non-systematic travel, strongly influenced by extra-metropolitan movements, tourism, or recreational flows affecting the metropolitan area from outside.

Finally, the *transit* component shows a clear reversal of the trend compared to other months: on public holidays, especially Sundays, transit movements through the territory far exceed those on weekdays. These are most likely supra-local or regional flows, linked to holiday mobility or long-distance routes crossing the basin without an internal origin or destination.

Overall, **the macro-components in July show that mobility was less focused on work/school dynamics and more oriented towards non-systematic uses, leisure, and interregional travel**.

From the point of view of hourly trends (Figure4), July shows a significantly different hourly mobility profile compared to the spring and autumn months, reflecting the typical characteristics of the summer season: a reduction in systematic mobility, greater flexibility in schedules, and an increase in travel for recreational or personal reasons. **Weekdays** show a much more spread-out distribution of trips, with less pronounced peaks and a smoother pattern throughout the day. The morning peak is between 7:00 a.m. and 9:00 a.m., but with less pronounced values than in May and November. Between 9:00 a.m. and 3:00 p.m., there is a constant flow with no obvious peaks, partly due to the absence of school travel, which in other months contributes to a lunchtime peak.

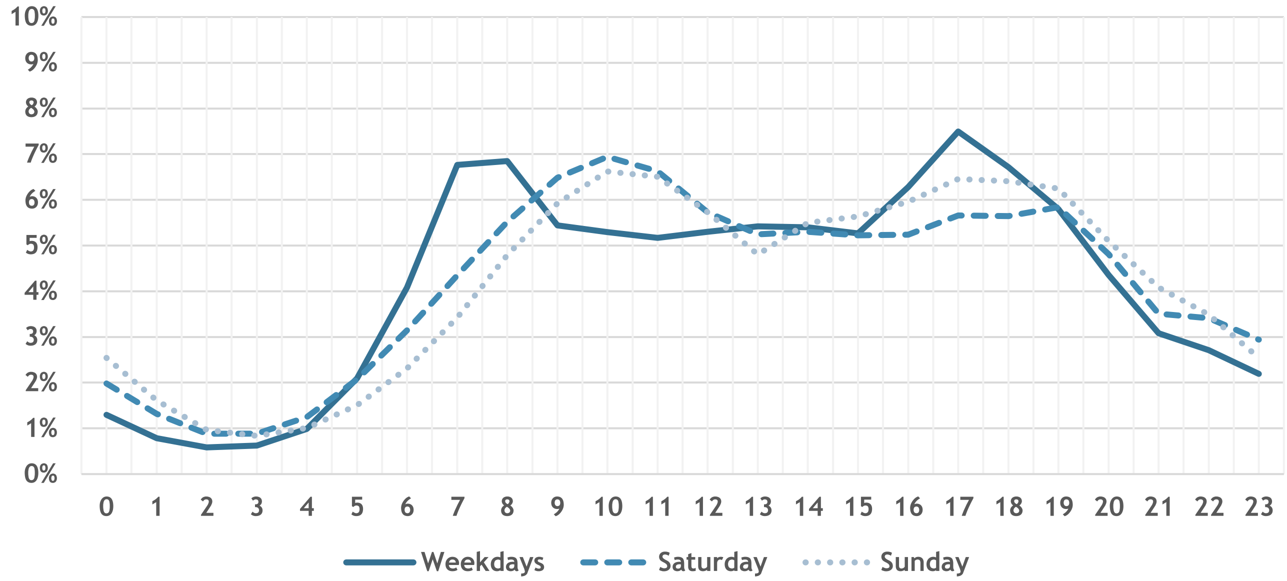

Figure4 Hourly distribution of trips in the metropolitan city of Bologna on a typical day - July 2024 (Source: GO-Mobility analysis)

Overall, the weekday pattern in July is more similar to that of public holidays, suggesting greater coexistence between systematic and occasional mobility. This results in more continuous and widespread pressure on the public transport system, but with demand less concentrated in specific time slots.

Saturdays and Sundays follow the patterns observed in previous months, but with some seasonal differences. The morning peak is brought forward to around 10:00 a.m., while the afternoon peak is more spread out, extending between 5:00 p.m. and 7:00 p.m. There is also a significant amount of evening travel, more pronounced than in May and November, reflecting greater activity in the late afternoon and evening, typical of the summer period.

General considerations

A comparison of the three months analyzed—November, May, and July—shows a **fair degree of consistency in overall levels of mobility demand**, with differences that are more evident in **the functional and temporal structure of demand than in absolute volumes**. Weekdays are the days with the highest number of trips in all months, but Saturdays and Sundays also show consistent values, confirming the structural centrality of holiday mobility in the metropolitan area (seeTable 8).

Seasonality	Weekdays	Saturday	Sunday
November	3,679,090	3,390,773	2,933,979
May	3,477,588	3,656,053	3,354,106
July	3,532,738	3,186,069	2,809,632

Table 8 Comparison between estimated average daily travel figures and seasonality (Source: GO-Mobility analysis)

On a weekday basis, November remains the month with the highest overall volume, exceeding 3.6 million trips, and representing a useful reference point for analyzing systematic trends. May and July are very close to each other, but with different patterns: July shows a higher value in *the Bologna interior* and in *exchanges with the outside*, probably due to greater tourism or transit mobility, while May stands out for a more balanced distribution across all components.

Saturday in May is the day with the highest number of trips among all Saturdays observed, even exceeding the weekday of the same month, a sign of highly active spring mobility, including for recreational and non-systematic reasons. In contrast, July shows lower values on Saturdays, but a clear increase in the components of crossing and exchange with the outside, confirming the importance of interregional mobility or summer transit.

Sunday in May represents the highest value among the three Sundays, with over 3 million trips, distributed across all components, but with a marked increase in trips within municipalities and between municipalities. July, on the other hand, saw a decline in local components and a sharp increase in crossings, which became the second largest component in terms of volume, signaling a change in the function of the catchment area from a local mobility service area to a transit hub for external flows.

From the point of view ***of the analysis of hourly trends for a typical day***, *weekdays* in the three months considered (May, July, November) show a demand structure which, while maintaining some constants linked to systematic mobility, adapts significantly to seasonal conditions:

- ***November***: demand is highly structured and concentrated, with a clear prevalence of work- and study-related travel;
- ***May***: the pattern is similar but with a more pronounced and extended lunchtime peak (1:00–3:00 p.m.), reflecting greater mobility in the middle of the day. This indicates a more diversified demand, which integrates the systematic component with trips related to leisure or social activities;
- ***July***: stands out for its much more diluted and uniform profile. The morning and afternoon peaks are less pronounced and the period between 9:00 a.m. and 3:00 p.m. shows stable but poorly segmented demand, in the absence of school travel. The hourly pattern on weekdays in July is similar to that on public holidays, indicating that seasonality is less tied to standard schedules and more influenced by personal reasons and leisure time.

Behavior on *Saturdays and Sundays* remains fairly consistent across the three months, but with variations in the timing and intensity of peak periods.

- ***November and May***: Saturdays show a regular distribution of movements between 9:00 a.m. and 7:00 p.m., while Sundays show a sharp drop around lunchtime and an afternoon peak between 4:00 p.m. and 5:00 p.m.;
- ***July***: the pattern is similar but with some time shifts: the morning peak is brought forward to around 10:00 a.m., the afternoon peak is more extended between 5:00 p.m. and 7:00 p.m., and there is a significant increase in evening travel, linked to summer leisure activities.

The seasonal comparison therefore suggests that **mobility demand may be homogeneous in absolute terms throughout the year but with varying spatial and temporal characteristics**. Consequently, the public transport system must modulate its service according to the time structure, intensity, and reasons for travel.

An effective service model can benefit from the adoption of a **seasonal and flexible approach**, capable of adapting to different demand patterns. In particular, it may be useful to provide additional services during peak hours on weekdays during the school and work year, greater coverage during the middle and evening hours in the spring and summer, and a reorganization of services on public holidays and during the summer months, taking into account the needs of non- r systematic mobility and the characteristics of areas with low or scattered demand, especially in less urbanized areas.

3.3.2. Average weekday

Analysis of weekdays in the three months observed—May, July, and November—shows an overall **stable** picture **in terms of travel volumes**, with demand remaining at similar levels between seasons. The differences observed in the hourly distribution reflect physiological adjustments in mobility with respect to the seasonal context (e.g., school calendar, weather conditions, recreational activities), but do not substantially alter the overall structure of demand.

In this context, **November** is a **balanced and representative** period, falling outside the seasonal peaks of tourist and school travel. Its position in the middle of the working and school year allows for stable, ordinary, and fully active demand to be observed, with a clear and easily readable hourly structure. This makes it particularly suitable for analyzing dynamics such as *modal split* and the *composition* of travel *users*.

As a month without marked seasonal anomalies, **November is therefore a good operational reference point for analyzing transport demand in the metropolitan area**, useful for comparative assessments to support planning. Overall, on a typical weekday in November, **mobility in the metropolitan city of Bologna is full, regular, and systematic,** offering a representative picture of the ordinary dynamics that animate the area during periods of full school and work activity. The total volume of trips exceeds 3.6 million, the maximum value compared to Saturdays and Sundays, confirming the centrality of weekdays in metropolitan mobility planning.

The main travel routes are attributable to mobility within the territory, both in the municipality of Bologna and in other metropolitan municipalities, with **a distribution that reflects the centripetal force of the capital, but also the liveliness of local centers (Imola in particular)**. Flows between municipalities in the metropolitan area, as well as those to and from Bologna, contribute to shaping **a polycentric network of daily exchanges,** supported by well-established systematic mobility. The external exchange component is also significant, demonstrating that the metropolitan city is strongly integrated into regional flows. The flow of external traffic through the area is more limited on weekdays, but still present, confirming the infrastructural function of the basin as a transit hub.

The **hourly distribution of demand reinforces the image of structured mobility**: the day is marked by two peaks, one in the morning, between 7:00 and 8:00 a.m., triggered by the convergence of school and work, and one in the afternoon, between 5:00 and 6:00 p.m., which is the symmetrical counterpart, where occasional or leisure trips also converge. In addition, the afternoon peak is slightly more diluted, indicating a more fragmented and differentiated return journey.

The middle part of the day maintains a constant and sustained flow with a peak around 1:00 p.m., indicating systematic and significant demand (returns from school). Finally, although the evening hours show a gradual decline, they remain active until 8:00 p.m., suggesting the opportunity to maintain service in the mid-evening hours as well.

This overall profile paints a picture of consistent, predictable, and dense mobility, ideal for conducting in-depth analyses of modal split and profiling. In fact, in the absence of distorting factors related to summer seasonality or holiday periods, November provides a robust basis for evaluating adjustment options and realistically calibrating service levels.

Reason for travel

The **distribution of trips generated from home by reason highlights a functional structure of the metropolitan area that is strongly oriented towards commuting**, especially in inter-municipal and radial flows. Work is the main reason for overall travel (around 30%), but its incidence increases significantly in movements connecting Bologna to the rest of the territory: over 45% of trips to/from the capital are for work purposes, with a maximum value in the flow out of Bologna (54%), indicative of **the presence of production centers and company headquarters in neighboring municipalities.**

On the contrary, for *travel within individual municipalities*, both in Bologna and elsewhere, the reasons are mainly related to daily life and proximity: shopping is the second most common reason for travel (over 28%), with a particularly high proportion in municipalities other than Bologna (over 34%) and also within the capital (30%), indicating widespread and frequent mobility based on short distances and accessible destinations.

Social activities (around 25%), which include visits, leisure, and recreation, also show a homogeneous distribution but are more localized, with a higher incidence of trips within municipalities and less significant inter-municipal flows. These are less structured trips, but they contribute substantially to non-systematic demand, which must be managed with more flexible service models.

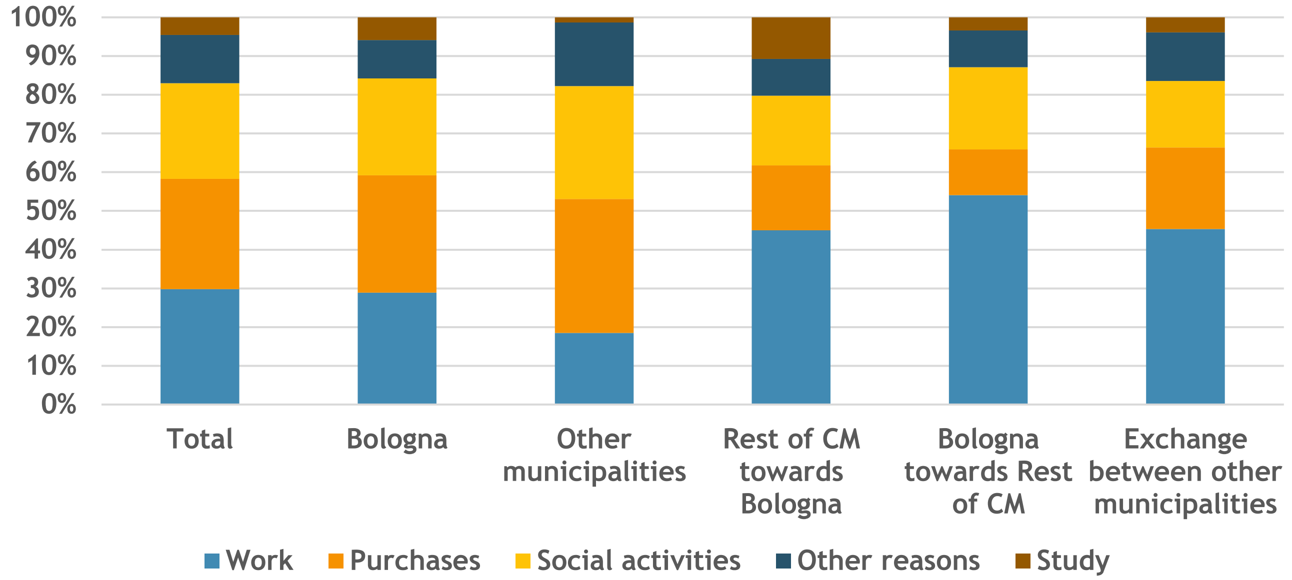

Figure5Percentage weight of reasons for travel in the metropolitan city of Bologna by macro-component on a typical weekday (Source: GO-Mobility analysis of PUMS survey)

The *'other reasons'* category, which includes secondary or occasional reasons, remains around 10-15% in the various components, with a slight increase in journeys within municipalities other than the provincial capital, probably associated with personal or health-related reasons or accompanying others.

