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Moving identities
Innovating smart mobility guidelines in small and mid-sized towns

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Moving identities. Innovating smart mobility guidelines in small and mid-sized towns

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Abstract (Italian version)

L'obiettivo di questa ricerca di dottorato è quello di favorire lo sviluppo della smart mobility nelle città di piccole e medie dimensioni, per immaginare come saranno le strade del futuro e l'identità urbana delle città. La mobilità è stata uno dei principali ambiti di innovazione del XX secolo, e in questi anni i processi di trasformazione digitale stanno trainando un'ulteriore rivoluzione nel settore verso nuovi modelli di mobilità. Se questi cambiamenti hanno riguardato principalmente le città di grandi dimensioni, cambiando il modo di muoversi e viverle, le città di piccole e medie dimensioni hanno beneficiato solo in parte di queste opportunità. Nell'ambito europeo e soprattutto italiano, questo tema rappresenta una sfida irrinunciabile per promuovere un'idea di città più salubre, responsabile e contemporanea. La ricerca indaga il contributo del progetto urbano alla smart mobility nelle città di piccole e medie dimensioni, sviluppando una metodologia operativa capace di mettere in relazione infrastrutture di trasporto, soluzioni di smart mobility e identità urbana. Dopo un'ampia revisione di letteratura, sono stati presentati una serie di casi di studio per un migliore inquadramento del contesto e del campo di indagine.

Il prodotto principale della ricerca è la definizione di una metodologia per sviluppare strategie di smart mobility in centri di piccole e medie dimensioni considerando il potenziale impatto sulla qualità dello spazio pubblico in termini di accessibilità, prossimità e identità urbana. I risultati ottenuti sono stati testati su un caso studio selezionato nel territorio regionale per verificare i potenziali contributi a livello regionale della smart mobility e approfondire la conoscenza del territorio attraverso le attività di analisi, progetto e ricerca.

Il modello e gli strumenti presentati possono essere utilizzati da tecnici, comunità e amministratori per innescare progetti innovativi di smart mobility in questi territori.

Parole chiave: smart mobility | smart city | urban identity | accessibilità | urban design

Abstract (English version)

The goal of this doctoral research is to promote the development of smart mobility in small and medium-sized cities, envisioning what the streets of the future will look like and how the urban identity will change.

Mobility has been one of the main fields of innovation in the 20th century, and currently the ongoing digital revolution is driving another paradigm shift toward new models of mobility. While these changes have mainly affected large cities, changing the way people get around and experience them, the development of innovative mobility solutions didn’t have the same impact in small and medium-sized cities. This represents an important issue for European and especially Italian cities to promote the vision of healthy, responsible and contemporary towns.

The overall research question address how urban design could contribute to smart mobility in small and mid-sized cities, and is answered through a design-based research methodology that connects transportation network, smart mobility and urban identity. After an extensive literature research, a series of use cases were here presented to frame the context and the design field.

The research outcome is the definition of a methodology to develop smart mobility strategies in small and medium-sized centers that considers the potential impact on public space in terms of accessibility, proximity and urban identity. The results were tested on a selected case study in the Emilia-Romagna region to verify the potential contributions of smart mobility at this scale and to delve regional understanding of the territory through analysis, project and research activities.

The model and tools presented can be used by designers, communities and administrators to trigger innovative smart mobility design in this territories.

Keywords: smart mobility | smart city | urban identity | accessibility | urban design

Table of Contents

List of Figures

List of Tables

List of Abbreviations

ACES	Automated, Connected, Electrified and Shared (mobility)	ML	Machine Learning
AI	Artificial Intelligence	PT	Public Transport
AV	Automated Vehicle	SDGs	Sustainable Development Goals
B2B	business-to-business	STS	Socio-Technical System
B2G	business-to-government	SUMP	Sustainable Urban Mobility Plan
CAV	Connected and Automated Vehicle	TOD	Transport Oriented Development
CV	Connected Vehicle	ToD	Transport-on-Demand
DRT	Demand-Responsive Transport	URF	Unione dei Comuni della Romagna Faentina (Union of Municipalities of Romagna Faentina)
DSI	Digital Social Innovation	UTC	Urban Traffic Control
EV	Electric Vehicles	V2I	Vehicles-to-Infrastructure
ICT	Information and Communication Technology	V2V	Vehicle-to-Vehicle
IoT	Internet of Things	VMS	Variable Message Signs
IT	Information Technologies	PNIRE	Piano nazionale delle infrastrutture di ricarica elettrica (National electric charging infrastructure plan)
ITS	Intelligent Transportation Systems	P-LOS	Pedestrian Level Of Service (Highway Capacity Manual)
KET	Key Enabling Technology	P2P	Peer-to-Peer
MaaS	Mobility as a Service		

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The European Social Fund (ESF), founded in the foundation year of the European Economic Community, is one of Europe’s major financial mechanism for investing in high-level education. Europe allocates economic resources to the member states with the goal of investing in the development of strategic skills to match the evolution in the labor market.

This research project develops one of the research areas identified by the “Memorandum of Understanding for the activation of the ‘Three-year project for the expansion of the research laboratory and the construction of a research and training center on the contemporary smart and sustainable city’” as part of the “Smart city 4.0 Sustainable Lab - SC4.0SL” research laboratory. The regional lab is coordinated by the University of Parma and consists of the regional stakeholder table, the interdisciplinary/interuniversity network and the inter-university working group. This organization has then established a network of researchers and teachers to which, in addition to Parma, the Universities of Piacenza (Cattolica and Politecnico), Reggio Emilia and Modena, Bologna and Ferrara have joined.

In this area, five research fields have been defined referring to doctoral research namely “Strategic Urban Design”, “Urban Ethics”, “Historical City Identity”, “Automated Mobility for the Smart City”, “Information Engineering” and “Smart Cities and Smart Regions”. This scholarship relates to the research training project of the University of Ferrara and the field of “Historical City Identity.” All doctoral fellowships are intended to contribute to the goals of the “Three-year project for the expansion of the Research Laboratory and the establishment of a research and training center on the contemporary smart and sustainable city” as part of the smart city 4.0 sustainable lab.

The act of approval of the ranking and fundability of research training projects is GR Resolution No. 1114 of 08/07/2019 entitled “Alte competenze per la città contemporanea intelligente e sostenibile: approvazione dei progetti di formazione alla ricerca presentati a valere sull’invito approvato con DGR n. 793/2019. POR FSE 2014/2020”.

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Chapter 3 reviews a range of applied research conducted before and during the development of this

thesis. We report below the credits of the research presented, referring for further information to the full research reports and to the authors:

Research title: “CASTELLO SMART TOWN PLANNING”
Year: 2017
Research team: CFR Consorzio Futuro in Ricerca – MD Next City lab. Walter Nicolino (coordinator), Gabriele Lelli (coordinator), Marco Negri (project manager), Ilaria Fabbri
Advisors: prof. Alfonso Acocella, prof. Theo Zaffagnini, prof. Giuseppe Mincolelli, prof. Andrea Rinaldi
Financial support: Municipality of Castel Bolognese (RA)

Research title: “BiCi A CB. STRATEGIE PER UN PIANO DELLA MOBILITÀ INNOVATIVA”
Year: 2018
Research team: Strategic design, Design coordination, innovative urban cycleway project: CFR Consorzio Futuro in Ricerca – MD Next City lab. Gabriele Lelli (coordinator), Marco Negri (project manager), Ilaria Fabbri
Rural cycleway project: GEAprogetti
Financial support: Municipality of Castel Bolognese (RA)

Research title: “INNOVATIVE REGENERATION STRATEGY”
Year: 2018
Research team: CFR Consorzio Futuro in Ricerca – MD Next City lab. Gabriele Lelli (coordinator), Marco Negri (project manager), Ilaria Fabbri
Financial support: Municipality of Castel Bolognese (RA)

Research title: “SMART COMMUNITY AND MOBILITY”
Year: 2018
Research team: EI4SMART srl + MD Next City Lab. Gianni Lodi, Gianluca Cristoforetti, Gabriele Lelli (scientific director), Marco Negri (project manager), Ilaria Fabbri
Technology solutions employed: “pedibus 2.0” e “kids go green” by Bruno Kessler Foundation - FBK
Involved institutions and financial support: Ministry of the Environment, Union of municipalities of Romagna Faentina, Municipality of Castel Bolognese

Research title: “SMART MOBILITY NETWORK – PART I”
Year: 2020
Research team: MD Next City Lab. Gianluca Cristoforetti, Gabriele Lelli, Marco Negri, Ilaria Fabbri
Financial support: Municipality of Faenza

Research title: “SMART MOBILITY NETWORK – PART II”
Year: 2021
Research team: MD Next City Lab. Gianluca Cristoforetti, Gabriele Lelli, Marco Negri, Ilaria Fabbri
Financial support: Municipality of Faenza

Project title: “STRADAPERTE FAENZA”
Year: 2022
Project team: Gabriele Lelli – LBLA+Partners, Andrea Luccaroni – LBLA+Partners,
Research consultant: Marco Negri
Financial support: Union of municipalities of Romagna Faentina, Municipality of Faenza
Contractors: Montana Valle del Lamone Soc.Coop.p.a., Lorenzoeventi s.r.l., Safer s.r.l.

Research title: “AUTONOMOUS DRIVING IN FAENZA”
Year: 2022
Research team: Marco Negri, Otello Palmini, Mariaelena Busani
Financial support: -
Project developed as one of the master thesis of MICmaster – Academic master programme level II A.A. 2020-2021

Finally, the author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this PhD thesis.

Chapter 1.

Introduction and research background

1.1. Introduction

Mobility has been a key area of innovation in the 20th century, easing the movement of people, goods, and information at an increasingly rapid pace. This acceleration gained momentum between the late 20th century and the early 21st century, driven by digital technologies and the consequent process of digital transformation. Various authors emphasized the strategic role of information and communication technologies (ICT) and networks in innovating cities, providing a competitive edge (Batty, 1990; Hall, 2014). Then, the notion of smart mobility has emerged: a brand-new concept that gathers multiple approaches and experiences within mobility planning to leverage opportunities presented by technological, social, and environmental progress (Bıyık, C. et al., 2021).

In urban settings, where smart mobility has been extensively deployed, this has led to a reflection on the current mobility culture and its future. Shifting from an approach stemmed from transportation engineering, focused on optimizing car traffic and infrastructure development, it made a transition to mobility planning, that considers also its environmental, social, and cultural impact. A reviewed approach more focused on accessibility solutions that enhance the wellbeing of cities, residents, and city users.

Smart mobility has had a lower uptake in small and mid-sized towns, mainly adopting solutions from larger urban areas. Despite the limited research context, several studies and projects revealed innovative smart mobility solutions tailored for rural areas and addressing similar needs, such as reducing traffic, enhancing public transportation, promoting active mobility, and improving territorial accessibility (Bonomi and Masiero, 2014). However, the limited amount of these studies and the diversity of rural areas slowed down a comprehensive investigation of rural mobility culture innovations. We are therefore witnessing a progressive decoupling between smart mobility proposals for cities and those for small and mid-sized towns. In the past decade this phenomenon has confined “smart” discourse primarily to global cities, following an exclusive logic that disregards the newness of innovations already occurring in rural areas. This highlights the need for a different perspective where “the inevitability of Total Urbanization must be questioned, and the countryside must be rediscovered as a place to resettle; to stay alive” (Armstrong, Therrien and Koolhaas, 2020, p.3)

Further elements support the need to study smart mobility in these contexts. First of all, the physical and demographic significance of small and mid-sized towns, with 48.7% of the EU's total area consisting of towns, suburbs, and rural areas near cities, and 30.6% of the population residing in rural areas (EU, 2019). While the size of the areas represents the broadness of this issue in terms of square meters, the demographics highlights the social issue represented by a rapidly ageing population that has limited access to services and connectivity compared to those living in cities.

Secondly, the ongoing transformation of urban mobility introduces new means of transport, mobility solutions, and design criteria impacting both urban and rural areas. A new set of mobility solutions designed to entice travelers to more sustainable options, new design criteria for inclusive, people-oriented, healthy streets. Smart urban mobility innovations such as ITS, DRT, EVs, CAVs, alternative fuel systems are currently used in urban and suburban contexts to evaluate their effective impact in terms of social and environmental sustainability (Butler, Yigitcanlar, and Paz, 2020). A recent UIA report on Innovation in Urban Mobility in the 2020s (UIA, 2022) points out three essential issues: the contribution of data to exploit and transform the urban mobility landscape, the role of collaboration in mobility policy to deliver a multi-modal mobility system, and the importance of nudging mobility behavior towards greener, healthier and safer mobility options. Despite the existing challenges, the paper suggests that there are concrete opportunities to move ahead toward a more sustainable mobility scenario.

A third element is the need to support the ability of small and mid-sized towns to manage innovation, creating a long-term vision. Most small municipalities have limited organizational and economic resources, unlike larger cities that have dedicated structures to deploy and manage smart city solutions (CCDR 2023). Furthermore, smaller contexts often lack up-to-date transportation policies and rely on private initiatives, adopting solutions without a specific assessment. As a consequence, rural smart mobility projects may result in limited mobility options for residents who often resort to personal means of transport (Lorenzini, Ambrosino, and Finn, 2021).

Motivated by these considerations and a personal interest in suburban conditions, this doctoral research aims to explore smart mobility in small and mid-sized towns, examining its most relevant impacts on urban design. Starting with an apparently straightforward question – what will future mobility spaces look like in these towns? – the study will investigate how smart mobility solutions and strategies can be applied to low-density areas and the expected impact on their urban identity. The discussion on the potential contribution of urban design is grounded in the observation that innovative mobility solutions - EVs, shared mobility, AVs, and micromobility – mostly arise from the transportation industry without providing an idea of the city (Rykwert, 2002). This research aims to engage with the smart mobility landscape, considering urban design as its critical counterbalance to enhance the quality of life in small and mid-sized towns.

1.2. Research background

1.2.1. Smart mobility and urban identity

The research aims to explore the relationship between mobility and urban identity. In the following paragraphs, we will provide a preliminary framework to illustrate this part of the research background and the goals of this thesis.

Various studies highlighted the social and cultural role of mobility. According to the theory of sociotechnical transitions, mobility is considered one of the societal functions, fulfilled through sociotechnical systems, alongside housing, energy supply, and feeding. Sociotechnical systems are defined as "a cluster of elements, including technology, regulation, user practices and markets, cultural meaning, infrastructure, maintenance networks, and supply networks" (Geels, 2005). This model, while capturing the cross-cutting nature of mobility, considers it within a broader perspective, incorporating elements present in urban identity studies. Here we should remark on how urban identity is a multifaceted concept studied in different disciplines. While studies could lead to different perspectives and meanings, this concept often revolves around the qualities that distinguish someone or something from others (Heidegger, 2009). Among the various contributions found in literature, Relph's seminal work (1976) will be our main reference on identity issues, as it provides a model still practiced by most scholars for identifying the character of places through clear, concise, and systematic analyses.

Building on these premises, it becomes even more evident that mobility innovations impact the identity of places and cities. According to Relph, the fundamental components of place identity are physical setting, meanings, and activities. While these components are interconnected, we can break them down to allow better understanding: the physical setting is formed by the major features of a place, its objects, materials, and location; the activities, which are the observable actions of people in public spaces which influence and complement the physical setting; and meanings, the properties of human intentions and experiences that may change over time (Relph, 1976, pp.46-47). These elements align with the definition of sociotechnical systems and their dimensions, with the physical setting akin to infrastructure and maintenance networks, activities to user practices and markets, and meanings to cultural meaning. Therefore, when design addresses these elements—infrastructures, users, and cultural meanings—we influence urban identity. When mobility innovations modify these elements, the character of places can also change.

These considerations are particularly evident in the 20th century, with mobility innovations profoundly shaping the form and the identity of cities. The global phenomenon of mass motorization had varying impacts depending on the level of industrialization in different geographical areas, and lead to urban planning geared towards facilitating vehicle movement (Buchanan, 2015). In Italy, mass motorization significantly influenced transport culture, particularly due to the concurrent development of mass society and motorization in the same period. This had a profound impact on the identity of both urban and lower-density areas. As early as 1966, the penetration of motor vehicles into societal customs and deeply rooted lifestyle habits was noted, signaling a transformative effect on cities, relationships between urban and rural centers, and overall ways of living, working, and enjoying life (Santoro, 1966, cited in Maggi, 2009, p.123).
The impact of mobility on urban areas was so significant that literature described the different phases of their development based on the prevalent type of mobility [see Table 1.1.] . This radical development deeply transformed suburban and rural areas. The rise of private cars in these areas generated the urban sprawl phenomenon, leading to widespread urban development characterized by high settlement dispersion and a progressive infrastructure development to accommodate increasing traffic flows. [Figure 1.1, 1.2]
Initially aligned with the ideals of progress and freedom, this mobility model revealed its limitations over time (Newman and Kenworthy, 1999; Whitelegg, 1997). In peri-urban rural areas, where dependence on private cars is stronger, the identity of places changed even more radically than in urban areas. The dispersion of settlements and road infrastructure led to a detachment between individuals and their territory. Augè, with his well-known concept of non-places, effectively captures interventions born to respond to a dense and accelerating contemporary society—the supermodernity—resulting in spaces that cannot be defined as “anthropological places”, i.e. identity, relational, and historical spaces. According to Augè, non-places represent our times, measuring it quantifiably by combining airways, railways, highways, mobile dwellings called “means of transport” (planes, trains, cars), airports, railway stations, major hotel chains, leisure facilities, large commercial spaces, and the complex network of wired or wireless networks mobilizing extraterrestrial space for a communication so peculiar that it often puts the individual in contact only with another image of themselves (Augè, p. 78). If non-places represent the measure of the zeitgeist, low-density areas symbolize the second half of the 20th century. These are areas designed for cars, where the road loses its relational character, reducing itself to a monofunctional transport tool. People moving through these territories do so passively, with visual landmarks replaced by road signs. The territory reduced to a sequence of images assembled without a narrative structure. The lack of urban planning results in a “Jump

Period	Urbanization phase	City or Metropolis typology	Type of Mobility	Populations involved
1871-1945	Urbanization (phase II)	Generation I Metropolis	Transit City	Residents Commuters (in USA)
1946-1975	Suburbanization	Generation II Metropolis	Automobile city	Residents Commuters
1976-2016	De-Urbanization (Peri-Urbanization) Reurbanization (high-attractiveness city)	Generation III Metropolis (meta-city)	Means integrated city	Residents Commuters City Users New urban populations

Table 1.1. Urban development phases and types of mobility. Author's translation (source: Colleoni, 2019).

Cut Urbanism" (Ingersoll, 2004), producing a confused and disoriented image of the territory and its identity.

With the mobility turn in social sciences, the prominent role of mobility in studying contemporaneity becomes evident (Urry, 2000). The progressive acceleration of mobility, involving not only people but also vehicles, goods, and information, extends its influence from transportation to cities and from cities to our way of life and thinking (Rosa, 2015). In this scenario, a new and polycentric vision of contemporary mobility emerges—multi-locality (Weichhart, 2015). Unlike the previous model, which envisaged a single residence from which one commutes for practical or leisure reasons, multi-locality sees individuals belonging to different places where they establish meaningful relationships. From this condition arises a multi-local identity, based more on intensity than the duration of stay in places, manifesting in the need/capacity to live in multiple locations (Colleoni, 2019, p. 109). This condition directly concerns small and mid-sized cities, transitioning from commuting to a polycentric mobility model.

The development of digital technologies and the increasing importance of smart mobility represent the latest transition in the sociotechnical transport system (Geels and Schot, 2007; Geels et al., 2017). The multi-level perspective of sociotechnical systems emphasizes the significance of social, environmental, political, and cultural aspects in the smart mobility domain. These aspects bring forth new mobility needs and topics, such as connectivity and accessibility, influencing transport planning and city identity.

Connectivity is intertwined to the development of digital technologies. Mitchell, in his seminal contribution on ICT in architecture and urban planning, discusses how in connected cities, many daily activities could migrate from physical space to a new electronic space, creating a “fundamentally different physical structure” that would make modern city spaces obsolete (Mitchell 1996, in Carpo, 2022). Other contributions focused on networks and infrastructures point out the importance of connectivity by showing how ICT has increased differences between connected and unconnected areas. Neighborhoods and cities linked by high-speed communication tunnels can exchange knowledge, data, and information, cutting off neglected urban areas that lack access to opportunities of digital transformation processes (Graham and Marvin, 2001). Following this perspective of an increasingly disadvantage of rural areas compared to urban ones, Picon (2015) reflects on the need to introduce gradients to enhance local intelligences and prevent the countryside from becoming less smart than cities.

At the same time, the themes of accessibility and proximity gain increasing importance in the debate on future mobility. This phenomenon can be explained by the fact that accessibility and digital technologies are characterized by a common relational dimension. Both realize themselves not so much in the element itself but in the ability to relate multiple elements. Additionally, the environmental and social crises make the negative externalities of a car-based mobility paradigm increasingly evident, promoting the need to develop mobility models that offer greater accessibility.

Hence, there arises the need for a complete transformation in transport planning (Whitelegg, 2016) increasing streets accessibility. Curbing speeds and distances traveled cities are made more accessible and inclusive, overcoming the monofunctional approach typical of transport engineering. Here comes the raise of accessibility, as it creates a virtuous relationship between mobility and the urban environment, communities, and the identity of territories. Jan Gehl is one of the pioneers of this line of thought. Building on his seminal contributions to urban studies (Gehl, 2010), he highlighted the crucial role of individuals and active mobility in designing livable and inviting public spaces. Over the years, this approach has evolved by integrating the opportunities of digital technologies, leading to the development of the Public Life Data Protocol in 2017, a complex digital tool that manages the collection and storage of data about people in public space (Gehl Institute, 2017). Concerning mobility, this tool combines measures of car traffic and property values with measures of public life to understand how people move through public spaces. This approach underlies a vision of mobility

Figure 1.1. Faenza, corso Mazzini. An historical street part of the public space network. (source: author)

Figure 1.2. Faenza, via XX settembre. An historical street deeply transformed by a car-based planning approach. (source: author)

centered on proximity, human-scale, and made smart through the conscious use of digital tools. Another approach that has gained interest worldwide is that of the 15-minute city. Without delving into a detailed analysis of the model already discussed in other contributions (Büttner et al., 2022), its widespread adoption has significantly contributed to placing the themes of accessibility and proximity at the center of the disciplinary debate while introducing a more blended use of digital technologies. By reducing travel times and distances, it is possible to improve the quality of public spaces, combining elements of historic cities with current mobility needs. In this context, new digital technologies can become extraordinary tools to promote participation, service accessibility, and the enhancement of mobility experiences. The 15-minute city model aims to change the overall urban experience through mobility. This model promotes "place identity through the concept of chrono-urbanism, allowing those seeking alternative lifestyles—away from automobile-dependent cities—to access almost urban services and amenities within walkable and biking distance" (Moreno et al., 2021).

These experiences spilled over into the streetscape design, which tackled its physical elements – as the travel lanes and the sidewalks – and also studied their interaction with people and urban objects. Complete Streets, Healthy Streets, Smart Urban Services, and X-minute streets are considered the most relevant for this study. Complete Streets is an approach to planning, designing, building, operating, and maintaining streets that enables safe access for all people who use them, including all ages and abilities. Complete Streets' method varies based on the community context. The design output is therefore diverse, as it may address a wide range of physical elements, such as sidewalks, bicycle lanes, bus lanes, public transportation stops, crossing opportunities, refuge islands, accessible pedestrian signs, curb extensions, modified vehicle lanes, streetscape and landscape materials and treatments.

A second approach is Healthy Streets, a human-centered framework for embedding public health in transport, public realm and planning. Lucy Saunders, a public health specialist, urbanist and transport planner, created this method that has been included in the "Mayor's Transport Strategy 2018" which sets out the vision of public transportation for London. The Healthy Streets approach is an evidence-based framework for decision making composed by ten main Indicators focused on different aspects of wellbeing such as street safety, air quality, user experience.

Smart Urban Services seeks to improve accessibility by designing innovative street furniture such as public fountains or mobility hubs, combining physical and digital elements to improve well-being and offer innovative urban services. An integrated approach between service, product, and urban design that can provide significant improvements in public health conditions, social inclusion and access to services. Smart Urban Services aim to combine digital technologies (i.e. IoT) with a contemporary design suitable for different locations and seamlessly integrable into the urban space to promote public health in cities.

The last innovative method we're reviewing here is the x-minute street, which includes street layout solutions adopted in the 15-minute city and its variants (e.g. 1, 20, 30 minute neighborhoods). Beyond the differences related to the context, they are all based on a street layout that favors pedestrians, cyclists and public transport over vehicle lanes. By reducing the space for motor vehicles, this approach to street layout aspires to slow down the pace on streets, with the intent of fostering the character of those places. Borrowing some principles of tactical urbanism, the street layout is often shaped with participatory design to quickly prototype new and agile street designs, so some parts of it can easily be swapped out or moved if the need arises.

All these frameworks and experiences focused on connectivity and accessibility, primarily developed in urban areas, highlight the need for smart mobility proposals that can balance the right to mobility with movements suitable for the ongoing social, environmental, and technological revolution. In small and medium-sized cities, there is a gap in literature and design tools that needs to be filled. This thesis explores possible solutions for these territories by researching applied methodologies to support smart mobility in small and mid-sized towns, aiming to investigate the potential impacts on urban identity.

1.2.2. Smart mobility in the regional context

As part of the regional research project on the contemporary smart and sustainable city, this thesis aims to contribute to the development of smart mobility of small and mid-sized towns in Emilia-Romagna Region. Emilia-Romagna is particularly committed to innovation and research, ranked first at national level in the 2023 Innovation Scoreboard of the European Commission, an index that provides a comparative assessment of research and innovation performance at different scales.

This outstanding ranking matches its vibrant regional innovation ecosystem and the numerous public initiatives developed within Emilia-Romagna in the field of smart mobility. A recent report by the ITL Foundation (2020) analyzed the regional context of Emilia-Romagna regarding smart mobility. The report highlights the industrial growth of the mobility sector, an excellent regional coverage of shared mobility services (all the Emilia-Romagna provinces have at least one shared micromobility service, while the Italian average is 54%), and a wider electric mobility infrastructure compared to the national average (93% of land coverage versus 68%). In this section we will introduce a part of the regional smart mobility landscape presenting the main programs and projects on this topic, and particularly those activated by the Emilia-Romagna Region. The information presented here does not aim to review exhaustively the state of the art, but rather to provide an overview of the regional context to which the research aims to contribute.

The first major area of interest in the regional context refers to programs and projects developed by the Emilia-Romagna Region. Here we can find several innovative programs and projects for sustainable mobility, particularly on the issues of improving air quality and promoting cycling and electric mobility.

Among the projects related to air quality improvement, noteworthy are the PREPAIR project and the AIRBREAK project:

– PREPAIR, a joint LIFE project among various regions in the Po Valley and coordinated by Emilia-Romagna, promotes interregional cooperation and public information actions to limit polluting emissions in the Po Basin. In the transport sector, one of the major sources of pollution, the project regionally promotes cycling mobility, electric mobility, and the development of ICT tools for public transport. Beyond the analysis of individual measures (PREPAIR, no date), which are closer to policy making than our research focus, it is worth mentioning that the project promotes a common vision to be adopted by all urban centers – major and smaller cities – recognizing the mutual influences of urban and peripheral/rural movements.
– The AIR BREAK project in Ferrara, an Urban Innovative Action (UIA) initiative focused on promoting and co-producing innovative air quality solutions to transform degraded areas into healthy living environments (UIA, no date). AIR BREAK is a smaller-scale project than PREPAIR, blending physical interventions with co-design actions to involve city users. A key action is the installation of Smart Hub Street Furniture, an innovative urban service dedicated to e-mobility contributing to the AIR BREAK project's goal of reducing air pollution by 25% in 3 years in areas with poor environmental quality. For our study, it's important to note that Smart Hub represents an innovative mobility concept that enhances service accessibility and urban quality. An urban service contributing to promoting smart mobility by combining IoT-based urban services with contemporary design suitable for both urban and rural areas. [Figure 1.3.]

Regarding cycling mobility, the region has promoted a series of calls for proposals to enhance the network of cycle paths and create safe cycling and pedestrian routes for home-school and home-work commuting. Among the most significant initiatives, we here cite the most relevant to our study:

– The "Call for the realization of regional interest cycle paths and promotion of sustainable mobility" activated in 2018 and ongoing (Emilia-Romagna Region, 2019), has strengthened the cycle-pedestrian network or interchange services with the railway system for municipalities regardless of their population. It is worth to note that the call promotes a view of transport systems as a network, at the same time infrastructure and service, that involves the entire territory, including smaller municipalities, to experiment innovative solutions that blends local infrastructure with regional mobility planning.

Figure 1.3. Air-Break Smart Hubs, an innovative urban services installed in Ferrara. (source: author)

- The “Bike to Work 2021” project (Emilia-Romagna Region, 2021a) promotes cycling for work commuting, school commuting, and bolsters cycling routes with the construction of cycle paths and routes and maintaining the existing network. The main goal is to discourage the use of private cars offering more sustainable and cost-effective alternatives. The project’s points of interest include increased awareness compared to the previous call for proposal about the need to extend these interventions to smaller municipalities, with a specific funding line for municipalities with a population of less than 50,000 inhabitants. The importance of maintenance, especially extraordinary repair works, highlights the need to improve daily user experience rather than expanding the road network.
- Two initiatives to promote biking, namely the “Mi Muovo In bici” plan (Emilia-Romagna Region, 2021b), which experiments tariff integration to access the bike rental service throughout the regional territory, and the call offering a contribution to the purchase of electric bikes and cargo bikes (Emilia-Romagna Region, 2023a) in more than 200 municipalities in the regional territory. It’s interesting to note how these initiatives recognize the need to promote the use of less polluting means in various forms – shared or owned, electric bikes or cargo bikes – and to extend their use on a large scale, not only in major cities.

Moreover, the Emilia-Romagna Region has promoted various initiatives to promote electric mobility, particularly in developing charging infrastructure. Currently, the main regional initiatives are the “Mi Muovo M.A.R.E.” plan, the regional participation in the national plan on charging infrastructure

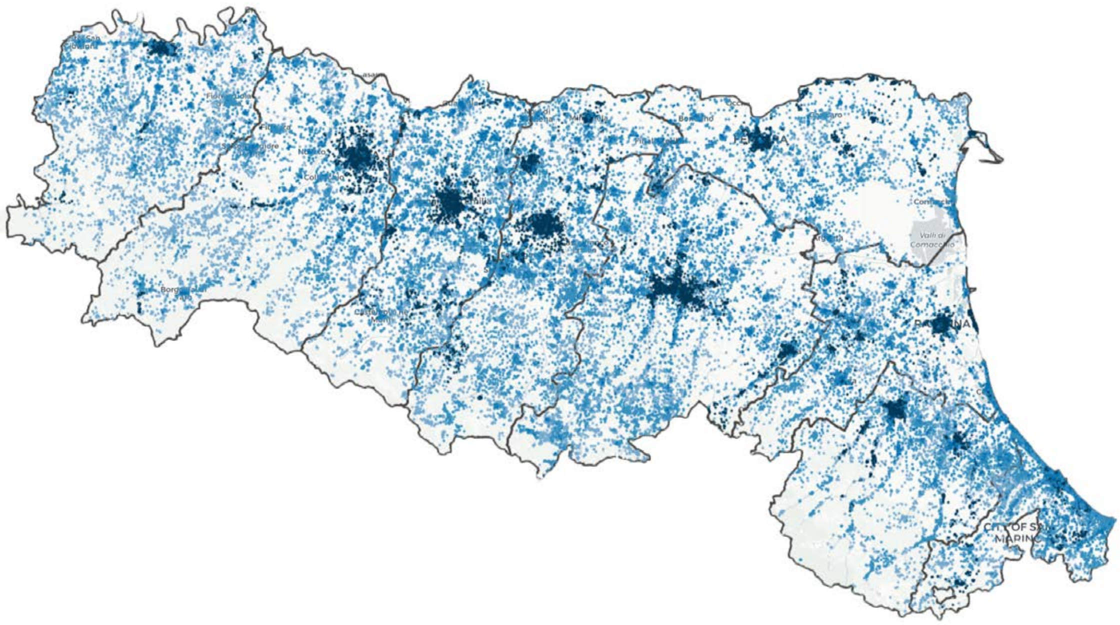
(PNIRE), and a series of pilot projects to expand charging stations in cities (Emilia-Romagna Region, 2023b). The first two initiatives aim to promote the use of electric vehicles in daily travel to coastal areas and enhance the regional electric charging network, while pilot projects focus on urban areas. The reiteration of the network logic for this type of infrastructure and vehicles, combining it with existing infrastructure, and the idea to take advantage of the flexibility of electric charging infrastructure combining urban and suburban commuting with smart grids.

These projects then contribute to the main regional planning acts that define the objectives and targets in the field of mobility and smart mobility:

- The Integrated Regional Transport Plan (PRIT2025), which indicates strategies and guidelines for promoting mobility at the provincial and municipal levels.
- The Regional Integrated Air Plan (PAIR2020), which sets goals for reducing atmospheric pollutants to comply with air quality limit values set by European directives.
- The Energy Plan of the Emilia-Romagna Region (PER 2030), which adopts the main climate and energy objectives tied to the region’s development.
- The Pact for Work and Climate, in which the main guidelines for relaunching and developing economic activities characterized by environmental, economic, and social sustainability are shared.