Finally, although it accounts for only 4.5% of total trips, the study plays an important role in flows into Bologna (around 11%), consistent with the presence of attractive schools and universities in the metropolitan area.

In summary, the functional picture that emerges highlights a **fairly marked distinction between systematic commuting and local mobility**: in general, inter-municipal and radial flows are driven purely by work and school needs, while journeys within municipalities reflect, to a greater extent, daily, social, and shopping activities.

Modal split

An analysis of ***the modal split of total average weekday travel within the metropolitan city of Bologna*** reveals a highly differentiated picture, reflecting both the urban structure and the availability and accessibility of different modes of transport (Figure 12).

Private vehicles are the most common mode of transport in the metropolitan area, accounting for over 59% of the total, but with significant variations depending on the geographical area. While its use is reduced to 42% for journeys within the municipality of Bologna, in favor of soft mobility and urban public transport, in exchanges between Bologna and the rest of the metropolitan area, the share exceeds 90%, reflecting a strong structural dependence on cars for radial and inter-municipal journeys.

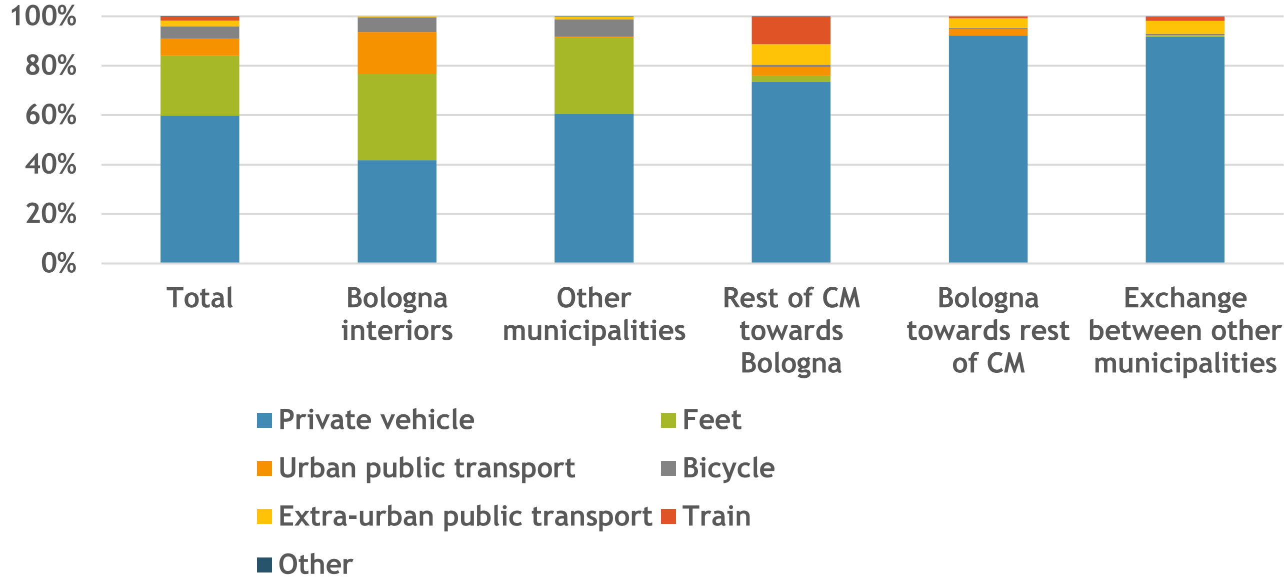

Figure 12 Modal split of trips originating from home by macro-component on an average weekday (Source: GO-Mobility analysis of PUMS survey data)

Local urban public transport is significant only within the municipality of Bologna (17%), with virtually no use in other areas of the territory. This highlights the strong concentration of urban public transport services and their effectiveness in the capital, while suggesting the need for strategies to enhance and integrate services on a metropolitan scale.

Extra-urban public transport is most prevalent on routes into Bologna (just over 8%), where it plays an important role alongside trains, which account for 11% of journeys on the same route. In other contexts, however, its share is significantly lower, highlighting the need to strengthen modal integration in areas outside the capital.

Pedestrian mobility emerges as the second most important mode in terms of incidence (just over 24%), with particularly high values for journeys within urban centers (35% in Bologna and 31% in other municipalities), where short distances and the density of services make walking competitive. However, this mode disappears almost entirely in larger-scale exchanges, where it is impractical.

Cycling, with an average of 5%, achieves interesting shares in journeys within municipalities other than Bologna (7%), indicating room for growth in small and medium-sized contexts, but remains marginal in larger-scale journeys, probably penalized by distances and less favorable infrastructure conditions.

Overall, the picture that emerges is therefore one of a **system with strong modal and geographical polarization, where the capital stands out for its greater balance between modes, while in the rest of the territory, private vehicles remain dominant**.

Furthermore, a clear picture emerges from the ***modal breakdown of trips originating from home*** on an average weekday, showing systematic morning mobility oriented towards public transport, especially in the early hours of the day (Figure 13), with a balance gradually shifting towards car use and active mobility during the rest of the day (Figure 14). **Between 7:00 and 9:00 a.m., public transport (in all its forms) reaches particularly high levels of use:** urban public transport peaks at 8:00 a.m., accounting for 27% of journeys; a similar figure is observed for extra-urban public transport, which meets the demand of commuters from more peripheral municipalities. During this same time slot, trains play a decisive role in medium- and long-distance connections, covering over a third of trips at 8:00 a.m.

This intense concentration of demand makes the early morning hours the peak time for public transport, driven by the need to get to work, school, or university. After 9:00 a.m., the use of public transport gradually decreases, although it remains significant until late morning. In the afternoon and evening, public transport becomes marginal, with low shares and a visible decline in systematic mobility.

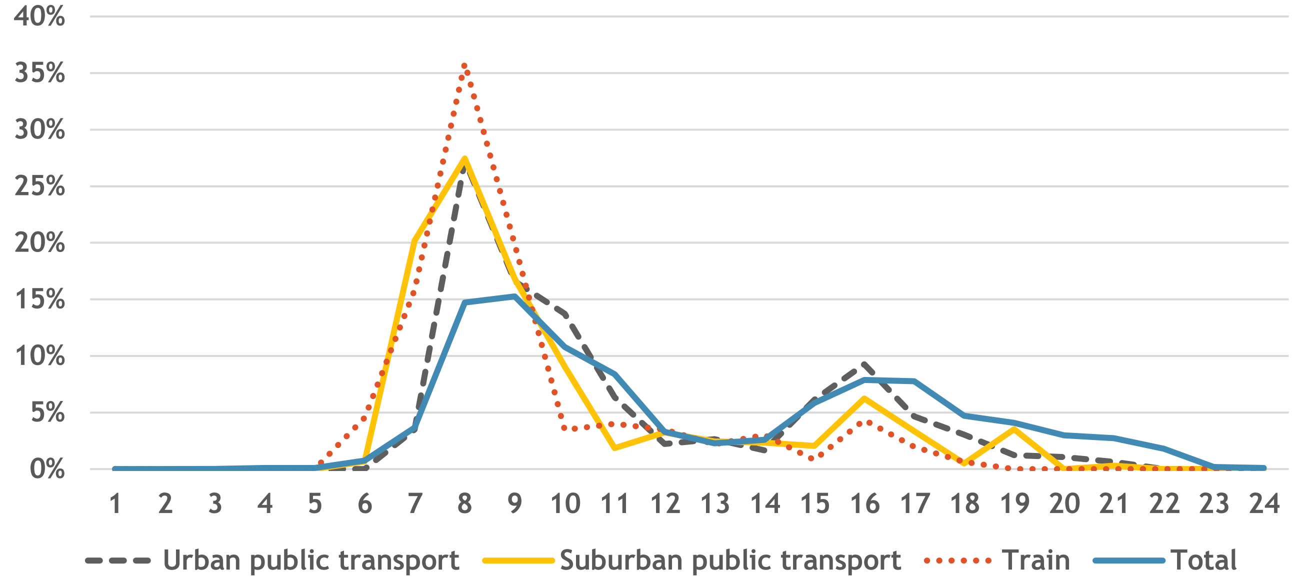

Figure 13 Modal split of public transport journeys originating from home in the metropolitan city of Bologna on an average weekday (Source: GO-Mobility analysis of PUMS survey data)

Private vehicles, on the other hand, maintain a constant presence throughout the day, but are also concentrated between 7:00 a.m. and 9:00 a.m., with peaks of 16% in the same time slots when public transport is most used. This suggests competitive use of cars for commuting, particularly where accessibility conditions or a lack of alternatives make public transport less effective.

Active mobility—represented by walking and cycling—is particularly significant between 8:00 a.m. and 11:00 a.m., especially in urban contexts and over short distances. Pedestrians account for up to 14% of trips at 10:00, while bicycle use is stable between 10% and 16% in the same time slot. This is a time slot when shorter distances and more flexible schedules (such as errands, accompanying others, or working different hours) make light individual vehicles competitive.

Overall, therefore, weekday trips originating from home show a more marked dependence on public transport in the middle of the morning, compared to the return trips observed in the evening, when private vehicle use regains a dominant role.

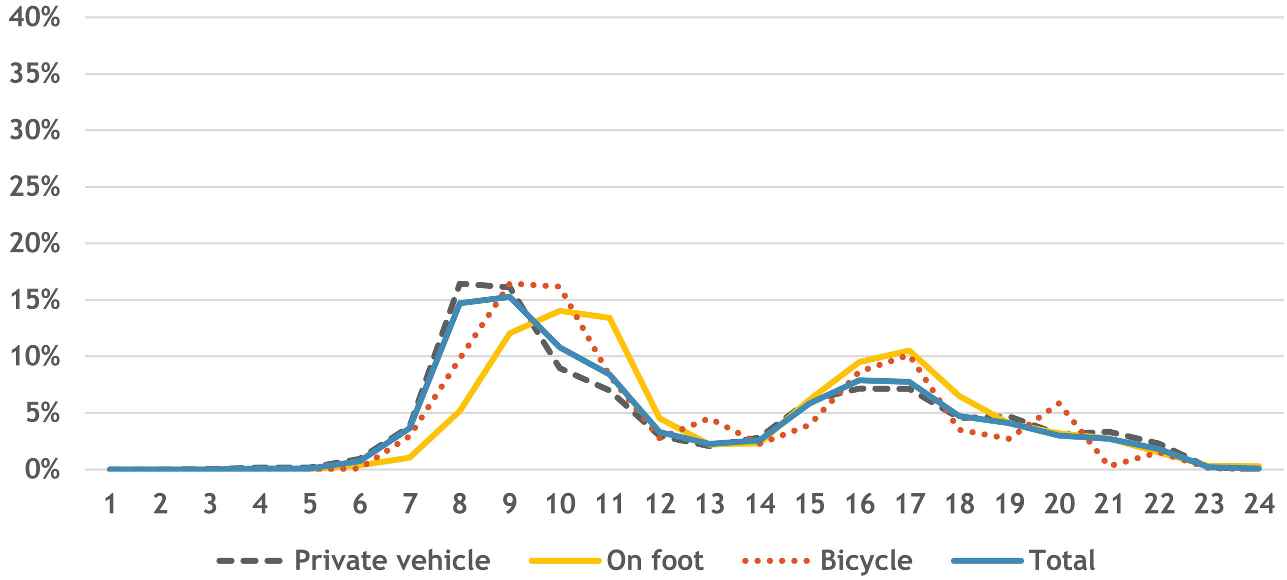

Figure 14 Modal split between private transport and soft mobility for journeys within the metropolitan city of Bologna with destination home on an average weekday (Source: GO-Mobility analysis of PUMS survey data)

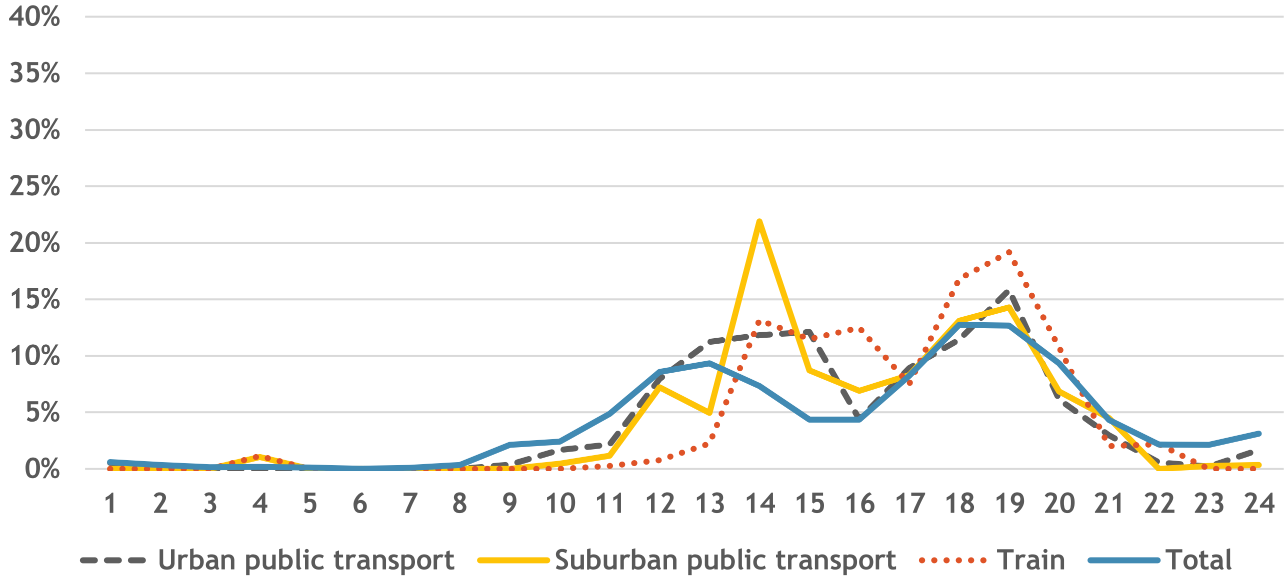

Figure6 Modal split of public transport for journeys in the metropolitan city of Bologna with destination home on an average weekday (Source: GO-Mobility analysis of PUMS survey data)

At the same time, analysis of ***the modal split by time of*** day ***for journeys to home*** on an average weekday reveals a complex pattern that changes significantly throughout the day, both in terms of the most common modes of transport and the territorial function of the journeys. Public transport is busiest in the afternoon between 1:00 p.m. and 4:00 p.m., when urban and suburban public transport and trains record some of the highest percentages of the entire day (Figure6). In particular, **suburban public transport** reaches a peak of 22% around 2:00 p.m., probably linked to school and work returns from medium-long journeys; at the same time, urban public transport shows a significant incidence, especially in the middle of the day, while trains, although less used overall, perform well between 1:00 p.m. and 4:00 p.m., confirming their strategic role in inter-municipal mobility . Outside these times, public transport use for returning home drops significantly, becoming almost non-existent in the evening and morning hours.

In contrast, **private vehicles are distributed more evenly throughout the day**, with evening peaks between 5:00 p.m. and 7:00 p.m., coinciding with the general return from work (Figure 16).

It is also present in the early morning hours, reflecting a proportion of early returns, while **active mobility**, represented by walking and cycling, emerges more clearly in the middle of the day and in the early afternoon, with peaks between 11:00 a.m. and 2:00 p.m. Walking, in particular, reaches 13% in the afternoon, suggesting short journeys in urban or semi-urban areas. Cycling also shows a significant presence in afternoon returns, with percentages close to 15% between 5:00 p.m. and 6:00 p.m.

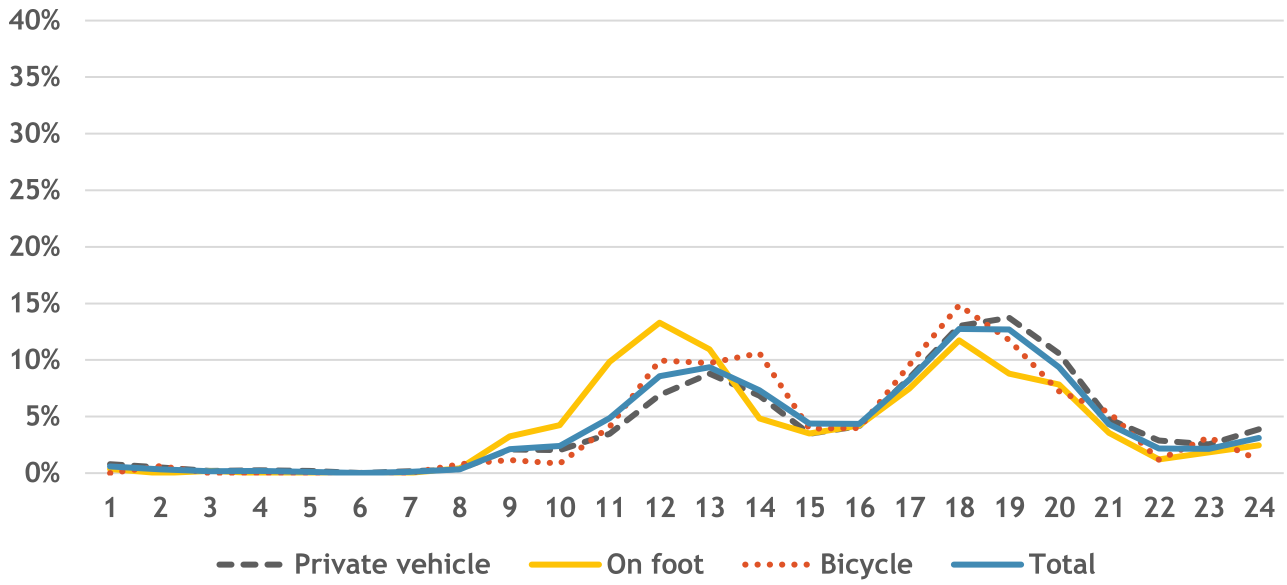

Figure 16 Modal split between private transport and soft mobility for journeys originating from home in the metropolitan city of Bologna on an average weekday (Source: GO-Mobility analysis of PUMS survey data)

Overall, therefore, these data confirm a mobility system that is still heavily reliant on car use for evening returns, with signs of consolidation of public transport and active mobility during peak hours, especially where territorial and infrastructural conditions allow.

User profiling

To better understand the dynamics of mobility demand in the metropolitan city of Bologna, this section analyzes the hourly distribution of trips, distinguishing between ***residents*** and ***city users***. This analysis allows us to identify differences in temporal behavior between those who live permanently in the area and those who access it daily for work, study, or other services. Furthermore, user profiling allows us to further refine the interpretation of actual demand and to tailor public transport solutions more closely to different mobility needs.

Residents (Figure 17) account for about three-quarters of total trips recorded in the metropolitan city of Bologna, confirming their position as the dominant component of mobility demand. Analyzing their **hourly distribution for a typical weekday in November**, we observe behavior that is entirely consistent with the overall trend in demand (as illustrated inFigure 6).

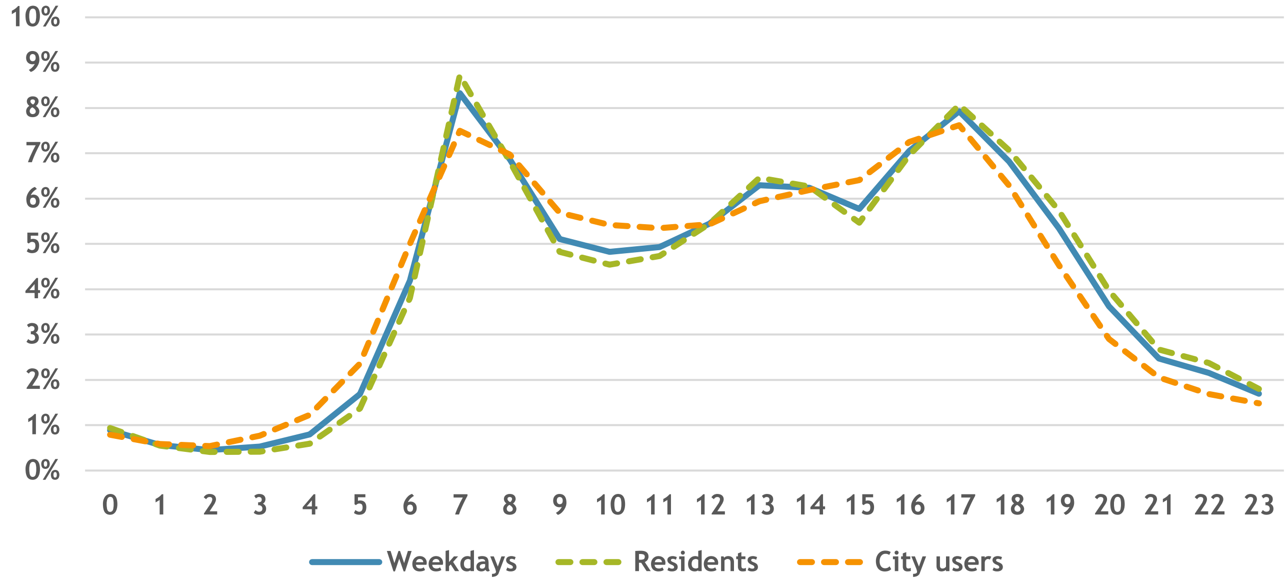

Figure 17 Hourly distribution of trips by residents and city users in the metropolitan city of Bologna by typical day - November 2024 (Source: GO-Mobility analysis)

The morning and afternoon peak times, as well as the stability of travel during the central hours, are almost identical, reflecting the fact that the time choices of the resident population largely shape the hourly structure of the weekday mobility system.

On the other hand, ***city users***, i.e., those who do not reside in the area but travel there for functional reasons, show a slightly different time profile compared to residents, while maintaining a consistent structure in terms of volume. On weekdays, in fact, **behavior is similar to that observed in July,** with a double peak (morning and afternoon) that is symmetrical in terms of both percentage weight and duration, both distributed over several hours, reflecting greater flexibility in arrival and departure times. The middle of the day, between 9:00 a.m. and 3:00 p.m., also shows a steady trend, with sustained levels but no marked peaks, confirming the presence of not only systematic trips but also those related to services, appointments, and personal activities. Overall, therefore, the mobility of city users is more fragmented and less bound to standard schedules than that of residents, but still significant in all time slots.

Systematicity

The analysis of ***systematic trips***, defined as those that **are repeated at least 13 times in November 2024**, allows for a more targeted understanding of the recurring and predictable component of mobility demand, distinguishing it from the more occasional or flexible component. On an average weekday, this systematic component represents a minority of total trips, but with values that vary significantly depending on the macro-territorial component considered (Figure7). Journeys *within the municipality of Bologna* have the highest proportion of systematic journeys (31%), reflecting the presence of structured daily demand linked purely to homework or home-school journeys in urban areas. This figure reflects the density of services and the concentration of central functions in the capital, which attract recurring and regular mobility even over short distances.

Moving down the territorial scale, the share of systematic trips decreases in exchange flows: both *towards the interior* of the metropolitan area (around 20%) and *towards the exterior* (around 19%), the systematic component remains less than one-fifth of the total, leaving room for more irregular mobility, consisting of occasional, flexible, or infrequent trips. This suggests that inter-municipal and inter-regional mobility, although intense in absolute terms, is less anchored to daily routines and more sensitive to non-systematic motivations such as services, errands, events, or non-recurring personal needs.

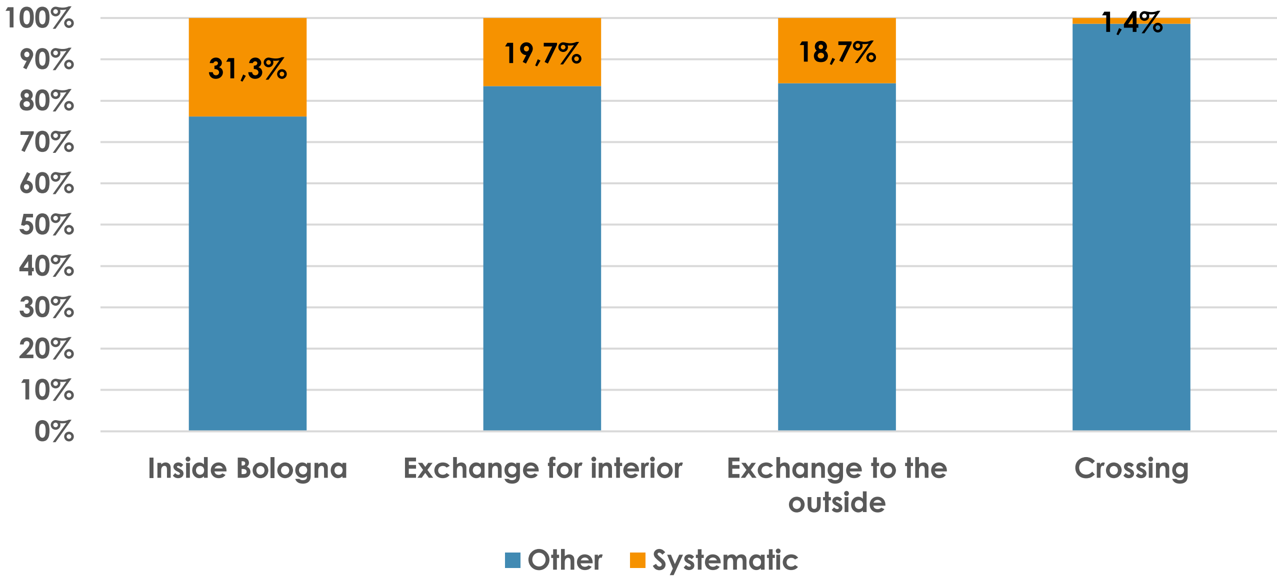

Figure7 Percentage weight of systematic trips in the metropolitan city of Bologna by macro-component on a typical weekday - November 2024 (Source: GO-Mobility analysis)

Finally, the component of *travel* across the metropolitan area remains almost entirely non-systematic, accounting for just 1.4%, indicating that transit traffic is likely to be highly episodic or occasional, linked to long-distance flows, tourism, or passing traffic that does not directly involve the area as its origin or destination.

Overall, therefore, the data confirms that **systematic demand is concentrated mainly within the capital**, while irregular mobility patterns prevail in other areas, requiring more flexible and adaptable planning approaches over time.