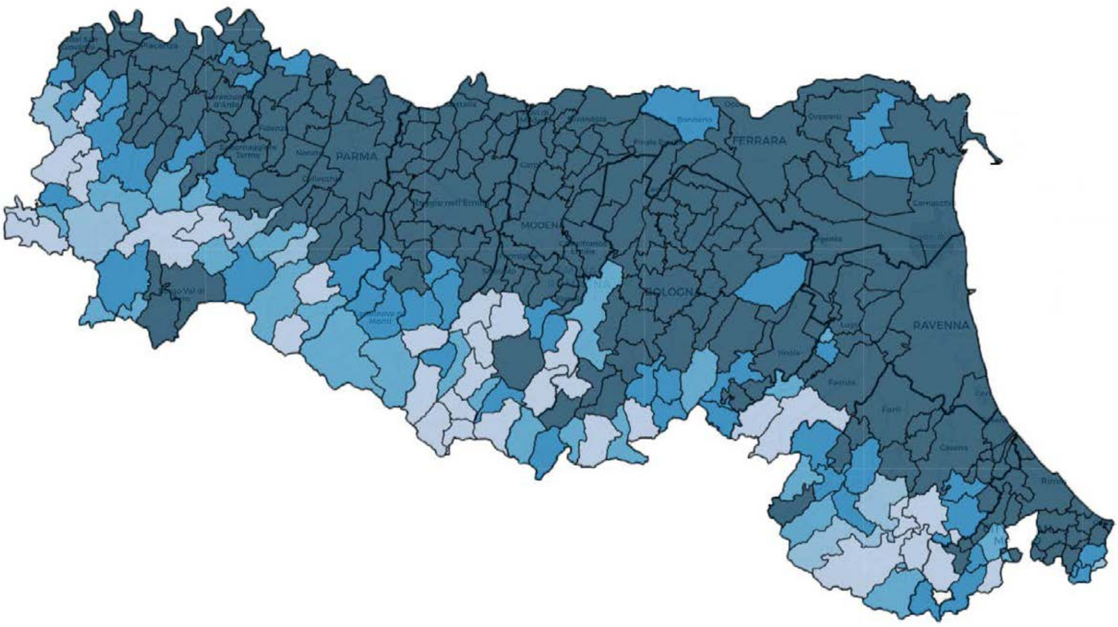
In particular, the PRIT contains a series of guidelines and technical information drafted in 2021 dedicated to innovative mobility solutions such as Mobility Manager, DRT, MaaS, smart parking, CAVs, Geofencing (Emilia-Romagna Region, 2022). The document, while presenting solutions compatible with small and mid-sized towns, focuses on application in cities as their higher population density, services, flows, and investments make them more likely laboratories for innovative mobility. The cost-effectiveness analysis of various measures confirms the leading role of cities. The research highlights that solutions with higher technological content – MaaS, CAVs, Big data – have substantial investment and management costs and face higher levels of uncertainty and risks, making them more easily applicable in high-density areas. Other measures consist of ‘soft’ solutions – mobility management – and ‘intermediate’ solutions – DRT, geofencing – emphasizing how innovative mobility management and the use of market solutions are more easily usable in areas with lower density.

All smart mobility measures are linked to connectivity. In this sense, the Digital Agenda of Emilia-Romagna (ADER) is the regional structure responsible for coordinating and promoting actions for the digital and technological development of the territory. Among the various projects and plans developed by ADER, we highlight the “Connectivity Observatory” project, the DESIER indicator, the Data Valley Common Good DVBC plan as those of greatest interest for our research. The “Connectivity Observatory” project develops an updated mapping of the state of connectivity in



Legend
- 0-2 Mbit/s
- 2-30 Mbit/s
- 30-100 Mbit/s
- 100-1000 Mbit/s
- > 1000 Mbit/s

Figure 1.4. Download speed in Emilia-Romagna municipalities. (source: ADER https://osscon.lepida.it/)



Legend
- 0-20%
- 20-40%
- 40-60%
- 60-80%
- 80-100%

Figure 1.5. Percentage of cabled territory in Emilia-Romagna municipalities. (source: ADER https://osscon.lepida.it/)

Emilia-Romagna. Analyzing the maps [Figure 1.4, 1.5] (Emilia-Romagna Region, 2023c), we note that the municipalities located in a plain have a high percentage of cabled areas (80-100%), regardless of their population, while it is lower for municipalities in the mountain (ranging between 20% and 80%). The map of network speed reveals a gap between major cities and suburban areas and the rest of the region, further highlighting the differences. The region appears to have a medium-to-high-level connectivity but can improve by enhancing the network signal in mountain areas and implementating connectivity in small and mid-sized areas.

DESIER is an indicator activated in 2022 by ADER in collaboration with Art-ER and Lepida. It measures the level of digitization of municipalities in the Emilia-Romagna Region. DESIER consists of 4 dimensions of analysis - Human Capital, Connectivity, Integration of digital technologies, and Digital public services – and 60 indicators, each of which is related to the analysis dimensions of the European DESI and the regional DESI developed by the Politecnico di Milano. In the context of this research, it's interesting to note how various indicators can provide useful data to assess smart mobility and territory accessibility. In particular, the most relevant indicators are connectivity, seen in the previous case and here proposed to measure the level of internet and IoT network spread, and the Digital public services dimension, measuring access to local public administration services and open data. The graph [see Figure 1.6] on the level of connectivity and public services of small plain municipalities, the main object of analysis, highlights their intermediate position between mountain municipalities and those with more than 15,000 inhabitants and the positive impact of the number of inhabitants and belonging to a union of municipalities. Not falling within the objectives of this thesis, we suggest as a future research direction the possibility of developing a smart mobility indicator linked to DESIER and the results illustrated in the next chapters.

The initiatives mentioned above fall under the regional digital agenda Data Valley Common Good (DVBC), a strategy that includes tools, challenges, objectives, and guidelines (ADER, 2021). In particular, the DESIER indicator was developed in implementation of Challenge 1 "Data for widespread intelligence available to the territory," and the Connectivity Observatory in implementation of Challenge 6 "Hyper-connected Emilia-Romagna." To these, we add the importance of initiatives carried out within Challenge 7 "Digital Communities," which aims to create communities capable of using technology to qualitatively transform the local reality in territories at risk of marginalization, such as small municipalities. The proposed actions highlight the need to create proximity spaces, invest in the social dimension of the territory, and thus also mobility networks, promote natural and identity heritage in marginal areas.

Another major area of interest of the regional context are the innovation ecosystem activities. The regional innovation ecosystem includes various stakeholders, including ART-ER, a Consortial Company of Emilia-Romagna established to promote territorial innovation; the High Technology

Figure 1.6. Desier assessment of the level of digital public services and connectivity in municipalities with less than 15.000 inhabitants. (source: ART-ER https://emiliaromagnainnodata.art-er.it/on-line-il-cruscotto-desier/)

Network, consisting of accredited laboratories and research centers; Technopoles, hosting and organizing specialized activities and services to support innovation; Clust-ER, associations created for product and supply chain development according to an open innovation approach; and EROI, the regional open innovation community. Among the many activities carried out by the above-mentioned stakeholders, two initiatives activated by the Clust-ER network are noteworthy for our research. The establishment in 2022 of the Clust-ER Urban Economy, which promotes the creation of proximity infrastructures to organize service offerings by studying differentiated models for different territorial conditions. The goal is to “go beyond the concept of the Smart city towards an idea of an “augmented” city and territory, a city of people 4.0 that reconnects workplaces, living spaces, and services to the individual” (Emilia-Romagna Region. 2023d). These themes are also present in Clust-ER Build, which since 2018 promotes the sharing of skills, ideas, and resources to support the competitiveness of the construction and building sector. In 2021, Clust-ER Build activated a Thematic Table on sustainable mobility to enhance and follow up on the fruitful collaboration between the University of Bologna, the “Enzo and Dino Ferrari” International Autodrome in Imola, and other important stakeholders, research institutions, and public administrations. In particular, the focus of this table develops an integrated approach promoting the interaction between infrastructure, means, and people to reduce the environmental impact of mobility and make it increasingly inclusive through new materials, more sustainable means of transport, and immersive technological solutions. The Thematic Table has promoted a series of projects and events, including a recent meeting focused on the impact of artificial intelligence on future mobility (Emilia-Romagna Region, 2023e).

All of these initiatives and projects highlight the importance of smart mobility in Emilia-Romagna. The projects address this theme with a "network" approach, relating infrastructural development to technological, social, environmental, and service development. While on the one hand, this integrated approach has allowed the experimentation of several aspects of smart mobility, on the other hand, we can observe that the experiments were mainly focused on cities. A perspective that sees cities as driving elements of territorial development, but can be overcome by a Smart Land model (Bonomi and Masiero, 2014) that broadens the experimentation scope to the entire territory. This is because the transfer of innovative solutions between large and small cities is not granted and, in part, not possible, as different contexts present different mobility needs and cultures, requiring complementary and specific solutions. The research aims to contribute to the development of smart mobility in small and mid-sized towns with this perspective, bridging the gap between different territories and integrating applied research and innovative urban projects in this field.

1.3. Research framework

The following paragraphs will chart the main aspects of the thesis, discussing the research question, its outline and goals, the expected outcomes. The central issue revolves around understanding how urban design can contribute to the advancement of smart mobility in small and mid-sized towns and, thus, envisioning key design tools for future mobility spaces.

The thesis structure and their goals reveal the operational focus of the research, with the constant purpose of identifying in case study analyses and theoretical elaborations possible supports for the design of smart mobility solutions.

The dissertation unfolds in six chapters, each dedicated to distinct facets of the research journey. The first chapter sets the stage, introducing the study's context, goals, and assumptions. The following chapters delve into the state of the art of smart mobility, applied research in the study area, guidelines for small and mid-sized towns. The research outcomes aim to increase the development of smart mobility strategies in this context. Also, the research could have an international interest given that the research topic is linked with various research programs in EU – e.g. Smart Rural 27 (2023) - and the available literature and case study is limited when compared with urban areas. The research aims also to stimulate further research and contribute to reshaping the current mobility paradigm.

1.3.1. Research question

The research background and the above-mentioned considerations help us to frame the research question. The first question the research wants to answer is how urban design can contribute to foster smart mobility solutions in small and mid-sized towns; and if so, how future mobility spaces will look like. To address these questions, it is necessary to investigate the topic of smart mobility, researching its relations with the broader domain of smart cities and reviewing both current and past case studies relevant to this research. Then, these insights should reveal how smart mobility is deployed in small and mid-sized towns, and its key principles. The analysis will serve a dual purpose: to analyze the current condition of mobility spaces, and on the other hand, to underscore the potential role of urban design in innovating streetscapes.

Then, the analysis will shift to the operational dimension. The aim of this thesis is to create, starting from literature and relevant case studies, a step-by-step design framework that supports a sound smart mobility vision and suggests the key elements of future smart mobility spaces. We should therefore implement our initial question, elaborating the research question of this study as: What applied methodology can be developed to support smart mobility in small and mid-sized towns? Starting from this question we can identify four main research objectives as follows:

1. Broadening the knowledge on smart mobility in small and mid-sized towns, pointing out the differences with smart mobility and smart city at a urban scale.
2. Investigating EU and local case studies, exploring if they can provide useful insights to frame smart mobility guidelines
3. Presenting guidelines as a design roadmap to assess smart mobility and suggest innovative design solutions.

1.3.2. Research outline and goals

This thesis is composed of six chapters. Below you will find an outline of each chapter and its main goals, to ease the reading of this study.

Chapter 1: Introduction and research background

Goals: Framing the context, research topics and assumptions of the study

Chapter 2: Smart mobility in small and mid-sized towns

Goals: Broadening the knowledge about the thesis' topic, exploring its relation with smart city and urban identity. Introducing the key concept of accessibility and collecting international case studies.

Chapter 3: Smart mobility case studies in small and mid-sized towns

Goals: Presenting key applied research conducted in a study area. Analyzing regional case studies and deepening the context knowledge. Defining the key domains for evaluating smart mobility initiatives in small and mid-sized cities and their relation to urban identity.

Chapter 4: Smart mobility assessment tools

Goals: Develop innovative design tools to analyze and assess smart mobility solutions, highlighting their impact on smart mobility issues.

Chapter 5: Smart mobility design guidelines

Goals: Defining guidelines, in the form of an 'innovation roadmap' to foster 'smart mobility vision' in small and mid-sized towns. Explore expected impact on design and urban identity.

Chapter 6: Conclusions and further research

Goals: Presentation of the results of this thesis, methodological insights and further research paths.

1.3.3. Research's expected outcomes

The research reported in this doctoral thesis aims to provide a design guideline to support smart mobility strategy in small and mid-sized towns. More specifically, this guideline will show a step-by-step roadmap to elaborate a 'smart mobility vision', assessing the current situation in order to define an action plan that provides smart mobility design solutions tailored to these contexts. As described in Chapter 5, the 'smart mobility vision' is closely related with the concept of proximity, considered a key issue because it bridges innovation, urban wellbeing and urban identity. This research will then illustrate innovative design tools to analyze smart mobility leveraging the existing data and technological tools. These design tools will form the basis for assessing the main issues to be addressed in smart mobility deployment, indicating possible design references and potential impacts on urban identity.

The main expected outcome of this research is to proof the feasibility of these smart mobility guidelines, with the aim to increase the number of smart mobility projects and so increasing their positive impacts on local communities and on the environment. The feasibility and effectiveness proved with this research would support the adoption of smart mobility solutions at a larger scale, broadening their application field and contributing to innovate the current mobility model.

The second principal outcome is the literature gap reduction between urban and rural smart mobility. By presenting new applied research on smart mobility and consolidating existing literature case studies, it is possible to increase the knowledge about this topic by sharing best practices in other contexts.

In conclusion, the results obtained with this doctoral research aim to stimulate further research on smart mobility. The ambition is to contribute to changing the current mobility paradigm starting from innovative solutions from the everyday regional landscape of small and mid-sized towns.

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Chapter 2.
Smart mobility in small and mid-sized towns

2.1. Introduction

This section is dedicated to conducting a review of smart mobility in both urban realm and small to mid-sized towns. We will present the most relevant contributions in the literature, and analyze their case studies and best practices. This chapter aims to gain valuable insights into the current state of the art, from outlining the main study frameworks to identifying the most promising solutions. Furthermore, another objective is to identifying existing literature gaps, highlighting the overlooked topics and research areas. Within this perspective, we will address the issue of public space design, that despite its profound implications for smart mobility has actually a marginal role. This understanding is critical as it could unlock new research and innovation paths, contributing to the promotion of more integrated and effective solutions in the field of smart mobility.

2.2. Aims and methodology

In the realm of smart mobility, it is essential to recognize and highlight the most notable examples and initiatives. This serves a threefold purpose: first, it outlines the overarching scope of analysis, allowing for a comprehensive examination of the field. Second, it underscores the significance of smart mobility, both in the academic discourse and design practice. Lastly, it reveals the evolving nature of the term itself, shifting from techno-corporate connotations to a more holistic and inclusive approach.

The first part of this chapter delves into the broader domain of smart mobility. Its primary objective is to trace the evolution of the concept of smart mobility over time, to identify its most significant outcomes, and to examine its impact on small and mid-sized towns. This approach allows us to outline the general context of the research, underscoring the relevance of this topic in both academic studies and urban design, and bringing attention to the existing literature gaps within medium and low-density areas.

In terms of research methods employed in these paragraphs, we focused on basic research, gathering multiple information to expand our understanding of observable phenomena and their underlying facts. In this context, we chose to explore the smart mobility phenomenon by presenting various smart mobility experiences such as projects, research findings, academic contributions, and bibliometric analyses to provide the broadest possible perspective on smart mobility.

The second part offers a more specific investigation of smart mobility in small and mid-sized towns. This part has three main objectives: to elucidate the current state of the art in this research domain, identify the most commonly utilized smart mobility solutions, and uncover the reasons for the limited development of rural smart mobility.

Concerning the methodology, we adopted a comprehensive research strategy. Initially, we conducted an extensive literature review on academic databases. Then, we screened the existing literature to uncover the key features of this research field. Finally, we performed a detailed analysis of the European Union's current strategies on rural smart mobility, examining the most relevant programs and EU-funded projects in this domain.

2.3. Smart mobility in cities

This first paragraph aims to highlight, starting from relevant studies and initiatives, the evolution of the concept of smart mobility, outlining its interconnected relationship with the smart city and the key features of this field of research and experimentation. A strong correlation between smart city and smart mobility has existed since the early days of the smart city concept. As noted by Komnios and Mora (2018), from 1986 to 1990, one of the first uses of the term "smart city" in scientific literature was to describe innovations in urban mobility supported by information technologies, the utilization of IT for city service provision, and the improved performance of cities in environmental, economic, and social aspects.

In this same period, Mitchell (1996) made one of the most significant contributions to the field of smart cities and related areas, identifying the infrastructural nature of this concept and the pivotal role of transport infrastructure within this paradigm. From the first example given in the text, fiber optic cabling, emerges the central role of infrastructure, one of Mitchell's main points of reflection. Taking up Maldonado's intuition of the digital reality as an infrastructure in dialogue with other ones, the author explores their operational implications in the design process. Their diagrammatic, computational-like logic enables the relationship to other logical systems such as digital tools and platforms.

Giffinger et al. (2007)[1], the author of one of the earliest European studies on medium-sized smart cities, identifies Smart Mobility as one of the six characteristics of Smart Cities, alongside Economy,

[1] The importance of smart mobility has been reported even in the author's definition of Smart City: *A city well performing in a forward-looking way in economy, people governance, mobility, environment, and living built on the smart combination of endowments and activities of self-decisive, independent, and aware citizens*

People, Governance, Environment, and Quality of Life. The key indicators considered revolve around accessibility, ICT infrastructure, and the need for sustainable, innovative, and safe transportation systems. Taking a more policy-oriented approach than urban studies, it's evident that the theme of mobility is treated comprehensively, encompassing mobility networks within the realm of telecommunications
infrastructure—previously explored by Mitchell and later revisited by other authors such as Graham and Marvin (2001). This approach also emphasizes the necessity of viewing transportation infrastructure as socio-technical systems with environmental and social impacts, all of which significantly influence the urban identity of a city.

As noted by Vanolo, the classification proposed by Giffinger et al, composed by six domains – including mobility – has been reported in most of the literature about smart city; for example, in Caragliu, Del Bo and Nijkamp (2011) and Lombardi et al. (2012).

In 2014, an EU report taken up in the later literature on Smart Cities (Manville, 2014) highlighted how "although Europe was the leading areas in SC initiatives with a relatively holistic approach, most of Smart Cities initiatives frequently focus on smart environment and smart mobility with less attention on the other four dimensions of Smart Cities". The same report gave one of the earliest definitions of smart mobility in which, while retaining the same themes covered in Giffinger's research, the key role of ICT technologies, efficiency and real-time data acquisition in making a city truly "smart" was highlighted.

2.3.1. The techno-centric approach

The meaning shift mentioned above on Smart Cities recalls to a series of approaches regarding the interplay between territory and digital technologies, that Picon (2015) defines as neo-cybernetic. For the author, neo-cybernetic approaches aim to exert direct control over urban activities, standing in contrast to a more spontaneous and collaborative approach. The prominent endeavors embodying this initial approach are those undertaken by global ICT corporations such as IBM, Cisco, and Siemens. One of the most significant initiatives in this realm was the IBM Smarter Cities Challenge program (Fondazione IBM Italia, no date) running from 2010 to 2017, which offered a range of free consultations and services to address the key strategic challenges of cities using enabling digital technologies. Developed in three main sections – People, Planning and Management, and Infrastructure – the Smarter Cities program encompassed the theme of transportation in the latter two domains [Figure 2.1]

Given the B2B and B2G orientation of these companies, the primary solutions aimed to optimize major air and rail transport systems, alleviate urban traffic congestion, and enhance urban safety.

These concerns were addressed using a mobility planning approach that persisted for much of the 20th century, focusing on removing obstacles to the movement of goods, vehicles, and people, and bolstering the infrastructural capacity of the territory without considering all their externalities.

A remarkable example of this approach is Rio de Janeiro's operation center, a centralized control room where a limited number of experts received data from various districts of the metropolis, projecting them onto a large central screen for real-time management. This approach effectively reduced the complexity of urban fabric only in a few sets of data, treating traffic as one of the emergencies requiring control and management (Singer, 2012). Another example is the infographic illustrating the proposed solutions for the Commonwealth of Massachusetts and the City of Boston. As noted by Picon (2015), the city is perceived as a "system of systems," depicted abstractly, almost akin to videogames, using a top-down axonometric view and stylized buildings. In this context, mobility spaces constitute one of these systems, categorized as "traffic," but also appearing under the category of "physical assets," encompassing lampposts and hydrants, as well as air transport.

Focusing on road networks, as in the example mentioned above , we observe a simplification of the urban landscape into a mere problem to be managed. Several authors have subsequently developed a critical understanding of this approach, examining the underlying values of this socio-technical system and its influence on the narrative of the smart city (Söderström, Paasche and Klauser, 2014; Sadowski and Bendor, 2018, Grossi and Pianezzi, 2017). Notably, they emphasize that the considerable interest generated around this topic coincided with the development of a specific narrative about the smart city, one that views technology as the solution of all urban problems, preserving the dominant positions of global companies while leaving the relationships among urban stakeholders unchanged. This perspective tends to overlook potential synergies with the physical urban space. Furthermore, it is worth noting that the above-mentioned solutions leave the current modal share intact, with cars remaining the primary mode of transportation. These solutions attempt to address the main challenges, such as traffic congestion, but without questioning the fundamental underlying principles of this transport mode.

This reduction of the city to a showcase for IT service platforms offered by IT consulting firms is even more evident in a series of projects on the city and mobility spaces built from scratch (Benedikt, 2016), such as Masdar and Songdo, then analyzed by several authors (Cugurullo, 2015; Yigitcanlar et al., 2019)) who have pointed the possible risks of over-involving private companies on strategic spatial planning choices [Figure 2.2, 2.3]. Risks that include accelerating social inequalities and interpreting environmental sustainability as a derivative of economic policy.

Despite the limitations highlighted above, it is clear that these experiences have promoted a number of applications and technological trends of primary interest for urban mobility. Albino, Berardi and Dangelico (2015) describe Smart Mobility as "the use of Information and Communication Technology

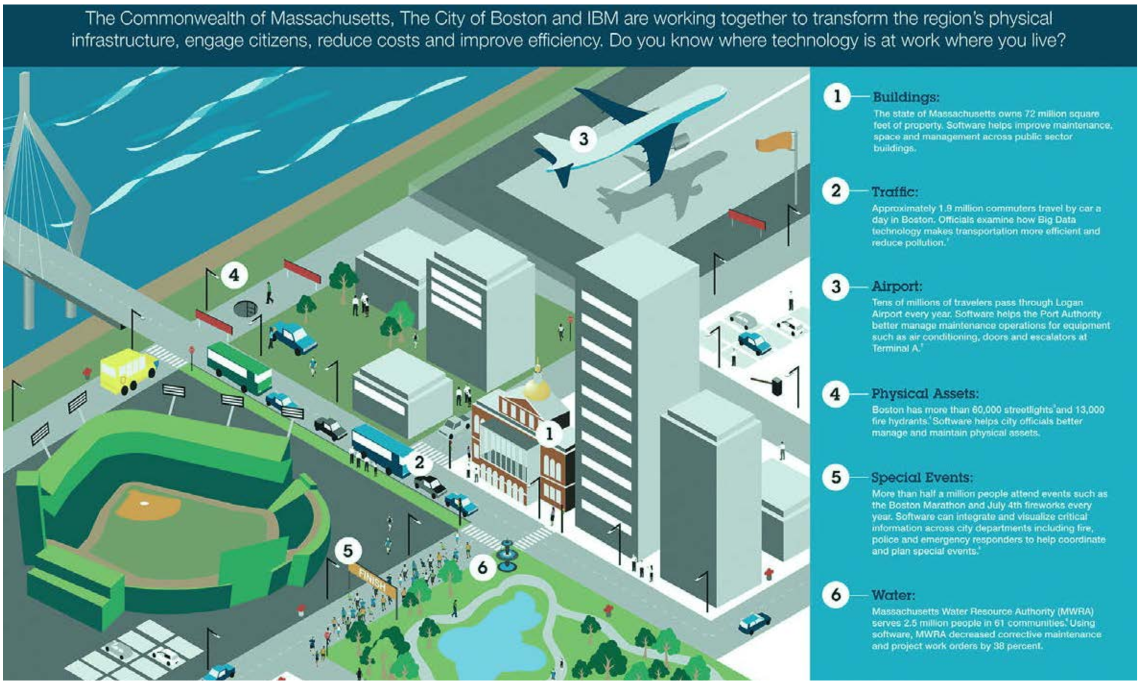

Figure 2.1. IBM's smart cities illustration, outlining a performative visualization of "smartness". (source: Picon, 2015)

in modern transport technologies to improve urban traffic"; Chun and Lee (2015) pointed out that Smart Mobility "is a concept of comprehensive and smarter future traffic service in combination with smart technology. A Smart Mobility society is realized by means of the current intelligent traffic systems".

During this period, the momentum of IT consulting companies and the growth of research contributions contributed greatly to the development of ITS solutions for urban traffic management and a more integrated IT infrastructure. Faria et al. (2017), one of the most cited smart mobility reviews of this period, discuss the current approaches and concepts related to Smart Cities and Smart Mobility pointing nine area of interests: Driving safety (i.e. Street safety technologies), Smart lighting systems, Sharing and urban mobility, Electric mobility, Green mobility, Smart payment system. The author then argues the prominent role of ITS, pointing out the role of this technology as an enabler for V2V V2I communications in the perspective of a closer integration between physical infrastructures, sensor technologies and means of transportation. It is interesting to note that the author highlights city size as one of the barriers of Smart Cities, pointing out the possibility to generate uneven geographic development in villages and small towns.

This perspective has been integrated by Smith (2020) envisioning new perspectives for Smart Infrastructure for Urban Mobility. The issue of traffic congestion is addressed avoiding a traditional traffic engineering approach, based on building more road capacity, but rather focusing on using technology to increase the efficiency of existing streets. After discussing current smart traffic signal control system that address multimodal traffic flows, they focused on recent research work on integrating this with CVs, exploring possible benefits such as vehicle route sharing, safe intersection crossing for pedestrians with disabilities, route choice decisions. This contribution envisions a more connected and automated transportation system in congested urban environments, indicating AVs as possible drivers of this change to increase people mobility.

2.3.2. The community-led approach

In parallel with the techno-centric approach, a second line of research emerged. This research pattern aimed to put in perspective digital technologies in mobility, integrating them with other practices and disciplines. The seminal contribution of Staricco (2013) noted how different approaches to Smart Mobility also spilled over into different uses of ICT. On one side, the idea that an efficient and effective mobility system was independent from the role played by ICT, but rather connected to the use of appropriate technologies; the second one relates to a mobility system characterized by a consistent and systematic use of ICT in the urban realm.

Follow up research by Benevolo, Dameri and D'Auria (2015) analyze Smart Mobility initiatives as part of a larger framework and investigating the role of ICT in supporting people's mobility, quality of life and impact on city. The authors operate a multi-level classification of a wide series of Smart Mobility initiatives creating a sort of taxonomy that consider three main issues: Smart Mobility actors, the Use and intensity of ICT; goals, benefits and impacts. We can here cite two important findings of this taxonomy. The first one regards the positive correlation between the Smart Mobility maturity and the use of ICT pointing that a wide range of the analyzed initiatives is not strictly tied to high ICT intensity, which is important when the maturity of Smart Mobility project increases. The second finding is that public mobility, private mobility, infrastructure and policies not spatially coordinated, regarding only a small portion of the urban area, difficult to replicate elsewhere. Two major issues that put into perspective the role of ICT and reveals the crucial role urban design to achieve the complex environmental and social goals of smart mobility.

During the same years, other scholars (Singh and Mittal, 2015) questioned the current mobility trends in developing countries, highlighting how increasing the road capacity would erode land and financial resources, and worsen infrastructure shortages. Authors find that a change in transportation mode from private vehicles, namely cars, to public transportation systems such as BRT and LRT represents the best solution for that contest. This contribution shows the role of public transport as one of the key factors to make smart mobility projects, underlining how this change cannot be

Figure 2.2. Street view of downtown Masdar City, that recalls the historic city streetscape. (source: https://masdarcity.ae/about.html)

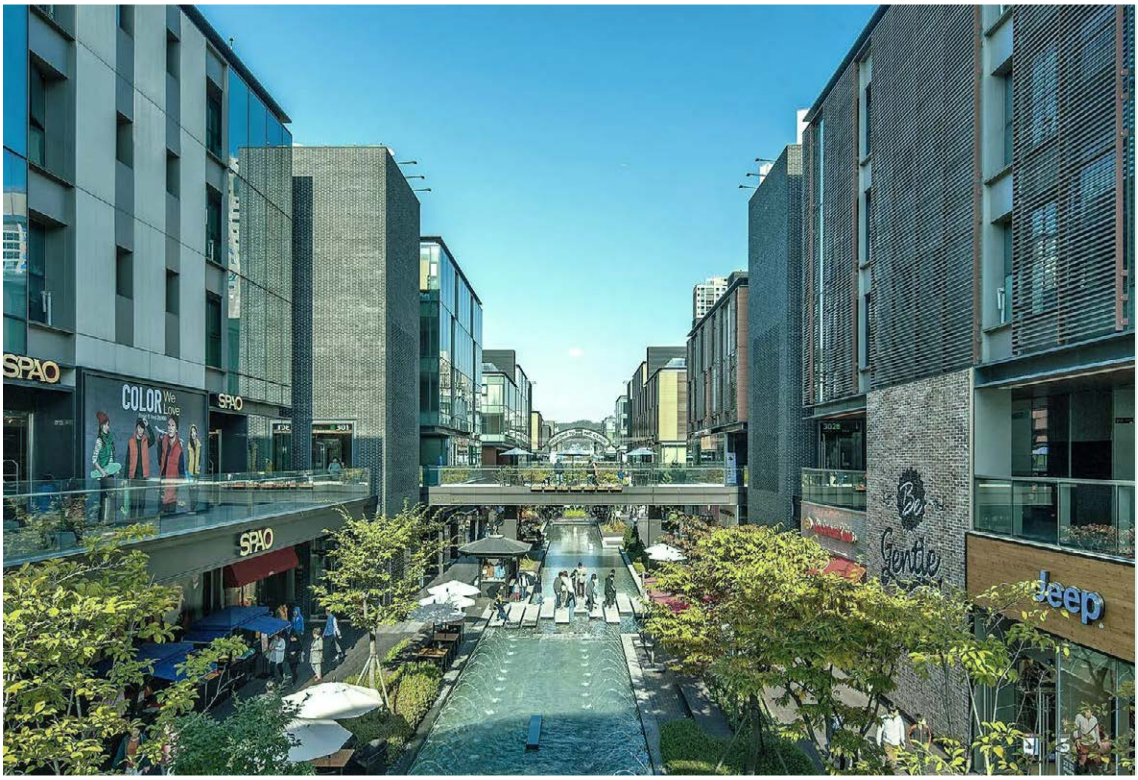

Figure 2.3. View of the Songdo Canal Walk, revisiting the multi-level shopping street layout. (source: https://www.kpf.com/project/songdo-canal-walk)

possible without an integrated approach with urban policies, technologies and tackling social issues. The maturity of digital technologies, and in particular the exponential growth in the number of smartphones at the European and global level, has enabled people not only to communicate but also to be connected with mobility platforms. This enabled the development of a range of research and practices based on people's mobility behaviors and how these could impact the way people moved through an area. Without claiming to exhaustively cover these lines of research and design, we will mention the contributions we consider the most significant ones, which address the latest trends in this field: crowdsourcing, gamification, gender policies, and shared mobility solutions.

Crowdsourcing applications to smart mobility, i.e. the use of digital technologies to gather and organize contributions from citizens in order to improve urban mobility, has been a relatively recent trend developed in the last years. Several authors such as Tomaras (2018) made a literature review to find the main crowdsourcing techniques applicable to this topic. An issue later reviewed by authors as Marzano, Lizut and Siguencia (2019) which selected the most discussed urban crowdsourcing/ citizensourcing applications for supporting urban mobility in the literature. They then divided the most relevant crowdsourcing strand into three classes which are personalized maps for urban mobility and accessibility, urban mobility analysis and urban mobility and public transport. The findings draw the attention to the potentiality of these techniques to guide the behavior of drivers and feed public transport software with their data. On the other side, they find some issues in terms of data security and accuracy.

Another line of research is about gamification, that can be defined as "the use of game design elements in non-game contexts" (Deterding et al., 2011). Johannessen and Berntzen (2016) discuss this issue enhancing its potential to foster implicit participation leveraging smartphones as portable sensors. Analyzing a case study, they o show how citizens can actively participate through implicit participation, awarding their responsible behavior with social incentives. Follow up research showed the potential of these methods promoting a user-centric vision with more flexible, personalized, and on-demand mobility services (Marconi et al., 2019). In particular, the cited contribution presents two successful cases of gamified systems to promote sustainable mobility using technological tools - namely Play&Go and Kids Go Green - investigating the potential of gamified systems, in combination with MaaS solutions, in terms of citizens' engagement and behavior change. The attractivity of these solutions lies in the combination of relatively low cost and the easy scalability of these solutions [Figure 2.5].

The issue of gender equity in public transportation using digital technology is another relevant field of research, broader than the previous two. Singh (2019) focuses on the possible impact of this topic on shared mobility, conducting an exploratory review of the existing research on this field.