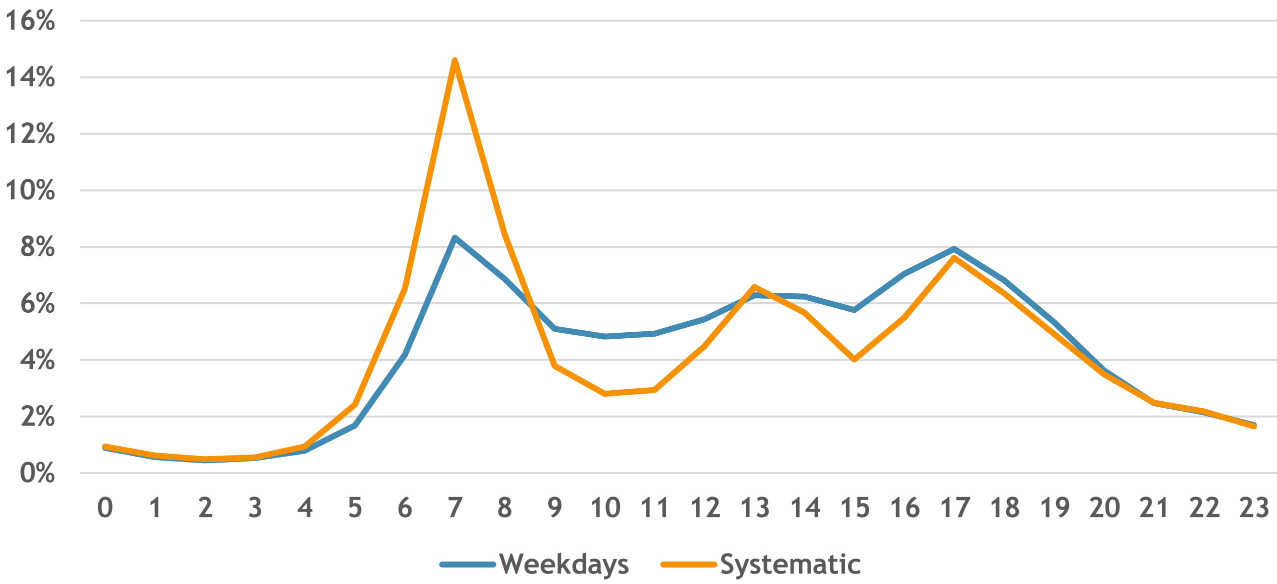

Figure 19 Hourly distribution of systematic trips in the metropolitan city of Bologna on a typical weekday - November 2024 (Source: GO-Mobility analysis)

As regards the comparison between the ***hourly distribution of systematic trips and that of total weekday trips***, there are some structural differences that help to distinguish more precisely the behavior of the different components of demand (Figure 19). Although following a similar general pattern, **systematic** trips **show a more concentrated profile in the standard time slots, consistent with working and school hours**.

The most pronounced peak is in fact recorded at 7:00 a.m., when systematic trips account for 15% of the systematic total, compared to 8% of the total on weekdays. The 6:00–8:00 a.m. slot is also busier overall, with higher-than-average percentages, indicating greater punctuality and regularity in the behavior of this specific user group. Immediately afterwards, between 8:00 and 9:00, the two curves tend to overlap, indicating that the bulk of systematic demand has already been activated, while the rest of the population moves in a more distributed manner.

Starting at 10:00 a.m., systematic trips drop more sharply than the total, indicating that mobility linked to occasional or flexible reasons becomes predominant in the middle of the day. The same phenomenon can also be observed in the early afternoon, where the systematic curve is flatter, with values between 3% and 5%, while the total curve remains higher and more stable until 5:00 p.m.

The afternoon and evening hours (5:00 p.m.–8:00 p.m.) see an alignment between the two profiles, with identical values at the afternoon peak (5:00 p.m., 8%) and a gradual evening decline common to both curves. This indicates that even among regular trips, there is a second wave of returns, although less concentrated than in the morning. Overall, therefore, **systematic trips are characterized by greater intensity in the early hours of the day,** reduced presence in the middle of the day, and significant but more diluted participation in the late afternoon.

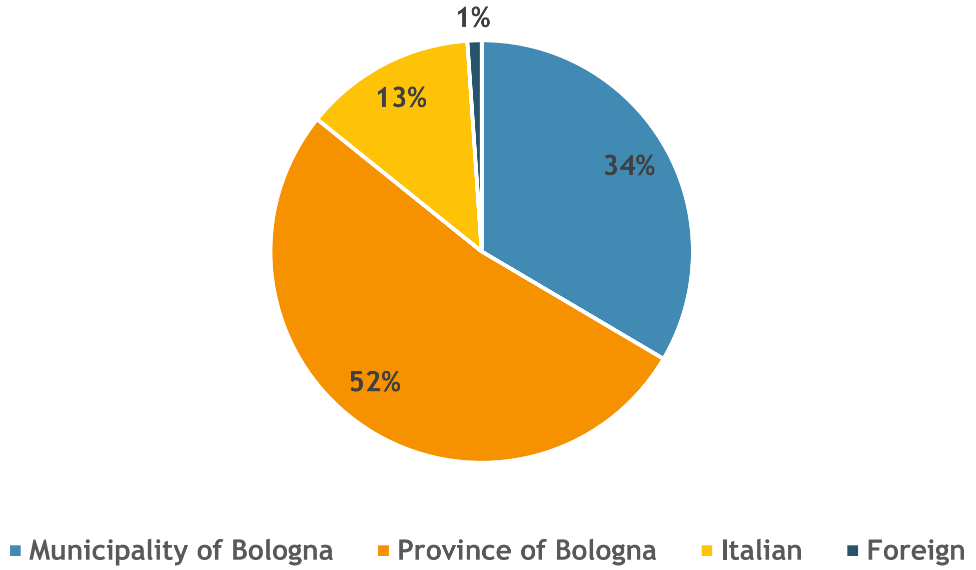

Figure 20 Percentage weight of the user profile of systematic trips in the metropolitan city of Bologna on a typical weekday – November 2024 (Source: GO-Mobility analysis)

Finally, analysis of ***the composition of systematic trips by user type*** (Figure 20) highlights **the central role of metropolitan residents**, who together generate 85% of this type of mobility. In particular, more than half of systematic trips (52%) are generated by residents in the municipalities of the Province of Bologna, a sign of strong inter-municipal and radial commuting that crosses the metropolitan area on a daily basis. The municipality of Bologna also contributes significantly, with 33% of the total, confirming its importance as a point of origin (and not only of attraction) for recurring flows related to work, study, and services.

The contribution of city users, i.e., those who do not reside in the metropolitan city but access it systematically, **is** significantly **lower**: only 13% of systematic trips are attributable to non-resident Italian users, while foreigners account for just 1%. These figures confirm that systematic demand for mobility is mainly internal to the metropolitan area and that service planning strategies, particularly on weekdays and at peak times, must take into account the central role of the resident population in shaping daily mobility. At the same time, the small proportion of regular users among external users suggests that mobility from outside the area is less regular and more oriented towards occasional use, which requires flexible tools that are less constrained by high-frequency logic.

Mobility to/from Bologna

Mobility to and from the municipality of Bologna **highlights a functional centrality consistent with the demographic weight of the capital**: journeys within Bologna account for just over a quarter of the metropolitan total (28%), a figure slightly lower than the percentage weight of the resident population, confirming that the capital accounts for a significant part of the demand for mobility.

Traffic between the capital and the rest of the country amounts to approximately 95,000 trips per day in each direction, covering a total of approximately 40% of total traffic between the entire metropolitan area and the outside (i.e., trips into and out of the metropolitan city). This is a significant share, confirming the intense, two-way relationship between the city and the rest of the country, which is distributed evenly throughout the average working day.

Looking at the overall weight of exchanges, a particularly significant figure emerges: exchanges between Bologna and the rest of the metropolitan city (approximately 470,000 trips) are equivalent in magnitude to all other exchanges between municipalities in the metropolitan area, demonstrating the central role of the capital in the territorial system. In this sense, Bologna is at the center of a network of strong relationships that extend outward and balance its attractive and distributive roles. It is also interesting to note that 320,000 of these exchanges take place with municipalities in the first belt, confirming the role of urban proximity of these territories and their daily integration with the city.

Finally, it is worth noting that internal movements within Bologna are more than double those with the rest of the metropolitan area, confirming that the city generates and absorbs very dense and autonomous internal mobility, as well as interacting steadily with the hinterland. This balance between internal and relational mobility reinforces the idea of Bologna as a compact but connected urban center, capable of supporting a dual function: serving its resident population and structuring metropolitan-scale relationships.

After analyzing the structure of exchanges between Bologna and the rest of the metropolitan city, it is useful to focus on an equally significant component, namely the **overall "through" demand for Bologna**. These are journeys that, although they do not originate or terminate in the capital, pass through it to connect areas and municipalities in the inner belt located on opposite sides of the urban center.

This component was estimated by considering the journeys involving the five PUMS survey areas adjacent to Bologna (*N internal, NE internal, NW internal, W internal, SE internal*), which include 11 municipalities in the first belt, including **Casalecchio di Reno, Castenaso, Zola Predosa, San Lazzaro di Savena, Anzola dell'Emilia**, and others. The connections considered are not tangential but involve crossing the municipal territory of Bologna, often in the absence of alternative routes.

On an average weekday, this type of mobility can be quantified at approximately 9,000 trips, out of a total of 320,000 exchanges involving Bologna, which is a numerically limited figure (less than 3%) but should not be underestimated in terms of infrastructure pressure, as it generates through traffic that is not destined for the capital, which can have an impact on congestion and vehicle load, especially during peak hours.

In particular, the highest intensity of these movements is concentrated along the axis between the inner north (municipalities of Castel Maggiore and Granarolo dell'Emilia) and the inner southeast/inner west (municipalities of Casalecchio di Reno, San Lazzaro di Savena, Sasso Marconi, Pianoro, and others), confirming the presence of radial routes crossing the provincial capital.

This 'transit' mobility represents a form of potential demand that is often poorly served by public transport and difficult to capture by traditional policies. Its relatively marginal weight in the total does not reduce its interest but, on the contrary, offers a useful starting point for reflecting on the central role of Bologna in metropolitan flows and on possible strategies for improving connectivity between municipalities in the belt. A more in-depth analysis of these movements could help to evaluate infrastructure or service solutions that can better support inter-municipal demand, reducing the indirect burden on the city and promoting a more balanced distribution of flows across the metropolitan area.

Mobility to/from neighboring provinces

Mobility exchanges between the metropolitan city of Bologna and the province of Ferrara amount to approximately 80,000 trips on an average weekday, a figure which, although significant in absolute terms, represents **only about one-sixth of the total number of trips to and from outside the Bologna basin**. This figure places Ferrara among the neighboring territories least involved in structured mobility with Bologna, especially when compared with flows generated towards other regional or interprovincial centers (especially the Province of Modena).

A second factor reinforces this interpretation: about half of the trips are limited to nearby destinations, mainly between municipalities located along the border, such as Pieve di Cento and Molinella. These are therefore largely short-range trips, likely linked to local and daily reasons, which do not indicate a systemic relationship between the two territories as a whole.

Overall, these elements suggest that the relationship between Bologna and Ferrara is more one of administrative contiguity than of an integrated functional area: the low volumes, the local nature of trade, and the absence of significant flows towards the major centers of Ferrara confirm a weak structural interconnection between the two basins, limited to territorial margins and not to extensive commuting or economic complementarity.

At the same time, trade with the province of Ravenna amounts to around 70,000 movements on an average weekday, a figure similar to that of Ferrara (around one sixth of total trade to/from outside the area), but which is distinguished by greater intensity along the administrative border and the centrality of local centers. In particular, the strongest links involve the municipalities of Conselice, Lugo, Massa Lombarda, and Castel Bolognese on the Ravenna side, connected to Imola and Castel San Pietro on the Bologna side.

Even more significant is the situation in the province of Modena, with approximately 120,000 trips per day, equivalent to a quarter of total external trade. In this case, there is strong urban and functional continuity along the western border of the metropolitan city. The most intense relations are concentrated in the area between Castelfranco Emilia and Crevalcore, San Giovanni in Persiceto, and Valsamoggia. These are areas with strong infrastructural and productive integration, reflecting structured economic and residential links, in some ways comparable to those within the Bologna basin.

3.3.3. Event days

In order to assess the impact of mobility induced by exceptional events on the metropolitan area, a comparison was made between the hourly distribution of journeys on average days and that observed during two types of event: a concert at the Unipol Arena in Casalecchio di Reno and a football match at the Renato Dall'Ara stadium. This analysis **makes it possible to understand whether and to what extent such events affect the daily dynamics of mobility demand**, altering their temporal structure or introducing peaks and abnormal concentrations in flows.

Concert

This section compares ***the trips generated and attracted*** on an average weekday in May with those on weekdays when a concert was held at the Unipol Arena (Wednesday 15, Thursday 16, and Friday 24 May) to assess the impact of this type of event. As can be seen fromTable 9 , with reference only to the area affected by the event, there was an increase in attracted demand.

	Weekday May	Concert	Δ	Δ
Generated towards Bologna	1	21,510	+5,649	+35
Generated to all	45,763	66,252	+20,489	+44.8
Attracted by Bologna	16,310	23,105	+6,795	+41.7
Attracted by all	45,473	69,395	+23,922	+52.6

Table 9 Comparison of travel in the concert area, Unipol Arena (Source: GO-Mobility analysis)

The analysis of ***the hourly distribution of journeys between Bologna and Casalecchio di Reno*** is shown below. The differences are more evident **in the early evening and evening**, but with distinct dynamics.

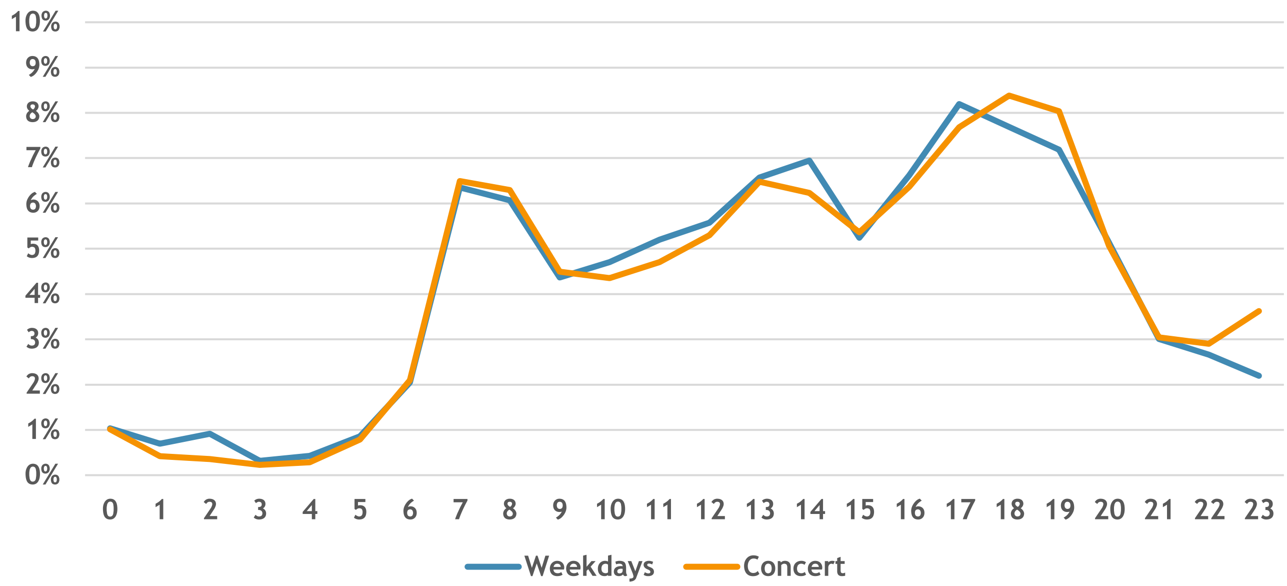

Figure 21 Hourly distribution of journeys between Bologna and Casalecchio di Reno on a typical weekday and on a weekday when there is a concert at the Unipol Arena - May 2024 (Source: GO-Mobility analysis)

In the hours leading up to the event, between **5:00** p.m**. and 8:00 p.m.**, travel volumes remain **in line with those of an average weekday, albeit slightly delayed**: this suggests that **the influx to the concert is distributed smoothly**, probably diluted and partially absorbed by the flows already present linked to commuters returning home. The fact that no abnormal peaks are detected at this stage indicates **that the regular transport system is able to absorb the audience well,** with no noticeable effects on overall pressure.