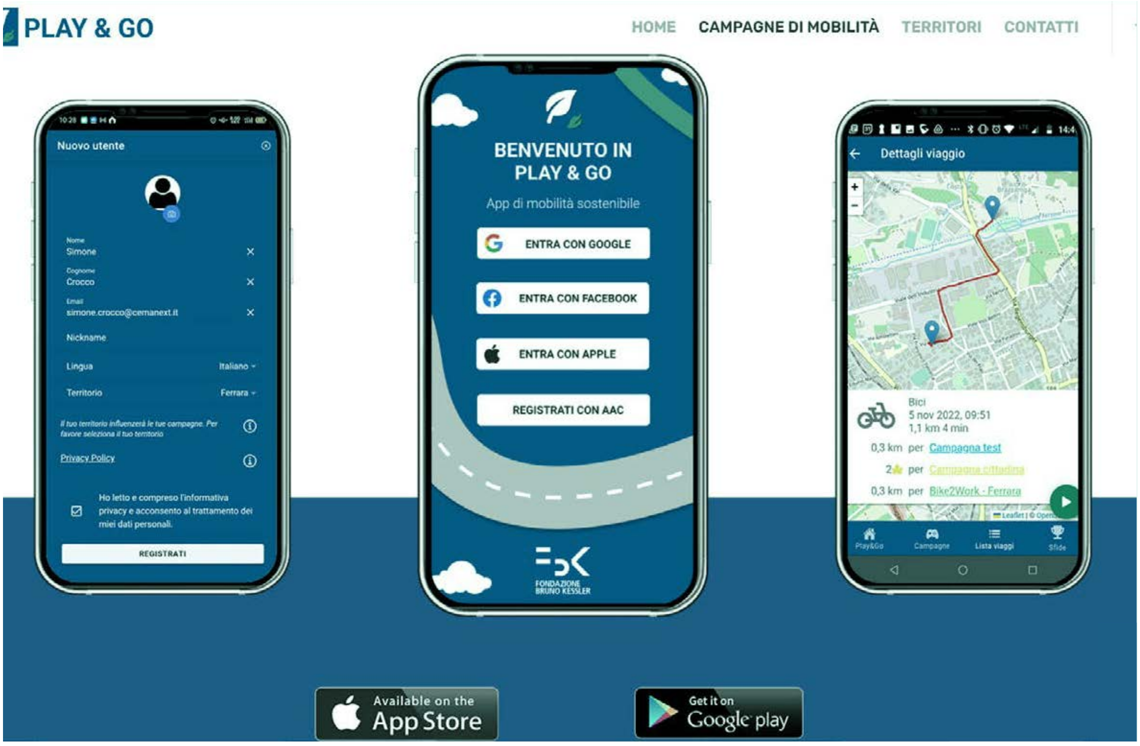

Figure 2.4. The Play&Go app combines gamification with incentives to promote sustainable and smart mobility activities for the citizenry. (source: https://playngo.it/portfolio-articoli/playgo-cittadini/)

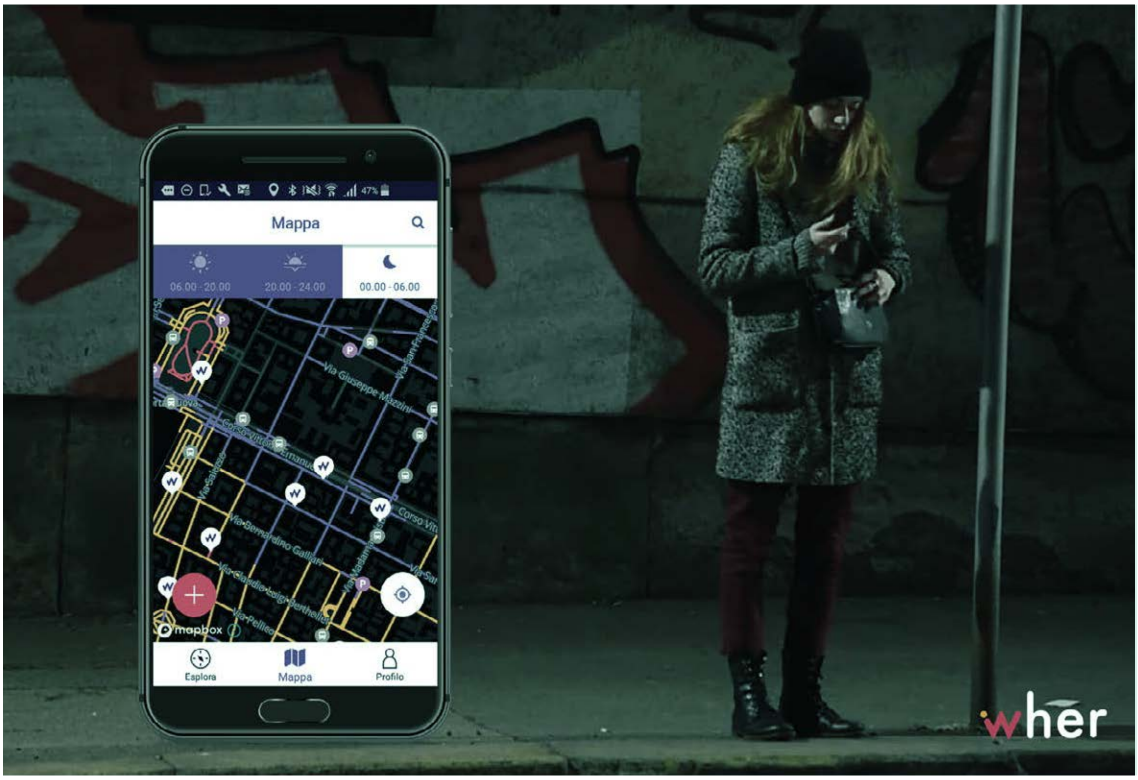

Figure 2.5. The Wher app uses gamification tools and mapping to improve mobility safety showing the safest route to return home. (source: https://rb.gy/c6pqgu)

The findings reveal how there is little attention paid to this issue, considering that female needs are strikingly different than men's. The scholar also speculates on how sharing transport, if not managed, could contribute to widen the gender gap in cities.

McIlroy (2023) further explores this topic relating with MaaS, studying scholarly literature to give insight on the extent to which gender is considered, then using the SWOT framework to investigate how and where MaaS may contribute (or not) to gender parity in transportation. The findings show how MaaS's concentration on multi-modal, non-car travel is one of its strengths, since it is prone to facilitate women's travel habits. On the other side, MaaS weakness lies in its inability to address the larger social and cultural norms that inform the inequalities in how men and women travel. It is also out of the scope of MaaS to implement infrastructural changes to enhance perceptions of security and safety, particularly among women. Then the author discusses opportunities and threats. The main opportunity is to overcome some of those security and safety constraints through the availability of information on MaaS.

A last set of practices related to the broader area of smart mobility is shared mobility solutions. Several European studies (Fromm et al., 2019; FLUCTUO, 2022) point that Shared mobility is a growing market that is increasingly oriented toward light vehicle sharing and micromobility. One possible reason to choose these means of transportation is the greater balance between costs and benefits of these solutions, as car sharing tends to replace the use of public transport or cabs rather than private cars. The literature has debated different approaches related to this issue. Midgley (2009) discusses the state-of-the art of the earlier generation of smart bike-sharing systems in Europe, with a particular interest on sustainable transportation. The author analyzes the most relevant examples of urban bike sharing systems, showing how they work in terms of bike unit, implementation, payment, stakeholders and bike station schemes. It is worth to note that in his conclusions, indicating some key conditions for cities which are considering the introduction of bike-sharing schemes, he stresses the need for a strong commitment to sustainable urban mobility, an adequate cycling infrastructure, and the necessity of financial support by transport operator or public agencies. The author also cites that bike sharing systems are most suitable for cities with more than 200.000 inhabitants.

As sharing mobility systems matured, the above-mentioned operational approach was integrated by a set of complementary studies on the historical and cultural roots of this issue, allowing this phenomenon to be framed in a broader historical and cultural context. In particular, a recent publication of Ploeger and Oldenziel (2020) connects the practices of car and bike sharing in the Netherlands- very widespread in this country - to the urban planning and mobility policies in the past. The Dutch experience is of particular interest as it provides valuable insights into the efficacy of shared mobility in attaining various urban objectives, including the reduction of traffic congestion, enhancement of air quality, and promotion of social inclusion. The authors establish a connection

Figure 2.6. The White Bicycle Plan promoted by the Anarchist movement PROVO in the Netherlands can be considered as a shared mobility forerunner as it proposes to create bicycles for public use that cannot be locked. (source: https://beeldkraken.nl/les.php?xml=provo.xml&it=0&i=0)

between contemporary mobility paradigms and mobility solutions conceived in the 1960s by the anarchist Luud Schimmelpennink. In 1965, during the Provo anarchist movement in Amsterdam, the pioneering White Bike Plan was launched as a protest against excessive car usage in cities [Figure 2.6]. This initiative involved painting bikes in white, making them freely available without locks, thereby promoting a sense of collective ownership and widely distributing them throughout the city. Another innovative proposal was Schimmelpennink's Witkar, a social and technical adaptation of the original anarchist bicycle sharing plan, which incorporated electric car-sharing mechanisms. The authors further elaborate on the evolution of present-day sharing mobility schemes, emphasizing that successful innovation in this domain necessitates a comprehensive socio-technical process, where in all factors must align harmoniously.

These two narratives on smart mobility, namely one more technologically oriented and another more oriented on users' needs have deeply influenced the smart mobility framework in these last years, especially after covid-19 pandemic. Today, smart mobility is no longer regarded as a mere technical matter due to the need for interaction with other aspects of urban life. Nor is it seen purely as a social or cultural issue, due to the evident opportunities that would be missed by embracing fossil attitudes. The most compelling research is moving in the direction of a multi-layered approach, identifying solutions that combine transportation issues with urban life complexity:

– Shared mobility is increasingly shifting toward active, electric and non-electric transportation systems, simultaneously ensuring greater sustainability from a management perspective and promoting active mobility in cities.
– CAVs are more and more subject to investigation, not only concerning their potential urban use, with smart labs and living labs in urban areas but also with regards to the social, environmental, and urban impacts they may generate in medium and large cities.
– Electric Vehicles (EV), a solution ready to use, are studied in terms of their overall environmental impact, adopting a circular design perspective, highlighting that, particularly in urban settings, they exhibit certain limitations in environmental impact compared to other solutions.
– The meaning of active transportation, especially in recent years, has been extensively examined, emphasizing its social, environmental, psychological, and economic benefits.
– Car reduction measures are becoming increasingly prevalent, driven by the diversification of mobility away from exclusive car use. The implementation of these measures is particularly encouraged in central areas and sensitive contexts—with historical, heritage, social, and environmental issues —due to the reduction in negative externalities resulting from extensive car usage.

Among the most relevant contributions regarding the possible advances in smart mobility, Docherty, Marsden and Anable (2018) debate the impact of emerging technologies such as AV and P2P sharing, and the key role of public value to steer this process. Their struggle to find a rationale to govern Smart Mobility process comes from the wide impact on cars not just in transportation but in shifting a long list activities and values. In their opinion we are already at a 'critical juncture' in determining how will develop some Smart Mobility trends, namely the shift towards MaaS, new context-specific information, increasingly connected infrastructure, electrification, automated vehicles. They concluded the paper stressing the importance of finding solutions for broader social goals, rather than for competitive advantage on economic innovation grounds. Regarding the city size, the authors point out the potential inequalities between urban, peri-urban and rural experiences of a 'Smart Mobility' future, demonstrating the potential asymmetry of power between the state and global corporates emerge in many analyses of the impacts of the Smart Mobility transition.

Butler, Yigitcanlar and Paz (2020) conducted a comprehensive analysis of contemporary smart urban mobility innovations from a sustainable perspective, aiming to find their relevance and potential applications. Notably, the term "innovation" assumes a critical role, as it highlights the importance of discerning how the expansion of smart mobility solutions can lead to varying degrees of "smartness".

To this end, the authors examined a range of smart mobility innovations, encompassing intelligent transportation systems, electric vehicles, autonomous vehicles, demand-responsive transportation, shared transportation, and mobility-as-a-service. These innovations underwent a sustainability evaluation, utilizing criteria such as safety, congestion, energy consumption, environmental impact, and accessibility.

The subsequent discussion provides policy recommendations for the implementation of mature smart mobility solutions. Among these recommendations, a prominent focus is directed towards shared mobility and the promotion of shared autonomous vehicles, as these are seen as instrumental in optimizing resource utilization and enhancing overall efficiency. Furthermore, the need for investment in smart infrastructure is emphasized, as it serves as a foundational element in facilitating seamless integration and effective functioning of smart mobility systems. Additionally, encouraging reduced travel is advocated as a means to curtail environmental burdens and foster sustainable transportation practices.

2.3.3. Bibliometric analysis and results

The trends and evolutions of the smart mobility concept can be compared with the most recent bibliometric analyses carried out in this area, of which we present the two we consider the most significant.

Tomaszewska and Florea (2018) articulate the research trends adopting a scientific literature review from 2000 to 2017. One part of the study creates a map clustering the main research trends. The authors find 7 main clusters: Computer simulation of urban traffic, Urban public transport, Urban smart transport planning, Innovations in urban transportation, Data fusion in ITS, Intelligent solutions in urban traffic, Safety of urban computing. While different clusters concern mainly technical applications of computer science to transportation, the second third and fourth are more directly involved in urban design. Regarding “urban public transport” the authors point out that the quality of infrastructure and the city size are the starting point to find effective solutions. In “urban smart transport planning”, the authors highlight the importance of finding tailored solution based on the city characteristics and needs through exchanges and good practices between cities. The cluster “Innovations in urban transportation”, represents the challenge to bring innovative solutions while improving sustainability, to find its most likely research trend on improving the integration of sharing mobility services with public transport, AVs, parking management. Finally, the authors research the terms that had the highest co-occurrence ratio - smart city, ITS, big data, sustainability, public transport - concluding with some remarks. For our purpose, it is worth to note that this review shows the literature gap in infrastructure design, that is not take into account “as much as it should” and not designed considering the city needs and the potential innovation.

Then Allam and Sharifi (2022) proposed a wider analysis on smart mobility trends. The authors review and map the evolution of the concept of 'Smart Urban Mobility' through a bibliometric analysis of white literature from 1968 to 2021, and divided into four sub-periods, namely 1968 to 2010, 2011 to 2015, 2016 to 2019, and 2020-2021 [Figure 2.7, 2.8]. In the first period, 1968–2010, the interest was relatively low and increasing in pace after 2000 when the digital revolution emerged with the main interest in ITS and traffic change and traffic congestion was not a main issue.

In the second period, 2011-2015, the topics grew increasingly, proportionally to the emergent interest in Smart Cities raised also by the Smarter Cities Challenge. The ITS domain expanded, including smart cities and urban mobility, and other two clusters. The first one refers to technology applications in different traffic scenarios, including keywords as Safety, Volume, Travel time, Intelligent Vehicles and Performance. The second one denotes methodologies used in the application of technology in the transport sector.

The third period, 2016-2019, the number of published researched increased significantly and the research areas become more interrelated clustering in three areas. In the most populated cluster, related to ITS solutions, the term smart mobility has been more cited than ITS itself, including keywords such as Architecture, Management and Frameworks. The second cluster encompasses the focus on car traffic scenarios, including wider travel behaviors and transportation modes. The third cluster is focused on technical applications in the mobility sector. From the literature, this period is characterized by an exponential growth, especially in urban planning. An interest focused more on sustainability agendas that may be stimulated by the different global agreements that came into force from 2015 such as UN SDGs or Paris Agreement. Furthermore, the authors noted that during this period the number of cars increased significantly, as the amount of digital solutions in transport mobility.

The fourth period, 2020-2021, has also an increasing evolution of smart mobility studies grouping in three clusters. The ITS-Smart City cluster originates into two distinct categories. ITS encompasses technical terminologies focusing on a wide range of control systems, including AI. Smart Cities has strengthened the networked dimension of 'smartness' in urban areas, including mobility. The cluster previously linked to traffic scenarios, has expanded including Smart Urban mobility and terms such as Models and AVs. The rise in disciplines connected with smart mobility research in these years could be explained with the impacts of COVID-19 pandemic emergency, and the raised awareness about the negative externalities of car-centered mobility.

The authors then speculate about future trends in mobility research, pointing the emerging role of micromobility and STS to reduce private car dependency, and the possible use of AV / CAV to face

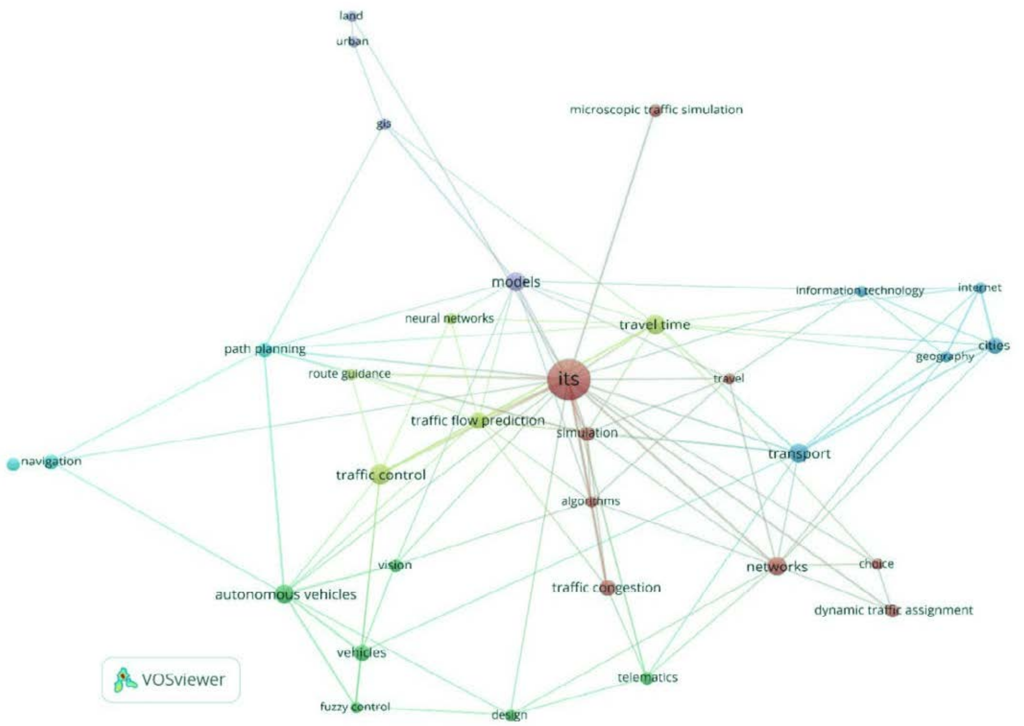

Figure 2.7. Mapping keywords output from 1968 to 2010. (source: Allam and Sharifi, 2022)

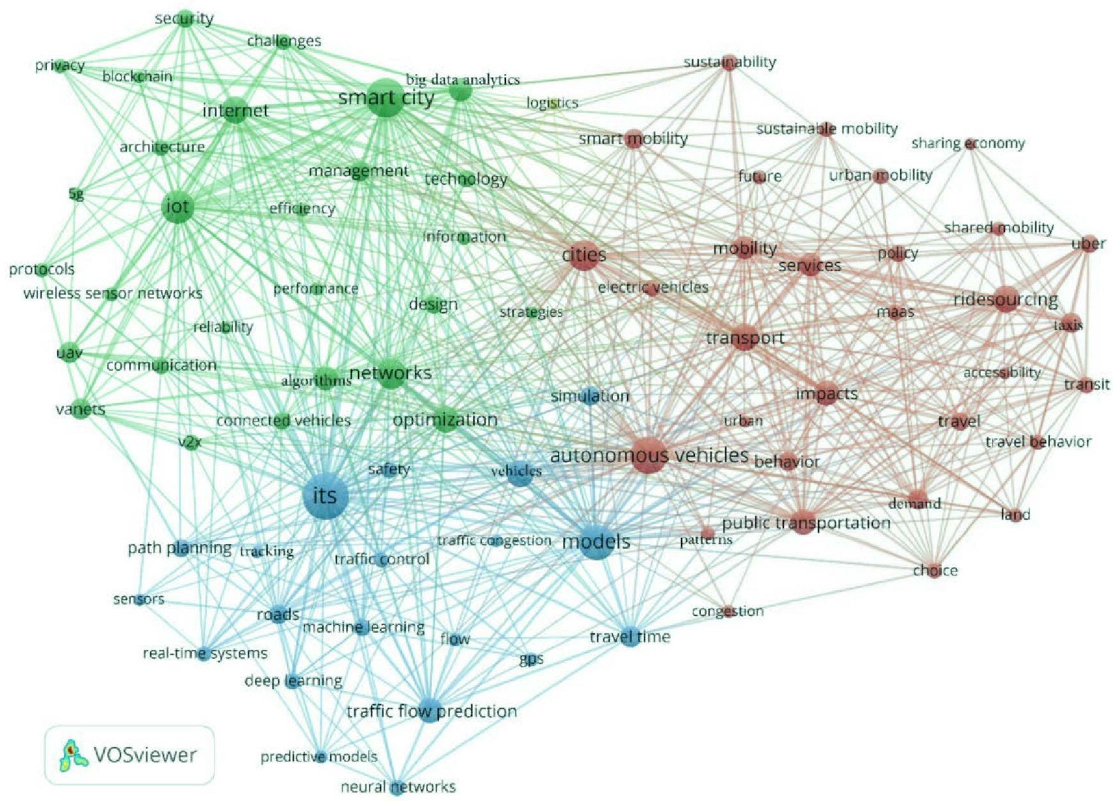

Figure 2.8. Mapping term co-occurrence from 1968 to 2021. (source: Allam and Sharifi, 2022)

the current environmental crises.

These results are in line and integrate the contributions on smart mobility illustrated in the previous paragraph. Until 2010, the concept of smart mobility had limited scientific dissemination, with initial systematizations – such as the ones of Mitchell and Giffinger – emphasizing the correlation between smart cities and smart mobility, and their impacts on urban fabric and city infrastructure. From 2010 onwards, this topic has seen exponential growth in terms of research, experimentation, and implementation. One of the main reasons for this growth undoubtedly lies in the direct involvement of ICT corporations, which have sought to develop this sector on a global scale, focusing primarily on Intelligent Transportation Systems (ITS) and smart vehicles. While they undeniably deserve credit for drawing economic and scientific attention to smart mobility, research has highlighted the limits of an overly technology-focused approach divorced from the complexities of urban implementation. A greater consideration of these aspects, combined with socio-economic factors and the increasing technological maturity reflected in research, has led to improvements in ITS systems in urban environments and the proliferation of other smart mobility practices, some of which were already present, such as shared mobility, crowdsourcing, and gamification.

From 2019 onwards, there has been a further evolution in the landscape of smart mobility. Experimentation increasingly seeks to establish a stronger connection between the technological and physical components of the city. Connected and Autonomous Vehicles (CAV) are being tested in living labs; AI solutions are supporting ITS systems that are increasingly geared towards promoting sustainable mobility practices [Figure 2.9]. The pandemic has contributed to direct these trends towards a greater emphasis on wellbeing, particularly by promoting greater hybridization of road networks, the enhancement of micromobility systems and pedestrian-cycling networks, the digitization of daily practices – notably work and commerce – and a reduction in car usage.

2.4. Smart mobility in towns, rural areas and low-density areas

This chapter is dedicated to the exploration of smart mobility within regions characterized by low population density, specifically rural territories and small- to mid-sized towns. The aim is to provide a comprehensive overview of the current state of the art in this field, drawing from insights that have evolved from reflections on smart mobility within urban settings. This chapter will place particular emphasis on European mobility solutions due to their compliance with the research topic. This emphasis is confirmed by the fact that Europe has already established the basic infrastructure for mobility, unlike some less-developed regions where such infrastructure is yet to be established (Cvar et al., 2020).

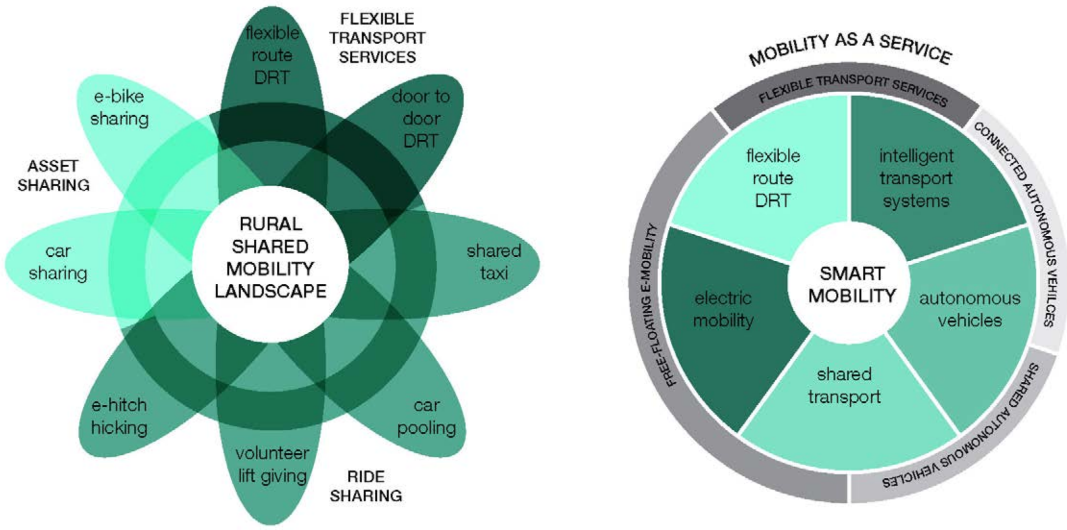

Figure 2.9. The evolution of mobility solutions framework in low-density areas. (source : SMARTA EU project, 2019; Butler et al., 2020)

The choice to scrutinize European mobility solutions is motivated by their pertinence to the research topic. Scholars, including Porru et al. (2020) and Zavratnik, Kos and Duh (2018) already mentioned in the previous paragraph, have underscored the importance of a context-wise choice in this field of research, namely significantly sensitive to the different environmental, social and economic conditions in rural areas. These contributions underscore the pivotal role of the context in evaluating smart rural mobility, finding that the established European mobility infrastructure is a fundamental element in addressing future transportation challenges of low-density areas. Furthermore, the demographic and geographic relevance of this subject within the EU is noteworthy. According to statistics from 2018, slightly less than two-thirds of the EU's population lives in towns, suburbs, or rural areas. Remarkably, rural areas, despite their lower population density, encompass a substantial 83% of the EU's total land area. These demographic and geographic issues frame the background of smart mobility solutions in EU rural areas.

In conclusion, this chapter investigates smart mobility in low-density areas, with a focus on EU rural territories. It will review the existing literature in this field, addressing the most relevant subjects and approaches to smart rural mobility. Then, it will further explore the main EU projects on rural mobility investigating their main goals, the most relevant issues and the recurrent mobility solutions. Moreover, these findings will be related to the demographic and geographic relevance of this topic to discuss its level of smartness, which in this context means how smart mobility solutions are tailored to the context and how enhancing transportation accessibility and sustainability in low-density areas.

2.4.1. Rural smart mobility – literature review

In the previous paragraph we argued that various solutions have been tested in rural and suburban areas with the spread of smart mobility projects in urban areas. Then, the goal of this literature review was to gain insights into the most relevant experiences, approaches and methods that may be integrate the discussion on smart mobility in small and mid-sized towns and the development of this research. This review focuses mainly on academic research, selecting scientific-wise material appropriate to our research field.

The growing interest in smart mobility, illustrated in the previous paragraphs has supported an extension of this research field from the urban sphere, where the main smart city projects are located, to less densely populated areas. Novel approaches, complementary or alternative to the smart city, have thus been developed to promote the integration of digital technologies in these areas. The following are the main ones:

– smart land. 'Smart land' refers mostly to the integration between environmental studies and digital technologies, for example as climate smart agriculture or land use or land governance. The broad range of applicability and the lack of definitions makes it suitable for many contexts. This term is associated with an important scientific production that spans through diverse areas of study, from technologies to agriculture to spatial planning.
– smart region. 'Smart region' term is more focused on electronic and computer science studies. It has a wide number of publications, even more than 'smart mobility' for WoS, one of the most important research database. Matern et al. (2019) define smart regions as "diverse urban-rural areas that are spatially reframed by digital technologies and the respective social practices in a variety of fields (citizenship, governance, economy, environment, mobility, infrastructure) on a discursive, implemental and regulative level. The concept of smart regions follows a relational and social constructivist understanding of spaces and emphasizes an integrated approach towards the social (re-)construction of smart regions by actors and their networks". This very promising definition for our research has translated mainly into the area of ICT integration in regional planning, particularly in Smart Specialization Strategies (S3) and limited output concerning smart mobility.
– smart territory. The concept of 'smart territory' explores new solutions in large-scale areas, leveraging ICT solutions already developed for the urban environment. It can be defined as "a geographical space, which seeks to solve public problems through technology-based solutions within the framework of a partnership between multiple participants from different sectors. The key to the movement of smartening territories lies, therefore, in applying similar

ICT tools that have been used in urban areas and apply them to a wide variety of geographical contexts" (Navío-Marco, et al., 2020). At the academic level, it is mainly developed in urban studies and promotes a view focused on technology and a static relationship in development processes.

- smart village(s). 'Smart Village' is an approach framed in a series of EU thematic projects to develop rural areas, started in 2017 and currently ongoing. One of the first definitions, discussed in more detail in the next paragraph, presents Smart Villages as "communities in rural areas that use innovative solutions to improve their resilience, building on local strengths and opportunities" (European Commission, DG-AGRI, 2020). Although it has a lower scientific production associated with it than the first two terms, its innovative approach has produced several projects in this area and several lines of research including the following ones.
- smart countryside. It is a niche of the wider concept of 'smart village' developed mostly in UK academia. One of the most relevant contributions on this approach was developed by Bosworth et al. (2020) , recalling several aspects of the EU 'smart villages' concept. It emphasizes the importance of place-based approach in rural context to effectively address the needs of local communities, even in transportation domain.
- smart rural mobility. Although there are no comprehensive definitions, the name of this field already frames its main aspects. Like the previous term, this field of research is also very specific and directly related to the concept of smart village. However, compared to smart countryside it has a steadily growing number of related publications.
- X-minute city / 30-minute territory. The concept of the 30-minutes territory is one of the multiple versions of the well-known X-minute city concept. Proposed by prof. Carlos Moreno, the 30-minutes territory concepts extend the transportation means of the 15-minute city – walking and cycling – with other transportation means such as electric vehicles or on-demand transport to maintain adequate accessibility even in small towns. It was not possible to gather further information in Moreno's public contributions that did not go beyond the theoretical analysis of this concept. Then this concept, even if it is considered promising for the research aims, was therefore considered only from a theoretical and methodological point of view.

While characterized by a wide scientific production, a quick analysis of contributions found in major academic libraries reveals that the first three approaches provide a limited influence on this research. The first approach finds applications in the field of land estimate, agriculture, and planning, integrating digital technologies into land use and land governance to optimize processes. Mobility appears as a secondary research topic with few significant contributions. The second and third research areas encompass an extremely broad range of contributions, with a significant portion of scientific output focusing on neuroscience or the field of energy. Excluding the less relevant parts, those closer to the content treated here relate to regional planning or political sciences, offering an analysis that does not specifically delve into the physical dimension of the territory but provides insights on a broader scale.

The latter three approaches are more aligned with the objectives of this research. 'Smart Village,' in addition to being a keyword associated with a robust scientific output, is the title of a series of European initiatives linked to research, studies, and projects with a specific focus on mobility. The connection between theoretical frameworks and practical implementation is particularly valuable in the research presented here to assess the limitations and opportunities of adopted solutions. Although the term 'Smart Countryside' has limited scientific output, it offers some relevant theoretical contributions. Such as those by Bosworth et al. (2020), Tollis, L'Hostis and Boubakour (2020), and Mounce, Beecroft and Nelson (2020), which expand upon the conceptual framework of 'Smart Village,' moving towards a more innovation-led and socially grounded approach, differentiating it from the common vision of 'smart cities.' Finally, 'Smart rural mobility,' although having fewer contributions compared to the previous research areas, is the closest to the contents of this exposition. Contributions associated with this term provide an overview of the primary approaches and solutions for smart mobility in sparsely populated territories, highlighting current directions and trends in this research domain.

Based on these considerations, an extensive literature search was conducted using the main scientific publication search engines, incorporating the most relevant keywords, namely 'Smart Village,' 'Smart Countryside,' and 'Smart rural mobility.' An initial analysis of the publications, attached in the annex 1 assesses the most recurring themes in the titles and abstracts of contributions resulting from the literature research. It emerges that the most frequent themes are participation and social impact (13.4%); energy (8.2%); tourism (8.2%); climate and environment (9%); aging and health (14.2%); smart mobility (14.9%); economy (8.2%) [Figure 2.10].

Therefore, several considerations can be made. Mobility, health, and social impact are the most prevalent topics in the reviewed publication. As highlighted in the previous chapter, mobility represents one of the primary dimensions of smart villages. While in urban contexts mobility is an autonomous field of research with its own specific aspects such as parking, vehicles, and transportation infrastructure, in rural areas is mostly examined in correlation with other issues. We infer this result from the unique conditions of rural areas, including the accessibility gap with more urbanized areas, exacerbated by the advent of digital technologies, and its potential consequences in terms of accessibility to urban services and social and environmental resources, which are particularly pronounced in low-density areas. The focus on health and social impact also reflects the characteristics of these territories.

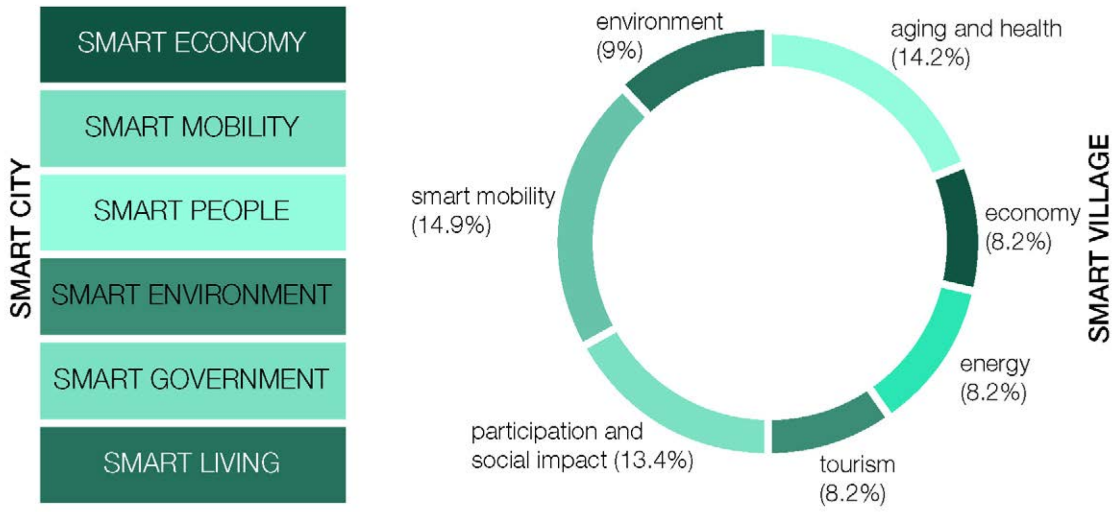

Figure 2.10. The main topics of smart cities with the most frequent issues in smart villages. (source: Giffinger, 2007; author)

Well-being is often associated with aging, aligning with the demographic features of these areas. Similarly, the social impact likely stems from the recognition that the local community often represents the primary resource for initiating innovation processes with immediate repercussions on the territory. Consequently, smart rural mobility projects cannot avoid a social assessment.

When comparing these dimensions with those of the smart city proposed by Giffinger—Economy, People, Environment, Government, and Living—it becomes apparent that the categories cover the same areas, albeit with some differences. Governance becomes participation, living turns into tourism, and people shifts to aging. In this context, the transition of 'smartness' from urban areas to outskirts takes into account the diverse urban resources of the context. In the following section, the additional screening of existing literature will analyze the primary features of smart mobility in medium and low-density areas, addressing the issues of the relationship between density and accessibility and between technology and innovation.

2.4.2. From density to accessibility. Avoiding the mobility gap in rural areas

Reducing the mobility gap from rural and urban areas and increasing accessibility is one of the fundamental challenges debated in smart mobility literature. The main positions on the one hand broaden the scope of the smart city to the rest of the territory using a common logic, and on the other hand propose a different approach between urban and rural 'smartness' because they are structurally different areas.

Naldi et al. (2015) question how the concept of smart growth in urban policies can be transferred to rural regions. One of the main issues is the definition of 'place', due to the fact that rural areas are not uniform and may significantly affect the design approach. For instance, in intermediate rural areas smart specialization could be a successful strategy, while in more peripheral rural regions the main leverage could come from natural resources or social infrastructure. "Hence, there is a need to decompose not only the meaning of space but also the different components that are included in the broad concept of place-specific characteristics and how they can be expected to influence the growth potential for different rural regions". The lack of a unique operative definition of smart rural development was remarked by other scholars (Adamowicz and Zwoli ska-Ligaj, 2020). Following this perspective, Davidenko, Menshikova and Gorbenkova (2018) resume the smart city layout proposed by Giffinger to promote 'Smart Settlements'. Although it is conceived in accordance with the Smart City concept, the author remarks on the need for an improvement of social and utility infrastructure, and the new business models needed to integrate existing towns and settlements with cities. This approach has been used also by other scholars (Smékalová and Ku era, 2020), especially in policy context, with mobility seen as one of the main dimensions in smart rural development. In more recent years, other scholars proposed an innovative smart region framework characterized by the combination of TOD and ICT tools (Lam, Li and Yu, 2021). A very demanding approach, mainly applicable to developing countries, that supports smart regions to reach a sound physical and virtual connectivity in both cities and rural areas. From a mobility perspective, the study analyzed the possible benefits and proposed a smart region model in which low density areas are characterized by a sort of digital ruralism bolstered by a series of e-services such as e-employment, e-health, e-education, e-commerce, e-entertainment.

Several comparative studies, conducted mainly in Europe, have shown that using the same smart mobility solutions requires a different approach from rural to urban settings. An overall evaluation of the most appropriate technical solutions that support Smart Cities and Smart Villages (Cvar et al., 2020) pointed how even using the same digital tools the Smart Villages' innovation ecosystems demand different strategic approaches due to their lower density and their multifaceted background. Then, a comprehensive study on Shared Mobility Services in Germany (Schaefer et al., 2022) evaluated the users' feedback to local public transportation between large cities and rural regions. Results showed that in the second case, although there is an interest in these solutions, the lack of the necessary infrastructure, the high rate of car ownership, and the weak communication about the benefits of these solutions limit a full deployment of these solutions.

These considerations confirmed the need to adapt the smart city paradigm to the needs of rural

areas. Slee (2019) further explores the concept of 'smart villages' in relation to the specific context of Scottish rural development. Here he noticed the importance of the social, economic, environmental context, and how a much more community-centered approach is fundamental to develop smarter rural areas. This marks a shift of 'smartness' towards a more social-oriented and 'spontaneous' approach, framing this concept "as a phenomenon associated with self-organized, bottom-up community action [that] contribute to local people's wellbeing or exploits emergent opportunities through collective means". In this perspective, 'smart villages' are intended as communities that wisely use their resources that highly depend on contest, for instance to the proximity with other cities or towns. Thus, "smartness should be assessed with respect to relative socio-economic outcomes where one community outperforms other similar communities" to create an effective smart region.
A seminal contribution that remarked the key importance of the context in small and mid-sized towns and paved the way to prioritize a multi-sectoral approach in smart mobility. Starting from the assumption that a multidisciplinary approach is the only way to tackle rural areas issues, some authors (Zerrer and Sept, 2020) considered Digital Social Innovation (DSI) as a possible solution to manage rural digitalization processes. In this perspective, every domain relates to others to spread its innovative potential, and mobility solutions should be designed in relation to the context and community interactions to reduce urban-rural digital divide. Other scholars blended 'smart' strategy with sustainable development and local services (Renukappa et al., 2022), highlighting that the deployment of innovative mobility solutions has to be coupled by providing basic infrastructure to have a relevant impact.

Further contributions analyze rural smart mobility in the frame of promoting responsible innovation (Agriesti, Soe and Saif, 2022) defined as "a way of doing and thinking about research and innovation which acknowledges that the design of new technologies creates power imbalances resulting in uneven benefits and disadvantages within different stakeholder groups" (Cowie, Townsend and Salemink, 2020). The results suggest that the mobility needs of low-density areas not only differ from cities, but they also widely change based on their specific context. We infer that the high variability in mobility needs may explain the literature gap on impact assessment of mobility solutions in this field.

In this context, accessibility plays a fundamental role as one of the most recurrent factors contributing to the success of rural smart mobility solutions. Mounce, Beecroft and Nelson (2020) conceive smart countryside as fundamentally different from smart cities due to its sparseness. With these premises, rural transport services have to be designed to enable people to access services, linking accessibility to people's quality of life. The most noticeable conclusion from the analysis was that linking rural mobility services with the public transport network may much more influence the effectiveness of the solutions, and highlight how transport, health and educational services are particularly relevant in these areas. From this perspective, other authors as Gross-Fengels and Fromhold Eisebith (2018), describe rural context in terms of main services and attractions.

In their work, Bosworth et al. (2020) developed a multi-layered framework of rural needs associated with older people, younger generations, and businesses. This framework, connecting rural needs with urban services, outlines the basic service offer to promote inclusive and accessible rural mobility. The authors emphasize the inner social value of mobility, that encompasses its basic function of enabling access to essential goods, services, work, healthcare, and education, arguing that the social function of mobility must be the cornerstone of any future rural strategy. This approach advocates for a balanced perspective on accessibility that combines digital services such as e-health or e-retail with spaces and infrastructures that promotes social interactions.

This perspective is echoed by other authors (Butler, Yigitcanlar and Paz, 2020) who besides underscoring the connection between accessibility and quality of life, highlight the key role of vehicles in rural areas to provide a secure and free access to social activities, employment, healthcare. A perspective that wants to limit the optimistic view that depicts a transportation system where everybody has equal access and all users group use on-demand services, pointing out the risk of the difficulty in predicting the possible consequences of massive use of on-demand services and the critical role of having a means of ownership in rural settings. Other authors (Brovarone and Cotella, 2020) framed a multi-layered approach to better connect accessibility issues to the policy context and to provide innovative solutions that encompasses the transport domain. The proposed framework connects different levels of recommendation with decision-making clusters to seize mobility solutions relating to the context. The proposed approach aims to "weighting" the different potential of mobility solutions in the low-resources context of rural areas. More recent contributions uptakes accessibility issues in rural areas including mobility justice and remarking the importance of updating urban services. Regarding the first issue, the paper shows different issues in mobility justice for rural residents such as the longer distances to essential services and amenities, the higher costs for transportation and the lack of consideration in transportation policy making the decision-making process (Flipo, Ortar and Sallustio, 2023). Mobility policies – and we should include design solutions – have to take into account also this topic, which is strictly related to social interaction, particularly relevant in rural mobility. The second issue highlights the role of rural coworking spaces (Bosworth et al., 2023), pointing how these places could become significant network nodes, combining local and extra-local networks around a space that depends upon both social and digital infrastructures.

2.4.3. From smart-ness to smart-less. Mobility prospects in low density areas

Knowing how to interpret ‘smartness’ in rural areas has been one of the recurring goals of smart rural mobility projects. A topic considered early in the scientific literature given the different urban resources present in medium and small towns compared to urban contexts. Several contributions have dealt with the topic of technology integration, both by analyzing possible ways of transferring innovative solutions developed in urban contexts and by elaborating specific approaches to finding innovative solutions for rural areas.

‘Smart’ transfer and innovation strategies in rural settings turn out to be hybrid processes, bringing together multiple elements in order to be able to respond to the needs of the context. Gross-Fengels et al (2018), analyzing the deployment of a DRT system as case study, remark how Smart Mobility solutions in rural areas require adaptations and interpretations to be used in a broader context “due to the specific mobility demand patterns and the idiosyncrasies for sustainability-related innovation”. They also notice how the deployment of innovative mobility solutions should encourage simple solutions rather than brand-new complex digital tools. Also Bosworth et al. (2020) questioned the common assumption that technological advances in mobility will simply transfer into rural areas as-is, highlighting how data science methods for the smart countryside need to be qualitatively different from smart cities and more conventional statistical methods are more appropriate for them.

These considerations result in several studies on rural areas which preferred the use of well-known analysis methods and tools because of their cost-effectiveness and reliability in relation to the goals to be achieved.

Zavratnik et al. (2020) includes in his core principles and recommendations for designers of ICT solution to calm technology nuancing it to a community-oriented design.

Over the years, other scholars opted for the use of basic research methods in rural contexts. A study on the impact assessment results of MaaS pilots (Eckhardt, Lauhkonen and Aapaoja, 2020) used qualitative research based on case studies to collect data on which to draw their conclusions. Another research on context-based approach to smart and sustainable development in the Baltic Sea Region (Kalinka et al., 2020) datasets were elaborated using a geographic information system (GIS) to connect datascape with landscape. Moreover, academic papers evaluating DRT services (Campisi et al 2023) (Bruzzone, Scorrano and Nocera, 2021) used well-known analytical models as cost analysis or a simple transportation cost function on PT and city users. In some cases, it has been compounded by the community’s refusal to use unfamiliar technologies. A research project focused on smart suburbs project (Tollis, L’Hostis and Boubakour, 2020) showed how resident participation discredited the hypothesis that technologies were essential to trigger mobility transition in suburban areas. Even the use of state-of-the-art technologies is being tempered by cost reasons or usage limitations. Aráuz (2021) proposed the use of Machine Learning (ML) to improve performance of a low-cost solution for distributed monitoring of the use of public transit in small communities. Another study on developing countries (Billones et al., 2021) proposed high-tech models to develop a smart region mobility framework. The research refers mostly to a deep integration of an ITS platforms with all transportation services such as PT, information platforms, route plans. It is worth to note that the authors do not fully take into consideration the economics of the massive deployment of technological systems.

Franco et al. (2023) in a recent paper on introducing new mobility services in rural areas used data mining and data fusion techniques to understand typical daily travel patterns and to promote their deployment. In order to get this amount of data, which was not always possible in all areas, it was necessary to use GIS systems or existing databases with a series of questionnaires to validate the collected data. Another recent contribution (Beckmann and Zadek, 2023) on CAVs discusses their acceptance, control and performance on the results of questionnaires and interviews to users combining high-end transportation solutions as CAVs with low-tech analysis tools to be acceptable for local users and communities.

The balance between technology and processes of technology transfer and integration in rural areas is expressed into adaptations and combinations of smart mobility solutions to match the context strengths and opportunities. Scientific literature presents several contributions on this issue.

Gross-Fengels et al (2018) analyze the deployment of a DRT system as case study remarking how Smart Mobility solutions in rural areas require adaptations and interpretations to be used in a broader context "due to the specific mobility demand patterns and the idiosyncrasies for sustainability-related innovation". In-depth research on car sharing (Rotaris and Danielis, 2018) found that the main user groups differ depending on their location. In rural regions, car sharing is mostly used by students and unemployed people while in urban areas the main user group is professionals. Another case study on the integration between PT and MaaS (Porru et al., 2020) observed how the territorial context has a significant influence on choosing the right solution, particularly in spatial and demographic terms. One applied research (Marconi and Loria, 2020) on two case studies of gamified systems investigate their potential in combination with MaaS solutions. The research shows how this approach could fit both in urban and rural areas because it is not e-skill demanding, is easily scalable to different contexts, and promotes social innovation. Bruzzone, Scorrano and Nocera (2021) matches the growing awareness on the environmental and social costs of travelling as well as the need for fair, inclusive, and accessible transport systems proposing as a valuable solution the combination of e-bike sharing and DRT system.

Regarding smart mobility solutions, the literature under review predominantly features DRT, MaaS platforms, car and bike sharing, and e-bike sharing. In contrast, other technology-oriented solutions like ITS and TOD receive less attention. This observation is likely attributed to their limited cost-effectiveness and the reduced funds available in low-density areas. Furthermore, contemporary technological trends in smart mobility, such as CAVs and Electric Vehicles EVs, do not appear as frequently as in urban contexts. Some scholars, including Bosworth et al. (2020), have delineated potential limitations in their adoption. This may stem from similar challenges encountered by the aforementioned solutions, including a lack of maturity that hinders precise calculations of the payback period and the benefits associated with their deployment.

From the contributions mentioned above, it is possible to see how the methods of smart rural mobility project analysis and solution development refer mainly to open innovation models. These, consider technological innovation as a means of improving the quality of life in low-density areas. The next section will elaborate on these considerations based on major European projects.

2.4.4. Smart rural mobility literature and urban identity

We finally deepen how these contributions discuss urban identity issues, considering the three broad domains of place identity as defined by Relph (1980) which are physical setting, meanings, activities. The physical setting is the main topic in the articles cited in this section, resulting in two findings. First, the physical context is often discretized into services, amenities, and POIs. We infer that this elaboration highlights how the design of smart rural mobility scenarios should necessarily analyze the accessibility of the available urban services in the area. Second, infrastructure, particularly road infrastructure, is recognized as an enabling factor to promote proximity. In this case, we infer that the quality of the physical space is considered as the principal alternative to scenarios involving extensive use of online services and interactions mainly taking place on digital platforms. In most contributions, these elements are addressed as policy recommendations without further in-depth exploration. Agriesti, Soe and Saif (2022), however, elaborate on this aspect in greater detail, emphasizing that the general recommendation to develop physical infrastructure should translate into the reorganization of transport means hierarchy to promote cycling and walking, the revision of the road network and public spaces, and the enhancement of connections to the city, schools, and meeting points. These actions reduce the car-dependency and have a positive influence on having well-connected social communities.

The second most prevalent area is the one of activities, particularly those that consider the needs of the local community in proposing smart rural mobility solutions. In the analyzed contributions, this topic is characterized by two main orientations. The first aims to use digital technologies to enhance social interactions, to more clearly identify the latent needs. An example is the use of apps and social media to promote meetings and communication regarding mobility initiatives. The second approach seeks innovation by combining existing solutions with the needs of underrepresented categories. Examples include activities related to organizing transport according to social requirements, social and mobility-impaired transport, transport for schools, and kindergartens. This aspect of urban identity reflects the social and demographic dynamics common to most rural areas, proposing solutions that, if correctly designed and adopted, we believe can be applicable in most cases.

The last topic reviewed are the meanings, more challenging to frame compared to the other two, that can be explored in the literature by adopting a place-based approach in the development of smart rural mobility solutions. Co-design activities allow users to express the personal values of individuals and communities involved, combining different horizons of meaning in the adopted project. This requirement emerged in response to the need to enhance local communities and stakeholders, which can make the solution useful for a specific context but not for other areas. The literature has repeatedly questioned the 'place' issue in place-specific approaches, recognizing that rural areas are not uniform and vary due to a wide range of factors. As stated by Cvar et al. (2020), "A place-based approach is designed to target the unique conditions of specific environments, enhancing collaborative decision-making processes, sharing initiatives, fostering local talents, resources, and stakeholder interests." This dimension of urban identity is currently still debated, and the literature does not always clearly address how much the existing best practices are transferable and which part of them depend on context.

2.5. Smart rural mobility in the EU

The growing development of the smart city concept and smart mobility solutions in urban areas has led to an extension of these models to less urbanized regions over the years. The relationship between urban and non-urban models is multi-layered due to the varying population density, services, and infrastructure. In urban areas, the smart city model could rely on the deployment of advanced technological solutions or the integration of digital technologies into urban processes. The lower density in terms of infrastructure, population, and services makes it challenging to fully apply this model in smaller-sized centers. To promote sustainable development in these territories, and especially rural areas, the European Commission has initiated several funded programs and policy actions to promote innovative measures. This journey has seen significant milestones in the Cork Declaration 1.0 of 1996 (CORDIS, 1996) and the Cork Declaration 2.0 (EU, 2016). While they do not directly mention the topic of smart mobility, there are some relevant elements related to this area.
The first element refers to the specific demographic, social, and environmental conditions of rural areas. Precisely, how the particularity of the context induces the consideration that an integrated

approach is the best way to operate in the countryside to deliver innovative, inclusive, and sustainable solutions to address current and future challenges. We can find this consideration in both documents and, in 2016, is further developed including sustainability, social inclusion, local development, and the concept of identity as a focal point for rural area development. Although not further elaborated, this concept finds correspondence in other parts that emphasize the need to preserve the rural and natural heritage, which is one of the resources of rural landscapes, and to enhance the diversity among different areas.

The second element of interest concerns urban infrastructure and services, both of which are highlighted as areas that can generate substantial value for these territories. The importance of achieving an “adequate” and “essential” level of infrastructure is reiterated as a key element in supporting the development of vital and sustainable communities. Among these, the increasing importance of ICT infrastructure in improving the quality of life in these territories is emphasized. While the first document advocated for the integration of these technologies to support the development of viable rural communities and the revitalization of villages, the second one recognizes the gap that has emerged with smart city initiatives in urban areas, underscoring the importance of bridging the digital divide and harnessing the potential offered by connectivity and digitization in rural areas.

2.5.1. From EU Smart Villages to Smart rural 21 and Smart Rural 27

Since 2017, the European Network for Rural Development (ENRD) has launched the Thematic Work on Smart Villages. This initiative, which has continued over the years, aims to promote the development of smart solutions in low-density contexts. It was initially formulated through the EU Action for Smart Villages in 2017 by the European Commission, representing an attempt to implement and actualize the directives laid out in the Cork Declarations by executing tangible actions that revitalize rural services through digital and social innovation.

The “Smart Villages” initiative (2017-2019) represents the pioneering effort in this field, introducing a novel approach to thinking about rural areas. This initiative relies on the recognition of technology’s pivotal role in regional development. Furthermore, it emphasized the need to accelerate the digitalization processes in small urban centers, acknowledging the increasing importance of digital technologies as a developmental factor. Consequently, the endeavor aimed to extend the applications of these technologies to broader territories, as highlighted by Slee (2019). The concept of smart villages is also interconnected with smart specialization, a concept previously explored in a rural context by Naldi et al. (2015) and Teräs et al. (2015), as discussed in the previous paragraphs.

Smart Village was developed as sub-theme of a broader ENRD thematic work entitled ‘Smart and Competitive Rural Areas’ and from 2017 to 2019 has explored ideas and initiatives to improve rural services with digital technologies and social innovation. One of their pilot projects proposed a

definition of Smart Villages as “communities in rural areas that use innovative solutions to improve their resilience, building on local strengths and opportunities. They rely on a participatory approach to develop and implement their strategy to improve their economic, social and/ or environmental conditions, in particular by mobilizing solutions offered by digital technologies. Smart Villages benefit from cooperation and alliances with other communities and actors in rural and urban areas. The initiation and the implementation of Smart Villages strategies may build on existing initiatives and can be funded by a variety of public and private sources.” (European Commission and DG-AGRI, 2020).
This definition allows us to identify some important points that distinguish smartness in small towns from urban settings:

– The central role of communities, which is reflected in the constant search for social value in projects and strategies at varying scales - of block, municipal, inter-municipal - depending on local needs.
– The constant search for multi-disciplinary strategies, linking different disciplines to increase the resilience of proposed initiatives and to link them to global trends in development and innovation (OECD, 2022).
– A vision of digital technologies that is subordinate to innovation and targeted to the pursuit of social, economic, and environmental goals, far removed from the smart city programs promoted by ICT companies launched since 2010.

The result is therefore a vision of Smart Villages where the concept of “smartness” is translated into the innovation of products, processes, services in the broadest sense, disconnecting it from technological innovation alone by taking up some of critical positions already explored in the context of smart cities and discussed in the previous paragraphs of this research.

In a retrospective reflection, Slee clearly marked the paradigm shift induced by the Smart Village concept compared to smart cities, pointing that “The idea of Smart Villages has evolved from the idea of Smart Cities, but these are more associated with technical solutions. Smart Villages also exploit the opportunities provided by new technology but put more emphasis on the potential for social innovation to bring major improvements in well-being. Smart Villages are, therefore, more than the country cousin of Smart Cities” (Slee, 2020).
Further to this point, a Thematic Briefing was developed by the ENRD in order to promote digital transformation framework in villages and rural areas. The document outlined the essential conditions that enable digital transformation (ENRD, 2020):

– Access to fast internet connection, intended as a combination to ‘hard’ infrastructure with the development of ‘soft’ capacities and skills in local communities to take full advantage of it;

- Mechanisms for involving local stakeholders in the identification of digital needs and in the co creation of digital solutions need to be in place, such as a digitalization plan;
- Accessibility to ‘spaces’ that support digital transition processes, such as Digital hubs, fab-labs, co-working spaces, living labs and other intermediate bodies that contribute to develop new smart products and services for rural communities and their stakeholders;
- Cooperation with other digital players in wider regional and national ecosystems, creating an innovation system that links major corporations, research institutions and large urban and metropolitan areas.

All of these conditions define the level of digital maturity of the territory. Connectivity and accessibility to innovation spaces assess the level and quality of its digital resources and skills, while stakeholder engagement and promotion of cooperation assess the digital functions that rural settlements are able to provide both locally and within wider digital ecosystems. An approach to digital transition that is affected by context conditions, where the digital gap makes the massive use of technology less feasible than in more densely populated settings.

Smart Villages projects share some of the most relevant features of ENRD’s vision on Smart Villages. In particular, an interest in the social impact of the project, intended as a way to find practical solutions that balance the goals of equity and efficiency, and the role of digital technology, to be used not for its internal appeal but only when appropriate, in relation to a broader concept of innovation rather than intensive use of technical solutions. Within this framework, the projects develop city events – moving, working, socializing – as needs to be met with urban services made more efficient by the Smart Villages approach. The combination of these services - e.g., educational, work, health, energy services - define a smart ecosystem, a network that dialogues with existing spatial resources - e.g., natural and transportation networks.

Mobility is a fundamental part of this ecosystem, since mobility-related issues are part of rural areas and their impact tends to be transversal, involving multiple domains and deeply affecting the quality of life of local communities. Pointing that rural mobility has received far less attention than urban mobility, as remarked in the previous literature review, a thematic briefing was prepared to highlight the most relevant factors and conditions for designing sustainable mobility solutions within the Smart Villages strategy. Here mobility is defined as “a basic freedom; it is the possibility to access work, education, services, society and everything else that is part of a person’s life. In other words, mobility is one of the vital enablers of any community, especially of rural communities where many essential things are located some distance away” (ENRD, 2019). A definition more related to the issue of accessibility than proximity, highlighting the gap between the natural expectation to move and the settlement dispersion of these areas, which highlights the enabling and cross-cutting character of mobility as a value adding component to other economic, social, tourism or environmental projects.

The European experiences and projects presented in the program aim to enhance "the connectivity of a village or rural area or increase the number of people who can access a business/activity" (ENRD, 2019). The landscape of mobility solutions encompasses a range of shared mobility and DRT services, targeting user groups such as young people, the elderly, and vulnerable individuals, who are typically excluded from the traditional car-based mobility model. These services also contribute to improving "the level of connectivity of local communities, businesses, and activity points" to enhance the territory's attractiveness.

In rural areas, the topic of connectivity, primarily associated with the transport sector, is integrated with the need to create an inclusive and accessible urban system. The mobility system envisioned in the Smart Village initiative comprises various components adapted to the local context. Public transportation is redefined by combining conventional public transport, with stops and frequencies tailored to the local population's needs, with shared mobility solutions such as DRT services and carpooling coordinated by different municipalities. Moreover, a network of mini-hubs/interchange points is established in each town and its outskirts. These hubs are strategically located near train stations or major bus stops and offer various bike/car-sharing services, as well as multimodal travel information and payment systems. This mobility ecosystem also encourages bottom-up initiatives, involving local retirees and other volunteers who provide additional low-cost community mobility services.

In terms of physical investments, the Smart Village's mobility system primarily comprises the aforementioned mini-hubs scattered across the territory and the potential for combining the use of electric vehicles with energy generation, e.g., community energy initiatives and photovoltaic installations. While some mobility solutions (e.g., e-bikes) were not considered due to their limited adoption during the initiative's timeframe, it is noteworthy that the proposals related to mobility spaces are of secondary importance, primarily focused on accommodating new mobility forms. Consequently, there is a lack of comprehensive reflection on the road as a public space and the character of the road network within the smart mobility solutions.

The EU's Smart Village Concept has continued from 2019 to 2022 with the "First Preparatory Action for Smart Rural Areas in the 21st Century", known as "Smart Rural 21". Smart Rural 21 represents an initiative supported by the European Commission (DG AGRI). The primary objective of this initiative is to encourage and inspire rural areas throughout Europe to develop and implement smart village methodologies and strategies. The program builds upon the Smart Village initiative, refining its scope of action and further developing a roadmap toolbox for planning and monitoring a Smart Village Strategy based on the experiences gained and planned [Figure 2.11].

This roadmap toolbox starts seeking to clarify the terms “Smart” and “Village” within the initiative. With respect to the term “Village,” it references communities in rural areas, specifying the target population and the urbanization level. An analysis of projects undertaken from 2017 revealed that pilot initiatives varied in population size from 50 to over 10,000 residents, with over 90% located in areas classified as rural by OECD or EUROSTAT, including some areas classified as “towns and suburbs” due to shared thematic challenges. Then, the initiative extends the target of rural areas to larger territories that share common issues, such as depopulation, an aging population, the lack of services, and have to cope with the digital gap.

Regarding the ‘smart’ concept, in the Smart Rural 21 initiative has go through a paradigm shift, emphasizing innovation over technology in low-density areas. Although innovation is recognized as a crucial feature of Smart Villages, defining innovation within this context is complex, as the context significantly influences whether a solution is deemed innovative. In terms of digital technologies’ role in Smart Rural 21’s innovation processes, it acknowledges that while “smart” does not solely refer to “digital,” the digital transition cannot be ignored, especially in the 21st century. Low-density areas must keep the pace with digital innovation to address local and global challenges effectively.

These considerations have formed the basis for developing a roadmap to assist villages in implementing smart village strategies, incorporating elements from established innovation models such as Nesta’s Innovation Spiral (NESTA, 2019) and the Impact Gaps Canvas (Papi-Thornton, 2016), adapted to existing project management and policy-making models. Smart Rural 21 promotes an inclusive approach based on community and stakeholder needs, incorporating continuous economic monitoring and precise territorial mapping of data. The overarching goal is to define a virtuous path for the development and implementation of smart village approaches and strategies across Europe and support future policy interventions on smart villages.

Mobility remains a crucial topic within Smart Rural 21. The analysis of smart village strategies (Smart Rural 21, 2022a) from twenty-one selected municipalities highlights common challenges related to depopulation, outmigration, and the lack of services, including transportation and facilities, education, housing, and healthcare. These challenges are countered through leveraging territorial resources, emphasizing assets like attractiveness, rich nature, resilient community, participation, cultural heritage, and tourism. Regarding the number of proposed projects, mobility and connectivity represent the second thematic areas indicated by the selected Smart Rural 21 villages after Economy. Mobility is thus recognized as an essential dimension of smart strategies, though it has evolved from the focus on transportation solutions in Smart Villages – particularly DRT and sharing mobility – to be integrated in a more comprehensive strategy of territorial development.

The most complete case study of Smart Rural 21 is Ostana, a mountain village of about 85 inhabitants in the province of Cuneo, Italy. Starting with the need to develop a smart mobility plan to provide sustainable solutions for reducing private transportation and carbon emissions, Ostana has created a high-quality offer for residents and tourists: an alpine wellness house, and cultural centers. In this case, mobility was used as part of a broader strategy to develop a long-term infrastructure involving multiple areas-transportation, culture, tourism, welfare-to achieve the main goal of renewing community spirit, regenerating local heritage, and improving the overall attractiveness of the village [Figure 2.12].

The maturation of mobility solutions has led to their integration with other domains, as e-caring for the elderly, digital platforms for improving local services, renewable energy, and local energy communities (Smart Rural 21, 2022b). However, the physical implications of future mobility in terms of road infrastructure and public space design in small communities are not fully explored. Nonetheless, Smart Rural 21 makes a considerable effort to create "connected rural areas," aligned to one of the four pillars of the EU rural areas strategy (European Commission, 2021), aimed at enhancing social, digital, energy, environmental services, and improving the quality of life in rural areas.

In December 2021, the "2nd Preparatory Action on Smart Rural Areas in the 21st Century," known as Smart Rural 27, was launched. As the third program following Smart Villages and Smart Rural 21, its primary goal is to prepare Member States and rural communities for the implementation of the Common Agricultural Policy (CAP) post-2020 and other EU policies and initiatives that could potentially support the emergence of additional Smart Villages in the EU (Smart Rural 27, no date). While Smart Rural 27 builds on previous smart initiatives, such as the Smart Eco-social Villages Pilot Project and Smart Rural 21, its focus appears to be primarily directed toward agronomic and environmental aspects, such as biodiversity, farm-to-fork, and climate action. Materials concerning previous projects are being organized into a smart inventory and mapping to promote the dissemination of best practices. As Smart Rural 27 is still in its early stages, further insights related to this project's salient features and its relationship with previous programs will be the subject of future research and document updates.

2.5.2. Smart rural mobility projects in the EU

In this section, we will delve more deeply into the characteristics of the smart mobility solutions adopted in Smart Villages, Smart Rural 21, and Smart Rural 27. The selection of case studies was based on projects developed within these programs or connected to them.

Concerning Smart Villages, the main references were obtained from the Thematic Briefing dedicated to rural mobility, which identifies key projects related to sustainable mobility within the initiative. The primary ones are SMARTA and MAMBA, two EU projects conducted during the Smart Villages

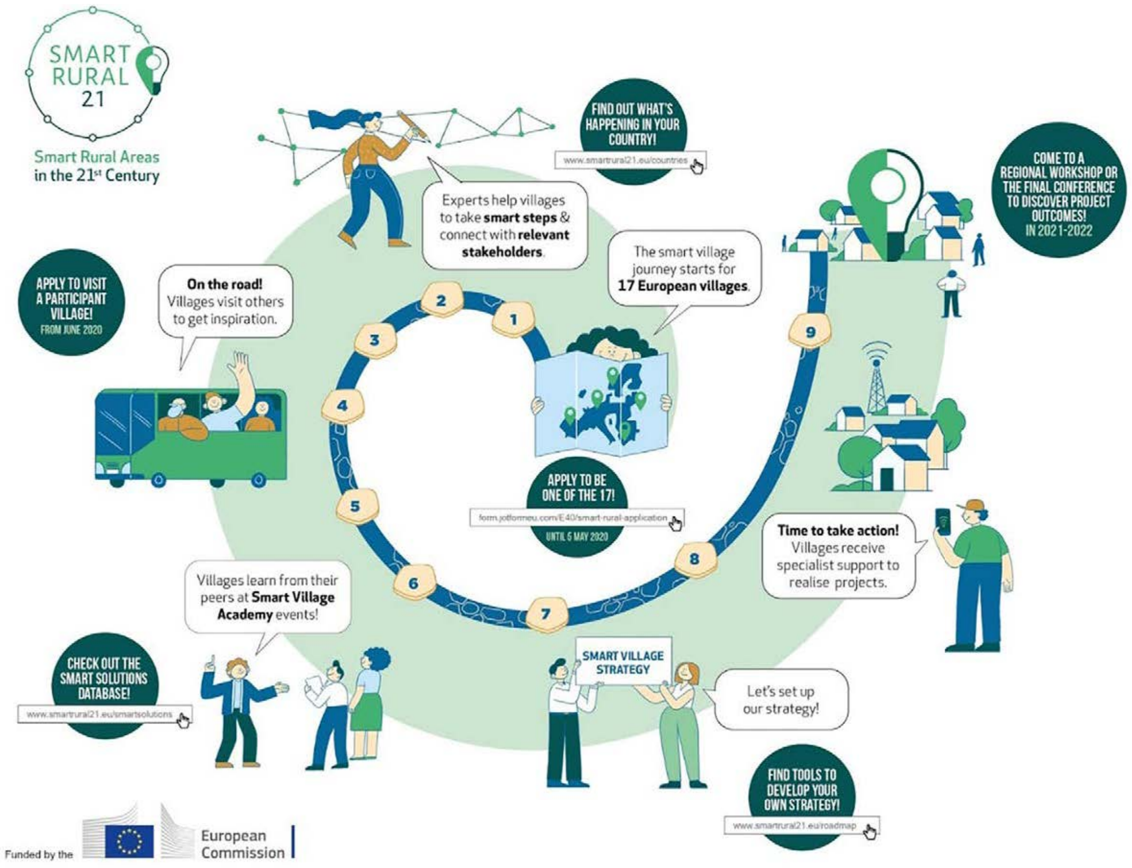

Figure 2.11. The smart rural 21 roadmap. (source: https://www.smartrural21.eu/)

Figure 2.12. Ostana, Alpine Welfare House. In this smart village, smart mobility combined the improvement of electric mobility with with the promotion of local services. (source: https://www.smartrural21.eu/wp-content/uploads/3rd-Regional-WS-Smart-Rural-21-Professor-Antonio-de-Rossi.pdf)

program period, and they have significantly influenced the program's outcomes. SMARTA, funded by the European Commission – DG MOVE, focuses on shared mobility and public transport. In 2018 and early 2019, the project conducted a comprehensive review of best practices covering mobility services, rural policies, and governance initiatives from across Europe and beyond. In 2019, the follow-up project SMARTA 2 - DEMONSTRATORS commenced, focusing on testing the shared mobility solutions in previously selected pilot areas. MAMBA, another essential reference cited in Smart Village documentation, is an INTERREG Baltic Sea Region project that commenced in 2017, concentrating on mobility in rural areas facing demographic challenges such as aging and declining populations.

For Smart Rural 21, the research was based on the smart solutions of the thematic area "connectivity and Mobility" on the project's website. The analysis includes a selection of actions and projects related to the development of transportation and IT networks, emphasizing those most relevant to the research themes. Since Smart Rural 27 is in its initial phase, the available documentation primarily reports on the previous initiatives, which have not been reanalyzed in this study.