However, the main difference is observed in **the evening after the event**: at **11:00 p.m.**, travel increases from **2% of the average weekday to 4% on concert days**, marking an **increase in outbound traffic** between the two municipalities. This effect can be attributed to **the departure of concert attendees**, which is concentrated at the end of the event. Although numerically limited, this difference represents a **localized**

and recognizable pressure, which **only** manifests itself **after the event has ended,** without altering the overall demand profile.

Overall, the analysis shows that events such as concerts at the Unipol Arena **do not interfere with pre-existing mobility in the two-way flows between Bologna and Casalecchio** but introduce **a well-defined additional evening share** (from 60,000 to 80,000, equal to a 30% increase), which can be managed with targeted interventions focused on the outflow phases.

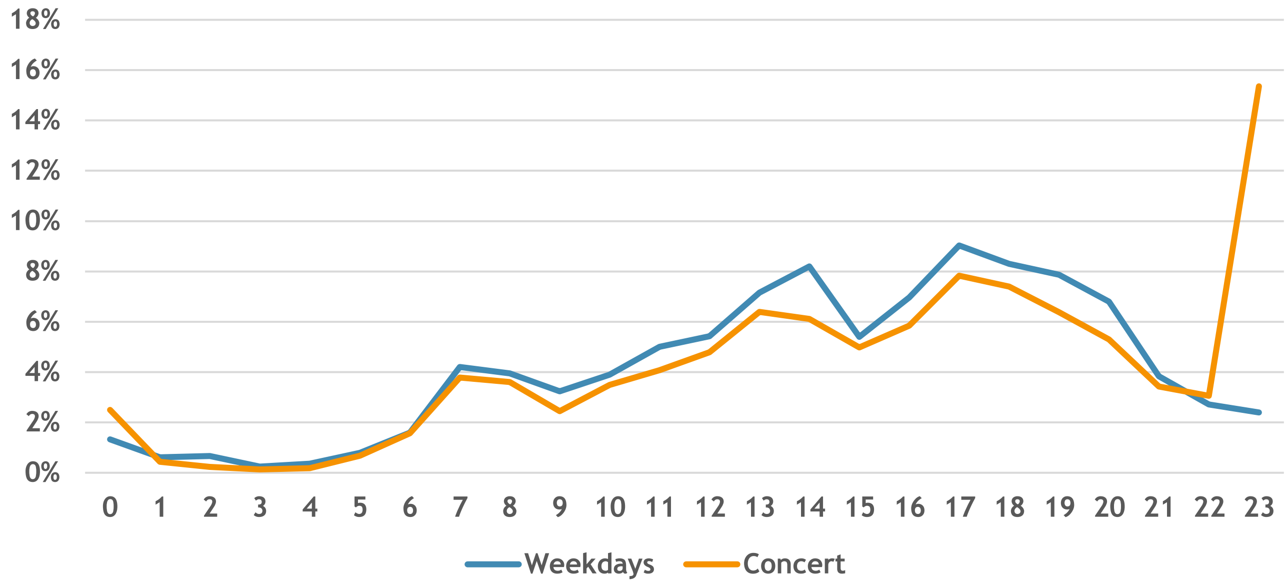

Figure 22 Hourly distribution of total trips originating from the Unipol Arena area on a typical weekday and on a weekday when there is an event at the stadium - November 2024 (Source: GO-Mobility analysis)

In this regard, analysis of ***total movements originating from the Unipol Arena area alone*** clearly highlights the localized impact generated by evening events, such as the concerts on May 15, 16, and 24. A comparison between concert days and an average weekday shows a net increase in mobility volumes, with an estimated increase over the course of the day equal to 60% of journeys to and from the entire country. This data confirms that the event not only attracts an additional audience but also generates a marked change in the hourly distribution of journeys.

Until 8:00 p.m., the travel curve remains almost superimposed on that of a weekday, with minimal differences, indicating that the neighborhood's ordinary mobility is not particularly altered during the day. However, starting at 9:00 p.m., the distribution begins to diverge, and at 11:00 p.m., the most evident data is recorded: trips rise from 2% to 15% of the daily total. This evening peak clearly represents the post-concert outflow, which is much more concentrated than that observed in the stadium area for sporting events.

This localized and highly time-dependent pressure demonstrates the polarizing effect of the event, as the return journey is concentrated, placing particular strain on road infrastructure and exit points in the late evening.

At the same time, the hourly profile of ***total inbound travel to the Unipol Arena area*** on concert days shows a significantly different pattern compared to the average weekday from late afternoon onwards (Figure 22), with a **concentrated but progressive influx effect**, clearly distinct from ordinary mobility. During the day, until 4:00 p.m., the distribution of arrivals remains largely in line with that typical of a weekday, with a slight decline in the middle of the day, suggesting a lower percentage of routine activities (work, school) on event days.

However, starting at 5:00 p.m., there was a clear and progressive increase in movement toward the concert area: the percentage of arrivals rose to 10% between 5:00 p.m. and 7:00 p.m., reaching a peak of 12% at 6:00 p.m., compared to 7% at the same time on an average weekday. This trend indicates a continuous and distributed influx that intensifies progressively in the hours immediately preceding the start of the event, without generating sudden peaks. After 8:00 p.m., the curve returns to standard levels, indicating that the audience has now entered the venue and that pressure on the access network has already peaked.

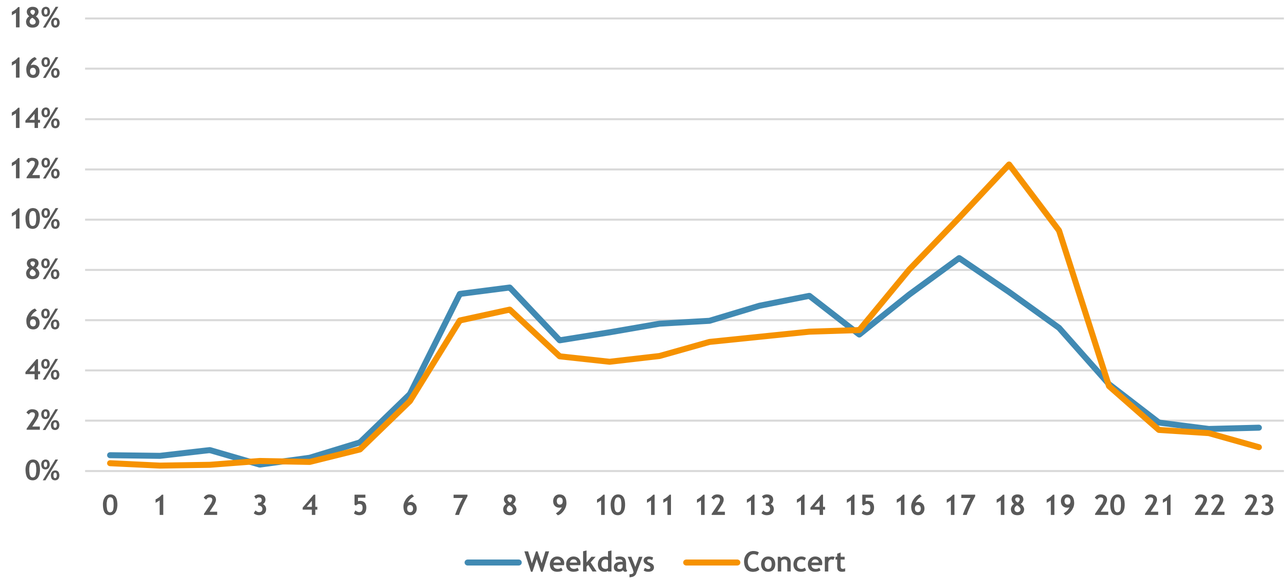

Figure8Hourly distribution of total movements to the Unipol Arena area on a typical weekday and on a weekday when an event is taking place at the stadium - November 2024 (Source: GO-Mobility analysis)

Overall, therefore, the Unipol Arena area shows a good capacity to absorb the mobility induced by concerts, with an orderly but concentrated influx between 5:00 p.m. and 7:00 p.m. and more pronounced pressure during the evening outflow, when flows significantly exceed the norm. The estimated increase in travel **confirms the significance of the impact on the area, without compromising its resilience.** These factors suggest that operational planning should be strengthened, particularly in the pre- and post-event periods, through the introduction of targeted measures on traffic and public transport to ensure efficient absorption of temporary peaks.

Stadium

This section compares a standard weekday in November with a match day to assess the impact of the latter on ***the overall travel generated and attracted*** to the area where the Renato Dall'Ara stadium is located.

	Weekday in November	Match	Δ	Δ
Generated towards Bologna	81,247	88,458	+7,211	+8
Generated to all destinations	132,955	146,674	+13,719	+10.3
Attracted from Bologna	80,687	91,409	+10,722	+13.3
Attracted by all	132,789	153,195	+20,406	+15.4

Table5Comparison of travel in the stadium area, Renato Dall'Ara (Source: GO-Mobility analysis)

A comparison between travel within the municipality of Bologna on an average weekday and on the day of the match (Tuesday, November 5, at 9:00 p.m.) confirms an **almost total overlap in the hourly profile**, with variations that do not alter the general structure of demand. The two curves develop regularly, reflecting the daily urban mobility patterns dictated by work and school schedules.

The main peaks – in the morning between 8:00 a.m. and 9:00 a.m. and in the afternoon between 5:00 p.m. and 7:00 p.m. – occur on both days, with very similar values. The only significant deviation is recorded at 5:00 p.m. and 7:00 p.m., when a slight increase in travel (up to 8%) is observed on match days, likely linked to the approaching sporting event and local travel by those going to the stadium or benefiting from it (e.g., traffic, services, commercial activities).

Even in the evening (from 8:00 p.m. onwards), the 'stadium' curve remains substantially in line with the weekday curve, with a slight increase at 8:00 p.m. and 11:00 p.m., probably due to the post-match exodus. However, there are no off-scale peaks or concentrations that alter the ordinary curve: the urban system absorbs the event flows without any particular discontinuity.

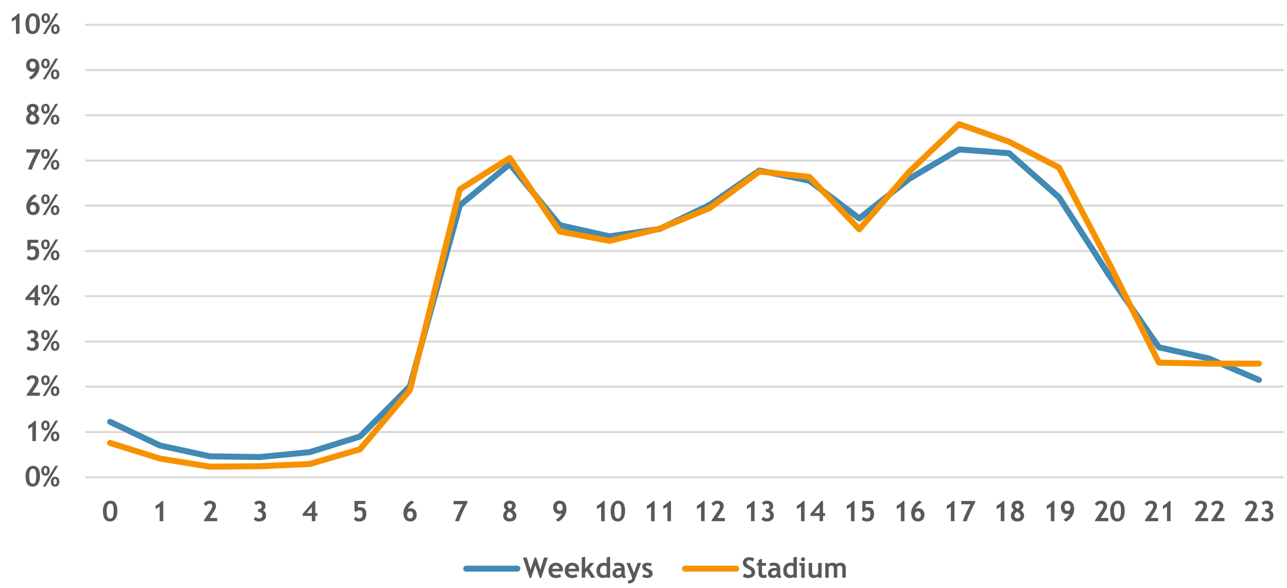

Figure9Hourly distribution of internal movements in Bologna on a typical weekday and on a weekday with an event at the stadium - November 2024 (Source: GO-Mobility analysis)

Focusing **solely on total outbound movements from the Renato Dall'Ara stadium area**, a clear and localized effect linked to the sporting event emerges, especially in the evening (Figure 25). Until 9:00 p.m., the travel curve on match days follows a pattern very similar to that of an average weekday, with minimal deviations reflecting normal neighborhood, school, and work mobility. However, starting at 10:00 p.m., the first signs of a discrepancy appear: the share of outbound travel rises from 2% on weekdays to 4% on match days.