Using these criteria, 67 best practices in rural mobility from Europe and other regions were selected, encompassing cases from 25 different countries. For each project, the analysis identified the corresponding EU program, the country in which it was developed, a brief description of the solution, and the primary mobility macro-area addressed. To categorize these areas effectively, the broader theme of mobility was broken down into three main dimensions, as listed below:

- Vehicles. This dimension involves features centered predominantly on innovation, promotion, or invention of transportation means. Examples include the use of private cars, new micro-mobility systems, drone deployment, autonomous driving systems, and their potential consequences.
- Behaviors. This dimension concerns potential changes induced mainly by the introduction of new mobility behaviors and habits. Actions such as sharing mobility, promoting different types of vehicles already on the market, MaaS that streamlines the use of various mobility systems in the area, and parking management apps all fall into this category.
- Infrastructure. This dimension focuses on the relationship between physical space and mobility and how the characteristics of physical space can contribute to innovation. Of particular importance are environmental and energy-related services and infrastructure, as well as transportation networks. These factors give rise to different applications regarding proximity, accessibility, and the connectivity of both material and immaterial networks. While exploring various topics, the main issue of this domain concerns the design, management and use of spaces related to mobility issues.

These three distinct aspects are clearly interconnected. The widespread use of private cars has significantly altered behaviors and infrastructures. The various townscapes and the unique urban identity of historical town centers promote diverse mobility behaviors and provide intriguing insights for contemplating mobility models based on service density and population. For the purpose of our research, it seemed useful to explore which of these dimensions constitutes the primary reference domain, allowing for a deeper analysis of these solutions and for identifying potential gaps to be bridged.

The project data collected reveals that 74% of the case studies focused primarily on the dimension of behaviors and services. In contrast, 34% of the case studies experimented the use of innovative vehicles, and 15% included infrastructures in smart mobility actions. Although we infer that the higher occurrence within the behaviors and services domain results from the SMARTA project's primary focus on shared mobility solutions, there is still a noticeable disparity between the various dimensions of mobility identified, reflecting an approximate ratio of 4:2:1.

Another aspect considered is the general characteristics of the context, particularly important in smart rural mobility solutions. Regarding this issue, the projects are relatively evenly distributed across the continent, with Ireland, Italy, the UK, Germany, and Finland being the top five countries, accounting for 50% of the total projects. Regarding the geographical features of the project sites, it is observed that 63% are located in plain areas, 19% in mountainous regions, 10% in hilly areas, and 8% on islands. Additionally, there is a noticeable interest in specific user groups, particularly prevalent in this area of research due to the mobility dynamics in rural regions. For the four most relevant categories - vulnerable people, students, working commuters, and tourists - the analysis indicates a significant focus on vulnerable people (26%), followed by other groups ranging from 6% (students) to 13% (commuters).

A comparative analysis of geographical domains and specific user categories indicates that these solutions have been experimented across all regions, primarily in plain areas due to their higher prevalence in the European Union. The focus extends to user categories that mirror the trends of depopulation, aging, and increased tourism in rural areas [Figure 2.13].

Regarding the content of these projects, it is possible to identify how the Rural Shared Mobility Landscape (ENRD, 2019), outlined in Smart Village, has evolved throughout the programs. In SMARTA and SMARTA 2, projects primarily centered on shared mobility, exploring a wide range of solutions in this domain, particularly DRT and asset and ride sharing, including car sharing, carpooling, and volunteer lift-giving. These directions align with one of the primary EU projects, MOG - Move On Green (EUROMONTANA, no date), which was a key reference for the Smart Village program, known for its research on good practices in the main areas of smart rural mobility. SMARTA adopts the solutions with the highest number of shared initiatives, such as social dedicated mobility initiatives, transport on demand, and energy efficiency, promoting environmentally friendly attitudes toward mobility. In MAMBA, the project's purpose evolved to focus on maximizing mobility and service accessibility. The analysis of the selected projects reveals that shared mobility interventions remain prevalent but are complemented by actions that affect the organization of transportation systems and the physical nature of mobility spaces, such as mobility programs, co-working hubs, and cooperative mobility centers.

Shared mobility solutions mainly involve apps and platforms to manage intermodality, enabling asset and ride sharing, primarily involving cars and buses. In SMART RURAL 21, MAMBA's multidisciplinary approach is confirmed, in line with the project's interdisciplinary nature highlighted in previous chapters. Projects related to accessibility and connectivity encompass smart mobility interventions and projects that link mobility demand with urban services and physical spaces. The platforms and apps are not only used for demand management but also for a digital farmer's marketplace and finding, booking, and renting shared resources. Similarly, interventions affect physical spaces by renovating buildings as service hubs for the local community or implementing smart solutions in public spaces, such as sensors, benches, cycle-pedestrian network upgrades, and ICT.

In summary, 80% of the analyzed projects fall under the shared mobility domain, with over half of them related to DRT and shared mobility solutions. The majority of selected projects aim to blend traditional transportation methods (e.g., buses and taxis) with digital technologies (e.g., autonomous vehicles and MaaS). These technologies are playing an increasingly important role in sustainable mobility solutions, especially DRT services, which improve public transportation efficiency and reduce costs. The data underscores the growing influence of digital tools and platforms, particularly smartphone applications, online mapping platforms, and digital marketplaces, to enhance accessibility, communication, and resource sharing among mobility users and specific target groups. On the other hand, emerging technologies such as EVs, CAVs, or AI have been marginally utilized, typically in areas with strong industrial infrastructure and advanced IT capabilities, likely due to the development costs associated to these solutions. The remaining 20% of projects encompass solutions addressing accessibility and the physical dimension of the territories. The number of projects in this field has gradually increased over the period analyzed, and we infer that the reimplementation of technological solutions previously tested has allowed these projects to achieve sufficient maturity to be successfully integrated with services and transportation networks, facilitating innovation.

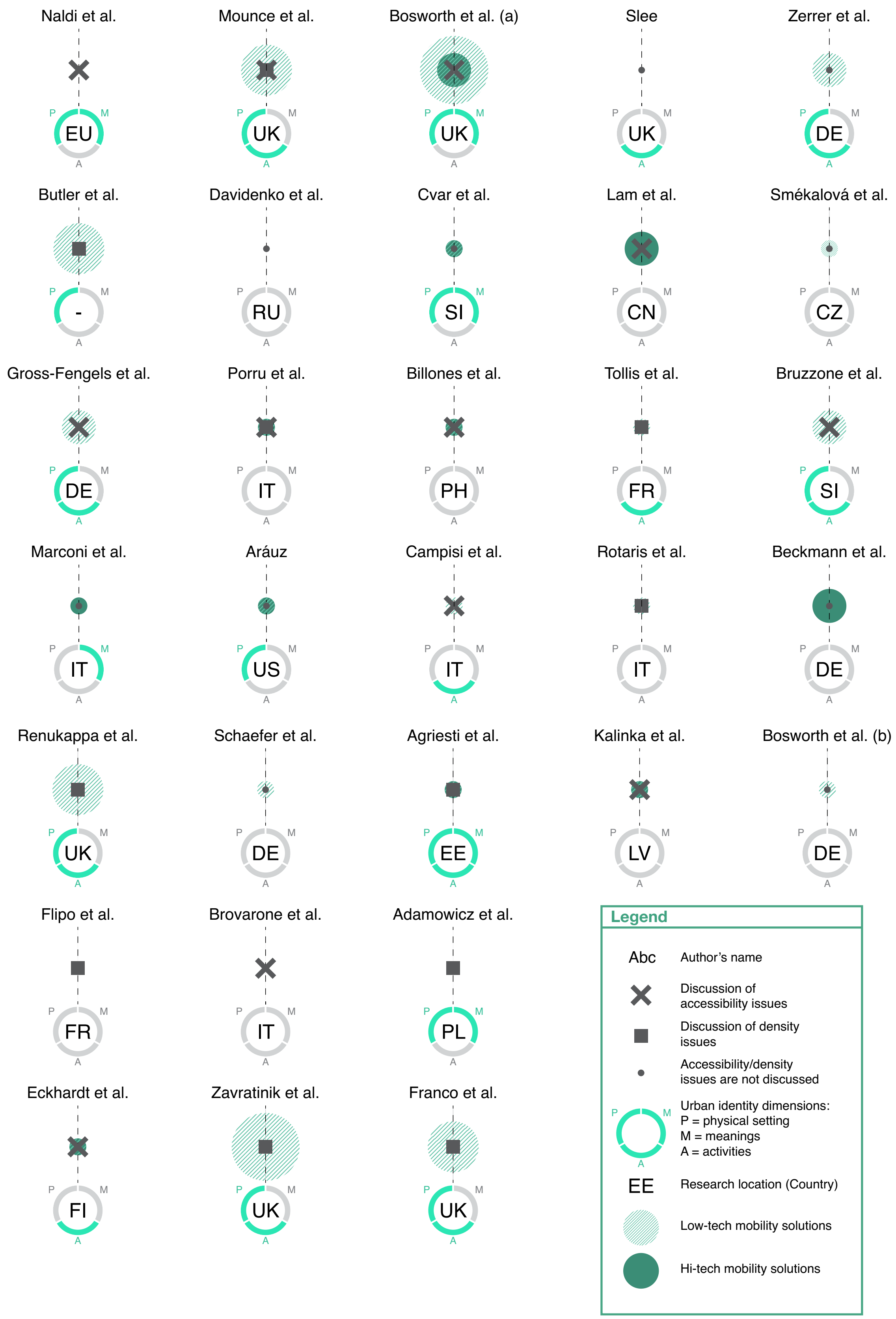

Figure 2.13. Infographic of the case study analysis. (source: author)

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Chapter 3.
Smart mobility case studies in small and mid-sized towns

3.1. Introduction

This section presents different applied research studies conducted from 2017 to 2022 in the Emilia-Romagna Region, more precisely in Faenza and Castel Bolognese, two municipalities which are part of the Unione dei Comuni della Romagna Faentina (URF - the Union of Municipalities of Romagna-Faentina). An overview of all the applied research carried out is provided in Table 3.1 and 3.2. In every study, the theme of smart mobility has been examined, delving into different aspects depending on the pre-established objectives. Some areas and solutions of greater interest have been addressed among the various studies, such as the reorganization of the road network to promote active mobility. The chapter is structured in three parts. The first part frames the methodological approach used. The second part illustrates a selection of applied research studies carried out within the URF research context. They are here used as case studies to capture key issues regarding urban design and urban identity, and acquire insights on local mobility needs, and collect more smart mobility solutions. Then, the last part discusses the most relevant outcomes of the studies. The aim is to highlight the key domains for evaluating smart mobility initiatives in small and mid-sized cities. For a more in-depth interpretation of the single case study, an excerpt of the final report of each study is available as an annex [see ANNEX 3]. For each report we selected the parts considered as most relevant for the research aims.

3.2. Aims and methodology

The methodological approach used was research by design (Roggema, 2017), specifically in the design and post-design phases. This methodology was chosen because it is a means to explore new research pathways, innovative ideas and concepts that stakeholders and researchers would not encounter in a regular research or design process; and also because the project is the means by which the architect poses a problem and develops a solution in relation to places, contexts and needs (Ramsgaard Thomsen and Tamke, 2009). In the context of small and medium-sized towns and cities, this methodology is particularly useful in several aspects. Firstly, it makes it possible to capture different sensitivities within various communities and local identity in an open and unstructured way.

Secondly, it makes it possible to vertically investigate the most significant urban resources of the territory, which are often limited and coming from different areas, verifying their possible involvement in change scenarios. Finally, it makes it possible to test alternative visions of mobility while limiting costs and time, increasing the awareness and involvement of communities and organizations involved in the issue of smart mobility.

In the final part of the chapter, the main elements of interest of the various applied research studies will be discussed. In this part, a qualitative analysis method will be used based on the available design documentation. As also highlighted in the literature, (Sheydayi and Dadashpoor, 2023; Schöbel, 2006) the decision to use qualitative analysis is motivated by the need to maintain information and implicit meanings that would be undetectable if reduced to numbers. Based on the criteria identified by the literature available on the subject, we will then conduct a qualitative interpretation of the design values expressed by each individual study with the aim of highlighting themes and characteristics which are valuable in the assessment of the project.

3.3. Applied research studies in Faenza and Castel Bolognese

3.3.1. Castello ++ smart town planning, 2017

Completed in 2017, this study was conducted in order to understand how new technologies will change the habits of citizens and the urban development models of small towns. The area studied is the municipality of Castel Bolognese, considered an interesting case study because it represents a sort of standard small Italian town, and therefore a model potentially more replicable than most due to its population size and its location, a small town where larger cities can be reached within 30 minutes.

Based on these premises, a strategic methodology called 'small town planning' was created with the aim of investigating how the use of innovative resources in small municipalities could indicate development scenarios. The research is structured in different parts. The first is an interpretation and analysis of the territory, summarized by a SWOT analysis and the answers to a travel habit questionnaire open to the entire population. The second part describes the 'small smart town' model. This model differs from the idea of corporate smart cities by associating the technological and infrastructural part with a strong social component. The small smart town model is divided into three levels. The 'Smart City', the basic layer, represented by digital infrastructure; 'Smart Governance', which is an intermediate level to guarantee and guide the innovation process; and the 'Smart Community', formed by citizens who use special platforms to generate value for the territory. Starting from this model, ten strategic themes for 'smart planning' are identified, namely: Governance;

SMART COMMUNITY
cooperation
public value
identity

\+

SMART GOVERNANCE
transparency
simplificatiton
subsidiariety

\+

SMART CITY
optimimzation
efficiency
sustainability

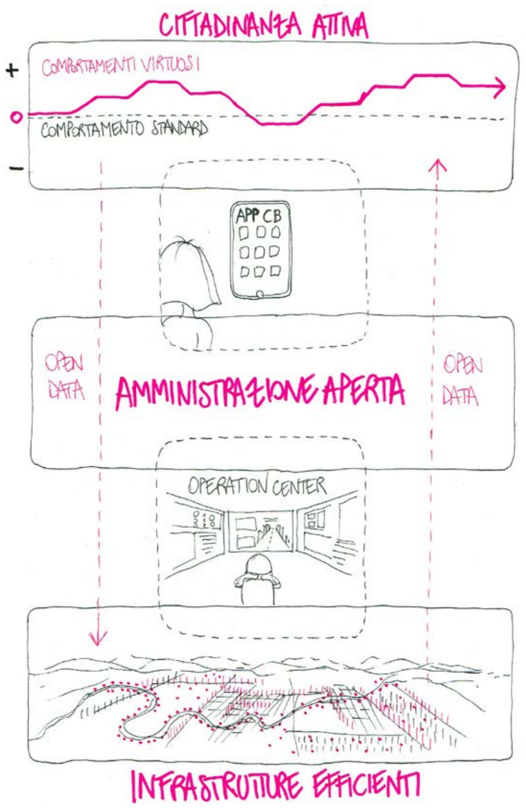

Figure 3.1. Diagram of the Castello++ smart town planning strategy. (source: Next City Lab)

Services; Social Capital; Health; Leisure Time; Flows; Trade; Production/Manufacturing & Agriculture; the Environment; and Risk. For each theme, a series of actions have been identified, divided into phases. As a general rule, each theme includes short-term strategic actions and more structured actions to be carried out over five years. The actions, both strategic and specific, cover the general themes in the specific local context to guide the choices of the administration and the local community. Several 'smart planning' actions propose a few solutions related to the theme of smart mobility. In the Health category, the creation of a network of 'trim trails' to promote movement and active mobility is proposed; and the Flows category includes the proposal of a smart community for the sharing of home-school and home-work travel, the redevelopment of the Castel Bolognese railway station, and the drafting of a Sustainable Urban Transport Plan for more strategic mobility. In addition to these actions, there are some long-term infrastructure proposals, namely the implementation of the connectivity level, the integration of smart and IoT solutions into the public lighting network and the urban services network.

This study addresses the issue of mobility with a medium-term strategic approach, presenting some elements of interest. Regarding the innovation model, research into the 'small smart town' highlights the importance of social and technological factors and the strategic role of infrastructure to support this paradigm shift in the digital transition. A perspective consistent with the Smart Villages EU initiative is illustrated in section 2.5.1. Another element of interest is the mapping of the existing mobility model through a questionnaire, which detects excessive private car use in relation to the type and length of travel. The 'smart planning' actions seek to change the status quo by involving all mobility domains and rethinking the identity of the town. It is a resilient approach that, by linking mobility domains and transport systems, proposes a more innovative, sustainable and socially responsible mobility ecosystem. In addition, the study highlights the strategic role of infrastructure to support the paradigm shift of mobility within digital transition processes. In fact, infrastructure is the fundamental physical support network of the mobility ecosystem, the interface that makes it possible to avoid the excessive use of immaterial networks and the impoverishment of the material resources and networks present locally. In conclusion, the study reveals different elements of interest in relation to the type of approach used, the criteria for choosing mobility solutions, and the solutions proposed.

3.3.2. Smart active network, 2018

The study, which began in 2018, explores the feasibility of one of the actions contained in small town planning methodology to submit it to a regional call for proposals for the construction of bicycle paths and the promotion of sustainable mobility. The trim trail proposal is detailed and reworked to meet the objectives of the call for proposals, and includes the creation of an innovative network of cycle/pedestrian paths integrated with smart signage systems. Compared to the action described in the small town planning methodology, the network of paths starts from the urban fabric (interlacing key points of the town centre) to the extra-urban part (which connects the urbanized area with natural elements and places of interest). The goal is to connect the main services, points of historical interest and places of aggregation of Castel Bolognese, enhancing the social, infrastructural and technological resources of the territory in an innovative way.

Regarding the urban part, the proposal provides for a series of integrated interventions to improve the usability and level of safety of pedestrians and cyclists and accessibility to services, combining infrastructure elements and digital sensors. To achieve these objectives, analyses of traffic flows and the road layout were resumed and implemented, applying a series of principles and literature models (FIAB, 2003; NACTO), such as better/more signage near intersections, a continuous bicycle/ pedestrian routes, the maintenance of roads to guarantee the same level of importance to all users and enhancing the existing walking bus service. One of the critical points of the network of urban routes concerned the crossing of Via Emilia, a heavily trafficked road of national interest: more than 20,000 vehicles/day in the section examined for our study. This road divides the urbanised area into two parts, which penalises north-south cycle-pedestrian accessibility and access to the services

Figure 3.2. The design proposal for the urban cycling network. (source: Next City Lab)

Figure 3.3. Image of the smart intersection on Via Emila and the Historical Centre. (source: Next City Lab)

located in the old town. To solve these problems, the creation of Safe&Smart crossings was proposed, a series of safe passage points for bicycles, vehicles and people along Via Emilia, equipped with a predictive signage system to limit the risks deriving from the different blind spots at road intersections in the historical context. To ensure the economic sustainability of this change, technological solutions have been proposed at the most critical points, choosing market solutions. Among the various options, a system was chosen consisting of a vehicle presence detector and a LED strip along the main road which lights up before the passage of the vehicle to signal its approach.

The elements of interest of this study concern different aspects. As in the previous case, the proposed innovation model is not merely based on the sole use of technological solutions, but rather their balancing with the social initiatives present (e.g., walking buses) and with local resources (e.g., the River Senio and buildings of historical and architectural value). Also in this case, the study highlights how infrastructure, and in particular the bicycle/pedestrian network, is an enabling element for the transition to sustainable mobility. Flow analyses are deepened with a mapping of the road network, detecting situations and steps to take that will help promote active mobility and impact the urban identity of places. In summary, the study highlights the possibilities which arise from a rethinking of the network of mobility spaces, to be seen not as an element of caesura, but one which re-weaves the urban fabric. A network that connects streets and public spaces, integrating people and digital technologies, the urban fabric and places of local historical memory.

3.3.3. Innovative regeneration plan, 2018

The study, concluded in 2018, proposes a strategy to refurbish the old town of Castel Bolognese, to apply for a regional call for proposals for urban regeneration. The proposal re-works the actions contained in the smart town planning methodology concerning the development of the old town, expanding it into a strategic vision that involves commerce, road traffic, and the enhancement of identity and social heritage.

Starting from an analysis of the existing context and the dynamics regarding the old town, the strategy defines a series of strategic objectives, shaping the steps to take and planned actions accordingly. The objectives of the strategy are: to enhance the most attractive parts of the old town; to rework a strong identity in line with current cultural horizons; to improve the quality of public spaces; to define actions that will support commerce and services and foster innovation within them; and to reactivate Via Emilia and improve the level of road safety in the old town.

The general strategy then gave rise to a series of interventions designed to enhance identity and innovation in the old town. The interventions cover different areas – artistic, architectural, technological, and communication – to impact as many levers of urban development as possible, focusing on the central areas of the old town of Castel Bolognese. In particular, the interventions concern Via Emilia and the network of porticoes and squares in the immediate vicinity to better interconnect the different actions and therefore improve effectiveness.

Several interventions are connected to the theme of smart mobility and urban identity. In particular, the upgrades to the porticoes along Via Emilia through a new lighting system, the redevelopment of the most dilapidated parts, the recovery of the historic cobbled pavements and other pertinent ones. The installation of a monumental work of art on the site where the civic hall once stood in the central town square (no longer in existence because it was mined by the Germans during World War II), to evoke, in a contemporary way, one of the symbols of the town's historical memory. The re-proposal of the Safe&Smart system used in the previous case and the repaving of part of the road along Via Emilia with absorbent asphalt to improve accessibility to the porticoes, limit noise pollution, and improve road safety.

Despite being a general strategy for the redevelopment of the old town, we chose to include this study in the analysis of the case studies because it intersects the themes of mobility, technological innovation and urban identity. The approach adopted understands innovation as the sum of the different interventions, which together redefine the identity of the old town. A sum of interventions which partly highlight symbols of collective memory – the civic hall, the porticoes, the squares – and partly rework it – the artistic installation, the different street layouts. Technological solutions are part of this process, and the carrying over of solutions already used highlights the strategic role of planning to incrementally achieve long-term goals. The study therefore highlights the importance of the theme of local civic identity, especially in places subject to social and demographic impoverishment, and how it impacts mobility needs (e.g., the excessive use of cars is partly determined by the lack of public transport and road safety for pedestrians and bikes). In this perspective, it becomes clear how the layout of streets can modify behaviour and become a place of experimentation in relation to the collective memory.

3.3.4. Smart community and mobility, 2019

This study, completed in 2019, experiments with collaborative models for transit between the home and school and between the home and athletic facilities in Castel Bolognese. The main theme examined is that of the smart community, one of the points already present in the small smart town strategic plan, which in this case is applied to mobility. The objective is to seek a collaborative model

capable of reducing vehicular traffic and enhancing the virtuous behaviours of the community.
The first part of the study reports the results of the 'smart walking bus' experiment, which consists of the use of IoT signage to improve the current walking bus service. The second part, arising from the results of the first part, establishes an integrated Smart Community model focused on school-age transit.
In the smart walking bus experiment, illustrated in the first part of the study, two technological solutions were tested: PedibusSmart, consisting of an app for the management of volunteers and attendance and Bluetooth Low Energy sensors that detect users in the vicinity; Kids Go Green, a gaming platform accessible by computer and mobile that indicates the kilometres travelled by children on customizable maps with interactive content. The resulting trial data were substantially positive, with a good level of participation (93%). Moreover, the answers to the questionnaires highlight the ease with which the new system is incorporated into the existing service, and the usefulness of IoT solutions for the improvement of bottom-up mobility services. In particular, children's interest in the platform-game has confirmed the usefulness of gamification as way to reinforce virtuous mobility behaviours.
During the second part of the study, these results were developed into an integrated Smart Community model to manage the 'commutes' of school-age children. The model is divided into three parts. The Smart Community, intended as a technological platform that enables initiatives to improve school commute services, the Kids Mobility Network, i.e., a network of safe routes suitable for vulnerable users, safe intersections (already part of previous case studies), and the CB Mobility Lab, i.e., various initiatives to raise awareness about sustainable mobility. The integration between urban services, infrastructures and behaviours seeks to address that which has emerged from the questionnaires during the first phase of the research, which indicated how the quality of the service provided is closely linked to the level of road safety and to a mobility model excessively linked to private vehicles. The integrated Smart Community model was then analysed from an economic point of view, revealing a good feasibility level in reference to the target users of the proposed services.

The study deepens a 'collaborative' innovation model, where value is generated by the virtuous behaviours of the community as a whole. Starting from the mobility domain of behaviours, it is interesting to note how, during the course of the trial, it was necessary to complement the Smart Walking Bus with improvements to road safety. It is further proof of the central role that infrastructure plays in the mobility experience – a role also recognized by the community itself – and of the interrelation between means of transport, infrastructure, and services. Another topic of interest of the study is collective transport managed by Smart Communities, highlighting how, especially in small towns, it can be a valid substitute for 'standard' public transport and is seen as more desirable by

Figure 3.4. Image of the refurbished main town square with the public art installation. (source: Edoardo Tresoldi)

the community. Finally, the study highlights the importance of cultural and social factors in changing the current mobility model, even more than the technical aspects of the solutions adopted. Many journeys by private car can already be replaced or optimised with innovative or existing mobility solutions – active mobility or shared mobility – and this transition can be accelerated by getting the community directly involved in the trial phase and presenting them with the potential benefits of a change in everyday behaviours.

3.3.5. Smart mobility network, 2020

Concluded in 2020, this study explored development opportunities for the city of Faenza in terms of innovation in the field of urban mobility. A strategy was then devised by introducing a series of innovative mobility solutions useful for achieving the long-term objectives defined by the Urban Transport Plan approved in 2017. There are three main goals of the study: to improve the quality of life of the communities by improving the mobility ecosystem; to integrate innovative mobility solutions into the existing context, in line with the needs and opportunities of the territory; to verify the level of compatibility of the proposal with solutions related to digital transformation.

Starting from these objectives, the study was divided into a first phase, which illustrates the strategic mobility plan for the city of Faenza, and a second phase, which investigates the possible consequences in relation to the scale of the urban plan.

The strategic programme incorporates a number of top-down and bottom-up key areas which emerged during the study. In particular, they are the guidelines and objectives of the Urban Transport Plan, the mapping completed by the local section of the Federazione Italiana Ambiente e Bicicletta (FIAB, the Italian Environment and Bicycle Federation), and a photographic survey conducted by the research team on the main hubs of the road network. Based on these key areas, the Smart Mobility Network creates a safe, inclusive, smart mobility plan focused on greater safety and well-being. The proposed plan is divided into four main points:

- Upgrading mobility in the old town, transforming it from a 30 km/h zone that is partially pedestrianised to a low emission zone (LEZ). This solution makes it possible to manage the entry and parking of vehicles in relation to environmental pollution levels, and also makes it possible to redevelop the road network and add IoT solutions for the collection of environmental and mobility data;
- The upgrading of existing cycle paths, to be redeveloped as fast and safe connections dedicated to active mobility that connect the old town with the main residential, industrial and service areas;
- The redevelopment of road sections near schools to increase road safety, the networking of existing routes dedicated to school transport and the creation of temporary routes for walking and bike buses;
- The creation of neighbourhood environmental units in the main residential and service areas, creating 30 km/h zones to improve road safety and foster social relationships.
- The different points highlight how the Smart Mobility Network varies according to the context.

The second part of the study verifies potential city-wide changes regarding one of the main streets that run through the city centre. Two proposals for modifying the street layout – a “living road” and a “shared road” – have been developed to promote the adoption of sustainable mobility. Both proposals are valid and safe alternatives to the use of cars because they incorporate some of the basic elements of road safety: a reduction of the speed of cars and motorcycles thanks to better-planned routes and intersections; an increase in the degree of attention paid by road users thanks to a different design of the road section; better visibility thanks to preventive signage and more intense night-time lighting in hazardous areas.

The study highlights the urban mobility opportunities for towns and small cities that can arise by

Figure 3.5. Testing the Smart Walking Bus in Castel Bolognese. (source: Next City Lab)

intersecting the existing context with the technological, social and environmental innovations which are currently under way. In particular, the latent demand for active transit demonstrates that there is some sensitivity towards this issue; however, this demand will not be met if limited to safe and convenient infrastructure exclusively for vehicles; thanks to their physical qualities, cities and towns are compatible with the creation of proximity zones similar to the X-minute city model, even in those of this size, with subsequent benefits in terms of the environment and safety; the old town, which is a draw for services, is compatible with integrated traffic regulation systems; home-school and home-work transit can be easily reorganized or replaced with more sustainable solutions through small-scale changes or easily implemented platforms. In conclusion, the research highlights how an innovative model based on accessibility by proximity can have positive effects on all mobility domains and contribute to redefining the urban identity of the city.

3.3.6. Smart Parking Network, 2021

Concluded in 2021, this study proposed different measures for intermodal mobility and the reorganization of parking spaces in the old towns of Faenza and Castel Bolognese. The management of transit to and from the old town is one of the main issues addressed in the Urban Transport Plan, which highlights on the one hand how proximity mobility can be promoted in the old town of Faenza, given that its urban fabric is compatible with cycling and the town is home to 50% of schools and services, and on the other how the organization of parking, and in particular parking scattered throughout the city, limits the creation of safe cycling routes and therefore the development of active mobility.

The study starts by analysing current car parks and the salient features of the topography of the old town, giving rise to a series of proposals to enhance the parking network and make it more intermodal. The proposal verifies the ability to renew and reuse marginal areas, investigating their capacity to accommodate new urban services and parking spaces. The objective is to improve the quality of marginal or undefined spaces within the urban fabric (parking areas, outbuildings and annexes, abandoned areas) by increasing the services provided and the spaces that can be used by citizens and city users.

The proposed interventions for Faenza include the upgrading of different parking areas around the old town and near the railway station, while for Castel Bolognese they include the construction of a bicycle parking station near the railway station. Six car park areas have been selected for Faenza, of which four already exist and two are new. The areas were chosen in such a way that users can reach the main road axes of the centre or the town square in 5 minutes on foot coming from the car parks in the old town, and 10 minutes on foot from the station. Each intervention has been designed in relation to its surroundings, while maintaining some material constants, such as the color of the paving. For example, in the proposal for Via Renaccio, the slope of the land is exploited to create an additional level for parking, while the existing routes to the River Lamone and the town square are integrated into the area and enhanced; in the street-level parking lot in Piazza Ricci, a multi-storey car park is proposed which better meets the needs and density of the surrounding urban fabric; at the back of the station, the creation of a new car park is proposed, which is an opportunity to redesign the secondary access point of the station by providing it with a new underpass accessible to bikes. The reorganization of the parking network to better serve the historical center of Faenza is accompanied by an intervention to strengthen the railway connection between Faenza and Castel Bolognese. Given that the latter town is smaller, the proposal envisages the construction of a covered bicycle parking station for 130 bicycles – traditional or electric – near the railway station, mainly frequented by commuters. The landscape and environmental impact of the bicycle parking station is mitigated by the characteristics of the structure, a metal canopy that combines the main functions of parking and charging electric bicycles. The envisaged overall parking plan includes the creation of 650 parking spaces for cars. As a benchmark, to date the main car parks in the town have a capacity of 773 cars (MOVS 2023). In addition, most car parks have bicycle and electric bike stands and all are compatible with the incorporation of smart urban services (e.g., lockers, urban fountains, etc.) and smart parking systems.

The study highlights how the reorganization of the parking system in the old town is an opportunity to impact different aspects of the mobility experience. In this case, the innovative element is the

Figure 3.6. Image of the design proposal “living road layout” for Corso Matteotti, Faenza. (source: Next City Lab)

Figure 3.7. Image of the design proposal “shared road layout” for Corso Matteotti, Faenza. (source: Next City Lab)

project, in its ability to integrate mobility needs, the characteristics of the context, and smart mobility solutions. The choice of the area highlights a condition common in small and medium-sized cities, namely the old town as a draw and a hub in terms of services and the economy, and a point of reference for the collective civic identity. The proposed changes favour walking or cycling in the old town, a goal expressed at the planning level and by citizens and city users given the density of services and traffic. The goal can be achieved through a series of specific and strategic interventions, oriented towards an overall strategy of proximity mobility. The distances between the parking areas in fact make it possible to create a network of services that makes the use of a car in the old town inconvenient both for those who park and for residents or tourists. The proposed innovation model combines digital technologies with the historical memory of the city, transforming part of the existing road network and undefined spaces in the urban fabric into places.

3.3.7. StradAperte, 2022

Concluded in 2022, this study concerned the implementation of a temporary experiment in a limited traffic area in the old town of Faenza and the monitoring of the initiative.

The trial area covered a section of Corso Garibaldi approximately 230 m long, and included the adoption of changes designed to reduce the surface of the road intended for vehicular traffic, to highlight spaces for mixed pedestrian/bicycle use, and finally to slow the speed of cars. The changes implemented are similar to that of a Dutch woonerf and the basic principles of shared streets, currently adopted by the main guidelines on roads and their surroundings (Appleyard, McAndrews, and Litman, 2021). The reduction in speed and the change of the street layout aim to promote coming together and social relationships, to increase spaces for pedestrians and bicycles in the old town, and to promote business activities.

The proposal provides for the reduction of the width of the carriageway to 3.50 m and the maintenance of the one-way direction of travel to limit the speed and parking of vehicles, while the space for pedestrians on both sides of the carriageway is increased, maintaining a minimum width of 1 m at all points. While the road maintains the signs required by the Highway Code, the proposal includes a number of changes to the pedestrian spaces which follow the tactical urbanism concept on streets and public spaces. There are two main interventions. The first is to highlight the ground surfaces with a paint for removable temporary signage. The surface pattern has “stamps” of the same diameter arranged in a regular grid, with a bright green color which stands out from the usual colors of horizontal street signs. The second intervention in the pedestrian areas is the placement of street furniture and greenery, such as potted plants, bicycle racks, and places to sit. These elements visually define the hierarchy of space, creating the conditions to induce a reduction in speed without

Figure 3.8. Image of one of the proposed refurbished parking lots in via Renaccio, Faenza. (source: Next City Lab)

Figure 3.9. Image of the proposed underpass below the existing train station, Faenza. (source: Next City Lab)

hindering circulation and making the use of space more comfortable for pedestrians and cyclists.