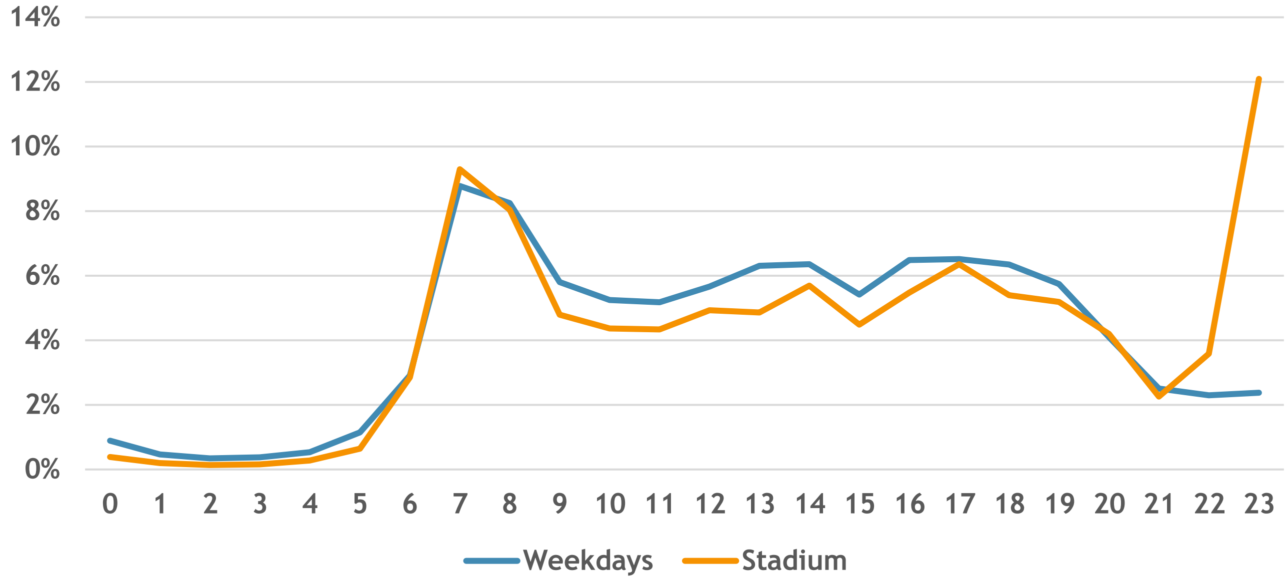

Figure 25 Hourly distribution of total trips originating from the Renato Dall'Ara stadium area on a typical weekday and on a weekday when there is an event at the stadium - November 2024 (Source: GO-Mobility analysis)

However, the most significant data emerges in the 11:00 p.m.-midnight time slot, where the curve for the day of the match reaches a peak of 12%, compared to 2% on an average weekday. This increase is unequivocally attributable to post-match traffic, which concentrates a significant portion of mobility demand in a limited time frame, when the neighborhood normally experiences low traffic intensity.

This is clear evidence of the pressure exerted by the event on the local system, which requires attention not only during the influx phases but also (and above all) in the management of the evening outflow, when the effect on accessibility, the road network, and any public transport services can be more critical for coexistence with ordinary mobility.

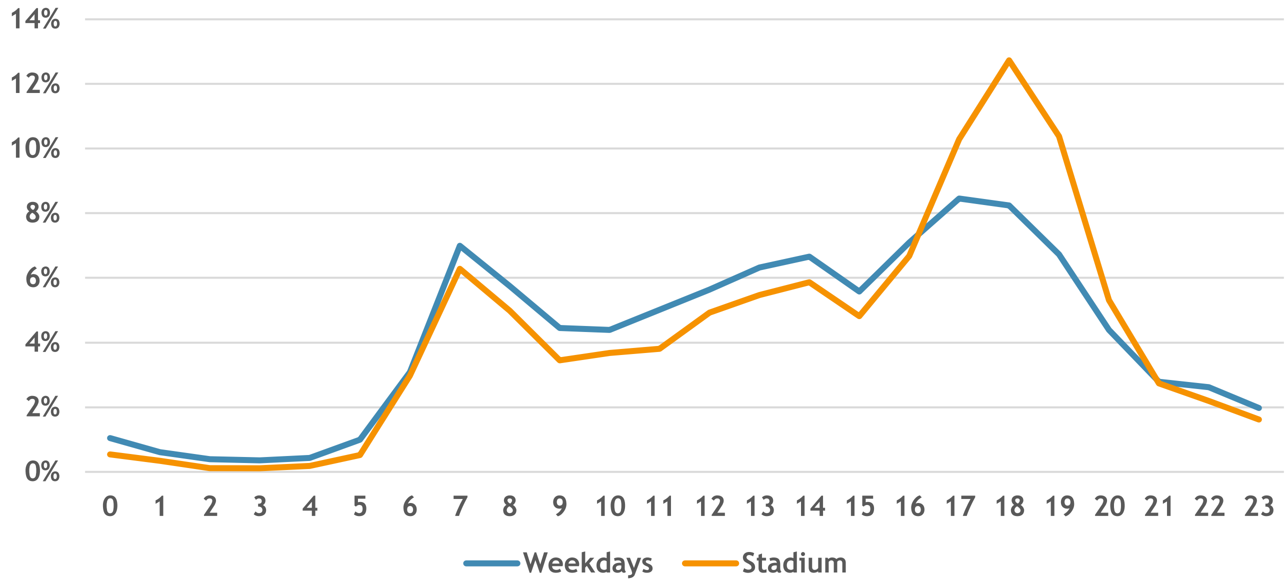

Figure 26 Hourly distribution of total trips to the Renato Dall'Ara stadium area on a typical weekday and on a weekday when an event is taking place at the stadium - November 2024 (Source: GO-Mobility analysis)

At the same time, focusing the analysis on **total journeys into the Renato Dall'Ara stadium area on match days**, these show an hourly profile that is broadly similar to the average weekday ( ) until late afternoon, but with clear differences in the early evening slots, which clearly highlight the pressure exerted by the event on the local system (Figure 26). Until 4:00 p.m., the percentages of arrivals on the day of the match are almost identical to those of the average weekday, suggesting that ordinary systematic mobility (work, school, services) maintains its usual pattern.

However, starting at 5:00 p.m., the picture changes significantly: there is a gradual increase in arrivals, peaking at 6:00 p.m. (13%), well above the average weekday value (8%). This time slot marks the start of the influx of fans and staff heading to the stadium, but even at 7:00 p.m., the percentage remains high (10%), with higher values than on a typical day. The distribution of arrivals on match days therefore shows a concentration between 5 p.m. and 7 p.m., which adds to normal traffic and increases pressure on the road network and public transport.

In contrast, in the following hours, the curve returns to the weekday profile: between 8:00 p.m. and 11:00 p.m., arrivals are stable or slightly decreasing, consistent with the closure of access once the event has started. This suggests that the impact of the influx is concentrated over a period of two to three hours and requires dedicated management in terms of security, traffic management, and support services to ensure accessibility and safety without compromising regular urban mobility.

Overall, therefore, the evidence provided by the analysis of the stadium area suggests that, **although generating localized and concentrated pressure in the hours immediately before and after the event**, a midweek soccer match **does not structurally alter established urban mobility patterns**. The influx and outflow associated with the event are superimposed on internal urban demand in Bologna, which remains **stable and resilient** and appears capable of **absorbing temporary peaks** without any noticeable disruption to the overall travel pattern.

The local impact, although limited, is nevertheless significant, with an **estimated pressure of around 10% more than the ordinary mobility in the area**, i.e., around **30,000 additional trips on a basis of 260,000 exchanges with the rest of the metropolitan area**. Even in the presence of symbolically significant and potentially attractive events, therefore, the city **maintains a functional capacity to adapt,** integrating such phenomena into the usual flows.

4. Repeatable methodology for the calculation of potential demand and defining service levels in low demand areas

This chapter aims to provide a **methodological and operational framework to support the identification of effective solutions for the planning of public transport services** (including DRT services) in the metropolitan area of Bologna, with particular reference to the organization of service areas and their articulation according to demand.

The work falls within the guidelines established by Resolution No. 48/2017 of the ART and aims to provide elements consistent with the objectives of Measure 3, which requires an assessment **of the most suitable modes and types of transport to meet low demand**, taking into account economic, environmental, and contextual variables, as well as the principles of modal integration and sustainability.

In order to outline a coherent and objective picture, the chapter integrates two complementary analyses:

- the ***definition of areas with low demand***, in implementation of Measure 2 and in accordance with the criteria set out in Article 4, paragraph 4, of Ministerial Decree 157 of March 28, 2018, which guides the identification of the least densely served areas or those with the most fragile demand levels;
- ***the definition of a methodology for calculating potential demand and service levels***, in line with the provisions of Measure 3, in order to understand the geographical and temporal distribution of mobility needs, drawing on the detailed information provided in the previous chapter §2.5.1 and with a specific focus on areas with low demand.

With regard to the first point, the information sources used (including territorial, socio-demographic, and local public transport supply and demand databases) are illustrated, as well as the indicators to be calculated in accordance with MIT Ministerial Decree No. 157. In addition, the results of the identification of municipalities with low demand in the metropolitan area of Bologna are presented, with the aim of providing technical support for the definition of a service configuration capable of responding in a targeted manner to the different characteristics of demand, both in urban and less densely populated areas.

The methodology proposed for calculating potential demand and service levels in areas with low demand is designed to be clear and replicable, so that it can be reused in subsequent phases of planning, updating, or verification of DRT services.

4.1. Methodology for identifying 'low-demand' areas in accordance with DM 157/2018

Based on the above, the identification of areas with low demand is a key step in the local public transport service planning process, especially in relation to the need to ensure a minimum level of accessibility even in less dense or more fragile areas from a socio-demographic and economic point of view. Accordingly with Article 4, paragraph 4, of the Decree of the Ministry of Infrastructure and Transport No. 157 of March 28, 2018, the analysis of these areas must be conducted on the basis of ***objective indicators*** capable of providing a coherent representation of the territorial characteristics and potential mobility.

The orographic, temporal, subjective, or socio-economic characteristics of a territorial area determine the presence of areas in which potential mobility is modest, spatially dispersed, or rare over time, and can therefore be defined as "low demand." Specifically, this phenomenon is closely related to factors such as:

- the ***physical conformation of the territories***, such as orography, population distribution and density, degree of urbanization, and accessibility;
- the ***social and demographic structure of the population***, with particular reference to 'vulnerable' groups such as minors, the elderly and the disabled;
- ***economic conditions***, which influence the degree of inclusion and autonomy in travel.

When these factors reach critical levels, the generative potential of mobility is low, resulting in limited transport demand that is unevenly distributed in space and/or time. In such contexts, even in the presence of low demand, there is still a need to ensure adequate, integrated, and sustainable mobility solutions, in line with the principles of equity and territorial cohesion.

Therefore, in accordance with Resolution No. 48/2017, the identification of areas with low demand in the metropolitan area of Bologna was carried out by examining the five territorial and socio-economic indicators provided for in Ministerial Decree 157/2018. The following paragraphs detail the indicators established by the ministerial decree, accompanied by the relevant thresholds, information sources, and calculation methods.

4.1.1. Indicators for the assessment of areas with low demand

The indicators provided for in Ministerial Decree No. 157 for calculating areas with low demand were created with the aim of providing parameters capable of **objectively and comparably describing the territorial, socio-demographic, and economic characteristics of the various areas of the basin**. These indicators make it possible to assess the presence of structural conditions that hinder or limit the potential demand for collective mobility, providing a useful information base for defining priorities for action, designing coherent services, and planning service areas.

This section lists the indicators used for the analysis, divided into the two categories provided for by Ministerial Decree No. 157:

- ***primary indicators***, which represent the structural factors most directly linked to the generation and concentration of public transport demand;
- ***secondary indicators***, which supplement the analysis by providing additional contextual elements useful for territorial interpretation and calibration of the assessment.

'Primary' indicators

Primary indicators represent the fundamental structural factors for identifying areas with low demand, as they directly describe the generative capacity of mobility, the demographic composition of the population, and the degree of remoteness of the territories:

- ***Generative potential:*** a municipality is considered to have low demand if it generates a total number of daily trips of less than 3,000 according to data provided by ISTAT. This value represents an indicative threshold for identifying areas with low mobility density and therefore limited demand for public transport services;
- ***Demographic composition of the population:*** a municipality is considered to have fragile demand characteristics if more than 10% of the population belongs to the school age group (5-24 years) or if more than 10% consists of residents over the age of 70[1] . These groups are typically associated with greater dependence on public transport or specific forms of mobility;
- ***Degree of peripherality***: municipalities with a degree of peripherality of 'D' (*intermediate*), 'E' (*peripheral*) or 'F' (*ultra-peripheral*) are considered to be indicators of low demand. This classification[2] is based on the functional distance from the main centers and the availability of essential services, indirectly reflecting the difficulty of access to mobility opportunities.