To evaluate the results of the trial, a questionnaire was administered to residents and shopkeepers, resulting in 392 responses. Unlike what is reported in the literature, the general evaluations of the trial were poor both in terms of the overall result and in terms of the use, visibility, and road safety experience. According to the research team, one of the main causes of this feedback probably was the paint dissolving on one day with particularly bad weather during the testing period, due to an error during the implementation phase. This led to having to review the project proposal while it was in progress, generating controversy and causing the initiative to be exploited for other purposes. The distribution of the questionnaires highlights this aspect, with an off-scale trend for the lowest assessments. A qualitative analysis of the comments reveals more meaningful feedback, with the main observations concerning the difficulty of understanding the point of the experimentation, the narrowness of the spaces in the new street layout and the lack of perceived security. As has already emerged in previous research, road safety is a key factor in encouraging cycling and walking. In addition, the comments highlight the need to promote a culture of people-oriented mobility, providing more information and experimenting with street layouts based on principles from 50 years ago, but which thus far have infrequently been applied to these contexts.

The proposed innovation model seeks greater accessibility to services and greater attention to pedestrians and cyclists and the quality of the city in transit spaces. A principle to be implemented with light-handed and incremental interventions, changing the current mobility culture through spaces and initiatives that highlight the advantages of innovative mobility models. And, once again, the testing was done in parts of the old town, because it is more emblematic and denser in terms of services, activities and residents. The results of the experiment highlight the difficulties of making this change a reality, indicating the pain points in stimulating people's interest. To encourage a new mobility culture, it is necessary to invest in more information on ongoing and planned projects, more involvement of stakeholders and citizens in the process, and more attention to the issue of road safety.

3.3.8. Shared Autonomous Vehicle Service, 2022

Concluded in 2022, this study experimented with the possible use of CAVs in a medium-sized city like Faenza.

The study investigates how this emerging technology can improve the current mobility system and generate new approaches to smart mobility in smaller contexts than smart cities. To investigate

Figure 3.10. Photos of the innovative street layout in Corso Garibaldi, Faenza. (source: LBLA+partners, Next City Lab)

these aspects, the most appropriate approach is that of service design, understanding CAVs as an expression of a socio-technical system that includes technology, infrastructure, knowledge, the market, user habits, cultural and symbolic meanings, policies, institutions and industries (Docherty, Marsden and Anable, 2018). From a design perspective, the use of service design techniques makes it possible to turn this socio-technical system into mobility options that integrate most of the aspects listed above.

The proposal indicates smart community mobility as a possible development perspective. A perspective that guides the use of technology according to two main objectives: on the one hand, the enhancement of local human capital and community knowledge; on the other hand, the protection of more vulnerable members of the community. The smart mobility proposal is inserted within this context, which consists of a demand-responsive transport (DRT) service carried out with CAVs to accompany people with reduced mobility (e.g., the elderly, people with disabilities and their caregivers, etc.) to shops, medical facilities, meeting points, family members' homes, etc. The target user group was chosen based on the perspective described above and according to an analysis of the current context, especially the data concerning transit, demographics, and the characteristics of the urban fabric. In fact, said analysis shows that the old town of Faenza is attractive but incompatible with the widespread use of cars, that the over-65 demographic is constantly growing, and that 68% of trips within the municipality last less than 15 minutes.

The service is similar to the many examples of DRT described in section 2, with a shuttle providing transport during specific time slots. The possibility of using CAVs would make it possible to streamline the current model, managing transport more effectively and at the same time drastically reducing the number of cars on the road. In fact, the study calculated how to meet most of the demand at the municipal level with just 76 shuttles, an extremely small number compared to the current motorization rate, of which only 6 to manage demand in the old town. The adoption of this solution requires investments and decisions to make it effective, namely the acquisition and management of new vehicles within the city, the implementation of technological systems to manage the service, an openness to change by the majority of the population involved, and the creation of dedicated lanes and 20 km/h zones for the use of CAVs in the municipality and old town. Though certainly a challenge, they are all actions which are achievable in the short term.

The study proposes an innovation management model to guide the opportunities provided by smart mobility solutions according to shared local values. The proposal aims to respond to recurring critical issues in these contexts (an ageing population, marginalized members of society, ineffective or undesirable public transport) by identifying feasible solutions which will spark technological innovation, urban innovation, and civic ethics. Technological innovation brings new means of transport and services to the territory; urban innovation experiments with the potential of the urban fabric in the processes of digital transformation; and civic ethics determine the quality and quantity of relationships in the city. The findings of the study highlight how effective smart mobility must use technology as a means and not an end, adapting to the idea of a shared city. In this case, that's a city able to express social value in terms of space, ethics and services by limiting the number of motor vehicles in circulation, fostering inclusion, and adapting mobility spaces to better meet the needs of pedestrians and cyclists of all ages.

3.4. Results and discussion

The applied research illustrated in this section investigates different aspects of the topic of smart mobility in small and medium-sized cities. The proposed solutions and the project scales of the study measure the scope of the possible field of investigation, highlighting the complementarity of smart mobility and the multidisciplinary nature of this field of research, which concerns urban planning, urban design, service design, and social design. The design tools also highlight a wide variety of solutions, especially if we consider that the case studies concern the same area of investigation.

Figure 3.11. Diagram showing the CAVs used to assist people with reduced mobility. Numbers refer to the territorial units of the town, Faenza. (source: author)

The interventions, illustrated in Table 3.1 have been pared down to a smaller number of areas of intervention to facilitate their comprehension and analysis, that is: coordination/policy, cycling routes, roads, the community, and urban services. The changes proposed to the cycling and road network are the most significant, given that the various studies specifically explore the possible local transformations induced by smart mobility; however, it should be noted that in most cases said transformations are accompanied by other types of actions, as proof of the hybrid nature of these solutions.

The findings of the study also make it possible to formulate some considerations on local mobility needs and mobility culture. The most obvious fact is the deep-rooted and widespread use of private cars, which often results in their overuse. Combining this fact with the structural limitations of local PT, it becomes clear that there is little use and preference for PT in small towns, and that PT is mainly used by specific users – e.g., students or commuters. In this context, active mobility is a potential area to be expanded, given that it is a transit option which people are relatively interested in, especially within urbanized areas, and that several stakeholders point to the need to strengthen the infrastructure which supports this type of transit, such as bicycle paths or parking spaces. Another relevant factor highlighted above is the importance of the involvement of local communities. This can be done in the first place by listening to and involving institutional entities, the local community, and/or interest groups in the conception and development of projects (for example, in the ‘smart town planning' document or in the 'smart active network' proposal for Castel Bolognese). Another method is to develop services and platforms that promote collaborative behaviours, as seen in the feasibility study of a smart community linked to home/school transport or in the creation of a smart walking bus or a CAV service for the transport of vulnerable people. Finally, another way to encourage the involvement of local communities is to create local structures which the community can identify with and which support dialogue with other stakeholders. The enhancement of the old town and local businesses, schools, tram stops, even the parking network can become elements that strengthen accessibility by proximity and give character to anonymous places or those that do not have essential services nearby. All these considerations, although referring to the scope of study, reflect more general themes already highlighted above [see chapter 2].

The considerations on mobility needs and mobility culture highlight a few key elements to consider when assessing the quality of smart mobility proposals in small and mid-sized cities. The first of these elements concerns access to transit based on proximity. It's a central theme for the development of smart mobility, given its connection to the theme of innovation, public health, and urban identity. Accessibility by proximity is a possible area of innovation within smart mobility in small and mid-sized towns because it makes it possible to connect this research topic, often analyzed in terms of means of transport and behaviors, to the X-minute city model (and its different variations), which has greater impact on infrastructure and public spaces. It's a model that we consider interesting beyond its relevance in terms of policy and regulations, because it interprets accessibility by proximity by integrating the physical elements of the land with its material and immaterial infrastructure. In addition, the X-minute city model positively impacts the main determinants of public health (Capolongo et al., 2020) and studies of one of its possible versions (Mueller et al., 2020) confirm that reclaiming public space, reducing motorized transport, promoting active mobility, and providing greening and cooling can reduce premature deaths related to car-centered planning. Finally, it directly involves urban identity because it has its roots in the culture of historical cities, in which the development of the city was directly connected to available means of transport, and involves the various aspects of urban identity highlighted in the literature. Urban accessibility therefore allows us to highlight potential changes in mobility spaces based on revisitations of infrastructure, vehicles and behaviors, as analyzed in this section and in the previous one.

The second element to consider in the evaluation of smart mobility scenarios is infrastructure, starting from the road and bicycle path network. It's a complementary theme to the previous one, which looks at the local level of connection. Strategically speaking, this theme can be analyzed by investigating the topology of mobility spaces and verifying their compatibility with the types of trips people take daily. These contexts are often structurally different from urban contexts in their

Research title and year	Proximity to essential services	Proximity to public transport	Density	Mixed land use	Walkable and cyclable streets	Public space and placemaking	Inclusiveness	Use of digital / innovative tools
"CASTELLO+ SMART TOWN PLANNING CB, 2017"	X			X	X	X	X	X
"SMART ACTIVE NETWORK CB, 2018"	X				X	X	X	X
"INNOVATIVE REGENERATION PLAN CB, 2018"	X				X	X	X	
"SMART COMMUNITY AND MOBILITY CB, 2019"	X	X		X	X	X	X	X
"SMART MOBILITY NETWORK FAENZA, 2020"	X	X		X	X	X	X	X
"SMART PARKING NETWORK FAENZA, 2021"	X			X		X		
"STRADAPERTE FAENZA 2022"	X	X			X	X	X	
"SHARED AUTONOMOUS VEHICLES SERVICE FAENZA, 2022"	X	X				X	X	X

Table 3.1. Design KPIs of the applied research projects. (source: author)

quantity and connections. At the scale of the urban plan, however, the theme of infrastructure mainly concerns the experience of using spaces and their urban character. Even a well-connected road and bicycle-pedestrian network can be ineffective if it is set within a street layout that is unsuitable for the type of trips to be encouraged, or not adequately accompanied by awareness raising efforts among the main stakeholders and city users. The research presented above, StradeAperte in particular, highlights that this is a particularly important issue to address, especially in relation to the response of the local community.

Accessibility by proximity and a road network compatible with sustainable travel are therefore key to improve the quality of mobility spaces and integrate them with the principles of smart mobility. Consequently, we find it useful to identify whether and to what extent these case studies can share planning and design principles. To identify possible comparison categories, we used those identified by EIT (2022) as a baseline (Büttner et al., 2022) which in turn are an extension of the key concepts of Moreno's 15-minute city, a particularly significant model because it highlights the key role of infrastructure and accessibility by proximity. The categories – Proximity to Services, Proximity to Public Transport, Mixed Land Use, Density, Place-making, Ubiquity, Walkability and Cyclability, and Inclusiveness – were then reworked based on the insights gathered in the various projects. For example, Proximity to Public Transit has been expanded to create a broader category entitled 'Alternative Mobility Solutions to Private Cars', since several projects illustrated in this section and in the previous one promote solutions alternative to the increase of traditional public transit in those areas. The reduced density of services has led to the replacement of Mixed Land Use with the Community Hub category, i.e., spaces capable of hosting different urban services (e.g., co-working spaces, transit hubs, service hubs, or post offices) or urban units that become reference points for the local community (e.g., public buildings, schools, neighborhood shops, etc.). Finally, the Density and Ubiquity categories were not included again as the former was evidently too distant from the nature of small and medium-size towns and the latter was scarcely present in the surveys carried out by EIT. Then, the key design and planning concepts are:

- Proximity to essential services: Residents can access essential services within a reasonable distance by foot, bicycle, or other non-motorised devices.
- Alternative mobility solutions to private cars. Residents can reach all the main services within a reasonable time. This could be done by using nearby public transport or other alternative solutions such as smart mobility, CAVs, DRT, cycle highways, and digital platforms without having to rely on a car.
- Community hubs: Schools, public buildings, and intermodal spaces become community hubs that integrate essential urban services for residents close to their homes.

name	discussed mobility solution					
CASTELLO+ SMART TOWN PLANNING, CB, 2017	soft trail	smart community house-to-school commuting	PUMS	urban services	integrated IoT	smart community house-to-work commuting
SMART ACTIVE NETWORK, CB, 2018	pedibus smart	smart cycling path	outdoor cycling network			
INNOVATIVE REGENERATION PLAN, CB, 2018	smart urban services	integrated IoT	smart lighting	improving street accessibility		
SMART COMMUNITY AND MOBILITY, CB, 2019	smart community house-to-school commuting	pedibus smart	kids mobility network			
SMART MOBILITY NETWORK, FAENZA, 2020	low speed zones	bike freeway	school streets	shared road	integrated IoT	smart urban services
SMART PARKING NETWORK, FAENZA, 2021	parking network	LEZ				
STRADAPERTE, FAENZA 2022	residential streets					
SHARED AUTONOMOUS VEHICLES SERVICE, FAENZA, 2022	CAVs	Maas				

Legend
urban policies / urban planning · cycling network design · road network design
social innovation · smart urban services

Table 3.2. Discussed mobility solutions of the applied research projects. (source: author)

- Walkable and cyclable streets: Walking and cycling paths are well connected, free of barriers and comfortable for pedestrians, cyclists, and all other non-motorized road users.
- Public space and placemaking: Promoting the co-creation of places in public areas and streets to strengthen the connection to and identity of new destinations according to their needs.
- Inclusiveness: All residents are able to move safely and free of barriers in public spaces and

make use of services, irrespective of their individual capabilities, age, gender or origin.

In the next section, we will incorporate these principles with the ‘smart mobility vision’ guidelines for small and mid-sized towns.

The observations on the key elements of smart mobility in small and mid-sized towns (accessibility by proximity and infrastructure) are reflected on a further, particularly relevant area, that of urban identity. As discussed in previous sections, Relph is the main reference on this topic, defining the physical setting of places, their inner meanings, and the activities carried out within them as the major components of urban identity. Based on the above, a qualitative analysis of the impacts of the various projects on the key features of urban identity was carried out. The analysis, reported in Table 3.1 and 3.2, reveals the potential of redesigning mobility spaces. Pedestrian areas incorporated with urban services, streets redesigned according to the people-first concept, car parks designed as local ‘stations’ instead of as non-places, cycle paths integrated with the historical urban fabric and the main local amenities: the projects illustrated above demonstrate how a few simple design choices can radically change the urban identity of places. This point is directly connected with the other two dimensions of urban identity: meanings and activities. Each plan starts with a careful assessment of local mobility needs, considering both detected and latent needs. For example, the smart walking bus is meant to replace car journeys with active mobility journeys, while the study on CAV shuttles highlights how, even with a limited number of vehicles, it is possible to offer efficient services to the majority of the elderly population considered. We can therefore see how mobility needs are often the result of a car-based mobility model, and that questioning it has repercussions on the urban identity of places, especially in terms of public space and buildings, space-making, and inclusiveness.

Then we can discuss the role of meanings, which from our perspective are the most delicate to evaluate because they are both intangible and evident in the urban realm. If we understand ‘meaning’ as the ability of the people involved to contribute to making a certain place meaningful, the research presented here highlights how smart mobility is capable of strengthening existing identities or giving new meaning to places with little identity. For example, in the redevelopment project of the old town of Castel Bolognese, the urbs was the starting point, interpreting the historical memory of the place as a key element to update the existing activities and the physical context of the area. Conversely, the smart community project is instead a manifestation of civitas, in which belonging to a community allows us to share sustainable mobility means and behaviors, generating new collective identities. The other projects are in dialogue with these two poles, trying to combine local and specialist knowledge to create new places or strengthen those that already exist.

In conclusion, the analysis of the applied research illustrated in this chapter has highlighted some fundamental elements of the study, which will be continued in the next section. The central role of accessibility by proximity, which even in small and mid-sized towns continues to connect the quality of public spaces and urban well-being with innovation and civic identity. The importance of infrastructure, in particular roads and cycle paths, as an element of physical connection within the territorial schedule, is irrepressible in a logic of proximity mobility even in smaller contexts. They can be considered the main elements for assessing the quality of smart mobility scenarios in small and mid-sized towns.

Starting from these elements, some further aspects of interest were then explored. The first concerns planning and design principles, which confirm the importance of the quality of mobility spaces and its correlation with some determinants of urban health. The second addresses urban identity, confirming the importance of an overall vision of the smart mobility project that takes proper action in terms of vehicles, infrastructure and behaviour in accordance with the various types of urban intelligence found in a given place.

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Chapter 4.
Smart mobility assessment tools

4.1. Introduction

This chapter presents the findings of an analysis of access to proximity services in the municipalities of Faenza and Castel Bolognese, part of the Union of Municipalities of Romagna Faentina in the province of Ravenna, aimed at defining a 'smart mobility vision' to upgrade mobility spaces by orienting them towards greater accessibility by proximity. We propose the construction of an accessibility assessment based on the availability of services and the road network with the aim of linking smart rural mobility innovations, in particular those on transport systems, with the physical aspects of mobility spaces. These analyses were carried out to provide useful design tools in the application of the 'accessibility by proximity' concept to small and medium-sized towns in flatlands.

4.2. Aims, data sources, and study context

4.2.1. Aims

According to the thesis' goals, we here aim to elaborate a design roadmap to put in practice smart mobility in low-density areas, outlining its impacts in terms of urban identity. The concepts of 'accessibility' and 'proximity' were used as the main indicators as they can be associated with the different areas under study, as highlighted in the literature and in the applied research studies. By surveying accessibility and proximity, it is possible to estimate the main factors that define urban identity in the literature and receive useful indications on how to introduce smart mobility solutions compatible with the characteristics of the area considered.

The theme of accessibility by proximity is directly linked to a series of ideas, theories, and models of cities that seek the well-being of citizens by promoting a better use of time, urban services, and the physical aspects of the territory. In particular, accessibility shows which parts of the city and which percentage of its population can access the location of a given service within certain time thresholds, or a certain transportation mode. To have greater flexibility in terms of the means of transport to be promoted, the study determined accessibility levels according to distances travelled instead of journey times.

Therefore, the research methodology can be useful:

- in the diagnostic phase, to assess the most appropriate level of accessibility or proximity of the territory according to the selected means of transportation. In a rural smart mobility perspective, to assess the time or distance threshold and how much a certain city can be considered accessible regarding the actual spatial distribution of the locations of a given service;
- in the design phase, to spatially check their compatibility with the level of accessibility or proximity previously assessed. This means on one hand to verify which areas have low levels of accessibility to services, and then choose the most appropriate smart rural mobility solution (e.g. to increase the number of urban services in these locations, promote a different modal share or to re-define the urban character according to the specific feature of the context). On the other hand, this design tool identifies the topology of mobility spaces to verify their compatibility with different means of transport and the spatial implications which arise in terms of safety and street layout. For example, one part of the road network may be more compatible with motorized vehicles (e.g., shared, electric, or autonomous cars) while other areas may be topologically more compatible with walking or with ‘slow‘ vehicles such as bicycles, e-bikes, and mopeds.

In this study, attention will be focused on the application of the methodology in the analysis phase and in part of the design phase.

4.2.2. Data sources

This section will outline the main data sources used in the research. We can classify data regarding the different topics:

- Demographic data. The main data sources are demographic ISTAT data and data of the Faenza and Castel Bolognese PSC. We mainly used the last data source as, for the scope of our research, it has acceptable deviations from the updated data (the PSC data of 2009 have respectively 6.24% for Castel Bolognese and 5.19% for Faenza from the 2023 population) and is much more detailed. The data are in fact divided by elementary urban units, a more precise articulation of the census sections, and each one reports the number of inhabitants, population density, average age and age groups, households, and foreign population as a percentage. In addition, the data are connected with other useful urban planning analyses regarding urban growth, the nature of urban development in cities, and the historical evolution of the road network. For the sake of brevity, we will use the first two, referring any further information to future research.

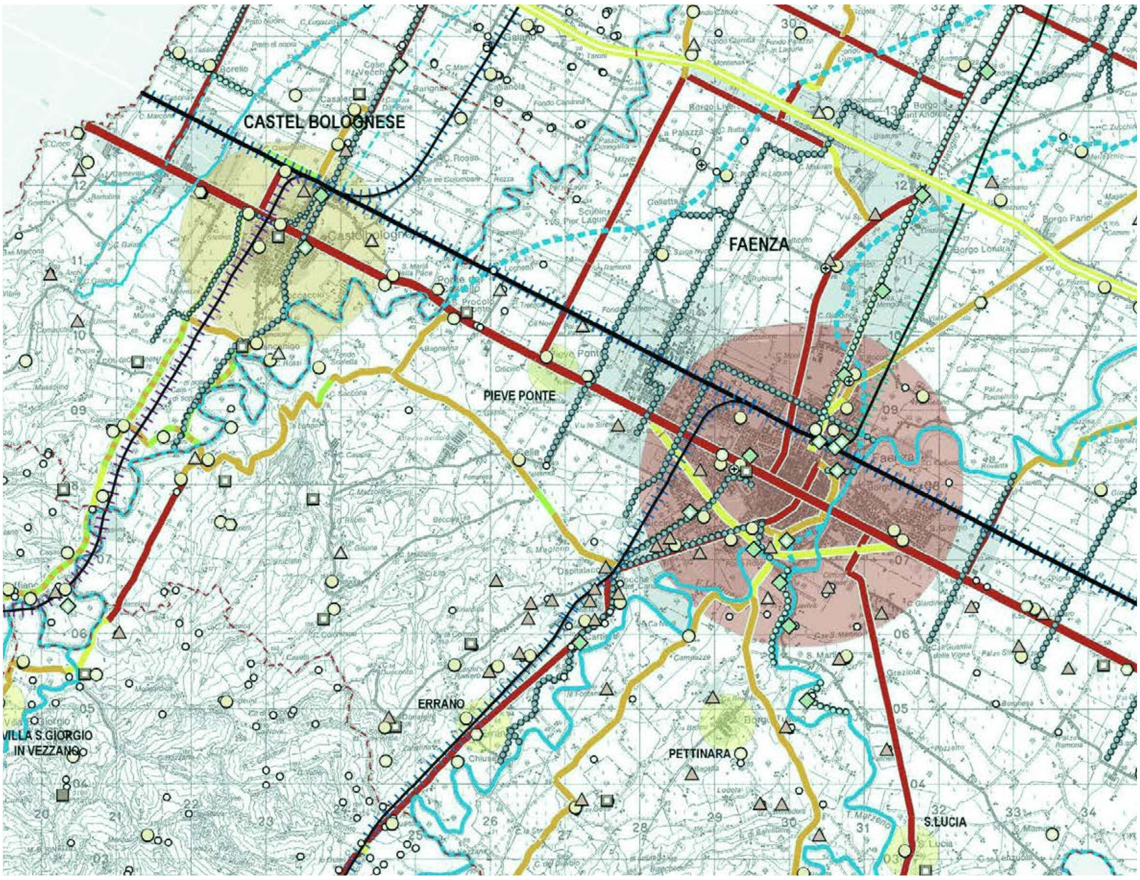


Figure 4.1. Detail of the PSC table C.1.2.4 , highlighting the historical evolutions of the road network in Faenza and Castel Bolognese. The road network built in Roman times is red, the roads built from the Middle Ages to the 18th century are orange, the roads realized in the 20th century are yellow. (source: URF website)

- Points of interest (POI) and urban services. We collected geo-referenced data mostly from openstreetmap (OSM), a collaborative project aimed at creating free-content maps of the world. Next, we checked the POIs in Google Maps. This allowed us to verify the quality of the OSM data, making any updates based on the most up-to-date database.
- Buildings and streets. The main data source is the regional geoportal. In particular, shapefiles regarding municipal boundaries, the main roadway graph, buildings, rail networks, and the public space system were used.

The decision to use these data sources and tools was based on a number of factors. Firstly, the limitations regarding data from sensors and actuators installed in public places. With regard to the scope of study, the real-time data available mainly concern traffic flows and are only partially collected from the two municipalities. Secondly, in addition to the above data, the PSC of Faenza and Castel Bolognese contains other tables, analyses and supplementary reports useful to gaining a historical perspective of the main dynamics of local development. In particular, the analyses of the historical evolution of the settlements and the land, and the historical evolution of the infrastructure and historical sites which have made it possible to recognize the main traces of the geographical layout from the Roman era to the present day were particularly useful. In addition, Faenza has its own SUMP from which it is possible to draw further specific analyses on the mobility model as the origin-destination mould, the evaluation of the mobility options offered, and the limits and opportunities of the current system.

Finally, the use of widespread, cost-effective and simple-to-use analysis tools can also provide useful indications in rural areas. Several literature contributions analyzed in the previous section have in fact found that smart countryside analysis methods should rely more on conventional methods such as statistics, mapping, or cost analysis because of their infrastructural and digital gap.

4.2.3. Study Context

The selected test area will be the municipalities of Faenza and Castel Bolognese. In the province of Ravenna, Faenza is the most populous municipality in the URF and is the core of the functional urban area of the union of municipalities that has 88,501 inhabitants overall (URF,2023a). It has 58,541 inhabitants on 215.72 km2 and a population density of 271.32 inhabitants per km2 (URF,2023b). Like the municipality of Carpi, in the province of Modena, it is one of the few municipalities in Emilia Romagna with about 60,000 inhabitants that does not have the title of provincial capital.

Castel Bolognese is one of the three lowland municipality in the URF with Solarolo and Faenza. It has 9,626 inhabitants on 32.28 km2 and a population density of 298.2 inhabitants/km2 (URF, 2023c). In the four classes of municipalities identified at the regional level[2] , Castel Bolognese belongs to the 'Municipalities in the plain with 5,000 to 15,000 inhabitants'.

These two municipalities can be considered an interesting case study for testing our research approach for a couple of reasons.

First, they are two car-dependent municipalities as the most part of Italy. Despite their marked difference in populations, the modal share of Faenza and Castel Bolognese is nearly the same. Faenza totals 5,015 commuting trips out of the municipality with 76% made by car, 23% by collective transport (train, city or company bus, motorcoach, etc.), and 1% by bike, by moped or by foot;

[2] DESIER classification of municipalities: Lowland municipalities with less than 5,000 inhabitants | Lowland municipalities with between 5,000 and 15,000 inhabitants | Municipalities with more than 15,000 inhabitants Provincial capitals | Mountain municipalities up to 15,000 inhabitants.

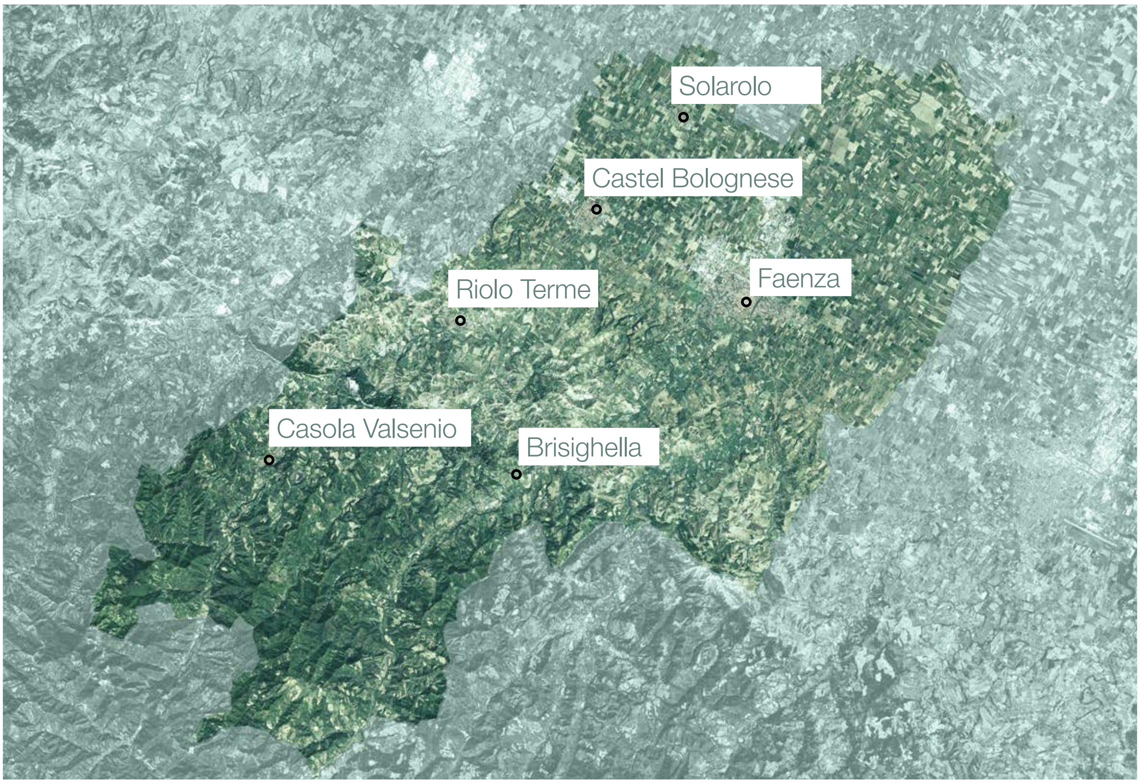


Figure 4.2. Image of the URF with its municipalities. (source: author)

Castel Bolognese totals 2,926 commuting trips out of the municipality with 73% made by car, 24% by collective transport (train, city or company bus, motorcoach, etc.), and 4% by bike, by moped or by foot[2]. These values roughly reflect the modal share at the national level (ISFORT, 2022), however, though they do include some deviations to be taken into account. The percentage of car journeys in the two municipalities is higher than the national average of 64%. While in the case of Castel Bolognese this is probably due to the fact that the national average also considers larger cities where PT and mobility are more widespread, for Faenza it is an opportunity for improvement compared to cities of equal rank. Regarding other means of travel, the overall rate of shared transit is higher than the national average of 7.6%. It's a difference which we presume is mainly motivated by the presence of major railway stations in the two towns and the fact that, for school-related trips in small and medium-sized towns, public transport is used almost exclusively. Analyzing the sustainable mobility rate, defined by ISFORT as the percentage of trips taken on public transport, on foot, by bicycle, and via micromobility vehicles out of the total, we see that Castel Bolognese has a rate of 26.3% and Faenza 24%, compared to the national average of 31.3%. It's a difference that can be bridged by increasing the number of trips with public transport, carpooling or promoting active mobility.

Second, the connectivity of both towns is good in terms of digital infrastructure and transport. The main DESIER indicators on connectivity (the percentage of households covered for bandwidth ≥ 30 mbps, the percentage of households covered for bandwidth ≥ 100 mbps, and the percentage of connected production areas out of all production areas detected) show how Castel Bolognese and Faenza, with 64%, 25%, 100% and 70%, 34%, 100% respectively, are above average in their DESIER municipal classes, and in the provincial and regional averages (64%, 32%, 85%). Furthermore, the dense morphology of old towns and urban centers favors the expansion of active mobility. In particular, the plan documents define Faenza as a city that, for its size, urban layout, location, and culture, is well-suited to the regular use of bicycles for urban travel (Municipality of Faenza, 2021). The same conclusions can be drawn for Castel Bolognese (although with due limitations as the two belong to different classes of municipalities), since it has a compact town center, a favorable position (both towns extend along Via Emilia, the most important arterial road in the region), and a similar mobility culture, as emerged in the applied research study described in the previous section. At the same time, the circulation of cars is poorly moderated (only Faenza has a limited traffic zone in the old town) and public transport makes up only 2.5% of all urban journeys (Municipality of Faenza, 2021). Though their city planning is relatively good, Castel Bolognese and Faenza still maintain the layout of small and medium-sized Italian towns: most services are located in the old town, surrounded by subsequent expansion areas which were developed mainly in the twentieth century and which mainly are home to industrial areas, residential neighborhoods (most of which were built by private venture), and medium and large commercial spaces.

Third, they already have implemented various experiments in the field of smart mobility. As demonstrated in the previous section, in these municipalities smart mobility has been addressed in its different aspects: from the urban quality of public spaces to that of mobility services, from the management of parking areas to the prediction of future mobility scenarios. The amount of research conducted in recent years represents on the one hand a fundamental knowledge base within which to incorporate already-acquired knowledge; on the other hand, it is an indication of low resistance to change on the part of the local administrations, stakeholders and communities involved, which is often a decisive limiting factor in the development of these projects.

Fourth, the decision to analyze the municipalities of Faenza and Castel Bolognese makes it possible to verify the dynamics between the center and what are known as ‘belt areas’ within a ‘union of municipalities’. An analysis of the individual municipality was avoided in favor of a comparative analysis that highlights their differences in terms of services and urban networks, working not only on the needs of internal mobility but also on the dynamics of commuting, which take on considerable importance in these contexts. In addition, studying inequality in access to the number and quantity of services available can help us understand and even foresee forms of marginalization (for example, the exclusion of the oldest segments of the population in areas where the use of private cars is prevalent) and suggest useful measures to mitigate inequality in access to urban opportunities.

In conclusion, the two municipalities of Castel Bolognese and Faenza have been selected to test the current mobility paradigm in low density and intermediate areas, such as smart rural mobility and the X-minute town, and to promote a more active role for urban design and civic identity. They are two municipalities which, in terms of size, transport options, urban quality, mobility spaces, and local dynamics, symbolize the 'normal city', which is often inadequately studied because there are no particular critical issues to solve (Lelli, 2022). At the same time, the two cities represent the majority of municipalities at the regional level, given that, in the DESIER municipality classes, the flatland municipalities that exceed 5,000 inhabitants and are not provincial capitals make up 48.8% of the total and, in the National Strategy for Inner Areas (SNAI) classification, 'hub' and 'belt' municipalities make up 50.6% of the total[3]. The goal of the study was to provide useful insights to adapt mobility spaces to the new paradigms of smart mobility and promote the well-being of the communities involved.

4.3. Methodology

The proposed methodology is designed to develop a complete design tool that takes into account the accessibility and topological features of the public spaces incorporated into the road network. A comparative analysis of the accessibility of urban services and the road network was then carried out. It can be summarized in 5 steps:

- Identifying 'urban elementary units'
- Identifying POI and urban services
- Drawing isochrones from the 'urban elementary units'
- Assessing access to services
- Assessing access to the street network

The analyses were carried out mainly with GIS and Space Syntax, instruments which have been tested and proven in the field of academic research and applied research, while, as evidenced in the previous sections, the data used are mainly from local planning tools (SUMP and PSC) and from regional and national open data. For methodological purposes, we note how the use of freeware, widely disseminated tools and easy-to-access data can increase the exportability of the findings and of the methodology, benefiting similar contexts.

4.3.1. Subdivision into 'urban elementary units'

The first step was the subdivision of municipalities into zones, which makes it possible to discretize

[3] The SNAI classification is: Hub, Belt, Peripheral, Intermediate, Ultraperipheral. (Agenzia per la Coesione, 2014)

the urbanized area and to conduct the main accessibility analyses.
In this case, the origins of the trips are assumed to be from each center of the most relevant urban area. To define the most appropriate partition, we chose the 'urban elementary unit' of the associated PSC (Piano Strutturale Comunale / Municipal Urban Plan) of the URF. In the demographic analysis tables, the number of inhabitants, density and other demographic indicators are associated with each urban elementary unit. Faenza and Castel Bolognese are divided into 55 and 17 urban elementary units, which individually or in clusters match their districts and their different land use. In addition, their hamlets were included, making up 46 additional units. All areas of the PSC were included, including those with few or no residents, such as industrial areas, parks, cemeteries, rivers etc., to verify the accessibility level in areas still used by city users.

The proposed distribution of urban areas highlights different contexts in the two municipalities. In Faenza, the largest residential area is that of the old town with 881,823 m2, which is also the urban area with the highest urban density: over 8,501 inhabitants per km2. In CB, on the other hand, the most extensive residential area is the twentieth-century expansion south of Via Emilia with 571,005 m2, while the highest urban density area is a publicly planned residential quarter with an urban density of over 8,501 inhabitants per km2.

4.3.2. Identifying POI and urban services

Twenty-eight types of services have been taken into account. They belong to five main categories:

- Education: Nurseries, Kindergartens, Libraries, Elementary schools, Middle schools, Secondary schools
- Health and social services: Pharmacies, Doctors, Hospitals and Neighborhood health centers, Police stations, Social care services, Town hall and public offices
- Entertainment: Sport associations, Gyms, Theatres, Cinemas, Places of worships, Swimming pools, Sport grounds
- Living: Public meeting places, Open air market places, Playgrounds, Parks and green areas
- Commerce: Supermarkets, Stores, ATMs, Banks, Post offices, Shopping malls

The selection of these services was based on a compared review of the most relevant services that are generally cited in the literature about accessibility and proximity (ITF, 2019; Büttner et al., 2022) and the secondary literature review in Staricco (2022).
In this overall list of potential services for assessing the accessibility level of the two selected towns, the services considered in this study have been selected according to two main criteria. First, the

Figure 4.3. Urban elementary units in Castel Bolognese (left) and Faenza. (source: author)

research includes services in all of the main domains reported in literature, because they all contribute to increased access. It's a choice that, with the appropriate fine-tuning between urban and non-urban areas, makes it possible to verify a broader level of access by checking the functional mix of the single urban units. The twenty-eight categories do not include single food shops, restaurants, or cafés because of their uncertain contribution to accessibility (choosing them often depends on factors other than closeness to home) and because of their widespread diffusion in the two built areas. Secondly, the studies annotated services at every scale, from the neighborhood level (such as ATMs, playgrounds, pharmacies, and shops) to the city level (such as hospitals and shopping malls). This is because, even if on a different scale, each of these services increases the access level of the area considered.

As shown in Figure 4.5, the surveyed number of services varies significantly from Castel Bolognese to Faenza. As expected, Faenza has many more services and POIs than CB, respectively 719 to 76. It is worth noting the different ratio of service domains in the two municipalities. While the percentages are similar in the Education category, in Health and Social Services and Entertainment, Castel Bolognese has higher relative values (26.3% v. 11.1%, 34.2% v. 28.1%) while in the other areas it is surpassed by Faenza: Living 14.5% v. 32.0%; Commerce 11.8% v. 15.7%.

Each location was georeferenced as a point near to the building address. Wide buildings such as shopping malls, public spaces, open air markets and green areas were georeferenced as points, calculating the centroid of the building polygons. The POIs and urban services detected allow accessibility to be analyzed both by category and by number of services.

4.3.3. Drawing isochrones from the ‘urban elementary units’

For each ‘urban elementary unit’, the geometric barycenter was identified. Then, for each centroid a series of isochrones were identified, representing the parts of the city that could be reached by the residents in a trip of 400, 800, 3350, 6700, 1050 meters from the barycenter. The selection of these distance-thresholds was not based on the current or desired travel time surveys, as they were not available. Instead, we referred to values commonly used in network and service planning literature (Hosseinzadeh, 2021), with the distances of 400 and 800 m chosen as reference distances for walkability and cyclability, while the distances of 3350 m and 6700 m were based on the distance of 10 km used by ISFORT to divide proximity and urban travel from medium to long distance commutes. As described above, the isochrones of Faenza and Castel Bolognese were defined as polygonal areas starting from the centroid of each ‘urban elementary unit’ and referring to the regional road graph. For isochrones of a distance greater than 3350 m, we selected some of the centroids of the ‘urban elementary units’ to avoid redundant values. The isochrones area is determined by the threshold distances described above, while the shape of the catchment areas depends on the structure of the road network and therefore does not form circular isochrones.

To draw the isochrones, we considered two alternative QGIS3 plugins. The first one is QNEAT3, a Phyton-based plugin that offers advanced network analysis algorithms that range from simple shortest path solving to more complex tasks like Isochrones Areas – such as service areas, accessibility polygons - and Origin-Destination-Matrix computation. The second QGIS3 plugin used for drawing isochrones is ORS Tools, a plugin that provides access to most of the API of openrouteservice, which offers user-generated and collaboratively collected free geographic data from OSM. ORS Tools can calculate routing, isochrones and matrix calculations. Here isochrones are calculated using an average walking speed of 5 km/h on pathways; the wheelchair profile has a base speed of 4 km/h, the e-bike profile 21 km/h on asphalt, and the car profile 35 km/h on urban areas. To verify the

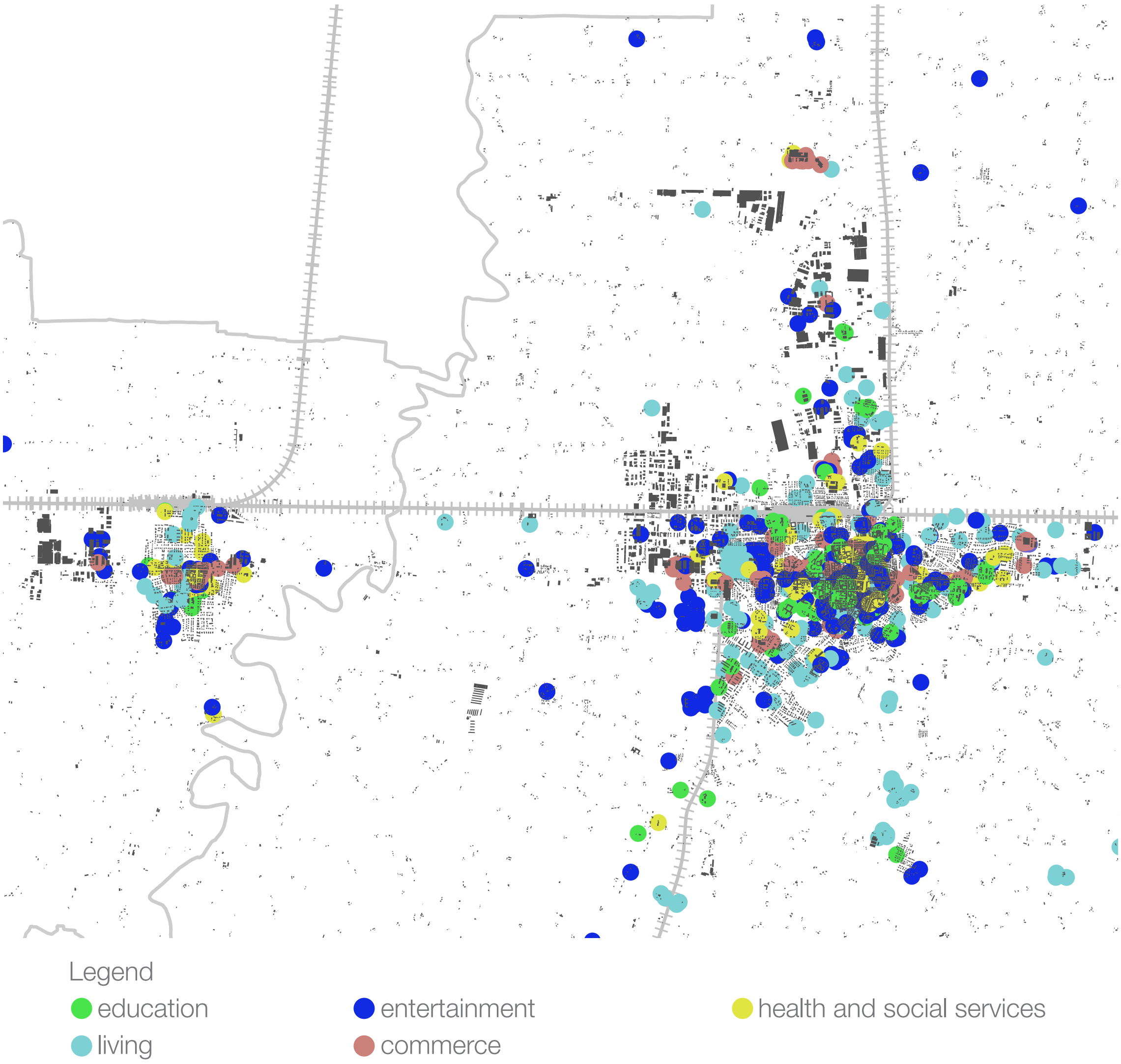


Figure 4.4. Point of interest (POI) in Castel Bolognese (left) and Faenza. (source: author)

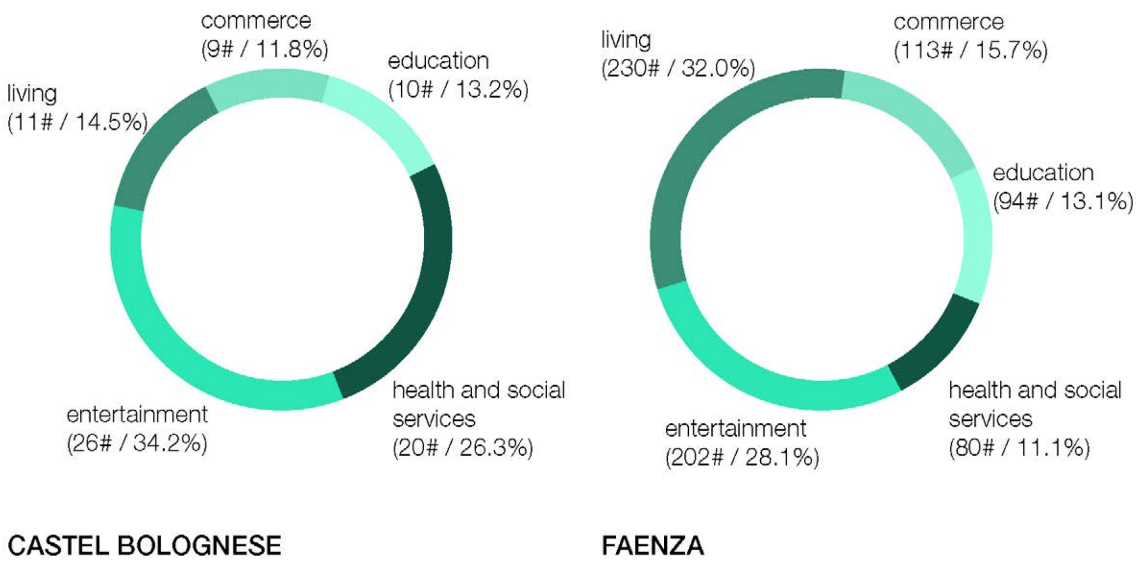


Figure 4.5. Urban services domains in Castel Bolognese and Faenza. (source: author)

accuracy of the isochrones, the author compared 10 of their distances with the corresponding ones obtained with Google Maps, verifying that for the thresholds of 400 m and 800 m, ORS Tools was the most accurate, and for the thresholds of 3350 m, 6700 m and 10 km, QNEAT3 was the most accurate. The line graph of Figure 4.7 illustrates the generally linear trend of the isochronous surface as distances increase.

The decision to use distances instead of travel times makes it possible for the concept of 'accessibility by proximity' to be distinguished more clearly from the generic concept of 'accessibility'. While accessibility 'relies on location, where the relativity of space is estimated in relation to transport infrastructures (Hall, Hesse and Jean-Paul, 2006) and distance, derived from the connectivity between locations' (Mayhew, 2009) accessibility by proximity highlights the physical distance between services, communities and amenities in a given space. Applying these considerations to the present study, we have the possibility to articulate the analysis in two phases, separately verifying the relationship between threshold-distance with the speeds of different vehicles. This type of investigation is useful to gaining insight into the idea of what a city is and the project to be carried out [see section 5.2].

By setting the thresholds in terms of distance, it is possible to refer the travel time to a specific distance with the consequent positive and negative externalities in terms of safety, environmental impact, and user experience. In a period of radical transformation in the transport vehicle industry, this approach makes it possible to keep the focus on the speed of travel in public spaces – one of the key factors in terms of road safety and urban quality – to refer to a mobility experience rather than to specific means of transport. In this way, it is possible to classify the various modes of travel as low speed (walking, cycling, elderly and vulnerable users), medium speed (micromobility, e-bikes, CAVs, EVs), and high speed (CAVs, EVs, cars), and to associate different levels of accessibility by proximity to them. In Figure 4.9, the distances chosen were compared with some of the main versions of the X-minute city.

4.3.4. Assessing access to services

For each of the twenty-eight services and for each 'elementary urban unit' indicated in the local planning documents, it was calculated (using the QGis 'aggregate' and 'intersect' function) how many services and of which domains were included in the isochrone from that census tract for the four main distance thresholds (400 m, 800 m, 6700 m, 10k m).

The aim of the analysis is to acquire basic accessibility indicators to find useful insights for the design

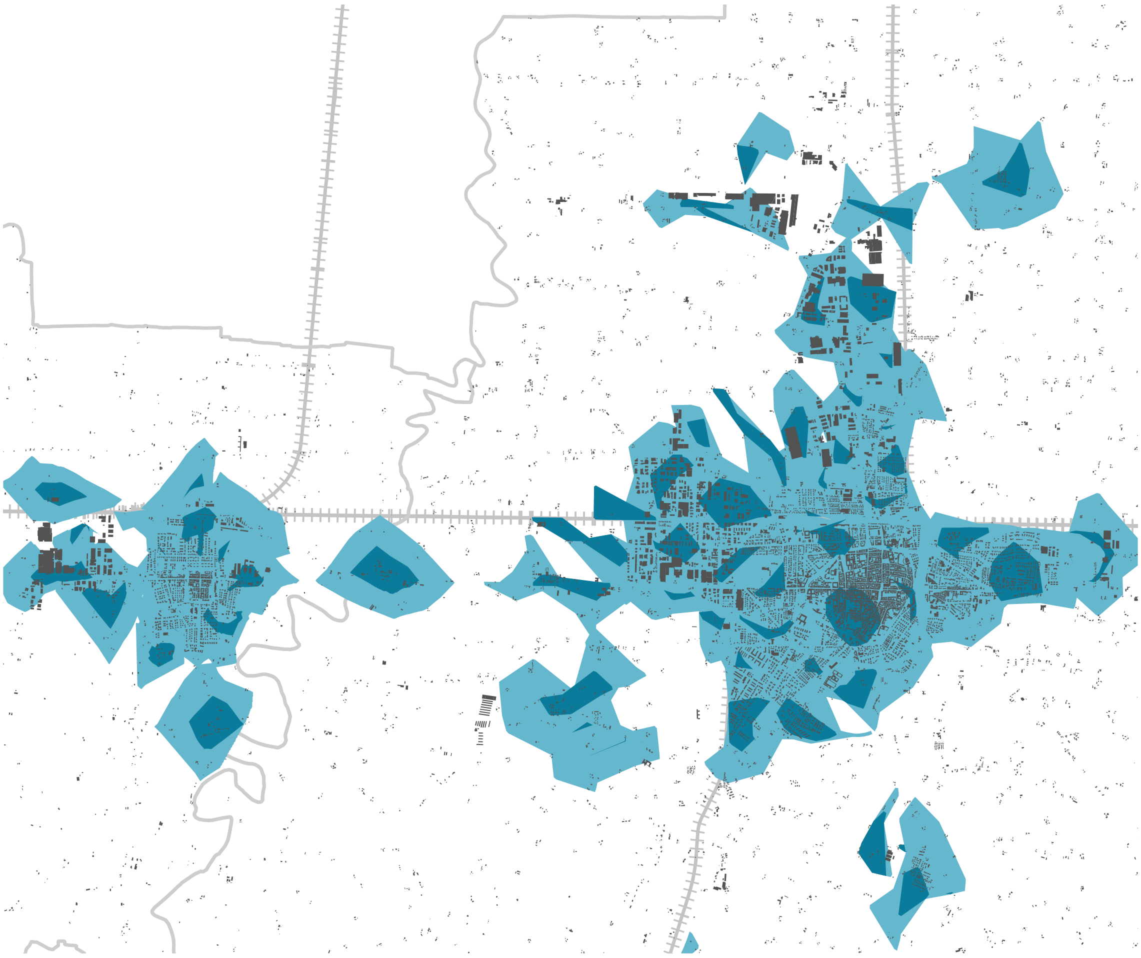
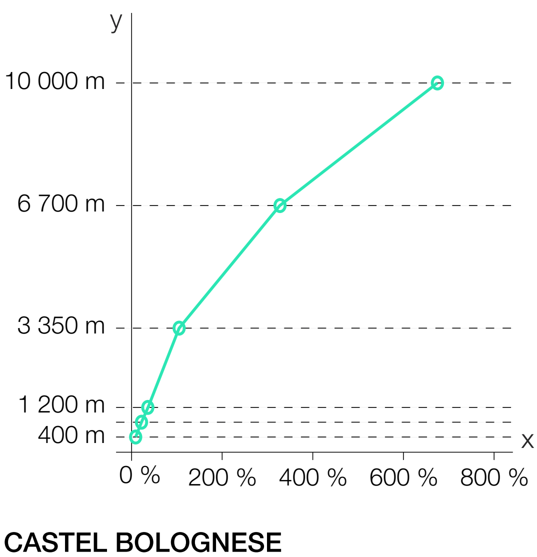


Figure 4.6. Isochrones in Castel Bolognese (left) and Faenza for the distances of 400 m (blue) and 800 m (light blue). (source: author)



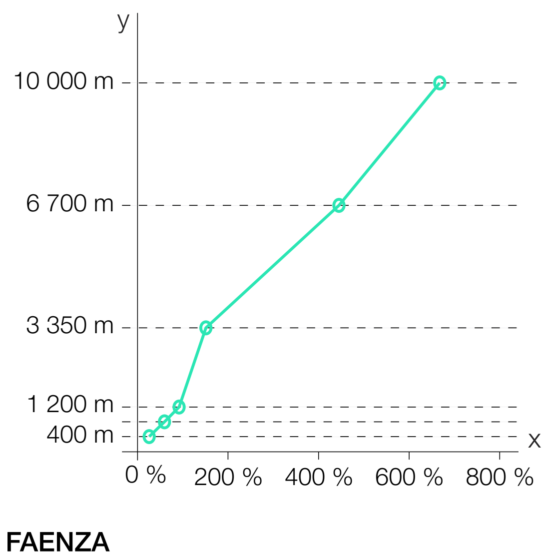


Figure 4.7. Diagram on the relationship between isochrones and spatial accessibility. On the y-axis the threshold distances of the isochrones, on the x-axis the percentage of reachable territory referred to the extent of the municipality. (source: author)

phase. In this way, for each service domain, it was possible to verify whether or not the residents in each 'elementary urban unit' had access to the selected services domain and their number within every single distance threshold [Figure 4.10].

The analysis described here[4] is based on a homogeneous classification of POIs and urban services, attributable to Hansen's (1959) original definition which linked accessibility to land use (such as the location of urban services) and transport variables (such as travel cost, or distance from a certain starting point).
Over the years, several authors have tried to clarify the differences between the different types of urban services, trying to highlight their differences in attractiveness in terms of the complexity of each service – from neighborhood supermarkets to shopping malls, from residual green spaces to playgrounds with trees and services for the various users – or potential demand. More complex indicators of accessibility were elaborated by several authors as Botham (1980), Fotheringham (1986), Van Wee, Hagoort and Annema (2001) and the secondary literature in Staricco (2022). Although these indicators can be useful in identifying the optimal balance between the number, size and spatial distribution of service locations for larger cities, the above reported findings suggest that even basic indicators can provide insights useful for our research question, with the advantage of simplifying the research pipeline while maintaining acceptable outcomes.

To validate the accessibility analysis, it was compared with the urban layout of the city and its public spaces. The main findings are illustrated in the results and discussion section. The same section also presents the main insights which arose from the comparison between the accessibility analysis and the population, the evolution of the urban system, and the network of transport systems.

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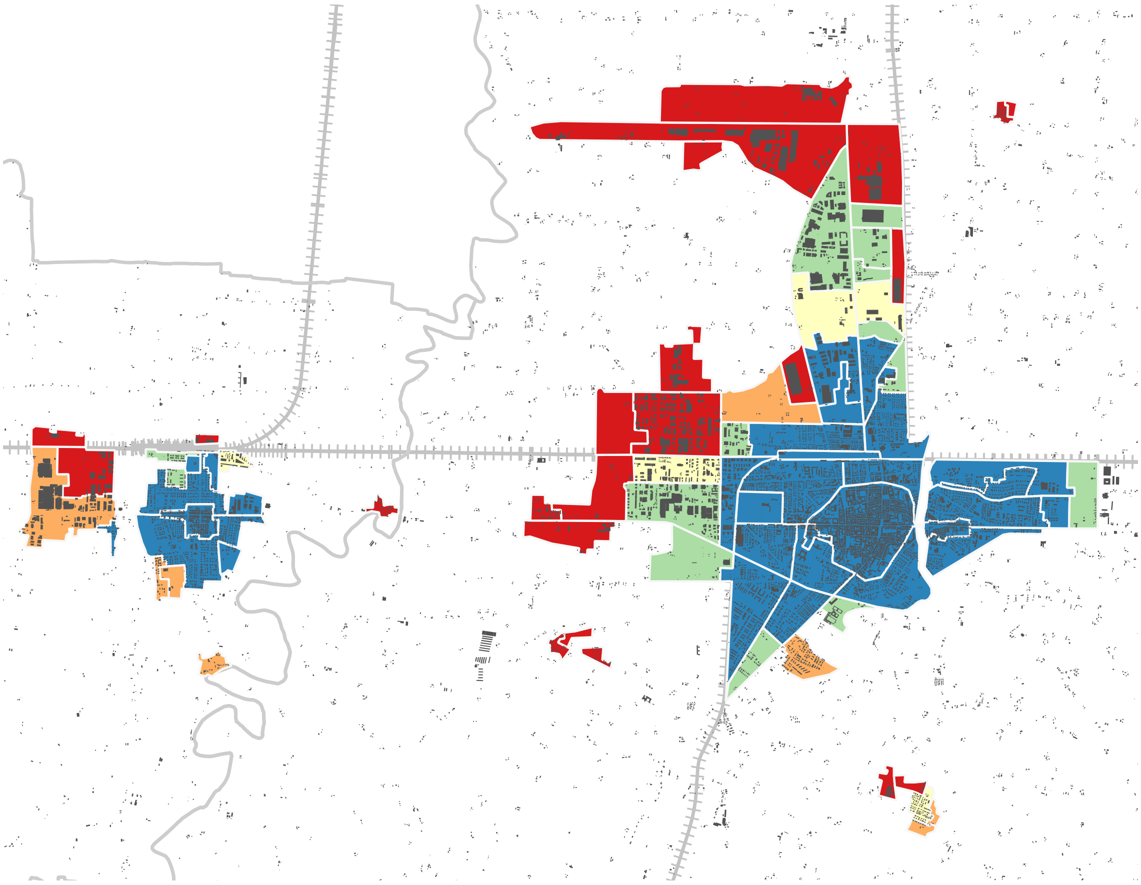
[4] We report below a typical string, in this case for the distance of 800 m:

concat('education ' , aggregate(layer:='POI_faenza_2', aggregate:='count', expression:="domain", filter:=("domain"='education' AND intersects($geometry, geometry(@parent)))) , ',','health ', aggregate(layer:='POI_faenza_2', aggregate:='count', expression:="domain", filter:=("domain"='health' AND intersects($geometry, geometry(@parent))))
, ',','entertainament ', aggregate(layer:='POI_faenza_2', aggregate:='count', expression:="domain", filter:=("domain"='entertainm' AND intersects($geometry, geometry(@parent))))
, ',','living ', aggregate(layer:='POI_faenza_2', aggregate:='count', expression:="domain", filter:=("domain"='living' AND intersects($geometry, geometry(@parent))))
, ',','commerce ', aggregate(layer:='POI_faenza_2', aggregate:='count', expression:="domain", filter:=("domain"='commerce' AND intersects($geometry, geometry(@parent))))).



Legend - accessibility to n. of urban service type
1 service type
2 service type
3 service type
4 service type
5 service type

Figure 4.8. Accessibility to urban services in Castel Bolognese (left) and Faenza using the threshold distance of 800 m. (source: author)

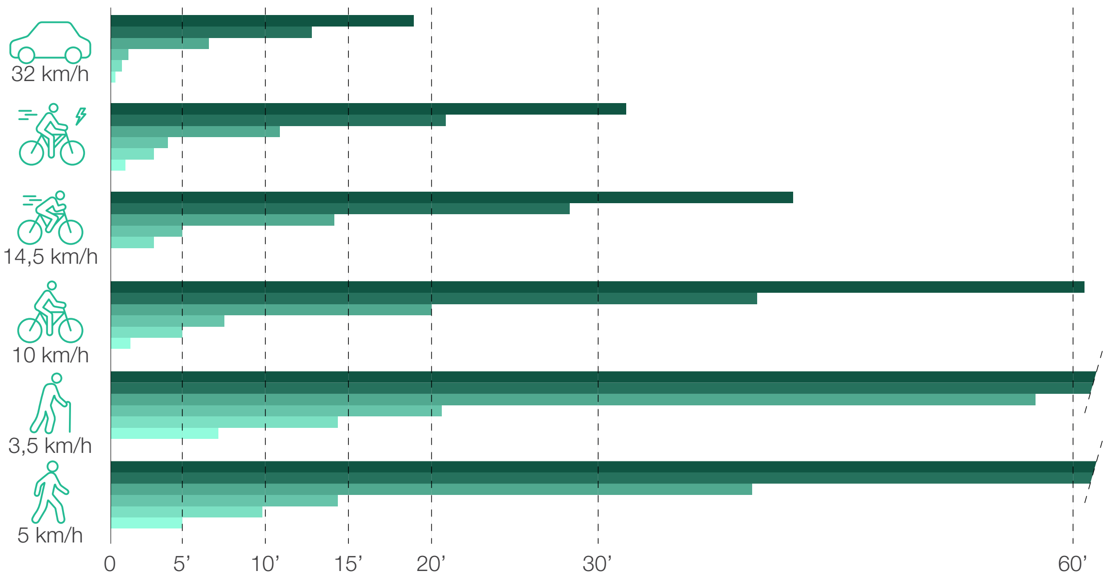


Figure 4.9. Comparison between travel modes, average travel speed with different X-minute city travel times. (source: author)

4.3.5. Assessing access to the street network

To assess the compatibility of the existing road network with the different degrees of proximity reported above, we carried out a geometric accessibility analysis with Space Syntax. We used a well-known network analysis tool, currently used both in urban science and computing science to measure spatial changes based on the topological and spatial features of networks (Hillier and Hanson, 1984). Literature (Yamu, Van Nes and Garau, 2021) has proved how Space syntax tools can assess spatial layouts and human activity patterns in buildings and urban areas.

The road graph found on the regional geoportal, updated with data up to 2021, was used as the basic graph (Regione Emilia-Romagna, 2019). Even if it does not consider secondary roads and dirt roads, it identifies the layout of the basic road network with sufficient precision. Furthermore, given that the analysis of this study is aimed at measuring the urban energy of the road network in relation to the different threshold-distances, the fact that the regional road graph does not consider the limited traffic zones or areas closed to road traffic does not affect the results of the analyses.

After defining the general aims, a series of spatial analyses related to accessibility was completed:

- Angular step depth analysis. Angular depth calculates how directly a street or road is connected to its vicinity, which in the literature is called connectivity analysis. On an urban scale, this analysis establishes where the foreground and the background networks are, considering the former as the more accessible to the other parts of the road network and the latter being the more disconnected and protected areas. Then we made an angular (segment) integration analysis with various metric radii to highlight the various to-movement potentials on different scale levels. Low radius analysis reveals where local shops and commerce are likely to be, while high radius analysis is connected to large and small shops or POIs.
- Angular Choice Analysis. As stated by Van Nes and Yamu (2021) ‘the angular choice analysis depicts the “through-movement” potential and therefore an urban route hierarchy’. In this study we added a metric radius to angular choice, a much more fine-grained analysis that applies various metric radii for the angular choice analysis and takes the geometrical features of the street network into consideration. For a small metric radius, such as 400, 800, or 1,200 m, the main local routes of local city centers are highlighted. The higher the applied metric radius, such as 6,000 or 8,000 m, the more the main routes running through and between a city’s neighborhoods are highlighted, up to taking over the highway network with an ‘n’ radius. We used the above-mentioned distance-thresholds of 400, 800, 6,700 and 10,000 m to compare the spatial analysis about the street network with the accessibility analysis previously detailed.

The results of the two analyses were then compared and reported at the various accessibility threshold-distances referred to in the previous point. To achieve this goal, two steps were necessary: the first was to weigh the data collected with respect to the length of the various road sections to connect them to the dimensional characteristics of the road network; the second was to carry out a logarithmic transformation to standardize the data, make them easier to interpret, and to reduce the impact of outliers[5]. The result is a single accessibility by proximity indicator that, for each distance-threshold, highlights the most compatible roads with respect to the radius considered: for 400 and 800 m they correspond to commercial and walking roads, while for other distances the roads are easily navigable by motorized vehicles. The areas where the index has lower levels are those less frequented in the different distance-thresholds: for 400 and 800 m, residential cul-de-sacs or 'service' roads; for higher values, the areas less compatible to be covered at medium or high speeds. To validate the street network analysis, the results obtained were compared with the road network of the city. Apart from some outliers deriving from a few road graph inaccuracies (for example, the subdivision of the network by individual municipality and the flattening of the network on a single altitude) the results coincide with the classification of the road network and the analyses formulated in the applied research found in chapter 3. In the results and discussion section, this comparative analysis will be deepened, highlighting the possible implications in terms of design.

4.4. Results and discussion

The primary objective of this section is to highlight the primary general findings of the above mentioned analysis and discuss their possible design implications, which will subsequently be subject to in-depth elaboration in the guidelines illustrated in the next section. The aim of this section is not to report all results across every service and every distinct distance-threshold.

4.4.1. A multi-scalar proximity of urban services and served population

A further elaboration was aimed at calculating the percentage of the urban population in Castel Bolognese and Faenza that can reach at least a certain number of different service domains within the distance threshold of 400 m and 800 m [Figure 4.12]. The data show that for the 800 m threshold, 87% of the population of Faenza – fractions included – and 79.9% of the population of Castel Bolognese are able to access all five service classes. That share rises to 92.8% and 85.7% considering the elderly population (>65 years old) and we infer that the increase is attributable to a greater presence of these population groups in well-established urban areas, denser in services. Given that already at these distances the percentage of the population concerned is more than significant, the other threshold-distances were not taken into consideration.

In the urban areas of Castel Bolognese and its hamlets, the most common types of services are ‘health and social services’ and ‘entertainment’ for both the 400 m and 800 m thresholds, while in the urban areas of Faenza and its hamlets, the most common types of services are ‘entertainment’ and ‘commerce’ for both thresholds. In addition, another interesting element of analysis is the local degree of accessibility to ‘living’ services that correspond to green areas and outdoor spaces. These are accessible for 24% within 400 m of the ‘elementary urban units’ of Faenza and for 93% within 800 m; for CB, they are accessible for 25% within 400 m and 60% within 800 m. A potentially improbable figure, given the importance of green areas and public spaces for urban well-being.

Again using the threshold values of 400 and 800 m, the levels of accessibility to urban services were then compared with the building density of the various elementary urban units to find any spatial correlations. The maps do not show significant matches between the two indicators, both in the central areas (the area marked as the old town of Faenza does not correspond to equal levels of accessibility) and in the peripheral ones (for example south Faenza, or north CB), where relatively building-dense clusters do not stand out from the neighboring areas for their level of accessibility. Instead, a correlation between center and suburbs emerges, with the former denser in services than the latter, especially in terms of the number of service domains.