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[1] Source: Resident population as of December 31, 2023, according to ISTAT

[2] Source: Metropolitan Statistical Atlas based on ISTAT data "Map of Internal Areas" ([https://www.cittametropolitana.bo.it/atlantemetropolitano/territorio/Mappe_Abitazioni/mappe_aree_interne/tabelle_aree_interne/mappe_aree_interne)](https://www.cittametropolitana.bo.it/atlantemetropolitano/territorio/Mappe_Abitazioni/mappe_aree_interne/tabelle_aree_interne/mappe_aree_interne)

Secondary indicators

Alongside the primary indicators, which represent the main structural reference factors for identifying areas with low demand, the methodology provides for the integration of ***secondary indicators*** capable of capturing additional elements of territorial complexity. Although these indicators alone are not sufficient to define an area as weak, they help to refine the knowledge base and better interpret the local dynamics that influence potential mobility and access to services. In particular, two relevant aspects are considered:

- ***Altitude range***: the difference between the maximum and minimum altitude above sea level in the municipal area is a useful indicator of the degree of orographic complexity of the territory. Values above 600 meters suggest a rugged morphology, which can constitute a natural obstacle to mobility, continuity of access, and rationalization of public transport services.
- ***Territorial dispersion***: this indicator measures the fragmentation of the settlement fabric within the municipality, through the average distance between the municipal center and its hamlets or districts, weighed up by the population residing in the hamlets themselves. Situations where the average distance exceeds 1.5 km are considered critical, as this leads to greater difficulty in providing service coverage and a potential increase in operating costs to ensure widespread accessibility.

To address the limited availability of data on the precise location of settlements, the indicator relating to territorial dispersion was calculated using the ***degree of urbanization*** provided by ISTAT and Eurostat for each municipality[3] . In particular, municipalities classified in ***class 3***, corresponding to so-called **'rural or sparsely populated** areas', were identified as critical, as they are more exposed to conditions of settlement isolation and difficulties in providing services.

4.1.2. Data sources used

This section briefly describes the information sources and territorial data used, with particular reference to their use in constructing the indicators and supporting the classification analysis.

Commuting Matrix - ISTAT (2019)

To construct the indicator relating to the generative potential of travel, ISTAT data on commuting for study and work purposes, updated to 2019, was used[4] . This choice was made because this information is fully consistent with the logic of Article 4, paragraph 4, of Ministerial Decree 157/2018, which identified systematic travel as a key factor in assessing the weakness of public transport demand.

The indicator takes into account the total number of daily trips generated by the municipality (i.e., outgoing) for study or work purposes, assuming a reference threshold of 3,000 trips/day. Municipalities that generate less than this threshold are classified as having low generative potential and therefore potentially falling within low demand areas.

The use of ISTAT data on commuting ensures territorial comparability, updating, and regulatory consistency, representing a solid and recognized indicator for assessing structural mobility demand.

Territorial and socio-demographic data - ISTAT

Among the main sources used to construct the indicators required by Ministerial Decree 157/2018, the data provided by ISTAT are an essential reference point due to their territorial coverage, temporal continuity,

[3] Source: ISTAT (https://www.istat.it/classificazione/principali-statistiche-geografiche-sui-comuni/)

[4] Source: Territorial mobility: changes of residence and daily commutes - ISTAT (https://istat.maps.arcgis.com/apps/dashboards/8ec70613105d4846849ca4cb49d416fb)

and methodological consistency. The combined use of these data makes it possible to calculate robust, territorially comparable, and up-to-date indicators that meet the requirements of transparency and replicability for identifying low demand areas.

Specifically, the following datasets were used: resident population by age group, municipal altitude variation, and degree of urbanization.

Map of Internal Areas - ISTAT (2022)

The ***Map of Internal Areas*** is a tool developed as part of the National Strategy for Internal Areas (SNAI) with the aim of identifying, on a municipal basis, Italian territories characterized by structural disadvantages in terms of access to essential services (education, health, mobility), depopulation, and socio-economic fragility. The classification is based on a functional and dynamic approach, which considers distance from hubs (i.e., centers capable of offering an adequate level of essential services) as the guiding criterion for defining internal territories. The basic territorial unit is the municipality, which is classified into one of the following five categories:

- ***Pole***: municipality or group of municipalities with a significant provision of basic services and high attractiveness (*class A*);
- ***Belt***: municipalities directly connected to the poles, which gravitate functionally towards them (*class C*);
- ***Intermediate***: municipalities with increasing functional distance from the poles, but still not completely isolated (*class D*);
- ***Peripheral***: municipalities distant from the poles, with reduced access to services (*class E*);
- ***Ultra-peripheral***: municipalities very distant from the poles, with serious connection problems and accentuated structural fragility (*class F*).

This classification is updated periodically (most recently in 2020) based on data relating to road travel times from municipalities to hubs and the presence of essential services. It is an important source for analyzing areas with low demand, as it captures the components of isolation, low density, and social fragility that often coincide with low demand for public transport and limited territorial accessibility.

4.1.3. Identification of areas with low demand

The analysis of the primary and secondary indicators provided for in Ministerial Decree No. 157 and described in the previous paragraph §4.1 therefore leads to the identification of two levels of areas with 'low demand':

- Areas ***with 'potentially low*** demand', where demographic and territorial characteristics determine an intrinsic weakness in transport demand. This category includes territories that **exceed all the thresholds of the primary indicators**;
- Areas ***with*** "***priority low demand***," where "intrinsic weakness" is compounded by additional urban/territorial factors. These are identified among territories where, **in addition to exceeding the threshold for primary indicators, at least one secondary indicator is also exceeded**.

Areas with "potentially" low demand

The municipalities that constitute 'potentially low demand' areas, i.e. those that 'activate' all three primary indicators (respectively shown inFigure10 ,Figure11 andFigure12) are the 11 shown in orange in the followingFigure13 .

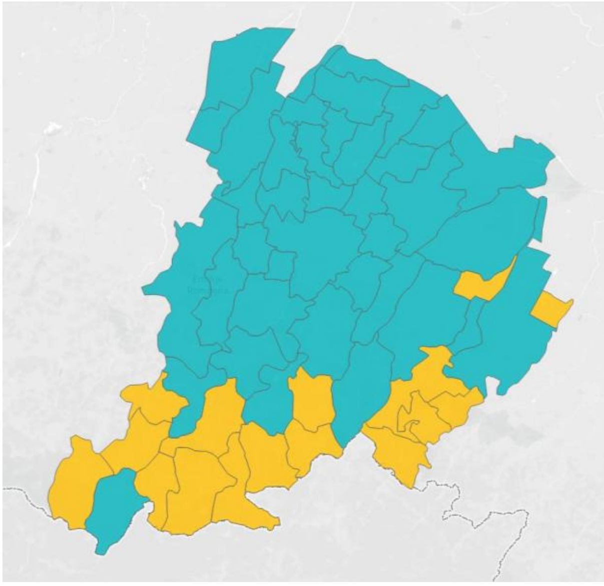

Figure10 Municipalities identified by the 'Generative potential' indicator (Source: GO-Mobility calculations)

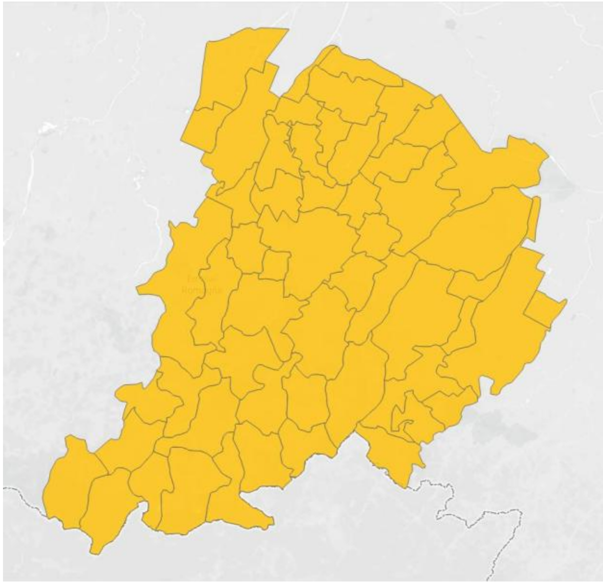

Figure11 Municipalities identified by the "Population composition" indicator (Source: GO-Mobility calculations)

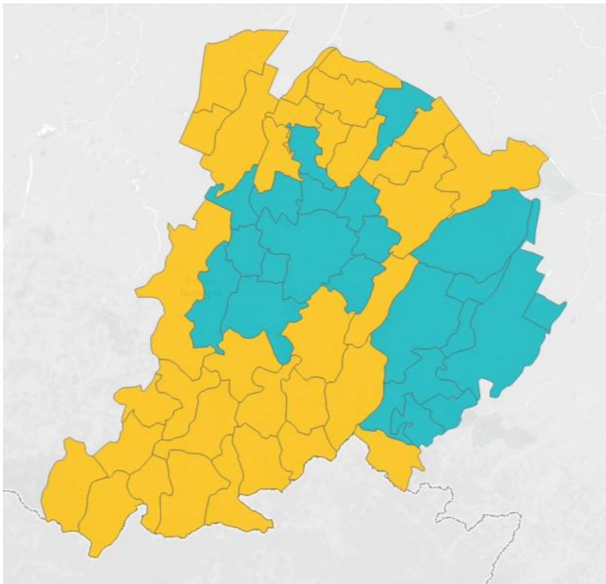

Figure12 Municipalities identified by the "Degree of peripherality" indicator (Source: GO-Mobility calculations)

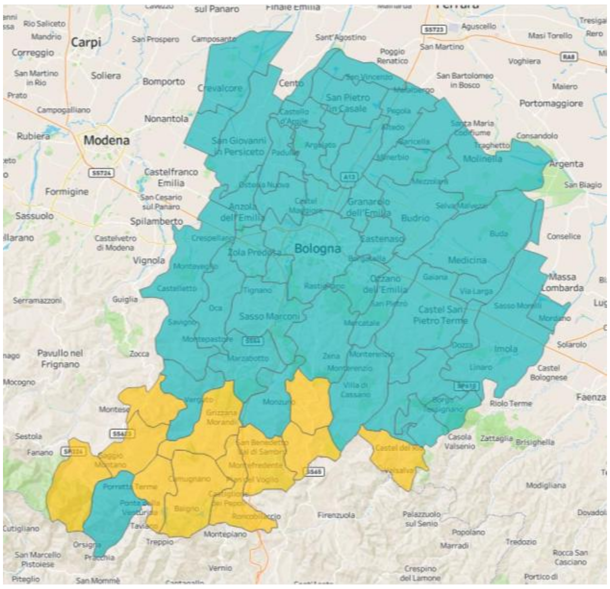

Figure13 Municipalities identified as "potentially low demand" (Source: GO-Mobility calculations)

Areas with "priority" low demand

The municipalities where the "secondary" indicators are activated are listed below (Figure14 andFigure15), while the map atFigure16 shows all 11 municipalities to be considered **"priority areas with low demand."**

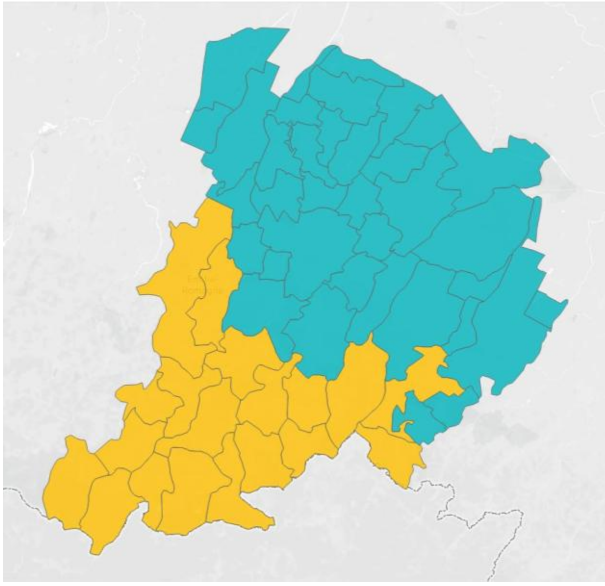

Figure14 Municipalities identified by the "Altitude range" indicator (Source: GO-Mobility calculations)

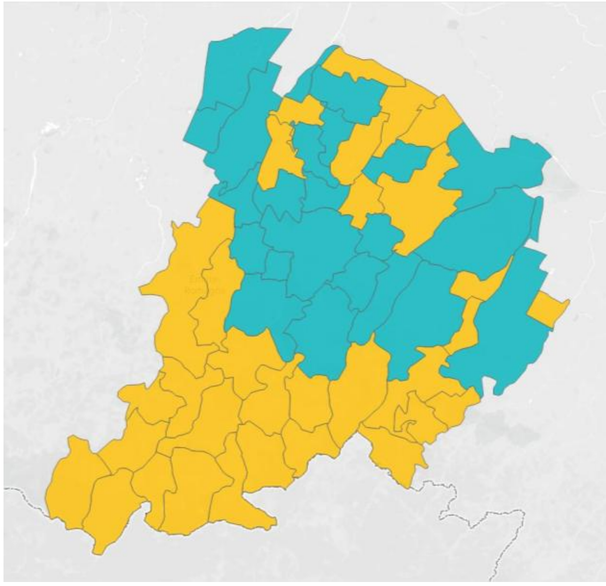

Figure15 Municipalities identified by the "Territorial dispersion" indicator (Source: GO-Mobility calculations)

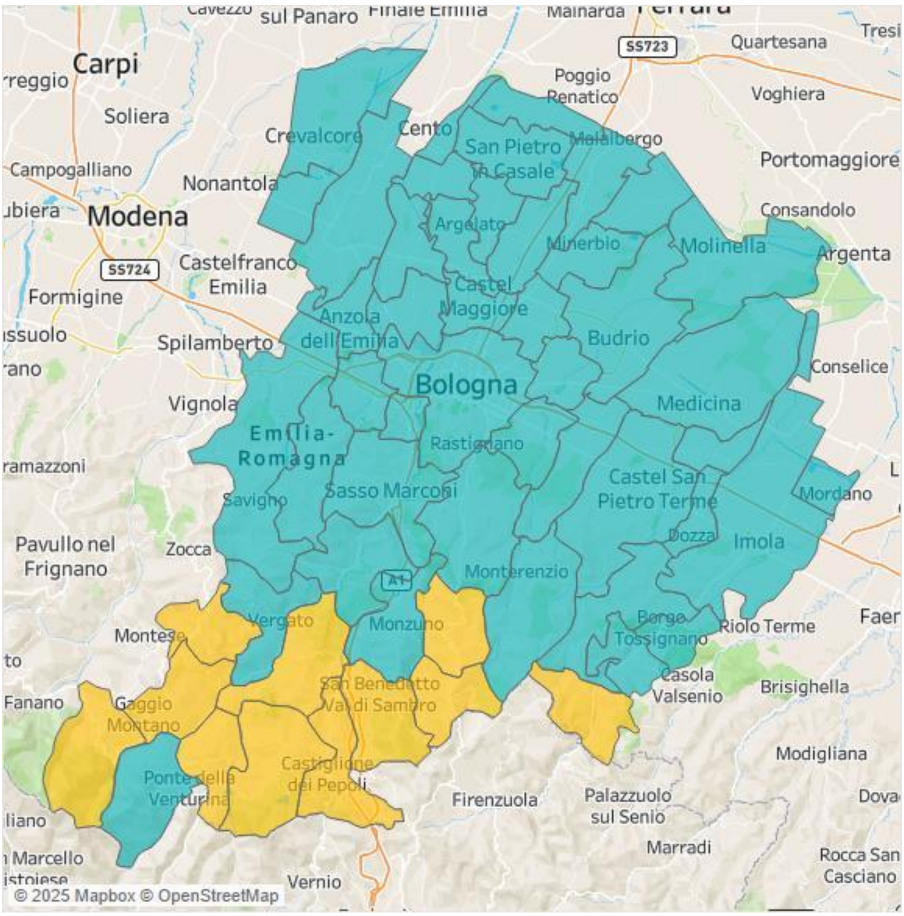

Figure16 Municipalities belonging to areas with "low priority demand" (Source: GO-Mobility analysis)

4.2. Methodology for calculating potential demand and defining service levels in areas with low demand

As indicated in Measure 3 of Resolution 48/2017, the effectiveness of planning choices depends on the ability to accurately identify the characteristics of demand in different segments of the territory, and in particular to recognize areas and relationships where demand is weak, discontinuous, or concentrated in specific periods or times. It is precisely in these contexts that it is crucial to identify flexible, integrated, and sustainable service modes that can guarantee accessibility while minimizing costs and externalities.