Various elements useful to the goals of the project have emerged from the analyses. First, they verified the population’s level of accessibility to different urban services, both in qualitative and typological terms. Second, it has highlighted how a single accessibility-by-proximity model can be proposed for medium and large cities (e.g., the examples illustrated in the literature in section 2, or the model of the 10’, 15’, or 20’ city), to be calibrated according to the characteristics of the urbanized territory under consideration; in medium and small towns it is difficult to find a single, one-size-fits-all model that can meet the different mobility needs. Indeed, in rural areas the different proximity levels are often hybridized, favoring the use of different means of transport for each of the different journey types. This can be considered a salient feature of these geographical areas, generating different mobility experiences that characterize the urban identity of places with different values. As designers,

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[5] We report below a typical row of the transformations used to calculate proximity accessibility referring to the road network in relation to the threshold distances of 400 800 6700 10,000 m:

*400 m | log10(“T64_Choice_Segment_Length_Wgt_1”) * log10(“T64_Total_Depth_Segment_Lengt_2”)*

*800 m | log10(“T64_Choice_Segment_Length_Wgt_3”) * log10(“T64_Total_Depth_Segment_Lengt_4”)*

*6700 m | log10(“T64_Choice_Segment_Length_Wgt_2”) * log10(“T64_Total_Depth_Segment_Lengt_3”)*

*10.000 m | log10(“T64_Choice_Segment_Length_Wgt_R”) * log10(“T64_Total_Depth_Segment_Lengt_1”)*

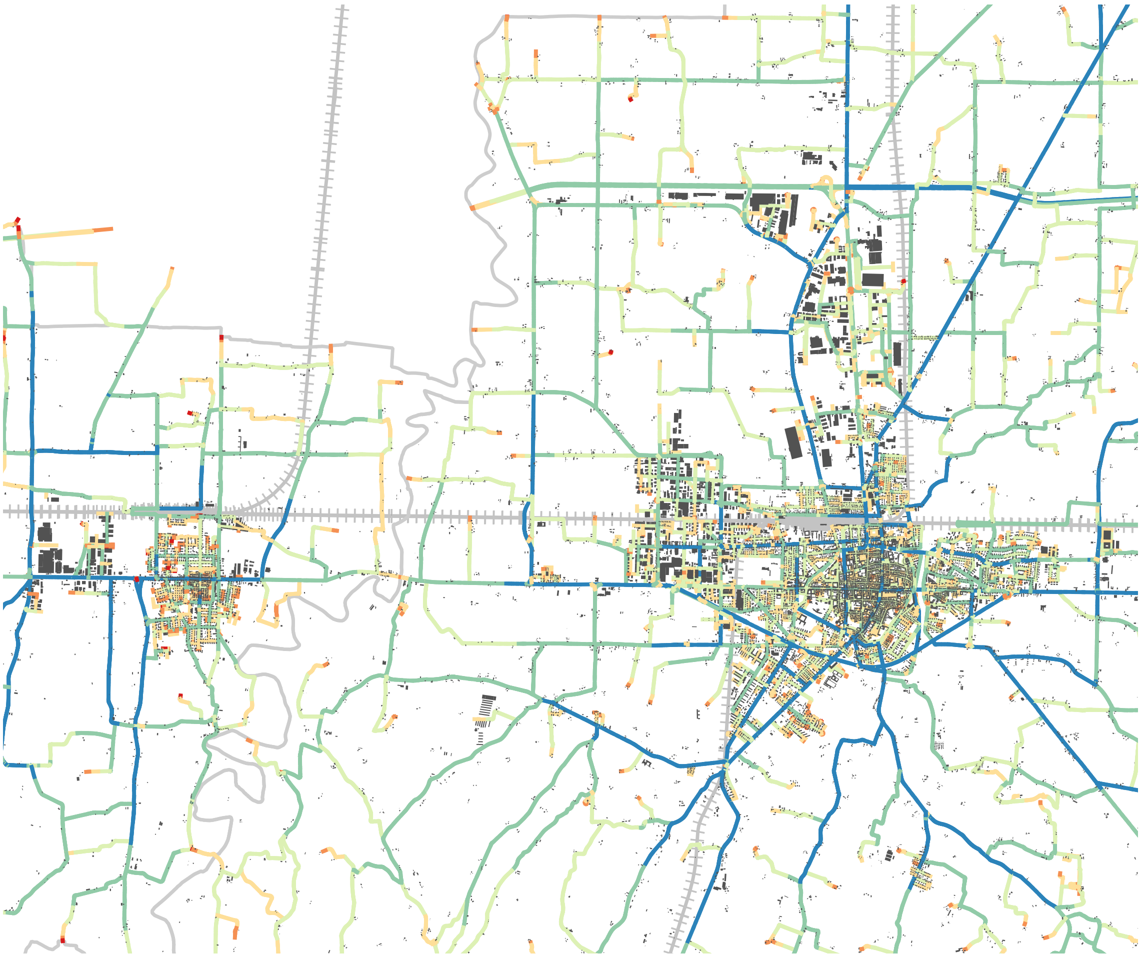

Figure 4.10. Accessibility of the street network in Castel Bolognese (left) and Faenza using the threshold distance of 10 km. In blue the most compatible roads respect to the distance threshold. (source: author)

the goal is to be able to recognize the range of different distances involved and assign them priority through design that impacts infrastructure, vehicles and behavior.

4.4.2. On distances and isochrones. The role of means of transportation

Developing a vision of smart mobility focused on accessibility by proximity highlights the relationship between the distance to essential services and the quality of life in cities and towns. The goal is to promote sustainable mobility through technological innovation and changes in society and civic spaces. All these innovations aim to intensify urban and local travel, which in 2022 made up 77.6% of national travel (ISFORT, 2022), and the use of public transport and active mobility.

To bring these considerations back to our scope of research, we compared the isochrone area with the extension of the municipalities and hamlets to highlight the areas potentially accessible within a certain distance. The map [Figure 4.13] show that the isochrones of 400 m and 800 m cover most of the urban area of the two municipalities, excluding only part of the manufacturing/industrial areas, while the isochrones of 3,350 m for Castel Bolognese and 6,700 m for Faenza have an area equal to that of the municipality. We can consider these threshold values useful for dividing urban, municipal or extra-municipal travel.

Maintaining the objective of promoting sustainable mobility solutions, we can therefore distinguish three main levels of proximity: the first, ‘immediate’ proximity, i.e., within the urban travel thresholds of 400 and 800 m found above and at a low speed (<20 km/h); the second, ‘desirable’ proximity, i.e., travel in the municipality between 3,350 and 6,700 m, found above and at a medium speed (between 20 and 30 km/h); the third is ‘territorial’ proximity, which corresponds to the threshold of 10 km and takes place at a medium-high speed (>= 30 km/h). This relationship between distances, vehicles and the land embodies a mobility model for the area analyzed which leads to a series of considerations based on the findings:

- Motorized vehicles maintain a key role in these places, especially in the hamlets and isolated settlements. The maps [see Annex 4] indicate how, in local hamlets, travel of about 3 km, above the ISFORT proximity travel threshold, only partially makes it possible to reach the nearest town centers, which are perhaps other hamlets. With the structural deficiency of the local public transport, the goal is therefore not the elimination of motorized vehicles, but the promotion of a modal shift towards other mobility systems, the optimization of existing travel through rewards or collaborative tools, and the replacement of such travel with other modes of coming together (e.g., service hubs, working from home, etc.);
- Active transport has latent potential that could leverage alternative ‘smart‘ mobility scenarios. The data show that it is possible to move around the main urban centers and nearby hamlets by bike, e-bike, other shared means in a desirable time. If we add to this data the fact that almost half or more than half of travel for study and work (43.4% for Castel Bolognese and 76.8% for Faenza) takes place within the municipality, we see the potential impact if that travel is funneled into more sustainable and healthy means [Table 4.1]. In addition, the promotion of active mobility affects the urban experience, tying it in more closely with local networks, and promoting a civic identity less linked to landmarks or events. In this perspective, smart mobility solutions can guide the promotion of active transport through vehicles, infrastructure and behavior to highlight possible improvements and expand its modal share.

The findings above highlight how the consideration described in the previous section, namely that the different levels of proximity often hybridize in rural areas, must be linked back to a design perspective in order to be effective. In the project, the different levels of accessibility by proximity must be put in order according to the type of mobility to be promoted.

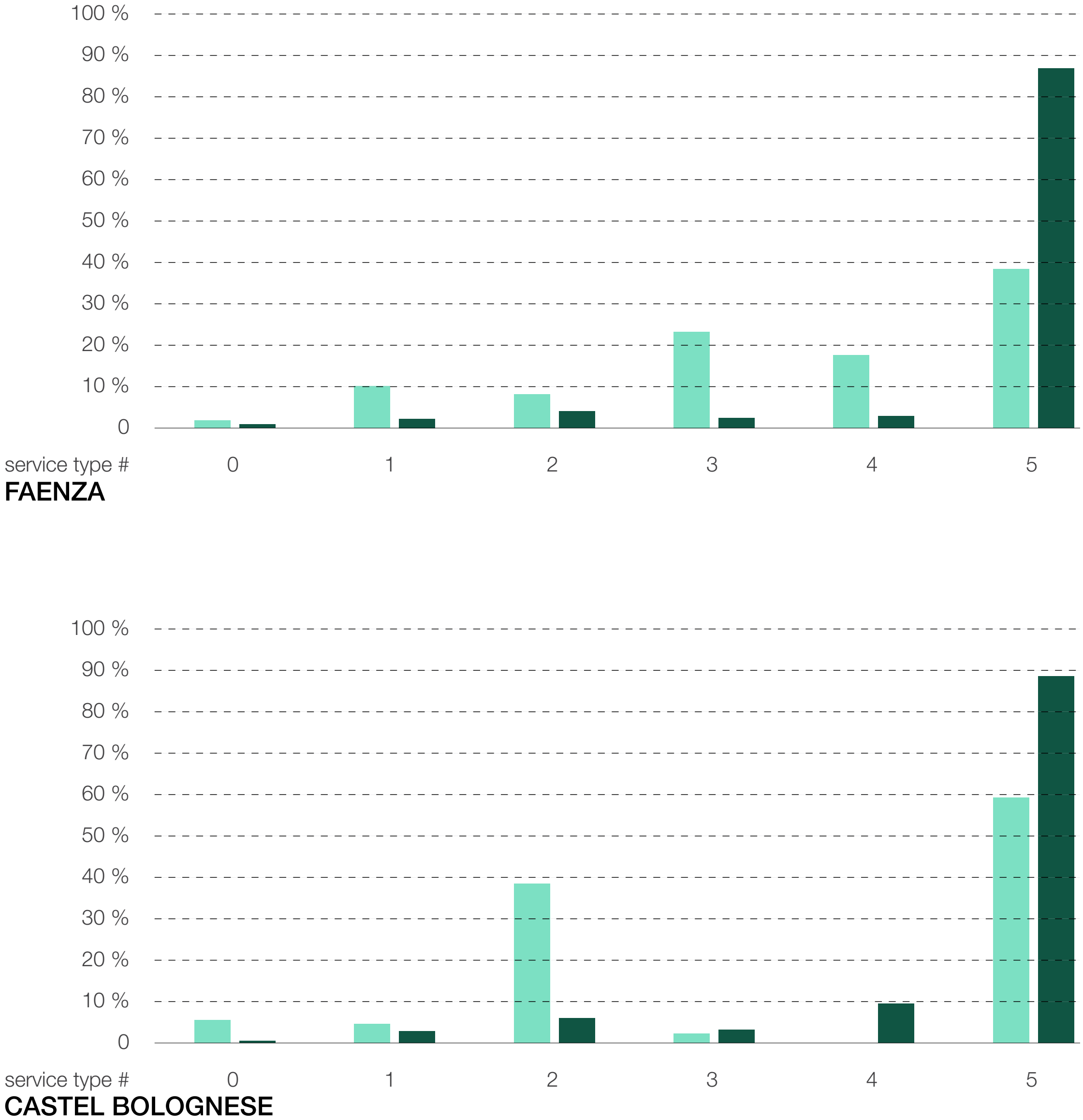

Figure 4.11. Accessibility to services sorted as share of population with access to urban services of different types within 400 and 800 m. (source: author) ● 400 m ● 800 m

In our case, we see two main models of proximity emerge. The first is immediate proximity which in 10 minutes allows you to get where you need to go on foot and by bike in the main urbanized areas and in the nearby hamlets. The second is territorial proximity which allows you to get from point A to point B in 20'-30' with motorized vehicles throughout the municipality. These considerations, when applied to the design level, highlight the importance of spatial data – understood both as distances to be covered and areas reachable within a certain period of time – in the creation of mobility in small and medium-sized towns. In fact, getting from one place to another in rural or less-dense areas is structurally different from doing the same in an urbanized area, and the characteristics of the land are fundamental factors in choosing what type of proximity and means of transport to promote. Another element of reflection is the variety of possible scenarios and means of transport available. To overcome this degree of complexity, we believe it is useful to bring the strategic vision to a single level of accessibility by proximity. This allows for an analysis of the territory which is effectively oriented towards planning.

4.4.3. Multi-service analysis and the role of public spaces

To validate the findings of the accessibility analysis, they were compared with the urban layout of the city with its network of public spaces. This analysis was carried out for the values related to the distances of 400 m and 800 m, considered more suitable for capturing any correlations since, as is easy to understand, as the distances increase, the scores tend to homogenize, ending up at values similar to each other [Figure 4.14].

Below are the main observations:

- In the urban center of CB, the highest number of urban services, classified by natural breaks (Jenks), corresponds to the old town and well-established residential areas. It is interesting to note how the mapping reveals tertiary parts within the industrial areas and the different character of each residential area – e.g., between the areas to the north and south of Via Emilia. Analyzing the areas by type of services, the differences noted above are more pronounced, probably due to the reduced number of subdivisions/classes. In this case, the areas where the indicator is lower correspond to the most recent residential developments, industrial areas, and the area near the railway station;
- In the hamlets of Castel Bolognese and in undeveloped areas, the values in terms of the number and quality of urban services are comparable to those of industrial areas;
- In the town center of Faenza, the areas with the most urban services are the old town, in the well-established residential areas, and in the tertiary areas. The difference between the various levels, defined by normal breaks (Jenks), makes it possible to distinguish the old town from its immediate expansions; the difference also decreases moving away from the town center. Areas with fewer urban services are those with a predominantly commercial character or shopping centers. As in the previous case, even in Faenza, the classes of urban services that are potentially accessible reveal more pronounced differences compared to the analysis of the number of services. Some residential areas and most industrial areas have access to two or three services, with the exception of some areas to the north-east of the station, characterized by a functional mix of residences, tertiary sector businesses and services. With regard to tertiary areas, in most cases their values are good in quantitative but not qualitative terms, data which corresponds to the general layout of these areas, with many poorly diversified services;

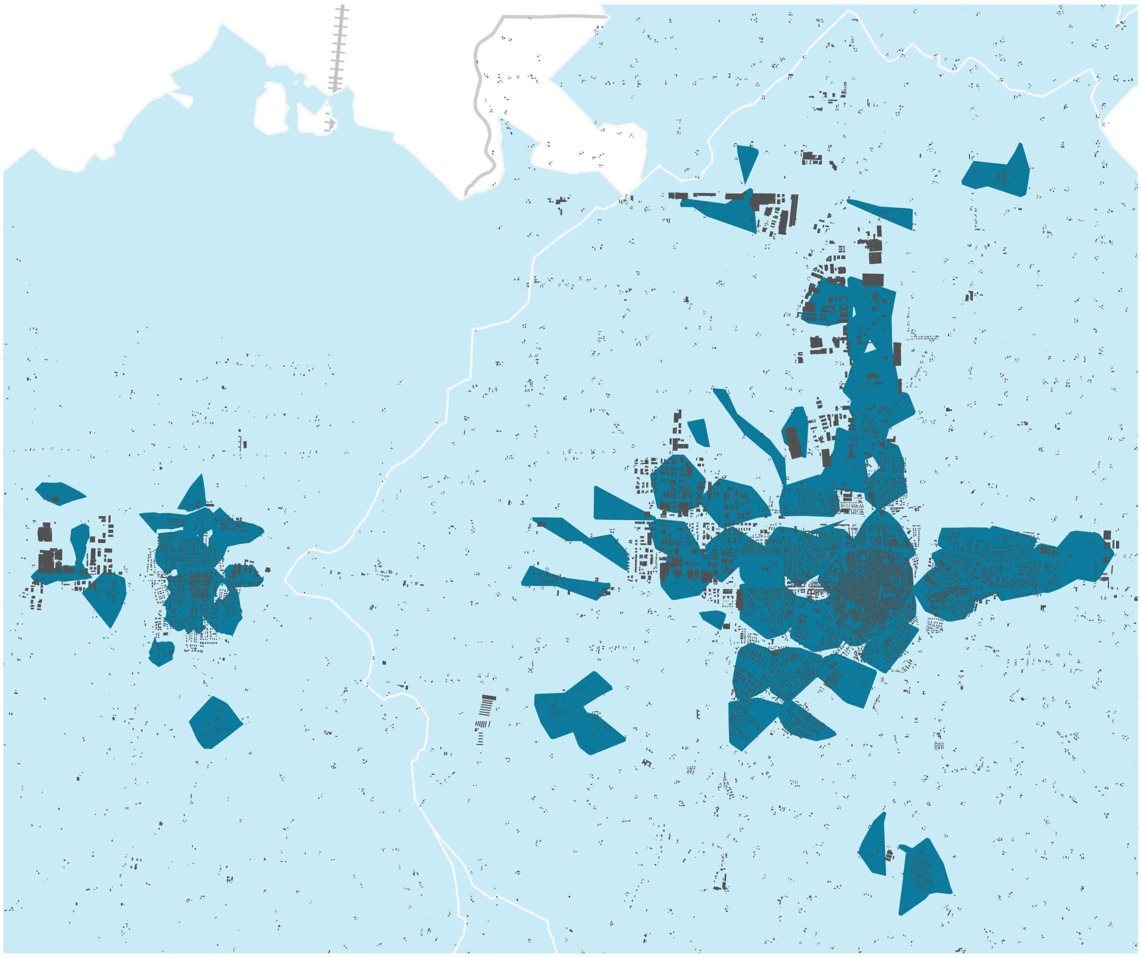

Figure 4.12. Isochrones in Castel Bolognese (left) and Faenza for the distances of 400 m and 6.700 m. (source: author)

	trips within the municipality			trips out of the municipality			all entries		
	work	study	tot	work	study	tot	work	study	tot
Castel Bolognese	1399	938	2337	2389	658	3047	3788	1596	5384
	26.0%	17.4%	43.4%	44.4%	12.2%	56.6%	70.4%	29.6%	100%

	trips within the municipality			trips out of the municipality			all entries		
	work	study	tot	work	study	tot	work	study	tot
Faenza	16677	8354	25031	6457	1121	7578	23134	9475	32609
	51.1%	25.6%	76.8%	19.8%	3.4%	23.2%	70.9%	29.1%	100%

Table 4.1. Residents' daily commuting analysis. (source: ISTAT website)

- In the hamlets of Faenza and in undeveloped areas, the number and quality of urban services is medium-low, with the exception of Granarolo and Reda, to the north and north-east of the center of Faenza.

Comparing the results of the accessibility analyses with the urban layout of the two towns, we can see how it can be a valid indicator of the degree of 'accessibility by proximity' of the urban unit considered, and highlights the direct connections with the historical development of the city and their prevailing uses.

In particular, a comparison with the PSCa tables on chronological evolution and urban growth [Figure 4.15, 4.16] show that the pre-nineteenth century old town, generally characterized by high population density, a dense road network, and a direct relationship between roads and buildings and between public and private space, is the most accessible especially when it comes to short distances. Late-nineteenth-century urban expansions up to 1944 – which incorporated the historical fabric of strategic services (e.g., railway stations), generally characterized by medium population density, and a relationship between roads and buildings mediated by green areas – coincided with areas with medium-high accessibility, especially those closer to the old town. The urban expansion from 1945 to 1980, characterized by a high variety of uses, lower population density, a relationship between roads and buildings often mediated by private areas, and a less dense and connected road network, corresponds to areas with varying degrees of accessibility.

The areas completing the existing fabric have a medium-high level of accessibility while in the more peripheral and industrial expansions the level is significantly reduced. Areas developed between 1980 and 2000 consisted mainly of the creation or expansion of industrial or tertiary areas and the completion of already urbanized residential areas, with changes that did not substantially alter the urban character.

While the old town represents a clear idea of a city with a high level of accessibility by proximity, the variety of uses and morphology of twentieth-century cities is a kaleidoscope of different levels of accessibility by proximity. We believe that one of the possible reasons for these differences derives from different ideas of cities and from their different urban identities. While in the old town the urban morphology, and in particular the full/empty ratio, plays a leading role in organizing the urban fabric and therefore the city model, in the twentieth-century city the different urban fabrics – particularly in the second half of the century – are based on road mobility. The pervasiveness of the road network, the expansion of parking spaces, the dispersion of uses and lower population density can be read as signs of a more or less marked adherence to car-oriented mobility.

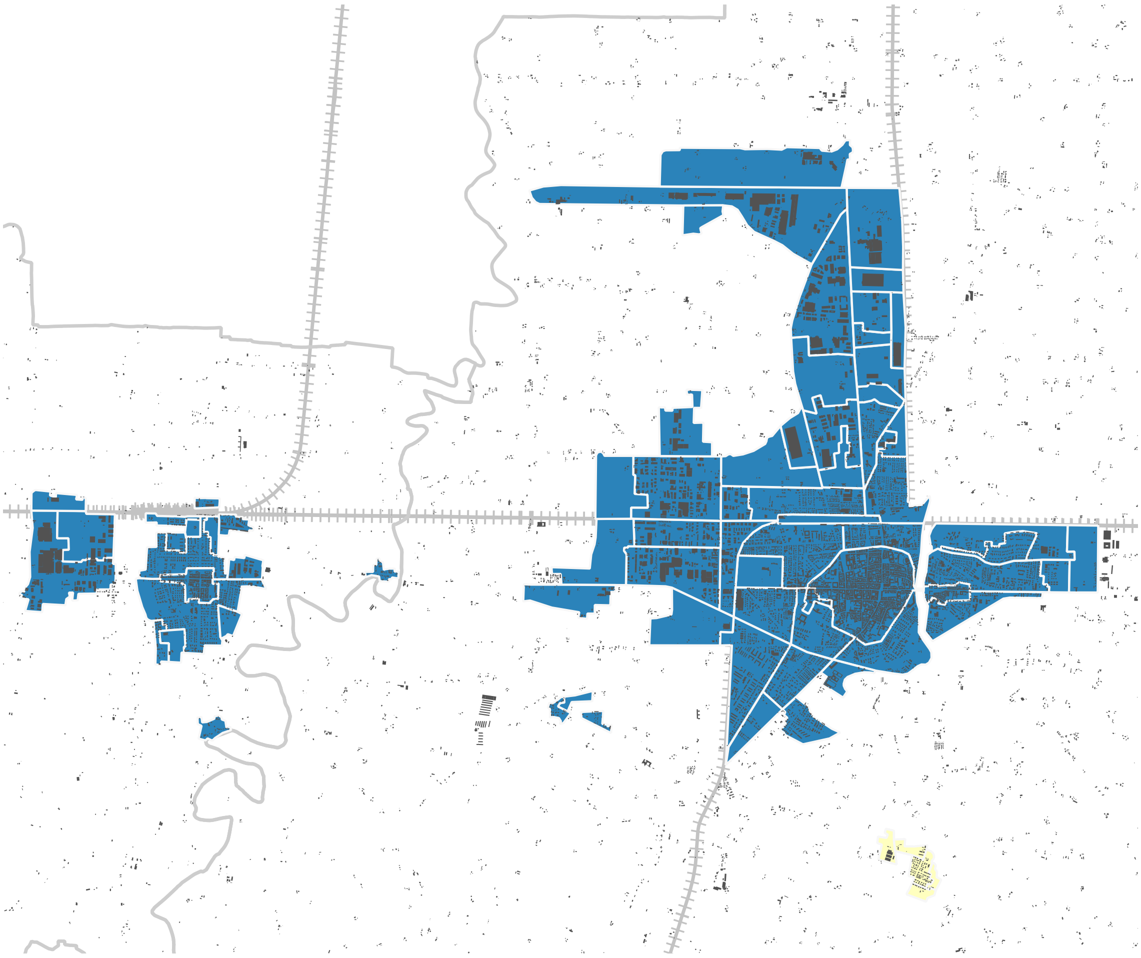

Figure 4.13. Accessibility to urban services in Castel Bolognese (left) and Faenza using the threshold distance of 6.700 m. (source: author)

Today, as this model shows its limits, new design spaces are opening up. Among the various lines of design research, we point out the need to redefine the priority level of roads and to rethink the role of urban services in urbanized areas. The former translates into the need to move from a car-first model to a people-first model, a path travelled since the second half of the twentieth century but still current especially in medium and low density areas. The second is part of an analysis of the accessibility of services to understand when and for which services to promote remote access – online-health, online shopping, working from home – and when and for which services to enhance accessibility by proximity.

4.4.4. Road networks and street vibrancy

To validate the street network analysis, the results obtained were compared with the road network of the city. The maps for the different threshold distances [see ANNEX 4] highlight the most-compatible parts of the road network at their respective distances, with urban centers for the lowest and main connecting arteries for the highest. Further comparison of the findings obtained with the positions of POIs and urban services validates the results described in the maps. In particular, it is noted how neighborhood shops and services are located in the parts where the road network has a higher index with values of 400 and 800 m, while high-demand shops and services are located in the streets with high values for higher distances. We therefore proceeded to explore the correlation between urban neighborhood services and the road network with a detailed analysis with respect to the distance of 400 m, corresponding to a more immediate proximity:

– In the city center and in the hamlets of CB, the main urban services are located in the areas where road network accessibility is highest. The services that deviate are linked in part to industrial or tertiary areas or to green areas or sports centers;
– In the hamlets around Castel Bolognese and in undeveloped areas, the accessibility of the road network scores as intermediate to low, with the index showing high variability in undeveloped areas;
– In the center of Faenza, the main urban services are located in the areas where the street network accessibility level is highest. The services that deviate are mainly found in parks, green spaces or sports centers; shopping centers; and in part in industrial and tertiary areas;
– In the hamlets around Faenza, the main urban services are located in areas where the street network accessibility level is high, with the exception of parks and places of worship – usually chapels or votive churches. The hamlets of Prada and Santa Lucia are the only two cases where this score is low, probably due to the lack of urban services and the fact that they are close to the perimeter of the road network. As in the previous case, the index is highly variable in non-urbanized areas.

Realizing that ‘density, mix and access networks are co-dependent, they co-evolve as part of an urban assemblage (Dovey and Pafka, 2014; 2017) that cannot be reduced to the spatial network as the “fundamental determinant” (Hillier, 1996, p. 170 in Pafka, Dovey and Aschwanden, 2018), the observations above connect the findings of the Space Syntax analysis to the main reference markers to verify the data collected. Although the network analysis described here makes it possible to reduce some of the limits found in SpaceSyntax (Ratti, 2004), it should be noted that there is still some degree of abstraction when it comes to the road network. In fact, while the logarithmic standardization of several network characteristics helps ensure that the influence of urban planning on social life isn’t too mechanical, the use of a road graph and topological values excludes the micro morphology of the street (Jacobs, 1961; Whyte, 1980), and thus pavements, benches, or trees. In addition, compared to other indicators present internationally (NACTO, no date) or in the literature, (Pajares et al., 2021; Lanza, Pucci and Carboni, 2023) such as the P-LOS, advanced software for

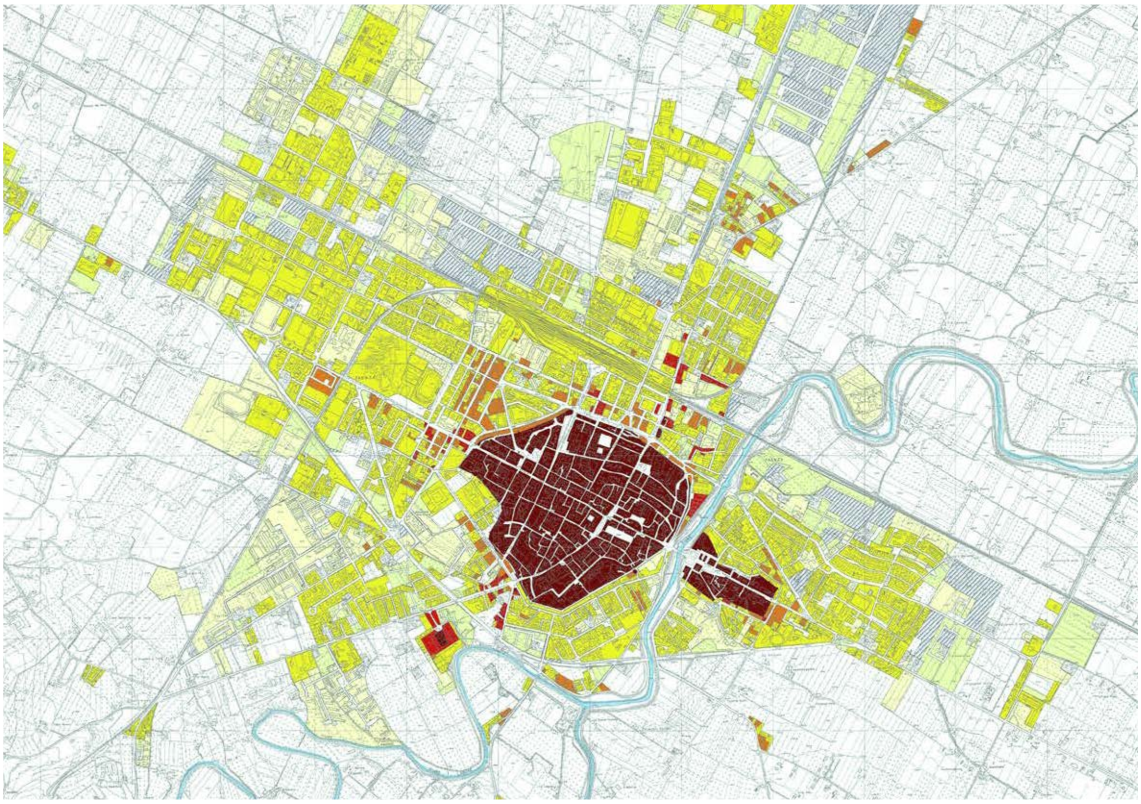

Figure 4.14. Detail of PSC Table C.1.3.1.1 on the historical evolution of Faenza. The lighter areas are the most recent ones. (source: URF website)

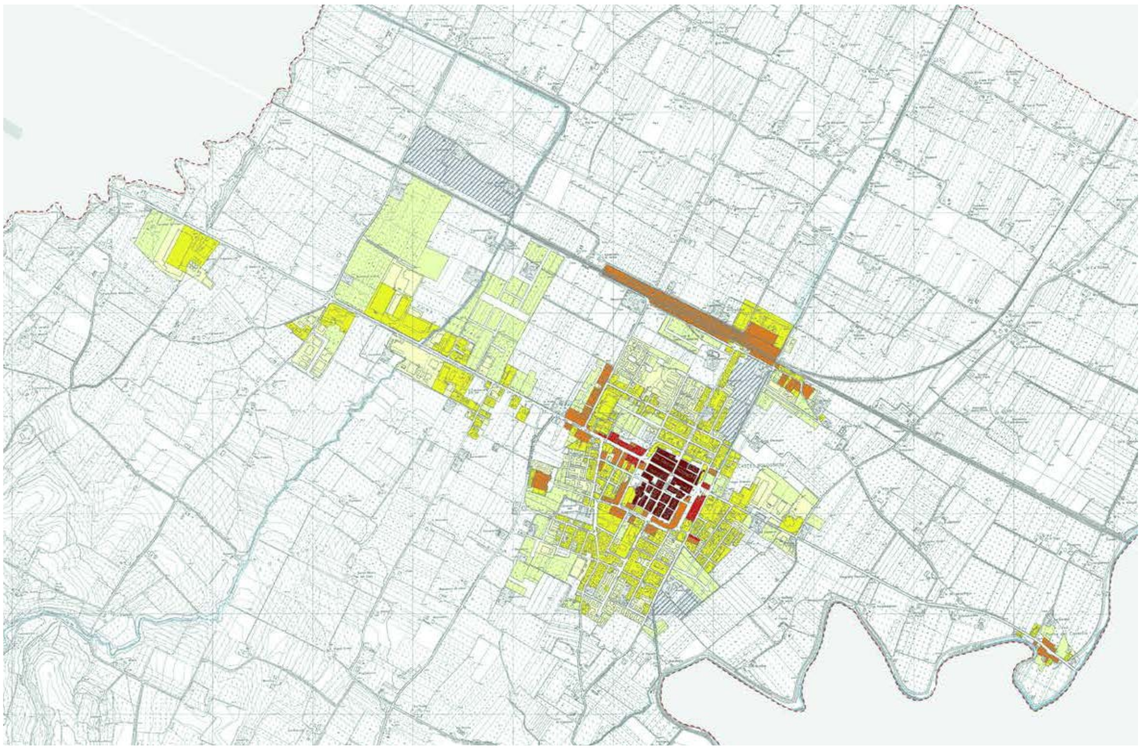

Figure 4.15. Detail of PSC Table C.1.3.1.4 on the historical evolution of Castel Bolognese. The lighter areas are the most recent ones. (source: URF website)

calculating accessibility, accessibility indices oriented to specific needs, this analysis rates street networks in terms of the compatibility of its spatial layout and the threshold distance represented.
This choice was motivated by the objectives of the analysis described here and by the study in general, which aims to provide useful design tools for the development of smart mobility solutions in small towns. In this case, we believe that a spatial analysis of the street network provides an initial framing of the current situation, leaving the detailed mapping to the scale of the intervention. In fact, the challenge of addressing the social logic of the street, intended as not just longitudinal but also a transversal feature (Appleyard, 2021), relies more on urban design process.
The findings of the analysis provide useful design guidance. In addition to showing the compatibility of the different thresholds with different means of transport, the different values for the distances of 400 and 800 m indicate different urban systems. Roads with reduced values are more isolated compared to the road network, indicating, for example, residential neighborhoods which are intentionally isolated to ensure more privacy and safety; conversely, roads with high values have the highest street vibrancy (Huang et al., 2019) i.e., roads to take and to cross with a high level of urban energy. This is reflected in the design guidelines. While in the first case the projects can increase connections with the center or bolster a sense of privacy, in the second case the projects encourage movement, and economic and cultural activities.

4.4.5. Comparing results. towards a ‘small town accessibility score’

The previous sections discussed the relationship between population and access to urban services, that between geographic extension and proximity travel, between urban services and urban structure, and between the street network and the network of public spaces. These themes may give rise to values that can help us pinpoint the main parameters of accessibility by proximity, which constitute a kind of ‘accessibility score’ of small and medium-sized towns. To make the results comparable, this score can be made up of a series of measures:

- Proximity. Percentage of the population served by the five classes of services defined in section 4.3.4. Given the particular demographic dynamics of these areas, this value can be supplemented by the percentage of the population over 65;
- Urban services. Percentage of the different service classes compared to the total [see section 4.3.2];
- Context. Percentage of the geographical area that can be traversed within a certain threshold-distance [see section 4.3.3].

These data can be reported as a percentage or standardized according to a scale based on the

Figure 4.16. Images of two points of the road network in Faenza with different levels of road network accessibility. (source: author)

Figure 4.17. Potential indicators of the 'small town accessibility score'. (source: author)

minimum and maximum values of the various municipalities examined. They can also be integrated with datasets of DESIER, the regional index of digital development. In either case, they are useful for highlighting the main aspects of the territorial accessibility level and outlining a useful framework for developing the urban project and smart mobility solutions.

Another positive element is the possibility of comparing different contexts, verifying if the same solution can be repeated under similar conditions or not. The importance of the context, understood both as an urban system/historical evolution and as street ecology is independent of any specific piece of data in the 'accessibility score'. In fact, we believe that these elements must be developed in the 'smart mobility vision' and most importantly on the scale of the urban project. In fact, the project has the ability to connect the theme of accessibility, which is more representable through data and indicators, to the complex structure of the urban fabric by proposing interventions that impact both aspects.

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