In order to allow for an objective and replicable classification of low demand areas, national legislation defines a methodological framework based on measurable technical criteria and territorial and mobility data. This section therefore describes the methodology used **to calculate potential demand and define service levels in areas with low demand in the metropolitan area of Bologna**, as well as the choices made to ensure consistency with regulatory references and adaptability to the local context.

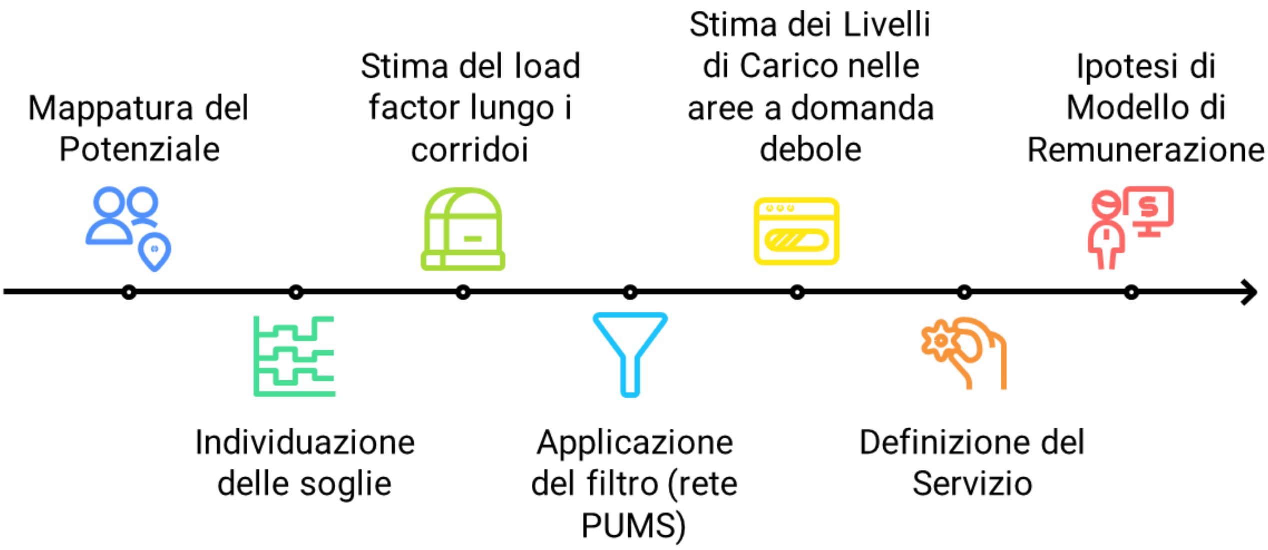

Figure 34 Graphical representation of the proposed methodology for calculating potential demand and defining service levels in areas with low demand (Source: GO-Mobility)

The identification and characterization of areas with low demand is carried out through a replicable methodological process, divided into several phases but readable as a logical and operational sequence (seeFigure 34).

1. ***Mapping of generative and attractive potential***: each area of the territory is analyzed in terms of the density of trips generated and attracted (in relation to the surface area), in order to construct a synthetic parameter of "potential demand";
2. ***Identification of classification thresholds***: **areas with very low potential demand** (e.g., less than 2-5 movements/km²) are distinguished from those with **high movement intensity** (e.g., over 60-80 movements/km²), corresponding to the main corridors of the public transport network. Intermediate areas are subject to specific assessment;
3. ***Estimation of load along the main corridors***: by calculating passenger*km, the expected volumes on board the services are assessed and compared with the available capacity (*load factor*) to estimate the number of trips required and the compatibility of the service with high-capacity (e.g., rail) or lighter (bus) modes;
4. ***Application of the filter to the existing network***: areas with low demand are reanalyzed in light of the public transport network provided for in the PUMS (Metropolitan Urban Transport Plan) of the metropolitan city of Bologna to assess its actual coverage and the frequencies offered. At this stage, areas served by the network provided for in the PUMS are excluded from the analysis;

5. ***Simulation of load levels in areas with low demand by type of relationship***: for each area with low demand, the expected number of passengers traveling to Bologna, to other municipalities, and within the same area is calculated. This defines the demand for calibrating the service;
6. ***Definition of the implementation and flexibility of the DRT service***:
    - *Operation*: a threshold is identified below which the service will not be activated (e.g., on routes where fewer than five passengers per trip are estimated);
    - *Flexibility*: spatial and temporal criteria are applied to decide whether the service should be fixed, regular, on demand, or on variable routes, depending on the concentration of demand.
7. ***Hypothesis for a DRT service remuneration model***: the methodology concludes with a preliminary indication for defining the economic model for the service, taking into account the estimated demand and the selected operating methods.

4.3. Guidelines for the replicable application of methodologies

Finally, this section provides some operational guidelines for replicating and adapting the methodologies developed in the analysis of mobility demand and service levels, with particular attention to contexts characterized by low population density and/or low demand.

Replicability concerns the two main methodological areas described in the document:

- on the one hand, ***the data fusion approach***, in terms of the integration of heterogeneous data sources with a view to producing a regularly updated and detailed picture of mobility behavior;
- on the other hand, the ***methodology for estimating potential demand and evaluating transport service levels in areas with low demand***.

Both methodologies can therefore be adapted to different territorial contexts, provided that up-to-date data is available, and represent replicable operational tools to support public transport planning at local and metropolitan level.

4.3.1. Data fusion process

The data fusion methodology described in this document has been structured from the outset to be ***replicable and updatable over time***, thus responding to the need to keep knowledge of mobility behavior in line with the evolution of socio-demographic, technological, and infrastructural contexts. In particular, the system developed allows both information outputs illustrated in paragraph §2.5 (overall matrix and detailed database for areas with low demand) to be regenerated whenever one or more information sources are updated or made available for more recent time periods. This flexibility is guaranteed by the modular nature of the process, which allows specific update phases to be inserted into the processing chain without the need to rebuild the entire data flow from scratch.

The information base may be updated in three different situations, each of which requires specific actions:

1. Updating socioeconomic data (e.g., new ISTAT estimates);
2. Updating the mobility survey (e.g., new campaigns in preparation for future updates to the PUMS);
3. Updating telephone data (which also involves a simultaneous update of FCD data to ensure consistency in the enrichment of data from the mobile network).

The following paragraphs describe the operating procedures to be adopted in the three scenarios, indicating for each one which steps of the methodology are involved, which additional processing must be carried out, and which measures must be taken to maintain consistency with previous processing.

In the event of an update of socioeconomic data

If updated socioeconomic data become available (such as new estimates of the resident population, updated data on employment or distribution by age and gender), the data fusion process can be easily adapted through targeted interventions in the early stages of the methodology. In such cases, it is assumed that the update only affects some of the available variables and that the other variables remain unchanged in order to maintain consistency in the reconstruction of flows.

- ***Updating census variables (phase 1)***: the demographic or employment base is recalculated based on the updated dataset. If the update is only available at the municipal level, an unchanged distribution is assumed at more granular levels (e.g., census tracts).
- ***Recalculation of outbound and return journeys (phase 2)***: the mobility indices by user profile calculated from the survey are kept unchanged and applied to the new updated socio-demographic data;
- ***Calculation of percentage changes by municipality (new step)***: the change in the volume of movements for each municipality is estimated compared to the previous version, and these changes are applied to the telephone matrix;
- ***Recalculation of the share of intra-zone trips (phase 3)***: the new demographic structure also affects the internal composition of the zones, requiring an update of the estimated share of trips not detected by the telephone data (intra-zone);
- ***Recalculation of the matrix from the homogeneous zoning survey (phase 3)***: the component derived from the survey matrix is recalculated on the new updated socio-demographic structure;
- ***Regeneration of the two final outputs (phase 3)***: both products of the methodology (both the matrix on aggregate zoning and the detailed database for areas with low demand) are updated, maintaining consistency with the new input bases.

This updating method therefore ensures methodological consistency and allows the evolution of mobility demand to be monitored over time in relation to demographic and socioeconomic changes in the area.

In the event of an update of the mobility survey

If a new mobility survey is conducted for a year following the original survey, the data fusion methodology allows for a consistent update of the knowledge outputs, maintaining the basic structure already developed.

- ***Recalculation of emission and return home indices (phase 2)***: the new survey allows for the re-estimation of mobility indices (average number of trips per person, broken down by socio-demographic profile), calculated on the population of the survey year. These indices represent the basis for estimating trips leaving and returning home;
- ***Calculation of percentage changes by municipality and updating of the telephone matrix (new step)***: the new volumes estimated by the new survey are compared with those of the previous version, estimating the percentage change for each municipality. This change is applied to the estimates of trips derived from mobile phone network data;
- ***Recalculation of the share of intra-zone movements (phase 3)***: the estimated share of movements within zones (not detected by the mobile radio network) is updated using the new survey data to calibrate the intra-zone component;
- ***Recalculation of the matrix from the homogeneous zoning survey (phase 3)***: the travel matrix constructed on the basis of the survey is also updated, taking into account the new zoning and the recalculated volumes, with redistribution on the basis of employees where necessary;
- ***Regeneration of information outputs (phase 3)***: both data fusion outputs are updated to describe the new mobility behaviors.

This updating method ensures that the outputs always remain consistent with the evolution of the behaviors measured through the sample of residents interviewed, maintaining the full reliability of the method even after its initial implementation.

In case of telephone data (and FCD) updates

If updated data from the mobile network and vehicle GPS tracking (Floating Car Data) become available, the entire analysis process can be updated, keeping the methodological structure unchanged and regenerating both outputs.

- ***Application of the bounce elimination algorithm (phase 2)***: the mobile data enrichment algorithm based on comparison with FCD is reapplied, which is essential for correcting any location errors in short-range movements measured through connection to cell towers;
- ***Calculation of variation indices by telephone zone (new step)***: compared to the data previously used, the percentage variations in travel volumes in each zone of the telephone grid are calculated;
- ***Recalculation of the share of intra-zone movements (phase 3)***: the share of undetected movements within zones is updated using the same estimation criteria applied in the initial phase, but recalibrated on the new data;
- ***Updating of correction coefficients for emission and return indices (phase 3)***: to maintain consistency between telephone data and survey matrices, the coefficients on the generation and attraction indices for each zone are recalculated in order to correctly calibrate the output based on the home-based movements of residents.
- ***Regeneration of information outputs (phase 3)***: based on the new information, both the aggregated database on telephone zoning and the high-granularity database for areas with low demand are regenerated, thus ensuring a complete and integrated update of the analytical evidence.

4.3.2. Methodology for calculating potential demand and service levels in areas with low demand

Thanks to its modular structure and full integration with the information outputs generated by the data fusion process, the methodology developed for calculating potential demand and defining service levels in areas with low demand is itself fully replicable and easily updatable.

The analytical framework, built on dynamic databases and fed by automated information flows, is designed to ensure maximum operational flexibility: each new update of information sources (telephone, socio-demographic, or survey) can be incorporated and reprocessed without having to redefine the underlying model, thus allowing subsequent territorial and temporal applications, even in different contexts. In particular:

- **the calculation of the generative and attractive potential** of areas (in terms of movements per km^2) can be updated based on new outputs from the data fusion process, reflecting the most recent developments in mobility behavior;
- **the thresholds for identifying areas with low demand and main corridors** can be kept stable or adapted according to the new mobility densities calculated;
- **the calculation of transported demand and passengers per kilometer** on corridors can be recalculated directly on the basis of the new updated mobility matrix;
- **the estimate of useful demand for the different types of relationship** (towards Bologna, inter-municipal, internal) is updated in line with the new flows, modifying the composition of demand for each area;
- **service activation thresholds** (e.g., minimum 5 passengers/bus) **and spatial and temporal flexibility criteria can remain unchanged** but will be applied to updated data, providing consistently coherent and up-to-date assessments.

This approach not only effectively supports the planning of public transport services in areas with lower demand, but also acts as a continuous monitoring tool, capable of detecting changes in mobility behavior and assessing the impact of policies, interventions, or changes in the settlement structure.

In this sense, therefore, potential demand analysis is not a mere static exercise, but an adaptive and updatable process capable of accompanying the evolution of mobility needs and public service strategies over time.